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Contribution of Farm Forest Plantation Management to the Livelihood Strategies of Farm Households in the High Forest Zone of Ghana

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Submitted by

Bernard Nsiah (18.03.1975)

M.Sc. Tropical Forestry

Supervisors:

Prof. Dr. Jürgen Pretzsch

Technische Universität Dresden - Fakultät für Forst-, Geo, und Hydrowissenschaften

Prof. Dr. Peter Spathelf

Hochschule für Nachhaltige Entwicklung (HNE) Eberswalde - Angewandter Waldbau, Fachbereich für Wald und Umwelt

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DEDICATION

This dissertation is dedicated to my family and wife who stood beside me throughout my studies in Germany

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ABBREVIATIONS

¢	Cedi (Exchange rate at the time of data collection (i.e. September, 2006) was $1 = ¢9,200 Cedis. Bank of Ghana (BoG), Quarterly Economic Bulletin (October – December, 2006)
AAC	Annual Allowable Cut
ADB	Agricultural Development Bank
ADRA	Adventist Relief Services Agency
AGDP	Agricultural Gross Domestic Product
AGI	Association of Ghana Industries
ANOVA	Analysis of Variance
B/C	Benefit Cost Ratio
BoG	Bank of Ghana
CBS	Competitive Bidding System
C	Celsius
cm	Centimeter
CO_2	Carbon Dioxide
d.f.	Degrees of freedom
DBH	Diameter at Breast Height
DCF	Discounted Cash Flow
ERP	Economic Recovery Program
FAO	Food and Agriculture Organization
FC	Forestry Commission
FGD	Focus Group Discussion
FIMP	Forest Inventory and Management Project
FSD	Forest Services Division
GGDP	Ghana Grains Development Project
GREL	Ghana Rubber Estate Limited
ha	hectare
HFZ	High Forest Zone
HH	Household
IRR	Internal Rate of Return
kg	Kilogram
km²	Square Kilometer
Ltd	Limited
m	Meter
m²	Square Meter
m^3	Cubic Meter
Md	Man-day
mm	Millimeter
MTS	Modified Taungya System
n	Number
NFPDP	National Forest Plantation Development Program
NGO	Non Government Organization
NPV	Net Present Value
NSCSZ	Northern and Coastal Savannah Zones

OLS	Ordinary least squares
p	Significance
PPS	Probability Proportionate to Size
PPS	Probability Proportionate to Size
PRA	Participatory Rural Appraisal
Qty	Quantity
SAP	Structural Adjustment Program
SPSS	Statistical Program for the Social Sciences
Std	Standard Deviation
st	Stems
TEDB	Timber Export Development Board
TS	Taungya System
TUC	Timber Utilization Contracts
TZ	Transition Zone
UNCCD	Convention to Combat Desertification
UNFCCC	UN Convention on Climate Change
$	United States Dollar
yr	Year

ABSTRACT

Ghana has experienced a remarkable degradation and depletion of its forest resources over the last 100 years. This process has undermined the socio-economic and socio-cultural importance of the forests for millions of rural people who depend on the resource to support their livelihood. Many rural households have over the past three decades developed strategies to minimize the effects of forest depletion on their livelihood. The establishment of smallholder forest plantation on agricultural land has emerged as an important form of land-use for households to diversify their sources of income and also improve their socio-economic well-being. The main objective of the study was to identify and analyze the endogenous and exogenous factors inducing farm household's decision to establish farm forest plantation and to analyze its financial contribution to household's income and livelihood strategies.

The study involved a survey of 280 randomly selected farm households from five communities in the Offinso district in Ghana. The multi-stage stratified random sampling technique was used to select as many as 165 households with farm forest plantation as well as 115 without farm forest plantation. A mixture of tools including semi-structured questionnaire, focus group discussions, wealth ranking, forest inventory and market surveys were used to collect the required data.

Results from logistic regression analysis revealed that the age of the household head, the number of years of education of the household head, the amount of household labor, the size of household landholding, the ownership of permanent land, the availability of non-agricultural land and household's participation in past forest plantation development projects are the most important endogenous factors influencing the farm household's decision to establish farm forest plantation. On the other hand, exogenous factors such as the availability of market and buyers for farm forest products and farm household's satisfaction with market prices for farm forest products positively influenced the household's decision to establish farm forest plantation. Prohibitive rules and regulations relating to the harvesting of trees and transportation of timber from private lands and uncertainty in tree tenure as a result of ambiguous policy framework, however, negatively influenced the decision to establish smallholder forest plantation on their agricultural land.

The results from household income portfolio analysis show that cash income from selling farm forest products contributed an average of $273.6 to total household's income in one agricultural season. This amount accounted for 17.6% of total household's income and represented the second most important source of income after agriculture. The profitability of different land-uses

practiced by the households was analyzed using a conventional economic method *(Net Present Value)*. The results from a comparative financial analysis show that the establishment of teak plantation on agricultural land inter-cropped with food crops is the most profitable form of land use for the households compared to pure teak plantation and maize-plantain cultivation. The results of the study underscore the potential contribution of smallholder farm forest plantation to increase the overall household's income and thereby improve household's well-being.

KURZFASSUNG

Ghana hat während der letzten 100 Jahre eine bemerkenswerte Degradation und Verminderung seines Waldvorkommens erlebt. Dieser Prozess hat die sozio-ökonomische und sozial-kulturelle Bedeutung des Waldes als Einkommensquelle zur Unterstützung des Lebensunterhalts für Millionen ländlicher Einwohner geschwächt. Während der letzen 30 Jahre haben viele Kleinbauern Haushalte Strategien entwickelt um den Effekt, den die Verminderung des Waldvorkommens auf ihren Lebensunterhalt hat, zu minimieren. Die Anlage kleinflächiger Forstplantagen auf Ackerland hat sich dabei als wichtige Form der Landnutzung erwiesen, da sie eine Einkommensquelle zusätzlich zu den vorhandenen bedeuten. Sie haben das Potential, die sozio-ökonomiche Situation der Bevölkerung zu verbessern. Ziel der Studie war die Identifizierung von internen und externen Faktoren, die bedeutend zur Entscheidung von Haushalten über die Errichtung kleinflächiger Forstplantagen beitragen. Desweiteren sollten der finanzielle Beitrag der Forstplantagen zum Einkommen und zu Strategien der Kleinbauern analysiert werden.

Für die Sudie werden Datensätze von 280 zufällig ausgewählten landwirtschaftlichen Haushalten aus fünf Gemeinden im Offinso Distrikt in Ghana erfasst. Die mehrstufig aufgebaute zufällige Auswahltechnik wurde benutzt, um die 165 Haushalte mit Forstplantagen und 115 Haushalten ohne Forstplantagen für die Studie auszuwählen. Mehrere Instrumente, wurden genutzt um die benötigten Daten zu sammeln darunter vor allem semi-strukturierte Befragungen, fokusierte Gruppendiskussionen, Wohlstandsranking der Haushalte und eine Forstinventur.

Ergebnisse einer logistischen Regressionsanalyse ergaben, dass das Alter des Haushaltsvorstands, die Anzahl der Ausbildungsjahre des Haushaltsvorstands, die Anzahl der im Haushalt vorhandenen Arbeitskräfte, die Größe des dem Haushalt zur Verfügung stehenden Ackerlandes, das Eigentum an Ackerland, verfügbare nicht-landwirtschaftlich nutzbare Flächen und die Teilnahme der Haushalte an Projekten zur Forstplantagenentwicklung die wichtigsten

internen Faktoren für die Entscheidung der Kleinbauern zur Errichtung von kleinflächiger Forstpantagen darstellen. Andererseits beeinflussten externe Faktoren wie das Vorhandensein von Markt und Käufern für Produkte der Forstplantagen und die Zufriedenheit der Haushalte mit den gebotenen Marktpreisen für diese Produkte die Entscheidung der Kleinbauern zur Errichtung von Forstplantagen positiv. Demgegenüber beeinflussten Verbote und einschränkende Regelungen zur Ernte und zum Transport von Bäumen auf Privatland und die Unsicherheit bezüglich des Eigentums an den Bäumen als Ergebniss unklarer politischer Vorgaben die Entscheidung zur Errichtung von kleinflächiger Forstplantagen auf Ackerland negativ.

Das Ergebniss der Analyse verschiedene Haushaltseinkommensquellen zeigt, dass das Jahreseinkommen der Haushalte mit Forstplantagen höher ist als das der Haushalte ohne Forstplantagen. Der Beitrag zum Jahreseinkommen aus dem Verkauf von Produkten der kleinflächiger Forstplantagen betrug im Durchschnitt 273,6 USD in einer landwirtschaftlichen Saison. Dies entsprach 17,6 % des gesamten Haushaltseinkommens und stellte somit die zweitwichtigste Einkommensquelle nach der Landwirtschaft dar. Die Rentabilität der verschiedenen Landnutzungsarten wurde mit der Kapitalwertmethode *(Net Present Value)* ermittelt. Diese vergleichende Analyse zeigte, dass kleinflächiger Forstplantagen auf Agrarland bei gleichzeitigem Anbau von Nahrungsmittel die profitabelste Art der Landnutzung für die Haushalte im Vergeich zu ausschließlichem Teakanbau und zum Anbau von Mais mit Kochbanane ist.

Die Ergebnisse der Studie unterstreichen das Potential kleinflächiger Forstplantagen, einen Beitrag zur Steigerung des gesamten Haushaltseinkommens und zur Verbesserung des Lebensstandards der Haushalte leisten zu können.

CHAPTER 1

INTRODUCTION

1.1 The research problem

Ghana like most African countries has experienced a remarkable degradation and depletion of its natural forests over the past 100 years. According to Wagner and Cobbinah (1993), one-third of Ghana's total land area of 23.9 million hectares was occupied by tropical natural forests at the beginning of the 20th century. However, forest inventory conducted in 1995 revealed that forest cover in the country has declined from 8.2 million hectares in 1900 to just 1.6 million hectares in 1995; representing about 80.0% loss of forest cover (FIMP, 1995). The global forest resources assessment 2005 (FAO, 2006) also indicated that Ghana lost an average of 135,000 hectares of natural forest per year between 1990 and 2000 and a further 115,000 hectares between 2000 and 2005; an indication that the country lost about 26.0% of forest cover between 1990 and 2005. Forest plantation establishment has been recommended by stakeholders to address forest destruction in Ghana and to meet the increasing demand for timber and non-timber forest products. It is expected that the development of forest plantations will relieve pressure on the remaining natural forests and thus decelerate the high rates of deforestation in the country (currently around 2.0% per annum). Forest plantation development is also being promoted to combat environmental problems such as soil erosion and loss of land fertility. Rural households are especially encouraged to establish tree plantations to generate additional income and ensure economic security, thus contributing to social equity and poverty alleviation. These objectives are seen as an important step towards achieving the United Nations Millennium Development Goals (MDGs).

In response to this recommendation, forest plantation establishment on agricultural land has emerged as an important land-use for many farm households in Ghana. This phenomenon is contrary to the period prior to the 1970s where many farm households showed no interest in the establishment of forest plantation. The lack of interest was attributed to a number of factors including (1) the relative abundance of forests in the country at that time, (2) the perception that forest plantation development is the domain of the Forestry Department (now Forestry Commission), (3) the increasing need to achieve short-term economic goals as well as the perception that forest plantation does not hold the potential to increase the socio-economic well-being of the household, (4) lack of right to benefits accruing from trees planted on government land (Milton, 1994), and (5) lack of clear enabling forest policy in relation to the ownership of trees planted on private land. According to the Forestry Commission (FC) of Ghana, several

thousand hectares of smallholder forest plantations have been established in many rural communities by farm households over the last three decades. Farm forest plantation has now been seen by many households as socially acceptable due to its ability to ensure the sustainability of the resource base and improve their socio-economic well-being. Some farm households have shifted from using their land to plant traditional cash crops such as cocoa and coffee to smallholder forest plantations inter-cropped with food crops.

Despite the rapid expansion of farm forest plantations in the study area, no significant research has been undertaken to identify and analyze the driving forces behind this new phenomenon. Most of the research that has been conducted in relation to forest plantation development has concentrated on the technical aspects such as the design, species composition, methods of land acquisition, management models and biodiversity conservation (e.g. Asibey and Siaw, 1999; Odoom, 1999; Owubah, et al., 2001). To understand the factors influencing the establishment of farm forest plantation by farm households, it is essential to analyze the decision-making behavior of these households. The present study will fill this knowledge gap by comprehensively identifying and analyzing both the endogenous and exogenous factors influencing farm forest plantation development by farm households and also evaluate the extent to which farm forest plantation contributes to the overall cash income and livelihood strategies of farm households. The study places farm forest plantation establishment decision-making within the broader livelihood of households. In this context, the study explores the links between macro-level factors (e.g. market conditions, policies and regulations) as well as micro-level factors (e.g. household asset endowments, household composition, etc) and farm forest plantation development on agricultural lands. The study used case studies from five communities located within the Offinso district in Ghana where an intensive and extensive field research was carried out between May and September 2006.

1.2 Objectives of the research

The main objective of this study is to identify the endogenous and exogenous factors inducing the establishment of farm forest plantation on agricultural land by farm households and to analyze its financial contribution to farm household's cash income and livelihood strategies. Specifically, the study will:

- explore the extent to which socio-economic characteristics of farm households, market conditions and policy related factors influence the decision to establish smallholder farm forest plantation,

- analyze the income portfolios of the study households and assess the financial contribution of farm forest plantation management to the overall household cash income vis-à-vis livelihood strategies,

- evaluate and compare the financial profitability of farm forest plantation management in relation to traditional maize-plantation cultivation in the study area, and

- make recommendations to promote the establishment of farm forest plantation by farm households.

1.3 Significance of the research

The present study is significant in terms of its contribution to both theory and practice. The study addresses concerns expressed by various researchers regarding the lack of understanding about the driving forces influencing farm forest plantation development by a diversity of farm households. Of particular relevance is the influence of endogenous and exogenous factors on farm household's decision-making behavior in relation to forest plantation establishment on agricultural land. These factors are yet to be fully understood by forest institutions in Ghana that promote forest plantation development in the country. Most of the institutions consider forest plantation development as more technical rather than socio-economic and behavioral. Majority of the studies that have been conducted in the country concerning forest plantation development have relied exclusively on descriptive statistics and have failed to test the relationships between the internal and external factors influencing forest plantation establishment decision-making by farm households. The present study applies rigorous statistical testing of the correlations between the socio-economic characteristics of the households, market and policy, and farm forest plantation decision-making. In addition, it provides insights into the contribution of farm forest plantation management to the cash income as well as the livelihood strategies of farm households. The study combines the analysis of survey data with extensive literature reviews to understand the context in which farm forest plantation development occurs. It is envisaged that the findings generated from the study can help improve and strengthen the benefits derived by households from this economic activity and also guide future policy design with regards to the promotion of farm forest plantation development.

1.4 Research hypotheses

Four hypotheses have been formulated to guide the study. Both qualitative and quantitative data collected from the field have been used to validate or falsify these hypotheses. The formulated hypotheses suggest that farm household's decision to establish smallholder forest plantation on

their agricultural land is explained by a combination of "endogenous" and "exogenous" factors. The endogenous frame conditions refer to the socio-economic characteristics of the households while the exogenous frame conditions refer to market factors and the policy environment under which farm forest plantation establishment takes place. Table 1.1 shows the various research hypotheses and their criteria.

Table 1.1: Research hypotheses and criteria

Hypothesis	Criteria
Hypothesis 1: The socio-economic characteristics of farm households (i.e. personal-demographic situation, resource endowments, etc.) determine their propensity to establish farm forest plantation	- Wealth status of the household - Size and age composition of the household - Age of the household head - Size of household labor force (man-equivalent) - Household head years of education - Size of household landholding (ha) and land tenure arrangement - Availability of household land not suitable for agriculture - Participation of household head or any member of the household in past forest plantation development projects
Hypothesis 2: The availability of market and buyers for farm forest products, and changes in policy regarding the ownership of trees planted on private lands vis-à-vis the right to harvest trees and transport timber positively influence household's decision to establish farm forest plantation	- Level of awareness of change in forest policy regarding ownership of planted trees in Ghana - Level of freedom to harvest and transport trees planted on private lands - Extent of influence of changes in forest policy on farm household's decision to establish farm forest plantation - Availability of market for forest plantation products - Availability of buyers for forest plantation products - Level of satisfaction with present market prices for forest plantation products - Perception of future demand for forest plantation products - Perception of future prices for forest plantation products
Hypothesis 3: Cash income from farm forest plantation management increases the overall household's income and enhances their well-being	- Household income portfolios - Total household annual income - Amount of cash income generated from farm forest plantation management per annum - Percentage contribution of cash income from farm forest plantation to total households annual income - Household's perception of the level of importance of income and products from farm forest plantation management to their livelihood strategies
Hypothesis 4: The profitability (financial returns) from farm forest plantation inter-cropped with food crops is higher than the traditional maize-plantain cultivation in the study area	- Initial and total investment needed to establish and manage farm forest plantation compared to maize-plantain cultivation - Labor requirements for farm forest plantation management over a 25-year rotation period - Labor requirements for food crop production over a 25-year rotation period - Average gross margin for farm forest plantation management over a 25-year rotation period - Average gross margin for food crop production over a 25-year rotation period

Source: Field Survey, 2006

1.5 Focus and structure of the dissertation

The focus of this dissertation is limited to farm forest plantation[1] established by farm households, due to which the study does not include companies, co-operatives or state forest plantations. The dissertation is organized into Eight Chapters. Following the introductory chapter (i.e. Chapter One), Chapter Two will present an overview of perspectives regarding the necessity for forest plantation development in Ghana. Various forest plantation development initiatives implemented in Ghana in the past are also reviewed. Chapter Three outlines the conceptual and methodological framework of the study. The methods employed in collecting data and the analytical methods used are described. Chapter Four presents a description of the study area (Offinso district). Background information on the entire study area and the selected study communities is provided. Chapter Five statistically investigates the patterns of differentiation between farm households with and without farm forest plantation in terms of their socio-economic characteristics. An assessment of the major income generating activities undertaken by the study households and their involvement in farm forest plantation establishment and management are evaluated. An analysis of returns from three land-uses options, namely, pure teak plantation establishment on agricultural land, teak plantation inter-cropped with maize and plantain, and maize-plantain cultivation are also performed in this chapter.

Chapter Six uses logistic regression model to identify the factors influencing farm household's decision to establish farm forest plantation in the study area. The various analyses in this chapter are used to explore the correlation between farm household's socio-economic characteristics, market and policy related factors, and variations in farm forest plantation establishment decision-making. The above factors will be related to the historical micro and macro-economic contexts. In Chapter Seven, the income and expenditure portfolios of the study households are analyzed to get an idea about their composition and importance. The financial contribution of the major economic activities to the overall cash income of the household's and livelihood strategies is also assessed. Finally, Chapter Eight presents the conclusions by summarizing the major research findings and also makes recommendations for future research.

[1] Farm forest plantation in the context of the study refers to the establishment of small-scale forest plantation by farm households on their agricultural land

CHAPTER 2

THE NECESSITY FOR FOREST PLANTATION DEVELOPMENT IN GHANA

2.1 Increased demand for wood and wood products

One of the most compelling reasons for forest plantation establishment is that consumption of industrial wood and wood for cooking and heating is rising steadily while at the same time efforts to reduce harvesting in natural forests are increasing (Sutton, 1999). In the view of Sutton (1999a, 1999b), the world's natural forests cannot cover the current and future global wood demand of the growing human population. According to FAO (FAO, 1997), total round wood consumption is projected to increase at an annual rate of 1.1% from 3.21 billion m^3 to 3.84 billion m^3 between 1994 and 2010 and industrial round wood is projected to increase by 1.2% annually, from 1.47 billion m^3 to over 1.78 billion m^3.

The demand for wood and wood products in Ghana has increased steadily over the past decades. According to TEDB (1995), the total lumber requirement for domestic consumption is estimated at 456,000 m^3/year. On the basis of a conversion rate of 40.0%, this amounts to 1.14 million m^3 of round logs. The volume of lumber retailed locally was estimated at 385,000 m^3 in 1995 with about 73.0% (i.e. 282,000 m^3) of this volume constituting chainsaw lumber. The remaining 27.0% was supplied by the saw mills and bush mills. There is thus a lumber supply gap of about 70,000 m^3 or more. So far thinnings from the Forestry Department's teak plantations have been the main source of raw material for the pole treatment companies in Ghana. The current demand for treated poles for rural electrification projects exceeds the supply from the existing plantations. According to Agyarko (2000), about 300,000 m^3 of treated teak poles is required each year for the national electrification program and this is expected to increase by 15.0% by the year 2020. Thus the total demand for electricity poles will increase to 345,000 m^3/year.

For most rural people, fuel wood is undoubtedly the most important product derived from the forests and woodlands. It is estimated that about 80.0% of the population in Ghana (mainly in the rural areas) depends on fuel wood derived from natural forests for cooking and heating. According to Armstrong-Mensah (1997), about 16.4 million m^3 of wood are consumed every year as fuel wood in the country with a per capita consumption of 1.1 m^3/year (round wood equivalent). The volume of fuel wood consumption is expected to rise to 20 million m^3 by the year 2010. It is thus necessary to consider fuel wood plantations in the establishment of farm forest plantations and as part of national forest plantation development programs. The milling industry has also continued to expand its capacity since 1995. According to Odoom (1998), the

combined capacity of the saw and bush mills in terms of log requirement is estimated at about 1.3 million m^3/year whilst the veneer and ply mills require about 390,000 m^3/year. He further estimated that illegal chainsaw operators add about 740,000 m^3 of sawn timber annually to the domestic market. Thus, the total log requirement for the local processing may be estimated at 2,430,000 m^3/year. This is about 143.0% more than the prescribed annual allowable cut (AAC) of 1 million m^3. Figure 2.1 shows a graphical representation of the estimated capacity of the wood processing sectors.

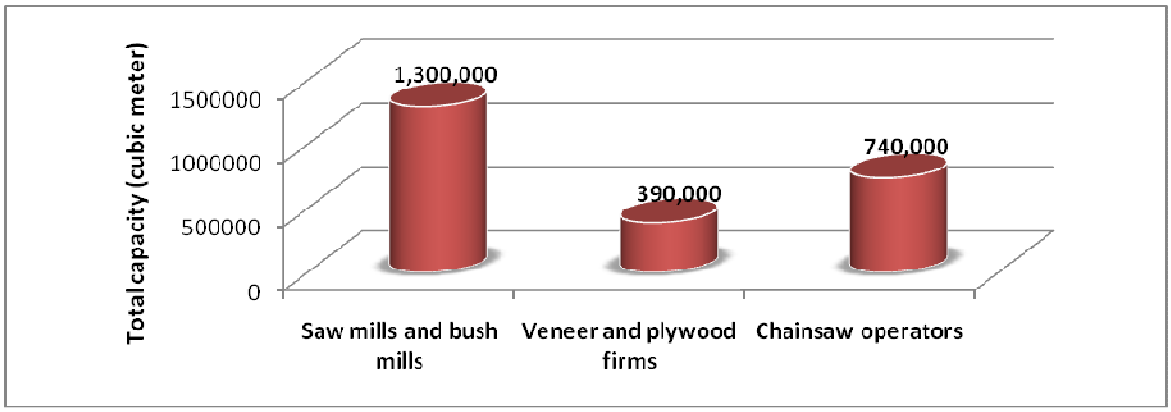


Figure 2.1: Estimated capacity of the wood processing sectors in 1995 (TEDB)
Source: Data based on Odoom (1998)

The gap between supply and demand for wood in the country is expected to be bridged through a combination of measures including efficient control of exploitation, utilization and protection of the remnant forest resources, importation of logs from other countries and the establishment of forest plantations (Odoom, 1998). The estimated theoretical local demand for wood is presented in Table 2.1. It has been assumed that all wood requirements would be met from future plantations whose average mean annual increment is about 10m^3/ha/year. It is estimated that if the remaining natural forest and the existing forest plantations can be effectively managed to fulfill the local demand for wood, about 415,500 ha of additional plantation area would be required.

Table 2.1: Estimated theoretical local demand for wood and forest plantation area required to meet future demand for wood in Ghana

End-Use	Annual requirement (m^3 round)	Supply from existing forests (m^3 round)	Balance (m^3 round)	Plantation area required (ha)
Industry[1]	4,000,000	750,000	3,250,000	325,000
Fuel wood[3]	16,400,000	8,000,000	8,400,000	840,000
Poles[3]	30,000	15,000	15,000	1,500
Local lumber[2]	1,140,000	250,0004	890,000	89,000
Total	21,570,000	9,015,000	12,555,000	1,255,500

[1]Sawmill, bush mill, veneer and ply mill, excluding chainsaw, [2]Including chainsaw, [3]50.0% assumed from the forests, [4]25.0% of AAC of 1,000,000m^3/yr , [5]75.0% of AAC of 1,000,000
Source: Odoom (1998)

2.2 Forest plantation establishment to restore degraded lands

The availability of large areas of degraded land that are not suitable for agriculture and also do not compete with existing land-uses provide an opportunity to be used for forest plantation development. According to Asare (2005), there is widespread degradation of forest and farm lands in the high forest zone making these areas lie idle. He estimates that about 8.5 million ha of land outside the forest reserves are available for forest plantation development. The necessity to use degraded lands for forest plantation development has further been enhanced with the advent of the United Nations Framework Convention on Climate Change (UNFCCC, 1992), the Kyoto Protocol (1997) and the Convention to Combat Desertification (UNCCD, 2008). These conventions call for the rehabilitation of degraded forests and fragile ecosystems through afforestation and reforestation to restore the contribution of forests and trees in mitigating the effects of climate change, reversing loss of natural forests and restoring landscapes. Following Brown et al. (1997), the potential benefits from forest plantations provide opportunities and incentives to initiate site rehabilitation activities. The above discussions point to the fact that converting degraded areas into forest plantations offers a great potential to utilize such lands.

2.3 Forest plantation establishment as a means to combat global warming

The need for forest plantation establishment has been echoed by various UN Conventions. For example, the Convention to Combat Desertification (UNCCD, 2008), Framework Convention on Climate Change (UNFCCC, 1992), and the Kyoto Protocol (1997) have recognized the importance of forest plantation to offset greenhouse gas emissions and thereby mitigate the impacts of climate change. According to Carle and Holmgren (2008), it is estimated that planted forests sequester about 1.5 giga tonnes of carbon per year, which is in parity with calculated losses from deforestation. Additionally, an estimated 0.5 giga tonnes of carbon is stored long-term in forest products from planted forests every year. This is a clear indication that forest plantation can play an important role in sequestering carbon and providing carbon sinks, hence combating global warming. It has been estimated that for each kilogram of carbon captured within wood, 3.7 kg of CO_2 are removed from the atmosphere (Bowyer, 2001). Thus, substantial carbon storage accompanies the growth of trees and the accumulation of woody debris on the forest floor. It has been proved by recent research that carbon storage can be significantly enhanced by periodic harvest of trees and their use in long-lived products (Marland, 1993). This shows that although forests are capable of off-setting CO_2 emissions, it does not imply that these forests should be preserved to keep the CO_2 from returning to the atmosphere.

2.4 Biodiversity as environmental concern in forest plantation development

While acknowledging the inevitability of forest plantation development, a number of concerns have been raised with regard to the environmental impacts of its development. Most of these concerns border on the issue of biodiversity. There are diverse opinions regarding the impact of forest plantation development on biodiversity. Some authors, for example Hakkila (1994), argue that forest plantations are not capable of supporting biodiversity characteristics of native forests. In the opinion of Lee (1992), forest plantations are not only incapable of supporting an array of biodiversity, but also the various management systems used to maximize timber yields lead to systematic reduction of species diversity through elimination of pests, predators, and competitors. It has also been indicated that the simple structure within forest plantations as compared to the complex structure within natural forests provides relatively few choices of food and habitats and thereby resulting in reduced biodiversity (Widagda, 1981). Citing an array of comparative studies of diversity within plantations and natural forests, Sawyer (1993) further argues that the high stocking density of plantations and lack of structural diversity result in relatively low diversity within plantations.

An increasing number of authors, however, challenge the contention that plantations necessarily have lower biodiversity compared to natural forests (Bowyer, 2001). According to Maclaren (1996), studies that have been conducted in New Zealand indicate a greater level of plant and animal diversity in mature radiata pine plantation than native forests in the same area. Norton (1989) has also disputed the assertion that forest plantations are 'biological deserts' after conducting a series of biodiversity studies in New Zealand. The important contribution of forest plantations in restoring biodiversity to an impoverished landscape has also been identified (Parrotta, 1992). The above discussions show that although there is little doubt that plantation forests offer less plant and animal diversity than natural forests, they nonetheless offer an opportunity to restore biodiversity to impoverished landscapes.

2.5 Historical assessment of forest plantation development initiatives in Ghana

2.5.1 Overview

The history of forest plantation development in Ghana can be divided into three contrasting periods, namely, the colonial period (1885-1956), post-independent period (1957-1999), and the period from 2000 onwards, which saw the implementation of the national forest plantation development program. The following section highlights the various historical events that served as precursor to the present interest in the establishment of forest plantation by stakeholders in Ghana.

2.5.2 Forest plantation development during the colonial period (1885-1956)

Ghana was characterized by abundant natural forests prior to 1900. Forest plantation development was therefore rarely considered by both the government and the private sector. Forest lands were mainly used for the cultivation of food crops and the establishment of cocoa and coffee plantations using the traditional slash and burn method. This period saw an attempt by the colonial government to develop a universal forest conservation policy to take control of the forests from the indigenous people to avert a perceived threat to the economic base of the colonial rule. As part of measures to conserve forest lands, the colonial government passed a law (Forest Ordinance) in 1927 which gave the government the power to compulsorily constitute reserves in most parts of the country. The implementation of this law resulted in widespread clearance of forests outside the reserves by the indigenous people for cocoa plantations leading to a decline in natural forests. This called for the establishment of forest plantation in the country at that time.

The Taungya System was therefore introduced in the 1920's as part of measures to replenish degraded forest lands and offer forest fringe communities with scarce land the opportunity to obtain land for farming. Portions of poorly stocked forest reserves (i.e. in terms of commercial timber species) were allocated to farmers for Taungya purposes. The farmers cultivated their food crops and inter-planted them with various timber species including Teak *(Tectona grandis)*, Cedrela *(Cedrela odorata)* and Gmelina *(Gmelina arborea)*. Crops such as maize, plantain, cocoyam, and vegetables were normally cultivated for three years after which they were made to discontinue the cultivation of any fresh crops on the allocated plot but were allowed to harvest from the previously planted crops for about two more years after which the farmers quit the plots permanently. The first set of thinning prescriptions for timber species planted on Taungya plots was drawn up in 1939 and a selective felling of teak by pit-sawyers was first done in the early 1940's.

2.5.3 Post-independent forest plantation development initiatives (1957-1999)

This period was characterized by the declaration of independence from the British in 1957. In an attempt to curtail deforestation in the country, the government launched a massive forest plantation development program in the early 1970s also using the Taungya System. This program basically converted degraded natural forests into forest plantations. The program was implemented by staff of the forestry department with the support of local communities. The benefit sharing arrangement that governed the Taungya System excluded the participating farmers from the benefits accruing from the planted trees. Nonetheless, many farmers

participated in the program due to the opportunity to obtain land to plant trees and also cultivate food crops, which the farmers had a 100% share. The program laid the foundation for the participating farmers to acquire skills in forest plantation development. This forest plantation development program was suspended in the early 1980s due to lack of financial resources leading to the inability of the forestry department to provide effective supervision and abuse of the program by the participating farmers.

Some farmers deliberately killed planted seedlings or failed to weed around the trees in order to extend their tenure over the land since a successful establishment meant the discontinuation of cultivation on allocated plots. Furthermore, some farmers illegally entered other degraded as well as undegraded forest reserves that were not allocated for the plantation program to carry out their farming activities. Other reasons which led to the failure of the plantation program include the corrupt practices of forestry officers when allocating plots to farmers. At the time the program was suspended, over 75,000 ha of forest plantation had been established. Due to lack of maintenance, about 40,000 ha of these plantations survived out of which only 15,000 ha can be considered as commercially viable. Approximately, 50.0% of this is made up of teak whilst the remaining 50.0% consisted of indigenous and other exotic species. It is believed that some participating farmers used the skills and knowledge acquired from the plantation program to establish forest plantation on their agricultural lands. The establishment of forest plantation by private individuals and other stakeholders increased significantly in the mid-1980s.

2.5.4 The national forest plantation development program (2000-present)

The period from 2000 onwards has seen the promulgation of various forest policies aimed at encouraging the establishment of forest plantation in the country. This period has also witnessed the implementation of the National Forest Plantation Development Program (NFPDP) launched in 2001. The current interest in forest plantation development has been fueled by the continued depletion of natural forests and the desire to reduce the dependence on naturally growing timber. It is expected that the NFPDP will rehabilitate a total of 20,000 hectares of degraded forest reserves each year in the High Forest Zone (HFZ), Transition Zone (TZ), and the Northern and Coastal Savannah Zones (NSCSZ). The program is anticipated to create employment opportunities for local communities; address wood deficits, increase food production and in the long run reduce poverty in forest fringe communities. The program is being implemented using a Modified Taungya System (MTS) which differs from the conventional Taungya System as it involves legally-binding land lease and benefit sharing agreements. Under the new system, participating farmers will be co-owners of the plantations together with the Forestry

Commission. The farmers will stay on the reforested land until the tree crops mature, instead of being driven away after three years, as was practiced in the past. Participating farmers are also entitled to 40.0% share of the plantation and 100% share of proceeds from the agricultural crops they plant. The government represented by the FC will earn 40.0% whilst the landowners (traditional authorities) and the forest fringe communities are entitled to 15.0% and 5.0% respectively. The major planted species is teak (60.0%) with the remaining area under other broadleaved species such as Cedrela, Gmelina, Terminalia *(superba and ivorensis),* Triplochiton and Khaya spp. Teak has become the most attractive species for afforestation in Ghana due to the high demand both at the domestic and international markets.

2.6 Extent of forest plantation in Ghana

According to FAO (2003), Ghana's total forest plantation area represented about 76,000 hectares in the year 2000. It is estimated that over 53,000 hectares of new forest plantation were established between 2001 and 2005 using the Modified Taungya System. A greater proportion of these plantations are owned by the state whilst the private sector including individuals, tree grower associations, NGOs and firms own a sizable amount of forest plantation. Further forest plantation areas continue to be established in the country each year through various forest plantation development projects implemented by the Forestry Commission in addition to small and medium scale forest plantations being established by private individuals, timber firms and NGOs. There is currently about 40,000 hectares of productive forest plantations belonging to the state being managed by the Forest Services Division (FSD) of the Forestry Commission.

This comprises of 38,000 ha in the High Forest Zone (mainly within Ashanti and Brong-Ahafo regions), 1,500 ha in the three Northern regions and 1,400 ha in the Volta region. It is estimated that more than 50.0% of these plantations have stocking rate of less than 300 good stems ha^{-1} and only about a third of these plantations have a basal area in excess of $18m^2$/ha/yr. This is due to lack of proper silvicultural practices such as pruning and thinning. Over 45.0% of existing state plantations consist of teak. Other species that have been planted on large scale include Cedrela, Gmelina, Oprono *(Mansonia altissima)* and Ofram and Emire *(Terminalia spp.)*. It is estimated that the private sector owns approximately 29,200 ha of plantations. This is made up of about 8,000 ha owned by individuals and tree grower associations; 5,000 ha of Gmelina owned by the Subri Industrial Plantations Limited; 6,000 ha owned by industries (British-American Tobacco, Ashanti Goldfield Company Ltd., Global Green, Dupaul) and 10,200 ha of rubber plantations owned by the Ghana Rubber Estates Limited (GREL).

2.7 Conclusion

This section has highlighted the necessity for forest plantation development, the concerns raised by various authors with regard to the negative impacts of forest plantation establishment and the various forest plantation initiatives implemented in Ghana. The accompanying discussions have shown that forest plantation establishment is expected to increase in the next decades due to the increase in demand for wood and fiber, concerns regarding natural forest depletion and the recognition that forest plantation holds potential to mitigate global warming. Despite the concerns raised with regard to the establishment of forest plantations, the benefits accruing from them are so significant that further development is inevitable. There is therefore the need to address the various concerns in order to balance the positive and negative impacts of forest plantation development.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Conceptualizing factors influencing farm household's decision to establish farm forest plantation

According to Scherr (1997), the analysis of farmer's incentives to integrate trees into their farming systems requires a comprehensive analytical framework. Hence, the study adopts the portfolio investment view (Shively, 1999) and diversification (Ellis, 2000) to holistically analyze the interplay of factors influencing farm household's decision to establish farm forest plantation and the resultant impact of the outcome(s) of the decision on their livelihood. The conceptual framework of the study focuses on linking the interaction of endogenous factors (household socio-economic characteristics, personal-demographic situation, resource endowments, etc.) and exogenous factors (market conditions and policy framework), and their implication on the decision-making process of farm households (see Figure 3.1 for an overview of the conceptual framework of the study). As indicated by Shively (1999), farmer's selection of crops to be planted can be viewed as analogous to an investor's portfolio selection problem. The farmer invests assets such as land, labor and capital in an agricultural portfolio consisting of one or more production activities. The above scenario can be compared to farm household's decision-making regarding the establishment of farm forest plantation, which is also taken under a web of complex endogenous and exogenous factors.

Given that resource endowments shape livelihood strategies (Scoones, 1998; Carney, 1998), it can be said that farm household's resource endowments constitutes the capacity and ability to add new activity portfolios. In this regard, the decision to establish farm forest plantation will be subjected to the availability and access to resources. Limited access to resources such as household labor, represented by the size and age composition of the household, household landholding, education of the household head, annual income, etc. are therefore important determinants for consideration. In general the internal resource endowment of the household and its characteristics will determine the capacity of the household to wait for long-term benefits, for example, income from farm forest plantation management, which accrues after several years of investment. Farm household's knowledge and perception, complex values, cognitive beliefs, and past experiences influence the way they view and react to external social and physical environments. Furthermore, household's decision-making strategies are culture-specific and thus strongly guided by the composition of the household (i.e. life cycle, stage of the family and personal characteristics of the household members) (Wahab, 1996).

