CONTRIBUTION OF MODIFIED TAUNGYA SYSTEM TO FOREST COVER AND LIVELIHOODS OF FOREST-FRINGE COMMUNITIES. A CASE STUDY OF WOROBONG SOUTH FOREST RESERVE IN GHANA

BY

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(10362346)

THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA, LEGON IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF M.PHIL ENVIRONMENTAL SCIENCE DEGREE

JULY, 2014

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DECLARATION

I hereby declare that except for references to other researcher's whose works have been duly cited, this is the results of my own research work. Besides, this research work has not been presented elsewhere for another degree.

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DEDICATION

I dedicate this work to the glory of the Almighty God for His favour and grace throughout this Thesis. To him be all the glory, honour and adoration. Amen.

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I wish to express my profound gratitude to my supervisors; Prof. G. K. Ameka (Dept. of Plant and Environmental Biology, UG-Legon and Dr. Ted Y. Annang (IESS, UG-Legon) for their invaluable contributions to this research work. May the Almighty God bless them richly. My thanks also go to all the lecturers as well as the Administrative staff of the Environmental Science Programme.

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ABSTRACT

Decline of natural forest cover through deforestation in Ghana has reached a critical stage. Loss of forest poses many problems, mostly to the communities that rely on the forests for their livelihoods. In the last decade several schemes to protect the remaining forest, restore degraded areas and improve people's access to forest resources have been introduced, of which the Modified Taungya System (MTS), an agro-forestry system, is one of them. The objective of this thesis was to examine the role of the MTS in contributing to forest restoration and improving livelihoods of farmers within the Worobong South Forest Reserve (WSFR, Akim portion). Geographic Information System (GIS) and Remote Sensing (RS) were used to assess the extent of forest cover change from 1990-2010. Analysis of the contribution of the MTS Scheme to forest cover restoration was also carried out by comparing the natural forest to the MTS plantation by using the 100 m x 100 m square transect techniques and applying the Simpson's Index of Diversity. A socio-economic survey involving semi-structured interviews was carried out to seek the opinion of the MTS farmers in the Akwansrem, Feyiase and Miaso communities and forestry officials on forest restoration as well as the contribution of the MTS to livelihoods of farmers in the study area.

The results of the study indicated that the forest cover in the WSFR had witnessed varying rates of transformation and/or improvement particularly in the closed forest canopy. The forest cover had decreased by 0.41% and 0.17% between 1990-2000 and 2000-2010 respectively. However, in terms of forest vegetation classes, a significant transformation was observed within the closed canopy. Between 1990-2000, the closed canopy experienced a percentage decrease of 45.55% but increased by 1.25% (41.4 ha) between 2000-2010. It was projected that between 2010-2020, there will be

further improvement in the closed canopy if current rate of restoration continuous. Results from the calculation of the Simpson's Index of Diversity indicated that the natural forest transect was more diverse (1-D = 0.93) in terms of richness and evenness, than the MTS transect (1-D = 0.41). However, stem counts was close to 50% higher favouring the MTS plantation. Information from the study indicated that between 600 to 800 trees on a 0.8 ha land was planted by individual farmers annually on degraded lands. Improvement of close forest canopy within WSFR was attributed to the success of the MTS scheme. The results also indicated that the livelihoods of MTS farmers (with reference to their access to income and farm produce as well as their ability to afford the education of their children and put up buildings) had improved. However, fear of future prospects and sustainability of the MTS, unequal allocation of MTS farms, wildfires and illegal logging were some issues they saw as threats to the scheme. As a result, a number of recommendations were made. Some of these were: Regular assessment of the composition and spatial extent of the forest cover to keep track of changes through the application of GIS and RS; The need to clarify the dictates and benefits of the MTS scheme to farming communities and; the enforcement of laws to cater for policies that will ensure sustainable management of the forest.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Forests play multiple roles at international, regional and local levels. It serves as a source of economically valued products – industrial wood, wood fuel, non-wood forest products such as fibre, food, medicines; soil generation, soil and water conservation. Other services provided by forests include purification of air and water, nutrient recycling, maintenance of biological diversity (habitats, species and genetic resources), mitigation of climate change and carbon sequestration and a shelter for the vast majority of terrestrial biodiversity. Forests provide employment and income generation, recreation, and protection of natural and cultural heritage (World Bank, 2005). Moreover, the Food and Agriculture Organization (FAO, 2001) estimates that 60 million indigenous people live within forests and wholly depend on them. Much larger numbers live on the fringes of forests, with some degree of dependency; thus dependence of people on trees and forests is unlimited. The World Bank also reported that almost 1.6 billion people in the world rely on forest resources for their livelihood (World Bank, 2001) and 86% of rural people (2.6 billion) are engaged in agriculture (including forestry) to generate food and cash (Crowley, 2010).

However, the rate of deforestation is increasing worldwide due to the transformation of forests through farming activities including commercial plantations and shifting cultivation, as well as logging, fuel wood collection, grazing and increasing urbanisation and industrialisation. About 80% of the world‟s forest areas decreased drastically over the past three decades reducing the earth‟s ability to absorb carbon dioxide (UNEP, 2000). According to the United Nations Food and Agricultural Organization, about 30% of forest area was lost between 1990 and 2005 alone (FAO,

2006). This situation has rather contributed to the release of high levels of green house gases into the atmosphere because trees are cut down (World Bank, 2010).

Forest resources in Ghana‟s forest zones have been depleted at an alarming rate. Ghana lost approximately 80% (8 m ha – 1.6 m ha) of its forest cover between 1900 and 1990, affecting biodiversity as well as crucial sources of livelihood for the rural populations (Ghana Forestry Commission, 2002; Opoku 2006). The Ghana Forestry Commission (2002) further noted that some forest reserves such as Pamu Berekum in the Brong Ahafo Region have lost over 98% of its forested cover within the same period.

According to Opoku (2006), the role of forest-fringe communities, in the massive destruction of forest has led to describing the forest as an "economic, social and human rights‟ decay." Reforestation and plantation schemes are therefore becoming increasingly important as a means of replenishing the deforested and degraded natural forests. The Forest and Wildlife Policy established in Ghana in 1994, stresses the importance of collaborative forestry management (CFM) and Community Based Natural Resource Management (CBNRM) and this has served as a catalyst in introducing several schemes to improve people's access to forest and tree resources. Furthermore, efforts have been made to protect remaining forests by creating forest reserves, resulting in two management schemes for Ghana‟s forests: forest reserves and off reserves (IUCN, 1996).

Reforestation and plantation schemes in the degraded parts of the forest reserves include the Modified Taungya System (MTS); while private timber tree plantations are notable in the off-reserve areas. All these schemes fall under the umbrella of the National Forest Plantation Development Programme (NFPDP) launched in 2001. The

1994 forest and wildlife policy aims at "conservation and sustainable development of the nation"s forest and wildlife resources for the maintenance of environmental quality and perpetual flow of optimum benefits to all segments of society" (MLF, 1996). This was followed with the re-launch of the NFPDP in 2001. The aims of the NFPDP are to stimulate participation of farmers in the programme with the view to restore lost forest (FPDC, 2002), enhance food security and ultimately reduce poverty (Ghana Forestry Commission, 2004). The MTS is a modification of the Traditional Taungya System (TTS) adopted for implementing the NFPDP.

The TTS, involved inter-planting of crops and trees, aimed at producing commercial timber and food crops. Through the TTS, 35,000 ha of forest plantations had been established as at 2000 (Agyeman *et al*., 2003). However, records at the Forest Service Division (FSD) confirmed that there were mixed successes. Major challenges attributed to the mixed success included problems of species-site-matching, inadequate expertise and supervision. Notable abuses of the TTS included farming in unauthorised forestlands and destruction of tree seedlings. In 1984, the TTS was suspended (IUCN, 1996). In spite of the challenges and abuses, forest communities requested for its re-introduction with changes, because Taungya is viewed as a beneficial forest tenure system for restoring forest cover and improve farmers" wellbeing (FAO, 2003). The TTS was therefore modified under the 1994 Forest and Wildlife Policy ratified by Ministry of Lands and Forestry (MLF) into the MTS, (MLF,1996). This is expected to help achieve the NFPDP goals. The NFPDP is aimed at encouraging the development of a sustainable forest resource base that will satisfy future demand for industrial timber and enhance environmental quality. Also, the programme is expected to generate jobs and significantly increase food production in

the country thereby contributing to wealth creation and reduction in rural poverty (NFPDP, 2008).

1.2 Problem Statement

Forest and forest products are the main source of livelihood for 70% of Ghanaians (ISSER, 2008). The Forestry sector directly employs 75,000 people and provides livelihoods for over 2 million people countrywide (FAO, 2002). In addition to providing fuel wood, bush meat, medicinal plants and other natural products, the forest contributes significantly to the agricultural, economic and socio-cultural welfare of most Ghanaians (FAO, 2002). However, with the expected population explosion in the coming years, and the attendant rippling demand for economic and social development, forest reserves have been affected negatively mainly by agricultural activities, human-induced bush fires and illegal logging (Seneadza, 2010). These activities destroy the natural forest canopy and subsequently endanger certain flora and fauna species in the forest. Other effects are the alteration in rainfall pattern, food insecurity, increased surface temperatures resulting from global warming which is having a debilitating effect on the livelihoods of the inhabitants living in and around the fringes of forest reserves (Seneadza, 2010).

Ghana‟s forest cover has shrunk from 8.2 million hectares to 1.8 million hectares in less than a century with the last 20 years alone witnessing significant reduction in the forest cover (FAO, 2005). According to the Ghana Forestry Commission (2002) some forest reserves have lost over 98% of its forest cover within the period. The only significant forest left in Ghana is in the Western Region which covers about 64% of the region. Other regions in the High Forest Zone (HFZ) have a total of 10% to 24% forest cover remaining (Ghana Forestry Commission, 2002). Ghana‟s population has

also increased at a rate of about 2.1% per annum, from 19.3 million in 2000 to 24.3 in 2010. It is further estimated that this will increase to 25.1 million by 2015 (Ghana Statistical Service, 2012), and as the population increases, there is increased pressure to convert "unused" (mostly forested) land into agricultural lands, human settlements, for industrial developments and other economic activities. Timber from the High Forest Zone (HFZ) has traditionally ranked the third largest foreign exchange earner in Ghana, after gold and cocoa. Timber harvesting has been at unsustainable levels and the rate of illegal logging has tripled. At this rate of logging, Ghana"s forest would disappear in the next ten years and Ghana would be a net importer of wood (Nanang, 2009). Thus, the decline of the natural Tropical HFZ in Ghana has reached a critical stage, judging from the rate at which timber resources are over-exploited and degraded.

Despite the introduction of various reforestation schemes in Ghana, forest cover has not been stabilised or restored. Further, forest resources do not adequately serve as reliable sources of livelihoods for forest-fringe communities. Among the schemes introduced in the last decade to improve people's access to forest and tree resources and to protect the remaining forest have been the MTS, an agro-forestry system. Forest management with the MTS is a response of government to the growing problems of forest degradation, poverty, landlessness and conflict over land (FPDC, 2002). MTS has a double objective of restoring forests cover and improving the welfare of the poor. MTS allows farmers to enjoy rent-free land for farming and retain all proceeds from crops cultivated. Farmers are also entitled to a share of the forest estate (FAO, 2003). The question arises whether the introduction of this new scheme (MTS) has improved forest restoration as well as people's access to forest resources, as well as succeeded in enhancing the forest and tree-based components in their

livelihoods. With mixed successes of the TTS, this study sought to examine the MTS as a strategy and how it provides benefits to improve conditions of rural farmers and forest cover in the Worobong South Forest Reserve (WSFR).

1.3 Justification for the Study

According to Westoby (1989), the focus of development should not only be on the trees in forest but it should go as far to serve the needs of people. The 1994 Forest and Wildlife Policy of Ghana also aimed at maintaining environmental quality and perpetual flow of benefits to all (Opoku, 2006). This is an improvement on the previous 1948 forest policy that focused only on protection and conservation. The World Bank has also recognised that the exclusive focus on protection misses opportunities for poverty reduction and improved management and conservation of productive forest (World Bank, 2005). This study therefore seeks to contribute to pertinent literature of forest restoration schemes and forest related livelihoods.

Again, this study attempts to contribute to achieving the first two objectives of the Ghana Poverty Reduction Strategy (GPRS) which are:

i. Ensuring sound economic management for accelerated growth
ii. Increasing production and promoting sustainable livelihoods

Further, the World Summit on Sustainable Development in 2000 reported that, sustainable forest management of both natural and planted forest for timber and non-timber products is essential to achieving sustainable development and is a critical means to eradicate poverty, significantly reduce deforestation, halt the loss of forest biodiversity and land degradation, improve food security, access to safe drinking water and affordable energy.

This study therefore justifies both national and international demand for sustainable forest management. Thus, it attempts to contribute to the efforts by the Ghana Ministry of Land Forestry and Mines and the Forestry Commission to protect Ghana‟s forest cover through the establishment of reserves and protected areas as well as contribute to achieving the United Nations Millennium Development Goals 1 and 7 which seeks to eradicate extreme poverty and hunger and ensure environmental sustainability respectively.

1.4 Research objectives

The general aim of this research is to examine the role of the introduction of the MTS in contributing to improved forest cover and livelihoods of farmers.

The specific objectives of the study were:

1. To examine the spatio-temporal changes in forest cover and the contribution of the MTS scheme in forest cover restoration within the WSFR over the last two decades (1990-2010);
2. To find out the benefits of the MTS scheme to local farmers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Historical Development of Forestry and Forest Policies in Ghana

Colonial Administrations in Ghana introduced new values and new ways of forest resource conservation, including the introduction of Commercial agriculture, cash economies, agri-business and linkages with world trade into the local culture. A number of Land Bills were passed at the turn of 20th century. A Timber Protection Ordinance (1907) preceded the establishment of a Forestry Department which promulgated the Forest Ordinance of 1910 and proposed a new Forest Bill in 1911(Ghana Forestry Commission, 2001). However, Seneadza (2010) indicated that most of such legislations were strongly resisted by indigenous militancy.

It must be noted that a number of ordinances were enacted between the First and Second World Wars, including the Local Government Ordinance, Forest Ordinance, the Concessions Ordinance, and the Tree and Timber Ordinance (Ghana Forestry Commission, 2001). The Forest Ordinance of 1911 for instance provided for the constitution of Forest Reserves and the protection and control of all forest produce within the reserve. The enactment of the Tree and Timber Ordinance enabled regulations to control the felling, extraction and disposal of timber. The Concessions Ordinance enabled the Chief Conservator of Forest to issue directives to control operations in timber concessions. The Local Government Ordinance replaced the Native Authority Ordinance and their predecessors, under which all Forest Reserves other than ordinance reserves were constituted by Bye-laws and rules. Moreover, landowners could grant concessions in Forest Reserves constituted under Bye-Laws but logging could not take place without the written authority of a Forest Officer as provided for in the bye-laws (Ghana Forestry Commission, 2001; Seneadza, 2010).

Furthermore, no great advances were made till the Second World War. Some reasons provided by the Ghana Forestry Commission (2001) dealt with scarce supplies, the building boom that engulfed war-shattered Europe and the conservatism that had hitherto characterized the trade. Forest revenues were small as timber revenues appeared the only significant output of the forests. After the Second World War, investment in local processing expanded the local industrial base and began to increase the revenue base. With the prevailing laissez-faire although, there were as many different royalty rates as there were chiefs and concessions (Ghana Forestry Commission, 2001).

After 1960, Ghana"s forest policy was characterized by centralization, exclusion, and restrictive legislation. New forest policies of local management from the 1990s attempted to change this but lacked effective fiscal decentralization (Wardell and Lund, 2006). Meanwhile, the 1992 Constitution of Ghana, under Article 36(9) enjoins the State to take proper measures required to protect and safeguard the natural environment for posterity and seek cooperation with other states and bodies for the purpose of protecting the wider international environment for mankind. In addition, Article 41(k) of the 1992 Constitution of Ghana, enjoins each citizen to protect and safeguard the environment (Government of Ghana, 1992). Opoku (2006) also noted that, the 1994 Forest Policy encouraged sector legislation and thus promoted competition but post-1994 legislation largely ignored community right issues.

Several proposals have been made for effective short, medium and long-term forestry policy for Ghana. According to the Ghana Forestry Commission (2001), the policy should vigorously address the following:

i. Dissemination of deforestation related information and education
ii. Promotion of research activities in deforestation
iii. Sound management of forest resources
iv. Monitoring of management and conservation programmes
v. Common approach to regional and global deforestation and international co-operation in forest management; and
vi. Implementation of forestry policies.

Ghana has taken measures to comply with its obligations under Conventions to which it is a party at the international level. Ghana has also given consent to global forests conservation effort by ratifying other instruments related to protection of the forests and their resources. Various Governmental and Non-Governmental Organizations are involved in addressing the ecological crises of deforestation in order to ensure the success of any forest policy. These bodies include: the Parliamentary Committees (agriculture, forestry, conservation, nutrition, conservation and rural development), Forestry Commission, Ministry of Lands and Natural Resources, Environmental Protection Agency, Friends of Earth Ghana and the Green Earth Organization. Other important organizations include; Ghana Agricultural Workers Union, Ghana Timber Marketing board and University Research Centres (Seneadza, 2010; Opoku, 2006).

2.2 Forest Governance

Governance is a crucial concept in development because it encourages interaction and participation at local as well as regional and international levels. It is helpful to refer to Kooiman *et al.* (2005) and their definition of governance:

> *Governance is the whole of public as well as private interactions taken to solve societal problems and create societal opportunities. It includes the formulation*

and applications of principles guiding those interactions and care for institutions that enable them.

It can be seen that this is a complicated process with the involvement of a wide spectrum of different actors with conflicting claims to the biophysical landscape. Of particular importance to my research is forest governance which is concerned with "the policy, legal and institutional conditions that can affect how people treat forests" (Higman *et al.* 2005), and can be described as a series of processes, mechanisms and institutions in place that determine:

- How and to what end forests are managed;
- How decisions on forest use are taken;
- Who are involved in these decisions;
- How forest policies, laws and regulations are enforced on the ground; and
- How conflicts with regard to forest resources are mediated.

