‘MAKING IT A WIN-WIN FOR ALL’

GLOBAL TO LOCAL SUSTAINABILITY: INTERNATIONAL CLIMATE CHANGE AGREEMENTS AND SHEA PRODUCTION IN GHANA

Shu-aib Jakpa Sumaila

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‘MAKING IT A WIN-WIN FOR ALL’

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by

Jakpa Sumaila Anwar Shu-aib
born on 26th of October 1975
in Kumasi, Ghana

This thesis is approved by**:**

Promotor: Prof. dr. Jon C. Lovett
Co-Promotor: Dr. S.A. Donkoh

Members of the Committee:

Chair/Secretary:	Prof.dr, T.A.J. Toonen	University of Twente Faculty of Behavioural, Management and Social Sciences, Netherlands
Promotor:	Prof.dr. Jon C. Lovett	University of Twente Faculty of Behavioural, Management and Social Sciences Department of Governance and Technology for Sustainability (CSTM), Netherlands
Co-Promotor:	Dr. S.A. Donkoh	University for Development Studies, Faculty of Agribusiness and Communication Sciences, Department of Agricultural and Resource Economics, Nyankpala, Ghana
Member:	Prof.dr.ir. T.H van der Meer	University of Twente Faculty of Engineering Technology Laboratory of Thermal Engineering, Netherlands
Promotor:	Prof. dr.J.S. Clancy	University of Twente Faculty of Behavioural, Management and Social Sciences Department of Governance and Technology for Sustainability (CSTM), Netherlands
Member:	Prof. G. Kranjac-Berisavlevic	University for Development Studies, Faculty of Agricultural Technology, Ghana
Member:	Dr. C.H. Quinn	University of Leeds, School of Earth and Environment, Umited Kingdom

Colofon

DEDICATION

To

The Almighty God;

and

my father, Labawura Shu-aib Mumuni Lanyo;

my mother, Shu-aib Ashata;

my wife and children;

siblings;

and

the rest of the family

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LIST OF ACRONYMS

A/R	Afforestation/Reforestation
ADF	Adaptation Fund Board
AfDB	African Development Bank
AFOLU	Agriculture, Forestry and Other Land Uses
ANOVA	Analysis of Variance
APRs	Annual Progress Reports
CAADP	Comprehensive Africa Agriculture Development Programme
CBD	Convention on Biological Diversity
CBFM	Community-Based Forest Management
CC DARE	Climate Change and Development-Adapting by REducing Vulnerability
CDM	Clean Development Mechanism
CDM/DNA	Clean Development Mechanism/Designated National Authority
CGE	Consultative Group of Experts
CHP	Combined Heat and Power Production
CO_2e	Carbon dioxide equivalent
CoP	Conference of the Parties
CREMA	Community Resource Management Areas
CRIG	Cocoa Research Institute of Ghana
CSOs	Civil Society Organizations
DANIDA	Danish International Development Agency
DBH	Diameter at Breast Height
DEAT	Department of Environmental Affairs and Tourism of South Africa
DfID	Department for International Development
DNA	Designated National Authority
DPCU	District Planning Coordinating Unit
DPs	Donor Partners
ECG	Electricity Company of Ghana
EGTT	Expert Group on Technology Transfer
ENAPT	Environmental Application and Technology Centre
ENRAC	Environment and Natural Resources Advisory Council
EPA	Environmental Protection Agency
ERCCU	Energy Resources & Climate Change
EU ETS	European Union Emission Trading Scheme
FASDEP	Food and Agriculture Sector Development Policy
FCPF	Forest Carbon Partnership Facility
FORIG	Forestry Research Institute of Ghana
GBA	Global Biodiversity Assessment
GECCA	Ghana Environmental Conventions Coordinating Authority
GEDAP	Ghana Energy Development and Access Project
GEF	Global Environment Facility
GEPC	Ghana Export Promotion Council
GFP	Growing Forest Partnership
GHGs	Greenhouse Gases