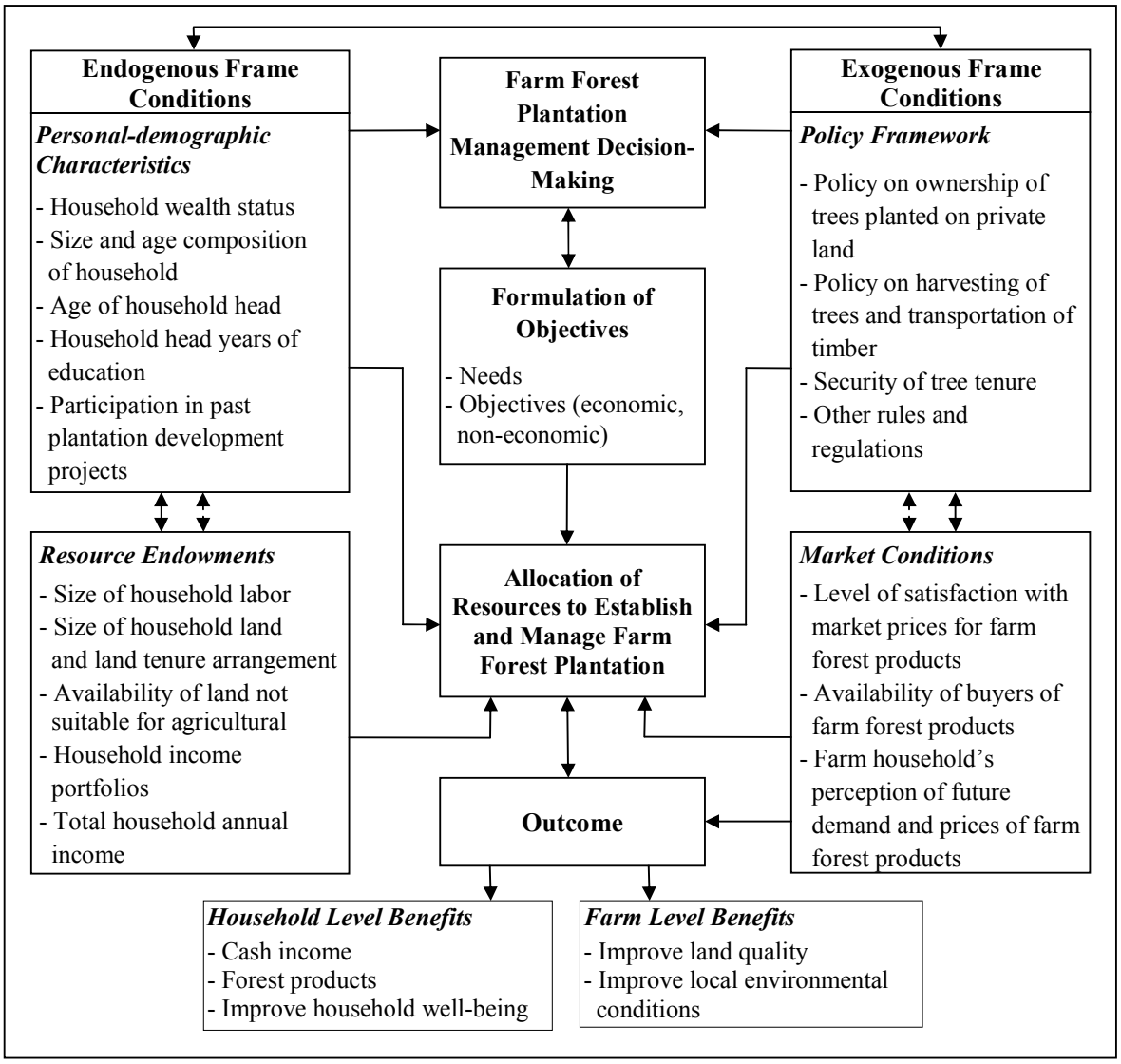


Figure 3.1: Conceptual framework of factors influencing farm household's decision to establish farm forest plantation and their interactions

The decision-making process may be further influenced by exogenous factors such as the policy framework and market conditions. For instance, the policy framework under which households operate can serve as motivation or disincentive to establish farm forest plantation (e.g. rules and regulations regarding tree tenure, harvesting of trees and transportation of timber, etc.). Such rules and regulations can determine whether the farm household has security over the trees they plant or able to harvest their trees and transport the timber freely. The market situation, on the other hand, will determine the amount of resources invested by the farm household to manage the plantation, demand for expected outputs, which is determined by market prices, both at the local, national and to some extent, at the international levels, and whether the expected returns from the plantation can compensate the opportunity cost for the resources invested. According to Scherr (1995), the financial discount rates, as well as farmer's implicit discount rates for

different types of farming activities will also affect their decision-making processes in addition to the degree of uncertainty of receiving benefits (in cash or kind) in the future. Other exogenous factors that can play an important role in the decision-making process include the regional and global economic situation, natural ecological elements consisting of the climate with all its constituents and fluctuations as well as biological elements.

Ellis (2000) provides theoretical arguments regarding the motives for diversification among rural households in developing countries. According to Ellis (1998), diversification is a heterogeneous social and economic process, following a wide range of pressures and possibilities. Rural households may diversify their economic activities out of necessity with the aim of ensuring family survival (Ellis, 2000). Diversification of activities enables the household to achieve various goals simultaneously including food security, maximization of cash income for purchase of outside goods and services as well as agricultural inputs with the objective of meeting future projected needs and contingent emergencies, increasing leisure, avoiding risk, etc. (Ellis, 1993). Activity diversification may occur either through the initiative of the households themselves or the influence of external factors which induces the households to invest in additional enterprises, especially in market-oriented products. Diversification of farm products as an insurance against stochastic biophysical factors may be conceived as an important goal of smallholder farmers in choosing various cropping systems. In most cases, diversification is pursued to maximize well-being rather than profit maximization. According to Heady (1952), diversification of economic activities offers an opportunity to complement and/or supplement production and also create financial synergies through economies of scope by lowering capital costs. Rural households therefore have a strong incentive to diversify their economic activities since they receive all the rewards of their efforts as 'owner and manager'. Reardon and Vosti (1995) and Scherr (1995) have also shown how poverty and economic risk influence investment decisions of smallholders.

The underlying principle behind the conceptual framework suggests that farm households decision to use their agricultural land to establish forest plantation depends on a multiplicity of factors that are internal to the household, including the wealth status of the household, age of the household head, size of the household, household labor force, education of the household head, size of household landholding and land tenure arrangement, size of household land not suitable for agriculture and participation in past forest plantation development projects, etc. On the other hand, there are factors that are external to the farm households and which also affect the decision to establish farm forest plantation, namely, the availability of market and buyers for farm forest products, level of satisfaction with current market prices for farm forest products, perception of future demand and future market prices for farm forest products, level of awareness of changes

in forest policy concerning ownership of trees planted on private lands, level of freedom to harvest trees and transport timber and the level of influence of changes in policy, etc. The above factors have been used as inputs for the logistic regression model presented in Chapter 6 to analyze their influence on farm household's decision to establish farm forest plantation.

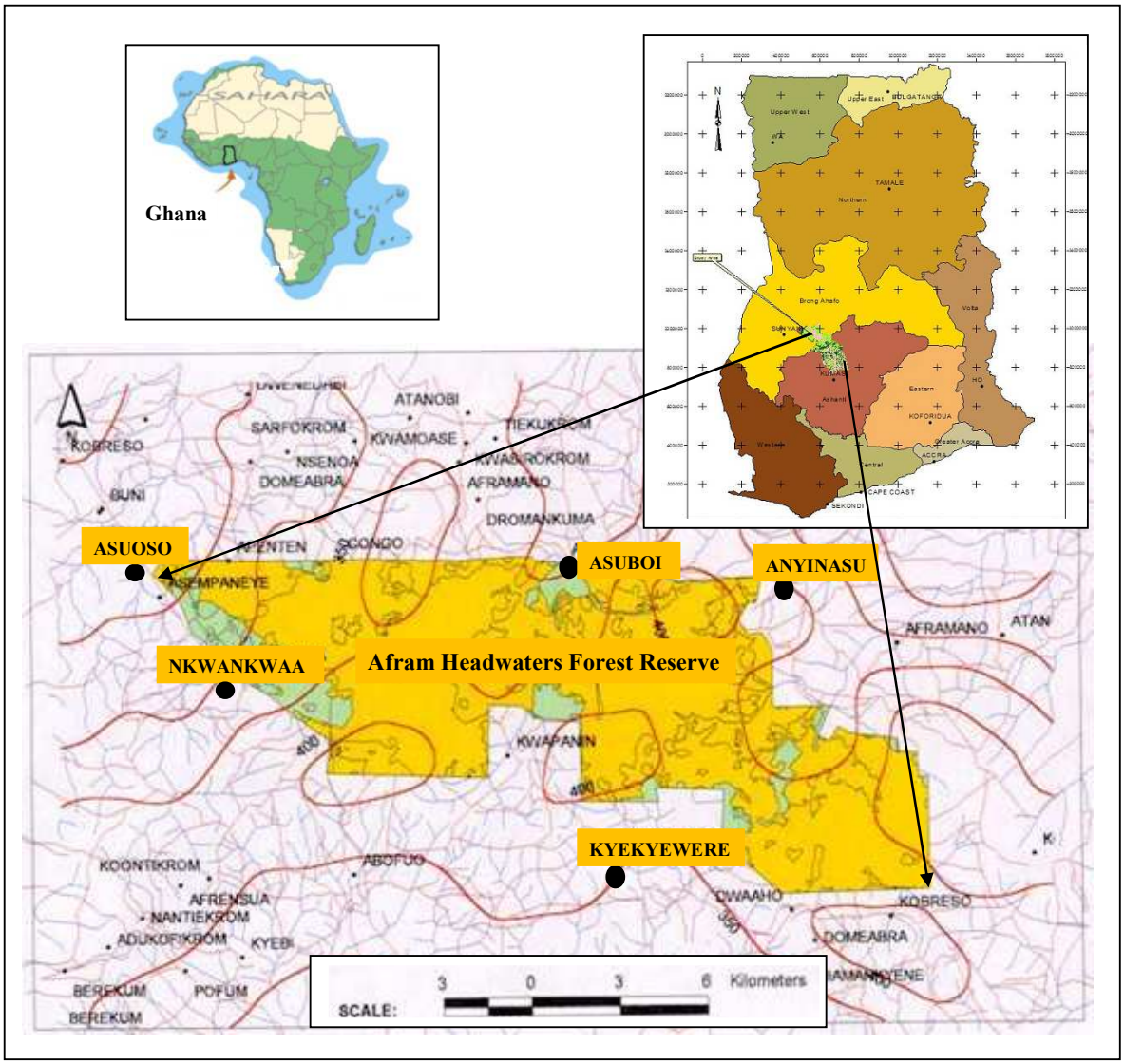
3.2 Selection of the study area and communities

3.2.1 Criteria used in selecting the study area and communities

The establishment of forest plantation has taken place in many districts in the "High Forest Zone" since the early 1970s. However, only a few districts have been able to implement their forest plantation activities successfully. The Offinso district is one of the districts with a long tradition of successful implementation of forest plantation activities, hence the decision to carry out the study in this district. The Forestry Commission of Ghana considers the district as having the largest state and private forest plantation in Ghana. Despite the rapid expansion of forest plantation in the area, relevant information regarding why many farm households continuously use their agricultural land to establish forest plantation and the motivation for undertaking such land-use is scanty. Conducting the study in this district therefore offered the opportunity to analyze the specific driving forces underlying the decision to establish farm forest plantation by the target farm households.

A further impetus for selecting the Offinso district is the shift in land-use practices in the past three decades. The district was renowned for the cultivation of cocoa, coffee and other traditional cash crops in the 1940s and 1950s. However, the last three decades has seen a shift in the cultivation of these cash crops to new farming practices including cashew cultivation and the establishment of farm forest plantation. The district is also characterized by diverse biophysical, socio-economic and market conditions. The favorable climatic condition in the district facilitates the establishment of forest plantation. It was thus anticipated that a study under such environment would help to understand the decision of the household's to establish farm forest plantation. The initial intention was to carry out the study in as many communities in the district as possible. However, due to logistical constraints and financial resources, five communities were selected. The study communities were selected with the help of the district forestry officials with vast local knowledge about the area and on the basis of the researcher's personal knowledge about the area. The communities were selected to reflect different socio-economic and biophysical conditions, long tradition with forest plantation development, proximity to weekly marketing centers (which offers the opportunity to sell food and tree products), etc. These criteria were considered as having potential to influence relevant casual variables on the topic

under investigation. The procedure used in selecting the study communities was regarded as ideal compared to a random sampling of communities in the study area. The selected communities included Asuoso, Anyinasu, Nkwankwaa, Kyekyewere and Asuboi (see Map 3.1).



Legend: ● = Selected study communities

Map 3.1: Map of Ghana showing the geographic location of the study district and sampled communities
Source: Mapping Unit, Forest Management Support Center, Kumasi (2006)

3.2.2 Research phases, methods and tools employed in the study

The research was divided into three distinct parts as indicated in Figure 3.2. The first part (Part 1), involved the identification of the research problem, revision of past and current literature, determination of research goals and methods, and the formulation of research questionnaires. In the second part (Part 2), the selected field assistants were trained to fully understand the content

and procedure of the study, whilst the study households were sampled. Pre-testing of the questionnaire was done to observe the reaction of the target respondents to the research procedures and data collection tools, assess the robustness and adequacy of issues covered in the questionnaire and to allow the respondents to comment on the issues. Certain changes were made to the questionnaire following the pre-testing, most importantly, the revision of the sequence and wording of the questions. The results from the pre-test also enabled the researcher to determine the best time to get the study population at home to provide answers to the questions and how much time is needed to administer the questionnaire. The proposed methods used to establish contact with the study population were modified after the pre-test to conform to the local tradition.

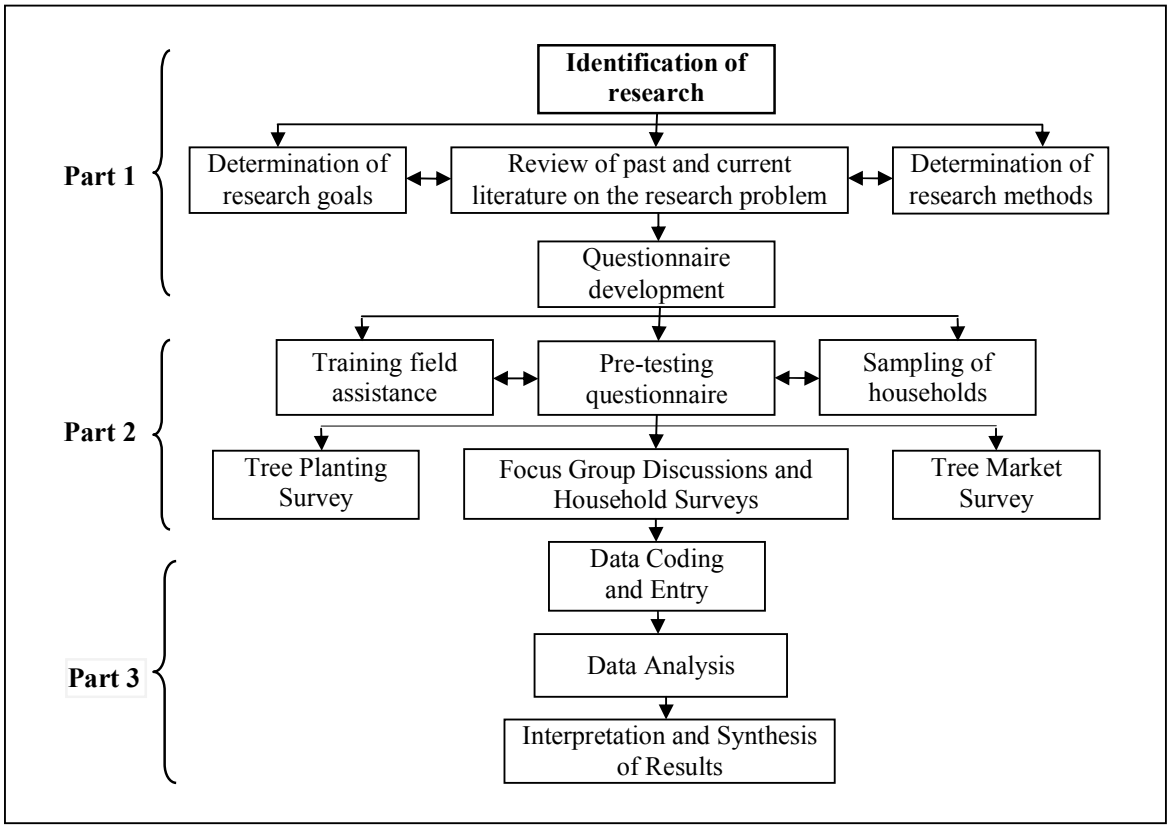


Figure 3.2: Schematic representation of the research processes
Source: Field Survey, 2006

Household socio-economic surveys, focus group discussions, tree inventory and market surveys were conducted to get in-depth information at the household and community level as well as to cross-check the reliability of the gathered information. In the last part (Part 3), the various field data were coded and entered into a computer for analysis. Two different statistical programs, namely, Statistical Program for the Social Sciences (SPSS 13.0) and Excel software were used to analyze the results from the household survey.

3.2.3 The research design and sampling procedure

The research design was based on a combination of methodologies involving semi-structured questionnaires, focus group discussions, review and analysis of secondary data, market surveys and forest plantation inventory. The study relied on in-depth qualitative and quantitative data from farm households with and without farm forest plantation. The multi-method approach enabled a comprehensive understanding of the factors influencing farm forest plantation development, especially from the perspective of the farm households. This approach also provided a means of cross-checking and validating information and also providing leads into important areas of inquiry.

A multi-stage stratified random sampling technique was used to select farm households for the study. According to de Vaus (1996) and Neuman (2000), this approach is considered as appropriate due to its advantage of ensuring representativeness and accuracy in sample drawing. The multi-stage stratified random sample was constructed by first dividing all the households in the study communities into two categories on the basis of whether they have established farm forest plantation or not. Based on this criterion, two distinct classifications of households were produced; namely, households with farm forest plantation and households without farm forest plantation. In the second stage, a random sample of a representative number of households from three wealth groups[2] (i.e. better-off, average and poor) were selected from within each of the household categories derived at the first stage. These households were interviewed during the household survey. According to Neuman (2000), random sample drawing does not only help to depict the target population with sufficient accuracy but also enables the researcher to establish a statistical relationship between the sample and the population.

A total of 1,670 farm households were found in the selected communities (see Table 3.1). This comprised of 787 households with farm forest plantation and 883 without farm forest plantation. In all, 280 farm households with and without farm forest plantation and from different wealth groups were selected for the study (i.e. 50 farm households each from Asuoso, Anyinasu, Nkwankwaa and Asuboi, and 80 households from Kyekyewere) (see Table 3.2). The number of households selected from the communities was based on probability proportionate to size (PPS) and as trade-off between the financial resources available for the study. The need for sufficient cases for statistical testing, and the need to collect sufficient detail to allow for the assessment of the household's forest plantation management practices in the context of their socio-economic

[2] Grouping of households into wealth groups was done through participatory wealth ranking exercises conducted during focus group discussions. See Table 3.4 for the criteria used to classify the households into the various wealth groups

characteristics and livelihood strategies also played an important role in the selection of the survey households.

Table 3.1: Total number of households in each study community and number of households with and without farm forest plantation

Community	Total number of households	Households with forest plantation	*% of households*	Households without forest plantation	*% of households*
Asuoso	295	126	*42.7*	169	*57.3*
Anyinasu	308	175	*56.8*	133	*43.2*
Nkwankwaa	216	63	*29.2*	153	*70.8*
Kyekyewere	709	328	*46.3*	381	*53.7*
Asuboi	142	95	*66.9*	47	*33.1*
Total	*1,670*	*787*	*47.1*	*883*	*52.9*

Source: Field Survey, 2006

Table 3.2: Number of households selected from each community and wealth group for the study

Community	Households with forest plantation			Households without forest plantation			Total
	Better-off	*Average*	*Poor*	*Better-off*	*Average*	*Poor*	
Asuoso	10	10	10	5	5	10	50
Anyinasu	10	10	10	5	5	10	50
Nkwankwaa	10	10	10	5	5	10	50
Kyekyewere	15	15	15	10	15	10	80
Asuboi	9	11	10	5	5	10	50
Total sampled households	*54*	*56*	*55*	*30*	*35*	*50*	*280*
Total number of households	*151*	*303*	*333*	*111*	*310*	*462*	*1,670*
Sampling fraction (%)	35.8	18.5	16.5	*27.0*	11.3	10.8	*16.8*

Source: Field Survey, 2006

3.3 Data collection

3.3.1 Overview

It has been argued that using a combination of qualitative and quantitative methods of data collection in research improves its overall strength. According to Carvalho and White (1997); McGee (2000) and Kanbur (2001), whereas quantitative approaches such as formal surveys are characterized as having breadth, qualitative approaches such as open interviews are characterized as having depth. The key is however to combine the breadth of one and the depth of the other. Other authors (e.g. Creswell, 1994; Ragin, 1987; Sechrest and Sidani, 1995; White, 2002) have also argued that combining qualitative and quantitative approaches in a study improves triangulation and complementarity. Current trend in social research also shows a growing tendency towards a synergy between qualitative and quantitative approaches (Bradshaw, Wood, and Williamson, 2001; Harris, 2002; Powell, 1999; Sale, Lohfeld, and Brazil, 2002; Sechrest and Sidani, 1995; White, 2002). Using studies from African labor, White (2002) argues that

productive synergy may exist between different methods and disciplines and that "the combination of techniques will frequently yield greater insight than either one used in isolation". Based on the above reasons, it was seen as imperative to use both qualitative and quantitative approaches in the present study.

A mix of qualitative and quantitative research methods were flexibly combined during data collection to benefit from the positive side of each of the methods. These methods were used to gather data from varied sources, including reviewing and analyzing secondary data, reconnaissance surveys, focus group discussions with community members, household socio-economic surveys, interviews with key informants and experts, forest plantation inventory, and forest plantation product market surveys. The following sections will discuss the different sources of data in more detail.

3.3.2 Review and analysis of secondary data

Prior to primary data collection, a thorough review and analysis of both published and unpublished secondary data was made. The various sources used included the Ghana forest policy, land-use systems in Ghana, livelihood strategies of rural households and forest plantation development. A number of reports (both published and unpublished) at the Forestry Commission of Ghana provided additional information on forest plantation development initiatives in Ghana as well as forest plantation development by private individuals, timber firms, NGOs, etc. This additional material was especially useful for detailing the background of forest plantation development in the country and understanding the past, current and future developments. Previous surveys relating to households and/or communities involvement in forest plantation development programs provided important baseline information for the study. Literature addressing the issue of socio-economic, policy and institutional factors influencing the development of forest plantation were also examined. The review and analysis of literature provided a basic understanding of the issue being investigated and also facilitated detailed characterization of socio-economic, socio-cultural and political-institutional issues relevant to the current study.

3.3.3 Reconnaissance surveys and recruitment of field assistants

Reconnaissance surveys were conducted in all the selected communities to enable the researcher to get a better insight of the study communities and also determine the suitability or otherwise of the communities. This stage was also used to gain acquaintance with the community leaders and to find out their willingness to allow the community members to participate in the study. Some

community leaders refused to participate in the study. They indicated that the community has taken part in several studies in the past but have never obtained any benefit from such studies. In such cases other communities were contacted to participate in the study. The reconnaissance visits were also used to select field assistants and enumerators to help in collecting field data. In all, three field assistants and two enumerators together with the researcher conducted the household socio-economic surveys, focus group discussions and key informant interviews. The criteria used for selecting the assistants was based on their local knowledge about the study area and selected communities, ability to speak the local dialect and their level of education. Contacts with the District Assembly[3] and the District Forestry Office (DFO) were made at this stage of the study.

3.3.4 Participatory rural appraisal (PRA) methods and techniques employed

3.3.4.1 Focus group discussion (FGD)

A series of focus group discussions (FGD) were held in each of the study communities. The objectives of these discussions were to gather background information about the communities which is not likely to be found in written documents (e.g. the community history and dynamics), generate information on land-use patterns in the study area, obtain criteria to be used to categorize the study households into wealth groups, and obtain a more detailed understanding of how the local people have incorporated forest plantation development into their farming system and livelihood strategies. The FGD generated valuable information which was incorporated into the final development of the household survey questionnaire. The FGDs were carried out by the researcher, field assistants from the District Forestry Office (DFO) and the study communities. The FGDs were conducted in the local dialect (Twi), since majority of the local people do not understand English - the official language in Ghana. A total of 50 participants including the community chief (i.e. head of the community), elders, assemblymen[4], teachers and community members attended the FGD in each of the study communities. The FGDs were usually conducted during taboo days. The advantage here is that community members are by tradition not allowed to go to their farms to work on such days and therefore offer the opportunity to meet the community members. In order to complete the FGD activities in one day, the participants at the meeting were divided into two groups. The division of the participants resulted in more manageable group sizes, thereby avoiding excessive arguments among them and also reducing the potential for one or two individuals to dominate discussions. Each sub-group was given the same topics to discuss. After the completion of the activities, the groups were brought back

[3] Highest political decision-making institution at the district
[4] Local community's political representative

together to present their results to the whole group. This presentation gave all participants the opportunity to discuss and comment on the results.

3.3.4.2 Participatory wealth ranking

Participatory wealth ranking exercises have been heralded as a quick and effective means of assessing the socio-economic status of households (Chambers, 1994c). It has therefore been recommended to encourage participation of community members in research activities, for example, to help in stratifying households into wealth categories. According to Balbarino (2001), some researchers rely almost entirely on the use of classification criteria defined by the participants in a study. Other researchers use the local knowledge of participants to refine their criteria after selecting broader topics to be used on the basis of conceptualizations developed from theoretical constructs (Belsky, 1984; Caldwell et al., 2002) and review of existing information about the topic of interest (Busck, 2002). The study adopted the use of classification criteria defined by participants at the FGD and verified by key informants from the study communities. The reason for using this approach was based on the fact that the local people who live and work in the same community and have also observed others over a long period of time may be a better judge of levels of wealth than the researcher. Furthermore, the local people have their own concepts of wealth, which are not only dependent on cash income. Utilizing local people to determine the levels of wealth therefore helped to bring out the complexities and realities of wealth, rather than using definitions predetermined by the researcher.

The FGD participants in each of the study communities were divided into three groups to carry out the wealth ranking exercise. Each group consisted of a minimum of 10 participants and a maximum of 15 participants. The groups identified a number of wealth groups to be used to categorize the study households. About 3 to 5 wealth groups were identified by the participants, ranging from the poorest strata up to the better-off strata. There were variations in the number of wealth groups identified by the groups. However, a high degree of agreement was obtained between the groups over the characteristics of the better-off and poor households. There was lack of clarity regarding the classification of some households as “averagely better-off and “average” as well as those classified as “poor” and “very poor”. Therefore, to ensure clarity and also avoid problems during data collection, the participants were made to re-classify the wealth groups into three main groups, namely, “better-off”, “average” and “poor” households. The main criteria used by the participants to classify the households into the different wealth groups included the size of landholding, level of food sufficiency, children’s education, household assets, and number of wives (see Table 3.3). It must be emphasized that although some households were

classified as 'better-off', these households are not necessarily a 'rich' household but they are classified as such because they are distinguishable from the 'average' and the 'poor' households in terms of their asset endowments as well as other characteristics.

Table 3.3: Endogenous criteria used by FGD participants to characterize households into wealth groups

Criteria	Household wealth groups		
	Better-off	Average	Poor
i. Size of landholding	Large, good quality landholding (>15.0 ha)	Possess between 5.0 - 10 ha of landholding	Small landholding usually less than 2.0 ha or in some cases landless
ii. Level of food sufficiency	Able to meet household food needs throughout the year	Able to meet family food needs for at least 9 months but sometimes experiences periodic food shortage	Food secured for 3 to 6 months and sometimes experiences chronic food shortage
iii. Children's education	Children attend good schools and colleges	Children attend good schools	Children have only primary school education or do not attend school at all
iv. Assets	Many household assets (bank savings, house with concrete walls and iron roof, more than one source of income, possesses large size of livestock (>10 livestock) and also maintains animals through tenants)	Few household assets (some household have bank savings, house with cement block and iron roof, farming as main source of income, reasonable number of livestock (about 5 livestock)	Very few or no household assets (no bank saving, house with mud wall and thatch roof, one source of income (mainly farming), keeps few or no livestock,
v. Number of wives	Usually more than one wife	Usually one wife	One wife, single or widowed

Source: Field Survey, 2006

While the better-off households were characterized as having more assets, large landholding, children attending good schools, more than one source of income and also having more than one wife, the poor households were considered as having few or no assets, small landholding, experiences chronic food shortage and unable to meet basic household needs. As expected, the poor households constituted the highest percentage of the total number of households surveyed (47.6%) while the better-off households represented the least percentage (15.7%). The average households accounted for 36.7% (see Table 3.4). The percentage of better-off households in Kyekyewere was the highest among the study communities (19.5%) while Nkwankwaa had the least percentage of better-off households (8.8%). In terms of the percentage of poor households, Asuboi had the highest percentage with 51.4% of the households considered as poor whereas Kyekyewere had the least with 43.5%.

Table 3.4: Total number of households in each community and households in each wealth group

Community	Total number of household	Households with forest plantation			Households without forest plantation		
		Better-off	Average	Poor	Better-off	Average	Poor
Asuoso	295	20 (6.8)	46 (15.6)	60 (20.3)	17 (5.8)	57 (19.3)	95 (32.2)
Anyinasu	308	31 (10.1)	69 (22.4)	75 (24.3)	22 (7.1)	31 (10.1)	80 (26.0)
Nkwankwaa	216	11 (5.1)	25 (11.6)	27 (12.5)	8 (3.7)	68 (31.5)	77 (35.6)
Kyekyewere	709	80 (11.3)	124 (17.5)	124 (17.5)	58 (8.2)	139 (19.6)	184 (26.0)
Asuboi	142	9 (6.3)	39 (27.5)	47 (33.1)	6 (4.2)	15 (10.6)	26 (18.3)
Total	1,670	151 (9.0)	303 (18.1)	333 (19.9)	111 (6.6)	310 (18.67)	462 (27.7)

Figures in parenthesis represent the percentage of households in each wealth group

Source: Field Survey, 2006

3.3.4.3 Interview with key informants and experts

A number of key informants and experts including forestry officials at the district and regional offices, community chiefs, assemblymen and managers of two local wood processing companies (Evans Timbers at Abofour and Dupaul Wood Treatment Company at Offinso) were interviewed during data collection. The discussions with the various key informants and experts offered the opportunity to obtain further information and also cross-check information given by other respondents. This process helped to ensure that the data obtained were an accurate reflection of the situation. The discussions usually lasted between one to two hours depending on the time availability of the informant. In some cases, more visits were required if comparable responses were not found from other informants within the same community and also for the informants to explicitly clarify the information given to ensure correct interpretation. Community chiefs and assemblymen were contacted to verify the various criteria used by the FGD participants to rank farm households. The forestry officials at the district office were also interviewed to give information relating to past and present forest plantation development activities in the study area and most importantly the establishment of forest plantation by farm households in the area.

3.3.5 Household socio-economic surveys

Household socio-economic surveys were conducted using semi-structured questionnaires. The questionnaires were administered to households from three different wealth groups identified by participants at the FGDs. A total of 280 households comprising 165 households with farm forest plantation and 115 households without farm forest plantation took part in the household survey. The household surveys were conducted to obtain quantitative data that could be used to analyze

the factors that influence the farm household's decision to establish or not to establish farm forest plantation. Two different sets of questionnaires (i.e. one tailored to farm households with farm forest plantation and another one for households without farm forest plantation) were developed for the household surveys (see Appendix 1A and 1B for details of the questionnaires). The use of two different questionnaires enabled the researcher to gain an understanding of the differences between the two household's categories under study and the perspective of the households in relation to farm forest plantation development. The contents of the questionnaires were drawn up on the basis of a review of existing literature and discussions with key informants. Areas covered in the questionnaires included personal-demographic characteristics (i.e. details of the age, education, household size, wealth status, sources of income, etc.), household's livelihood activities and sources of income, asset endowments, viewpoints on factors influencing households decision to establish farm forest plantation and information on food crop and tree product marketing.

Dates for the administration of the questionnaires were agreed with the selected farm households. The household heads were usually chosen as respondents based on the presumption that they have the widest access to data regarding their household. As in the case of the FGDs, the household's surveys were mostly conducted during taboo days. On non-taboo days, the surveys were carried out in the evenings after dinner from the residence of the respondents. The advantage of this type of interview lies in the fact that both the head of the household, his wife and other family members can participate in the interview. Responses to the various questions were immediately recorded on the questionnaire papers during the interviews. Each interview lasted between 2 and 3 hours. It must be emphasized that the accuracy of responses to quantitative questions could sometimes not be fully ascertained, as some of the information was based on recollection. Nevertheless, with the experience and familiarity of the field assistants with the area, this risk was minimized.

3.3.6 Forest plantation inventory

Forest plantation inventories were performed in a selected number of farm forest teak plantations in the study communities. The importance of the inventories was to collect data to help determine the yield characteristics of the plantations. There are a number of sampling techniques used in conducting forest inventories. However, the choice of a particular sampling technique is governed by a number of factors including the relative costs, size of the area to be covered, precision desired, number of people available for the fieldwork and the length of time available for the inventory. A systematic sampling technique was used in the present study as a

compromise between cost effectiveness and measurement precision. Complete inventories are on one hand expensive and tedious, and on the other hand, non-sampling errors (i.e. incorrect recording of tree diameters, heights and quality) tend to increase. One farm forest teak plantation plot was chosen from each study community for the inventory. The selected plantation had 10-year-old and 20-year-old trees. A sample plot of 1,875m^2 split into three sub-plots (each sub-plot measured 625m^2) was set up in each of the plantations for the inventory. Data collected from each plot included tree species, age, diameter (DBH at 1.3m), height (m) and stock density (stems/ha) (see section 5.3.3, Tables 5.15 and 5.16 for the empirical results of the inventory). A spreadsheet program developed in MS Excel format and data from the field inventory was used to calculate the following parameters:

$$\text{Stocking Density (stems/ha)} = \frac{\text{Trees in plot (stems)}}{\text{Plot area (ha)}}$$

$$\text{Standing Tree Basal Area } (m^2/ha) = \frac{\text{Sum of plot tree basal area } (m^2)}{\text{Plot area (ha)}}$$

$$\text{Standing Tree Volume } (m^3/ha) = \frac{\text{Sum of plot tree volume } (m^3)}{\text{Plot area (ha)}}$$

$$\text{Mean Annual Increment (MAI)} = \frac{\text{Standing tree volume } (m^3/ha)}{\text{Age of stand (years)}}$$

3.3.7 Forest plantation product market surveys

Tree market surveys were conducted using a rapid survey format to identify and understand (i) forest plantation tree species and products sold on the market, (ii) marketing channels and agents involved in the marketing of the tree products, and (iii) prices paid by buyers for various tree products. The market survey was conducted by direct interview with farm households with farm forest plantation, market agents (middlemen/intermediaries), retailers and traders at the district and regional capital (Kumasi). The information provided by the various stakeholders was followed through to the market chain until information concerning the market channel was complete. The information gathered was cross-checked with direct observation by visiting tree market centers, informal discussions with key informants and review of relevant secondary information. Managers at the local wood processing companies were also contacted to verify and also obtain information regarding prices paid for various forest plantation products. The cross-checking process continued until the information gathered was clear and consistent, with no new information being found. Detailed analysis of results from the market survey is presented in section 5.4, Tables 5.17 and 5.18.

3.4 Data analysis

According to Crabtree and Miller (1992), data analysis strategies can be categorized along a continuum. At one end of the spectrum, they see some techniques of analysis as 'objective' in the sense that they tend to isolate the researcher from the object of the research. At the other end, techniques exist that are subjective, context-dependent, interpretative and generative. Yin (1984) also suggests data analysis techniques that are suitable for case study research. These include pattern-matching, explanation-building and time-series analysis. The type of data analysis to be conducted, however, depends on the type of data collected (i.e. whether qualitative or quantitative data and/or both). The present study employed a combination of qualitative and quantitative methods to analyze the field data.

All data analysis was carried out using the Statistical Package for the Social Surveys (SPSS) and Excel software. Highly negatively skewed data were transformed before performing the statistical tests. A number of statistical techniques were used to explore differences and relationships between selected variables and groups of respondents. Pearson chi square (χ^2 test), a non-parametric test for examining association between two unordered categorical variables was used to test the relationship between household's socio-economic characteristics and the decision to establish farm forest plantation. T-test, a parametric test for comparing means of two groups was used to compare the annual income of households with and without farm forest plantation with particular emphasis on the percentage contribution of income from farm forest plantation to total household income. One-way ANOVA was also employed to assess the relationships between categorical and continuous variables and correlation tests to assess the degree of linear association between the continuous variables. Binary logistic regression was used to analyze the influence of independent variables (endogenous and exogenous factors) on a dependent variable (in this case, household's decision to establish farm forest plantation). Finally, financial analysis was performed using the Net Present Value (NPV) to determine the financial performance of the farm forest plantation.

3.5 Summary

The present study adapted the concept of portfolio investment (Shively, 1999) and rural household diversification (Ellis, 2000) as conceptual framework to analyze the factors influencing farm household's decision to establish farm forest plantation and the contribution of the outputs from farm forest plantation management to the livelihood strategies of the households. The study relied on a mixture of data collection methods to collect in-depth information. PRA tools were used to collect data at the community level to augment data at the

household level. Household surveys were also conducted to collect in-depth information about the socio-economic characteristics of the study households. These surveys facilitated the collection of information in relation to the economic activities performed by the households as well as issues regarding farm forest plantation development. Key informants and experts were interviewed to augment information collected from the households. Furthermore, forest plantation inventory and market surveys were conducted to assess the yield and market opportunity for the plantation. The use of these methods was considered appropriate as against relying solely on one method due to their advantage to enable the collection of diverse information from the target group. Both qualitative and qualitative data obtained from the field have been analyzed using various analytical techniques.

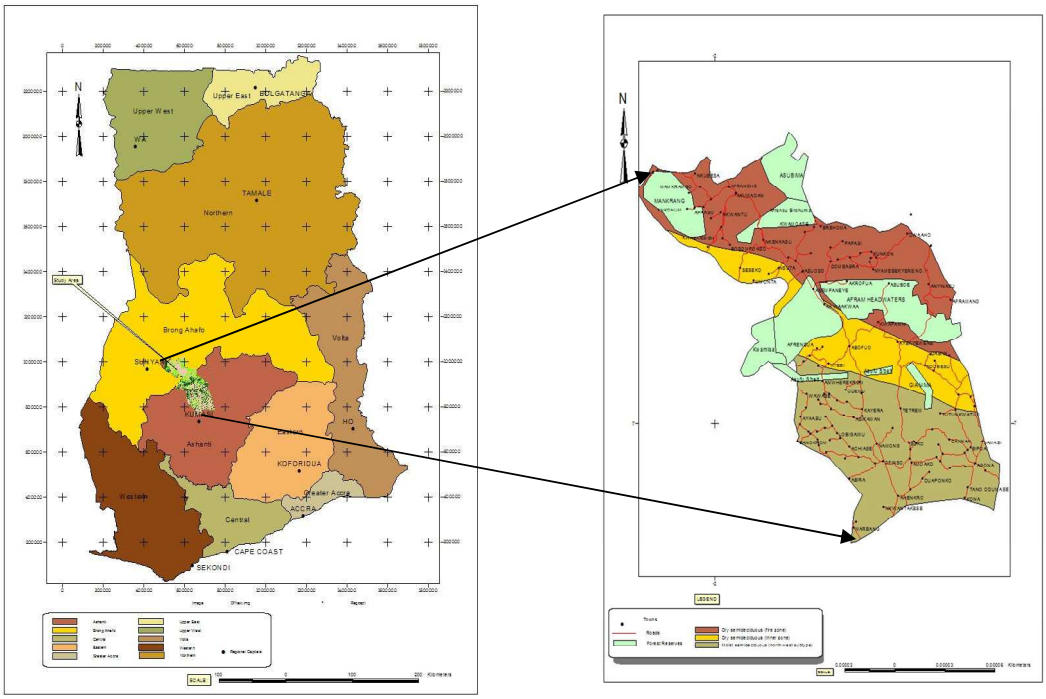
CHAPTER 4

GENERAL DESCRIPTION OF THE STUDY AREA AND CHARACTERISTICS OF THE STUDY COMMUNITIES

4.1 Biophysical characteristics of the study area (Offinso district)

4.1.1 Geographic location and size of the district

The Offinso district lies between longitude 1° 65 W and 1° 45 E and latitude 6° 45 N and 7° 25 S. It is located in the extreme North-Western part of the Ashanti region with about half of its boundary bordered by the Brong-Ahafo region in the North and West. It is bordered in the East by Ejura-Sekyere Odumasi district and in the South by Kwabre, Afigya Sekyere, Ahafo Ano South and Atwima-Nwbiagya districts. The district covers a land area of 125,500 ha, which is about 5.9% of the total land area of the Ashanti region. New Offinso, which is made up of 22 suburbs, is the capital town of the Offinso district. The district is made up of two groups of people: indigenes, who are mainly Akans and migrant farmers from the Northern region of Ghana (Offinso District Assembly, 2006). Map 4.1 shows the study district and its location in Ghana.