In Ghana, various governance arrangements have been introduced as part of the 1994 Forest and Wildlife policy. There is a wide range of different actors involved all with competing claims, values and interests: the central government, the Forestry Commission and its subdivisions, stool landowners, district assemblies, people in forest-fringe communities, timber contractors, NGOs, administrators of stool lands, as well as private plantation developers (Boakye and Baffoe, 2006). Indeed, increasingly the role of the central government is reduced with the increased prevalence and influence of non-state actors (Ros-Tonen *et al.*, 2009). These policies may be advocating collaborative approaches to forestry management involving formal institutions with farmers, landowners and smallholders in the forest fringe communities, but this is hindered by confusion of the different systems of customary and statutory law. Even if the customary law may advocate involvement of traditional

leaders, statutory law can override access and ownership rights. The MTS, created through a collaborative framework of stakeholders, advocates a collaborative approach, at least on paper. However it is necessary to see the MTS in action before confirmation of the collaborative nature of the MTS can be achieved.

2.3 The Livelihood Concept and Forest Livelihoods in Ghana

The relationship between natural resources and the livelihoods of people who depend on them, in large part, is determined and heavily dependent on the quality of the natural resource base *i.e.* the content and condition of the landscape on which they are dependent (Dubois, 2003). The concept of „livelihood" has been found by many scholars to be a people-centred approach that aims at addressing poverty related issues. Chambers (1995) defined livelihoods to comprise the capabilities, assets and activities including material and social resources that are required for a means of living. However, Ellis and Freeman (2002) also defined the concept of livelihood to comprise the wider context of governance, institution and an enabling environment for poverty alleviation. They argue that an „institution context" for rural livelihood is important because it helps to track the effects of expansion or contraction of opportunities that permit the poor to build their own pathways out of poverty. Livelihood has also been seen as an interlocking concept. In their study of rural livelihood and poverty reduction in four African countries, Ellis and Freeman (2002) identified five interlocking areas of livelihoods in rural areas which are household size, livestock, education, area owned and tools.

A livelihood is sustainable when it can cope with and recover from the shocks and stresses and maintain or enhance its capabilities and assets now and in the future, while not undermining the natural resources base. This is the adopted definition of the

Department For International Development (DFID) Sustainable Livelihood Approach (Ros-Tonen *et al*., 2010). The Sustainable Livelihoods Approach (SLA) recognises the multifaceted dimension to poverty and offers a framework through which one understands the way people express themselves, the assets they draw upon and the strategies they devise, and activities they take part in. Moreover, the SLA recognises that the poor know best what their needs are and thus should thus be involved in processes that can contribute to policies being made (Krantz, 2001). The concept also focuses on assets also referred to as capital, upon which individuals draw on to build their livelihoods. These are natural capital, human capital, financial capital and physical capital and these are linked to structures, processes and strategies that affect livelihood outcomes (Carney, 1998).

The potential of sustainable forest and tree-related livelihood activity is grounded in the concept of SLA, however as Shackleton *et al.* (2008) point out, these capacities are reliant upon the availability and accessibility of options which are ecological, socio-cultural, economic and political, and are predicated on equity, ownership of resources and participatory decision making. This can also be applied to forest-related livelihoods in Ghana, and the importance of empowering individuals to improve the farmers‟ capacities to generate and maintain their means of living and enhance their well-being, as well as that of future generations.

However, there have been several critics of the DFID livelihood approach. It has been criticised as merely a reinvention of the failed integrated rural development paradigm of the 1970s (Scoones, 2009). Bebbington (1999) also finds the framework‟s lack of inclusion of the role of access to resources as problematic, since access is the most important resource in determining the capacity of people to build sustainable poverty

alleviating rural livelihoods. In addition, Kaag *et al*. (2004) contest that many of the existing livelihood studies focus too narrowly on the action and strategies of a group of people and take insufficiently into account the context of structure constraints such as power inequalities in which these people have to make a living. He emphasised that, this is dangerous because it diminishes the urge to address the structure and cause of poverty which includes unequal power relations and unequal access to productive resources. Hence, the livelihood approach is criticized that in as much as it focuses on poor people"s action and strategies, it overemphasizes this to the detriment of studying the relationship that exist and should exist between the poor people and the broader society. Moreover, most livelihood research is clouded in schemes, tools definition, and frameworks. These, however, cannot adequately capture the complex dynamics of the livelihood system.

Forestry contributes to the economy and social welfare of Ghana. Apart from the timber industry however, the contribution of forestry to the economy is greatly undervalued, mainly because of lack of reliable statistics, especially with respect to non-wood products which generates a wide range of income generating opportunities for many forest communities (Kaag *et al*., 2004). On the farm, agro-forestry systems help to maintain soil fertility and tress yield a wide variety of non-wood products (traditional medicinal products such as tubers, fruits and nuts) which are important for subsistence use and for income generation. Of particular significance is the reliance on bush meat as a source of animal protein in rural areas, and the commercial trade supplying bush meat to urban areas (Ros-Tonen *et al*., 2005). In the fringes of the forest, livelihoods are thus, built nearly entirely on the use of local natural resources, be it from farming, forestry, chainsaw operations, charcoal production, or hunting and gathering (Marfo *et al.,* 2002). The Forests of Ghana (both on and off reserve) provide

both direct and indirect livelihood benefits to the entire population (Blay et al., 2006). The forest-fringe communities are thus vulnerable to changes in the environment and shifts in policy.

2.4 Deforestation in Ghana

Ghana lost approximately 80% of its forest cover between 1900 and 1990, destroying biodiversity as well as crucial sources of livelihood for the rural populations (Opoku, 2006). The forest cover lost was from 8m ha to 1.6m ha. Meanwhile, Satellite images of state managed forest reserves taken in 1990 and 2000 reveal rapid deforestation within these reserves (Ghana Forestry Commission, 2002). Although there have not been any comprehensive measurements of forest cover in recent times, communities and Forest Watch Ghana members working at the forest fringe continue to report rapid shrinkage of forests. Official estimates suggest that logging is proceeding at about four million m^3per year (Birikorang *et al*., 2001).

Ghana is ranked among the first countries to have lost some of her major primate species since the Convention on Biological Diversity came into force (UNEP, 2000). The Forestry commission has joined the forestry industry in blaming farmers, chainsaw operators and bush fires for deforestation. However, this is a gross distortion of the truth. While there have, for example been bush fires (especially within the 1980‟s), there is also illegal clearance for farming, but this, too, often occurs in the wake of industrial devastation. The main driver of deforestation is the timber industry, which is able to suborn national policy processes in order to protect its profits and systematically defy permit regulations with absolute impunity (UNEP, 2000).

The United Nation set up the Intergovernmental Panel on Forest in 1998 to promote and monitor the implementation of Chapter 11 of Agenda 21 and the forest-related

issues, including *‚µnderlining causes of deforestation and forest degradation'* (UNEP, 2000). In its report, it noted the historical dimensions of deforestation. The panel also noted that many of the factors causing deforestation or forest degradation interact and some are synergistic. An interesting finding was that most causes were social and economic in character. The Panel pointed out some causes such as unsustainable timber extraction, inappropriate policy choice and approaches in other sector can also influence deforestation and forest degradation. A number of potential underlining causes mentioned by the Panel included production and consumption patterns, land occupation patterns, land tenure patterns, land speculation and land market, illegal logging, illegal occupation and illegal cultivation, the demand for fuel wood and charcoal to meet basic energy needs refugee-related problems, mining and oil exploitation, natural climatic events and forest fires, discriminatory international trade and trade distorting practices, poorly regulated investment, structural adjustment programs, external debt, market distortion and subsidies including those for agricultural commodities, poverty and demographic pressure (UNEP, 2000).

According to Evans (1982), the main causes of deforestation are intensive logging, urban and industrial expansion, accidental or deliberate burning of forest and ravages of war. Yiridoe and Nanang (2001) however, attribute deforestation to a number of underlining causes such as overtly inequitable land distribution, low agricultural productivity, poor land-use policy, weak institutions and rapid population growth.

Deforestation produces negative impacts on living things and the ecosystem. In addition to the destruction of forest area, deforestation causes climatic change, soil erosion and desertification. Deforestation may thus create serious consequences for food security, energy, land productivity, income which normally motivates people to

temper with forests, and ecological sustainability in Ghana. Globally the impacts of deforestation mainly relate to changes in global cycles of carbon and other atmospheric gases that may contribute to global warming and rise in sea levels (Houghton *et al*., 1983; Woodwell *et al*., 1983). Kuffour (2000), points to a 1987 report by the Overseas Development Agency which claims that, "*forests are known to play a major regulatory role in maintaining the atmosphere's carbon dioxide balance – the main greenhouse gas*."

Farming has led to a considerable loss of Ghana"s forest and therefore its biodiversity. Millions of cubic metres of timber and NTFPs are lost each year during the "slash and burn" process of land preparation for farming. Through farming many animal species have been driven away because of destruction of their habitats. During the 1940"s there was a phenomenal expansion of cocoa production in Ghana which also saw widespread clearance of forests by small scale farmers (Southgate *et al*., 1991; Benhin, 2006).

2.5 History of forest improvement through reforestation

Tree planting in Ghana dates back to the late 1890s. According to Kadambi (1972), it is on record that *Cedrela odorata* was introduced in Ghana in 1898. He further noted that, *Tectona grandis* (teak) trials in Ghana also date back to 1905 under the German administration in the Volta Region. Earliest records on the plantation establishments date back to the 1930s. The general policy at the time concentrated on indigenous species in the forest reserves. The few exotic species introduced were mainly for fuelwood plantations near large towns. Those exotic species included *Eucalyptus torelliana* and *Eucalyptus tereticornis*. In the Savanna zone, most of the natural vegetation had been cleared for agricultural purposes and there was shortage of wood

for all purposes. The policy at that time was to find suitable species to supply timber, poles and fuelwood. In 1951, a large number of exotic species were tried. They include *Cassia siamea, Cedrela mexicana, Gmelina arborea,* and *Tectona grandis.* The country of origin was India except for *Cedrela mexicana* which came from the Caribbean area and *Tectona grandis* species from Burma (Kadambi, 1972).

Furthermore, the original taungya system was introduced in the 1920s to Ghana whereby farmers were given small degraded sections of forest land, with the idea of growing both timber trees and agricultural products on the same piece of land with the aim to address both the lack of farmland in Ghana‟s forest reserves and in order to grow commercial timber quickly (Marfo, 2009). However the farmers were not included and did not receive any revenue from the timber. According to Marfo (2009) and Agyeman *et al*. (2003), the consequences of the exclusion of farmers from timber revenue soon became apparent and the scheme failed due to a wealth of weaknesses. These were:

i. Inequitable distribution of benefits accrued (which in turn saw farmers deliberately killing seedlings,
ii. Not tending to weeds,
iii. Abuse of power by officials,
iv. Lack of supervision, and
v. Conflict of interests between growth of trees and crop production.

2.6 The Modified Taungya System (MTS)

The MTS is an agroforestry system, and a newly adapted version of the original taungya system. It was designed after an 18 month consultation period from July 2001 to December 2002 with the Government of Ghana, and with support from FAO and

the World Bank (Agyeman *et al*., 2003). The MTS reflects shifts in forest management thinking and is a clear example of collaborative forest management (CFM). Under the MTS, farmers are given land to grow a mixture of food crops alongside the planted timber trees during the early years of a plantation"s development (Blay *et al*., 2006). The food crops are mainly annual agricultural crops such as cocoyam and plantain. After a few years the shade from the growing trees impedes the growth of the agricultural crops. One crucial evolution in the MTS is the improvement in tenure security and benefit arrangements: farmers are now essentially the co-owners of forest plantation products, with the Forestry Commission, landowners and forest-adjacent communities acting as shareholders. The ownership of the trees has been transformed from a single entity (the government) to multiple owners (farmers, local communities, government and landowners).

All participants in the MTS, including the farmers, are eligible for a share of the benefits accruing from the plantation (Agyeman *et al*., 2003). The framework is based on the contribution of participants: Forestry Commission, Farmers, Community and Traditional Authorities; the division of responsibilities under the MTS as outlined (Marfo, 2009);

a. Forestry Commission

- Supply of good quality seedlings to the farmer group
- Provision of training and extension services
- Marketing and accounting of the plantation products
- Manage oversees and see to day-to-day supervision of activities
- Provide financial resources and equipment to fulfil its own obligations

b. Farmers

- Provision of labour include site clearing, pegging, planting, weeding and pruning over the tree rotation period
- Provision of labour for wildlife protection strategies
- Bear financial cost to recruiting additional labour to assist them (if need be)

c. Community

- Assist FC with labour for wildfire prevention and control
- Prevention of members from setting fires
- Assist FC to prevent illegal activities within the plantation

d. Traditional Authority

- Provide land within the degraded forest
- Guarantee uninterrupted access to the allocated land for the FC and other parties

The arrangement is legally binding and upon sale of the timber (after between 10-20 years depending on tree species and location) the benefits are to be shared with the intention that the compensation received is proportional to the level of input: Forest Commission: 40%; Farmers: 40%; Traditional landowners: 15%; Forest Adjacent Community: 5%. The farmer is however entitled to 100% of the benefits from the agricultural crops (Marfo, 2009).

The objectives of the MTS are consistent with the overall objectives pursued by the National Forest Plantation Development Programme (NFPDP report, 2003), whose main aims are:

i. The restoration of forest cover of degraded forest reserves;

ii. To address the wood deficit situation in the country, especially timber. This deficit is estimated at 4-5 million m^3 /year, with the fuel wood consumption estimated to be at some 14 million m^3/year;

iii. The creation of employment opportunities at the rural community level and to generate income for plantation owners, timber processors and the national economy;

iv. To contribute to food production in the country.

Aside the provisions listed above, the reforestation of the degraded lands offer indirect benefits than could include: improvement of soil fertility, control of water and soil erosion, regulation of water quality, and prevention of desertification (Kalame, 2009). The FSD aims to establish 20,000 ha of plantation a year under the MTS (NFPDP Annual Report, 2008). The MTS is not suitable for all communities and setting it up is a somewhat laborious process. The communities chosen to take part in Ghana were selected based on recommendations received from regional and district forest managers, the strength of community participation in various plantation activities, and their success rate in previous schemes as well as their location (Agyeman *et al*., 2003). The tree species selected for planting include *Cedrela odorata,Tectona grandis, Eucalyptus torelliana, Eucalyptus tereticornis*, *Cassia siamea, Cedrela mexicana, Gmelina arborea,* and *Tectona grandis* (Ghana Forestry Commission, 2004). The benefit sharing agreement stipulates that at least 5% of trees planted must be indigenous (Ghana Forest Commission, 2002). However, the agricultural crops planted are the choice of the farmer (and these mainly consist of a mixture of cocoyam, plantain, maize, as well as tomatoes, onions, peppers and garden eggs).

2.7 Conceptual Framework

The conceptual framework (Fig. 2.1) explains the Sustainable Forest Model which was derived from a critical study of literature on forest livelihoods, forest restoration schemes and the MTS practice. According to Chambers (1995), poverty is caused by a multiplicity of factors such as forest degradation, soil infertility and scarcity of lands. These factors will lead to low productivity of farmers and thereby worsen incomes and make farmers poorer. The effects of poverty will aggravate food insecurity, loss of power, low income and poor livelihood outcomes and worsening degradation. MTS is a strategy for forest restoration and improvement in livelihoods or poverty reduction. The factors that attract participation of farmers into the programme include access to degraded forest lands, 40% of forest estate and authority-sharing in forest management.

The Sustainable forest model in Fig. 2.1 is therefore derived to explain farmers access to farm lands for crop production and sustainable forest restoration strategies.

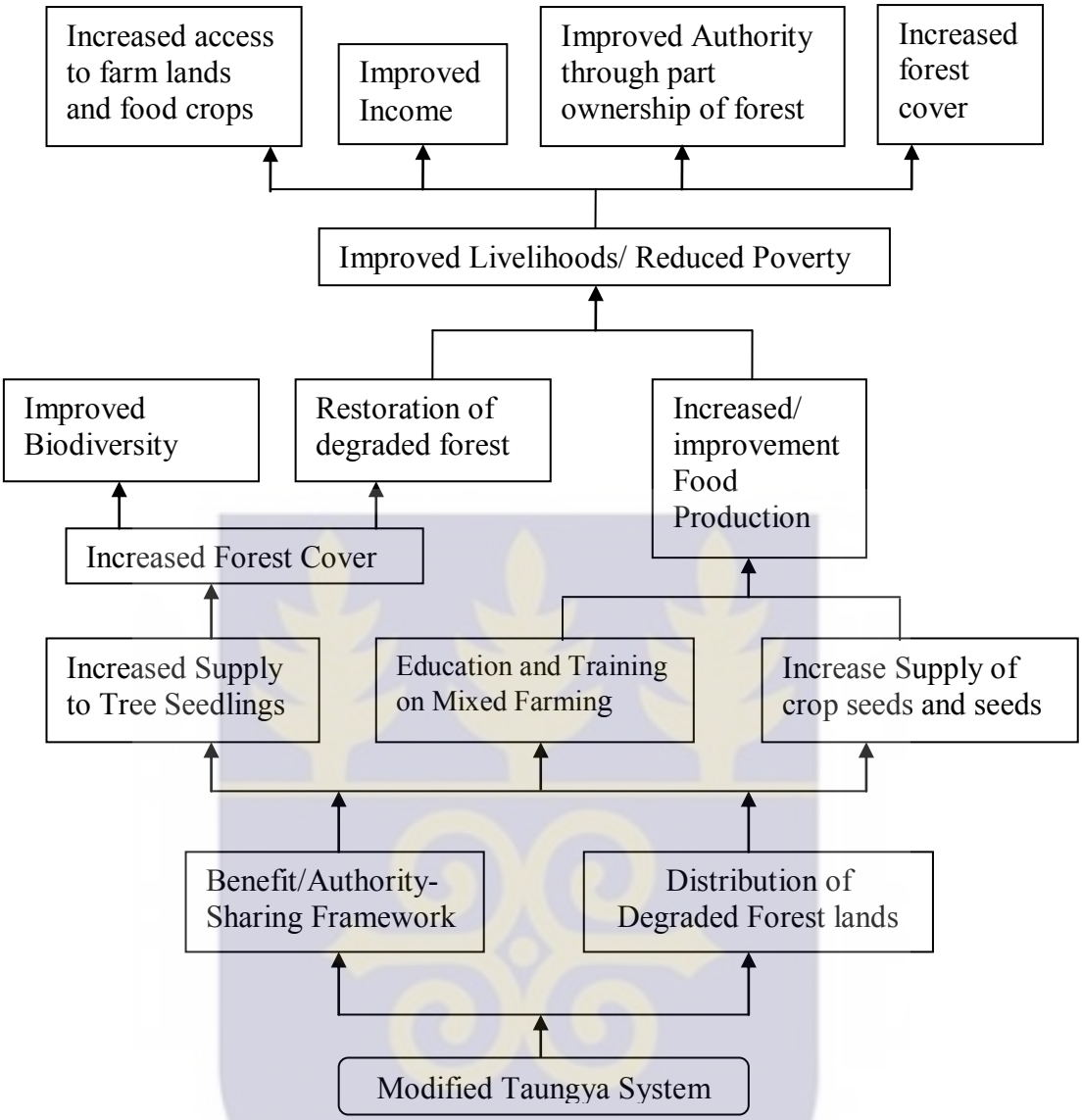


Fig. 2.1 The Sustainable Forest Model (Source: Researcher).