Map 4.1: Map showing the geographic location of the study district and the sampled communities
(Source: Mapping Unit, Forest Management Support Center, Kumasi [2006])

4.1.2 Topography, climatic conditions and soil characteristics

The land in the study area is generally undulating with the Papasisi and Mantukwa area standing out as the highest section of the district. The Koforidua–Kintampo range of hills with the highest elevation of about 594.36m above sea level is conspicuous in the northern part of the district. Low-lying areas with elevation between 182.88m and 304.8m exist in the Nkenkaasu–Afrancho area (Offinso District Assembly, 2006). The district is drained by some rivers and streams notable among them are Offin, Anyinasu, Ode, Pro and Mankran. The district experiences semi-equatorial and tropical conventional climate characterized by moderate to heavy rainfall annually. Two rainfall seasons are experienced in the area. The major rains start from April and last until July whilst the minor rains start from September to mid-November (Offinso District Assembly, 2006). Annual rainfall ranges from 1,500mm in the North to 1,700mm in the South. Relative humidity is high during the major raining season reaching its peak of 90.0% between May and June. A maximum temperature of 30^{o}C is experienced between March and April. The mean monthly temperature is about 27^{o}C (Offinso District Assembly, 2006).

The district is characterized by different soil types developed from different parent materials of valued rock formations. The Kumasi-Offin series are developed from granite and are deep, well drained and permeable, suitable for the cultivation of food crops such as yam, cassava, maize, as well as vegetables. The Bekwai-Akumadan-Oda compound associations are also developed from Birimian rock (Offinso District Assembly, 2006). They are well drained and support the cultivation of food crops and trees. The Bediesi-Sutawa and Pimpimso associations are developed from Voltaian sandstone and are red, well drained and suitable for the cultivation of crops such as yam, maize and tomatoes. Irrespective of their parent rock materials soils in the district are generally rich in humus, well drained and are suitable for the cultivation of a wide range of food and cash crops (Offinso District Assembly, 2006).

4.1.3 Vegetation patterns and conditions of forest lands in the district

The vegetation in the district is classified as moist semi-deciduous forest, which is interspersed with thick vegetation cover. The rich natural forests that existed in the district in the 1960s and 1970s have been reduced to secondary forest in most parts of the district. This is attributed to a number of factors including the adverse effects of wildfires. For example, the wildfires of 1983 burnt farm and forest lands especially in the northern portions of the district and reduced the vegetation to grassland and savannah. Inappropriate farming methods and logging have contributed to land degradation in the study area. For instance, most households in the district practice slash and burn method of land clearing. This practice has left most forest lands bare and

rapidly altered and destroyed the natural vegetation. Households in the district continue to depend on the forest to support their livelihood. It is estimated that about 85.0% of the households in the district use wood and charcoal as the main source of energy for cooking. This situation further contributes to the depletion of the forest. The degradation of forest land in the district has resulted in the reduction of agricultural output due to declining soil fertility. The Forestry Commission, NGOs and some private land owners are currently carrying out intensive reforestation activities in the district aimed at restoring the degraded lands.

4.2 Socio-economic characteristics of the study area

4.2.1 Demographical indicators

The 2000 population and housing census put the population of the district at 138,676. The current population represents an increase of 32.0% over the 1984 population of 104,805. The increase in population could be attributed to improved health delivery system in the district and the influx of migrant farmers mostly from Northern Ghana. The district's population comprises of 68,713 males and 69,477 females. The annual birth rate between 1984 and 2000 was 5.0% which is higher than the birth rate of Ashanti[5] region which is estimated at 3.4% (Population and Housing Census, 2000). If measures are not put in place to control the high birth rate, social services and infrastructure in the district will not be able to meet the needs of the population in the future. The population density for the district in 1960, 1970 and 1984 were 28 persons, 45 persons and 63.5 persons / km^2 respectively. However, in 2000, the population density increased to 110 persons / km^2. This is higher than the national figure of 79.3 persons / km^2 in 2000. The average household size is 5.5 persons. Members of the household are composed of persons from the nuclear family, extended family and persons outside the nuclear and the extended families. Heads of the households are usually male. In households where females are heads, it is either single or single parent household.

4.2.2 Settlement, ethnic composition and labor force

There are about 126 settlements in the district. In line with the national classification of localities in Ghana, which considers localities with a population size of 5,000 or more as being urban and less than 5,000 being rural, five settlements in the district are classified as urban. These include New Offinso (36,190), Akumadan (14,018), Abofour (11,177), Nkenkaasu (10,014) and Afrancho (7,727) (Offinso District Assembly, 2006). The district is composed of heterogeneous tribes. It is estimated that about 70.0% of the total population is made up of Akans while the remainder is composed of migrants, mostly Northerners and Ewe farmers. According to the 2000

Population and Housing Census, the economically active labor force (i.e. 18-64 years) in the district constitutes 47.0% of the population while those under 18 years accounts for about 46.6% of the population. The elderly (i.e. 65 years and above) make up 6.4% of the population. This implies a higher economic dependency ratio. About 64.0% of the labor force is engaged in agriculture and therefore serve as the main economic activity in the district. This is followed by commerce (16.0%), service (12.0%) and small-scale industry (8.0%).

4.3 Land tenure systems in the study area

Farmers in the study area operate under various land tenure systems. The indigenous people usually acquire land through kinship, maternal or paternal lineage, and spouse's family land. Within the family set up, land is passed on from generation to generation of which a member is entitled to a portion of the land which he/she has and passes it on to the next of kin. The local chiefs and some families own large landholdings. The size of land owned by such individuals and families may reach over 500 hectares, with an average ownership in the order of 100 hectares. Land tenure in the study area has changed from a system where land was given free of charge to friends and needy ones in the past to leasehold, renting or outright purchase. The indigenes resort to leasing lands when there is a shortage of family land. Leaseholds take two forms, namely, share-cropping and annual land rental payment. Sometimes land rental payment is small or merely symbolic. Leaseholds are restrictive and do not offer any security of land tenure to the farmers (Benneh, 1989). The period of leasehold ranges from a year for the cultivation of annuals to 50 years for the establishment of tree plantations. According to Odoom (1999), the acquisition of a determinable title in a plot of land by a farmer requires continuous occupation although this does not confer absolute ownership. The current cultivator of a field under indigenous land-use rights has no discretionary land transfer rights because the land belongs to a corporate body (Benneh, 1989). Aidoo (1996) indicates that individuals can sometimes enhance their rights in such holdings by making long term investments. Some farmers however, hold outright ownership over lands they cultivate. Farmers with freehold interests in their lands have an absolute right to deal with them. Outright ownership confers on these farmers secured land rights (Benneh, 1989; Aidoo, 1996).

Because migrants cannot own land in the community, they access land for farming and other purposes through share-cropping, renting/leasing and Taungya System[6]. According to Kasanga (1988), the long, undisturbed possession of land by a migrant or a trespasser cannot develop into

[5] The region where the Offinso district is located

[6] A forest plantation establishment technique whereby the Forestry Commission of Ghana allocates parcels of degraded forest land to farmers to produce food crops and to help establish and maintain timber trees

title to the land. The acquisition of land through share-cropping entails using the land for planting a specific crop or combination of crops usually determined by the landlord. Because of fear of cheating by migrant farmers over sharing of farm produce, most landlords now prefer to rent their land out to migrants rather than entering into share contracts with them. Some migrant farmers declare only part of the produce obtained for sharing with the landowners, while the rest is hidden somewhere to be taken later by them. Again, most migrant farmers harvest part of the produce for home consumption whilst the produce is yet to be shared, often resulting in conflicts. From the point of view of migrant farmers, it is more profitable to rent land rather than engage in share-cropping because the quantity of farm produce that is usually given to landowners as their share of the farm produce, is usually higher than the money that could have been used to rent the land and also part of the farm produce could be harvested for home consumption at any time without having conflict with the landowner.

Most landowners do not lease or rent out lands for tree plantations. Landowners often see tree planting as an attempt by lessee farmers to perpetuate their stay on land, which in turn may indirectly imply ownership of the land (Odoom, 1999). For this reason, the indigenous people usually establish their forest plantations on family lands while migrants establish forest plantation mainly on degraded government forest land (i.e. under Taungya System) or land under outright ownership (e.g. purchased land).

4.4 Land-use and production systems in the study area

4.4.1 Agricultural production

Agriculture is the main economic activity in the district. Over 70.0% of the active population is engaged in farming and about 25.0% of the farmers constitute the youth (i.e. =<18 years) (Population and Housing Census, 2000). Agricultural land covers about 66,500 ha representing 53.0% of the total land area in the district. The agricultural economy in the district is characterized by a combination of subsistence farming and market-oriented production, with the local mix depending on geographical proximity to markets and urban areas, as well as local farming conditions. A total of 24,000 ha are under food crops production while 21,000 ha are under permanent cultivation of tree crops. It is estimated that 21,500 ha of farm land lie fallow each year in the district. Large tracts of fertile land thus remain uncultivated each year in the study area.

Crop production remains extremely important in the study area in terms of labor demands and household consumption. A number of crops are cultivated to meet the consumption and cash

needs of the households. The range of crops cultivated by the households is broad but dominated by crops such as maize *(Zea mays)*, plantain *(Musa sapientum),* yams *(Dioscorea spp.)* and cassava *(Manihot esculenta)*. The cultivation of these crops has increased in the last four decades, namely, 1970s, 1980s, 1990s and 2000s[7] as shown in Figure 4.1. In addition to food crops, a range of vegetables including tomatoes *(Lycopersicum spp.),* pepper *(Capsicum spp.),* okra *(Abelmoschus esculentus)* and onions *(Allium cepa)* are often inter-planted on the same piece of land. The responsibility for crop production is usually shared between the male head of the household and his wife/children and in some cases, the female head of the household and her children (especially where the husband is absent or where the woman is widowed or divorced).

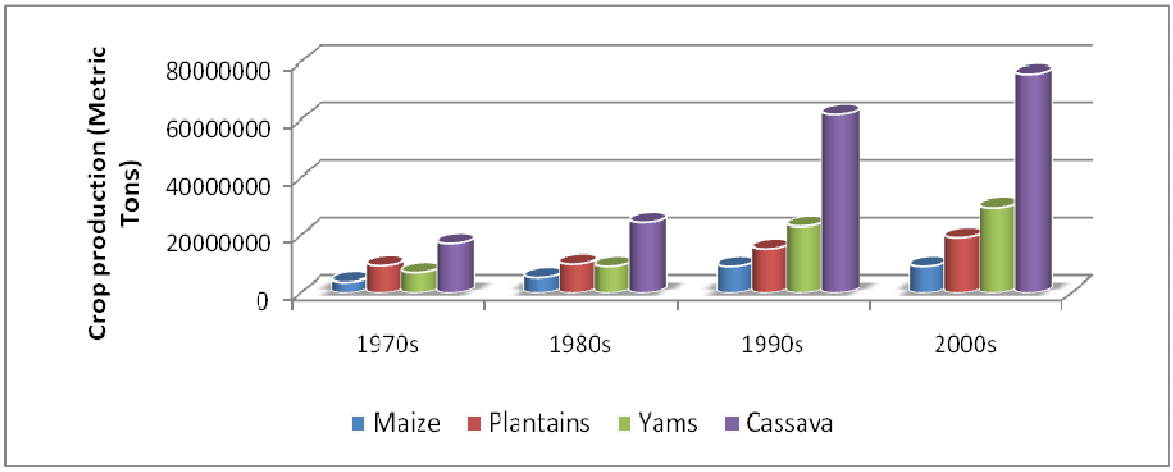


Figure 4.1: Major food crops produced in Ghana from 1970s to 2000s
Source: Computed from FAO Statistics Database, 1970-2007

Animal production is mainly poultry and small ruminants including sheep and goats usually kept for subsistence use but in some cases also for sale. Most households own about 10 free range chickens, 5 goats and 5 sheep. Oil palm and cashew are gradually gaining prominence in the district, especially in the Nsenoa area where the 1983 wildfires affected most of the cocoa farms. Cashew production in the Asuoso area covers about 85.0 ha. The Adventist Relief Services Agency (ADRA) has been supporting farmers in the area in cashew production.

4.4.2 Commercial tree crop production

Commercial tree crop production in the district has undergone various changes over the last four decades as a result of population pressure, declining land fertility, and dismantling of parastatal input supply and marketing services. The backbone of many households in the district until the 1970s was commercial tree crop production, notably cocoa and coffee. These crops served as the main source of cash income for the households. A typical household in the district possessed

[7] The data for 2000s covers only the period from 2000 to 2007

about 30 hectares of fertile agricultural land in the past, with half of the land under cocoa and coffee production in various stages of maturity. The tree crops were originally established by indigenous farmers through a process of annual clearance. Each year the households clear as much land as they can manage with family labor and then plant cocoa and/or coffee. Food crops (a mix of cassava, cocoyam, cereals, and pulses) were planted between the trees. After a year or two, family labor was not sufficient to manage both the newly cleared land and the care of the plots established during previous years. Farmers therefore contracted the care of their second and third year cocoa and coffee plantations to migrant farmers in exchange for the right to inter-plant food crops among the trees and one third of revenue accruing from the cocoa / coffee plantation. Once the tree canopy closed and the tree crops began bearing fruits, farmers were able to get enough money to pay for hired labor. In general, farmers were generally food self-sufficient and earned a per capita income above the poverty line. Poor land fertility and annual wildfires have resulted in the discontinuation of cocoa and coffee production in most communities in the area.

4.4.3 Forestry

The Offinso district has a total of 70,494 ha of land under forestry, accounting for about 56.2% of land in the district. This is made up of natural forests and forest plantations. There are a total of eight forest reserves in the district, namely, Afram Headwaters, Afrensu-Brohoma, Asufu East and West, Gianima, Asubima, Mankrang, Kwamisa and Opro River. These forests contain high valued timber species including Mahogany *(Khaya senegalensis)*, Odum *(Milicia excelsa)*, Emire *(Terminalia ivorensis)*, Ofram *(Terminalia superba)*, Wawa *(Triplochiton scleroxylon)*, and Dahoma *(Piptadeniastrum africanum)*. A large portion of the district's wood supply is obtained from these forests. The forests serve as home for animals such as monkeys, antelopes, rats, grass cutters, snails, and a number of bird species. Forest inventories conducted by the Forestry Commission (1995) indicated a rapid decline in both the quality and quantity of resources in these forests. This was attributed to the activities of timber firms and illegal chainsaw operators, conversion of forest land into agricultural land and the incidence of wildfires.

4.5 Availability of physical infrastructure

4.5.1 Roads

A network of feeder roads as well as track roads link settlements in the district. The Kumasi-Techiman trunk road (the only tarred road in the district) passes midway through the district from south to north and links all the major settlements in the district, namely, New Offinso, Abofour, Nkenkaasu, Akumadam and Afrancho. Feeder roads in the district are inadequate and

most of these roads are hardly motorable during the rainy seasons when they develop gullies and become muddy. Thus most of the rural areas in the district are not accessible especially during the rainy season. The southern portion of the district is better connected by feeder roads than the northern section.

4.5.2 School and health facilities

There are forty four Nursery Schools with 2,779 pupils, ninety five Primary Schools with 6,135 pupils, forty eight Junior Secondary Schools with 5,967 pupils, four Senior Secondary Schools with 1,930 students and one teacher training college with 726 students (Offinso District Assembly, 2006). The teacher-pupil ratio for Nursery Schools, Primary Schools and Junior Secondary Schools are 1:19, 1:28 and 1:16 respectively. There are 13 health care facilities in the district. These are government and mission hospitals, health centers and rural clinics. The district has a doctor-patient ratio of 1:16 391 while nurse-patient ratio is estimated at 1:1 707. About 60.0% of the population in the district has access to health facility (Offinso District Assembly, 2006).

4.5.3 Electricity and water supply

About 45.0% of communities in the district have been connected to the national grid. Four of the study communities, namely, Asuoso, Anyinasu, Nkwankwaa and Kyekyewere have been connected to the national electricity grid. Only Asuboi does not have access to electricity. Potable water supply in the district is inadequate. The main sources of water supply in the district are pipe-born, boreholes, hand-dug wells, rivers and streams. It is estimated that 42.0% of the population depends on untreated and unsafe water sources for drinking and cooking.

4. 6 Characteristics of the study communities

A total of 1,670 farm households are present in the study communities as shown in Figure 4.2. All the communities have primary schools with Asuoso, Anyinasu and Kyekyewere also having Junior Secondary Schools but no secondary schools. Anyinasu and Kyekyewere are the only communities with health care facilities - health centers and rural clinics. Household members from the other study communities travel to these two communities and sometimes to other places for medical care. A network of feeder roads links the study communities. The poor condition of the roads makes the transportation of food stuffs from the communities difficult during the raining season. There are a number of local markets organized regularly in some of the study communities. For example, weekly markets are organized in Kyekyewere and Anyinasu. These markets serve not only as a venue for selling and buying crops, livestock and general

merchandise, but also provide important social functions. The local people are able to generate income to support their livelihood through these markets.

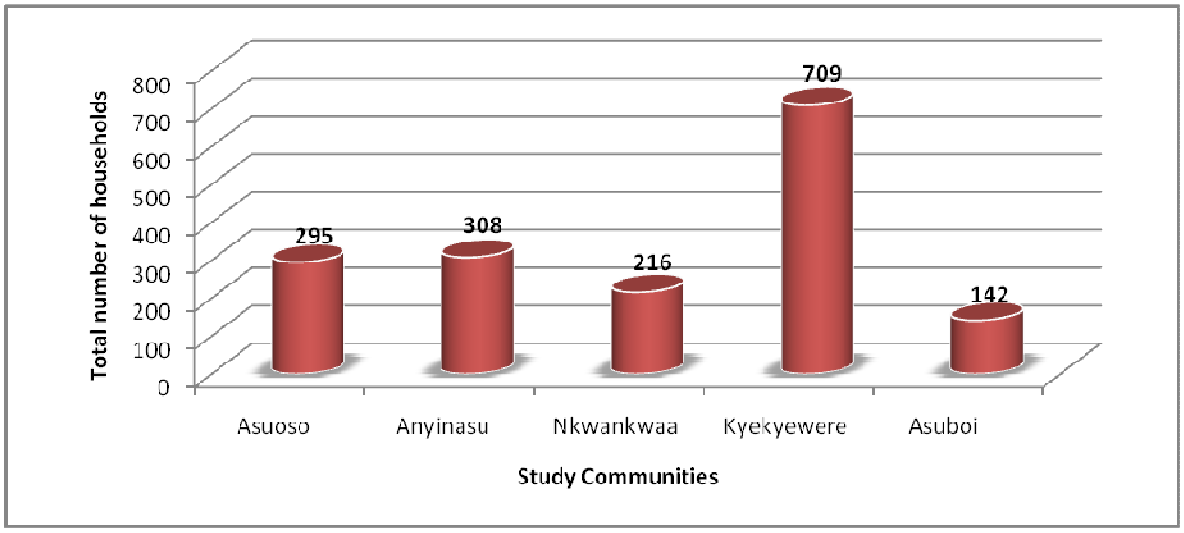


Figure 4.2: Number of households in each of the study communities
Source: Population and Housing Census, 2000; Field Survey, 2006

CHAPTER 5

SOCIO-ECONOMIC CHARACTERIZATION OF FARM HOUSEHOLDS SAMPLED IN THE STUDY COMMUNITIES

5.1 Household resource endowments

5.1.1 Household size and structure

The size and structure of the farm household define the level of dependency of younger household members to the family labor force, and influences production decisions. Due to the absence of a functional labor market in rural areas, the amount of family labor force possessed by the household determines its ability to participate in economic activities in order to produce the needed food and generate adequate income for the household. A statistical t-test analysis conducted to compare the difference between farm households with and without farm forest plantation in terms of the size of the household showed significant differences at the $p<0.05$ level for the two household categories $[t(278)=3.45, p=0.001]$. In general, study households with farm forest plantation have larger household size (Mean=5.47) than those without farm forest plantation (Mean=4.43) (see Table 5.1). One important observation from the household composition is that households with farm forest plantation have more adult males and females (i.e. the most active working group) and fewer infants compared to study households without farm forest plantation. Study households with farm forest plantation has an average of 5.47 household members comprising of 0.33 infants, 0.61 children, 2.09 adult males, 1.95 adult females and 0.49 aged members. On the other hand, study households without farm forest plantation have an average of 4.43 household members with 0.52 infants, 0.63 children, 1.51 adult males 1.40 adult females and 0.37 aged members (see Table 5.1).

Table 5.1: Average number of household members among study households with and without farm forest plantation

Indicators	Households with forest plantation (n=165)	Households without forest plantation (n=115)	All household categories
Mean household size	5.47	4.43	5.04
Household composition			
Infants	0.33	0.52	0.41
Children	0.61	0.63	0.62
Adult males	2.09	1.51	1.85
Adult females	1.95	1.40	1.71
Aged	0.49	0.37	0.45

Source: Field Survey, 2006

A comparison between the two household categories under study with regard to the age of the household head also showed significant differences *[t(278)=5.83, p=0.000]*. Household heads among those with farm forest plantation tend to be relatively older (Mean=46.04) than those without farm forest plantation (Mean=40.66). A greater proportion of households with farm forest plantation (35.8%) are between the ages of 50-59 years whilst those without farm forest plantation are within the 40-49 years of age (Figure 5.1).

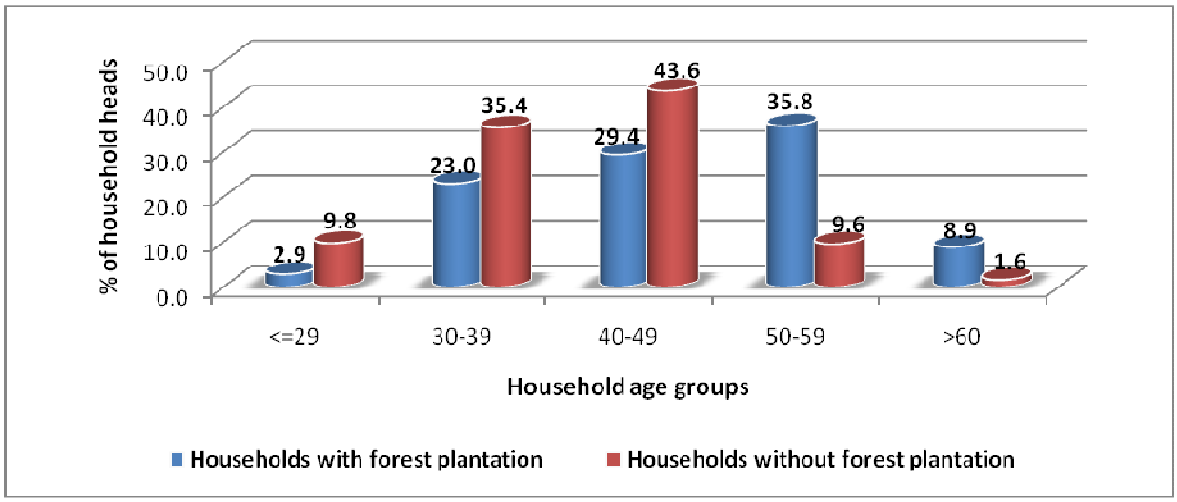


Figure 5.1: Age composition of households with and without farm forest plantation
Source: Field Survey, 2006

5.1.2 Educational attainment of the household heads

The household heads were asked to indicate the highest level of formal education they have attained. About 19.3% of the household heads surveyed have never been to school whilst 30.0% have only been to primary school (i.e. 6 years of formal education). Of the rest, some 24.3%, have completed Middle School (i.e. 10 years of formal education), 4.6% with Junior Secondary School education (i.e. 9 year of formal education), 19.3% have Senior Secondary School as their highest level of education attained (i.e. 12 years of formal education) whilst 2.5% have tertiary education (>12 years of formal education) (see Table 5.2). A comparison between male and female household heads in terms of the highest level of education attained showed significant differences among the gender with male household heads attaining higher education compared to female household heads *(d.f.=5, chi square=24.01, p=0.001)*.

Table 5.2: Proportion of household heads surveyed and their highest level of education by gender

Highest level of education attained	Male headed households (n=184)	Female headed households (n=96)	All household heads (%)
	% of household heads		
No Formal Education	8.6	10.7	19.3
Primary School (6 years)	18.9	11.1	30.0
Middle School (10 years)	17.5	6.8	24.3
Junior Secondary (9 years)	2.5	2.1	4.6
Senior Secondary (12 years)	13.6	5.7	19.3
Tertiary (>12 years)	2.5	0.0	2.5

Source: Field Survey, 2006

There were marked differences between households with and without farm forest plantation in terms of the level of educational attainment *(d.f.=5, chi square=24.77, p=0.000)*. Differences between the two household categories that stand out in terms of educational attainment are that, whilst 28.7% of households without farm forest plantation have no formal education, only 12.7% of households with farm forest plantation have not been to school (Table 5.3). Furthermore, 25.5% of households with farm forest plantation have attained senior secondary education whilst only 10.4% of households without farm forest plantation have senior secondary education. These results show the direct correlation between the level of education of the household head and the establishment of farm forest plantation. As mentioned by a number of authors (e.g. Higman et al., 1999), education is seen as perhaps the most basic ingredient to stimulate for example local participation in a variety of development and natural resource management initiatives. Higher educational attainment could enable people to become aware of the potential benefits from forest plantation management and therefore induce them to establish forest plantation on their land. It is therefore not surprising that households without farm forest plantation have lower educational attainment than those with farm forest plantation.

Table 5.3: Percentage of household heads with and without farm forest plantation and their highest level of education

Household Category	Highest level of education						Total (%)
	None	Primary School	Middle School	Junior Secondary	Senior Secondary	Tertiary Education	
	% of household heads						
Households with forest plantation (n=165)	12.7	24.8	27.9	6.1	25.5	3.0	100.0
Households without forest plantation (n=115)	28.7	37.4	19.1	2.6	10.4	1.7	100.0
All household categories (n=280)	19.3	30.0	24.3	4.6	19.3	2.5	100.0

Source: Field Survey, 2006

5.1.3 Household landholding characteristics and land tenure arrangement

The amount of land owned and managed by the household and the tenure arrangement of the land can play an important role in the economic activities of the household. This section of the analysis concentrates on the landholding characteristics of the study households and its implication on their decision to establish farm forest plantation. The results from the household survey show that landholding in the study area is relatively large. A comparison between households with and without farm forest plantation in terms of the size of household's landholding using an independent–samples t-test showed significant differences between the two household categories *[t(278)=4.15, p=0.000]*. Study households currently with farm forest plantation have considerably larger landholding (Mean=9.11 ha) compared to those without farm forest plantation (Mean=5.35 ha) (Table 5.4). In the same way, a comparison between the wealth groups and the size of household landholding also showed that in general the better-off households (both with and without farm forest plantation) have larger landholding compared to the average and poor wealth groups. A greater proportion (76.4%) of households with farm forest plantation were more likely to own the land they manage compared to 62.6% of those without farm forest plantation *(d.f.=1, chi square=6.19, p=0.013)*.

Table 5.4: Mean household landholding for households with and without farm forest plantation

Household category	Wealth groups	Mean (ha)	All wealth groups mean (ha)	Minimum (ha)	Maximum (ha)
Households with forest plantation (n=165)	Better-off (n=54)	17.09	9.11	2.14	46.96
	Average (n=56)	7.34		1.31	23.46
	Poor (n=55)	3.07		1.01	20.24
Households without forest plantation (n=115)	Better-off (n=30)	10.11	5.35	1.07	20.63
	Average (n=35)	6.20		1.05	16.99
	Poor (n=50)	1.89		0.20	12.14

Source: Field Survey, 2006

The method of land acquisition between the study households also varies significantly *(d.f.=3, chi square=20.57, p=0.000)*. In general, the majority of households with farm forest plantation (65.5%) acquire land through family inheritance whilst 58.3% of households without farm forest plantation acquire land through family inheritance (Table 5.5). On the other hand, 36.5% of those without farm forest plantation obtain land through share-cropping popularly referred to as *"Abunu or Abusa"*[8] system compared to 17.6% of those with farm forest plantation. The rest of the households with farm forest plantation acquire land either through outright purchase (9.1%) or have obtained degraded government forest land to farm and establish forest plantation (7.9%).

[8] *"Abunu"* is a land tenure system in which a piece of land is given to a farmer for farming. Food crops from the farming activities are shared equally between the farmer and landowner. In the case of the *"Abusa"* system, food crops are shared 1/3. The farmer takes two-thirds of the food crops while the landowner takes the remaining one-third

About 5.2% of households without farm forest plantation own land through outright purchase but none of the households use degraded government forest land. This is attributed to the fact that the acquisition of such land requires the households to carry out their agricultural activities and also plant trees on the land. Most households however want degraded forest lands for only agricultural purposes and therefore avoid acquiring such land.

Table 5.5: Land tenure arrangement among households with and without farm forest plantation

Household category	Wealth groups	Mode of land acquisition			
		Family land	Outright purchase	Share cropping	Government land
		% of households			
Households with forest plantation (n=165)	Better-off (n=54)	68.5	14.8	9.3	7.4
	Average (n=56)	66.1	8.9	17.9	7.1
	Poor (n=55)	61.8	0.0	29.1	9.1
All wealth groups		65.5	9.1	17.6	7.9
Households without forest plantation (n=115)	Better-off (n=30)	50.0	16.7	33.3	0.0
	Average (n=35)	71.4	2.9	25.7	0.0
	Poor (n=50)	54.0	0.0	46.0	0.0
All wealth groups		58.3	5.2	36.5	0.0
All household categories (n=280)		62.5	7.5	25.4	4.6

Source: Field Survey, 2006

5.2 Economic activities of the study farm households

5.2.1 Overview

This section of the dissertation illustrates the major economic activities undertaken by the study households to support their livelihood. A key observation from the household survey is that households in the study area pursue a diverse range of income generating activities including food crop production, livestock production, farm forest plantation management and off-farm activities. These activities are performed through judicious allocation of household's resources, namely, land, labor and capital with the aim of meeting the household's subsistence food needs and to generate income to meet other needs such as improving housing conditions, health care, education and better satisfaction of socio-cultural needs. The varied household's objectives coupled with limited resources implies that activities that complement each other are selected to avoid competition for household resources. As depicted in Figure 5.2, although the final decision of the farm household regarding which economic activity or activities to undertake is influenced by the above mentioned aims and the resources available to the household, the decision-making processes are further subjected to the influence of external frame conditions such as policies, institutions, infrastructure, markets, climatic conditions, etc. This shows that the decision of the farm household is in close relationship with the factors that shape the final selection of economic activities to be pursued.

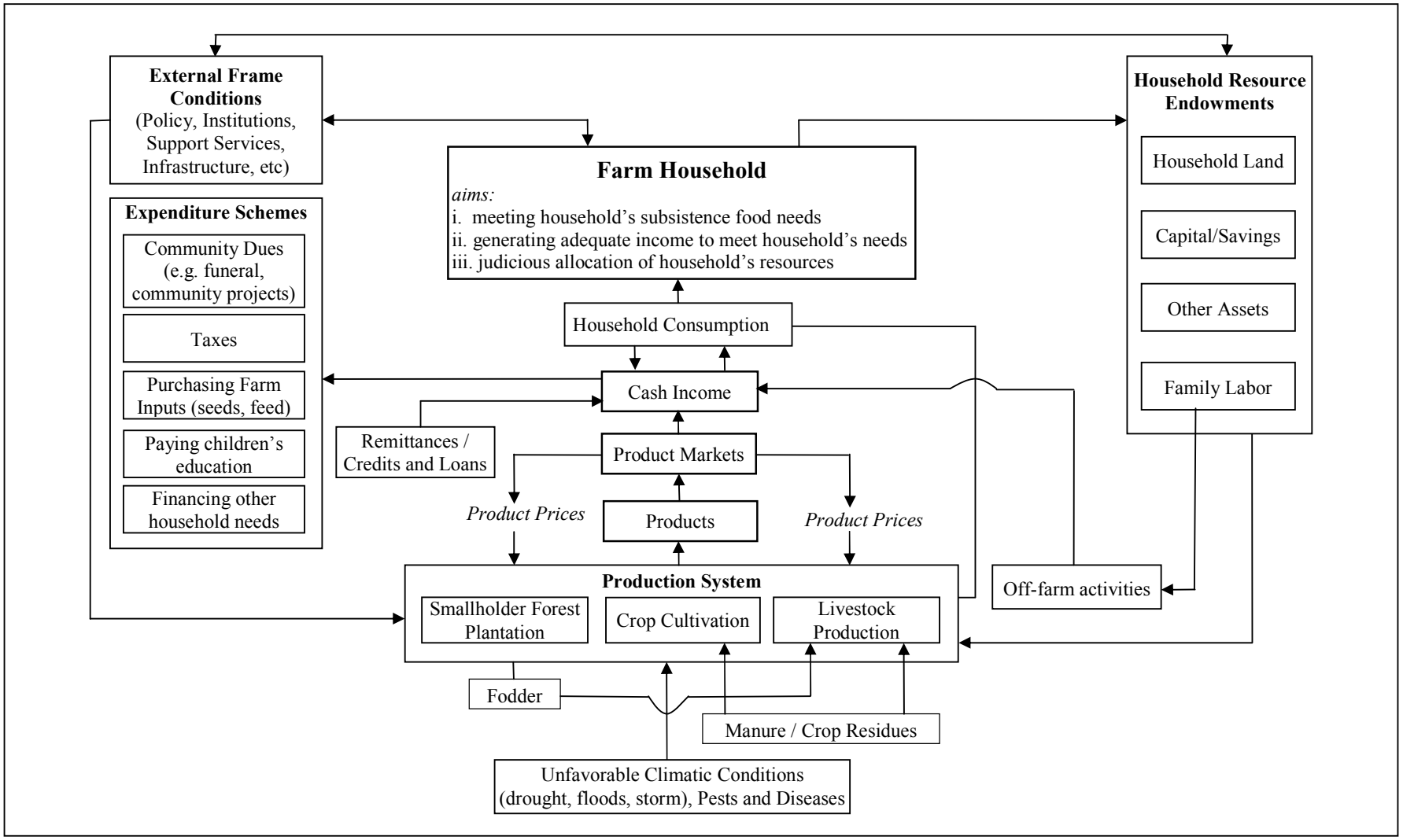


Figure 5.2: Overview of economic activities undertaken by the study households and their interaction with other endogenous and exogenous factors

Source: Adapted from Upton, 1996; Dillon and Hardaker, 1993; Beets; 1990

5.2.2 Food crop production

5.2.2.1 Maize cultivation

Maize *(Zea mays)* is Ghana's most important cereal crop cultivated by the vast majority of rural households in all parts of the country except for the Sudan savannah zone (Morris et al., 1999). The crop is the most widely consumed staple food in Ghana. This is evidenced in a survey carried out by Alderman and Higgins (1992) in Ghana in 1990 which revealed that 94.0% of all households had consumed maize during an arbitrarily selected two-week period. Maize is particularly important to the food security strategies of all household categories. For instance, maize and maize-based foods account for 10.8% of food expenditures for poor households and 10.3% of all income groups (Boateng et al., 1990). Although maize cultivation is popular in the study communities, it is not a leading staple food among the farm households and much of the crop is sold. The planting of maize has gained importance in the study area in the last two decades largely as a result of the spill-over effect of the advances in maize breeding and market development. According to the survey results, all the surveyed households planted maize in the 2005/2006 agricultural season. A comparison between households with and without farm forest plantation in terms of the size of land allocated to maize cultivation showed no statistical significant differences among them *[t(278)=0.76, p=0.449]*. However, further analysis showed that households with farm forest plantation allocate relatively larger size of land for the cultivation of maize (Mean=1.9 ha) compared to those without farm forest plantation (Mean=1.5 ha) (Table 5.6). As pointed out earlier in this chapter, households with farm forest plantation possess larger land area and therefore able to allocate large portions for the cultivation of maize to meet a greater part of the food and cash needs of the household.

Table 5.6: Estimated average farm area planted to maize by the study households

Household category	Mean (all households) (ha)	Wealth groups	Mean (all wealth groups) (ha)	Minimum (ha)	Maximum (ha)
Households with forest plantation (n=165)	1.9	Better-off (n=54)	2.5	0.6	5.0
		Average (n=56)	1.9	0.5	4.0
		Poor (n=55)	1.3	0.4	2.7
Households without forest plantation (n=115)	1.5	Better-off (n=30)	2.2	0.3	4.5
		Average (n=35)	1.8	0.4	4.3
		Poor (n=50)	0.9	0.2	3.0

Source: Field Survey, 2006

Land for maize cultivation is manually prepared using cutlass and axe from January to February. This activity is usually tedious and labor intensive due to the presence of large trees and shrubs that have to be removed from the land. It takes an average of about 45 man-days for the households to prepare a hectare of land for maize cultivation. Majority (91.2%) of the

household's plant maize in scattered plots usually inter-cropped with cassava, plantain, and/or cocoyam as part of a bush fallow system. This practice is contrary to the cultivation of maize in the other agro-ecological zones in Ghana in which significant amounts of maize are cultivated. The crop is planted during the major cropping season (April through July) as well as in the minor cropping season (September through November). These periods coincide with the major rainy season (beginning in March) and the minor rainy season (beginning in September) respectively.

In most cases, the cultivation of maize is shared among men and women. Where the maize plot is managed by a male household head, the women contribute an important proportion of the overall labor requirements. However, the men exercise discretion over the disposal of the harvest. Results from the field survey indicated that 23.8% of women manage their own maize fields and also exercise complete discretion over the disposal of the harvest. It is estimated that at least half of the maize crop produced in Ghana enter the local market (GGDP, 1991; Alderman, 1991). About 84.4% of households that planted maize in the 2005/2006 agricultural season indicated that they sold at least 62.8% of the maize they harvested. This makes maize the most widely traded crop in the study area. The extensive marketing of maize plays an important role in the welfare of the study households. This is because revenue from selling maize represents one of the important sources of income for the households.

5.2.2.2 Plantain cultivation

Plantain *(Musa sapientum)* production is a very important socio-economic activity in Ghana. According to FAO (2006), plantain is ranked as third after yam and cassava in the food crop sector in Ghana and contributes about 13.1% of the Agricultural Gross Domestic Product (AGDP). Its per capita annual consumption of 101.8kg per head is higher than other starchy staples except cassava (FAO, 2006). This makes plantain an essential component of diet in Ghana. It is grown across all the humid agro-ecological zones in Ghana and forms an integral component in most of the complex farming systems (Swennen and Vuylsteke, 1991). According to Marriott and Lancaster (1983), plantain production is attractive to farmers due to its low labor requirement compared to maize and yam as well as the high demand on the local market. All the study households allocated various proportions of land to the cultivation of plantain in the 2005/2006 agricultural season. This is a clear indication of the significant role plantain cultivation plays in the food and cash needs of the study households. Results from a statistical analysis conducted to compare the area of land allocated by the study households for plantain cultivation showed no significant differences between the two household categories *[t(278)=4.04, p=0.073]*. Study households with farm forest plantation planted an average of 0.3

ha whilst those without farm forest plantation assigned an average of 0.2 ha for plantain cultivation (Table 5.7).

Table 5.7: Estimated average farm area planted to plantain by the study households

Household category	Mean (all households) (ha)	Wealth groups	Mean (all wealth groups) (ha)	Minimum (ha)	Maximum (ha)
Households with forest plantation (n=165)	0.3	Better-off (n=54)	0.5	0.1	0.9
		Average (n=56)	0.2	0.1	0.8
		Poor (n=55)	0.2	0.1	0.6
Households without forest plantation (n=115)	0.2	Better-off (n=30)	0.4	0.2	0.9
		Average (n=35)	0.2	0.2	0.8
		Poor (n=50)	0.1	0.1	0.6

Source: Field Survey, 2006

The cultivation of plantain is mainly done using the slash and burn method. Like in the case of other food crops, plantain is planted during the major cropping season (April through July). Results from the household survey revealed that the study households have adopted two different strategies to plant plantain. While the majority of households (92.4%) plant their plantain at the same time after preparing the land, some households (7.6%) planted in stages. The latter strategy enables the households to harvest plantain almost throughout the year. Sole cultivation of plantain is seldom due to the tendency to lose the entire crop through storm. The inter-cropping of plantain with other crops such as yam, cassava, maize and/or cocoyam is therefore a common practice among the households. The households usually maintain their plantain farm from the previous year in addition to new farms. Harvesting of the crop usually takes place in the second planting year. Most of the households weed and plant plantain suckers again after the first harvest or leave the good suckers to grow. After three or four years, the land is normally abandoned to enable the soil to regain fertility. The harvested crop is usually sold to market women who visit the communities (usually two times a week or during market days). Getting traders to buy the produce is therefore not a problem. The major marketing problem is however low prices offered by the traders. Unripe boiled plantain and cassava are pounded into a paste called *fufu*[9]. Ripe plantain are also fried in oil and eaten with beans stew which is locally called *"red red"*.

5.2.2.3 Yam cultivation

Yam *(Dioscorea spp.)* is another important staple food crop appreciated for its taste and dietary value among the study households. It attracts far higher price than other root and tuber crops like

[9] *Fufu* is a traditional Ghanaian dish mostly made from boiled cassava and unripe plantain but also from cocoyam and yam pounded together to form a thick paste. This food is eaten in almost every household in the study area

cocoyam and cassava. Yam cultivation like cocoyam still depends largely on labor intensive, traditional hoe and cutlass techniques of production. Many aspects of production like clearing, planting, weeding, staking and harvesting are done manually. A disaggregation of the two household categories with regard to the size of farm land allocated for the cultivation of yam showed no differences *[t(172)=4.63, p=0.281]*. Study households with farm forest plantation have allocated relatively larger farm area to yam cultivation (Mean=0.2 ha) compared to those without farm forest plantation (Mean=0.1) (Table 5.8).

Table 5.8: Estimated average farm area planted to yam by the study households

Household category	Mean (all households) (ha)	Wealth groups	Mean (all wealth groups) (ha)	Minimum (ha)	Maximum (ha)
Households with forest plantation (n=165)	0.2	Better-off (n=54)	0.4	0.3	0.9
		Average (n=56)	0.2	0.2	0.5
		Poor (n=55)	0.2	0.1	0.4
Households without forest plantation (n=115)	0.1	Better-off (n=30)	0.3	0.2	0.8
		Average (n=35)	0.2	0.1	0.5
		Poor (n=50)	0.1	0.1	0.3

Source: Field Survey, 2006

Land for yam cultivation is usually prepared using cutlass to clear the existing bushes followed by burning of the dried vegetation on the land. Yam is planted at the onset of the major rainy season together with other food crops such as cassava, plantain and maize on the same piece of land. The crop is traditionally planted on mounds by the households although it can also be grown on ridges or on flat soil. According to the households, the planting of yam on mounds produces higher yields compared to other planting methods. The yam tubers that have been stored from the previous year harvest are used for planting. The whole tuber is either planted or cut into small sizes (mini-setts). Weed control is done manually using a hoe or cutlass at the early growing stage to avoid competition.

Harvesting of yam takes place 8-10 months after planting when most of the leaves have extensively dried up. The yam tubers are usually harvested in the dry season using cutlasses or hoes with which the mounds are opened up while making sure that the tubers are not wounded. The tubers are immediately removed from the farm after harvesting to prevent the sun from weakening the skin and thereby predisposing them to rot during storage. Most of the yam produced by the household is sold due to the high demand for yam especially in the cities. Yam tubers are normally eaten as boiled yam or fried in oil. The use of yam in preparing *fufu* (as practiced in other parts of Ghana) is not common among the study households. The yam tuber is a good source of energy for the households due to its rich carbohydrate content.

5.2.2.4 Cassava cultivation

Cassava *(Manihot esculenta)* is the most widely cultivated crop in the study area. It has grown to become one of the most popular staple food crops among households in the area. The crop is particularly important for poor households reflecting its importance to household's food security strategies under poor and/or variable market conditions. Cassava is ranked as the leading staple crop in Ghana. Its production has increased in the last four decades although the crop has only received a fraction of the attention given to other crops. This is attributed to the unique characteristics of the crop including its ability to grow and produce reasonable yields in low fertile or degraded soils. According to Hillocks et al (2001), the ability of cassava to grow on poor soils and under difficult climatic conditions as well as the advantage of flexible root harvesting makes it the crop of last resort for families and their domestic animals in the tropics. The crop's production generally requires less labor per unit of output than other staples such as yam, plantain and maize.

All the study households allocated a portion of their farm land for cassava cultivation. Farm area allocated to cassava cultivation is generally small (Mean=0.1 ha) compared to other food crops (see Table 5.9). The reason attributed to this disparity is that, most households prefer to apportion larger farm area to crops such as yam, plantain and maize which fetch more income than cassava. Some households usually buy cassava from the market if they are not able to produce enough to meet their household's needs.

Table 5.9: Estimated average farm area planted to cassava by the study households

Household category	Mean (all households) (ha)	Wealth groups	Mean (all wealth groups) (ha)	Minimum (ha)	Maximum (ha)
Households with forest plantation (n=165)	0.1	Better-off (n=54)	0.1	0.1	0.4
		Average (n=56)	0.2	0.1	0.4
		Poor (n=55)	0.2	0.1	0.5
Households without forest plantation (n=115)	0.1	Better-off (n=30)	0.2	0.1	0.6
		Average (n=35)	0.2	0.2	0.5
		Poor (n=50)	0.1	0.1	0.4

Source: Field Survey, 2006

Cassava is either planted as a single crop or inter-cropped with maize, yams and plantains by the households. Although the plant grows best on light sandy loams or on loamy sands which are moist, fertile and deep, the experience of some of the households shows that when cassava is grown on very rich soils the plant produces more stems and leaves at the expense of roots. Hence, none of the study households apply fertilizer when the land is freshly cleared. Study households who planted cassava as a mono-crop usually used lands that are depleted and have

become unsuitable for other crops. The various activities involved in cassava cultivation including planting, weeding, topping and harvesting is done manually. None of the households used machinery for any of the activities. This was attributed to the availability vis-à-vis low cost of manual labor compared to the high cost of machines.

The plant is ready for harvesting as soon as there are storage roots large enough for consumption. However, most of the households interviewed (87.6%) indicated that they harvest their cassava between 8-12 months after planting. This is to ensure that the tubers are large enough to attract good market prices. A small number of households (12.4%) leave their cassava plants un-harvested for more than one growing season to allow the storage roots to enlarge further. Harvesting of cassava is done manually. The day before harvesting, the cassava stalks are cut off some few centimeters above the ground using a cutlass and piled at the side of the field. Materials required for the next planting is selected from the stalks and the rest is left to rot on the farm. Soils in the study area are heavy and therefore the households use either a hoe or cutlass to dig up the cassava roots before the plant is pulled out. This is contrary to other areas with light soils where the cassava roots are drawn from the soil by pulling the stems. The harvested cassava begins to deteriorate after few days (usually after 48 hours) and therefore the cassava tubers are harvested to coincide with market days. In communities where no market days are organized, most households harvest and sell their cassava on the same day or leave the roots undetached from the plant and store them in the ground for longer periods.

As a food crop, cassava provides a major source of calories for the households due to its high starch content. It is one of the most efficient producers of carbohydrates and energy among all the food crops. Most of the households mainly boil and eat the tubers in the form of *fufu*. The tubers are sometimes fried and eaten as *gari*[10]. Some households reported eating the leaves of the plant as a green vegetable, which provide a cheap and rich source of protein and vitamins A and B. The leaves and stem are also used to feed livestock such as sheep and goats. The demand for starches in recent decades especially for the textile, pharmaceutical, pulp and paper, adhesives for packaging industries and flour for bakery and confectionery industries has served as an opportunity for cassava cultivation among the households.

5.2.3 Livestock production

Livestock production is an important activity for majority of households in the study area, contributing in diverse ways to their livelihoods and simultaneously fulfilling several other

[10] *Gari* is a fine to coarse granular, starchy food traditionally made from grated, fermented, and roasted fresh cassava tubers

functions. For these households, the various animals raised serve as productive assets which can be crucial in maintaining household survival in emergency cases. More importantly, the raising of livestock serves as a source of livelihood security by diversifying risk and buffering crop production. The animals are either consumed by the households or sold when needed to generate income. The main livestock raised in the study communities include sheep, goats, pigs and poultry. Sheep, goats and poultry are usually raised on free-range. These animals are only kept in stalls during the night and released in the afternoon to graze freely in the nearby surroundings. The practice of supplementary feeding of the animals is not common among the households. However, some households indicated feeding their animals with maize, crop residues and food leftovers in the evenings. In contrast to sheep, goats and poultry, pigs are generally kept in stalls but sometimes released to graze in the surrounding fields. The practice of allowing pigs to graze freely in the nearby surroundings is forbidden in most of the study communities due to the risk of damaging agricultural fields and other properties. Supplementary feeding of pigs with crop residues is practiced by the households in order to fatten them. The animals are normally sold after one to two years when they have attained the appropriate body weight. Table 5.10 shows the distribution of livestock owned by the study households. Income generated from livestock rearing is presented in Chapter 7.

Table 5.10: Distribution of livestock owned by the study households

Household category	Wealth groups	Average no. of sheep	Average no. of goats	Average no. of chicken	Average no. of pigs	Total LUs[11]
Households with forest plantation (n=165)	Better-off (n=54)	5.96 (27)	5.59 (22)	5.42 (35)	5.60 (5)	2.23
	Average (n=56)	4.89 (19)	3.87 (16)	5.86 (37)	5.00 (3)	1.94
	Poor (n=55)	4.30 (20)	3.28 (14)	6.85 (48)	0.00 (0)	0.95
All wealth groups		*5.51 (66)*	*4.02 (52)*	*6.13 (120)*	*5.38 (8)*	*2.04*
Households without forest plantation (n=115)	Better-off (n=30)	5.50 (18)	4.56 (16)	5.83 (18)	4.43 (7)	1.96
	Average (n=35)	4.52 (23)	3.58 (19)	6.48 (27)	6.50 (4)	2.17
	Poor (n=50)	3.65 (17)	3.21 (14)	7.19 36)	6.00 (1)	1.96
All wealth groups		*4.57 (58)*	*3.79 (49)*	*6.56 (81)*	*5.25 (12)*	*1.96*
All household categories (n=280)		*4.77 (124)*	*3.91 (101)*	*6.30 (210)*	*5.30 (20)*	1.99

Figures in parenthesis indicate the number of households in each wealth group owning various livestock
Source: Field Survey, 2006

A comparison between study households with and without farm forest plantation using a two-way between-groups ANOVA showed no statistical significant differences in terms of the number of sheep owned *[F(1, 118)=1.835, p=0.178*]. However, the wealth groups differed

[11] LUs = Livestock units; conversion factors by FAO (2005a): cattle (0.50), sheep and goats (0.10), pigs (0.20), poultry (0.01)
[13] See Chapter 7 for detailed information on income generated from off-farm activities by the households

significantly with regard to the number of sheep owned *[F(2, 118)=7.714, p=0.001*]. In general, the better-off households (both with and without farm forest plantation) own higher numbers of sheep compared to the average and poor households (Table 5.10). In contrast to the ownership of sheep, statistically significant differences were found between the households with regard to the number of goats owned *[F(1, 95)=5.07, p=0.027*]. Study households with farm forest plantation own relatively higher number of goats (Mean=5.59) compared to those without farm forest plantation (Mean=4.56). The difference between the two household categories is however small (partial eta squared=0.05).

Poultry keeping and most importantly chicken rearing is a long tradition by households in the study communities. About 71.8% of the interviewed households own chicken and possess an average of 6.30 chickens that are over six months old. No statistical differences were found between households with and without farm forest plantation in terms of the number of chicken owned *[F(1, 195)=1.28, p=0.259*]. However, in general, the poor households own higher number of chicken compared to the better-off and average households (Table 5.10). The results from the household survey show that majority of the households (78.6%) keep poultry for household consumption while 21.4% raise poultry for the market. The rearing of pigs is not a common practice in the communities. This is attributed to the low demand for pork in the area coupled with the extra care that has to be given to the animals to prevent them from destroying properties. Only 7.1% of the study households own pigs with an average of 5.30 pigs per household. The two household categories did not differ in terms of the number of pigs owned *[F(1, 15)=0.05, p=0.828*].

5.2.4 Off-farm income generating activities

Off-farm income generating activities were considered in the past as a temporary activity undertaken during the slack period in the agricultural season or in response to critical cash needs. Today they are undertaken by most households in the study area to generate income to meet living costs and other needs not satisfied by income from agriculture. A total of 199 households (representing 71.1% of all the study households) participated in various off-farm activities. This comprised of 90 households with farm forest plantation (i.e. 54.5% of households in this group) and 109 households of those without farm forest plantation (i.e. 94.8% of households in this group) (see Table 5.11). The off-farm activities included operating stores, renting small farm equipment to other farmers or leasing out land to non-family members, especially to migrant farmers for cropping and other purposes, petty trading involving retailing of agricultural crops, livestock and other products at the local market (usually during market days), casual farm

laboring and remittances. The high percentage of households without farm forest plantation participating in off-farm activities is a clear indication of the importance of off-farm income for this category of households.

Both male and female household members are involved in off-farm activities. However, in general the number of female household members participating in off-farm activities is higher than the male household members. Women that participate in off-farm activities are either the wife of a male head of household or they are themselves the head of the household. The two most important off-farm activities engaged by the households are the operation of stores / petty trading (33.9%) and as casual farm labor (22.8%). Stores operated by the households are usually small and only a limited range of stock such as rice, vegetable oil, sugar, biscuits, cigarettes, matches, drinks and snacks are sold. The most common type of stores operated by the study households is operating a kiosk. Renting of small farm equipment and land, and working as casual farm labor were common among households in Asuoso. This was attributed to the presence of relatively large farm plots in this area.

Table 5.11: Proportion of the study households participating in off-farm income activities

Type of off-farm activity	Household category						All household categories (n=280)
	Households with forest plantation (n=165)			Households without forest plantation (n=115)			
	Wealth groups			Wealth groups			
	Better-off (n=54)	Average (n=56)	Poor (n=55)	Better-off (n=30)	Average (n=35)	Poor (n=50)	
	% of households in each wealth group						
Stores / trading	31.5 (17)	19.6 (11)	23.6 (13)	66.7 (20)	54.3 (19)	30.0 (15)	33.9 (95)
Renting	22.2 (12)	10.7 (6)	0.0 (0)	20.0 (6)	14.3 (5)	0.0 (0)	10.4 (29)
Casual farm labor	0.0 (0)	17.8 (10)	27.3 (15)	0.0 (0)	28.6 (10)	58.0 (29)	22.8 (64)
Remittances	0.0 (0)	3.6 (2)	7.3 (4)	0.0 (0)	0.0 (0)	10.0 (5)	3.9 (11)
% (wealth group)	*51.7*	*51.7*	*58.2*	*86.7*	*97.2*	*98.0*	71.1
% (household category)	*54.5 (90)*			*94.8 (109)*			

Figures in parenthesis indicate the number of households in each wealth group that participated in each off-farm activity

Source: Field Survey, 2006

The results from the household survey show that majority of the study households (76.1%) are involved in off-farm activities primarily to meet the household cash needs. The rest of the households cited reasons such as making use of unused household labor (18.6%) and personal satisfaction (5.3%) (see Figure 5.3). The participation in off-farm income generating activities is seen by the households as a means to generate supplementary income to meet the needs of the

household. Income from off-farm activities are generally used to improve household welfare (e.g. paying children school fees, community dues, etc) and to buy farm inputs.

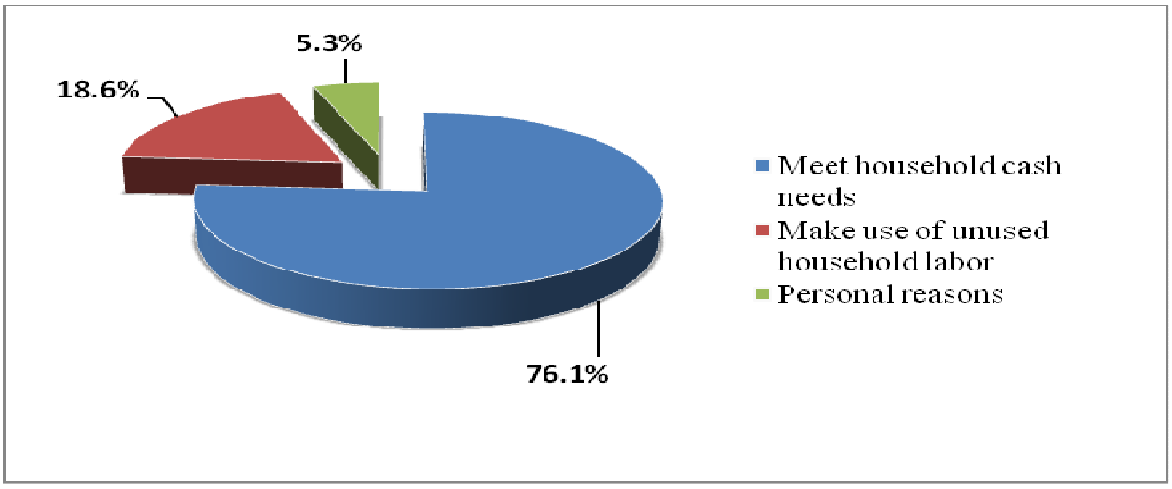


Figure 5.3: Study household's reasons for participating in off-farm income activities
Source: Field Survey, 2006

5.2.5 Smallholder farm forest plantation development

5.2.5.1 Establishment of farm forest teak plantation in the study communities

Teak *(Tectona grandis)* has become an important tree species for households in the study area. The majority of households with farm forest plantation (61.2%) have planted teak as the main tree species. The prominent reasons cited for preferring teak to other tree species included the strong demand for teak poles and teakwood especially on the local market, high adaptability of teak to the local conditions, the advantage of earning benefits in a relatively short time and the availability of planting materials. Although the exact commencement of farm forest teak plantation establishment in the study communities is not known, it is estimated that a number of farm forest teak plantations were established by some farmers after the suspension of the government initiated forest plantation development program in the early 1980s. The results from the household survey show that some households began planting teak on their farm lands even in the early 1970s (see Table 5.12). The number of households was however very small. These households (mainly better-off households) can be described as pioneers in the establishment of teak plantation on farm lands in the study communities.

The number of households establishing farm forest plantation increased by 30.4% between 1981 and 1990 compared to the previous 10 years (i.e. between 1970 and 1980) with only 6.1% of the households establishing farm forest plantation (Table 5.12).

Table 5.12: Number of study households establishing farm forest plantation between 1970 and 2005 by wealth groups

Year of establishing forest plantation on farm lands	Wealth groups			All study households (n=280)
	Better-off (n=54)	Average (n=56)	Poor (n=55)	
	Number of households			*%*
>=1970	2	0	0	0.7
1971-1975	4	1	0	1.8
1976-1980	6	3	1	3.6
1981-1985	14	10	8	11.4
1986-1990	20	18	15	18.9
1991-1995	30	27	18	26.8
1996-2000	31	22	20	26.1
2001-2005	58	52	43	54.6

Source: Field Survey, 2006

This significant increase was attributed to a number of factors including the destruction of forest and non-forest lands in the study area by wildfires in 1983 which rendered a large proportion of land unsuitable for farming and also led to the scarcity of forest products from surrounding forests. The resultant consequences were the planting of teak and other species on these lands with the aim of meeting the household's wood requirement and as a means to regenerate the land. There was a further increase (52.9%) in the number of households who used their land to establish farm forest plantation between 1991 and 2000. As compared to the period between 1991and 2000, the number of households who established farm forest plantation between 2001 and 2005 increased to 54.6%. This further increase can be attributed to the launching of the National Forest Plantation Development Program (NFPDP) in 2001 by the president with the aim of promoting forest plantation development in Ghana. This period also saw the formulation of various environmental NGOs that created awareness about the consequences of forest destruction and encouraged tree planting in rural communities and in schools.

Analysis of the intended goals for establishing farm forest teak plantations shows that the majority of households (47.9%) have established teak plantation in anticipation of the financial benefits to be derived. They foresee such land-use option as an important source of income in the future and can reduce the risks associated with traditional agricultural crops. Other reasons mentioned included the opportunity to utilize non-productive agricultural land for the establishment of forest plantation (24.8%) and the possibility to use the plantation as collateral to secure loans/credits (20.0%). This was especially noteworthy for the poor households who usually lack the needed security to access loans and credits. A small percentage of the households (7.3%) intend to secure their construction wood and fire wood from the plantation.

There were significant differences between households currently with farm forest plantations and those without farm forest plantation in terms of the future intentions to use their land to establish forest plantation (see Figure 5.4). About two thirds (72.1%) of households currently with farm forest plantation management had positive intentions to establish more forest plantation in the future as compared to 19.1% of those without farm forest plantation. Among households with farm forest plantation, about 14.6% would discontinue using their land to establish more forest plantation whilst 13.3% are undecided. On the other hand, 35.7% of households without farm forest plantation do not intend to use their land to establish forest plantation in the future whilst a large proportion (45.2%) of households in this category are undecided. The above results show that households currently with farm forest plantation are positive about their desire to put more land into forest plantation development in the future compared to those currently without farm forest plantation.

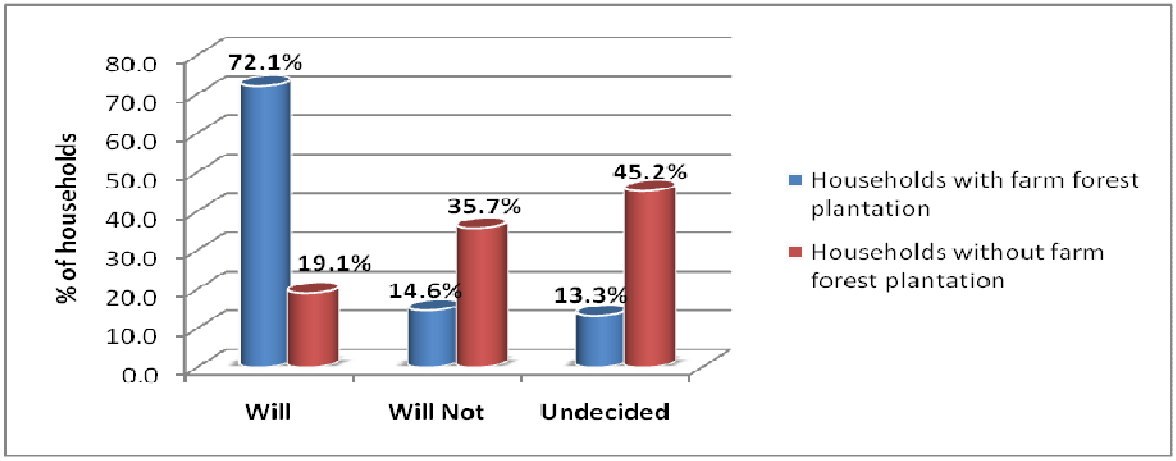


Figure 5.4: Study household's intention to establish farm forest plantation in the future
Source: Field Survey, 2006

5.2.5.2 Management systems used by the study households to establish farm forest plantation

Two main management systems are used by the households to establish farm forest plantation. Most households plant teak on their existing farm lands (i.e. teak inter-cropped with food crops) while other households establish pure teak plantations by devoting the entire land or large parts of it for this purpose. The results from the household survey and farm visits show that the majority (84.7%) of households have established farm forest plantation in combination with food crops while 15.3% have established pure teak plantations. The inter-cropping of maize and plantain is most common. This was attributed to their high use as staple food in the study area. In some cases, vegetables such as tomato, pepper and garden eggs are also inter-planted. The inter-cropping of teak plantation with food crops was seen as advantageous by the households since no

additional expenditure is incurred for stand establishment and tending operations. In addition, cash income can be generated from the agricultural crops while waiting for the trees to mature. Some households reported competition between the trees and food crops for nutrients, light and growing space resulting in reduction of crop yields. According to the households, the extent of yield reduction increases with increasing age of the trees. For instance, some households estimated the average decline in yield of maize and plantain to about 10.0% during the second year of growing and up to 20.0% during the third year. In addition, the growth of young trees is affected by the agricultural crops. This is particularly mentioned when trees are in-cropped with plantain due to the shading effect of the plantain at the early stages of tree growth.

5.2.5.3 Planting materials and spacing

Most households used wildlings from existing forest plantations as planting material to establish their plantations in the past. However, stands are now being established using seedlings raised by the households or purchased from the Forestry Commission or private seedling producers ($0.06/seedling). Seeds for the nurseries are either collected from existing plantations or purchased from the Forestry Commission and other sources. The collection of seeds from existing plantations was reported as the most economical way of obtaining seeds. However, since seeds are often collected from parent stock with inferior traits, off-springs from these seedlings are often of low quality. According to Hedegart (1995), the selection of seeds from superior trees can increase volume production by 10.0% to 15.0%. The quality of the tree is also improved. Seeds and/or seedlings from the Forestry Commission were reported to be of good quality due to the collection of seeds from superior trees by experienced nursery workers. Most households (73.9%) use bare-rooted stumps whilst 26.1% reported using potted or containerized seedlings to establish their plantation. The ease of transporting stumps, lower labor intensity and ability to raise large nurseries within a short time were cited as reasons for preferring bare-rooted stumps although the survival rate of the seedlings was reported lower than the potted or containerized system.

The initial planting spacing has profound effect on teak production since the number of trees, timing and intensity of thinning largely determines the space made available to the individual trees as they grow. A range of planting spacing is used by the households to establish teak plantation. The spacing used depended on whether teak is established as pure stand or in combination with food crops. The use of 2.5m x 2.5m and 2.7m x 2.7m was reported in the case of pure teak plantations. However, when teak is established in combination with food crops, planting spacing of 3.0m x 3.0m is normally used. The amount of work needed to plant a hectare

of teak seedlings in the study area depended on the type of planting material used. It is estimated that 10 man-days are used to plant a hectare of bare-rooted stumps as compared to 15 man-days for potted or containerized seedlings. Planting is usually done during the rainy season, normally from April to June. However, due to changes in the rainfall pattern, planting is timed to coincide with the heavy rains. Table 5.13 shows the working calendar of teak establishment followed by the majority of the study households.

Table 5.13: Work calendar for establishing teak with food crops in the study communities

Activity	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
i. Land preparation												
Land clearing												
Burning												
Removal of debris												
Stumping												
ii. Planting (trees)												
Peg cutting												
Pegging												
Planting												
Beating-up												
iii. Planting (food crops)												
Maize												
Plantain												
Harvest (Maize)												
Harvest (Plantain)												
iv. Tending/Maintenance												
1st weeding												
2nd weeding												
Fire belt construction												

Source: Field Survey, 2006

5.2.5.4 Size and age distribution of farm forest plantation

The results from the household survey indicate that on average, each study household with farm forest plantation possesses about 2.9 ha of forest plantation. The size of the plots however ranges between 0.3 ha and 8.9 ha (Table 5.14). Farm households in Asuboi possess the least average size of farm forest plantation plot with about 1.8 ha. This was attributed to the small size of land possessed by these households. There is not much difference between the mean size of farm forest plantation plot among households in Asuoso and Kyekyewere as well as households in Anyinasu and Nkwankwaa (Table 5.14). Further analysis of the distribution of households with regard to the size of farm forest plantation plot planted show that the majority (26.8%) own between 1.0 ha and 2.5 ha forest plantation while 19.3% possess between 2.5 and 4.0 ha. About 4.3% and 3.6% of the households own 5.5-7.0 ha and 4.0-5.5 ha forest plantation respectively. Only 3.9% had forest plantation equal or less than 1.0 ha while 1.1% possesses more than 7.0 ha.

Table 5.14: Size of forest plantation plot owned by the study households (ha)

Study community	Size of forest plantation plot			
	Mean (ha)	Minimum (ha)	Maximum (ha)	Std. Deviation (ha)
Asuoso (n=30)	3.4	0.3	8.9	2.0
Anyinasu (n=30)	2.5	0.3	4.4	1.1
Nkwankwaa (n=30)	2.7	0.7	6.5	1.4
Kyekyewere (n=45)	3.7	1.3	8.1	1.8
Asuboi (n=30)	1.8	0.7	3.6	0.7
All study communities	2.9	0.3	8.9	1.6

Source: Field Survey, 2006

Using 1970 to 2005 as the reference point for the commencement of farm forest plantation development by the households, the results from the survey show that the majority of households (153 households with farm forest plantation) have forest plantation stands that are between 0-4 years while 17 households planted their trees over 25 years ago (see Figure 5.5). This result clearly shows that farm forest plantation development is a recent phenomenon for majority of the study households.

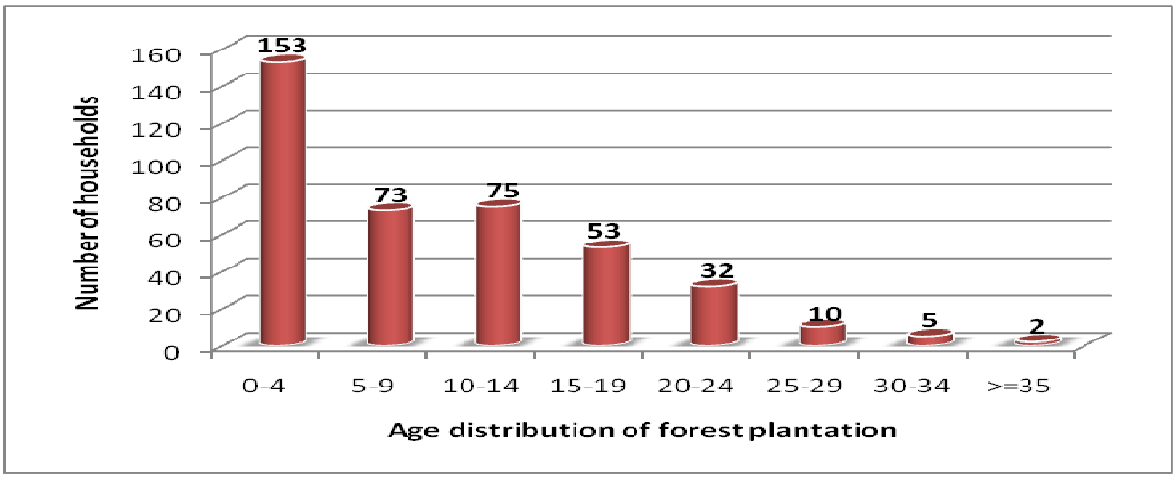


Figure 5.5: Age distribution of farm forest plantation owned by the study households
Source: Field Survey, 2006

5.3 Silvicultural activities and performance of farm forest teak plantation

5.3.1 Thinning and pruning

Thinning and pruning operations are closely inter-related with a strong influence on the quality of the wood and production performance. Bermejo et al. (2004) and Keogh (1987) recommend thinning to ensure optimum development of stand and to increase the merchantable yields by distributing volume growth on fewer larger stems. According to Redes (1998), thinning should start at the onset of competition (indicators of competition include touching of crowns and mortality of lower branches). Koegh (1987) recommends that the first thinning in teak plantation should be carried out between the 5th and 6th year when the top height has reached 8m or more.

He further recommends second thinning at 7 years or at a top height of 16m on good sites and 12 years on poor sites. Subsequent thinning should be made when the basal area reaches between $20m^2$ and $21m^2$ / ha.

The majority of households (84.2%) reported carrying out first thinning between the 4^{th} and 5^{th} year. Subsequent thinning is done at the 10^{th}, 15^{th}, 20^{th} and 25^{th} year, which also correspond to the first, second, third and final harvest respectively. Despite the importance of thinning, a visit to some forest plantation plots showed that some households have not thinned their stands. According to them, thinning is expensive and small wood produced from the first thinning has little value except for fence posts or fire wood. Most households leave the cut trees from first thinning on the farm to decompose. Following lack of thinning, teak plantation in the study communities are over stocked for their age causing unnecessary competition and reduction of diameter growth. Keogh (1987) indicates that lack of thinning leads to low to negative financial returns due to the loss of the tree's productive potential and the production of small diameter classes which reduces the price of the log. On average, 30 man-days / ha are needed by the households to carry out the first thinning. Subsequent thinning requires only 25 man-days / ha due to the reduction in stocking density from previous thinning.

Pruning is regarded as an essential silvicultural activity in forest plantations to keep trees free from knots, increase the merchantable height of the trees and improve the quality of the wood (Briscoe and Nobles, 1966). Koegh (1987) recommends that branches on teak should be pruned before reaching 5cm diameter just after the period most new leaves are produced. The majority (75.2%) of the households reported pruning their stands. However, a visit to some forest plantation plots showed stands with knots and crooked stems. This was attributed to improper pruning techniques. A greater percentage of the households (64.8%) carry out first pruning between the 4^{th} and 5^{th} year when the majority of the trees have reached about 6m in height. Pruning is done at this age to prevent shading of agricultural crops. Subsequent prunings are done between the 8^{th} and 10^{th} year. An average of 45 man-days / ha are needed for pruning the teak stand.

5.3.2 Weed control and protection against wildfire

According to Keogh (1987), young trees are susceptible to shading; hence it is essential to keep stands free of weeds. Results from the survey indicated that an average of three complete cleanings are undertaken by majority of the households in mix-culture stands in the first five planting seasons whilst two cleanings are carried out from the 6^{th} to the 10^{th} year. In the case of pure teak stands, two cleanings are performed from the first planting season up to the fifth year.

One weeding is made from the 6th year to the 10th year. Planting lines are usually cleared to ground level to a width of about two meters and any overhanging vegetation is cleared to ensure that the planted trees receive maximum exposure to light at all times. In addition to weeding, singling is done to reduce multiple stems to the one with best form and growth development. Generally, an average of 30 man-days / ha is needed for weeding and singling.

Annual wildfire is arguably one of the most significant threat facing forest plantation stands in the study area. Several hectares of farm lands in the area are burnt each year through the indiscriminate setting up of fire by hunters. The seasonal drying of grass and other highly combustible weeds, most notably *Chromolaena odorata,* provide a source of fuel. Allison et al. (1986) therefore recommend the construction of fire breaks around the plantation to reduce fire hazards. The results from the household survey and a visit to some forest plantation plots show that the majority (67.3%) of the households have not made fire belts around their plantation. They asserted that teak is able to withstand fires and therefore do not require fire protection. This assertion is in line with Centeno (2004) who indicated that teak is a fire-resistant species and once the tree reaches the size of saplings (8m to 10m tall) and diameters greater than 10cm to 15cm, they become quite resistant to wildfires. However, Keogh (1987) indicates that the incidence of fire in teak stands weakens the plant and causes unwanted side-effects. It is therefore recommended to provide fire protection.

5.3.3 Growth and yield performance of farm forest teak plantation

According to Ladrach (2009), in spite of the long history of teak as a plantation species, reliable information on its growth and yield is relatively scarce. Trinidad is considered as one of the best sources of teak growth and yield information, where plantation growth data were registered periodically during a 20-year span (Miller, 1969). Studies in that country have shown that the maximum mean annual increment in teak plantations managed in a 20-year growing cycle occurs at a relatively young age, between 7 and 12 years, depending on the site class (Miller, 1969; Fonseca, 2004). Pandey (1983) reported that 15-year-old teak in Indonesia established on "good sites" has a mean annual increment (MAI) of 21.0m^2/ha/yr while 12m^2/ha/yr to 15m^2/ha/yr can be obtained on "average sites". Growth projections based on younger stands in Costa Rica also suggests that higher MAI values can be obtained for plantations on "good sites" (Picado, 1997; Fonseca, 2004). Teak thinnings in Myanmar also produced between 12m^3/ha and 17m^3/ha on a 30-year thinning cycle (FAO, 1999). Recent growth and yield models of teak plantations in northern Ghana reported growth rates of 14m^3/ha/year at 24 years on the "best sites" while

growth on "second class sites" produced 9m^3/ha/year at 24 years (Oteng-Amoako and Sarfo, 2003).

Results from a rapid field inventory of 10-year-old and 20-year-old farm forest teak stands in the study communities showed a mean density of 299 stems/ha for the 10-year-old stand while the 20-year-old stand had a mean density of 203 stems/ha (see Tables 5.15 and 5.16). The average diameter of the stands ranged between 26.64cm and 42.46cm for the 10-year-old stand and 20-year-old stand respectively. The average diameter obtained at the study site is almost two times higher than that obtained by Barley and Wood (1976) who reported an average diameter of 14.0cm at age 10 in northern Nigeria. The average height oscillated between 21.88m and 35.30m. On the other hand, the average basal area per hectare ranged between 17.03m^2/ha and 28.92m^2/ha for the 10-year-old stand and 20-year-old stand respectively. The calculated average volume per hectare was 126.95m^3/ha/year, equivalent to an annual production of 12.69m^3/ha/yr for the 10-year-old stand while the 20-year-old stand had an average volume of 344.05m^3/ha/year and a mean annual increment of 17.20m^3/ha/year. The reported growth rates compared favorably with those achieved in northern Ghana by Oteng-Amoako and Sarfo (2003). As a comparison, results reported by Zuhaidi and Krishnapillay (2005) showed that 7-year-old plantation grown teak had an average production of 12m^3/ha/yr. At 10 years, the average height and diameter at breast height for 10-year-old teak stand in Malaysia were 16.21m and 16.5cm respectively with an average volume of 158.15m^3/ha/yr (equivalent to annual production of 15.80m^3/ha/yr).

Table 5.15: Summary statistics of a 10-year-old farm forest teak plantation in the study communities

Variable	Community					Average (all communities)
	Asuoso	Anyinasu	Nkwankwaa	Kyekyewere	Asuboi	
Measurement plot size (m^2)	1,875	1,875	1,875	1,875	1,875	1,875
Stems/measurement plot	70	54	51	56	52	56
Stems/hectare (st/ha)	373	288	272	299	277	299
Average stem diameter (cm)	26.58	27.75	28.09	25.23	25.67	26.64
Average stem height (m)	23.21	23.83	18.66	21.77	21.33	21.88
Average stem basal area (m^2)	0.06	0.06	0.06	0.05	0.05	0.06
Basal area per ha (m^2/ha)	21.01	17.65	17.01	15.04	14.51	17.03
Average stem volume (m^3)	0.45	0.50	0.40	0.37	0.38	0.42
Total plot volume (m^3)	31.46	26.82	20.30	20.74	19.70	23.80
Volume per ha (m^3/ha)	167.79	143.04	108.27	110.61	105.07	126.95
MAI (m^3/ha/yr)	16.78	14.30	10.83	11.06	10.51	12.69

Source: Field Inventory, 2006

Table 5.16: Summary statistics of a 20-year-old farm forest teak plantation in the study communities

Variable	Community					Average (all communities)
	Asuoso	Anyinasu	Nkwankwaa	Kyekyewere	Asuboi	
Measurement plot size (m^2)	1,875	1,875	1,875	1,875	1,875	1,875
Stems/measurement plot	42	37	33	40	38	38
Stems/hectare (st/ha)	224	197	176	213	203	203
Average stem diameter (cm)	41.86	44.21	40.85	43.50	41.73	42.46
Average stem height (m)	36.07	35.08	34.78	34.62	35.84	35.30
Average stem basal area (m^2)	0.14	0.15	0.13	0.15	0.14	0.14
Basal area per ha (m^2/ha)	30.99	30.40	23.36	31.95	27.95	28.92
Average stem volume (m^3)	1.68	1.81	1.57	1.74	1.67	1.70
Total plot volume (m^3)	70.52	67.04	51.81	69.79	63.38	64.51
Volume per ha (m^3/ha)	376.11	357.55	276.32	372.21	338.03	344.05
MAI (m^3/ha/yr)	18.81	17.88	13.82	18.61	16.90	17.20

Source: Field Inventory, 2006

5.4 Marketing of farm forest teak products in the study area

The initial step in the marketing of teak products from farm forest plantations involves searching for a buyer. After a buyer has been found, an agreement is reached regarding the price. The decision concerning the final selection of a particular buyer depends on the price offered and the ease of access or availability of the buyer in the area. Buyers found in the study area included a wood treatment company, middlemen (intermediaries) and timber firms / contractors. Table 5.17 shows the average prices paid by buyers for various assortments of teak products from forest plantation in the 2005/2006 season. As shown in Table 5.17, prices paid for the various products differ among the buyers and also in comparison with prices offered through the Competitive Bidding System (CBS)[12].