Access to more farmlands will increase farm holdings, enhance food production and income as well as boost employment (Fig. 2.1). As food security and incomes are increased, farmers would be able to meet their physical and social needs thereby improving their livelihoods and capacity building through training. Furthermore, benefit-sharing will enhance farmers‟ capacity in forest management and decisions that affect their well being. On environment, tree planting will lead to increased forest cover which will improve the habitat of birds and other animals ensure drought and flood control and enhance climate stability.

CHAPTER THREE

MATERIALS AND METHODS

3.1 The Study Area

3.1.1 Location, Extent and Ownership

Worobong South Forest Reserve (WSFR, Akim Portion) lies between latitudes 6˚30'N and 6˚24' N and longitudes 0˚33' W and 0˚21' W (Forest Management Plan, 2013). The Forest Reserve is located in the Eastern Region of Ghana within the Fanteakwa District Assembly with the headquarters at Begoro. The Forest Reserve forms part of the Forest Management Unit (FMU) 44. WSFR (Akim Portion) shares common boundaries with Southern Scarp Forest Reserve (Akim Portion) in the south-west and the WSFR (Kwahu portion) in the north-east. The WSFR (Akim Portion) covers a total area of 10,935.00 ha (109.35 km^2) with a total perimeter of 71.72 km. The external boundaries are fixed with concrete pillars at approximately 800 m intervals. There are fifteen (15) admitted farms in the reserve covering an area of 233.14 ha (575.85 acres), with an internal perimeter of 30.69 km. The internal farm boundaries are marked by cut lines with wooden beacons at the corners except for the first corners where concrete pillars bearing the number of the farm have been erected. The Akwansrem village is wholly within the Reserve with an admitted village-land area of 91.31 ha (225.53 acres). The land cover map of WSFR (Akim Portion) is presented in Figure 3.1(Forest Management Plan, 2013).

Ownership of WSFR (Akim Portion) is vested in the Begoro stool which owes its allegiance to the Omanhene of Akim Abuakwa. The Reserve was declared by the then Forestry Department in 1928 and gazetted by Gold Coast Governor Order Number 17 of 1936 (Forest Order Sec 15 of Cap 63 of 1936) (Forest Management Plan, 2013).

3.1.2 Physical Environment

According to the Forest Management Plan (2013), the WSFR falls within the Moist Semi-Deciduous South East (MSSE) Sub Type vegetation zone and the Tropical humid Climatic zone. The mean annual rainfall ranges between 1,250 mm and 1,500 mm. The average maximum temperature ranges between 27˚C and 35˚C whilst the minimum lies between 19˚C and 23˚C. The Forest reserve is mainly two-storied but three-storied structure exists in certain parts, and the emergent trees are relatively close together. The reserve is hilly and rocky at most parts with 50% of the slope greater than 15˚. The rest of the area is however fairly flat. The hilly areas have some steep slopes with contours varying between 1,840 m and 2,330 m above sea level and these are located in the central and south western part of the Reserve. The west end of the Forest Reserve overlies rocks of the upper and lower Birimian series. The remaining is mainly covered by the Voltaian Sandstones. The soil varies from reddish to brown in colour and it is mostly sandy loam with patches of clay. The Reserve is dissected by perennial streams such as Mia (at the western portion), Sutwum and Nubeso (at the southern portion) and the Worobong (at the northern part). The forest-fringe communities are: Feyiase, Mianya, Ayigbetown, Miaso, Pillar 10, Asarekwao, Akwamu, Kotoku, Kumfere, Ankensu, Owusukrom, Esaase, Ahomahomasu, Kronkronso, Bisibuom, Pesiator, Akoradarko, Amokrom, Apaa, Opare and Begoro. Akwansrem community is the only community located within the reserve (Forest Management Plan, 2013).

3.1.3 Stands Diagnostic of the Reserve

The total volume of timber in the WSFR is estimated at 3,359,888 $m^3$of which 1,158,235m^3(34.5%) is greater than 70 cm dbh and 2,201,653 m^3(65.5%) is between 10-69.9 cm dbh. The total volume of economic timber species is estimated at

2,061,466 $m^3$of which 870,863 $m^3$are greater than 70 cm dbh. Timber species average 188.5m^3/ha (approximately 42.2%) consists of trees greater than 70 cm dbh and 37.1 m^3/ha (approximately 19.7%) consists of trees greater than 110 cm dbh. Mean basal area for the Reserve is 23.1m^2/ha. Timber species account for 99 (58.9%) stems per ha while all other species apart from timber constitute 69 (41.1%) stems per ha (Forest Management Plan, 2013).

3.1.4 Stocking of Species

A total of 210 species have been recorded in the Reserve of which 59 are timber species (Forest Management Plan, 2013). Timber species such as *Chrysophyllum subnudum, Triplochiton scleroxylon, Cylicodiscus gabunensis, Entandrophragma candollei, Piptadeniastrum africanus, and Turraenthus africanus* are well represented above 70 cm dbh (more than 40 stems per 100 ha), in the Reserve. Others such as *Albizia zygia, Celtis milbraedii, Celtis aldolfi-frider, Nesogordonia papaveriferii, Piptadeniastrum africanum, Chrysophyllum subnudum, Hannoa klaineana, Parkia, Sterculia rhinopetala, Guarea cedrata, Parkia bicolor, Petersianthus macrocarpus, Piptadeniastrum africanus, Turraenthus africanu, and Strombosia glaucescens* also have a satisfactory level of stocking. However, timber species such as *Anopyxis klaineana, Ceiba pentandra, Daniellia ogea, Dailium aubrevellei, Entandrophragma candollei, Holoptelea grandis, Morus mesozygia, Okoubaka aubrevillei and Terminalia superba* appear to have low stem distribution in the Reserve (Forest Management Plan, 2013).

3.1.5 Socio-Economic Activities

The economy of the communities around the Forest Reserve is mainly agricultural based. Most of the inhabitants are farmers who mainly cultivate plantain, maize,

cocoyam, yam, cocoa, oil palm and vegetables like cabbage, tomato, garden-eggs, okro and pepper. The main non-agricultural activity is petty trading and basket weaving is the cottage industry in the area. Wednesdays are observed as „taboo days" for visiting the reserve. There is an exclusion zone in the Forest Reserve which serves as a sacred grove believed to be the abode of the wife of the fetish, Bosompra (Forest Management Plan, 2013).

3.2 Methods

3.2.1 Desk Study of Literature

A desk-study of pertinent literature was conducted in order to understand formal access rights to forest resources, regulations on benefits in reserves and off reserves in Ghana and Benefit-sharing Agreement of MTS. This information was collected from a review of relevant forest policies and acts as well as 2013 Worobong Forest Reserve Management Plan.

3.2.2 Forest Cover Change Analysis

To determine temporal and spatial changes in forest cover, at least two time-periods data sets are required (Jenson, 1986). In this study, three time interval data sets for 1990, 2000 and 2010 calendar years were used. The study was carried out using optical satellite imagery to create a time series of images. A set of high resolution multi-sensorial and multi-temporal satellites images from Landsat (TM and ETM+) family of satellites were analysed. Cloud-free scenes were obtained for 1990 (Landsat TM), 2000 (ETM+) and 2010 (Landsat ETM+) during the dry season. Both the Landsat TM and ETM+ images were geo-referenced using 1:50,000 topographic data sets from the Ghana Survey Department. The images were obtained from the Centre

for Remote Sensing and Geographic Information Services (CERSGIS, 2013) at the University of Ghana.

3.2.2.1 Satellite Imagery, Processing and Classification

The distinctive approach in developing forest cover maps with satellite imagery involves defining spectral classes by clustering the image data and assigning pixels into classes (CERSGIS, 2013). The Interactive Self-Organizing Data Analysis Technique Approach (ISODATA) algorithm was used to perform unsupervised classification with maximum iteration set at 99, convergence threshold at 0.9 and number of classes set at 30. The threshold value of 0.9 and maximum iteration values of 99 were used to determine the accuracy of the classes. Noise in the images was eliminated by passing a 3x3 majority filter over the resulting vegetation cover and land-use images. Ground truthing of the images was performed in the study area to determine the positional accuracy of the images using a Global Position System. In relatively flat areas, correction for terrain displacement is not necessary (Boakye *et al*. 2008), but in mountainous areas such as the WSFR, othorectification was used to avoid overlapping of images. The image processing software ERDAS IMAGINE 8.4 was used for the analysis.

In order to classify the images into forest cover/land-use types a post-classification method was adopted (Mas, 1999). The post-classification method which is based on a comparative analysis of images obtained at different moments after independent classification is the most obvious method used in change detection studies. This method has the advantage of minimizing the problem of normalization for atmospheric and sensor differences between different dates (Singh, 1989). Thus the post-classification approach to change detection was considered suitable for this study

because images were from different sensors, taken on different dates by CERSGIS and had been independently classified and labelled.

Post classification image referencing was performed in order to maintain the original Digital Number (DN) gray scale value during classification. Since the main purpose of this study was to detect temporal and spatial change in vegetation cover, all categories generated during the unsupervised classification process were merged into a binary image. The rasterised image of the WSFR of Ghana has not been regenerated since 1960 and thus the forest boundary was marked from this image to remove misclassified pixels outside the forest boundaries. The changes in forest cover that were recorded included change from forest to non-forest for logging, bushfires and tree crop plantation using ArcView 3.3 GIS software.

Table 3.1 Characteristic of Remote Sensing Imagery Data

Image Type	Sensor	Bands	Date of Acquisition	Spatial Resolution
Landsat	TM	453 (RGB)	08/02/1990	30 m
Landsat	ETM+	453 (RGB)	14/02/2000	30 m
Landsat	ETM+	453 (RGB)	01/02/2010	30 m

Specifically, the following processes were undertaken:

Acquisition of raw satellite image

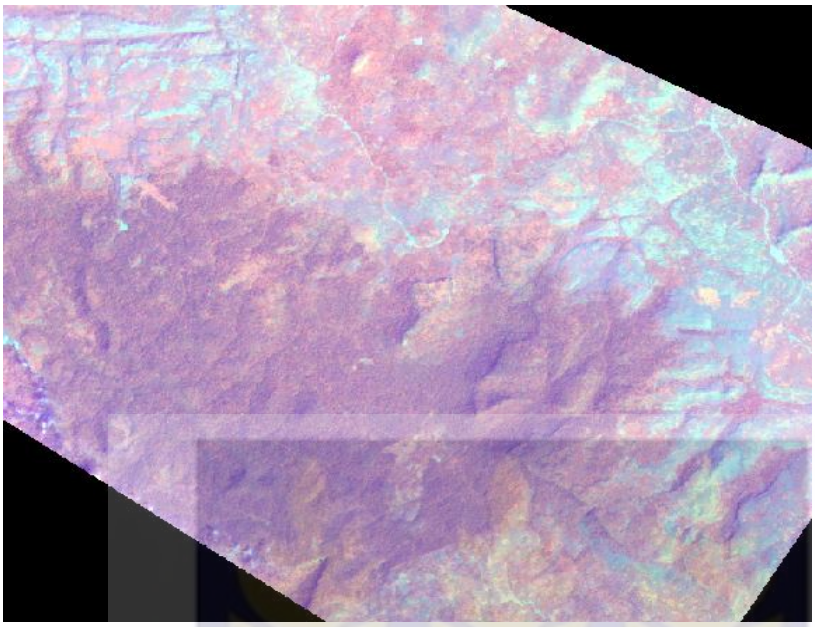


Fig. 3.2 Acquisition of raw satellite image

Rectification or Geo-referencing the raw image to Ghana Projection System.

That is assigning Ghana Coordinates to the image using 1:50000 Ghana Topographic data.

Example: Roads and Settlements from Survey Department.

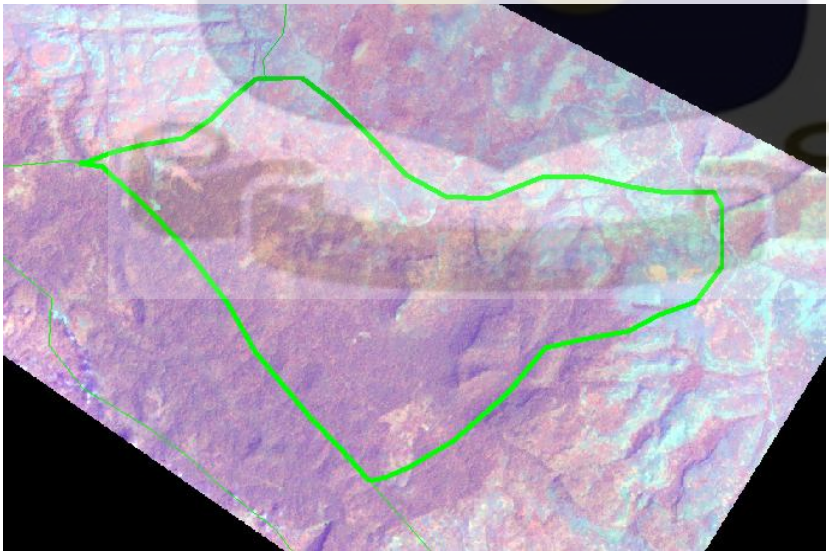


Fig. 3.3 Rectification or Geo-referencing the raw image to Ghana Projection System

Rectification is the process of projecting the data onto a plane and making it conform to a map projection system. Assigning map coordinates to the data is geo-referencing. Since all map projection systems are associated with map coordinates, rectification involves geo-referencing.

Classification of Images

Classification is the process of sorting pixels into a finite number of individual classes, or categories, of data based on their data file values. If a pixel satisfies a certain set of criteria, then the pixel is assigned to the class that corresponds to the criteria.

There are two ways to classify pixels into different categories.

- Supervise
- Unsupervised

Supervised classification is more closely controlled by the user than unsupervised classification. In this process, you select pixels that represent patterns you recognized or can identify with help from other sources. Knowledge of the data, the classes desired, and the algorithm to be used is required before you begin selecting training samples. By identifying patterns in the imagery, you can "train" the computer systems to identify pixels with similar characteristics. By setting priorities to these classes, you supervise the classification of pixels as they are assigned to a class value. While unsupervised classification is more computer-automated. It allows you to specify parameters that the computer uses as guidelines to uncover statistical patterns in the data.

Initially, the Unsupervised Classification option was chosen, and then the classified images were validated using Global Positioning System (GPS) for the purpose of orientation in the field.

Recoding

The next step is recoding, that is assigning a new class value number to all classes, creating a new thematic raster layer using the new class numbers. Some of the classes were combined through this process.

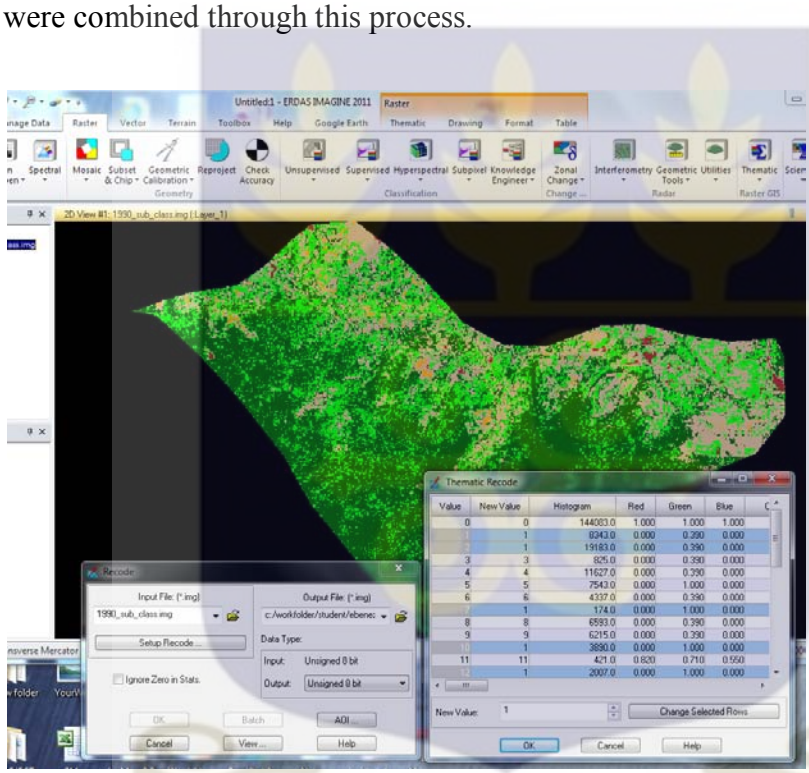


Fig. 3.4 Recoding

After recoding, the raster attribute table was exported as .dat. The exported file was open in excel and statistics for all the various classes were generated. Once the size of a pixel is known (eg. the Landsat 30mx30m = 900m) multiple the pixels per class by 900 to get the total area in meters per class, this was divided by 10000 to get hectares, then divided by 100 to get sq km.

Map Composition

The various maps were finally composed showing the changes in the cover types with statistics indicating the changes from 1990, 2000 and 2010.

3.2.2.2 Accuracy Assessment

Randomly selected points per class was done at the Centre for Remote Sensing and Geographic Information Services (CERSGIS) office. Class sampling to check accurary was as follows: closed forest riverine vegetation (15), Open forest riverine vegetation (20), Dense shrub/herbaceous (20), etc. Within the closed forest, 13 was really closed forest riverine whilst 2 was Open riverine vegetation and hence to calculate the Accuracy of the closed forest riverine vegetation, the formula was 13/15x100. This formula was applied to all the classes to derive the matrix in Table 4.4.

3.2.3 Analysis of Forest Diversity of the Natural Forest and the Modified Taungya System (MTS) Plantation

It is impossible to count every living and non-living thing in an ecosystem. So a great method for finding out what things exist in an ecosystem is by establishing transects (New Mexico State Universtiy (NMSU), 2013). Transect is an ecological tool that helps to quantify the relative abundance of organisms in an area (Philippoff and Cox, 2013). The NMSU (2013) also defines a transect as a defined area in which sample population counts of plants and animals can be taken. The defined area has to be large enough to truly characterize the biotic and abiotic factors of the ecosystem. To track changes over time, it is important to be able to quantify changes in abundance (Philippoff and Cox, 2013). Further, a transect line is any line, marked at regular intervals, that is easy to use in the field. Transect lines can be made from measuring

tape or rope marked off at regular intervals. The size of a transect (whether a one-meter square or a 10-meter or even a 100-meter square) is determined by the biotic factors in the area chosen to investigate (NMSU, 2013).

This study therefore, applied the 100 m x 100 m square transect technique to make a comparative analysis of the natural forest and the MTS plantation within the WSFR. A preliminary survey was done to select the transect sites and appropriate measurements done. Two sites were selected: One for the natural forest and the other for the MTS plantation. The same procedure was followed for both sites. This is shown in Fig. 3.5

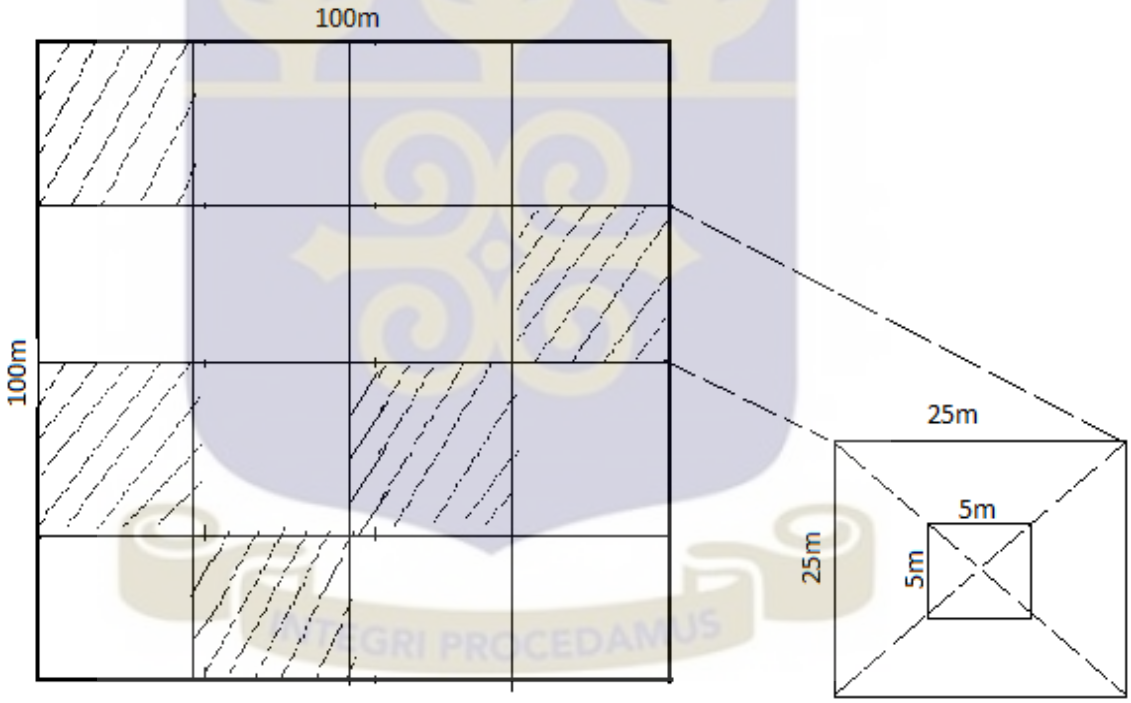


Fig. 3.5 100 m x100 m square transect

The 100 m x100 m square was measured for both sites. Each site was divided into 16 plots of 25 m x 25 m square. The measurements were done with a tape measure, marked with a cutlass and fixed with pegs. 5 plots were separately sampled randomly for both sites. All trees ≥10 cm diameter at breast height (dbh) were counted and

recorded noting different species. Then, within each sample (25 m x 25 m), a quadrant of 5 m x 5 m was measured with a tape measure and fixed with pegs and all trees species ≥1cm dbh was also counted and recorded. The circumference of the tress was measured with a tape measure and the dbh of tress was calculated by dividing the circumference of individual tress by $\pi = 3.14$. Further, species identification of all tree species were done in the field while those species that could not be readily identified were taking to the Herbarium at the Department of Botany, University of Ghana for Identification.

This technique gives the researcher the tools necessary to ask his own ecological questions and make comparisons among sites (Philippoff and Cox, 2013). This experience brought the researcher to a true understanding of what made the WSFR what it was.

3.2.3.1 Simpson's Index of Diversity

The nature of this research required that the stem numbers of trees in each transect should be calculated. This was done by counting the number of trees recorded. Meanwhile, species diversity (species richness, evenness and relative abundance) was analysed with the Simpson's diversity Index. According to Powell (1982), and Brower & Zar (1984), Simpson's Diversity Index is a measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species. **Simpson's Index (D)** measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species).

The formula for calculating **D** is ..... $\mathbf{D} = \frac{\sum n(n-1)}{N(N-1)}$

n = the total number of organisms of a particular species
N = the total number of organisms of all species

The value of **D** ranges between 0 and 1. With this index, 0 represents infinite diversity and 1, no diversity. That is, the bigger the value of D, the lower the diversity. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give: **Simpson's Index of Diversity** (1 – **D)** (Philippoff and Cox, 2013).

The value of this index also ranges between 0 and 1, but now, the greater the value, the greater the sample diversity. This makes more sense. In this case, the index represents the probability that two individuals randomly selected from a sample will belong to different species (Philippoff and Cox, 2013).

3.2.4 Socio-Economic Interviews

Data on the MTS practice, forest cover changes and socio-economic parameters were determined through observation and interviews with Authorities of the District Forestry Department in charge of the WSFR (Akim Portion), MTS farmers as well as key informants. Three forest-fringed communities out of seven were selected. The communities were Akwansrem (the only community within the reserve), Feyiase (located in the north-eastern fringe) and Miaso (located in the North-western fringe). These communities selected were purposively chosen in order to fit in with the scope and area of the larger research. These communities had also been actively engaged in the Modified Taungya System since its inception in Ghana in 2002.

The purposive sampling and the simple random sampling techniques were employed in this study. The purposive sampling was used to select a category of farmers i.e. MTS farmers. Then, within the purposive selection of only MTS farmers, respondents were chosen randomly and depending on availability as well as willingness to

participate. A total sample of 85 respondents was used, within the constraints of time and other resources. This comprised 31 MTS farmers in Akwansrem, 25 MTS farmers in Miaso and 24 MTS farmers in Feyiase. Thus, 80 MTS farmers representing 42.5% of target population were interviewed. Besides, semi-structured interview questionnaires was also administered to 3 MTS heads (one from each community sampled), the forest officer in charge of the MTS and the forest manager of the WSFR (Akim portion). Data from these sources served as a good means of balancing the information gathered as well as base the study not solely on MTS farmers" perceptions. Again, it presented an invaluable opportunity for the researcher to clarify components of the MTS that are neither always explicitly explained nor understood.

In each community, a pilot survey that involved a meeting (with the leaders of the community) was done and the objective of the research was explained. The age, gender and educational level of respondents as well as other factors likely to influence the scope of data to be obtained were considered in the administration of the questionnaire. Prior to the administration of the questionnaires, the objective of the study was thoroughly explained to the respondents in order to encourage participation.

CHAPTER FOUR

RESULTS

4.1. Demographic Characteristics of Respondents

A total of 80 questionnaires were administered to MTS farmers. 69 males representing 86.25% and 11 females representing 13.75% were interviewed. The educational level of respondents indicated a high percentage of semi-literates. About 8.8% of the respondents had no previous formal education while 59 representing about 73.8% of them have had primary/Junior High School/middle school education. About 65% of the respondents were married, 5% were widowed, 6.3% were divorced/separated and 21.3% were single. Table 4.1 gives further details. Meanwhile, the age-groups and occupation of respondents is presented in Table 4.2 and Fig. 4.1 respectively.

Table 4.1 Demographic Characteristics of Respondents

		AKWANSREM (N=31)	FEYIASE (N=24)	MIASO (N=25)	TOTAL
GENDER	**Male**	25	23	21	**69**
	Female	6	1	4	**11**
EDUCATIONAL LEVEL	**Primary**	24	15	20	**59**
	Secondary	3	5	2	**10**
	Tertiary	0	3	1	**4**
	None	4	1	2	**7**
MARITAL STATUS	**Married**	20	15	19	**52**
	Single	5	8	4	**17**
	Widowed	2	0	2	**4**
	Divorced/ Seperated	4	1	0	**5**

Table 4.2 shows the age-groups of respondents. Majority (42.5%) of the respondents were within the 40-54 age-group. This was followed by the 25-39 age-group while only about 6.3% of respondents were below 25 years.

Table 4.2 Age of Respondents

AGE GROUP	AKWANSREM (N=31)	FEYIASE (N=24)	MIASO (N=25)	TOTAL
Below 25	2	0	3	**5**
25-39	9	6	10	**25**
40-54	15	11	8	**34**
55 and above	5	7	4	**16**

Fig. 4.1 presents the occupation (or Alternative Livelihood) of Respondents aside the MTS. Majority of the respondents were farmers involved in activities such as cocoa farming, food stuff farming, fruits and vegetable farming, Poultry farming and goat rearing. Besides, there were some few respondents involved in trading while a a few others were into Carpentry, chainsaw operation and masonry. See fig. 4.1 below:

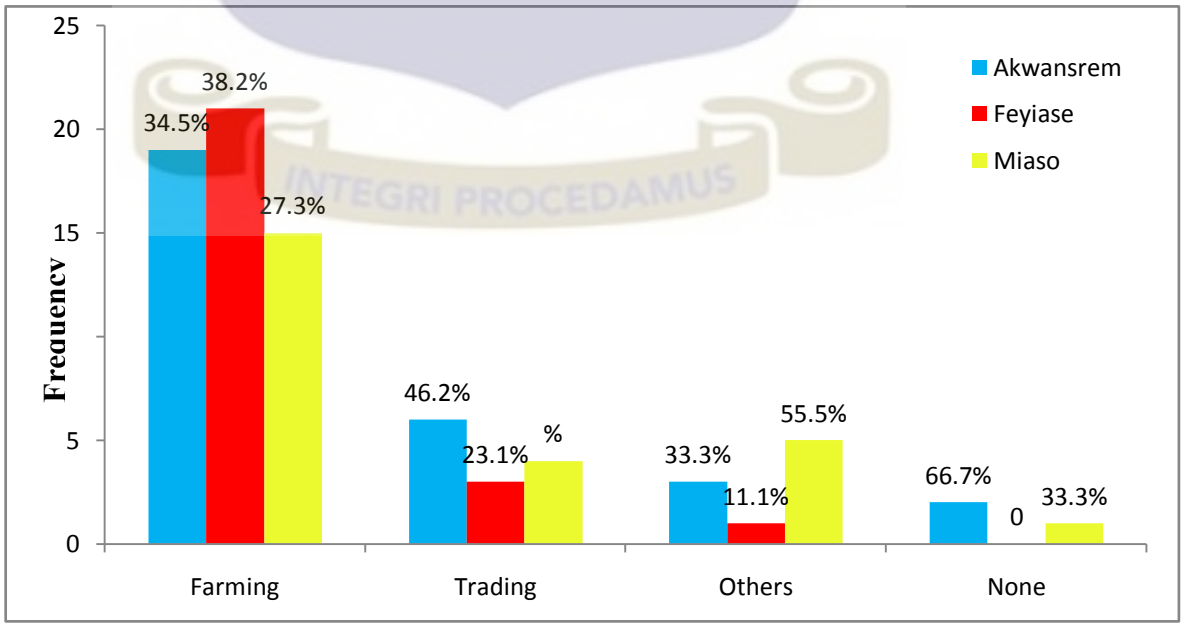


Fig. 4.1 Occupation (or Alternative Livelihood) of Respondents aside the MTS

4.2 Forest Cover Change Analysis

The temporal analysis in forest cover change reveals two different trends in the WSFR. These are: the period of severe forest cover loss between 1990 and 2000 followed by the period of reduced forest cover loss between 2000 and 2010. The area estimates revealed that during the first period (1990-2000) a total loss of 46.17 ha (0.46 km^2) representing 0.41% of forest cover had been lost while a total of 20.34 ha (0.20 km^2) representing 0.17% of forest cover had been lost between 2000 and 2010. Table 4.3 explains the information above.

Table 4.3 Temporal Changes in Forest Cover within the WSFR

Period	Forest Cover Change (ha)	% Change in Forest Cover	% Average Annual Rates of Forest cover Change
1990-2000	-46.17	-0.41	-0.03
2000-2010	-20.34	-0.17	-0.01

In addition to the above analysis, the forest cover change with respect to the different vegetation cover types was also analysed. The accuracy assessment presented in table 4.4 reveals an overall accuracy of 82.93%.

Table 4.4 Accuracy Assessment Table based on Error Matrix of the pixel-based method

CLASS	Closed riverine vegetation	Open riverine vegetation	Dense shrub/ herbaceous	Grass/ Herbaceous	Bult up/ bare areas	Sum
Closed forest/ riverine vegetation	13	2	0	0	0	15
Open forest riverine vegetation	2	16	1	1	0	20
Dense shrub/ herbaceous	0	1	17	2	0	20
Grass/herbaceous	0	1	1	15	3	20
Bare/built up area	0	0	1	2	22	25
Sum	**15**	**20**	**20**	**20**	**25**	**100**
Accuracy	**86.67%**	**80.00%**	**85.00%**	**75.00%**	**88.00%**	

Overall Accuracy = 82.93%

The forest cover change with respect to the different vegetation cover types was useful in noticing specific areas of deforestation, regeneration and the contribution of plantation development. Table 4.5 reveals the area in km^2 occupied by a class.

Table 4.5 Matrix of land cover by class values for the years 1990, 2000 and 2010

Class value	1990 (km^2)	%	2000 (km^2)	%	2010 (km^2)	%
Closed forest riverine vegetation	60.70	53.09	33.06	28.91	33.47	29.27
Open forest riverine vegetation	30.31	26.51	42.17	36.878	42.56	37.22
Dense shrub/ herbaceous	22.28	19.48	33.87	29.62	32.97	28.83
Grass/ herbaceous	0.65	0.57	4.39	3.84	4.28	3.74
Bare surface/ built up area	0.41	0.35	0.87	0.76	1.07	0.94
TOTAL	**114.35**	**100**	**114.35**	**100**	**114.35**	**100**

The area estimation revealed that massive deforestation took place during the first decade (1990-2000). Table 4.5 showed that a total area of 2764.89 ha (27.65 sq.km) of closed canopy forest was lost during the period 1990-2000. Fig. 4.2 also shows that there was some form of vegetation cover type transformation from closed canopy forest to open canopy forest during 1900 to 2000. For instance, while the area of closed canopy forest decreased from 60.70 km^2 to 33.06 km^2, the open canopy forest increased during the same period from 30.31km^2 to 42.17 km^2. The most significant change in forest cover during the first decade was observed within the closed canopy forest, which experienced a percentage decrease of as much as 45.547%.

The second decade (2000-2010) recorded a significant change in temporal pattern of change in the areas of both closed and open canopy forest. Analysis of forest cover for

the 2000–2010 period revealed that the closed forest canopy experienced an area increase of 41.4 ha representing 1.252% of area regenerated. There was also an increase in the area of open canopy from 42.17 km^2 to 42.56 km^2 between 1990-2000 and 2000-2010 respectively. However, the increase during the second period was far lesser (0.93% change) than within the first period (39.13% change) and the most significant forest cover type change from the 1900-2000 levels was observed in the closed canopy cover.

Visual analysis of the pattern of forest cover change among the different time intervals was also done looking at the spatial variation in forest cover. Figure 4.2 shows three different forest vegetation cover maps and their variation in spatial distribution that was produced. From 1990 to 2000, much of the deforestation occurred from the northern fringes/portions extending into the centre of the reserve. The intensity of deforestation was centred in the north-eastern corner close to the border with the Worobong South Forest Reserves (Kwahu portion) within the Kwahu South District. There was transformation of the thick closed forest canopy mostly into open forest canopy and to some extent herbaceous cover of grass or shrub. There were also huge patches of bare/built up areas concentrated in the north-eastern portions and fringes of the reserve.

During the period 2000-2010, forest cover loss still concentrated within the northern portions of the reserve but with reduced patches of herbaceous cover of grass or shrub. There was an increase in the bare/built up areas now with smaller patches but concentrated within the north western portions and fringes of the reserve. However, there was a significant improvement of closed forest canopy especially within the centre of the reserve. It could also be seen that some of the open forest canopy have

transformed into closed canopy forest. It is projected that between 2010-2020, there will be further improvement in the closed canopy forest increasing forest cover in the reserve.

4.3 The Modified Taungya System (MTS) and forest cover restoration

This section presents the results from the 100 m x 100 m Square Transect and people"s perception on the contribution of the MTS on forest cover improvement/restoration.