Table 5.17: Assortment of saleable teak plantation products and average unit price per tree in the 2005/2006 season

Buyer	Assortment of teak products			
	Telephone poles from 10 year old teak stand	Low tension electricity poles from 15 year old teak stand	High tension electricity poles from 15-20 year old teak stand	Saw logs from 20-25 year old teak stand
	Average unit price paid / tree ($)			
Wood Treatment Company	7.61	22.83	32.61	-
Middlemen	5.43	16.30	25.00	32.61
Timber Firms / Contractors	-	19.56	29.35	38.04
Competitive Bidding Quotes	-	25.00	33.69	40.22

Source: Offinso District Forest Office; Field Survey, 2006

[12] A new mechanism used by the Forestry Commission to allocate timber harvesting rights in Ghana. This policy applies only to state owned forests (i.e. natural forests as well as forest plantation)

The disparities in price are attributed to the absence of standard prices for the sale of forest plantation products in Ghana. It should be emphasized that farmers with teak plantation in Ghana sell teak on "per tree basis" and not "per volume" as practiced in other parts of the world. Prices of trees are therefore determined based on the age, quality of the trees and the distance of the farm from the main road network. Buyers usually pay between 10-15% less for plantations located far away from the main road network.

In general, the CBS offered the highest price per tree in comparison with the other buyers. The CBS is however used to give timber harvesting rights to buyers to harvest timber from state forest plantations. Farm forest plantation developers have to sell their products either to wood treatment companies, middlemen or timber firms / contractors. In this case, the wood treatment companies paid the highest price per tree for telephone poles, low tension and high tension electricity poles compared to prices paid by middlemen (intermediaries) for the same products (see Table 5.17). Despite the low prices paid by middlemen (intermediaries), the majority of the households (55.7%) sold their products to them (see Table 5.18). This was attributed to the easy accessibility to numerous middlemen in the study area as compared to the other buyers. About 28.4% of the households sold their products to timber firms / contractors whilst 15.9% sold to a wood treatment company.

Table 5.18: Percentage of farm forest teak products sold to each buyer during the 2005/2006 season

Buyers	Community					All communities (%)
	Asuoso (n=19)	Anyinasu (n=17)	Nkwankwaa (n=15)	Kyekyewere (n=24)	Asuboi (n=13)	
Wood Treatment Company	21.1	23.5	13.3	45.8	30.8	15.9
Middlemen	52.6	70.6	66.7	45.8	46.1	55.7
Timber Firms / Contractors	26.3	5.9	20.0	8.3	23.1	28.4
Total percentage	100.0	100.0	100.0	100.0	100.0	100.0

Figure in parenthesis indicate the number of households that sold assortment of teak products from farm forest plantations during the 2005/2006 farming season

Source: Field Survey, 2006

After the price has been agreed, the trees to be felled are marked. At this stage, the buyer has to apply for a permit from the district forestry office at Offinso to allow him to fell the trees. The application usually contains information regarding the number of trees to be felled and date to fell the trees. A forest officer is usually sent to the farmer's plot to verify whether the plantation belongs to him/her. The trees can be felled after the approval from the forestry office. The buyer is responsible for felling the trees and therefore bears the costs of felling. The households usually receive payment for the trees immediately after the trees have been felled. Another application is

made by the buyer at the district forestry office to obtain permit to transport the harvested timber from the farm. A forest officer is again sent to the plantation plot to check whether the number of trees harvested correspond to the number of trees that were agreed to be cut. A permit is issued for the conveyance of the harvested timber if the forest officer is satisfied with the results.

The various buyers encountered in the study area indicated that the market for teak poles and saw logs is very buoyant. The middlemen among the buyers sell their logs either to wood treatment companies, timber firms / contractors or to foreign timber merchants depending on the price offered by these buyers. Logs sold to wood treatment companies are treated and then sold at the local market as electricity transmission poles, telephone poles or exported. In the same way, timber firms process their logs into sawn wood for outdoor and interior structural wood work such as carvings, fittings, furniture, joinery and flooring. These products are either sold locally or exported. On the other hand, timber contractors and foreign timber merchants usually export their logs without any further processing. India represents an important destination for teak logs from Ghana. This is as a result of the increased consumption of wood in that country coupled with strict conservation policy which limits harvesting. Indian manufacturers therefore prefer to import timber in log form to feed the domestic industries. Figure 5.6 shows the main buyers and the marketing channel for assorted teak products from forest plantations in the study area.

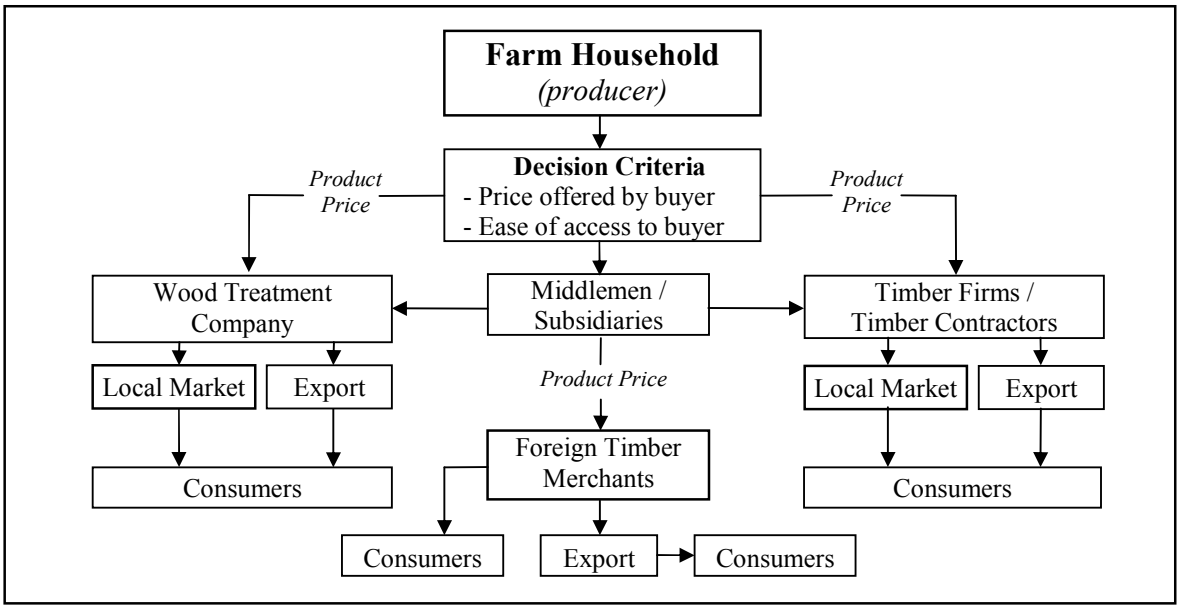


Figure 5.6: Flow chart showing the marketing channel for farm teak products in the study area
Source: Field Market Survey, 2006

5.5 Financial profitability of farm forest plantation management

5.5.1 Net Present Value (NPV) as a measure of financial profitability

Farm forest plantation development involves substantial initial costs and long-term investment of land, labor and other resources. It is therefore imperative for landowners to critically examine its financial feasibility and profitability before deciding to invest in it. The Net Present Value (NPV), a discounted cash flow (DCF) technique provides an objective means to compare the financial returns from farm forest plantation to other land-use options (e.g. conventional food crop production). Following Jefferies (1995), properties where the value depends on future irregular cash flows can be effectively valued using discounted cash flow techniques. The NPV is regarded as superior measure of profitability compared to other discounted cash flow techniques such as the IRR (Internal Rate of Return) when choosing among mutually exclusive investments. This is because the IRR method implies reinvestment rates that will differ depending on the cash flow stream for each investment proposal under consideration. With the NPV method, the implied reinvestment rate, namely, the required rate of return or hurdle rate is the same for each proposal. In essence, this reinvestment rate presents the minimum return on opportunities available to the investor.

The NPV discounts all future deposits and expenditures to the time immediately before the beginning of the investment. Discounting is done with an interest rate that is called the desired minimum interest rate or the bank interest rate which corresponds to the capital costs of an investor. An investment is therefore considered as economically viable if the NPV is greater than zero or equal to a given interest rate (i.e. NPV > = 0). Hence, a value-oriented investor will invest in projects that have a positive NPV. The decision rule for determining the financial profitability in the present study was based on the Net Present Value (NPV). Accordingly, if the NPV for food crop production is greater than the farm forest plantation option over the same period of time, then agriculture is the more profitable option and vice versa. It is assumed that due to cash flow and labor constraints and other intrinsic or personal reasons, a land-use option may be profitable but not feasible for some households. The NPV is calculated by the following equation:

$$NPV = \sum_{t=0}^{n} \frac{B_t}{(1+r_t)^t} - \sum_{t=0}^{n} \frac{C_t}{(1+r_t)^t} \quad \text{.....[1]}$$

Where B_t = benefit at time t; C_t = cost at time t; r = discount rate; n = number of years and t = time.

5.5.2 Inputs required for establishing and managing farm forest plantation

Field data was collected to facilitate the estimation of the costs of inputs (labor and materials) associated with pure teak plantation, teak plantation inter-cropped with food crops and food crop production (i.e. maize and plantain) in the study area (see Appendix 3, 6 and 9 for detailed information on inputs required by the three land-use options). For consistency, the costs analysis uses the costs per hectare whilst the costs of inputs are based on 2006 prices which are held constant throughout the term of the financial analysis. It was assumed that the households already own the land for the various land-uses options and furthermore no land tax is expected to be paid. The cost of land was therefore excluded from the projected costs. The various costs included in the analysis were grouped into costs of labor, materials, and transportation. The costs variables are based on the farm household's own way of estimating the cost of establishing and managing pure teak plantation, teak plantation inter-cropped with food crops and food crop production in the study area. It should be emphasized that these costs are the lowest investment costs possible which do not compromise the quality of the wood and/or food crops to be harvested. The majority of households excluded the cost of household labor from the cost estimation. However, it was found necessary to include this cost component in the analysis in order to obtain meaningful results. The direct cost of labor approach was applied to determine the cost of household labor. An average agricultural wage rate existing during the 2005/2006 agricultural season (i.e. $2.2/man-day)[13] was used as the standard to estimate the cost of household labor as well as hired labor.

The results from the estimation of labor inputs required by the three land-uses options showed significant differences. The establishment of teak plantation inter-cropped with food crops and sole food crop production required almost the same amount of labor in the initial establishment phase (i.e. 361 and 371 man-days respectively). A comparison between teak plantation inter-cropped with food crops, sole food crop production and pure teak plantation, however, showed a significant difference in terms of the initial labor required. Pure teak plantation demands about half of the labor needed by teak plantation inter-cropped with food crops and sole food crop production during the initial development phase (see Tables 5.19, 5.20 and 5.21)[14]. In general, food crop production requires more labor over a 25-year rotation period with 4,120 man-days compared to teak plantation inter-cropped with food crops which requires 1,390 man-days. Pure teak plantation attracted the lowest total cost over the same period with only 750 man-days needed.

[13] One man-day (Md) is equal to about 4 hours of work
[14] See Appendix 3, 6 and 9 for detailed information on inputs (labor and materials) required

Table 5.19: Summary of inputs (labor and materials) required to establish and manage one hectare pure teak plantation over a 25-year rotation period in the study area

Inputs	Year											
	0	1	2	3	4	5	6	7	8	9	10	11-25
Labor (Md)	Qty											
Land preparation	116											
Pegging	10											
Planting (teak seedlings)	10	4										
Weeding/Tending	30	30	30	30	30	90	15	15	15	15	55	0
Fire protection	30	30	30	30	30	30	15	15	15	15	15	0
Planting Materials												
Teak seedlings (No./ha)	1,200	300										
Pegs (No./ha)	1,200											
Transportation												
Teak seedlings (No./trip)	1,200	300										

Source: Calculations based on field data, 2006

Table 5.20: Summary of inputs (labor and materials) required to establish and manage one hectare teak plantation inter-cropped with food crops over a 25-year rotation period in the study area

Inputs	Year											
	0	1	2	3	4	5	6	7	8	9	10	11-25
Labor (Md)	Qty											
Land preparation	116											
Pegging	10											
Fertilizer application	40	40	40	40								
Planting (teak seedlings)	10	4										
Planting (maize seeds)	10	10	10	10								
Planting (suckers)	35	20	15	10								
Harvesting (maize)	15	15	15	15								
Harvesting (plantain)		15	10	8	7							
Processing (maize)	65	65	65	65								
Weeding/Tending	30	30	30	30	30	90	15	15	15	15	55	0
Fire protection	30	30	30	30	30	30	15	15	15	15	15	0
Planting Materials												
Teak seedlings (No./ha)	1,200	300										
Maize seeds (Kg/ha)	25	23	20	18								
Plantain suckers (No./ha)	600	150	100	50								
Pegs (No./ha)	1,200											
Fertilizer (Bag/ha)	7.5	7.5	7.5	7.5								
Transportation												
Teak seedlings (No./trip)	1,200	300										
Suckers (No./trip)	600	150	100	50								
Maize (Bags/trip)	25	22	20	18.5								
Plantain (Bunches/trip)		400	350	250	150							

Source: Calculations based on field data, 2006

Table 5.21: Summary of inputs (labor and materials) required to cultivate one hectare maize-plantain over a 25-year rotation period in the study area

Inputs	Year																
	0	1	2	3	4	8	9	10	11	12	16	17	18	19	20	24	25
Labor (Md)	Qty																
Land preparation	116					116					116					116	
Fertilizer application	40	40	40	40		40	40	40	40		40	40	40	40		40	40
Planting (maize seeds)	10	10	10	10		10	10	10	10		10	10	10	10		10	10
Planting (suckers)	65	45	25	15		65	45	25	15		65	45	25	15		65	45
Harvesting (maize)	15	15	15	15		15	15	15	15		15	15	15	15		15	15
Harvesting (plantain)		75	60	55	35		35	25	20	8		35	25	20	8		35
Processing (maize)	65	65	65	65		65	65	65	65		65	65	65	65		65	65
Weeding/Tending	30	30	30	30		30	30	30	30		30	30	30	30		30	30
Fire protection	30	30	30	30		30	30	30	30		30	30	30	30		30	30
Planting Materials																	
Maize seeds (Kg/ha)	25	23	20	18		25	23	20	18		25	23	20	18		25	23
Plantain suckers	1,500	350	200	100		1,500	350	200	100		1,500	350	200	100		1,500	350
Fertilizer (Bag/ha)	7.5	7.5	7.5	7.5		7.5	7.5	7.5	7.5		7.5	7.5	7.5	7.5		7.5	7.5
Transportation																	
Suckers (No./trip)	1,500	350	200	100		1,500	350	200	100		1,500	350	200	100		1,500	350
Maize (Bags/trip)	25	22	20	19		25	22	20	18.5		25	22	20	18.5		25	22
Plantain (Bunches/trip)		750	550	450	200		650	500	350	150		500	300	200	100		350

Source: Calculations based on field data, 2006

5.5.3 Comparative financial analysis of farm forest plantation management

The financial analysis uses as inputs the costs of inputs (labor and materials) and the expected outputs from pure teak plantation, teak plantation inter-cropped with maize and plantain, and conventional food crop production (i.e. maize and plantain) over a 25-year rotation period. The following assumptions have been made with regard to the harvesting scenario used to estimate the expected output from pure teak and teak plantation inter-cropped with food crops. It is assumed that the survival rate prior to the first thinning is 75.0% and no mortality is anticipated after first thinning. Thinnings are made at the 5th and 10th year, reducing the stand density to 500 trees/ha and 350 trees/ha respectively (see Table 5.22). Additional thinnings are done at the 15th and 20th year which further reduces the stand density to 250 trees/ha and 150 trees/ha respectively. A final harvest is expected to take place at year 25 using clear felling.

Table 5.22: Harvesting scenario used to estimate the expected output from one hectare farm forest teak plantation in the study area

Age (years)	Stocking before thinning (no./ha)	Stocking after thinning (no./ha)	Expected output (no./ha)				
			Posts[15]	Telephone poles	Low tension poles	High tension poles	Saw logs
0	1,200						
5	900	500	400				
10	500	350		150			
15	350	250			100		
20	250	150				100	
25	Final harvest	0					150

Source: Field Survey, 2006

The returns from food crops are based on the expected yield from maize and plantain over a 25-year rotation period. It is anticipated that maize and plantain yields will decline over the period despite the use of fertilizers (see Table 5.23 and Table 5.24). The decline will be gradual at the beginning of every planting cycle but more rapid at the end of the planting cycle. The yield decline is attributed to declining soil fertility as a result of continuous cropping and short fallow periods (usually 3 years), acidification of the soil due to the continuous application of organic fertilizers, rapid depletion and increased competition for nutrients such as phosphorus as observed by Porter et al (2003). According to Horst and Haerdter (1994), yield decline in maize production might also be due to allelopathic[16] effects.

[15] This output is mainly used by the household either as fuel wood, posts for house construction or simply left on the farm to rot

[16] Allelopathy refers to the beneficial or harmful effects of one plant on another plant, both crop and weed species, by the release of chemicals from plant parts by leaching, root exudation, volatilization, residue decomposition and other processes in both natural and agricultural systems (Rizvi, et al. [1999])

Table 5.23: Expected maize yields rate of decline over a 25-year rotation period in the study area

Year	Yield (bags/ha)	Expected rate of yield decline (%)	Year	Yield (bags/ha)	Expected rate of yield decline (%)
0	25	100.0	11	18.5	-26.0
1	22	-12.0	16	25	100.0
2	20	-20.0	17	22	-12.0
3	18.5	-26.0	18	20	-20.0
8	25	100.0	19	18.5	-26.0
9	22	-12.0	24	25	100.0
10	20	-20.0	25	22	-12.0

Source: Field Survey, 2006

Table 5.24: Expected plantain yields rate of decline over a 25-year rotation period in the study area

Year	Yield (bunches/ha)	Expected rate of yield decline (%)	Year	Yield (bunches/ha)	Expected rate of yield decline (%)
1	750	100.0	12	150	-77.0
2	550	-26.7	17	500	100.0
3	450	-40.0	18	300	-40.0
4	200	-73.3	19	200	-60.0
9	650	100.0	20	100	-80.0
10	500	-23.1	25	350	100.0
11	350	-46.1	-	-	-

Source: Field Survey, 2006

An optimistic price scenario (i.e. the highest price paid by buyers in 2006) was used as the standard to calculate the financial returns from the three land-use options. It was assumed that maize and plantain are continuously cultivated for four years and the land left to fallow for three years to regain fertility. The financial analysis uses a discount rate of 12.6% to calculate the present worth of each of the options. This percentage represents the standard interest charged by the Agricultural Development Bank (ADB) in Ghana for forestry and agricultural projects. It is presumed that if the calculated returns is greater than the interest rate charged by the bank, then the investment is financially viable and vice versa.

The results from the financial analysis showed positive NPV for all the land-use options at a discount rate of 12.6%. Table 5.25 presents a summary of the financial analysis (see Appendix 5, 8, and 11 for detailed information). The establishment of farm forest teak plantation inter-cropped with maize and plantain produced the best financial outcome with an NPV of $962.2 at 12.6% discount rate. Food crop production was the second most profitable land-use option with an NPV of $520.5. Pure teak plantation generated the lowest NPV ($53.2) and therefore represents the least profitable option. The NPV of teak plantation inter-cropped with maize and plantain is $909 higher than that of pure teak plantation and $441.7 higher than maize-plantain cultivation over a 25-year rotation period at 12.6% discount rate (see Table 5.25). The above result is a strong indication that households in the study area stand to gain more economic

benefits from farm forest teak plantation by integrating food crops into the plantation instead of the exclusive establishment of teak plantation. The inter-cropping of food crops will enable the households to earn income at the early stages of the plantation while waiting for the trees to mature. The profitability of establishing farm forest teak plantation is expected to increase in the future with the growing urban demand for forest products.

Table 5.25: Comparative financial analysis of returns from pure teak plantation, teak plantation inter-cropped with maize and plantain and, maize-plantain cultivation over a 25-year rotation

Land-use alternative	Net Present Value at 12.6% ($)	Net Present Value at 16.0% ($)	Net Present Value at 18.0% ($)
Pure Teak Plantation	53.2	-395.6	-503.4
Teak + Maize + Plantain	962.2	450.5	316.5
Food Crop Production (Maize + Plantain)	520.5	455.0	426.5

Source: Calculations based on field data, 2006

A sensitivity analysis conducted to assess the effect of variations in the discount rate on the profitability of farm forest plantation establishment revealed that an increase in the discount rate from 12.6% to 18.0% renders the NPV for pure teak plantation negative ($-503.4). This shows that establishing pure teak plantation at this discount rate will not be profitable. On the other hand, the NPV values for the establishment of teak plantation inter-cropped with maize and plantain remained positive but reduced from $962.2 to $316.5, representing a 67.1% reduction (see Table 5.25). In the same way, an increase in the discount rate to 18.0% reduced the NPV for food crop production from $520.5 to $426.5 (a decrease of 18.0%). The above results show that an increase in the discount rate will significantly reduce the returns for all the three land-use options analyzed.

The cash flow from farm forest teak plantation inter-cropped with food crops and food crop production shows positive returns in year one, after harvesting the food crops (see Table 5.26, 5.27 and 5.28 for a summary of cash flow from the three land-use options (Appendix 4, 7 and 10 shows details of benefits from the three options). This is important for the households due to the need to satisfy immediate household financial needs. Positive returns for pure teak plantation on the other hand, occur 10 years after establishment. This can create financial problems for cash-constrained households who have to wait all these years to reap the benefits from such land-use option. For this reason, it is anticipated that economic necessity will induce more cash-constrained households, whose objective is to maximize land productivity with scarce labor and capital, to embrace establishment of farm forest plantation inter-cropped with food crops in the near future to supplement their income.

Table 5.26: Cash flow from one hectare pure teak plantation over a 25-year rotation period in the study area

Item Description	Year													
	0	1	2	3	4	5	6	7	8	9	10	15	20	25
Costs (expenditure)	($)													
Labor	431.2	140.8	132	132	132	264	66	66	66	66	154			
Planting Materials	84	18												
Transportation	24	6												
Sum of expenditures	***539.2***	***164.8***	***132***	***132***	***132***	***264***	***66***	***66***	***66***	***66***	***154***	***0***	***0***	***0***
Revenues (receipts)														
Sale of teak products											1,140	2,280	3,260	5,700
Sum of receipts	***0.0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***0***	***1,140***	***2,280***	***3,260***	***5,700***
Net cash flow	-539.2	-164.8	-132	-132	-132	-264	-66	-66	-66	-66	986	2,280	3,260	5,700

Source: Calculations based on field data, 2006

Table 5.27: Cash flow from one hectare teak plantation inter-cropped with maize and plantain over a 25-year rotation period in the study area

Item Description	Year													
	0	1	2	3	4	5	6	7	8	9	10	15	20	25
Costs (expenditure)	($)													
Labor	794.2	503.8	473	458	147	264	66	66	66	66	154			
Planting Materials	359	201.4	171	159										
Transportation	211.5	175.4	144	110	30									
Sum of expenditures	***1,364.7***	***880.6***	***788***	***727***	***177***	***264***	***66***	***66***	***66***	***66***	***154***	***0***	***0***	***0***
Revenues (receipts)														
Sale of food crop	542.5	1,117.4	994	801.5	240									
Sale of teak products											1,140	2,280	3,260	5,700
Sum of receipts	***542.5***	***1,117.4***	***994***	***801.5***	***240***	***0***	***0***	***0***	***0***	***0***	***1,140***	***2280***	***3260***	***5,700***
Net cash flow	-822.2	236.8	206	74.5	62.6	-264	-66	-66	-66	-66	986	2,280	3,260	5,700

Source: Calculations based on field data, 2006

Table 5.28: Cash flow from one hectare maize-plantain cultivation over a 25-year rotation period in the study area

Item Description	Year								
	0	1	2	3	4	8	9	10	11
Costs (expenditure)	($)								
Labor	816.2	682	605	572	77	816.2	594	528	495
Planting Materials	455	223.4	191	169.4		455	223.4	191	169.4
Transportation	367.5	279.4	194	160	40	367.5	279.4	194	160
Sum of expenditures	***1,638.7***	***1,184.8***	***990***	***901.4***	***117***	***1,638.7***	***1,096.8***	***913***	***824.4***
Revenues (receipts)									
Sale of maize	542.5	477.4	434	401.5		542.5	477.4	434	401.5
Sale of plantain		1,200	880	720	320		1,040	800	560
Sum of receipts	***542.5***	***1,677.4***	***1,314***	***1,121.5***	***320***	***542.5***	***1,517.4***	***1,234***	***961.5***
Net cash flow	-1,096.2	492.6	324	220.1	203	-1096.2	420.6	321	137.1
Costs (expenditure)		12	16	17	18	19	20	24	25
Labor		149.6	816.2	594	528	495	149.6	816.2	594
Planting Materials			455	223.4	191	169.4		455	223.4
Transportation		40	367.5	279.4	194	160	40	367.5	279.4
Sum of expenditures		***189.6***	***1,638.7***	***1,096.8***	***913***	***824.4***	***189.6***	***1,638.7***	***1,096.8***
Revenues (receipts)									
Sale of maize			542.5	477.4	434	401.5		542.5	477.4
Sale of plantain		240		800	480	320	160		560
Sum of receipts		***240***	***542.5***	***1,277.4***	***914***	***721.5***	***160.0***	***542.5***	***1,037.4***
Net cash flow		50.4	-1,096.2	180.6	1.0	-102.9	-29.6	-1,096.2	-59.4

Source: Calculations based on field data, 2006

5.6 Summary

This Chapter painted a detailed picture of the socio-economic characteristics of the study households. A number of key conclusions can be made from the results and discussions presented in this Chapter. First, the analysis highlights variations between the study households in terms of their personal-demographic characteristics. The analysis shows that study households with farm forest plantation are headed by older people who have attained higher education. Their household size is also large with less infants and children. In contrast, most farm households without farm forest plantation have younger household heads, with low levels of educational attainment. Similarly, these households are characterized by small household size with more infants and children. These differences have implications on the ability of the households to undertake various economic activities.

Second, the results point to differences in resource endowments underpinning the economic activities undertaken by the households. The results show that the households pursue diverse income generating activities through a careful allocation of limited productive assets, including land and labor. As pointed out by Barrett et al. (2001), diversification patterns of individual's reflect their voluntary exchange of assets and their allocation of assets across various activities so as to achieve an optimal balance between expected returns and risk exposure conditional on the constraints they face. Focusing on the inter-connections between resource endowments and the economic activities undertaken by the individual households, the study found that household landholding and labor supply are important factors shaping livelihood diversification strategies.

Disparities in household landholding and labor force translated into the size of land allocated to various food crops such as maize, plantain, yam and cassava. Households with access to large land and labor force utilized these resources to ensure the socio-economic sustainability of the household's well-being compared to those with small land and labor force. In general, households with farm forest plantation assigned large farm area for the cultivation of maize, plantain and yam, and are able to meet a greater proportion of their food needs compared to those without farm forest plantation. The household's ownership of livestock including sheep, pigs and poultry did not vary among them. Variations were however found in terms of the number of goats owned with households with farm forest plantation possessing more goats than those without farm forest plantation. Animals are raised mainly for household consumption but can sometimes be sold to generate income. The participation of households in off-farm activities is not significant for most of the households due to the limited off-farm income-generating opportunities in the study area. More households without farm forest plantation were involved in

the few off-farm activities (mainly casual farm labor) to earn income. The above results confirm the observations made by participants at the focus group discussion.

Third, the results underscored the importance of farm forest plantation as a viable land-use option for the households. This has been shown through the results of the comparative financial analysis which showed farm forest plantation inter-cropped with food crops as the most profitable compared to pure teak plantation and maize-plantain cultivation. It is not surprising that although the establishment of farm forest plantation is relatively new to most of the study households, it has become an important income diversification activity for the households. It is anticipated that more households will adopt farm forest plantation into their farming systems as they realize its contribution to household's income and the potential to lower income risks by reducing vulnerability to fluctuating agricultural output prices. In sum, the understanding of variations in farm household's characteristics, resource endowments and the range of economic activities carried out by the households will assist to understand their decision to use their agricultural land to establish forest plantation.

CHAPTER 6

DRIVING FORCES INFLUENCING FARM HOUSEHOLD'S DECISION TO ESTABLISH FARM FOREST PLANTATION

6.1 Analytical modeling of farm household's decision to establish farm forest plantation

A number of factors act directly or indirectly to influence a farm household's decision to establish farm forest plantation. These factors can either be internal or external to the farm household. A variety of statistical techniques such as ordinary least squares (OLS), discriminant analysis, multiple regression analysis and logistic regression analysis can be used to estimate the outcome of binary or dichotomous response variables. However, a function form of choice probabilities and logistic regression models are applied in the present study to analyze the underlying driving forces influencing the farm household's decision to establish farm forest plantation. Hosmar and Lemeshow (1989) consider logistic regression model as the most efficient model to evaluate household's decision-making. In the view of Norusis (1993), the use of logistic regression allows direct estimation of the probability of an event occurring. Hosmer and Lemeshow (1989) also advocate logistic regression model as an alternative multivariate statistical technique for estimating the probability that an event occurs or not. Train (1990) and Aldrich and Nelson (1984) indicated that the use of choice probabilities and logistic regression models represent by far the most developed and widely adopted non-linear models. The advantage of using logistic regression is that it requires far fewer assumptions than, for example, discriminant analysis; and even when the assumptions required for discriminant analysis are satisfied, logistic regression still performs well (Hosmer and Lemeshow, 1989).

What distinguishes a logistic regression model from a linear regression model is that the outcome variable in logistic regression is binary or dichotomous (Hosmer and Lemeshow, 1989). This difference is reflected both in the choice of a parametric model and in the assumptions. Using multiple regression or discriminant analysis to evaluate farm household's decision-making can be problematic when a dependent variable has only two values to determine whether an event will occur or not. In this case the assumptions necessary for hypothesis testing in regression analysis are necessarily violated. Another difficulty with multiple regression analysis is that predicted values cannot be interpreted as probabilities. They are not constrained to fall in the interval between zero and one. As pointed out by Norusis (1992), linear discriminant analysis does allow direct prediction of group membership, but the assumptions of multivariate normality of the independent variables, as well as equal variance-covariance matrices in the two groups, is required for the prediction rule to be optimal.

According to Norusis (1992), the logistic regression model for the case of a single independent variable or the probability that an event occurs (for instance, that a farm household will establish farm forest plantation) can be expressed as:

$$Prob_{(event)} = \frac{e^{\beta_0+\beta_1 Xi}}{1+e^{\beta_0+\beta_1 Xi}} = \frac{e^{Z}}{1+e^{Z}} = \frac{1}{1+e^{-Z}} \quad \text{.....[2]}$$

Where $Z =$ the linear combination, $Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + ... + \beta_i X_i$, and represents log of the odds called a logit; $Prob_{(event)}$ ranges from 0 to 1, given explanatory variable X_1; $X_i =$ set of possible independent explanatory variables; $\beta_0 =$ the intercept representing the value of the log-odds in favor of the event if explanatory variables are zero; $\beta_i =$ stands for the coefficients estimated from the data (slope). The slope measures the rate at which log-odds in favor of smallholder farm forest plantation management change with a unit change in explanatory variables.

Conversely, the probability that an event does not occur (for example, that a household will not establish farm forest plantation) can be given as 1- $Prob_{(event)}$ and expressed as:

$$1\text{-}\ Prob_{(event)} = 1 - \frac{1}{1+e^{-(Z)}} = \frac{e^{-Z}}{1+e^{-Z}} = \frac{1}{1+e^{-Z}} \quad \text{.....[3]}$$

The estimation form of the logistic transformation of the probability that a household will establish farm forest plantation to the probability that it will not establish farm forest plantation is expressed by the function:

$$1n\left(\frac{\Pr ob_{(event)}}{1-\Pr ob_{(event)}}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + ... + \beta_i X_i \quad \text{.....[4]}$$

6.2 Empirical model employed to analyze the driving forces influencing farm household's decision to establish farm forest plantation

According to innovation adoption theorists (e.g. Spence, 1994 and Rogers, 1995) and theories describing the process leading to the development of sustainable land management practices, before people adopt new practices, they must first develop an awareness of the need for the practice. A decision is made following this awareness concerning whether the practice is suitable for them. In practical terms, since forest plantation establishment and management is a long-term economic activity requiring substantial investments, farm household's decision to establish farm forest plantation has to be analyzed by taking into account both endogenous and exogenous

factors that are likely to influence the decision-making process. In this regard, a set of factors relating to the endogenous characteristics of the study households vis-à-vis those regarded as exogenous to the households were assumed to affect the decision of the households to establish farm forest plantation. Figure 6.1 shows the interrelationships between factors assumed to influence farm household's decision-making process to establish farm forest plantation.

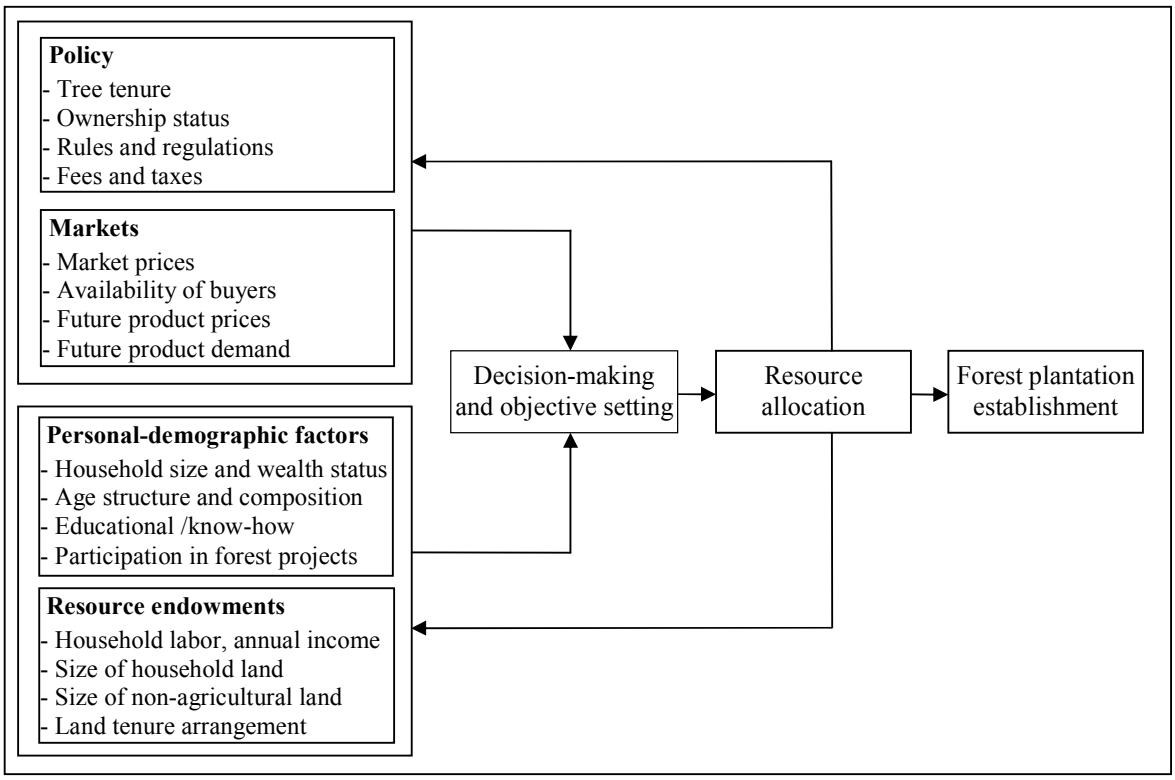


Figure 6.1: Interrelationships between factors affecting the decision to establish farm forest plantation
Source: Researcher's own derivation

The logistic regression model employed assesses the relationship between a number of endogenous and exogenous factors and their influence on farm household's decision to establish farm forest plantation (see Chapter One, Section 1.5 and Table 6.1 for an overview of the various explanatory variables included in the logistic regression model employed in the present study). A number of the variables included in the model have been documented in the past as factors that affect farmer's decision to adopt agroforestry-based technologies (e.g. Thangata and Alavalapati, 2003; Ajayi et al., 2003; Franzel and Scherr, 2002; Gladwin et al., 2002; Kuntashula et al., 2002 and Place et al., 2002).

Table 6.1: Description of variables included in the logistic regression model

Variable Label	Variable Name and Value Label	Type of Variable
Variables used to define household's personal-demographic and resource endowments characteristics		
HHWeaStat	Wealth status of household (1 = better-off ; 0 = otherwise)	Ordinal, categorical
HHSize	Household size	Continuous
HHLabor	Household own labor (man-equivalent)	Continuous
Edu	Household head number of years of formal education	Continuous
Age	Household head age in years	Continuous
PartForProj	Participation in past forest plantation development projects (1= yes; 0 = otherwise)	Dichotomous
LandTenure	Dummy variable for type of land tenure (1 = permanent; 0 = otherwise)	Dichotomous
TotHHLand	Total size of household landholding (ha)	Continuous
NonAgLand	Availability of household land not suitable for agriculture (land quality) (1= yes; 0 = otherwise)	Dichotomous
Variables used to define market and policy related factors		
ForProdMkt	Availability of market for farm forest products (1 = yes; 0 = otherwise)	Dichotomous
ForProdBuyer	Availability of buyers for farm forest products (1 = yes; 0 = otherwise)	Dichotomous
ForProdPrice	Level of satisfaction with current market prices for farm forest products (1 = satisfied; 0 = otherwise)	Dichotomous
FuDD	Perception of future demand for forest plantation products (1 = decrease; 2 = increase)	Dichotomous
FuPrice	Perception of future market prices for forest products (1= decrease; 2 = increase)	Dichotomous
AwareForPol	Level of awareness of change in policy regarding ownership of trees planted on private lands (1 = very much aware; 0 = otherwise)	Dichotomous
FreedHarTrans	Level of freedom to harvest and transport trees planted on private lands (1 = high level of freedom; 0 = otherwise)	Dichotomous
InfForPol	Level of influence of changes in forest policy on decision to establish smallholder farm forest plantation (1 = high influence; 0 = otherwise)	Dichotomous

Source: Field Survey, 2006

The estimated empirical model employed in the study is presented in equation 5 and 6. The influence of personal-demographic factors and resource endowments (i.e. endogenous factors) on farm household's decision to establish farm forest plantation is analyzed using the empirical model presented in equation [5] while the influence of market and policy related factors (i.e. exogenous factors) on the household's decision to establish farm forest plantation is analyzed with the empirical model presented in equation [6].

$$Y_i = \alpha + \beta_1 HHWeaStat + \beta_2 HHSize + \beta_3 HHLabor + \beta_4 Edu + \beta_5 Age + \beta_6 PartFor\,\mathrm{Pr}\,oj + \beta_7 LandTenure + \beta_8 NonAgLand + \varepsilon \quad \text{.....[5]}$$

$$Y_i = \alpha + \beta_1 For\,\mathrm{Pr}\,odMkt + \beta_2 For\,\mathrm{Pr}\,odBuyer + \beta_3 For\,\mathrm{Pr}\,od\,\mathrm{Pr}\,ice + \beta_4 FuDD + \beta_5 Fu\,\mathrm{Pr}\,ice + \beta_6 AwareForPol + \beta_7 FreedHarTrans + \beta_8 InfForPol + \varepsilon \quad \text{.....[6]}$$

Where Y_i = value of the dependent (dummy) variable on the i^{th} observation; α = constant/intercept; $\beta_i s$ = coefficients of each explanatory variable and ε = error/disturbance term. The explanatory powers of the explanatory variables in the analysis are expressed by the logistic coefficients and their corresponding odd ratios. According to Norusis (1993), the logistic coefficients represent the change in the log odds associated with a unit change in the independent variable. The odds ratios on the other hand, correspond to the odds of the first category of an explanatory variable belonging to the first category of the response variable. The odd ratios therefore offer a direct understandable statistic for the relationship between the response variable and an explanatory variable when all other explanatory variables are held constant.