4.3.1 Results from the 100 m x 100 m Square Transect

Table: 4.6 Natural Forest Samples (25 m x 25 m) ≥10 cm dbh

Species	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Total
Albizia zygia	3	0	2	0	3	**8**
Triplochiton scleroxylum	2	0	0	3	3	**8**
Pitherdeniastrum africanus	4	1	3	5	0	**13**
Mesogodemia paparifera	5	4	5	4	7	**25**
Maesobotrya barteri	2	0	0	0	0	**2**
Oxyanthus speciosus	1	0	0	0	0	**1**
Cola gigintia	1	0	0	0	0	**1**
Bathia nitida	3	0	0	0	0	**3**
Rothmania longiflora	2	0	0	0	0	**2**
Terminalia superb	1	0	0	2	2	**5**
Milicia excels	1	0	0	0	0	**1**
Monodora termifolia	1	0	0	0	0	**1**
Carapa procera	2	3	0	0	2	**7**
Turraenthus africanus	2	2	1	0	3	**8**
Celtis aldolfi-frider	3	4	0	4	0	**11**
Parkia sterculia	1	4	1	0	2	**8**
Bridelia microphyla	0	2	0	0	0	**2**
Terminalia ivorensis	0	2	1	0	0	**3**
Ficus exaparata	0	1	0	0	4	**5**
Rauvolfia vomitoria	0	1	0	0	0	**1**
Celtis albraedr	0	2	4	5	0	**11**
Entanbophragma angolensis	0	0	1	0	0	**1**
Strombosia glaucescens	0	0	3	0	2	**5**
Clanitha sp.	0	0	1	0	0	**1**
Erythhrina senegalensis	0	0	2	0	0	**2**
Ceiba pentandra	0	0	0	2	0	**2**
Entandrophragma candollei	0	0	0	3	0	**3**
Total	**34**	**26**	**24**	**28**	**28**	**140**

Table: 4.7 MTS Plantation Samples (25 m x 25 m) ≥10 cm dbh

Species	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Total
Cedrella sp.	39	48	38	33	35	**193**
Albizia zygia	3	3	1	2	0	**9**
Mesogodemia paparifera	4	3	0	2	2	**11**
Celtis malbraedrr	2	0	1	1	2	**6**
Ficus exasporata	2	1	0	0	0	**3**
Triplochiton scleroxylum	2	0	0	1	1	**4**
Ceiba pentandra	0	3	0	0	0	**3**
Ficus sur	0	1	0	0	0	**1**
Terminalia superba	0	2	3	1	0	**6**
Pitterdemiastrum sfricanum	0	0	3	4	2	**9**
Ricimodendrum sp.	0	0	1	0	0	**1**
Bombax bulukonum	0	0	1	0	0	**1**
Terminalia ivorencis	0	0	0	2	0	**2**
Adiantifolia mesogodanian	0	0	0	0	1	**1**
Bathia nitida	0	0	0	0	1	**1**
Total	**52**	**61**	**48**	**46**	**44**	**251**

Plate 4.1: A 2003 Modified Taungyya System Plot planted with *Cedrella sp.*

Table 4.8 Natural Forest Samples (5 m x 5 m) ≥ 1 cm dbh

Species	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Total
Uapaca togoencis	2	0	0	0	0	**2**
Bathia nitida	6	15	13	6	8	**48**
Picnocomia macrophylla	15	10	0	0	7	**32**
Turraenthus africanus	2	2	0	3	0	**7**
Xanthoxylum gilletii	1	0	0	0	4	**5**
Pitherdeniastrum africanus	2	0	0	0	0	**2**
Mesogodemia paparifera	1	0	0	0	3	**4**
Covenante sp.	0	1	0	3	0	**4**
Oxyanthus speciosus	0	2	1	0	0	**3**
Microdesmis poberula	0	3	5	0	0	**8**
Tabamonanthus craca	0	1	0	0	0	**1**
Maesobotrya barteri	0	2	0	0	0	**2**
Nepoleona gogelii	0	1	0	0	0	**1**
Carapa procera	0	2	0	0	0	**2**
Heisteria sp.	0	0	4	3	0	**7**
Connaraceae sp.	0	0	3	0	0	**3**
Albizia zygia	0	0	1	7	0	**8**
Celtis malbraedrr	0	0	4	5	0	**9**
Ficus exasparata	0	0	0	0	3	**3**
Cola milleni	0	0	0	4	4	**8**
Parka bicola	0	0	0	4	0	**4**
Total	**29**	**39**	**31**	**35**	**29**	**163**

Table 4.9 MTS Plantation Samples (5 m x 5 m) ≥ 1 cm dbh

Species	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Total
Cedrella sp	5	5	6	4	5	**25**
Cola millenii	11	4	0	18	15	**48**
Bathia nitida	5	6	0	0	7	**18**
Triplochiton scleroxylum	3	0	3	6	0	**12**
Terminalia superb	3	0	1	1	0	**5**
Terminalia ivorensis	0	4	3	0	0	**7**
Picnocoma macrophylla	0	5	0	0	4	**9**
Ficus exasporata	0	1	0	0	0	**1**
Microdesmis poberula	0	0	2	0	0	**2**
Celtis malbraedrr	0	0	0	1	0	**1**
Petersianthus macrocarpus	0	0	0	0	5	**5**
Total	**27**	**25**	**15**	**30**	**36**	**133**

4.3.1.1 Simpson's Index of Diversity

Formula for Simpson's Index (D) $= \frac{\sum n(n-1)}{N(N-1)}$

Results after the calculation of the Simpson"s Index (D) and the Simpson"s Index of Diversity (1-D) are as follows (Table 4.10):

Table 4.10 Results of the Simpson's Index of Diversity

Transect	D	1-D
Natural Forest (25 m x 25 m)	0.068	0.93
MTS Plantation (25 m x 25 m)	0.595	0.41
Natural Forest (5 m x 5 m)	0.138	0.86
MTS Plantation (5 m x 5 m)	0.196	0.80

The result from Simpson"s Index of diversity (Table 4.10) revealed that the natural forest is more diverse in terms of species richness and evenness/relative abundance than the MTS plantation. For the 25 m x25 m samples, Diversity values (1-D) of 0.93 and 0.41 were recorded for the natural forest transect and the MTS plot respectively. Although, stem counts for the later was higher than the former, richness (number of individual tree species) and evenness (relative abundance) was relatively higher for the former. This is evident by comparing Tables 4.6, 4.7, 4.8 and 4.9. For instance, comparing the number of species for Table 4.6 and Table 4.7 reveals that the natural forest recorded 8 tree species more than the MTS plantation. Examples of tree species lacking in the MTS plantation include *Monodora termifolia, Carapa procera, Turraenthus africanus, Celtis aldolfi-frider and Parkia sterculia.* The most abundant tree species in the natural forest sample was *Pitherdeniastrum africanusn* (13).

Similarly, comparing the 5 m x 5 m samples (Tables 4.8 and 4.9) revealed that the natural forest recorded more tree species (24) than the MTS plantation (14). However, while the most abundant tree species for the natural forest was *Bathia nitida* followed by *Picnocomia macrophylla*, that for the MTS plantation was *Cola millenii* followed by *Cedrella sp.* and *Bathia nitida.* Furthermore, the average number of trees per sampled plot was calculated by dividing the total number of stems for each community by the number of samples. Tables 4.6 and 4.7 shows the number of stems per plot sampled within the 25 m x 25 m transect squares. The average number of trees per a sampled MTS plot was 50 while that of the natural forest was 28. Meanwhile, Plate 4.1 shows a 2003 MTS plot.

4.3.2 Views from farmers concerning the Modified Taungya System and forest cover restoration

To assess whether the MTS has contributed to forest cover restoration, respondents were ask to state yes or no. Table 4.11 shows their responses.

Table 4.11 Respondents view on the contribution of the MTS to forest cover restoration

Response	Akwansrem	Feyiase	Miaso	Total
Yes	22	19	20	**61**
No	5	4	4	**13**
N/A	4	1	1	**6**

Most of the respondents (76.3%) noted that the MTS has contributed to forest cover restoration while a few others responded otherwise. Others were not sure. However interview with the MTS heads confirmed that the MTS has really contributed to forest cover restoration in the WSFR. Both respondents and MTS leader in all communities noted that about 600-800 trees were grown annually.

4.4 Plot allocation and Responsibilities of Farmers under the Modified Taungya System

Farmers were asked whether they were involved in MTS as individuals or as a group. If the farmers were a member of a group, they were asked if they had regular interactions with supporting institutions, to try and get an idea of how involved the farmers are in the implementation process and to find out the manner in which information was communicated to them and by them. The result indicated that there was a Community MTS Committee in all three communities who relay information to the farmers. The establishment of these committees is part of the arrangements put in place in order to give the community a voice and an arena of discussion and to ensure the compliance of all actors involved in the MTS scheme. The committee is made up of those members of the community who are elected after putting themselves forward and is headed by representatives from the Forest Services Division (FSD). It is the committees that allocate the degraded lands to farmers. They also monitor farmers‟ and FSD‟s performance as well as settle disputes, and help implement sanctions if necessary.

Most farmers had been involved in the MTS since its inception in 2002. Plots had been allocated annually, except for 2009 in Akwansrem and 2012 in Feyiase. Most farmers reported having being allocated plots roughly equivalent to half to an acre, each year that land was allocated. For some farmers, the precise measurement was quite difficult to tell, since different local farmers used different means of measuring. What became clear however was that the leaders of the Modified Taungya Committee in all villages had been allocated substantially more land (about two or three acres, each year of allocation) than other members of the committee.

Farmers were also asked about roles in the MTS with the view that, knowledge and full understanding of their roles is important in order for all the farmers to effectively contribute to the scheme‟s success. From the study, all respondents were keen to state that they needed to plant and then take care of the tree species and the crops. Some mentioned the need to weed and the need to maintain the trees and to replace seedlings if there is mortality, others mentioned the responsibility in the dry season is to protect the trees from fire. There was an overwhelming feeling of the importance to generally keep an eye on the trees, be it in the instance of fire, chainsaw operation, theft or encroachment.

4.5 Tree Species and Agricultural Crops cultivated under the Modified Taungya System

Information gathered from respondents including MTS heads and Forest Authorities indicated that the tree species farmers planted depended on what seedlings were available to them. According to the MTS farmers, this somewhat restricted their choices. This is because farmers were interested in planting fast growing species like Teak, *Cedrella* and Ofram (*Terminalia superba*). *Cedrella sp*. was the most commonly grown species by farmers (87%). However, 12% of farmers in Feyiase reported planting indigenous Wawa *(Triplochiton scleroxylon),* while 15% of farmers in Miaso planted slow-growing mahogany (*Khaya grandifoliola)*.

Furthermore, the products harvested from the land in-between the tree seedlings were taken into consideration. It was identified that almost all of the staples of the Ghanaian diet were grown. All MTS farmers planted plantain. Other crops included maize (47.5%), cocoyam (41.3%) and vegetables (55%). The vegetables included garden eggs, onions, tomatoes, peppers, okro, etc. However, cassava was not allowed

at the initial stages of planting and was only allowed when the tree seedlings had rooted sufficiently. This is summarized in table 4.12

Table 4.12 Crops cultivated under the MTS

Agricultural Crop	Number of Respondents			
	Akwansrem	Feyiase	Miaso	Total
Plantain	31	24	25	80
Maize	16	9	13	38
Cocoyam	10	13	10	33
Vegetables	17	12	15	44
Cassava	14	13	16	43

4.6 Motivation for Participating in the MTS

Table 4.13 shows the reason given by farmers for participating in the MTS programme. Out of the reasons listed, access to farm lands, increased access to food crops and improved livelihoods were identified from all three communities as the main interests for participating in the MTS. However, concern for the environment and income seem to be of less interest to the respondents.

Table 4.13 Reasons for Participating in the MTS

REASON	Number of Respondents		
	Akwansrem (N=31)	Feyiase (N=24)	Miaso (N=25)
Access to farm land	24 (80%)	20 (80%)	21 (84%)
Access to food crops	21 (70%)	22 (88%)	18 (72%)
Income	3 (10%)	5 (20%)	2 (8%)
Concern for the Environment	13 (43.3%)	5 (20%)	8 (32%)
Improved Livelihood	23 (76.6%)	19 (76%)	20 (80%)

4.7 Standard of living and Livelihood benefits from the MTS

The Farmers were asked about how the MTS is contributing to their incomes. Of the respondents in Akwansrem, 63.3% saw the MTS plot as a reliable source of income, hence a major livelihood option, whereas 36.6% saw it as a safety net. In Feyiase, 54% saw it as a reliable source of income while 44% saw it as a safety net. In Miaso 60.0% and 36% saw it as a reliable source of income and a safety net respectively. This is summarized in table 4.14

Table 4.14 The MTS as an alternative source of income (livelihood)

Contribution to Income	Frequency Akwansrem	Feyiase	Miaso
Reliable source of income	19	13	15
Safety net	11	11	9

Farmers who sold their farm products were asked to state the average income they have been earning from their MTS farm plots. The average income per season was as follows (Table 4.15).

Table 4.15 Average income from the sale of farm produce.

Income (Cash in GH₵)	Frequency Akwansrem	Feyiase	Miaso
Below 500	6	5	2
500–1,000	5	8	6
1,000-1,500	3	2	4
1,500-2,000	2	1	1
2,000 and above	2	0	1

Table 4.15 revealed that most farmers who sold their farm produce earn between GH' 500- GH' 1,000 every season. However, some farmers earned above GH' 1,000.

In order to try to establish any changes in their standard of living, farmers were asked to describe their ease of getting the following: farm produce, children‟s education, putting up a building, household‟s daily care and access to land for farming since the introduction of MTS. In all three communities, majority of farmers reported that it was now easier to access farm produce and land for farming. The percentage of farmers in Akwansrem reporting on their ability to afford children‟s education was much lower than that of Feyiase and Miaso. Approximately a third of farmers in Akwansrem and Feyiase reported putting up a building was easier. It was reported that the provision of the household‟s daily care was easier for the majority of the farmers. The farmers, who had not seen an improvement, reported that the level of ease to access the various options remained the same. This is summarized in Table 4.16

Table 4.16 Effects of MTS on household's ability to afford various livelihood components.

Consequence/Effect	Akwansrem	Feyiase	Miaso
household‟s daily care	21	19	22
access to farm produce	23	20	19
children‟s education	8	13	15
putting up a building	10	9	6

At the current stage of MTS it is clear that the MTS is having a positive effect on people‟s lives; the income generated from the agricultural crops Is enabling farmers to obtain an improved standard of living.

The interview with the MTS leaders revealed that small-scale subsistence farming with crops like maize, cassava, cocoyam and plantain is the main provider of income, together with NTFPs that can be harvested from the forest. They confirmed that they

and the farmers are able to make a reasonable income from the agricultural crops obtained from the MTS, since the crops belong to them and they collect all the revenue from their sale. On the occasions when they may have a surplus they are able to sell products in the local markets. At other stages the crops are used for subsistence, and hence form a non-cash component of their income. However concerns were raised at the lack of diversity in the livelihood portfolios of the community, in that it is mainly reliant on crops and with the potential for land degradation and wildfire, it means that it is not a very secure option. The purpose of the MTS scheme is not only to improve the livelihood of the local rural population within the surroundings of the plantation sites but also to expand the plantation sites in an economically and ecologically sound manner. By further interaction with farmers and MTS heads, it appeared to be difficult to obtain actual data on the extent to which the MTS contributed to people‟s livelihoods. Not just because of a lack of proper records, but moreover because so little is ever converted into a physical monetary value (*i.e.* much is petty traded, or a non-cash income).

4.8 Farmers' perception on the benefit-sharing in the MTS Scheme

In general, farmers were content that forty percent (40%) was an appropriate amount for the farmer to receive but the approach in which the revenue from the sale of the timber grown within the MTS will be shared was an important consideration. This is because the agreement is not clear about how the division would be done. Generally, farmers had some believe that the income from the sale of timber would be divided according to how much land or trees the respective villagers had tended. Most farmers (83%) suggested that the revenue should be divided up according to how much land the farmer had cultivated or how many trees he/she had tended. Others had little idea and hoped the authorities would divide the money up fairly.

However 53% of the respondents at Akwansrem, 67% at Feyiase 48% at Miaso indicated at present that there was not any mechanism in place and that they were unaware of how it would work and how the money would be divided. Majority (87%) of the respondents desired for some sort of loan or part payment to maintain the farm and buy farm logistics. This is because farmers reported spending a lot of time in planting and maintenance since they do not have money to hire labourers.

Results from the interview with the MTS leaders about farmers" perception on the MTS also revealed similar views. MTS leaders" perception for the future of the MTS is uncertain. They indicated that that the confidence of the farmers in the MTS is hampered by a lack of clarity and certainty in the scheme and how the revenue will be divided up as promised. Without the release of funds for some years now, farmers lack capital to invest in planting, pegging, weeding and maintenance of the MTS. They also reported that, lack of documentation signed and held by the communities in respect of the agreement had led to a feeling of insecurity.

Furthermore, there is a fear of fire, and there is a fear that if a farmer dies, the income due may not be put into the right hands. There is a general fear that illegal loggers may come and harvest the trees when they are mature enough and then the farmer would not receive any money. There is also the fear of destruction of the forests and with it the disruption of the income provided by NTFPs. Delays in the allocation of the plots of land to be planted are perceived, meaning that sometimes, there had been a tendency of seedlings to die or to be infested by insects. There is also the inevitable report of the inequitable distribution of the land by MTS leaders, and some had to travel long distances in order to reach their plots. Forest officials reported the idea of thinning as a means for the farmer to generate income; once the trees are beginning to

establish themselves, some need to be removed in order to allow sufficient space and light for the others to grow.

4.9 Threats to the MTS

Farmers were asked what they felt were particular threats to the scheme, since threats and fears affect participation. The result is summarized in Fig. 4.3

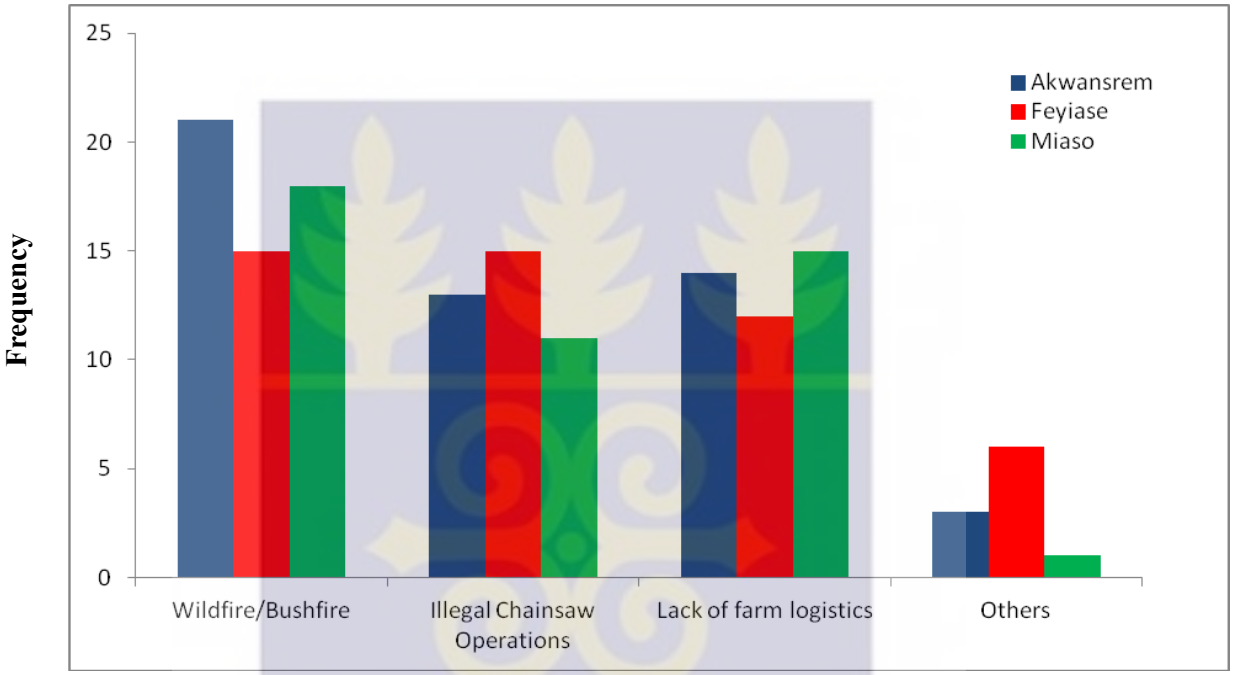


Figure 4.3 Threats to the MTS

The result indicated that most farmers (67.5%) were afraid of fire and the dramatic impact it would have on the scheme‟s success. For the most part it was wildfire that people feared, but several farmers voiced concerns that deliberately started fires was also a problem. It was noticed to some extent that jealousy existed between communities, particularly when one community is selected to be involved in a particular scheme while a neighbouring village is not chosen. With regard to other fears or threats to the scheme, 39 farmers raised concern at the prospect of illegal chainsaw lumber operations being carried out in the MTS plots. Others raised concern that some farmers putting more effort in the MTS scheme than others could be a

threat to the scheme as a result of weeds spreading from lazy farmers‟ plots. A number of farmers also indicated that, they neither had nor could afford equipment, for example proper rubber boots, cutlasses and rain coats, which sometimes infringes upon their ability to be able to farm.

4.10 Sustainability of the MTS Scheme

Suggestions made by respondents revealed that the scheme can be sustainable through the enactment and enforcement of laws, education and clarity of the scheme and its benefits, percentage share of revenue periodically. However, most farmers noted that there should be some percentage payment of their benefits from the timber before harvesting time is due. Some farmers explained that this will help reduce bulk payment at the time of harvesting of matured trees. All the MTS leaders agreed with the farmers noting that the pre-harvest benefit from the timber would serve to entice and motivate farmers to continuously invest labour. Table 4.17 shows the suggestions made by the MTS farmers.

Table 4.17 Suggestions on how to make the Modified Taungya System sustainable

	Frequency			
Suggestions	**Akwansrem**	**Feyiase**	**Miaso**	**Total**
Education	16	14	16	**46**
Enactment of laws	18	14	15	**47**
Periodic benefits from pre-harvested timber	20	15	18	**53**
Enforcement of laws	12	7	9	**28**

CHAPTER FIVE

DISCUSSION

5.1 Monitoring and Assessing Forest Cover Change of the WSFR

The researcher assessed the forest cover change of the WSFR from 1990 to 2010. Several studies have shown the alarming rate of forest cover loss in Ghana. According to Opoku (2006), forest cover loss between 1900 and 1990, was from 1.6 million ha to 8 million ha. Similar studies done elsewhere have indicated that tropical forests are being cleared, burned, logged, fragmented and overhunted on scales that lack historical precedent (Laurance and Bierre-gaard, 1997). Again, satellite images of state managed forest reserves taken in 1990 and 2000 reveal rapid deforestation within most reserves (Ghana Forestry Commission, 2002). The results of this study revealed a similar situation between 1990 and 2000 (Fig. 44.2).

However, the results of the forest cover change analysis revealed different trends as well as variations in the rate of forest cover change between the decades considered. The forest area estimation revealed that massive deforestation took place during the first decade (1990-2000) resulting in a vegetation cover type transformation from closed canopy forest to open canopy forest during 1900-2000. Similarly a study conducted by Ayivor (2007) in the Digya National Park indicated a rapid transformation of the closed forest cover into open forest and grassland. The reason for the degradation within the closed canopy forest during the first decade (1990-2000) could be that it was destroyed by illegal logging, increased agricultural activities and encroachment by human settlements as shown in this study.

The most significant forest cover type change for the second decade (2000-2010) was observed in the closed canopy cover. Thus, while there was a decrease in forest cover

during the first decade, there was however, a significant increase in forest cover during the second decade (Table 4.3 and Fig. 4.2). The increase in area of closed forest canopy was more pronounced at the centre of the reserve. It could also be noticed that some of the bare areas and open forest canopy had been transformed into closed canopy forest. Forest regeneration/restoration studies done have indicated that, forest vegetation recovery can usually be accelerated by planting trees (Holl, 2013) and that forest plantations, though generally intended for the production of timber, increase the total area of forest worldwide (Lund, 2006). The area improvement within the closed forest canopy during the second decade (2000-2010) could therefore be attributed to success of the MTS projects in the WSFR.

5.2 The Contribution of the MTS to Forest Cover Restoration

Reforestation is the primary objective of the NFPDP. Among the aims of establishing the 1994 Forest and Wildlife Policy was to ensure forest restoration and sustainable utilization of forest resources (NFPDP, 2003). Progress made so far in forest cover within the WSFR can be said to be significant. For the 25 m x 25 m plot samples, Diversity values (1-D) of 0.93 and 0.40 were recorded for the natural forest transect and the MTS plot respectively. This indicates that diversity was higher within the natural forest. However, the average number of tree stems for the later was 50 while that of the former was 28. Meanwhile most farmers reported that between 600-800 trees are planted on 0.8 ha, annually. This means that degraded areas within the reserve are being restored through the MTS Scheme. In a similar study done in the Offinso district in the Ashanti Region of Ghana, a total of 10,181 ha of degraded forest lands were planted from 2002 to 2007; and this led to the restoration of such lands. (Ghana Forestry Commission, 2001).

According to Ghana Poverty Reduction Strategy (GPRS) Report, plantation cover was to expand from the 2002 level of 20,000 ha to 60,000ha by end of 2008 (GPRS, 2005). In 2004 alone, the GPRS showed a cumulative figure of 58,726 ha, thus exceeding the 2008 targets. The GIS and RS analysis in this study also revealed that the second period (2000-2010) recorded a significant improvement of closed forest canopy, mostly from the transformation of the bare areas and open forest canopy to close canopy forest. According to Holl (2013), forest regeneration/restoration studies done have indicated that, natural regeneration of degraded forest may occur but at a very slow pace, biodiversity recovery can usually be accelerated by planting some climax forest tree species, especially large-seeded, poorly dispersed species. It is not feasible to plant all the tree species that may have formerly grown in the original primary forest and it is usually unnecessary to do so (Holl, 2013). In another study done in Gainesville, it was noted that forest plantations, though generally intended for the production of timber, increase the total area of forest worldwide (Lund, 2006). The area improvement within the closed forest canopy during the second decade (2000-2010) could therefore be attributed to success of the MTS projects in the WSFR.

In addition, the Programs on Forests (PROFOR, 2011) reported a forest restoration success story carried out in Ghana by the Community Collaborative Restoration Project in the Pamu Berekum forest area situated in the Brong-Ahafo Region of Ghana. Plantations included *Tectona grandis* and *Cedrella odorata*, also mixed with *Terminalia superba*, *Terminalia ivorensis* and *Cedrella odorata* (PROFOR Annual Report, 2011). This current study revealed that the MTS plantations grows similar species especially *Cedrella sp*. Forest restoration is therefore expected to be more successful by the end of the next decade.

However, increased forest cover resulted in reduction of farmlands around the forest reserves. This has the potential to reduce crop yield of farmlands around these plantations. Although this has the potential to reduce the area of farmlands, the aim of curtailing forest degradation and increasing forest cover under the NFPDP could be said to be achieving its targets within the WSFR (GPRS, 2005).

5.3 Benefits of the MTS to Farmers Livelihoods

The Forest of Ghana (both on and off reserve) provides both direct and indirect livelihood benefits to the entire population (Blay *et al.,* 2006). In the fringes of the forest, livelihoods are built nearly entirely on the use of local natural resources, be it from farming, forestry, chainsaw operations, charcoal production, or hunting and gathering (Marfo *et al.,* 2002).

The results of the study revealed that, majority of all MTS farmers cultivated plantain as major crop while a number of them cultivated maize, cocoyam and vegetables in different quantities. In a related study at Asuboi and Kunsu farming communities in Ghana, Amissah (2009) indicated that majority of Taungya farmers cultivated plantain and cocoyam as major crops while cassava, vegetables, groundnut and yam were cultivated as minor crops. This indicates that the programme was beneficial in reducing poverty of Taungya farmers. The intervention for overcoming subsistence poverty lies in providing sufficient food to meet the family requirement (O'Donnell, 1992).

Reports from the Forest Service Division (FSD) also indicate that MTS made substantial contributions to food production, particularly in plantain and maize crops in 2003 and 2004, although the report did not provide figures to quantify crop production (FPDC, 2002). Records at the Ministry of Local Government and Rural

Development (MLGRD) (2006) also showed that in 1998 the Mankranso district"s average yield per hectare for plantain, cocoyam, cassava and maize was higher than the regional figures. There is no doubt that MTS had improved crops production in the study area and subsistence poverty can be said to have reduced for farmers.

According to Webster (1990), Basic needs strategy adopts direct assistance to meet basic needs through employment and providing capital for investment in agriculture to improve incomes. Although, majority of the MTS farmers were employed while a few of them unemployed previously, majority of the respondents saw the MTS as a great alternative source of employment and for that matter income (Table 4.13 and Table 4.14). This was confirmed by those who were involved in the sale of their crops (Table 4.13 and Table 4.14). The MTS leaders also confirmed that small-scale subsistence farming with crops like maize, cassava, cocoyam and plantain is the main provider of income, together with NTFPs that can be harvested from the forest. They further emphasised that the farmers are able to make a reasonable income from the agricultural crops since the crops belong to them and they collect all the revenue from their sale. Other sources of income apart from the 40% share in trees grown are from site preparation, supply of seedling stocks, nursing and planting of seedlings as well as pegging (Marfo, 2009). The financial contributions, technical assistance and provision of planting materials to farmers increased the financial and physical capital of MTS farmers (FPDC, 2002).

Furthermore, in all three communities, majority of farmers reported that it was now easier to access farm produce and land for farming. Other farmers reported putting up a building, household"s daily care as well as provision of children"s school fees was easier (Table 4.16). This means that both physical and social capital of farmers was

improved. These reasons are consistent with the reasons that the farmers raised for participating in the MTS scheme. These reasons were: access to farm lands, increased access to food crops and improved livelihoods. Others were concern for the environment and income. Although concern for the environment was not mentioned by a number of them, it was however clear from the interactions that the farmers were unhappy with the degradation that was taking place and hence desired that something was done about it. It must also be noted that income is rooted in the above reasons because, access to farm land and food are all factors that leads to acquiring income. In a similar project in Pamu Berekum, successes attributable to the project included increased food production by the local farmers involved in the project, which translated into increased income to the farmers and improvement in rural livelihoods (PROFOR Annual Report, 2011).

The result of this study is also consistent with the third and fourth objectives of the MTS which are also consistent with the overall objectives pursued by the NFPDP discussed in the literature review. At the current stage of MTS it is clear that the MTS is having a positive effect on people"s lives; the income generated from the agricultural crops is enabling farmers to obtain an improved standard of living.

5.4 Threats to the MTS

Deforestation is caused by exploitation of natural resources including logging, agriculture, biofuel production, and wildfires. For instance, in the transition zone of Ghana, annual bush fires cause havoc to forest resources resulting in large tracts of reserves being burnt to the ground. In 1996, there were 127 incidences of bush fires in four major forest regions (Eastern, Ashanti, Western and Brong Ahafo) leading to a loss of 27 km^2 (Ghana Forestry Commission, 2002). The results of this study

indicated that, wildfires, illegal logging and lack of proper maintenance of MTS farms plots are some threats to the MTS. For the most part it was wildfire that people feared and the dramatic impact it would have on the scheme"s success; especially, deliberately started fires. It was reported that to some extent, jealousy existed between communities, particularly when one community is selected to be involved in a particular scheme while a neighbouring village is not chosen. This could mean that forest-fringed communities have identified tremendous benefits with the MTS scheme and those not involved wished that their community was chosen for the programme.

With regard to other fears or threats to the scheme, some farmers raised concerns with the prospect of illegal chainsaw lumber operations being carried out in the MTS plots. In a study done in the Atiwa district Seneadza (2010) and Anane (2003) noted that, forest cover loss was mainly due to agricultural activities, illegal mining, illegal logging and the development of infrastructure due to population explosion and the demand for economic and social development. Similarly, clearing forests for the production of biofuel is causing major concern, as experts contend that it has a significant negative impact on forests without doing much to reduce greenhouse gas emissions (World Bank, 2010). The result of the study indicated that illegal logging still exist within the WSFR (Fig. 4.3) and these activities destroy the natural forest canopy and subsequently endanger certain flora and fauna species in the forest (Seneadza, 2010).

Other concerns from the respondents were the lazy attitude of some famers as well as lack of logistics (Fig. 4.3). It was evident that some farmers seem to put more effort in the MTS scheme than others and hence posing as a challenge to the scheme. There were also a number of farmers who neither had nor could afford equipment, for

example proper rubber boots, cutlasses and rain coats, which sometimes infringes upon their ability to be able to farm. In a similar study in forest-fringe communities of the Tano Offin Reserve, it was emphasized that some farmers engaged in the MTS scheme, allowed weeds to spread on their plots (Ledger, 2009).

Furthermore, concerns were raised at the lack of diversity in the livelihood options of the inhabitants in and around the WSFR, in that there is overreliance on crops and with the potential for land degradation and wildfire, that option is not very secure. The purpose of the MTS scheme is to not only to improve the livelihood of the local rural population within the surroundings of the plantation sites but to also expand the plantation sites in an economically and ecologically sound manner (Ledger, 2009).

In relation to income, the result of the study showed that, most farmers were enjoying both cash and non-cash income (Table 4.15). The challenge to them was the sustainability of the income they enjoyed. They were particularly worried about available plots in the future. Thus, if almost all degraded portions of the reserve close to them are restored with planted trees, then there would be no land for farming and hence no income in the future. Nevertheless, farmers have a 40% share in the timber species planted.

Finally, Insaidoo (2012) in his work entitled "Management of Ghana's MTS: challenges and strategies for improvement" noted the following as MTS management challenges: Time lapse in income from canopy closure to timber harvesting, insecurity due to lack of signed agreement, lack of clarity in the benefit-sharing agreement, untimely provision of seedlings and distance from the community to MTS plot. Apart from timely provision of seedlings, all the other points were identified in this research as challenges/threats to the MTS. However, there is also the report of the inequitable

distribution of the land. This means that management of the MTS Scheme must take these issues seriously.

5.5 Sustainability of the MTS

The 1994 Forest and Wildlife policy of Ghana has an aim of maintaining environmental quality and perpetual flow of benefits to all society (Opoku, 2006). The World Bank has also recognised that focusing exclusively on protection misses opportunities for poverty reduction and improved management and conservation of productive forest (World Bank, 2005). According to Mwavu and Witkowski (2008), societies have rules to protect the collective welfare from harmful actions perpetrated by individual members of society. However, a successful implementation of these rules depends on an enabling environment. The willingness of all stakeholders to uphold them is a reflection of societies‟ conscious and unconscious ideologies entrenched through history (Tankpa, 2010).

The Institute of Statistical, Social and Economic Research (ISSER, 2008) stated that, sometimes the interests of indigenous people, who rely on the forest for their livelihood, are sacrificed for the economic gain that is reaped from logging trees for timber export. In this way, the Forestry Policy of Ghana, meant for the sustainable management of the forest is disregarded. The government‟s objective of increasing foreign exchange through exploitation of forest resources (such as lumbering), plantation agriculture and mining have often benefited foreign countries and the companies involved in the trade of timber, cash crops and mineral resources (Southgate *et al*., 1991). There are rules defining where, when, how and how much timber may be extracted, but they are generally not enforced effectively in Ghana (Hansen *et al*., 2009).

The 1992 Rio Summit made a remarkable impact on Ghanaian environmental consciousness leading to the adoption of the 1994 Forest and Wildlife Policy. The formulation of this policy galvanized government‟s commitment to managing the designated protected areas on a more sustainable basis (Ayivor, 2007). Forest conservation is of immense benefit not only in economic terms to society but also the global ecosystem at large due to direct and indirect services that forest resources provide. Similarly, all respondents in this study saw the need to adopt sustainable ways in the management of the MTS scheme (Table 4.17). The measures proposed included enactment and enforcement of laws to protect the MTS plots as well as the reserve, clarity of the MTS and its benefits through education and percentage share of revenue periodically.

According to Sayer (2004) in "The restoration of forest biodiversity and ecological values in Asia," large investments are being made in the establishment of tree plantations on degraded land in Asia. These initiatives are often politically driven and aspire to achieve both economic and environmental benefits. However, the lack of clarity about the precise objectives of these schemes means that they often fail to yield either local economic or global environmental benefits. There is often a failure to negotiate with all concerned stakeholders and to recognize and resolve trade-offs. Subsidies have often had perverse impacts, and market forces may be better drivers of economic objectives of restoration programmes. Security of tenure and use rights is an important but often neglected requirement for achieving sustainability. Similarly, many farmers perceived that in order for the MTS to be sustainable, after the end of the harvest of agricultural crops, there should be a flow of benefits so as to reduce bulk payment at the time of harvesting of matured trees. The pre-harvest timber

benefit would serve to entice and motivate farmers to invest labour on a continuous basis. Again there needs to be enough education and clarity on how and when the benefits from the timber would be shared because as noted in this research whereas the young farmers were mainly concerned about the agreement to be signed and legally binding, the older farmers were concerned about whether their efforts invested would be guaranteed for their next of kin (Ledger, 2009).