6.3 Empirical results from logistic regression analysis

6.3.1 Farm household's personal-demographic characteristics and resource endowments and decision to establish farm forest plantation

The findings from the logistic regression analysis using SPSS version 13.0 are shown in Table 6.2. The adequacy of the model employed is justified by the results from multiple indicators including the goodness-of-fit test statistic (Model Chi-Square value = 189.326 at $p<0.001$ significant level) and an overall correct prediction of 83.6%. The model was also able to correctly classify 85.5% of the study households with farm forest plantation at the time of the study and 80.9% of those without farm forest plantation. The Cox and Snell R^2 (1989) index as well as the Nagelkerke R^2 (1991) index suggest that between 49.1% and 66.2% of the variation in the dependent variable is explained by the set of household and farm level variables included in the model. The results from all these indicators clearly show that the model fits well to the data.

6.3.1.1 Farm household's wealth status

By employing a 0.05 criterion of statistical significance, the results show no statistical significance with regard to the wealth status of the study households and their decision to establish farm forest plantation (Table 6.2). The lack of statistical significance could be attributed to the fact that households from all the identified wealth groups are engaged in farm forest plantation establishment. An interaction with people in the study communities revealed that, most people have realized the potential benefits of farm forest plantation to diversify their income activities. This has led to households from different wealth groups to incorporate forest plantation into their current land-use. It can be said that the establishment of farm forest plantation in the study area is not the domain of a specific wealth group(s). This finding is in

contrast with the logical expectation because better-off households are viewed as having control of assets such as labor and capital to diversify their sources of income compared to poor households who often lack the needed labor and capital.

6.3.1.2 Age of the household head

The age of the household head is highly significant in explaining the farm household's decision to establish farm forest plantations (see Table 6.2). The results from the regression analysis show that the log of the odds to establish farm forest plantation is positively related to the age of the household head *($p<0.001$)*. For every one unit increase in the age of the household head, the odds of the household's decision to establish farm forest plantation versus the decision not to establish farm forest plantation increases by a factor of 1.12. The age characteristics of the study household's show that those with farm forest plantation are relatively older than those without farm forest plantation (see Chapter 5, Table 5.3). A close examination of the study area in terms of the economic activities undertaken by younger and relatively older people provides insights for this result. The relatively older people tend to engage in economic activities that have long-term asset accumulation potentials for instance, oil palm plantation, cashew plantation, etc. Their objective is to leave the trees as property for family members and improve upon the micro-climate in the area. This is contrary to younger household heads who are more interested in short-term benefits.

Table 6.2: Results of logistic regression analysis showing the influence of household's personal-demographic characteristics and resource endowments on decision to establish farm forest plantation

Explanatory Variables	Coefficients	Std. Error	Wald Statistic	Significance	Odds Ratio
Household Wealth status	0.868	0.530	2.687	0.101	2.382
Age of household head (years)	0.109	0.027	15.955	0.000***	1.115
Household head number of years of education	0.137	0.046	8.720	0.003***	1.147
Household size	0.160	0.076	4.441	0.035**	1.173
Household own labor (man-equivalent)	0.317	0.111	8.130	0.004***	1.373
Participation forest plantation development projects in the past	1.970	0.405	23.688	0.000***	7.169
Total size of household landholding (ha)	0.096	0.039	6.229	0.013**	1.101
Ownership status of household landholding	1.006	0.414	5.903	0.015**	2.735
Size of household land not suitable for agriculture	2.764	0.436	40.219	0.000***	15.858
Constant	-11.191	1.702	43.224	0.000***	
Model Chi-Square = 189.326***					
Overall Correct Prediction = 83.6%					
Cox and Snell $R^2 = 0.491$; Nagelkerke $R^2 = 0.662$					

Note: *,**, and *** indicate statistical significance at 0.05, 0.01, and 0.001 levels

Source: Calculations based on data from field survey, 2006

6.3.1.3 Household size and labor force

Household labor represents an important factor in the production activities of households. Due to the imperfect labor markets existing in rural areas, the abundance or scarcity of household labor can be a key asset endowment for the household. The availability of labor is often cited as a constraint to agroforestry adoption (e.g. Current et al., 1995). Hence, lack of household labor force will prevent farm households from engaging in long-term economic activities such as forest plantation development. This view is supported by the findings from the logistic regression analysis which show that every one unit increase in household labor force increases the odds of a farm household's decision to establish farm forest plantation versus the decision not to establish farm forest plantation by a factor of 1.37. It is not surprising that farm households with farm forest plantation in the study area have more household labor force than those without farm forest plantation due to the presence of high adult family members (see Chapter 5). The small household size and the presence of a high number of infants and children among farm households without farm forest plantation means that they lack the needed labor force to manage forest plantation especially after the trees have been established. Infants and children under the age of seven are considered as a net user of labor since they contribute nothing to the total labor force but uses up about 0.25 man-day of the mother's time. This means that the presence of a high number of infants and children takes away household labor required to perform other economic activities.

6.3.1.4 Educational attainment of the household head and participation in past forest plantation development projects

The results from the regression analysis show that the educational attainment of the household head has a high predictive power in determining the decision to establish farm forest plantation *($p<0.001$)*. An additional year invested in education increases the odds of the household to establish farm forest plantation by a factor of 1.15. Farm households with young heads were expected to have relatively higher educational attainment and therefore more aware of the potential benefits from farm forest plantation. This was assumed to serve as incentive to integrate trees into their farm lands. The results however show that households with younger heads and without farm forest plantation are not necessarily highly educated. They instead have low educational status relative to households with relatively older heads and owns farm forest plantation. The higher educational attainment of household heads with farm forest plantation could be inferred to translate into their decision to establish farm forest plantation.

The regression analysis further shows that the decision to establish farm forest plantation is positively related to the participation of the household head or any member of the household in forest plantation development project in the past *($p<0.001$)*. The odds of a farm household's decision to establish farm forest plantation increases by a factor of 7.17 if the household head or any member of the household has participated in forest plantation development projects in the past (see Table 6.2). Household heads who indicated that they and/or a member of the household have participated in forest plantation development projects in the past were more likely to have established farm forest plantation compared to households where no member of the family participated in forest plantation development projects. As pointed out by Ghadim and Pannell (1999), learning over time can be a significant factor in agroforestry adoption. Majority of the study households currently with farm forest plantation indicated having taken part in the government initiated Taungya forest plantation development program in the 1970s as well as the National Forest Plantation Development Program launched in 2001. It could be said that the participation in these programs have facilitated the acquisition of knowledge and skills in forest plantation development and also been informed about the potential benefits and contribution of forest plantation to their livelihood. The above results show that a higher level of educational attainment and know-how in forest plantation management are important decisive factors in farm forest plantation establishment decision-making process for the study households.

6.3.1.5 Size of household landholding and land tenure arrangement

The size of household land represents an important household asset endowment which facilitates the production activities of farm households. Hence, if all other factors are kept constant, the likelihood of a farm household to use part of his/her land to establish forest plantation will decrease if the household does not have enough land to produce food to feed the family compared to a household that possesses large landholding. The results from the regression analysis show that the size of household's landholding increases the probability of establishing farm forest plantation. An independent–samples t-test conducted to compare farm households with and without farm forest plantation in relation to the size of household's landholding showed significant differences *[$t(278)=4.15$, $p=0.000$]*. On the average, study households that have established farm forest plantation possessed larger landholding (Mean=9.11 ha) compared to those without farm forest plantation (Mean=5.35 ha) (Chapter 5, Table 5.7). This result highlights the important role the size of household landholding plays in the decision to establish farm forest plantation.

An assessment of land tenure in the study communities shows that most households own either permanent land (usually through family inheritance and outright purchase) or manage temporary land through share-cropping or renting. The regression analysis shows that the odds of a household deciding to establish farm forest plantation versus the decision not to establish farm forest plantation increases by a factor of 2.74 with the possession of permanent and secured land tenure. The conversion of land into forestry by share-croppers and land renters is seen in Ghana, as in other parts of the world, as a long-term appropriation of the land. Hence, share-croppers and land renters may be, in most cases, prevented by landowners from using such lands to establish permanent tree crops such as forest plantation. Share-croppers or land renters who establish forest plantation on share-cropped or rented lands without the consent of the land owner, risk losing such plantation through the expropriation of the land by the land owner. The establishment of forest plantation is therefore mostly done on lands either purchased outright or acquired through family lineage. Most households with farm forest plantation own family lands while those without farm forest plantation rent/lease land or acquire land through share-cropping. This is not surprising, since most farm households with farm forest plantation have secured land rights compared to those without farm forest plantation. The above results are in line with the assertion of Francis (1987), who indicated that the patterns of technology adoption will be shaped by the structure of opportunities and constraints presented by the rules of tenure. Raintree (1991) also found that if a farmer does not have security over the land, adoption of tree planting innovation may not occur. The possession of permanent and secured land is therefore important to increase the likelihood of a farm household to establish farm forest plantation.

6.3.1.6 Availability of household land not suitable for agriculture

The analysis show a highly statistical significant relationship between the availability of household land considered unsuitable for agriculture and the decision to establish farm forest plantation *($p<0.001$)*. The availability of non-agricultural land therefore increases the household's propensity to establish farm forest plantation on their land. This assertion is confirmed by the high percentage of households with farm forest plantation (77.6%) who reported that they possess land not suitable for agriculture. Only 13.9% of households without farm forest plantation indicated possessing such land (Table 6.3). This finding is an indication that most households use land with poor quality to establish their plantation while reserving productive lands for agricultural purposes.

Table 6.3: Ownership of farm forest plantation and distribution of study households by size of landholding not suitable for agriculture

Availability of land not suitable for agriculture	Households with forest plantation (n=165)		Households without forest plantation (n=115)		Total (Frequency)	Total (%)
	Frequency	%	Frequency	%		
No	37	22.4	99	86.1	136	48.6
Yes	128	77.6	16	13.9	144	51.4
All household categories (n=280)	165	100.0	115	100.0	280	100.0

Source: Field Survey, 2006

6.3.2 Influence of markets and policy related factors and farm household's decision to establish farm forest plantation

6.3.2.1 Overview

The economic and policy frame conditions under which farm households operate can provide incentive or serve as disincentive to carry out economic activities. It is therefore imperative to assess the influence of market and policy related factors on farm household's decision to establish farm forest plantation. Table 6.4 summarizes the results from the logistic regression analysis assessing the above factors. The predictive power of the empirical model is substantiated by the results from multiple indicators. For instance, the model had an overall correct prediction rate of 81.8% and also correctly classified 84.2% of farm households with farm forest plantation at the time of the study and 78.3% of those without farm forest plantation. In addition, the model Chi-Square value of 153.553 at $p<0.001$ significant level is an indication that the model is meaningful according to the dependent variable in relation to each specified independent variable. The Cox and Snell R^2 (1989) index of 0.422 and a high Nagelkerke R^2 (1991) index of 0.569 are further confirmation of the predictive strength of the model.

6.3.2.2 Market related factors and farm household's decision to establish farm forest plantation

Among the market related factors assessed in the study, the availability of market and buyers for farm forest products and the farm household's satisfaction with current market prices for farm forest products positively influenced their decision to establish farm forest plantation (see Table 6.4). An increase in the availability of market for farm forest products significantly increased the odds of the household's decision to use land to plant trees versus the decision not to plant trees by a factor of 11.38 while for each one unit increase in the number of buyers increased such odds by a factor of 7.98. Furthermore, the probability of a farm household to establish farm forest plantation is increased by a factor of 10.03 for every one unit increase in the level of satisfaction with current market prices for farm forest products (see Table 6.4). These results are in

congruence with the observation of Hedge (1990), who deduced from his studies that the most important incentive for farmers to grow any new tree species, depend among other factors, on assured demand for the produce, market outlets, minimum market price at which tree growing is profitable and the generation of cash surplus.

Table 6.4: Results of logistic regression analysis showing the influence of market and policy related factors on household's decision to establish farm forest plantation

Explanatory Variables	Logistic Coefficients	Std. Error	Wald Statistic	Significance	Odds Ratio
Availability of market for farm forest products	2.432	0.366	44.057	0.000***	11.381
Availability of buyers for forest plantation products	2.079	0.412	25.480	0.000***	7.997
Level of satisfaction with current market prices for farm forest products	2.305	0.414	31.070	0.000***	10.026
Perception about future demand for farm forest products	0.209	0.369	0.319	0.572	1.232
Perception about future market prices for farm forest products	0.083	0.382	0.047	0.829	1.086
Level of awareness of changes in policy regarding ownership of planted trees	0.233	0.349	0.445	0.505	1.262
Level of freedom to harvest and transport trees planted on private lands	-1.038	0.397	6.853	0.009**	0.354
Extent of influence of changes in forest policy on decision to establish smallholder farm forest plantation	0.456	0.366	1.556	0.212	1.579
Constant	-3.050	0.511	35.690	0.000***	
Model Chi-Square = 153.553***					
Overall Correct Prediction = 81.8%					
Cox & Snell R^2 = 0.422; Nagelkerke R^2 = 0.569					

Note: *,**, and *** represent statistical significance at 0.05, 0.01, and 0.001 levels

Source: Calculations based on data from field survey, 2006

The improvement in market access and the increase in the number of buyers in the area have been attributed to the liberalization of the local timber market after the implementation of the Economic Recovery Program (ERP) and Structural Adjustment Program (SAP) in 1981. The economy is much better integrated into the global economy in contrast to the pre-economic recovery period. An important aspect of the austerity measures was the deregulation of previously government-controlled trade and industry, and thereby facilitating the active participation of the private sector in many economic activities (e.g. marketing of goods and provision of services). For most of the study households, the impetus to use their land to establish forest plantation has been significantly influenced by these factors. Contrary to the above findings, the perceived future demand and future market prices for timber failed to show any statistical significant difference. It can be concluded that in terms of the market related

factors, the study households places more emphasis on the availability of market and buyers for farm forest products and current market prices when deciding to establish farm forest plantation.

6.3.2.3 Policy related factors and farm household's decision to establish farm forest plantation

Results from the logistic regression analysis show no relationship between the household's decision to establish farm forest plantation and their level of awareness of changes in policy regarding ownership of trees planted on private lands as well as the cumulative impact of the policy changes. This is an indication that the households continue to view forest plantation establishment as an insecure venture due to the impact of past policies that entrusted all trees in the country to the state. The findings further indicate that the farm household's decision to establish farm forest plantation is negatively influenced by their perception about the level of freedom to harvest trees and transport timber from their private lands. Thus prohibitive rules and regulations relating to the harvesting of trees and transportation of timber increased the odds of farm household's decision not to establish farm forest plantation versus the decision to establish farm forest plantation by a factor of 0.35 (see Table 6.4). These regulatory measures tend to force the household's to depend on intermediaries to sell their farm forest products due to the cumbersome and costly bureaucratic procedures they have to go through to obtain permits to harvest and transport their farm forest products.

Historically, the right to harvest timber has been controlled by the Forestry Department in an attempt to prevent illegal harvesting of timber. The Trees and Timber Decree, 1974 (NRCD 273) requires the registration of a property mark for the exploitation of timber from either on-reserve or off-reserve forests. This policy has however been reviewed with the introduction of the Timber Resources Management Act, 1998 (Act 547). Section 4(2) Act 547 accords the ownership of planted trees to the owner. However, the results from the study show that most of the farm households feel that the new Act does not explicitly separate planted trees from the legal controls afforded to naturally growing trees (e.g. the requirement of a Timber Utilization Contracts (TUCs) and a Registered Property Mark) to harvest trees. Act 547 does not allow private holding of TUCs. Therefore permission is required from a plantation owner for the issue of a TUC which does not make it explicitly clear whether a TUC can be issued to the plantation owner himself (Odoom, 1998). For the study households, this uncertainty in tree tenure is seen as a source of insecurity to establish forest plantation on their land.

6.4 Summary

The purpose of this Chapter was to analyze the socio-economic, market and policy related factors influencing farm household's decision to establish farm forest plantation in the study area. Using logistic regression model, the study provides evidence to show that farm household's decision to establish farm forest plantation is positively and negatively influenced by various endogenous and exogenous factors. In terms of the endogenous factors, the results show that, households with older heads have a greater propensity to use their land to establish forest plantation than those with younger heads. A significantly higher number of the study households with farm forest plantation reported being headed by someone with higher level of education, having large household size (but with fewer infants and children), higher household labor force and a higher level of know-how in forest plantation development. The results further show that households with farm forest plantation tend to have large, permanent and secure landholding and possess land not suitable for agricultural purposes. The wealth status of the household failed to show any relationship with the decision to establish farm forest plantation. The opposite of the above results is true for households without farm forest plantation. These findings validate the research hypothesis that the *"socio-economic characteristics of the farm households (i.e. personal-demographic situation, resource endowments, etc.) determine their propensity to establish farm forest plantation"*.

The results from the market related factors included in the regression analysis show that the availability of market for farm forest products, increase in the number of buyers and households satisfaction with market prices for farm forest products are good predictors of the study household's decision to establish farm forest plantation. This evidence supports the research hypothesis that the *"availability of market and buyers for farm forest products has positively influenced farm household's decision to establish farm forest plantation"*. On the contrary, the uncertainty in tree tenure and prohibitive rules and regulations regarding the harvesting of trees and transportation of timber has negatively influenced the study household's decision to establish farm forest plantation. The hypothesis that "*changes in policy regarding the ownership of trees planted on private lands* vis-à-vis *the right to harvest trees and transport timber has positive influence on farm household's decision to establish farm forest plantation"* is therefore rejected. The various analyses in this Chapter have been able to unpack the underlying driving forces influencing the study household's decision to establish farm forest plantation.

CHAPTER 7

INCOME AND EXPENDITURE PORTFOLIOS OF THE STUDY HOUSEHOLDS

7.1 Composition of farm household's income

Analysis of the study household's income portfolio provided important insight into the financial contribution of the major economic activities to the household's income and livelihood strategies. An important observation made during the data collection was that most of the study households participate in all the major economic activities apart from farm forest plantation establishment. Specialization in any of the activities is uncommon as the households generally grow all types of crops and trees either on the same piece of land or different farm plots and also keep some livestock at home. Figure 7.1 presents a summary of the major economic activities constituting the study household's income. There is the need for caution when interpreting the amount of income generated from the various economic activities due to the sensitive nature of information concerning household income vis-à-vis the difficulty in determining precisely the level of income collected through data from the household survey. Notwithstanding these difficulties, efforts were made to cross-check and verify information on household income from key informants (usually educated family members) and experts in the district.

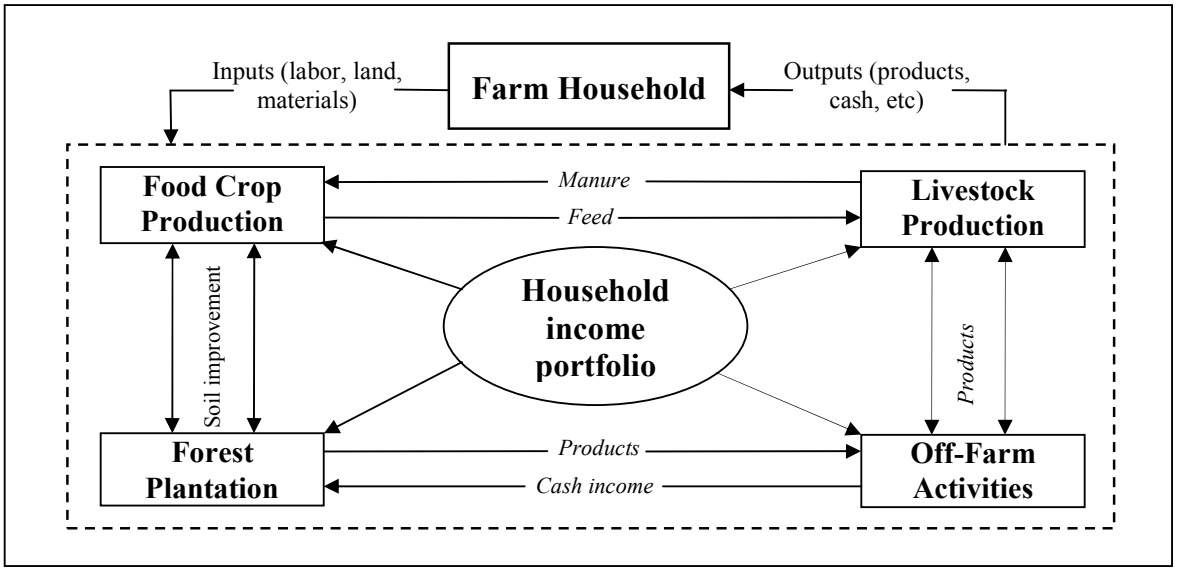


Figure 7.1: Major economic activities constituting the study household's income
Source: Field Survey, 2006

7.2 Income from household's agricultural activities

7.2.1 Income from food crop production

Income from food crop production represents an essential component of household income in the study area. The estimation of household income from crop production under the present study involves cash income generated from the cultivation of food crops such as maize, yam, plantain and cassava during the 2005/2006 agricultural season. Price variations for crops are a common feature in the study area due to lack of standardized market prices and differences in crop quality. Hence, the analysis is based on the average market prices and quantities of crops sold by the households, and calculated in United States Dollar ($). All the study households reported selling various food crops during the 2005/2006 agricultural season. The various food crops that were sold by the households and the income generated is presented in Table 7.1. Results from a two-way between-groups ANOVA conducted to compare households with and without farm forest plantation in terms of the amount of income generated from food crop production showed statistical significant differences between the two household categories *[F(1, 274)=570.43, p=0.000]*. There were however no significant differences between the wealth groups *[F(2, 274)=0.60, p=0.548]*. Study households with farm forest plantation generated the highest crop income earning an average of $1,033.1 per annum compared to those without farm forest plantation which earned an average of $794.4 from food crop production (Table 7.1). The differences in income from crop production between the households show the disparity in landholding and labor force available to the various wealth groups. One important observation from the household survey is that, although the poor households are not able to produce enough food to feed their household, they are compelled in certain circumstances to sell some of the crops they harvest to meet the cash needs of the household. In contrast to the poor households, the better-off and average households are able to produce enough food to feed their household members and therefore ensuring household food security. A proportion of what is harvested is also sold to generate the needed household income.

Table 7.1: Income generated by the study households from food crop production in the 2005/2006 agricultural season

Household category	Major crops cultivated	Area cultivated (ha)	Qty of food crops / area cultivated (ton)	Price per ton ($)	Income / area cultivated ($)	Production costs / area cultivated ($)	Net crop income ($)
Households with forest plantation (n=165)	Maize	1.9	3.2	253.6	803.8	415.2	388.6
	Plantain	0.3	2.6	313.4	821.2	473.9	347.3
	Yam	0.2	2.0	297.8	607.6	347.8	259.7
	Cassava	0.1	1.1	125.8	139.6	102.2	37.4
Mean total income from crop production					*2,372.2*	*1,339.1*	*1,033.1*
Households without forest plantation (n=115)	Maize	1.5	2.5	253.6	623.8	389.1	234.7
	Plantain	0.2	1.8	313.4	573.6	337.0	236.6
	Yam	0.1	1.6	297.8	482.5	202.2	280.3
	Cassava	0.1	1.4	125.8	171.0	128.3	42.8
Mean total income from crop production					*1,850.9*	*1,056.5*	*794.4*

Source: Field Survey, 2006

7.2.2 Income from livestock production

Income from livestock rearing plays an important role for the households since the animals can be sold at any time of the year to supplement household's income. Analysis of the survey results indicated that most of the study households sold various livestock to solve some immediate cash problems, for example, paying children school fees, sudden death of a family member or paying debt. Table 7.2 shows the distribution of farm households that sold various livestock and the average income generated. In general, study households with farm forest plantation earned the highest livestock income compared to those without farm forest plantation. However, a comparison between the two household categories with regard to income from selling livestock showed no statistical significant differences *[F(1, 274)=0.89, p=0.345]* as well as between the wealth groups *[F(2, 274)=0.14, p=0.874]*. Study households with farm forest plantation received an amount of $124.0 while those without farm forest plantation generated an amount of $110.4 from selling various animals during the 2005/2006 season (Table 7.2). The differences between the two household categories with regard to the amount of income generated from livestock is attributed to the higher number of households with farm forest plantation that sold livestock during the 2005/2006 agricultural season as indicated in Table 7.2. Income from livestock rearing is evenly distributed among the wealth groups. Nonetheless, the better-off households generated higher livestock income compared to poor households. This difference could be attributed to the higher number of livestock possessed by the better-off and average households compared to the poor households.

Table 7.2: Income generated by the study households from selling livestock in the 2005/2006 agricultural season

Household category	Wealth groups	Type of livestock sold				Mean income from selling livestock ($)
		Sheep	Goats	Pigs	Chicken	
		Mean income generated per HH ($)				
Households with forest plantation (n=165)	Better-off (n=54)	77.5 (32)	60.5 (25)	7.3 (3)	7.3 (3)	152.6 (63)
	Average (n=56)	57.5 (34)	42.2 (25)	5.1 (3)	13.5 (8)	118.3 (70)
	Poor (n=55)	54.9 (32)	31.0 (18)	0.0 (0)	15.4 (9)	101.3 (59)
Mean total income from selling livestock						*124.0*
Households without forest plantation (n=115)	Better-off (n=30)	51.4 (17)	45.3 (15)	12.1 (4)	9.1 (3)	117.9 (39)
	Average (n=35)	42.7 (18)	57.0 (24)	7.1 (3)	2.4 (1)	109.2 (46)
	Poor (n=50)	45.7 (25)	36.6 (20)	1.8 (1)	20.1 (11)	104.2 (57)
Mean total income from selling livestock						*110.4*

Figures in parenthesis indicate the number of households that sold various livestock during the 2005/2006 agricultural season

Source: Field Survey, 2006

7.2.3 Total household's income from agriculture

Total farm household agricultural income in the context of the present study comprises income from food crop production and livestock rearing. Table 7.3 presents a summary of the total annual household agricultural income for households with and without farm forest plantation. An independent–samples t-test conducted to compare farm household's income from agriculture between the two household categories showed significant differences *[t(277)=2.67, p=0.008]*. Although both household categories generated most of their income from agricultural activities, households currently with farm forest plantation earned relatively more income from agricultural activities during the 2005/2006 agricultural season generating an average of $1,157.1 per household compared to households currently without farm forest plantation who generated an average of $904.8 from agricultural activities (see Table 7.3). Income from food crop production constitutes the highest household's agricultural income for the household contributing 89.3% of total household agricultural income for households with farm forest plantation while those without farm forest plantation generated 87.8% of total household agricultural income from food crop production. On the other hand, income from livestock accounted for 10.7% of total household agricultural income for households with farm forest plantation and 12.2% for those without farm forest plantation (see Table 7.3).

Table 7.3: Total household agricultural income generated by the study households during the 2005/2006 agricultural season

Household category	Agricultural income ($)		Mean total income from agriculture ($)
	Crops	Livestock	
Households with forest plantation (n=165)	1,033.1	124.0	1,157.1
Households without forest plantation (n=115)	794.4	110.4	904.8

Source: Field Survey, 2006

7.3 Income generated from selling farm forest teak products

Study households with farm forest plantation generated income from selling various teak products, namely, telephone poles, low tension electricity poles and high tension electricity poles. A total of 112 households (representing 67.9% of the households) sold farm forest teak products in the 2005/2006 agricultural season. Households that did not sell any product were either waiting for a good market price (52.8%) or their stands were not matured for harvesting (32.1%). The rest of the households were able to generate enough income from other sources. Table 7.4 shows the number of households from each wealth group that sold assortment of farm forest teak products and the average income generated. On the average each household generated $273.6 from selling farm forest teak products. In terms of the wealth groups, the "average" households generated the highest income from selling assortment of teak products (an average of $283.9) whilst the "better-off" households earned $280.4. The "poor" households earned the least income from selling teak products, generating an average of $256.4 (see Table 7.4).

The majority of the households (73.2%) sold telephone poles with 16.1% selling low tension electricity poles while 10.7% sold high tension electricity poles (Table 7.4). The high proportion of households that sold their trees as telephone poles was attributed to the high demand for this product by the telecommunication companies in the country. On the other hand, cash income is limited for most of these households and therefore they are unable to wait for the trees to mature before selling them. Selling the trees as telephone poles has financial implication for the households due to their inability to get optimum value for the tree.

Table 7.4: Distribution of income generated by the study households from selling assortment of teak products during the 2005/2006 agricultural season

Household category	Wealth group	Type of farm forest product sold			Mean income from selling farm forest teak products ($)
		Telephone poles	Low tension electricity poles	High tension electricity poles	
		Mean income generated per HH ($)			
Households with forest plantation (n=165)	Better-off (n=54)	195.4 (25)	49.9 (6)	35.1 (4)	280.4 (35)
	Average (n=56)	197.5 (33)	45.9 (7)	40.5 (5)	283.9 (45)
	Poor (n=55)	197.9 (24)	40.1 (5)	18.4 (3)	256.4 (32)
Mean total income from selling farm forest teak products					273.6

Figures in parenthesis indicate the number of households that sold various farm forest products during the 2005/2006 agricultural season

Source: Field Survey, 2006

7.4 Income generated from off-farm activities

Income from off-farm activity does not play a major role for most of the study households. This is attributed to the few opportunities available to the households to generate income from such activities in the study area. Households in two of the study communities, namely, Anyinasu and Kyekyewere are the most beneficiaries of income from off-farm activities (mainly from operating stores or involved in petty trading) due to the presence of weekly markets in these communities. About 54.0% of households with farm forest plantation participated in off-farm activities while 93.9% of those without farm forest plantation also engaged in various off-farm activities. Results from a multiple comparison between the two household categories showed significant differences in terms of the amount of income received from off-farm activities *[F(1, 274)=30.54, p=0.000]*. The households without farm forest plantation earned a higher proportion of off-farm income generating an average of $179.7 compared to those with farm forest plantation which earned an average of $132.4 (see Table 7.5). In terms of the individual off-farm activities, operating a store or petty trading was considered as the most popular means of earning off-farm income by the households with 44.4% and 48.6% of households with and without farm forest plantation participating in these activities respectively. The second most popular off-farm activity is casual farm laboring. A small percentage of off-farm income was obtained from renting and remittances (see Table 7.5).

Table 7.5: Income generated from off-farm activities during the 2005/2006 agricultural season

Household category	Wealth group	Off-farm activity				Mean off-farm income ($)
		Stores / trading	Renting	Casual farm labor	Remittances	
Households with forest plantation (n=165)	Better-off (n=54)	87.5 (17)	61.8 (12)	0.0 (0)	0.0 (0)	149.3 (29)
	Average (n=56)	47.9 (11)	26.2 (6)	43.6 (10)	8.7 (2)	126.4 (29)
	Poor (n=55)	49.4 (13)	0.0 (0)	57.0 (15)	15.2 (4)	121.6 (32)
Mean total income from off-farm activities						*132.4*
Households without forest plantation (n=115)	Better-off (n=30)	155.2 (20)	46.6 (6)	0.0 (0)	0.0 (0)	201.8 (26)
	Average (n=35)	99.4 (19)	26.2 (5)	52.3 (10)	0.0 (0)	177.9 (34)
	Poor (n=50)	48.8 (15)	0.0 (0)	94.4 (29)	16.2 (5)	159.4 (49)
Mean total income from off-farm activities						*179.7*

Figures in parenthesis indicate the number of households that participated in various off-farm activities during the 2005/2006 agricultural season

Source: Field Survey, 2006

7.5 Total households income

Total household income in the context of this study represents the combined income generated from the main economic activities, namely, income from agriculture (i.e. food crop income and livestock income), income from selling farm forest teak products and income from off-farm activities (e.g. operating a store / petty trading, renting, casual farm laboring and remittances). The composition of total household income varies among the households. In the case of households with farm forest plantation, total household income comprises income from agriculture (i.e. food crops and livestock), income from farm forest products and off-farm activities. For households without farm forest plantation, total household income consists mainly of income from agriculture (i.e. crops and livestock) and off-farm activities as depicted in Figure 7.2.

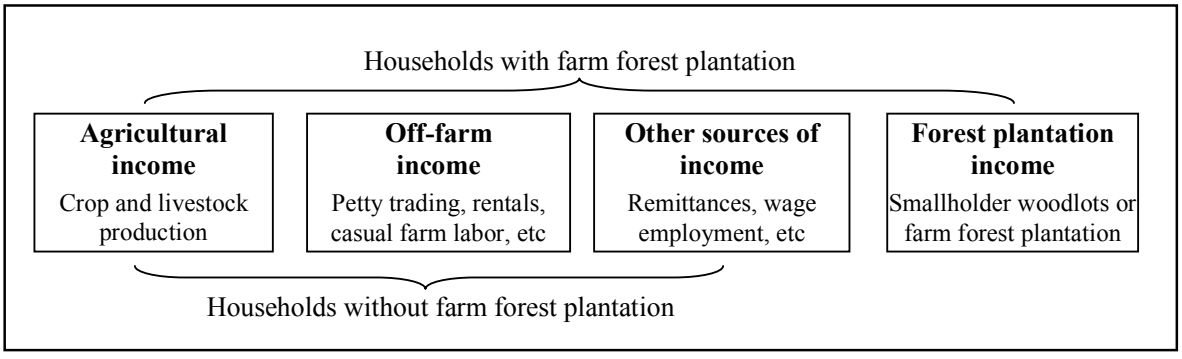


Figure 7.2: Components of total household's income for households with and without farm forest plantation

Source: Field Survey, 2006

A two-way ANOVA tests revealed differences between the study households in terms of the average gross annual income *[F(1, 274)=15.81, p=0.000]*. A multiple comparisons conducted to identify the sources of the difference between the two household categories revealed that households without farm forest plantation have lower average gross annual income compared to those with farm forest plantation (Table 7.6). Households with farm forest plantation generated an average of $1,563.1 per annum. This amount is equivalent to a per capita income of $285.8 for these households. On the other hand, households without farm forest plantation earned an average of $1,084.5 and a per capita income of $244.8 (see Table 7.6).

Table 7.6: Components of total household income for households with and without farm forest plantation

Household category	Components of household income				Household income / annum ($)
	Income from agriculture ($)		Income from off-farm activities ($)	Income from selling farm forest products ($)	
	Crops	Livestock			
Households with forest plantation (n=165)	1,033.1	124.0	132.4	273.6	1,563.1
Households without forest plantation (n=115	794.4	110.4	179.7	0.0	1,084.5

Source: Field Survey, 2006

7.6 Contribution of income from agriculture and off-farm activities to household's income and livelihood strategies

Agriculture represents by far the most important source of income for the households. Cash income from agricultural activities accounted for as much as 74.0% of total household income for households with farm forest plantation while it represented 83.4% of total household income for those without farm forest plantation (see Figure 7.3). Agriculture continues to play a significant role in the livelihood strategies of the study households. Additional income was generated from various off-farm activities. In general, households without farm forest plantation generated the highest off-farm income earning an average of $179.7 compared to households with farm forest plantation which generated an average of $132.4. Income from off-farm activities accounted for 8.5% and 16.6% of total household income for households with and without farm forest plantation respectively (Figure 7.3).

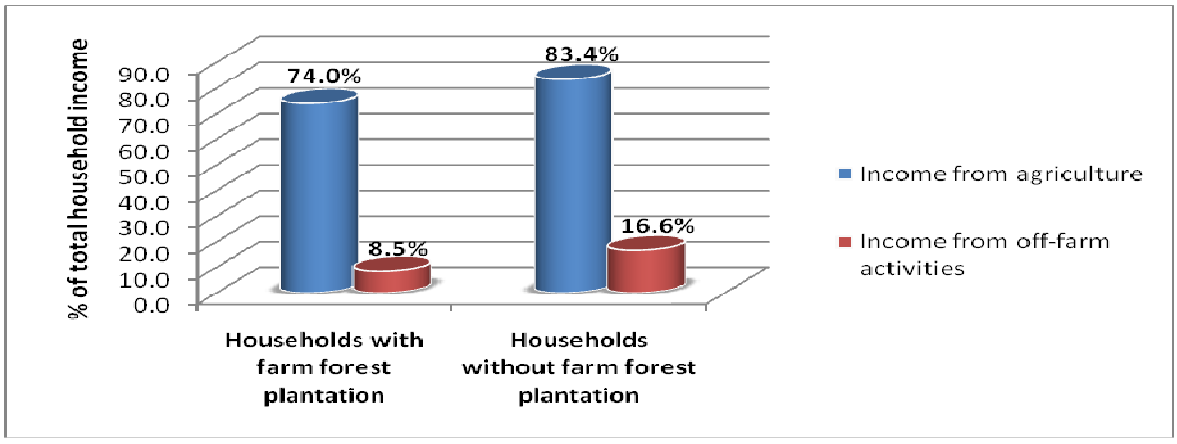


Figure 7.3: Percentage contribution of income from agriculture and off-farm activities to total household's income for households with and without farm forest plantation
Source: Field Survey, 2006

7.7 Contribution of income from farm forest plantation management to household's income and livelihood strategies

Farm forest plantation establishment is a relatively recent phenomenon for most of the study households. However, it has become an important income diversification activity for the households. The discussions in this section highlight the financial contribution of farm forest plantation management to the income streams of the study households and the importance of this income component to the household's well-being. One of the most significant benefits of integrating trees into existing farms is the opportunity to improve farm incomes (Tonts, et al., 2001). As shown in the present study, income from the sale of various farm forest products in one agricultural season contributed as much as $273.6 of total household income for households that own farm forest plantation (see Figure 7.4).