CHAPTER SIX

SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary of Findings

The main objective of this study was to examine the role of the MTS scheme in contributing to improved forest cover and livelihoods of farmers. This was carried out through among others the application of GIS and RS techniques to quantify the spatio-temporal changes of the vegetation cover types between 1990-2000 and 2000-2010 in the WSFR. Furthermore, the views of some MTS farmers in three communities within the study area were sought on issues on forest cover and the consequences of the MTS scheme on livelihoods of farmers.

The results of the study indicated that the forest cover in the WSFR had witnessed varying rates of transformation particularly in the closed forest canopy. Based on the GIS and RS analysis, the forest cover in general recorded a total loss of 0.41% during the first period (1990-2000) and 0.17% loss during the second period (2000-2010). The notable change in forest cover between 1990 and 2000 was observed within the closed canopy forest, which experienced a percentage decrease of 45.5%. The satellite images revealed that during this period, there was forest cover transformation from closed to open canopy. Nevertheless, there was a success story for the closed forest canopy during the second decade (2000-2010). The GIS and RS analysis for this period revealed that the closed forest canopy experienced an area increase of 41.4 ha representing 1.25% of area restored. It was therefore projected that for the next decade (2010-2020), there will be further improvement in the closed canopy forest if current rate of restoration continuous.

Secondly, analysis of the contribution of the MTS Scheme to forest cover restoration was also carried out through the 100 m x 100 m square transect techniques and

application of the Simpson‟s Index of Diversity as well as views from respondent through interviews. The results of the study indicated that although diversity was higher in the Natural forest transect than the MTS Plot transect, stem counts was close to 50% higher for the later than the former. Most farmers also reported growing between 600 to 800 trees on 0.8 ha, annually on degraded lands. The GIS and RS analysis further revealed that, during the second period (2000-2010), there was a significant improvement of closed forest canopy, mostly from the transformation of the bare areas and open forest canopy. The area improvement within the closed forest canopy was therefore attributed to the success of the MTS projects in the WSFR.

Furthermore, in relation to the benefits of the MTS to farmers, it was clear that the MTS is having a positive effect on their livelihoods. The results of the study revealed that the MTS made substantial contributions to food production, particularly in plantain and other staples in the Ghanaian diet. There is no doubt that MTS had improved crops production in the study area and subsistence poverty can be said to have reduced for farmers. Majority of the respondents saw the MTS as a great alternative source of employment and for that matter income. The results further revealed that both physical and social capital of farmers was improved. For instance, in all three communities, majority of farmers reported that it was now easier to access farm produce and land for farming. Other farmers reported putting up a building, household‟s daily care as well as provision of children‟s school fees was easier. Among the reasons given by farmers for participating in the scheme was access to farm lands, increased access to food crops and improved livelihoods. Others were, concern for the environment and increased income levels.

Notable among the threats to the MTS scheme were wildfires, illegal logging and lack of proper maintenance of MTS farms plots. Others were insecurity due to lack of signed agreement, untimely provision of seedlings, distance from village to MTS plots, and the inequitable distribution of the land were some threats to the scheme. Furthermore, in relation to income, although at present the MTS was a main source of income, the challenge to the farmers was about the sustainability of the income they enjoyed. They were particularly worried about available plots in the future. The management of the MTS scheme must therefore take these issues seriously.

6.2 Conclusion

Forest, with its multi-roles and services, has been one of the most important natural resources on earth which mankind rely on for food, income and shelter. However, this resource has been under serious threat due to some anthropogenic activities that leads to its degradation. Several forest restoration and forest livelihood schemes have been adopted of which most of them had led to further degradation. This study particularly looked at the MTS in practice within the WSFR and how it has contributed to forest restoration as well as livelihoods of farmers.

The study examined the spatio-temporal forest cover change of the WSFR through the application of GIS and RS techniques. The results indicated that during the period 1990-2000, the was massive forest cover loss with transformations particularly from closed canopy to open canopy and bare/grassland vegetative cover. However, during the period 2000-2010, the rate of forest loss had drastically reduced and it was evident that part of the open canopy and bare areas had transformed into closed canopy. This study has therefore demonstrated the importance of the application of RS and GIS

methods in studying forest cover change for information, conservation and management of forest resources.

The study further examined the contribution of the MTS to forest cover restoration. Comparing the dbh of the 100 m x 100 m natural forest transect to that of the MTS plot transect indicated by the Simpson‟s Index of Diversity that the former was more diverse than the later. But, the number of individual stem counts for the later was far higher than the former. It was therefore clear from all indications that the MTS which started in 2002 within the reserve, has contributed to the improvement of the closed canopy forest and hence, forest restoration.

Moreover, among the aims of establishing the MTS scheme is to ensure improvement in the livelihood of farmers (Marfo *et al*., 2002). The result of this study indicated that this goal of the MTS is being achieved. There is no doubt that MTS had improved crops production in the study area and subsistence poverty can be said to have reduced for farmers. Farmers were witnessing improvements in the various aspects of their social and physical capital. The result of this study is consistent with the third and fourth objectives of the MTS which are also consistent with the overall objectives pursued by the National Forest Plantation Development Programme. A number of issues were however raised by farmers as posing threats to the MTS scheme. These issues relates to inadequate understanding of scheme, environmental dangers as well as the absence of farmlands in the future. A holistic approach is therefore required to address these concerns.

6.3 Recommendations

Based on the objectives and findings of this study, the following recommendations have been made to ensure the sustainability of the MTS scheme and forest resources in the WSFR.

- The Forestry Commission should conduct a regular assessment of the spatial extent and composition of the vegetation/forest cover to keep track of changes in the various vegetation sub-types. This would help in comparing changes identified over a specific period of time.
- The application of GIS and RS techniques in forest cover and land-use change analysis should be encouraged. This is because, it allows for detailed information in forest cover to be captured at resolutions which may be difficult to achieve through other methods such as statistical and social surveys. Besides, through ground truthing, features captured through remote sensing are verified with what pertains on the ground in order to guarantee high level of accuracy of data. The Forestry Commission should therefore establish GIS and RS department to harness the capabilities of these technology in their operations.
- Enactment and enforcement of laws to cater for policies that will ensure sustainable management of the forest. This will help reduce the activities of illegal logging that contribute significantly to forest cover loss.
- The forest management should be collaborative, embracing all major stakeholders to ensure inclusion and recognition, responsibility and accountability of all players. Participation of all stakeholders can ensure greater achievement of the NFPDP goals.
- To curtail the reoccurrence of the abuses of the Traditional Taungya System, training on alternative livelihoods such as grasscutter rearing, mushroom

cultivation, bee farming and snail farming should be employed to enable farmers have sustainable income after vacating MTS farms. This has the potential to reduce deforestation and ensure sustainability of the MTS programme.

- The government should have the political will to implement the full components of the programme, especially by not reneging to pay labour engaged in order not to dampen the loyalty of farmers to the programme.

- All stakeholders of the plantation estates must be covered with legal documentation that spell out part-ownership, responsibility and share of benefits in the matured timber. This will forestall doubts, future litigation on ownership, and benefits of the forest estate.

- There is the need for massive awareness creation and educational campaigns to clarify the dictates and benefits of the programme to farming communities. Farmers and fire volunteers should be informed of their special responsibilities on fire prevention and suppression.

- An immediate concern in the villages was that there is an absolute need for release of some of the money from the timber, after perhaps 5 or 10 years. The reality is that farmers cannot afford to tend, to weed and to spend time on tree seedlings that do not give them any benefit for at least 10 years. A lump sum after such a long wait would not be helpful to the community or the farmers unless it is accompanied by financial advice and support and could be quite detrimental and used up quickly. A much more feasible approach would be instalments every few years after the last crops are harvested (Ledger, 2009).

- The Forest Commission should expand the target group to embrace more farmers in the communities in order for the livelihoods of more farmers to be improved thereby reducing poverty.

REFERENCES

Agyeman, V.K., Kasanga, K.R., Danso, E., Marfo, K.A., Whiteman, A., Asare, A.B, Yeboah, O.M. &Agyeman, F. (2003*). Equitable revenue sharing from costs and benefits on) plantation development: A case study of public, private and local community partnerships in Ghana.* Draft Report of the Community Forest Plantation Management Programme. Forest Commission, Accra.

Amissah, J. K. (2009). Utilising a Taungya Plantations Programme to Reduce the Poverty of Farmers in Ashanti Region: A case study of Asuboi and Kunsu Dotiem Farming Communities. Department of Sociology, University of Cape Coast. Ghana.

Anane, M. (2003) Implementing Agenda 21: Religion and Conservation in Ghana, New York: United Nations Non-Governmental Liason Service. New York. USA.

Ayivor, J. (2007). An Exploration of Policy Implementation in Protected Watershed Areas: Case Study of Digya National Park in the Volta Lake Margins in Ghana. Unpublished Msc. Thesis. Ohio University. USA.

Bebbington, A. (1999). Capitals and Capabilities: a Framework for Analysing Peasant Viability, Rural Livelihoods and Poverty. *World Development*. Vol. 27. Pp. 2021-2044.

Benhin, J. K. A. (2006). Agriculture and Deforestation in the Tropics: A Critical Theoretical and Empirical Review. Royal Swedish Academy of Sciences. *Ambio*. Vol 35(6). Pp. 9-16.

Birikorang, G., Okai, R., Asenso-Okyere, K., Afrane, S. and Robinson, G. (2001). Ghana Wood Industry and Log Export Ban Study. Forestry Commission

Report to the Ministry of Lands and Forest. Forest Commission, Accra, Ghana.

Blay, D., Appiah, M., Damnyag, L., Dwomoh, F.K., Luukkanen, O., Pappinen, A. (2006). Involving local farmers in rehabilitation of degraded tropical forests: Some lessons from Ghana. Accra, Ghana.

Boakye, E., Odai, S. N., Adjei, K. A., Annor, F. O. (2008). Landsat Images for Assessment of the Impact of Land-use and Land Cover Changes on the Barekese Catchment in Ghana. *European Journal of Scientific Research*. Vol 22(2). Pp. 269-278.

Boakye, K.A., and Baffoe, K.A. (2006). *Trends in forest ownership, forest resources tenure and institutional arrangements: Case study from Ghana*. Prepared for the regional workshop on Trends in Forest Ownership, Forest Resource Tenure and Institutional Arrangements in Africa, held in Nakuru, Kenya.

Brower, J.E., and Zar, J.H. (1984). Field and Laboratory Methods for General Ecology (2nd Ed.). Wm. C. Brown Publishers. Dubuque, IA.

Carney, D. (1998). Implementing the Sustainable Rural Livelihoods Approach. Sustainable Rural Livelihoods: What contribution can we make? D. Carney. DFID, London.

Centre for Remote Sensing and Geographic Information Services (CERSGIS), (2012). University of Ghana. Legon. Accra.

Chambers, R. (1995). Poverty and Livelihoods: Whose Reality Counts? Institute of Development Studies. Brighton. UK.

Crowley, E. (2010). Rural Employment and Decent Work. Building Employment and Decent Work into Sustainable Recovery and Development. International Labour Organization. Turin. USA.

Dubois, O. (2003). Forest-based poverty reduction in less developed countries: some facts, figures, challenges and possible ways forward, Forestry Policy and Institutions Branch, FAO, 0315-A2, Rome.

Evans, J. (1982). Plantation Forestry in the Tropics, Clarendon Press, Oxford, U.K.

Ellis, F. & Freeman, H. (2002). Rural Livelihoods and Poverty Reduction Strategies in four African Countries. LADDER Working Paper No. 30. Kenya.

FAO. (2001). Global Forest Resources Assessment 2000 – main report. FAO Forestry Paper No.140. Rome. Italy.

FAO. (2002). Forestry Laws & Regulations. http://www.fcghana.com/publications/ laws/ index.htm

FAO. (2003). *A journal of international forestry and forest industries.* Forestry Paper No: 212. Rome: FAO.

FAO. (2005). Global Forest Resources Assessment 2005. Progress Towards Sustainable Forest Management. Food and Agricultural Organization Forestry Paper 147. Rome, Italy.

FAO. (2006). Global Forest Resources Assessment. Progress Towards Sustainable Forest Management. Food and Agriculture Organization of the United Nations. Rome, Italy.

Forest Plantation Development Centre (FPDC), (2002). National Forest Plantation Development Programme. *Plantation Bulletin*. Accra, Ghana.

Forest Management Plan, (2013). Worobong South Forest Reserve, Akim Portion. Begoro District Forest. Begoro, Ghana.

Ghana Forestry Commission, (2001). Protecting Our Forest and Wildlife Resources for the Future: The Service Charter of the New Forestry Commission. Forestry Commission. Accra, Ghana.

Ghana Forestry Commission, (2002). Annual Report, Ghana Forestry Services Department. Accra. Ghana.

Ghana Forestry Commission, (2004). *Progress report on the National Forest Plantation Development Programme. Annual report, 2003-2004*. Accra: Forestry Commission, Ghana.

Ghana Statistical Service, (2012). Population and Housing Census of Ghana. Demographic and Economic Characteristics. Accra. Ghana.

Ghana Poverty Reduction Strategy, (2005). Annual Report. Accra. Ghana.

Government of Ghana, (1992). The 1992 Constitution of Ghana. Assembly Press. Accra. Ghana.

Hansen, C. P., Lund, J. F., and Treue, T. (2009). Neither Fast, Nor Easy: The Prospect of Reduced Emissions from Deforestation and Degradation (REDD) in Ghana. *International Forestry Review.* Vol. 11 (4). Pp. 439-455.

Higman, S., Mayers, J., Bass, S., Judd, N., Nussbaum, R. (2005). The Sustainable Forestry Handbook, Second Edition. Earthscan. UK.

Holl, K. D. (2013). Restoring Tropical Forest. Nature Education Knowledge. Department of Environmental Studies, University of California. Santa Cruz, CA.

Houghton, R. A., Hobbie, J. M., Melillo, J. E. Moore, B. Peterson, B. J., Shaver, G. R. and Woodwell, G. M. (1983). Changes in the carbon content of terrestrial biota and soils between 1860 and 1980: A net release of CO_2 to the atmosphere. *Ecological Monographs*. Vol. 53. Pp. 235-262.

Insaidoo, T. F. G. (2012). Management of Ghana's Modified Taungya System (MTS): challenges and strategies for improvement. Ghana.

Institute of Statistical, Social and Economic Research (ISSER), (2008). The State of the Ghanaian Economy in 2007. University of Ghana, Legon. Accra. Ghana.

International Union for the Conservation of Nature (IUCN), (1996). *Communities and forest management. A report of the IUCN working group on community involvement in forest management with recommendations to the intergovernmental panel on forest.* Washington DC: IUCN.

Jenson, J. R. (1986). Introductory Digital Image Processsing. Prentice Hall. New Jersey. USA.

Kaag, M., Van Berkel, R., Brons, J., de Bruijn, M., Van Dijk, H., de Haan, L., Nooteboom, G. and Zoomers, A. (2004). "Ways Forward in Livelihood Research" in Globaization and Development. Themes and Concepts in Current Research. Dordrecht/Boston/London: Kluwer Academic Publishers. London.

Kadambi, K. (1972). Silviculture and management of teak. *School of Forestry.* Bulletin 24. Pp. 1-133.

Kalame, F. (2009). The Modified Taungya System in Ghana"s transitional zone. Forests and Climate Change: adaption and mitigation, November 2009. ETFRN. Finland.

Kooiman J., Bavinck M., Jentoft S., Pullin R. (Eds), (2005). *Fish for Life: Interactive Governance for Fisheries* MARE Publication Series Interactive Fisheries Governance: A Guide to Better Practice, No. 3. Amsterdam University Press, Amsterdam.

Krantz, L. (2001). The sustainable livelihoods approach to poverty reduction. SIDA. Sweden.

Kuffour, K. O. (2000). Forest Management in Ghana: Towards A Sustainable Approach. *Journal of African Law.* Vol. 44 (1). Pp. 52-64.

Laurance, W. F., Bierregaard, R. O. (Eds), (1997). Tropical Forest Remnants: Ecology, Management, and Conservation of Fragmented Communities. University of Chicago Press. Chicago. USA.

Ledger, J. (2009). Consequences of the introduction of the Modified Taungya System in Ghana‟s High Forest Zone for the livelihoods of forest-fringe Communities. KNUST. Kumasi. Ghana

Lund, H. G. (2006). 'Definitions of Forest, Deforestation, Afforestation, and Reforestation.' Gainesville, VA.

Marfo, E. (2009). Security of Tenure and Community Benefits under collaborative forest management arrangements in Ghana: A Country Report. CSIR-INSTI, Accra.

Marfo, K., Anchirinah, V., Wiggins, S. (2002). Environmental policies and livelihoods in the forest margins of Southern Ghana. CSIR, Ghana.

Mas, J. F. (1999). Monitoring Land Cover Changes; A Comparison of Change Detection Techniques. *International Journal of Remote Sensing*. Vol. 20 (1). Pp. 139-152.

Ministry of Lands and Forestry (MLF), (1996). *Forestry development master plan 1996-2000.* MLF, Accra.

Ministry of Local Government and Rural Development (MLGRD), (2006). *Medium term development plan, (2005-2006). Offinso district assembly projections*. GOG. Accra.

Mwavu, E. N. and Witkowski, E. T. F. (2008). Land-Use and Cover Changes (1988-2002) around Budongo Forest Reserve NW Uganda: Implications for Forest

and Woodland Sustainability. *Land Degradation and Development.* Vol. 19. Pp. 606-622.

Nanang, M. D. (2009). Analysis of Export Demand for Ghana"s Timber Products: A Multivariate Co-Integration Approach. *Journal of Forest Economics.* Vol. 16. Pp. 47-61.

New Mexico State University (NMSU), (2013). The Transect Method. www.nmsu/2013.

NFPDP Annual Report, (2003). http://www.fcghana.com/publications/forestry_issues/plantation/nfpdp_annual%20report_ 2003.pdf.

NFPDP Annual Report, (2008). http://www.fcghana.com/publications/forestryissues/plantation/nfpdp_annual%20report_ 2008.pdf.

O'Donnell, M. (1992). *A new introduction to sociology*. New York: McGraw-Hill Companies. New York.

Opoku, K. (2006). Forest Governance in Ghana. An NGO perspective. A Report Produce for FERN (UK) by Forest Watch Ghana, March 2006. *Zuidam Uithof.* Utrechht. Netherlands.

Philippoff, J. & Cox, E. (2013). Measuring Abundance: Transects and Quadrants from lessons developed by Erin Baumgartner and Chela Zabin. USA.

Powell, F.C. (1982). Statistical Tables for the Social, Biological and Physical Sciences. Cambridge University Press. London.

Programs on Forest (PROFOR) Annual Progress Report, (2011). *Assessment of Forest Landscape*. Restoration Opportunities in Ghana. Collaborative Landscape Restoration in Ghana. PROFOR. Accra, Ghana.

Ros-Tonen, M.A.F., Zaal, F., Dietz, T. (2005). *African Forests Between Nature and Livelihood Resources: Interdisciplinary Studies in Conservation and Forest Management.* Lewiston NY: The Edwin Mellen Press. New York.

Ros-Tonen, M. A. F., Derkyi, M., Insaidoo, T., Bell, A., Ledger, J. (forthcoming 2010). Governance for sustainable forest-related livelihoods in Ghana‟s High Forest Zone, Presented at Governance for sustainable forest-related livelihoods in Ghana‟s High Forest Zone-IOI Project workshop in Ghana. October, 2009. Erata Hotel, Accra.

Ros-Tonen, M.A.F and Kusters, K. (2009). Pro-poor Governance of Non-Timber Forest Products: The Need for Secure Tenure, the Rule of Law, Market Access and Partnerships. Heidelberg: Springer Verlag.

Sayer, J. (2004). The Restoration of Forest Biodiversity and Ecological Values. Center for International Forestry Research. Bogor. Indonesia.

Scoones, I., (2009). Livelihood Perspectives and Rural Development. *Journal of Peasant Studies*. Vol. 36. Pp. 171-196.

Seneadza, O. K. (2010). Deforestation in Ghana: New Challenges and New Strategies. http:/www.articlesbase.com/national-state-local-articles/deforestion-in-ghana-newn challenges-and-new-strategies-1954711.html.

Shackleton, S.E., Campbell, B., Lotz-Sisitka, H. Shackleton, C. (2008). Links between the Local Trade and Natural Products, Livelihoods and Poverty Alleviation in a Semi-arid Region of South Africa. *World Development.* Vol. 36(3). Pp. 505-526.

Singh, A. (1989). Digital Change Detection Techniques Using Remotely Sensed Data. *International Journal of Remote Sensing.* Vol. 10 (6). Pp. 989-1003.

Southgate, D., Sierra, R., and Brown, L. (1991). The Causes of Tropical Deforestation in Ecuador: A Statistical Analysis. *World Development*. Vol. 19(9). Pp. 1145-1151.

Tankpa, V. (2010). Assessment of Spatio-Temporal Vegetation Cover Changes and Its Implications in the Atiwa District of Southern Ghana. Unpublished Thesis. University of Ghana. Legon. Accra.

United Nations Environmental Programme (UNEP), (2000). *Global Environmental Outlook 2*. Earthscan. London, UK.

Wardell, D. A. and Lund, C. (2006). Governing Access to Forests in Northern Ghana: Micro-Politics and the Rents of Non-Enforcement. *World Development*. Vol. 34 (11). Pp. 1887-1906.

Webster, A. (1990). An *introduction to sociology of development*. (2nd ed.). Palgrave Macmillan. London.

Westoby, J. C. (1989). Introduction to World Forestry: People and Their Trees. Blackwell Scientific Publishers. Oxford. UK.

Woodwell, G. M., Hobbie, J. M., Houghton, R. A., Melillo, J. E. Moore, B. Peterson, B. J. and Shaver, G. R. (1983). Global Deforestation: Contribution to Atmospheric Carbon dioxide. *Science*. Vol. 222. Pp. 1081-1086.

World Bank, (2001). World Development Indicators. World Bank. Washington D. C. USA.

World Bank, (2005). Getteing to know the World Bank: A Guide for Young People. Washington D. C. USA.

World Bank, (2010). Development and Climate Change. World Development Report. Houghton, R. (Ed.). World Bank. Wahshington D. C. USA.

Yiridoe, E. K. and Nanang D. M. (2001). An Econometric Analysis of the Causes of Tropical Defforestation: Ghana. Selected Paper Presented at the American Agricultural Economics Association Conference. Chicago, IL. USA.

APPENDICES

APPENDIX I. QUESTIONNAIRE TO MTS FARMERS

This questionnaire seeks to solicit responses from MTS farmers within communities around the Worobong South Forest Reserve (Akim portion) for a research about the contribution the Modified Taungya System on forest restoration and livelihoods of farmers of forest fringed communities. The researcher, therefore request for your full cooperation in responding to the questions listed below. Your responses shall be treated with the needed confidentiality.

Background Information of Respondents

1. Sex: Male [ ] Female [ ]
2. Age: < 25 [ ] 25-39 [ ] 40-54 [ ] >55 [ ]
3. Marital Status: Married [ ] Single [ ] Divorced/Separated [ ]
4. Education: Basic [ ] Secondary [ ] Tertiary [ ] None [ ]
5. Occupation: Farming [ ] Trading [ ] Others [ ] Specify…… None [ ]

Questions about the MTS scheme

1. When was the MTS started in your community?
   ……
2. How long have you been part of the MTS scheme
   ……
3. Why did you join the MTS scheme
   ……
4. How is access to forest and tree resources arranged under the MTS? Example: the motivation, group participation, plot allocation, etc
   ……
   ……
5. Is your MTS farm located close to the reserve or within the reserve? If close, how close is your farm to the forest reserve?
   ……
   ……
6. What Tree species are planted under the MTS
   ……
7. What agricultural crops have been planted on your MTS farms?
   ……
8. What is the size of your MTS farm?
   ……

9. What are your responsibilities as a farmer in the MTS scheme
   ……
   ……
10. Has the MTS scheme improved or restored the degraded areas of the forest? Explain
   ……
   ……
11. What are the Threats to the MTS scheme?
   ……
   ……
12. What do you recommend should be done to improve the MTS scheme
   ……
   ……

Questions aboutLivelihoods of Farmers in relation to the MTS

1. What benefits do you enjoy in participating in the MTS scheme?
   ……
   ……
   ……
2. What agricultural products do you derived under the MTS?
   ……
   ……
3. What is the contribution of these products to your livelihood?
   ……
   ……
4. How much do you earn from the sale of your products annually.
   ……
   ……
5. What is your perception of the benefit sharing of MTS?
   ……
   ……
   ……
6. What challenges/problems do you in the scheme?

……

……

……

APPENDIX II. QUESTIONNAIRE TO MTS HEADS AND FOREST OFFICIALS

This questionnaire seeks to solicit responses for a research about the contribution the Modified Taungya System on forest restoration and livelihoods of farmers of forest fringed communities of the Worobong South Forest Reserve (Akim portion) The researcher, therefore request for your full cooperation in responding to the questions listed below. Your responses shall be treated with the needed confidentiality.

Personal Information

Position at work/ within the scheme ……..

Male ☐ Female ☐

Questions about the MTS scheme

1. When was the MTS started in the reserve?
   ……
2. How is access to forest and tree resources arranged under the MTS? Example: the motivation, group participation, plot allocation, etc
   ……
   ……
3. Are the MTS farms located close to the reserve or within the reserve? If close, how close are the farms to the forest reserve?
   ……
4. What Tree species are planted under the MTS
   ……
5. What agricultural crops have been planted on the MTS farms?
   ……
6. What is the size of the farm for each farmer?
   ……
7. What are the Responsibilities as a farmer in the MTS scheme
   ……
   ……
8. How many farmers are engaged in the MTS?
   ……
9. Have the number of farmers engaged in the MTS been increasing yearly? If yes, what do you think accounts for this increase?
   ……
   ……
10. Do you have intentions to increase the size of tree plantation in the future? Yes / No. Give reasons
    ……
    ……

11. What are the Threats to the MTS scheme?
    ……
    ……
12. Have the MTS been successful? Explain
    ……
    ……
13. How is the MTS managed/supervised by the District forest commission?
    ……
    ……
14. Has the MTS scheme improved or restored the degraded areas of the forest? Explain
    ……
    ……
15. Do you think the MTS scheme is the best scheme so far? Why
    ……
    ……
16. What do you recommend should be done to improve the MTS scheme
    ……
    ……

Questions about Livelihoods of Farmers in relation to the MTS

1. What benefits do people enjoy in participating in the MTS scheme?
   ……
   ……
2. What kinds of forest and tree products are derived under the MTS?
   ……
   ……
3. What is the contribution of these products to people"s livelihoods?
   ……
   ……
4. Do people perceive the changes since the introduction of the MTS as an improvement of their livelihoods, and if so, why?
   ……
   ……
5. What is the farmers" perception of the benefit sharing of MTS?
   ……
   ……
6. What challenges/problems do the farmers face in the scheme?

……

……..

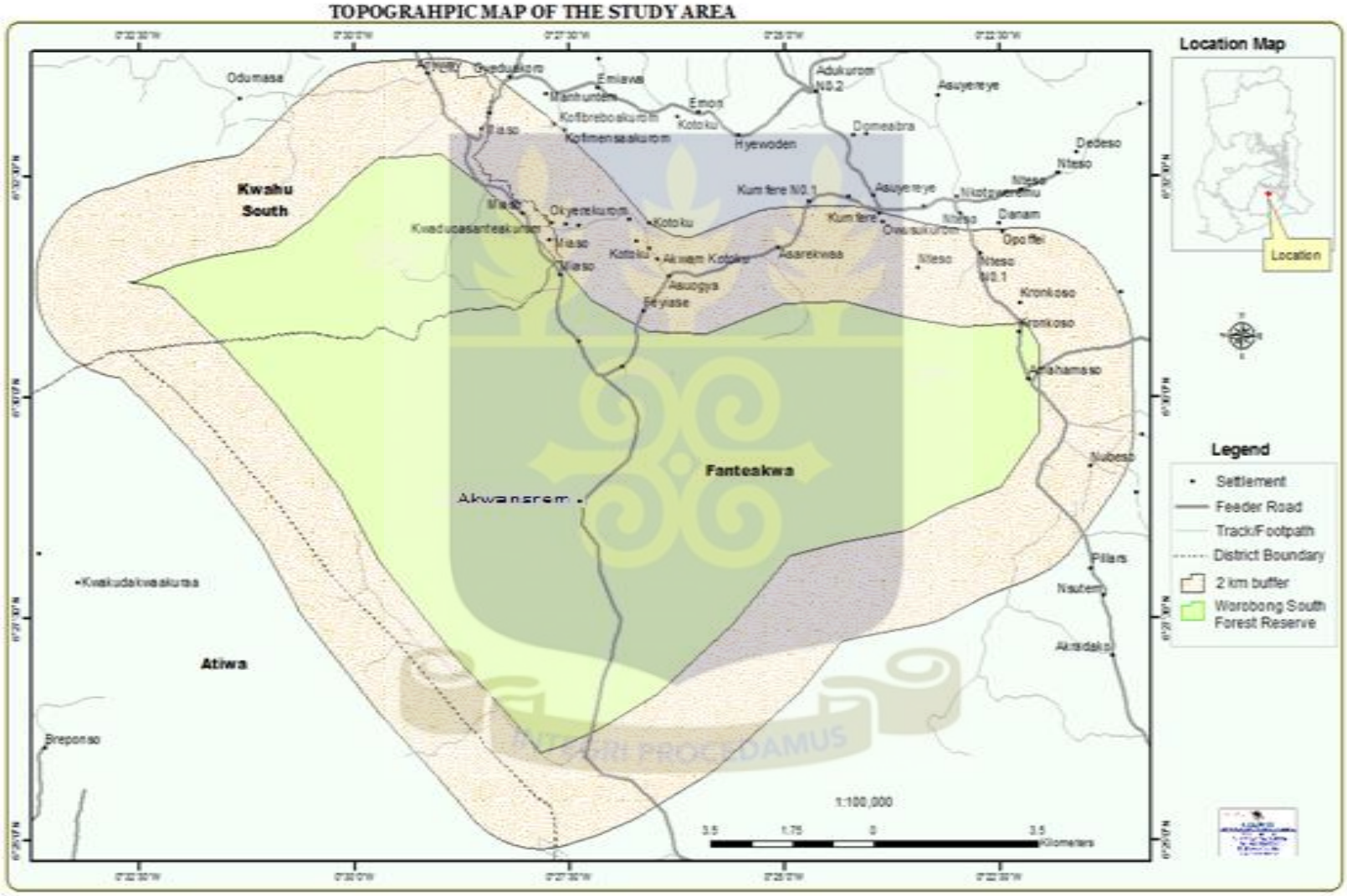
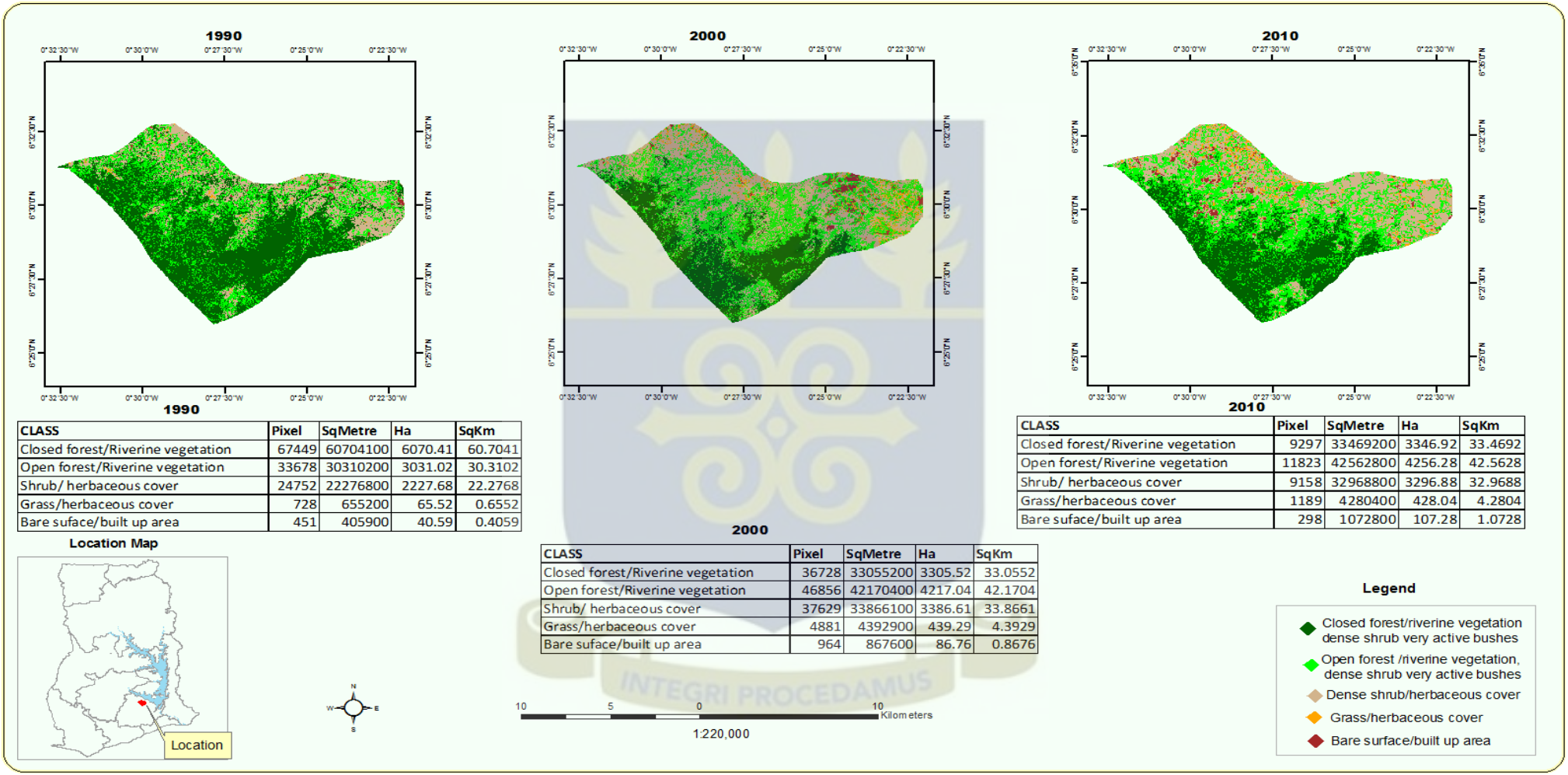


Fig. 3.1 Map of Worobong South Forest Reserve (Akim Portion) with a 2 km buffer (CERSGIS, 2013)

CLASSIFIED SATELLITE IMAGE MAPS OF THE PROJECT AREA



CLASS	Pixel	SqMetre	Ha	SqKm
Closed forest/Riverine vegetation	67449	60704100	6070.41	60.7041
Open forest/Riverine vegetation	33678	30310200	3031.02	30.3102
Shrub/ herbaceous cover	24752	22276800	2227.68	22.2768
Grass/herbaceous cover	728	655200	65.52	0.6552
Bare suface/built up area	451	405900	40.59	0.4059

2000

CLASS	Pixel	SqMetre	Ha	SqKm
Closed forest/Riverine vegetation	36728	33055200	3305.52	33.0552
Open forest/Riverine vegetation	46856	42170400	4217.04	42.1704
Shrub/ herbaceous cover	37629	33866100	3386.61	33.8661
Grass/herbaceous cover	4881	4392900	439.29	4.3929
Bare suface/built up area	964	867600	86.76	0.8676

2010

CLASS	Pixel	SqMetre	Ha	SqKm
Closed forest/Riverine vegetation	9297	33469200	3346.92	33.4692
Open forest/Riverine vegetation	11823	42562800	4256.28	42.5628
Shrub/ herbaceous cover	9158	32968800	3296.88	32.9688
Grass/herbaceous cover	1189	4280400	428.04	4.2804
Bare suface/built up area	298	1072800	107.28	1.0728

Fig. 4.2 Classified Satellite Image Maps of Worobong South Forest Reserve (1990, 2000 and 2010) (CERSGIS, 2013)