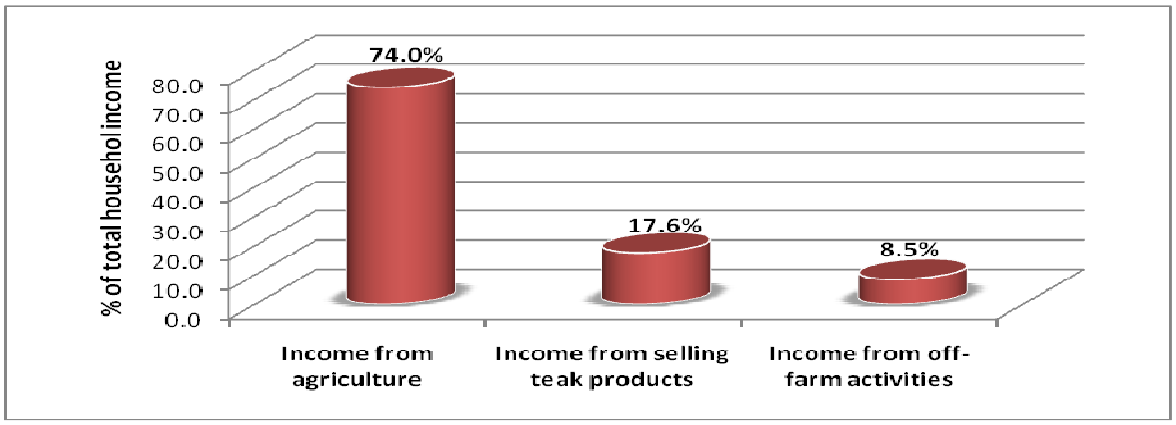


Figure 7.4: Percentage contribution of income from selling farm forest teak products to total household's income in one agricultural season[17]
Source: Field Survey, 2006

[17] This analysis applies only to households with smallholder farm forest plantation

This amount accounts for 17.6% of total household income and also represents the second most important income generating activity after agriculture for these households. Income from farm forest plantation seeks to broaden the income spectrum of the households and therefore allows them some level of flexibility and greater income security in the face of declining returns from traditional food and cash crop (e.g. cocoa and coffee) production as a result of fluctuating commodity prices. The additional income from farm forest plantation is able to pay about 16.9% of household's annual expenditure of $1,621.1 for households with farm forest plantation. For most of the households, farm forest plantation serve as collateral to secure loans/credits from the banks and as safety-net to assist them to cope with emergencies such as the sudden death of the breadwinner, crop failure, unanticipated increases in costs of staple foods, agricultural inputs, etc. The households can turn to their farm forest during such critical times by selling some trees to generate income. In this context, farm forest plantation establishment can be regarded as a form of rural insurance or a risk reduction strategy by the households. The earnings from farm forest plantations managed by the households are expected to increase in the future as the trees reach harvesting stage. More trees can then be harvested to generate income for the households.

Although not quantified in the present study, a casual observation in the study communities shows that "by-products" from farm forest plantation such as small poles and posts are used by the households to construct their houses, used as fuel wood or simply left on the farm to rot and thereby improve the fertility of the soil. This subsistence contribution is seen as important for the households due to the scarcity of wood and restrictions in the collection of wood from the remaining natural forests. The important contribution of income from farm forest plantation to household income shows that it offers an opportunity for households to enhance their livelihood needs and facilitates the accumulation of wealth required to reduce livelihood vulnerability. These findings confirm the third hypothesis that *"cash income from farm forest plantation management increases the overall household's income and enhances their well-being"*.

7.8 Households expenditure

7.8.1 Households expenditure on major expenditure items

The quantification of household's expenditure represented one of the most challenging tasks during data collection. The methodology developed for the study enabled the collection of detailed information on major household expenditure items from the sampled households. Five community residents and in some cases an educated person in the household were selected to record household subsistence and cash expenditure on food and non-food items purchased frequently by the household at seven-day intervals over a period of 60 days. Expenditure on

items that are less frequently purchased were collected directly by the researcher using a reference period of six months and in some cases twelve months, depending on the household's frequency of purchase. All expenditure values were subsequently projected to give annual estimates. The results from the expenditure analysis show that household expenditure on food is by far the highest among the expenditure groups. The households were spending an average of $748.6 per annum on food. This component of household expenditure represents 50.6% of total household annual expenditure (Table 7.7). Farm expenditure is the next most important household expenditure accounting for 28.0% of total household annual expenditure. Other household expenditure groups included clothing and footwear (8.8%), housing and utilities (5.6%), medical and health care expenditure (3.5%) and expenditure on education (3.5%) (see Table 7.7).

Table 7.7: Components of household expenditure, per capita expenditure and estimates of total annual household expenditure

Components of household expenditure	Mean annual household expenditure ($)	Mean annual per capita expenditure ($)	% share of household expenditure
Food expenditure (subsistence and cash expenditure)	748.6	148.5	50.6
Farm expenditure	414.2	82.2	28.0
Clothing and footwear	130.3	25.8	8.8
Housing and utilities	82.9	16.4	5.6
Medical and health care	52.3	10.4	3.5
Education expenditure	51.2	10.2	3.5
Total household expenditure	*1,479.4*	*293.5*	*100.0*

Source: Field Survey, 2006

A comparison between households with and without farm forest plantation in terms of expenditure on major household expenditure groups is presented in Table 7.8. The share of total household expenditure represented by expenditure on food for households currently without farm forest plantation is relatively higher than those currently with farm forest plantation. Expenditure on food accounts for 52.3% and 49.6% of total household expenditure for the former and latter household categories respectively (Table 7.8). The variation in food expenditure between the two household categories could be attributed to the fact that many households without farm forest plantation have to buy food products from the market to meet their food needs. The higher market prices for food products therefore increase the expenditure on food for this category of households. The next major household expenditure for both household categories is farm expenditure accounting for 29.4% and 25.4% for households with and without farm forest plantation respectively. Households with farm forest plantation spend 8.6% of their total annual income on clothing and footwear, 5.3% on housing and utilities, 3.5% on medical and health care

expenditure and 3.6% on education. On the other hand, households without farm forest plantation spend 9.2% on clothing and footwear, 6.1% on housing and utilities, 3.6% on medical and health care expenditure and 3.3% on education (see Table 7.8).

Table 7.8: Distribution of household expenditure for households with and without farm forest plantation

Major household expenditure items	Households with forest plantation (n=165)		Households without forest plantation (n=115)	
	Mean annual household expenditure ($)	% share of household expenditure	Mean annual household expenditure ($)	% share of household expenditure
Food expenditure (subsistence and cash expenditure)	804.8	49.6	667.9	52.3
Farm expenditure	476.6	29.4	324.7	25.4
Clothing and footwear	139.3	8.6	117.3	9.2
Housing and utilities	86.1	5.3	78.2	6.1
Medical and health care	56.4	3.5	46.4	3.6
Education	57.9	3.6	41.5	3.3
Total household expenses	*1,621.1*	*100*	*1,276*	*100.0*

Source: Field Survey, 2006

7.8.2 Households subsistence and cash expenditure on food items

The household survey collected detailed information on both household's subsistence[18] and cash[19] expenditure on food. The value of food produced and consumed by the households was quantified using the market value for the various food items. As expected, a large proportion of food consumed by most households was self-produced. On average households with farm forest plantation consumed an estimated amount of $804.8 of food annually consisting of 51.8% self-produced food and 48.2% cash expenditure on food items bought from the market (Table 7.9). On the other hand, households without farm forest plantation consumed an estimated amount of $667.9 of food annually with self-produced food accounting for 52.8% and cash expenditure on food items representing 47.2%. A breakdown of household food expenditure into item levels shows that cereal products represent by far the largest household food expenditure representing 21.6% of total household food expenditure. This shows the relative importance of cereals and cereal products in the diet of the study households. Other food items which also feature prominently in household food expenditure include meat and poultry products (17.0%), roots and tubers (13.7%), fish (9.8%), vegetables (8.5%), and oils and fat (5.6%) (see Table 7.9).

[18] Subsistence food expenditure refers to the value of food items produced and consumed by the households
[19] Cash expenditure on food refers to expenditure on food items bought from the market

Table 7.9: Average annual household subsistence and cash expenditure on major food items

Major food expenditure items	Households with forest plantation (n=165)		Households without forest plantation (n=115)		% of total food expenditure
	Subsistence ($)	*Cash ($)*	*Subsistence ($)*	*Cash ($)*	
Cereal products	125.0	42.6	107.5	43.0	21.6
Roots and tubers	64.3	40.6	61.3	35.4	13.7
Pulses and nuts	24.7	12.9	19.2	10.2	4.5
Vegetables	58.3	18.4	29.2	19.8	8.5
Fruits	4.4	3.4	3.9	2.2	0.9
Oils / fat	32.2	21.0	17.2	12.2	5.6
Meat and poultry products	70.5	48.4	76.8	55.3	17.0
Fish	8.7	75.8	6.4	53.6	9.8
Milk products	0.0	14.1	0.0	11.0	1.7
Spices	15.5	8.0	13.6	4.7	2.8
Prepared meals	0.0	36.0	0.0	29.4	4.4
Non-alcoholic drinks	0.0	23.5	0.0	13.5	2.5
Alcoholic drinks	12.8	20.1	15.5	17.5	4.5
Cigarettes and tobacco	0.0	23.5	2.0	7.8	2.3
Total food expenditure	416.5	388.3	352.5	315.4	100.0
Subsistence and cash expenditure on food as % of total food expenditure	51.8	48.2	52.8	47.2	100.0

Source: Field Survey, 2006

7.8.3 Households subsistence and cash expenditure on major farm inputs

Table 7.10 provides a summary of results on various costs involved in producing food crops and raising livestock. In general about 86.2% of total household subsistence and cash expenditure on farm inputs was spent on crop production while 13.8% was allocated to the production of livestock. Some variations were observed between households with and without farm forest plantation in terms of the expenditure on farm inputs. Households with farm forest plantation spent more in the production of crops (88.2%) compared to those without farm forest plantation which spent 83.1% of their total expenditure on farm inputs. This variation could be attributed to the larger farm lands operated by households in the former category. The most important expenditure on crop inputs for households with farm forest plantation include expenditure on labor (27.6%), fertilizers (21.1%), agro-chemicals (12.2%), harvesting and transportation of crops (10.8%), and farm implements (9.4%) of total expenditure on farm inputs (Table 7.10). Among households without farm forest plantation, expenditure on labor accounted for 27.8% of total expenditure on farm inputs while money spent on harvesting and transportation of crops represented 14.4%. Other crop inputs include farm implements (13.1%), fertilizer (11.7%), and planting materials (8.7%). In respect of livestock inputs, labor involved in caring for livestock and animal feed was the most important expenditure item indicated by most of the study households.

Table 7.10: Household subsistence and cash expenditure on major farm inputs

Major farm expenditure	Households with forest plantation (n=165)	Households without forest plantation (n=115)	Total farm expenditure ($)	% of total farm expenditure
	Mean annual farm expenditure ($)	Mean annual farm expenditure ($)		
Crop inputs	***420.5***	***269.9***	***690.4***	***86.2***
Labor (subsistence/cash)	131.6	90.4	222.0	27.7
Farm implements	45.0	42.6	87.5	10.9
Fertilizers	100.6	38.1	138.7	17.3
Agro-chemicals	58.3	23.8	82.1	10.2
Planting materials	33.7	28.3	62.0	7.7
Harvesting / transporting crops	51.3	46.8	98.1	12.2
Livestock inputs	***56.1***	***54.8***	***110.8***	***13.8***
Labor (subsistence/cash)	22.9	23.1	46.0	5.7
Animal feed	20.5	21.1	41.6	5.2
Medicine	12.6	10.6	23.2	2.9
Total farm expenditure	*476.6*	*324.7*	*801.2*	*100.0*

Source: Field Survey, 2006

7.8.4 Cash expenditure on other household expenditure items

An analysis of household cash expenditure on other expenditure items showed no significant difference between households with and without farm forest plantation. Both household categories spend almost the same amount on various expenditure items such as clothing and footwear as well as medical and health care. Expenditure on housing and utilities show some variations between the households. Those without farm forest plantation spend relatively more of their total other household expenditure on housing and utilities (27.6%) compared to those with farm forest plantation who spend 25.3% (Table 7.11). This variation can be attributed to the high cost of renting accommodation and the low expenditure on fuel and electricity. On the other hand, households with farm forest plantation spend proportionately more on education than those without farm forest plantation.

Table 7.11: Mean annual household cash expenditure on other expenditure items for households with and without farm forest plantation

Household other cash expenditure items	Households with forest plantation (n=165)	Households without forest plantation (n=115)	Total household other cash expenditure ($)	% of total household other cash expenditure
	Mean annual household other cash expenditure ($)	Mean annual household other cash expenditure ($)		
Clothing and footwear	**139.3**	**117.3**	**256.6**	**41.2**
Clothing materials	64.2	50.1	114.3	18.3
Tailoring charges	14.1	7.3	21.4	3.4
Ready-made clothes	40.7	40.3	81.0	13
Footwear	20.4	19.5	39.9	6.4
Housing and utilities	**86.1**	**78.2**	**164.3**	**26.4**
Rent and housing charges	12.5	20.8	33.3	5.3
Fuel and power (electricity)	64.2	50.1	114.3	18.3
Other utilities	9.4	7.3	16.7	2.7
Medical and health care	**56.4**	**46.4**	**102.8**	**16.5**
Medical products	18.8	18.3	37.1	6
Hospital services	37.6	28.1	65.7	10.5
Education	**57.9**	**41.5**	**99.5**	**16**
Children school fees	31.3	22.0	53.3	8.6
School uniforms	9.4	6.1	15.5	2.5
Text books	15.7	11.0	26.7	4.3
News papers and magazines	1.6	2.4	4.0	0.6
Total household other cash expenditure	*339.8*	*283.5*	*623.2*	*100.0*

Source: Field Survey, 2006

7.8.5 Total households expenditure

Total expenditure represents the combined household's subsistence and cash expenditure on major expenditure items. The total annual household expenditure relative to September 2006 prices for the entire study households was $1,479.4 while the mean annual per capita expenditure was $293.5. A comparison between the two household categories in terms of their annual expenditure schemes shows that those with farm forest plantation made more expenditure incurring a total of $1,621.1 and a per capita expenditure of $296.4. On the other hand, those without farm forest plantation made a total annual expenditure of $1,276 and a per capita expenditure of $288 (Table 7.12). On average, the annual expenditure for households with farm forest plantation is 27.04% higher than those without farm forest plantation. The difference in household expenditure could be attributed to the relatively larger household size among this category of households.

Table 7.12 Mean annual expenditure for households with and without farm forest plantation

Household category	Mean annual household expenditure ($)	Mean annual per capita expenditure[20] ($)	Mean household size
Households with forest plantation (n=165)	1,621.1	296.4	5.47
Households without forest plantation (n=115)	1,276.0	288.0	4.43
All households (n=280)	1,479.4	293.5	5.04

Source: Field Survey, 2006

Results from a direct comparison between total household income and expenditure streams for the study households are presented in Table 7.13. The analyses show that the households experience negative balance (deficit) between household income and expenditure. This is an indication that the households are not able to generate enough income to cover their expenditures. The disparity between household income and expenditure is higher among households currently without farm forest plantation (17.5% or $-191.5) compared to those with farm forest plantation with a negative income balance of only 3.7% (i.e. $-58). The implication for households with farm forest plantation is therefore lesser compared to those without farm forest plantation. The shortage of income is to some extent compensated through borrowing money from other relatives or local credit institutions to be able to meet the household's cash needs. This system of balancing household's income deficit is however not sustainable, hence the need to adopt long-term measures to generate enough income to meet the household's cash needs.

Table 7.13: Comparison between total household income and expenditure for households with and without farm forest plantation

Household category	Mean annual household income ($)	Mean annual household expenditure ($)	Balance between household income and expenditure ($)	Percentage balance (%)
Households with forest plantation (n=165)	1,563.1	1,621.1	-58	3.7
Households without forest plantation (n=115	1,084.5	1,276.0	-191.5	17.6

Source: Field Survey, 2006

[20] Mean annual per capita expenditure can be obtained by dividing mean annual household expenditure by mean household size

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

This chapter provides conclusions of the major research findings as well as recommendations to promote farm forest plantation establishment in Ghana and also enhance its potential contribution to the livelihood strategies of rural households. The incorporation of forest plantation into existing farming systems in the study area has become an important land-use option for many households. The present study was therefore set out to analyze the factors that influence household's decision to establish farm forest plantation and also assess the resultant contribution of the outcome from this land-use practice on household's livelihood strategies. Many households have adopted farm forest plantation as a key livelihood strategy to increase and diversify their income sources, and strengthen their capacity and ability to meet their well-fare needs. The following section summarizes the major conclusions of the study as highlighted in the results used to validate the various research hypotheses.

Hypothesis 1: The socio-economic characteristics of farm households (i.e. personal-demographic situation, resource endowments, etc.) determine their propensity to establish farm forest plantation.

The results presented in Chapter 5 and 6 with regard to household's personal-demographic characteristics and resource endowments have shown the direct relationship between household's socio-economic characteristics and the decision to establish farm forest plantation. The study has revealed that household's with and without farm forest plantation exhibit variations in personal-demographic characteristics and resource endowments. The results show that household's decision to establish farm forest plantation is positively and significantly influenced by an increase in the age of the household head, the educational attainment of the household head, size of the household, amount of household labor force, and the participation of the household head or any member of the household in forest plantation development projects in the past. Furthermore, an increase in the size of household landholding, the ownership of permanent land and the availability of non-agricultural land positively and significantly affected the household's decision to establish farm forest plantation. The regression analysis showed that the wealth status of the household has no predictive power in determining their decision to establish farm forest plantation. This finding is contrary to logical expectations in the sense that better-off households are seen as having control of a high level of resource endowments (e.g.

labor and capital) to enable them to establish forest plantation compared to poor households who often lack the needed labor and capital.

Hypothesis 2: The availability of market and buyers for farm forest products, and changes in policy regarding the ownership of trees planted on private lands vis-à-vis the right to harvest trees and transport timber positively influence household's decision to establish farm forest plantation.

The results from the logistic regression analysis (see Chapter 6) show that improvements in market conditions positively correlated with the household's decision to establish farm forest plantation over the years. In general, the availability of market and buyers for farm forest products and the high level of satisfaction with prices for farm forest products served as incentive for many households to establish farm forest plantation. The perception about future demand and prices for farm forest products, however, failed to show any influence on their decision to establish farm forest plantation. The above results support the hypothesis that the *"availability of market and buyers for farm forest products positively influence the household's decision to establish farm forest plantation"*.

A number of policy changes have been made in Ghana to promote forest plantation development, most importantly, the Timber Resources Management Act, 1998 (Act 547), which accords the ownership of planted trees to the owner. The results from the study, however, show that uncertainty in tree tenure as a result of ambiguities in the forest policy have served as a source of insecurity for many households to use their land to establish forest plantation. This finding is in line with the observation made by Besley (1995) who stated that when farmers' rights over trees they have planted or preserved are not clearly defined, they stay away from participating in forest plantation management and conservation exercises. Current rules and regulations that restrict the harvesting of trees and transportation of timber from private land have also negatively influenced the decision of the study households to establish farm forest plantation. Based on the evidence presented above, the hypothesis that *"changes in policy regarding the ownership of trees planted on private lands and the right to harvest trees and transport timber positively influence household's decision to establish farm forest plantation"* is rejected.

Hypothesis 3: Cash income from farm forest plantation management increases the overall household's income and enhances their well-being.

The establishment of farm forest plantation is relatively new for most of the study households. However, it has become an important income diversification activity for the households. Results from the study show that income from selling farm forest products significantly contribute to the household's total income (see Chapter 7). In general, income from selling farm forest products in one agricultural season increases the total income of households with farm forest plantation by an average of 17.6%. Furthermore, income from farm forest plantation serves as the second most important source of income after agriculture for these households. The significant role income from farm forest plantation plays in household's income shows that households can increase their income and also improve their livelihood needs by establishing forest plantation on their farm lands. Although farm forest plantation alone is not a panacea to alleviate rural poverty, household's decision to adopt such land-use can, undoubtedly, help them cope with emergencies and also prevent them from being pushed further into poverty. The evidence presented above fully support the third hypothesis that *"cash income from farm forest plantation management increases the overall household's income and enhances their well-being"*.

Hypothesis 4: The profitability (financial returns) from farm forest plantation inter-cropped with food crops is higher than the traditional maize-plantain cultivation in the study area.

The results from the comparative financial analysis showed positive financial returns for all the three land-use options analyzed, namely, pure teak plantation, farm forest plantation inter-cropped with maize and plantain, and sole maize-plantain cultivation (see Chapter 5). However, the establishment of farm forest teak plantation inter-cropped with maize and plantain produced the best financial outcome (NPV = $962.2 at 12.6% discount rate) compared to sole maize-plantain cultivation (NPV = $520.5) and pure teak plantation with an NPV of $53.2. These results are indication that the *"financial returns from farm forest plantation inter-cropped with food crops are higher than the traditional maize-plantain cultivation in the study area"*.

8.2 Relationship between the empirical findings and theoretical perspective on factors influencing farm household's decision to establish farm forest plantation

The conceptual framework of the study focused on analyzing the socio-economic, market and policy related factors influencing household's decision to establish farm forest plantation. The framework was set out under the assumption that the household's decision is embedded in a complex web of factors that are either endogenous or exogenous to the household. The study has

shown that the household's decision is affected by their personal-demographic characteristics (e.g. age of the household head, household size) and resource endowments (including land, labor and education or know-how). Differences in these factors among the households partly explained why some households are motivated to adopt farm forest plantation compared to others. This shows the importance of household characteristics in the decision-making process. The liberal economic theory contends that farmer's behavior is a consequence of a rational decision-making; hence, they act to maximize their benefits and also take advantage of emerging opportunities. The above observation is in line with the household's objective to incorporate forest plantation into their farming system. As indicated by most households, farm forest plantations are established as a strategy to increase their income sources. This is an indication of the rationality behind the household's decision to establish farm forest plantation.

Farm forest plantation establishment as a land-use involves economic trade-off for the household and therefore factors affecting its financial returns must also be taken into account in the decision-making process. This requires an evaluation of the cost of inputs (labor and materials) and the expected outputs from the plantation. As shown in the results from the comparative financial analysis, farm forest plantation yielded the best financial returns compared to pure teak plantation and traditional maize-plantain cultivation. Such positive returns therefore serve an important criterion for the households to adopt farm forest plantation into their farming system. The policy contexts under which households take their decision also played an important role in the decision-making process. Policies can on one hand, provide incentive for farm forest plantation establishment. As pointed out by the households, improvement in market access and availability of buyers as a result of the liberalization of the local timber market has positively influenced the decision to establish farm forest plantation. On the other hand, insecurity in tree tenure as a result of ambiguous policy and the existence of restrictive rules and regulations regarding the harvesting of trees and transportation of timber from private land have served as disincentive for farm forest plantation development by the households.

8.3 Recommendations

The following recommendations are made to promote farm forest plantation establishment by farm households in view of its potential to enhance the socio-economic well-being of the households. The results from the financial analysis show that households stand to gain financial benefits from farm forest plantation management. Hence, institutions which promote rural development and environmental awareness should incorporate farm forest plantation into the

development agenda to enable rural households improve upon their livelihood and also improve the local environmental condition.

The vibrant domestic wood markets will continue to provide incentive for more rural households to adopt farm forest plantation into their farming systems. Therefore, efforts should be focused on improving household's access to information on markets and prices and encourage the development of cooperative trading networks to strengthen the bargaining powers of the households.

The results from the household income analysis also show that farm forest plantation management offers an opportunity to increase household's income in the face of declining agricultural outputs and fluctuating output prices. A major constraint facing smallholder forest plantation developers in the study area as in other parts of the country is that the existing financial institutions lack familiarity with forestry projects whilst many smallholders also lack credit worthiness to enable them obtain credit/loans from conventional financial institutions. There will therefore be the need to set-up micro-finance schemes to provide financial services to smallholders currently managing or intending to establish farm forest plantation.

Special attention should be paid to existing policy provisions that serve as disincentive for forest plantation development by smallholders. Most importantly, Act 547 of the Timber Resources Management Act, 1998 which, on one hand, does not allow private holding of Timber Utilization Contract (TUC), but also does not explicitly separate planted trees from the legal controls afforded to naturally growing trees (e.g. the requirement of a Registered Property Mark to harvest timber). Currents rules and regulations regarding the harvesting of trees and transportation of timber from private lands have to be reduced or simplified but ensuring that it does not jeopardize the government's objective of protecting against illegal felling of trees. It is anticipated that the revision of such rules and regulations will provide security for more households to use their land to establish forest plantation.

It is expected that there will be an increased emphasis on short-rotation and farm forest plantations in Ghana in the future in view of the increasing local demand for wood and the declining wood supply from the remaining natural forests. Output from such plantations will be small-dimension and therefore the sawmilling industry (traditionally used to large-dimension logs) will be required to adapt to the change by employing technologies that will be able to process wood from short-rotation and farm forest plantations.

8.4 Limitations of the study and suggestions for further research

Notwithstanding the various measures that were taken to cross-check and verify information on household income (e.g. discussion with key informants and experts in the district), the accuracy of responses to quantitative questions could sometimes not be fully ascertained. This problem was attributed to the household's low level of comprehension of numerical questions, for example, information on household's incomes and expenditures, number of seedlings and size of land planted in the past years, quantities of food crops consumed in the past, etc.

Despite pre-testing the survey questionnaires prior to the conduct of the household socio-economic survey and making changes to reduce the number of questions, some respondents found the questionnaire to be too long to complete in one section which usually lasted for two to three hours. Some households could also not give answers to some questions during the interview, which required further meetings to be scheduled to give them the opportunity to provide answers to those questions.

The present study was conducted in one agro-ecological area, namely, the High Forest Zone, with its distinct socio-economic and environmental characteristics. It is thus quite difficult to predict the extent to which the study findings can be applied in other agro-ecological zones in the country. One therefore has to be careful in generalizing the study findings for other zones. Future studies should include communities from different agro-ecological zones in Ghana to facilitate comparison and generalization of the findings.

The estimation of expected outputs from pure teak plantation as well as teak plantation inter-cropped with food crops for the financial analysis relied only on tree ages instead of growth models differentiated by site classes. Future research should therefore consider teak plantation from different site classes and also incorporate more sample plots in order to obtain a more precise growth performance of such plantations. Given the limited information on the environmental impacts of farm forest plantation establishment at the farm level, future research should assess its potential environmental benefits to compliment information on financial benefits.

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RESEARCH PLATES

Plate 1: One-year-old teak plantation inter-cropped with maize

Plate 2: Two-year-old teak plantation inter-cropped with plantain

Plate 3: Two-year-old pure teak plantation

Plate 4: Three-year-old teak plantation inter-cropped with groundnut

Plate 5: Ten-year-old teak stand

Plate 6: Fifteen-year-old teak stand

Plate 7: Thirty-year-old teak stand

Plate 8: Timber from a 30-year-old teak stand

Plant 9: Three-year-old pure *Cedrela odorata* plantation

Plate 10: Five-year-old *Cedrela odorata* plantation planted with plantain

Plate 11: *Cedrela odorata* stand planted with black pepper

Plate 12: Ten year old pure *Cedrela odorata* plantation

APPENDICES

Appendix 1A: Questionnaire for Study Households with Farm Forest Plantation

Section 1: Identification

1.1 Name of Community: _____

1.2 Name of Household Head: _____

1.3 Name of Enumerator: _____

1.4 Date of Interview: _____

Section 2: Socio-demographic characteristics of the households

2.1 Gender of household head Male [ ] =1 Female [ ] =2

2.2 Age of household head: _____ (years)

2.3 In total how many people live in the household? _____

2.4 Household composition

Household Composition	2.1 Infants (<=5yrs)	2.2 Children (6-17yrs)	2.3 Adult males (18-64yrs)	2.4 Adult females (18-64yrs)	2.5 Aged (=>65yrs)
No. of household members					

2.5 Marital status Single [ ]=1 Married [ ]=2 Separated [ ]=3 Divorced [ ]=4 Widowed [ ]=5

2.6 Household head highest level of education
No Education [ ] =1 Primary School [ ] = 2 Middle School Leaving Certificate (MSLC) [ ] =3
Junior Secondary School [ ] =4 Senior Secondary School [ ] =5 Ordinary Level (O-Level) [ ] =6
Advance Level (A-Level) [ ] =7 Tertiary [ ] =8 Other: _____ [ ] =9

2.7 Household head main occupation
Farmer [ ] =1 Trader [ ] =2 Teacher [ ] =3 Public service [ ] =4 Laborer [ ] =5
Chop bar operator [ ] =6 Drinking bar operator [ ] =7 Driver [ ] =8 Other: _____ [ ] =9

2.8 Origin of head of household Indigenous [ ] =1 Migrant [ ] =2 Other:_____ [ ] =3

Section 3: Socio-economic status of the households

3.1 Does the household own a house? Yes [ ] =1 No [ ] =2

3.2 How many rooms are there in the house? _____

3.3 What material is the wall and roof of your house constructed from (e.g. light, mixed, concrete)?

Portion of house		Construction material
01	Wall	
02	Roof	

3.4 Do you or any other member of the household own a transport? Yes [ ] =1 No [ ] =2

3.4.1 If yes, please indicate the type of transport owned: _____

3.5 What is the wealth status of your household? Better-off [ ] =1 Average [ ] =2 Poor [ ] =3

Section 4: Landholding and farm characteristics

4.1 What is the total size of land managed by the household? _____ha

4.2 What proportion of land managed is owned by the household? All (100%) [ ] =1 Other:_____% [ ] =2

4.3 How was land managed by the household acquired?
Owned [ ] =1 Rented [ ] =2 Share-cropped [ ] =3 Borrowed [ ] =4 Leased [ ] =5 Other:_____ [ ] =6

4.4 Number of land parcels managed by the household
1 [ ] =1 2 [ ] =2 3 [ ] =3 4 [ ] =4 5 [ ] =5 Other: _____ [ ] =6

4.5. Does your household have land not suitable for agriculture (e.g. wet, steep slopes, difficult access, away from home, etc)? Yes [ ] =1 No [ ] =2

4.5.1 If yes, please indicate the size of land managed by the household which is not suitable for agriculture:_ (ha)

4.6 Did the household receive any income (cash or in-kind) from renting or leasing the land in the last 12 months? Yes [ ] =1 No [ ] =2

4.6.1. If yes, how many hectares of land did the household rented or leased in the last 12 months? _____ (ha)

4.6.2 What is the total value of income you received for this land in the last 12 months? ¢_____Cedis

Section 5: Household livelihood activities

5.1 Earnings from crop and livestock production

5.1.1 Indicate the type of food crops you cultivated in the last agricultural year, the quantity of crop harvested, the value of total income generated and the operational cost incurred

5.1.1 Crops cultivated by the household		5.1.2 Total quantity of crop harvested	5.1.3 Total income generated (¢ Cedis)	5.1.4 Estimated operational cost incurred (¢ Cedis)
01				
02				
03				
04				
05				
06				
07				
Other				

5.1.2 Please indicate the proportion of the households' total food needs which your household is able to produce (tick one answer) 0-25% [ ] =1 26-50% [ ] =2 51-75% [ ] =3 76-100% [ ] =4

5.1.3 Do you or any other member of the household owned livestock? Yes [ ] =1 No [ ] =2 Don't know

5.1.3.1 If yes, indicate the type of livestock owned, number of animals the household currently own, number of animals sold in the last 12 months and amount received from selling the animals

5.1.3.1 Type of livestock		5.1.3.2 Number of animals the household currently own	5.1.3.3 Number of animals sold in the last 12 months	5.1.3.4 Total amount received from selling animals (¢ Cedis)
01				
02				
03				
04				
05				
Other				

5.2 Off-farm income generating activities

5.2.1 Did you or any other member of the household undertake any off-farm income generating activities in the last 12 months? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

5.2.2 If yes, indicate the type of off-farm income generating activities your household undertook in the last 12 months and the revenue generated from the activities

5.2.2 Type off-farm activity		5.2.3 Income generated (¢ Cedis)
01		
02		
03		
04		
05		
06		
07		
Other		

5.3 Transfers and remittances

5.3.1 Did you or any other member of the household receive money from relatives, organizations, friends, etc in the last 12 months? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

5.3.1.1 If yes, indicate the total amount of money you received in the last 12 months? ¢_____ Cedis

5.3.2 Please, indicate the source(s) of the transfers or remittances you received in the last 12 months
Social Security [ ] =1 Religious organizations [ ] =2 Retirement Pension [ ] =3 NGOs [ ] =4 Relatives [ ] =5
Family friends [ ] =6 Interest from bank savings [ ] =7 Rent from property or other assets [ ] =8

Section 6: Smallholder farm forest plantation development

6.1 Households current forest plantation development activities

6.1.1 How many forest plantation plots do you own? 1 [ ] =1 2 [ ] =2 3 [ ] =3 4 [ ] =4 5 [ ] =5

6.1.2 Indicate the size and year of establishing each of the farm forest plantation plots?

Plot No.	Size (ha)	Year of establishment
1		
2		
3		
4		
Other		

6.1.3 What was the condition of the land when you first established your plantation?
Good condition (not degraded) [ ] =1 Slightly degraded [ ] =2 Degraded [ ] =3 Other:_____ [ ] =4

6.1.4 How was land for the plantation acquired?
Owned [ ] =1 Rented [ ] =2 Sharecropped [ ] =3 Borrowed [ ] =4 Leased [ ] =5 Other:_____ [ ] =6

6.1.5 How did you finance your forest plantation?
Self-financed [ ] =1 Loan (from_____) [ ] =2 Credit (from_____) [ ] =3

6.1.6 What factors influenced or convinced you to go into farm forest plantation development. Please use a scale from 1 - 5 to rank the following factors in order of importance to you (i.e., 1 = most important factor(s) and 5 = least important factor(s))

Underlying factors		Ranking
01	Increase in wood price	
02	Decline in natural forest	
03	Change in law regarding the ownership of forest plantation on private lands	
04	Availability of market for forest products	
05	The need for income	
06	The need for fuel wood and construction materials	
07	Decrease in prices of agricultural products	
08	Increased access to credit / loans	
09	Increase in my level of knowledge about forest plantation development	
10	The need to protect and improve my land	
11	Other, specify	

6.1.7 Name the tree species you have planted on your plantation

Tree No.	Name of tree species	Source of seedlings
01		
02		
03		
04		
05		
Other		

6.1.8 Indicate the source(s) of the seedlings you have planted on your forest plantation
Own nursery [ ] =1 FSD [ ] =2 MoFA [ ] =3 Bought seedlings from suppliers [ ] =4 Wildlings [ ] =5

6.1.9 Do you plant only one tree species on your plot or several tree species on the same plot?

Mode of species arrangement		
01. Mono-culture	Yes [ ] =1	No [ ] =2
02. Mix-culture	Yes [ ] =1	No [ ] =2

6.1.10 Do you plant food crops on your forest plantation plot? Yes [ ] =1 No [ ] =2

6.1.10.1 If yes, please mention the type of food crops planted on your forest plantation?

Crop No.	Crop Name
01	
02	
03	
04	
05	
Other	

6.1.11 What silvicultural activities do you performed on your plantation farm?
Pruning [ ] =1 Thinning [ ] =2 Pollarding [ ] =3 Lopping [ ] =4 Singling [ ] =5

6.2 Market and prices for forest plantation products

6.2.1 Do you have market for your forest plantation products? Yes [ ] =1 No [ ] =2

6.2.2 Do you have buyers for your forest plantation products? Yes [ ] =1 No [ ] =2

6.2.3 Indicate your level of satisfaction with the current prices paid for your plantation products
Very satisfied [ ] =1 Satisfied [ ] =2 Not satisfied [ ] =3 Undecided [ ] =4

6.2.4 Indicate your perception about future demand for plantation products
High [ ] =1 Medium (same price as now) [ ] =2 Low [ ] =3 Don't Know [ ] =4

6.2.5 Indicate what you think the future prices for plantation products will be like
Increase [ ] =1 Decrease [ ] =2 Remain the same [ ] =3 Don't Know [ ] =4

6.2.6 Did you sell any tree product(s) from your plantation in the last 12 months? Yes [ ] =1 No [ ] =2

6.2.6.1 If yes, please mention the tree products you sold and the amount of money you received

6.2.6.1 Name of tree species		6.2.6.2 Type of product sold	6.2.6.3 Buyer	6.2.6.4 Quantity sold	6.2.6.5 Unit price per product	6.2.6.6 Total income generated (¢)
01						
02						
03						
04						
05						
Other						

Key for type of products sold: 1=High tension electricity pole 2=Low tension electricity pole 3= Telephone pole 4= Sawn timber 5=Fuel wood 6=Other:_____
Key for buyer: 1=Timber contractors 2=Wood processing company 3=Charcoal producers 4=Middlemen

6.2.7 Indicate the level of freedom you have to harvest and transport trees on your plantation? (Please tick one option) Complete freedom [ ] =1 Some level of freedom [ ] =2 No freedom [ ] =3

6.3 Sources of information regarding forest plantation development

6.3.1 Did you seek advice before establishing your farm forest plantation? Yes [ ] =1 No [ ] =2

6.3.2 If yes, indicate where or from whom you got advice? _____

6.3.3 Are you aware of the change in the forest policy regarding the ownership of forest plantation on private lands?
Yes [ ] =1 No [ ] =2

6.3.3.1 If yes, in what year did you become aware of this law? 19 _____ or 20 _____

6.3.4 Are you aware of the new forest policy regarding the granting of timber harvesting rights in respect of land with private forest plantation? Yes [ ] =1 No [ ] =1

6.3.4.1 If yes, in what year did you become aware of this law? 19 _____ or 20 _____

6.3.5 To what extent has the change in the forest policy influenced your decision to establish and manage farm forest plantation? (Please tick one option)
Strong influence [ ] =1 Little influence [ ] =2 No influence [ ] =3 Don't know [ ] =4

6.3.7 How do you finance your farm forest plantation?
Self-financed [ ] =1 Loan (from_____) [ ] =2 Credit (from____) [ ] =3 Other: _____ [ ] =4

6.4 Households knowledge in forest plantation development and future intentions

6.4.1 Have you or any member of your household participated in government or any other forest plantation development projects in the past? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

6.4.1.1 If yes, name the forest plantation projects(s) you were involved: _____

6.4.2 Have you or any member of your household owned cash crops such as cocoa or coffee plantations?
Yes [ ] =1 No [ ] =2 Don't know [ ] =3

6.4.2.1 If yes, please name the type of cash crop(s) owned: _____

6.4.3 Do you intend to put more land into plantation in the future? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

6.4.3.1 If yes give reasons why you intend to expand your forest plantation in the future
01. _____
02._____
03. _____

6.4.3.2 If no what factors would influence you to expand your land under forest plantation in future?
01. _____
02._____
03._____

6.5 Cost of establishing and managing forest plantation

6.7.1 How much did it cost you to establish and manage your forest plantation?

Costs in each year in Cedis (¢)																
Year / Operation	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Other
Land preparation																
Planting materials																
Pegs and pegging																
Planting																
Beating up																
Weeding																
Fire protection																
Thinning																
Pruning																
Harvesting																

Section 7: Household expenditure

7.1 Expenditure on food items

7.1.1 Please indicate the value of food consumed by your household in the last 7 days

Food Items		Estimated total expenditure on food (¢ Cedis)	Estimated value of consumption from households own production (¢ Cedis)	Estimated value of consumption bought from the market (¢ Cedis)
01	Cereals			
02	Roots and tubers			
03	Pulses and nuts			
04	Vegetables			
05	Fruit			
06	Oils and animal fats			
07	Meat products			
08	Eggs			
09	Fish			
10	Milk and milk products			
11	Spices			
12	Other food products			

7.2 Expenditure on non-food items

7.2.1 How much did your household spend on the following items in the last 30 days?

Non-Food Items		Estimated total expenditure (¢ Cedis)
01	Tobacco, cigarettes, etc	
02	Personal care items (e.g. soap, cream, etc)	
03	Kerosene, fuel wood	
04	Transportation (e.g. purchased fares, etc)	

7.2.2 How much did your household spend on the following items in the last 12 months?

Non-Food Items		Estimated total expenditure (¢ Cedis)
01	House rent	
02	House maintenance	
03	Furniture and other household items	
04	Water	
05	Electricity	
06	Telephone	
07	Vehicle	
08	Festivals/celebrations (e.g. wedding, funerals, etc	

7.2.3 How much did your household spend on clothing and footwear in the last 12 months?

Clothing and footwear		Estimated total expenditure (¢ Cedis)
01	Clothing for adult men	
02	Clothing for adult women	
03	Clothing for children (excluding school uniform)	
04	Footwear for adult men	
05	Footwear for adult women	
06	Footwear for children	

7.2.4 How much did your household spend on education in the last 12 months?

Education		Estimated total expenditure (¢ Cedis)
01	School uniform	
02	School fees	
03	Extra payment (e.g. payment for private classes, etc)	
04	Books and stationary	
05	Other education expenditure	

7.2.5 How much did your household spend on medicals and health care in the last 12 months?

Medicals and health care		Estimated total expenditure (¢ Cedis)
01	Medical consultation and treatment	
02	Medicines	
03	Other medical services	

7.2.6 How much did your household spend on entertainment and other non-food items in the last 12 months?

Non-Food Items		Estimated total expenditure (¢ Cedis)
Entertainment		
01	Film shows	
02	Concert	
Other non-food expenditure (specify)		

Thank you for your precious time

Appendix 1B: Questionnaire for Study Households without Farm Forest Plantation

Section 1: Identification

1.1 Name of Community: _____
1.2 Name of Household Head: _____
1.3 Name of Enumerator: _____
1.4 Date of Interview: _____

Section 2: Demographic characteristics of the household

2.1 Gender of household head Male [ ] =1 Female [ ] =2

2.2 Age of household head: _____ (years)

2.3 In total how many people live in the household? _____

2.4 Household composition

Household Composition	2.1 Infants (<=5yrs)	2.2 Children (6-17yrs)	2.3 Adult males (18-64yrs)	2.4 Adult females (18-64yrs)	2.5 Aged (=>65yrs)
No. of household members					

2.5 Marital status
Single [ ]=1 Married [ ]=2 Separated [ ]=3 Divorced [ ]=4 Widowed [ ]=5

2.6 Household head highest level of education
No Education [ ] =1 Primary School [ ] = 2 Middle School Leaving Certificate (MSLC) [ ] =3 Junior Secondary School [ ] =4 Senior Secondary School [ ] =5 Ordinary Level (O-Level) [ ] =6 Advance Level (A-Level) [ ] =7 Tertiary [ ] =8 Other: _____ [ ] =9

2.7 Household head main occupation
Farmer [ ] =1 Trader [ ] =2 Teacher [ ] =3 Public service [ ] =4 Laborer [ ] =5
Chop bar operator [ ] =6 Drinking bar operator [ ] =7 Driver [ ] =8 Other:_____ [ ] =9

2.8 Origin of head of household Indigenous [ ] =1 Migrant [ ] =2 Other:_____ [ ] =3

Section 3: Socio-economic status of the household

3.1 Does the household own a house? Yes [ ] =1 No [ ] =1

3.2 How many rooms are there in the house? _____

3.3 What material is the wall and roof of your house constructed from (e.g. light, mixed, concrete)?

Portion of house		Construction material
01	Wall	
02	Roof	

3.4 Do you or any other member of the household own a transport? Yes [ ] =1 No [ ] =1

3.4.1 If yes, please indicate the type of transport owned: _____

3.5 What is the wealth status of your household? Better-off [ ] =1 Average [ ] =2 Poor [ ] =3

Section 4: Landholding and farm characteristics

4.1 What is the total size of land managed by the household? _____ha

4.2 What proportion of land managed is owned by the household? All (100%) [ ] =1 Other:_____% [ ] =2

4.3 How is land managed by the household acquired?
Owned [ ] =1 Rented [ ] =2 Share-cropped [ ] =3 Borrowed [ ] =4 Leased [ ] =5

4.4 Number of land parcels managed by the household
1 [ ] =1 2 [ ] =2 3 [ ] =3 4 [ ] =4 5 [ ] =5 Other: _____ [ ] =6

4.5. Does your household have land not suitable for agriculture (e.g. wet, steep slopes, difficult access, away from home, etc)? Yes [ ] =1 No [ ] =2

4.5.1 If yes, please indicate the size of land managed by the household which is not suitable for agriculture: __ (ha)

4.6 Did the household receive any income (cash or in-kind) from renting or leasing the land in the last 12 months?
Yes [ ] =1 No [ ] =2

4.6.1. If yes, how many hectares of land did the household rented or leased in the last 12 months? _____ (ha)

4.6.2 What is the total value of income you received for this land in the last 12 months? ¢_____Cedis

Section 5: Household livelihood activities

5.1 Earnings from crop and livestock production

5.1.1 Indicate the type of food crops you cultivated in the last agricultural year, the quantity of crop harvested, the value of total income generated and the operational cost incurred

5.1.1 Crops cultivated by the household		5.1.2 Total quantity of crop harvested	5.1.3 Value of total income generated (¢ Cedis)	5.1.4 Estimated operational cost incurred (¢ Cedis)
01				
02				
03				
04				
05				
06				
07				
Other				

5.1.2 Please indicate the proportion of the households' total food needs which your household is able to produce (tick one answer) 0-25% [ ] =1 26-50% [ ] =2 51-75% [ ] =3 76-100% [ ] =4

5.1.3 Did you or any other member of the household owned livestock? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

5.1.3.1 If yes, indicate the type of livestock owned, number of animals the household currently own, number of animals sold in the last 12 months and amount received from selling the animals

5.1.3.1 Type of livestock		5.1.3.2 Number of animals the household currently own	5.1.3.3 Number of animals sold in the last 12 months	5.1.3.4 Total amount received from selling animals (¢ Cedis)
01				
02				
03				
04				
05				
Other				

5.2 Off-farm income generating activities

5.2.1 Did you or any other member of the household undertake any off-farm income generating activities in the last 12 months? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

5.2.2 If yes, indicate the type of off-farm income generating activities your household undertook in the last 12 months and the revenue generated from the activities

5.2.2 Type off-farm activity		5.2.3 Income generated (¢ Cedis)
01		
02		
03		
04		
05		
06		
07		
Other		

5.3 Transfers and remittances

5.3.1 Did you or any other member of the household receive money from relatives, organizations, friends, etc in the last 12 months? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

5.3.1.1 If yes, indicate the total amount of money you received in the last 12 months? ¢_____ Cedis

5.3.2 Please, indicate the source(s) of the transfers or remittances you received in the last 12 months
Social security / Social subsidies [ ] =1 Religious organizations [ ] =2 Retirement Pension [ ] =3 NGOs [ ] =4 Relatives [ ] =5 Family friends [ ] =6 Interest from bank savings [ ] =7 Rent from property or other assets

Section 6: Smallholder farm forest plantation development

6.1 Households knowledge in forest plantation development and future intentions

6.1.1 Have you or any member of your household participated in government or any other forest plantation development projects in the past? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

6.1.1.1 If yes, name the forest plantation projects(s) you were involved: _____

6.1.2 Have you or any member of your household owned cash crops such as cocoa or coffee plantations?
Yes [ ] =1 No [ ] =2 Don't know [ ] =3

6.1.2.1 If yes, please name the type of cash crop(s) owned: _____

6.1.3 The following are reasons often cited by people for not engaging in farm forest plantation development. Please use a scale from 1 - 5 to rank the following reasons in order of importance to you (i.e., 1 = most important reason(s) and 5 = least important reason(s)

Reasons		Ranking
01	I don't have knowledge about forest plantation management	
02	I don't have the necessary labor to tend the trees	
03	We have enough forests in this area	
04	My land is too small to establish forest plantation on it	
05	My land is too productive for forest plantation	
06	I am not allowed by my land owner to use the land to establish forest plantation	
07	Establishing forest plantation on my land will reduce its value	
08	I am not sure whether I will get market for the timber	
09	I am not sure whether I can make profit from forest plantation	
10	Other land use options offer better returns than forest plantation	
11	I am waiting for further changes in policy before deciding to establish forest plantation	
12	I am waiting until loans / credits become available for forest plantation development	
13	It takes too long for trees to mature	

6.1.4 Do you intend to establish farm forest plantation in the future? Yes [ ] =1 No [ ] =2 Don't know [ ] =3

6.1.4.1 If yes give reasons why you intend to establish farm forest plantation in the future
01. _____
02. _____
03. _____

6.1.4.2 If no what factors would influence you to establish farm forest plantation in the future?
01. _____
02. _____
03. _____

6.1.5 If you intend to establish farm forest plantation in the future, indicate who or where you would obtain advice or information concerning forest plantation development?
01. _____
02. _____
03. _____

6.1.6 How do you intend to finance your farm forest plantation?
Self-financed [ ] =1 Loan (from_____) [ ] =2 Credit (from____) [ ] =3 Other, _____ [ ] =4

6.1.7 Are you aware of the change in the forest policy regarding the ownership of forest plantation on private lands?
Yes [ ] =1 No [ ] =2

6.1.7.1 If yes, in what year did you become aware of this law? 19 _____ or 20 _____

6.1.8 Are you aware of the new policy regarding the granting of timber harvesting rights in respect of land with private forest plantation? Yes [ ] =1 No [ ] =2

6.1.8.1 If yes, in what year did you become aware of this law? 19 _____ or 20 _____

6.1.9 To what extent has the change in the forest policy influenced your decision to establish and manage farm forest plantation in the future? (Please tick one option)
Strong influence [ ] =1 Little influence [ ] =2 No influence [ ] =3 Don't know [ ] =4

Section 7: Household expenditure

7.1 Expenditure on food items

7.1.1 Please indicate the value of food consumed by your household in the last 7-days

Food Items		Estimated total expenditure on food (¢ Cedis)	Estimated value of consumption from households own production (¢ Cedis)	Estimated value of consumption bought from the market (¢ Cedis)
01	Cereals			
02	Roots and tubers			
03	Pulses and nuts			
04	Vegetables			
05	Fruit			
06	Oils and animal fats			
07	Meat products			
08	Eggs			
09	Fish			
10	Milk and milk products			
11	Spices			
12	Other food products			

7.2 Expenditure on non-food items

7.2.1 How much did your household spend on the following items in the last 30 days?

Non-Food Items		Estimated total expenditure (¢ Cedis)
01	Tobacco, cigarettes, etc	
02	Personal care items (e.g. soap, cream, etc)	
03	Kerosene, fuel wood	
04	Transportation (e.g. purchased fares, etc)	

7.2.2 How much did your household spend on the following items in the last 12 months?

Non-Food Items		Estimated total expenditure (¢ Cedis)
01	House rent	
02	House maintenance	
03	Furniture and other household items	
04	Water	
05	Electricity	
06	Telephone	
07	Vehicle	
08	Festivals/celebrations (e.g. wedding, funerals, etc	

7.2.3 How much did your household spend on clothing and footwear in the last 12 months?

Clothing and footwear		Estimated total expenditure (¢ Cedis)
01	Clothing for adult men	
02	Clothing for adult women	
03	Clothing for children (excluding school uniform)	
04	Footwear for adult men	
05	Footwear for adult women	
06	Footwear for children	

7.2.4 How much did your household spend on education in the last 12 months?

Education		Estimated total expenditure (¢ Cedis)
01	School uniform	
02	School fees	
03	Extra payment (e.g. payment for private classes, etc)	
04	Books and stationary	
05	Other education expenditure	

7.2.5 How much did your household spend on medicals and health care in the last 12 months?

Medicals and health care		Estimated total expenditure (¢ Cedis)
01	Medical consultation and treatment	
02	Medicines	
03	Other medical services	

7.2.6 How much did your household spend on entertainment and other non-food items in the last 12 months?

Non-Food Items		Estimated total expenditure (¢ Cedis)
Entertainment		
01	Film shows	
02	Concert	
Other non-food expenditure (specify)		

Thank you for your precious time

Appendix 2: Man-equivalent conversion ratios used to quantify household labor

Age Group (years)	Sex	Man-Equivalent Value
<10	Male	0.0
	Female	0.0
10-13	Male	0.2
	Female	0.2
14-16	Male	0.5
	Female	0.4
17-50	Male	1.0
	Female	0.8
>50	Male	0.7
	Female	0.5

Appendix 3: Inputs (labor and materials) required to establish and manage one hectare pure teak plantation over a 25-year rotation period

Inputs	Year																	
	0			1			2			3			4			5		
	Qty	Price / Unit	Amt. ($)	Qty	Price / Unit	Amt. ($)	Qty	Price / Unit	Amt. ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Land preparation (Md)	116	2.2	255															
Pegging (Md)	10	2.2	22															
Planting Materials																		
Teak seedlings (No./ha)	1,200	0.06	72	300	0.06	18												
Pegs (No./ha)	1,200	0.01	12															
Planting																		
Teak seedlings (Md)	10	2.2	22	4	2.2	8.8												
Transportation																		
Teak seedlings (No./trip)	1,200	0.02	24	300	0.02	6												
Weeding/Tending																		
Weeding (Md)	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	15	2.2	33
Fire protection (Md)	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66
Thinning (Md)																30	2.2	66
Pruning (Md)																45	2.2	99
Total			**539.0**			**165.0**			**132.0**			**132.0**			**132.0**			**264.0**

Source: Calculations based on field data, 2006

Continuation of Appendix 3: Inputs (labor and materials) required to establish and manage one hectare pure teak plantation over a 25-year rotation period

Inputs	Year																	
	6			7			8			9			10			11-25		
	Qty	Price / Unit	Amt. ($)	Qty	Price / Unit	Amt. ($)	Qty	Price / Unit	Amt. ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Weeding/Tending																		
Weeding (Md)	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33			
Fire protection (Md)	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33			
Thinning (Md)													25	2.2	55			
Pruning (Md)													15	2.2	33			
Total			**66.0**			**66.0**			**66.0**			**66.0**			**154.0**			**0.0**

Source: Calculations based on field data, 2006

Appendix 4: Benefits (outputs) from one hectare pure teak plantation over a 25-year rotation period

Benefits (Outputs)	Year															
	0-9		10		11-14		15		16-19		20		21-24		25	
	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)
Telephone poles (No./ha)			150	1,140												
Low tension poles (No.ha)							100	2,280								
High tension poles (No./ha)											100	3,260				
Saw logs (No./ha)															150	5,700
Total	**0.0**	**0.0**		**1,140.0**	**0.0**	**0.0**		**2,280.0**	**0.0**	**0.0**		**3,260.0**	**0.0**	**0.0**		**5,700.0**

Tree price: Telephone pole =$7.6; Low tension pole = $22.8; High tension pole = $32.6; Saw log = $38.0 Source: Calculations based on field data, 2006

Appendix 5: Net Present Value (NPV) for one hectare pure teak plantation over a 25-year rotation period

Costs (expenditures)	Rotation period (years)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
	($)												
Land preparation	255.2												
Teak seedlings	72.0	18.0											
Pegs	12.0												
Pegging	22.0												
Planting (teak)	22.0	8.8											
Transportation (teak seedlings)	24.0	6.0											
Weeding/Tending	66.0	66.0	66.0	66.0	66.0	198.0	33.0	33.0	33.0	33.0	121.0		
Fire protection	66.0	66.0	66.0	66.0	66.0	66.0	33.0	33.0	33.0	33.0	33.0		
Sum of expenditures	**539.2**	**164.8**	**132.0**	**132.0**	**132.0**	**264.0**	**66.0**	**66.0**	**66.0**	**66.0**	**154.0**	**0.0**	**0.0**
Revenues (receipts)													
Yield from thinning teak											1140.0		
Final teak harvest													
Sum of receipts	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1,140.0**	**0.0**	**0.0**
Net cash flow	-539.2	-164.8	-132	-132	-132.0	-264	-66	-66	-66	-66	986	0.0	0.0
Cumulative net cash flow	-539.2	-704	-836	-968	-1,100	-1,364	-1,430	-1,496	-1,562	-1,628	-642	-642	-642
Discount factor	1.00	0.89	0.79	0.70	0.62	0.55	0.49	0.44	0.39	0.34	0.31	0.27	0.24
Discounted net cash flow	-539.2	-146.7	-104.3	-92.4	-81.8	-145.2	-32.3	-29	-25.7	-22.4	305.7	0.0	0.0
Cumulative discounted net cash flow	-539.2	-685.9	-790.2	-882.6	-964.4	-1,109.6	-1,141.9	-1,171	-1,196.7	-1,219.2	-913.5	-913.5	-913.5

Source: Calculations based on field data, 2006

Continuation of Appendix 5: Net Present Value (NPV) for one hectare pure teak plantation over a 25-yeaar rotation period

Costs (expenditures)	Rotation period (years)												
	13	14	15	16	17	18	19	20	21	22	23	24	25
	($)												
Land preparation													
Teak seedlings													
Pegs													
Pegging													
Planting (teak)													
Transportation (teak seedlings)													
Weeding/Tending													
Fire protection													
Sum of expenditures	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Revenues (receipts)													
Yield from thinning teak			2,280					3,260					
Final teak harvest													5,700
Sum of receipts	**0.0**	**0.0**	**2,280.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3,260.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5,700.0**
Net cash flow	0.0	0.0	2,280	0.0	0.0	0.0	0.0	3,260	0.0	0.0	0.0	0.0	5,700
Cumulative net cash flow	-642	-642	1,638	1,638	1,638	1,638	1,638	4,898	4,898	4,898	4,898	4,898	10,598
Discount factor	0.21	0.19	0.17	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05
Discounted net cash flow	0.0	0.0	387.6	0.0	0.0	0.0	0.0	293.4	0.0	0.0	0.0	0.0	285
Cumulative discounted net cash flow	-913.5	-913.5	-525.9	-525.9	-525.9	-525.9	-525.9	-232.5	-232.5	-232.5	-232.5	-232.5	52.5

NPV @ 12.6 Discount Rate = $52.5; B/C = 6.95 Source: Calculations based on field data, 2006

Appendix 6: Inputs (labor and materials) required to establish and manage one hectare teak plantation inter-cropped with food crops over a 25-year rotation period

Inputs	Year																	
	0			1			2			3			4			5		
	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Land preparation (Md)	116	2.2	255.2															
Pegging (Md)	10	2.2	22.0															
Fertilizer application (Md)	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0						
Planting Materials																		
Teak seedlings (No./ha))	1,200	0.06	72.0	300	0.06	18.0												
Maize seeds (Kg/ha)	25	0.8	20.0	23	0.8	18.4	20	0.8	16.0	18	0.8	14.4						
Plantain suckers (No./ha)	600	0.2	120.0	150	0.2	30.0	100	0.2	20.0	50	0.2	10.0						
Pegs (No./ha)	1,200	0.01	12.0															
Fertilizer (Bag/ha)	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0						
Planting																		
Teak seedlings (Md)	10	2.2	22.0	4	2.2	8.8												
Maize seeds (Md)	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0						
Plantain suckers (Md)	35	2.2	77.0	20	2.2	44.0	15	2.2	33.0	10	2.2	22.0						
Harvesting																		
Maize (Md)	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0						
Plantain (Md)				15	2.2	33.0	10	2.2	22.0	8	2.2	17.6	7	2.2	15.4			
Transportation																		
Teak seedlings (No./trip)	1,200	0.02	24.0	300	0.02	6.0												
Plantain suckers (No./trip)	600	0.2	120.0	150	0.2	30.0	100	0.2	20.0	50	0.2	10.0						
Maize to house (Bags/trip)	25	2.7	67.5	22	2.7	59.4	20	2.7	54.0	18.5	2.7	50.0						
Plantain to house (Bunches/trip)				400	0.2	80.0	350	0.2	70.0	250	0.2	50.0	150	0.2	30.0			
Post-harvest processing (maize)	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0						
Weeding / Tending																		
Weeding (Md)	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	15	2.2	33
Fire protection (Md)	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66	30	2.2	66
Thinning (Md)																30	2.2	66
Pruning (Md)																45	2.2	99
Total			**1,364.7**			**880.6**			**788.0**			**727.0**			**177.4**			**264.0**

Source: Calculations based on field data, 2006

Continuation of Appendix 6: Inputs (labor and materials) required to establish and manage one hectare teak plantation inter-cropped with food crops over a 25-year rotation period

Inputs	Year																	
	6			7			8			9			10			11-25		
	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Weeding / Tending																		
Weeding (Md)	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33			
Fire protection (Md)	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33	15	2.2	33			
Thinning (Md)													25	2.2	55			
Pruning (Md)													15	2.2	33			
Total			**66.0**			**66.0**			**66.0**			**66.0**			**154.0**	**0.0**		**0.0**

Source: Calculations based on field data, 2006

Appendix 7: Benefits (outputs) from one hectare teak plantation inter-cropped with food crops over a 25-year rotation period

Benefits (Outputs)	Year															
	0		1		2		3		4		10		15		20	
	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)
Food crops																
Maize yield (Bags/ha)	25	542.5	22	477.4	20	434	18.5	401.5								
Plantain yield (Bunches/ha)			400	640	350	560	250	400	150	240						
Tree crop (Teak)																
Telephone poles (No./ha)											150	1,140				
Low tension poles (No./ha)													100	2,280		
High tension poles (No./ha)															100	3,260
Saw logs (No./ha)																
Total		**542.5**		**1,117.4**		**994.0**		**801.5**		**240.0**		**1,140.0**		**2,280.0**		**3,260.0**

Tree price: Telephone pole =$7.6; Low tension pole = $22.8; High tension pole = $32.6; Saw log = $38.0; Maize price: Bag (50 Kg) = $21.70; Plantain price: Bunch = $1.60

Source: Calculations based on field data, 2006

Appendix 8: Net Present Value (NPV) for one hectare teak plantation inter-cropped with food crops over a 25-year rotation period

Costs (expenditures)	Rotation period (years)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
	($)												
Land preparation	255.2												
Pegging	22.0												
Fertilizer application	88.0	88.0	88.0	88.0									
Planting material													
Teak seedlings	72.0	18.0											
Maize seeds	20.0	18.4	16.0	14.4									
Plantain suckers	120.0	30.0	20.0	10.0									
Pegs	12.0												
Fertilizer	135.0	135.0	135.0	135.0									
Planting													
Teak seedlings	22.0	8.8											
Maize seeds	22.0	22.0	22.0	22.0									
Plantain suckers	77.0	44.0	33.0	22.0									
Harvesting													
Maize	33.0	33.0	33.0	33.0									
Plantain		33.0	22.0	17.6	15.4								
Transportation													
Teak seedlings	24.0	6.0											
Plantain suckers	30.0	7.5	5.0	2.5									
Maize to house	7.5	6.6	6.0	5.6									
Plantain to house		80.0	70.0	50.0	30.0								
Post-harvest processing (maize)	143.0	143.0	143.0	143.0									
Weeding / Tending	66.0	66.0	66.0	66.0	66.0	198.0	33.0	33.0	33.0	33.0	121.0		
Fire protection	66.0	66.0	66.0	66.0	66.0	66.0	33.0	33.0	33.0	33.0	33.0		
Sum of expenditures	**1,214.7**	**805.3**	**725.0**	**675.1**	**177.4**	**264.0**	**66.0**	**66.0**	**66.0**	**66.0**	**154.0**	**0.0**	**0.0**
Revenues (receipts)													
Maize yield	542.5	477.4	434	401.5									
Plantain yield		640	560	400	240								
Yield from thinning teak											1,140.0		
Final teak harvest													
Sum of receipts	**542.5**	**1,117.4**	**994.0**	**801.5**	**240.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**1,140.0**	**0.0**	**0.0**
Net cash flow	-672.2	312.1	269	126.4	62.6	-264	-66	-66	-66	-66	986	0.0	0.0
Cumulative net cash flow	-672.2	-360.1	-91.1	35.3	97.9	-166.2	-232.2	-298.2	-364.2	-430.2	555.9	555.9	555.9
Discount factor	1.00	0.89	0.79	0.70	0.62	0.55	0.49	0.44	0.39	0.34	0.31	0.27	0.24
Discounted net cash flow	-672.2	277.8	212.5	88.4	38.8	-145.2	-32.3	-29	-25.7	-22.4	305.7	0.0	0.0
Cumulative discounted net cash flow	-672.2	-394.4	-181.9	-93.5	-54.7	-199.9	-232.2	-261.2	-287	-309.4	-3.8	-3.8	-3.8

Source: Calculations based on field data, 2006

Continuation of Appendix 8: Net Present Value (NPV) for one hectare teak plantation inter-cropped with food crops over a 25-year rotation period

Costs (expenditures)	Rotation period (years)												
	13	14	15	16	17	18	19	20	21	22	23	24	25
	($)												
Sum of expenditures	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Revenues (receipts)													
Maize yield													
Plantain yield													
Yield from thinning teak			2,280					3,260					
Final teak harvest													5,700
Sum of receipts	**0.0**	**0.0**	**2,280.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3,260.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5,700.0**
Net cash flow	0.0	0.0	2280	0.0	0.0	0.0	0.0	3,260	0.0	0.0	0.0	0.0	5,700
Cumulative net cash flow	555.9	555.9	2,835.9	2,835.9	2,835.9	2,835.9	2,835.9	6,095.9	6,095.9	6,095.9	6,095.9	6,095.9	11,795.9
Discount factor	0.21	0.19	0.17	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05
Discounted net cash flow	0.0	0.0	387.6	0.0	0.0	0.0	0.0	293.4	0.0	0.0	0.0	0.0	285
Cumulative discounted net cash flow	-3.8	-3.8	383.8	383.8	383.8	383.8	383.8	677.2	677.2	677.2	677.2	677.2	962.2

NPV @ 12.6 Discount Rate = $962.2; B/C = 3.76 Source: Calculations based on field data, 2006

Appendix 9: Inputs (labor and materials) required to cultivate one hectare maize-plantain over a 25-year rotation period

Inputs	Year														
	0			1			2			3			4		
	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Land preparation (Md)	116	2.2	255.2												
Fertilizer application (Md)	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0			
Planting Materials															
Maize seeds (Kg/ha)	25	0.8	20.0	23	0.8	18.4	20	0.8	16.0	18	0.8	14.4			
Plantain suckers (No./ha)	1,500	0.2	300.0	350	0.2	70.0	200	0.2	40.0	100	0.2	20.0			
Fertilizer (Bags/ha)	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0			
Planting															
Maize seeds (Md)	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0			
Plantain suckers (Md)	65	2.2	143.0	45	2.2	99.0	25	2.2	55.0	15	2.2	33.0			
Harvesting															
Maize (Md)	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0			
Plantain (Md)				75	2.2	165.0	60	2.2	132.0	55	2.2	121.0	35	2.2	77.0
Transportation															
Plantain suckers (No./trip)	1,500	0.2	300.0	350	0.2		200	0.2		100	0.2				
Maize to house (Bags/trip)	25	2.7	67.5	22	2.7		20	2.7		18.5	2.7				
Plantain to house (Bunches/trip)	750	0.2	150.0	550	0.2	110.0	450	0.2	90.0	200	0.2	40.0			
Processing (Maize)	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0			
Weeding (Md)	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0
Fire protection (Md)	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0
Total			**1,788.7**			**1,015.4**			**886.0**			**781.4**			**209.0**

Source: Calculations based on field data, 2006

Continuation of Appendix 9: Inputs (labor and materials) required to cultivate one hectare maize-plantain over a 25-year rotation period

Inputs	Year														
	8			9			10			11			12		
	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Land preparation (Md)	116	2.2	255.2												
Fertilizer application (Md)	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0			
Planting Materials															
Maize seeds (Kg/ha)	25	0.8	20.0	23	0.8	18.4	20	0.8	16.0	18	0.8	14.4			
Plantain suckers (No./ha)	1,500	0.2	300.0	350	0.2	70.0	200	0.2	40.0	100	0.2	20.0			
Fertilizer (Bags/ha)	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0			
Planting															
Maize seeds (Md)	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0			
Plantain suckers (Md)	65	2.2	143.0	45	2.2	99.0	25	2.2	55.0	15	2.2	33.0			
Harvesting															
Maize (Md)	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0			
Plantain (Md)				35	2.2	77.0	25	2.2	55.0	20	2.2	44.0	8	2.2	17.6
Transportation															
Plantain suckers (No./trip)	1,500	0.2	300.0	350	0.2	70.0	200	0.2	40.0	100	0.2	20.0			
Maize to house (Bags/trip)	25	2.7	67.5	22	2.7	59.4	20	2.7	54.0	18.5	2.7	50.0			
Plantain to house (Bunches/trip)	650	0.2	130.0	500	0.2	100.0	350	0.2	70.0	150	0.2	30.0			
Post-harvest processing															
Maize (Md)	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0			
Weeding / Tending															
Weeding (Md)	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0
Fire protection (Md)	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0
Total			**1,768.7**			**1,046.8**			**883.0**			**764.4**			**149.6**

Source: Calculations based on field data, 2006

Continuation of Appendix 9: Inputs (labor and materials) required to cultivate one hectare maize-plantain over a 25-year rotation period

Inputs	Year														
	16			17			18			19			20		
	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Land preparation (Md)	116	2.2	255.2												
Fertilizer application (Md)	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0	40	2.2	88.0			
Planting Materials						0.0									
Maize seeds (Kg/ha)	25	0.8	20.0	23	0.8	18.4	20	0.8	16.0	18	0.8	14.4			
Plantain suckers (No./ha)	1,500	0.2	300.0	350	0.2	70.0	200	0.2	40.0	100	0.2	20.0			
Fertilizer (Bags/ha)	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0	7.5	18	135.0			
Planting						0.0									
Maize seeds (Md)	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0	10	2.2	22.0			
Plantain suckers (Md)	65	2.2	143.0	45	2.2	99.0	25	2.2	55.0	15	2.2	33.0			
Harvesting						0.0									
Maize (Md)	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0	15	2.2	33.0			
Plantain (Md)				35	2.2	77.0	25	2.2	55.0	20	2.2	44.0	8	2.2	17.6
Transportation						0.0									
Plantain suckers (No./trip)	1,500	0.2	300.0	350	0.2	70.0	200	0.2	40.0	100	0.2	20.0			
Maize to house (Bags/trip)	25	2.7	67.5	22	2.7	59.4	20	2.7	54.0	18.5	2.7	50.0			
Plantain to house (Bunches/trip)	500	0.2	100.0	300	0.2	60.0	200	0.2	40.0	100	0.2	20.0			
Post-harvest processing															
Maize (Md)	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0	65	2.2	143.0			
Weeding / Tending															
Weeding (Md)	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0
Fire protection (Md)	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0	30	2.2	66.0
Total			**1,738.7**			**1,006.8**			**853.0**			**754.4**			**149.6**

Source: Calculations based on field data, 2006

Continuation of Appendix 9: Inputs (labor and materials) required to cultivate one hectare maize-plantain over a 25-year rotation period

Inputs	Year					
	24			25		
	Qty	Price / Unit	Amt ($)	Qty	Price / Unit	Amt ($)
Land preparation (Md)	116	2.2	255.2			
Fertilizer application (Md)	40	2.2	88.0	40	2.2	88.0
Planting Materials						
Maize seeds (Kg/ha)	25	0.8	20.0	23	0.8	18.4
Plantain suckers (No./ha)	1,500	0.2	300.0	350	0.2	70.0
Fertilizer (Bags/ha)	7.5	18	135.0	7.5	18	135.0
Planting						
Maize seeds (Md)	10	2.2	22.0	10	2.2	22.0
Plantain suckers (Md)	65	2.2	143.0	45	2.2	99.0
Harvesting						
Maize (Md)	15	2.2	33.0	15	2.2	33.0
Plantain (Md)				35	2.2	77.0
Transportation						
Plantain suckers (No./trip)	1,500	0.2	300.0	350	0.2	70.0
Maize to house (Bags/trip)	25	2.7	67.5	22	2.7	59.4
Plantain to house (Bunches/trip)				350	0.2	70.0
Post-harvest processing						
Maize (Md)	65	2.2	143.0	65	2.2	143.0
Weeding / Tending						
Weeding (Md)	30	2.2	66.0	30	2.2	66.0
Fire protection (Md)	30	2.2	66.0	30	2.2	66.0
Total			**1,638.7**			**1,016.8**

Source: Calculations based on field data, 2006

Appendix 10: Benefits (outputs) from one hectare maize-plantain cultivation over a 25-year rotation period

Benefits (Outputs)	Year																	
	0		1		2		3		4		8		9		10		11	
	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)
Maize yield (Bags/ha)	25	542.5	22	477.4	20	434	18.5	401.5			25	542.5	22	477.4	20	434.0	18.5	401.5
Plantain yield (Bunches/ha)			750	1,200	550	880	450	720	200	320			650	1,040	500	800	350	560
Total		**542.5**		**1,677.4**		**1,304.0**		**1,121.5**		**320.0**		**542.5**		**1,517.4**		**1,234.0**		**961.5**

Benefits (Outputs)	12		16		17		18		19		20		24		25	
	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)	Qty	Amt ($)
Maize yield (Bags/ha)			25	542.5	22	477.4	20	434	18.5	401.5			25	542.5	22	477.4
Plantain yield (Bunches/ha)	150	240			500	800	300	480	200	320	100	160			350	560
Total		**240.0**		**542.5**		**1,277.4**		**914.0**		**721.5**		**160.0**		**542.5**		**1,037.4**

Source: Calculations based on field data, 2006

Appendix 11: Net Present Value (NPV) for one hectare maize-plantain cultivation over a 25-year rotation period

Costs (expenditures)	Rotation period (years)												
	0	1	2	3	4	5	6	7	8	9	10	11	12
	($)												
Land preparation	255.2								255.2				
Fertilizer application	88.0	88.0	88.0	88.0					88.0	88.0	88.0	88.0	
Planting material													
Maize seeds	20.0	18.4	16.0	14.4					20.0	18.4	16.0	14.4	
Plantain suckers	300.0	70.0	40.0	20.0					300.0	70.0	40.0	20.0	
Fertilizer	135.0	135.0	135.0	135.0					135.0	135.0	135.0	135.0	
Planting													
Maize seeds	22.0	22.0	22.0	22.0					22.0	22.0	22.0	22.0	
Plantain suckers	143.0	55.0	44.0	33.0					143.0	55.0	44.0	33.0	
Harvesting													
Maize	33.0	33.0	33.0	33.0					33.0	33.0	33.0	33.0	
Plantain		77.0	55.0	44.0	33.0					77.0	55.0	44.0	33.0
Transportation													
Plantain suckers	75.0	17.5	10.0	5.0					75.0	17.5	10.0	5.0	
Maize to house	7.5	6.6	6.0	5.6					7.5	6.6	6.0	5.6	
Plantain to house		150.0	110.0	90.0	40.0					130.0	100.0	70.0	30.0
Post-harvest processing													
Maize	143.0	143.0	143.0	143.0					143.0	143.0	143.0	143.0	
Weeding/Tending	66.0	66.0	66.0	66.0	66.0				66.0	66.0	66.0	66.0	66.0
Fire protection	66.0	66.0	66.0	66.0	66.0				66.0	66.0	66.0	66.0	66.0
Sum of expenditures	**1,353.7**	**947.5**	**834.0**	**765.0**	**205.0**	**0.0**	**0.0**	**0.0**	**1,353.7**	**927.5**	**824.0**	**745.0**	**195.0**
Revenues (receipts)													
Maize yield	542.5	477.4	434.0	401.5					542.5	477.4	434.0	401.5	
Plantain yield		1200	880	720	320					1,040	800	560	240
Sum of receipts	**542.5**	**1,677.4**	**1,314.0**	**1,121.5**	**320.0**	**0.0**	**0.0**	**0.0**	**542.5**	**1,517.4**	**1,234.0**	**961.5**	**240.0**
Net cash flow	-811.2	729.9	480	356.5	115	0.0	0.0	0.0	-811.2	589.9	410	216.5	45
Cumulative net cash flow	-811.2	-81.3	398.7	755.2	870.2	870.2	870.2	870.2	59	648.9	1,058.9	1,275.4	1,320.4
Discount factor	1.00	0.89	0.79	0.70	0.62	0.55	0.49	0.44	0.39	0.34	0.31	0.27	0.24
Discounted net cash flow	-811.2	649.6	379.2	249.6	71.3	0.0	0.0	0.0	-316.4	200.6	127.1	58.5	10.8
Cumulative discounted net cash flow	-811.2	-161.6	217.6	467.2	538.5	538.5	538.5	538.5	222.1	422.7	549.8	608.2	619

Source: Calculations based on field data, 2006

Continuation of Appendix 11: Net Present Value (NPV) for one hectare maize-plantain cultivation over a 25-year rotation period

Costs (expenditures)	Rotation period (years)												
	13	14	15	16	17	18	19	20	21	22	23	24	25
	($)												
Land preparation				255.2								255.2	
Fertilizer application				88.0	88.0	88.0	88.0					88.0	88.0
Planting material													
Maize seeds				20.0	18.4	16.0	14.4					20.0	18.4
Plantain suckers				300.0	70.0	40.0	20.0					300.0	70.0
Fertilizer				135.0	135.0	135.0	135.0					135.0	135.0
Planting													
Maize seeds				22.0	22.0	22.0	22.0					22.0	22.0
Plantain suckers				143.0	55.0	44.0	33.0					143.0	55.0
Harvesting													
Maize				33.0	33.0	33.0	33.0					33.0	33.0
Plantain					77.0	55.0	44.0	33.0					77.0
Transportation													
Plantain suckers				75.0	17.5	10.0	5.0					75.0	17.5
Maize to house				7.5	6.6	6.0	5.6					7.5	6.6
Plantain to house					100.0	60.0	40.0	20.0					70.0
Post-harvest processing													
Maize				143.0	143.0	143.0	143.0					143.0	143.0
Weeding/Tending				66.0	66.0	66.0	66.0	66.0				66.0	66.0
Fire protection				66.0	66.0	66.0	66.0	66.0				66.0	66.0
Sum of expenditures	**0.0**	**0.0**	**0.0**	**1,353.7**	**8,97.5**	**784.0**	**715.0**	**185.0**	**0.0**	**0.0**	**0.0**	**1,353.7**	**867.5**
Revenues (receipts)													
Maize yield				542.5	477.4	434	401.5					542.5	477.4
Plantain yield					800	480	320	160					560
Sum of receipts	**0.0**	**0.0**	**0.0**	**542.5**	**1,277.4**	**914.0**	**721.5**	**160.0**	**0.0**	**0.0**	**0.0**	**5,42.5**	**1,037.4**
Net cash flow	0.0	0.0	0.0	-811.2	379.9	130	6.5	-25	0.0	0.0	0.0	-811.2	169.9
Cumulative net cash flow	1,320.4	1,320.4	1,320.4	509.2	889.1	1,019.1	1,025.6	1,000.6	1,000.6	1,000.6	1,000.6	189.4	359.3
Discount factor	0.21	0.19	0.17	0.15	0.13	0.12	0.10	0.09	0.08	0.07	0.06	0.06	0.05
Discounted net cash flow	0.0	0.0	0.0	-121.7	49.4	15.6	0.7	-2.3	0.0	0.0	0.0	-48.7	8.5
Cumulative discounted net cash flow	619	619	619	497.3	546.7	562.3	563	560.7	560.7	560.7	560.7	512	520.5

NPV @ 12.6 Discount Rate = $520.5; B/C = 1.03 Source: Calculations based on field data, 2006

Erklärung

Hiermit versichere ich, dass ich die vorliegende Arbeit ohne unzulässige Hilfe Dritter und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe; die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als diese kenntlich gemacht worden. Bei der Auswahl und Auswertung des Materials sowie bei der Herstellung des Manuskriptes habe ich Unterstützungsleistungen von folgenden Personen erhalten: keine.

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Bernard Nsiah

Dresden, 23.06.2010