G-JAS	Ghana Joint Assistance Strategy
GMeT	Ghana Meteorological Agency
GoG	Government of Ghana
GPRS	Growth and Poverty Reduction Strategy
GSGDA	Ghana Shared Growth and Development Agenda
GSS	Ghana Statistical Service
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH (German: German Agency for Technical Cooperation)
ICSU	International Council of Scientific Unions
IDA	International Development Association
IFM	Improved Forest Management
INNOVKAR	Innovative Tools and techniques for Sustainable Use of the Shea Tree in Sudano-Sahelian Zone
IPCC	Inter-governmental Panel on Climate Change
IPGRI	International Plant Genetic Resources Institute
IUCN	International Union for Conservation of Nature
KITE	Kumasi Institute for Technology and Environment
LULUCF	Land Use, Land Use Change and Forestry
M&E	Monitoring & Evaluation
MD	Millennium Declaration
MDAs	Ministries, Departments and Agencies
MDGs	Millennium Development Goals
MEAs	Multilateral Environmental Agreements
MEST	Ministry of Environment Science and Technology
MESTI	Ministry of Environment Science, Technology and Innovation
MFA	Ministry of Foreign Affairs
$Mg\ C\ ha^{-1}$	Mega gram of carbon per hectare
$Mg\ C\ ha^{-1}\ yr^{-1}$	Mega gram of carbon per hectare per year
MLGRD	Ministry of Local Government & Rural Development (MLGRD)
MLNR	Ministry of Lands and Natural Resources
MoEn	Ministry of Energy
MoFA	Ministry of Food and Agriculture
MoFEP	Ministry of Finance and Economic Planning
MoI	Ministry of the Interior
NAMAs	Nationally Appropriate Mitigation Actions
NCCPF	National Climate Change Policy Framework
NCCAS	National Climate Change Adaptation Strategy
NCCC	National Climate Change Committee
NCSA	National Capacity Self-- Assessment
NDPC	National Development Planning Commission
NEPAD	New Partnership for Africa’s Development
NFPDP	National Forestation Plantation Development Program
NGOs	Non-Governmental Organizations
NLBI	Non-legally Binding Instruments
NREAG	Natural Resource and Environment Advisory Group
NREG	Natural Resources, Environmental Governance programme

NRSC	National REDDplus Steering Committee
PDD	Project Design Document
PoGH	Parliament of Ghana
PPMEDs	Policy Planning, Monitoring and Evaluation Divisions
REDD	Reduced Emissions from Deforestation and Degradation
RESPRO	Renewable Energy-Based Electricity for Rural, Social and Economic Development in Ghana
RMUs	Removal Units
RPCU	Regional Planning Coordination Unit
R-PP	Readiness Preparation Proposal
SADA	Savannah Accelerated Development Authority
SARI	Savannah Agricultural Research Institute (SARI) in Nyankpala
SPSS	Statistical Package for the Social Sciences
SRID	Statistics, Research and Information Directorate
SRREN	Special Report on Renewable Energy Resources and Climate Mitigation
STIP	Science, Technology and Innovation Policy
TAs	Traditional Authorities
tCO_2	Ton of carbon dioxide
UNCBD	United Nations Convention on Biological Diversity
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nation Development Programme
UNEP	UN Environmental Programme
UNFCCC	United Nations Framework Conventions on Climate Change
UNFF	United Nations Forum on Forests
Unit EECCU	Energy Efficiency and Climate Change Unit
URC	UNEP RISOE Centre
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
VPA	Voluntary Partnership Agreement
WCP	World Climate Programme
WEDO	The Women's Environment and Development Organization
WMO	World Meteorological Organization

ABSTRACT

In recent times, climate change has become one of the most important phenomena and a serious global concern to humans due to the severe threat it poses to life and property. As a result, carbon (C) storage potential of agroforestry systems has been recognized by the Kyoto Protocol as an alternative for mitigating greenhouse gases. Shea (*Vitellaria paradoxa)* parklands in sub-Saharan Africa provide ingredients to the multi-billion euro confectionery, cosmetic and food industries. These parklands occupy millions of hectares in twenty-one African countries, including Ghana, and serve as excellent sinks for atmospheric carbon. With increasing fears of how these useful trees are in serious danger due to logging and bush burning, there have been urgent calls for the trees to be properly managed and conserved. Farmers in shea-growing communities, in the midst of financial difficulties, manage these parklands using traditional methods. There is however a possibility of the farmers deriving cash benefits from the sale of carbon stored by these shea trees. To be able to assess how much farmers can benefit financially from such carbon credits it is useful to find out how much C shea parklands store as there is limited information on C stocks of the trees in these regions. This research postulates that shea parklands are capable of storing more C, and with the right policies farmers would be willing to continue managing the trees to obtain cash benefits. The research was divided into four components. The first component assessed the C stocks of shea parklands in the Transitional, Guinea and Sudan Savannah agroecological zones of Ghana. In each zone, field and fallow lands were subdivided into new (land under crop cultivation or fallow for 1-5 years), medium (land under crop cultivation or fallow for 6-10 years) and old (land under crop cultivation or fallow for over 10 years). The results indicate that the three zones differed significantly ($p<0.05$) in C stored, with Sudan savannah recording the most C (16.20 Mg ha^{-1}). There was however no significant difference between the two phases of landuse, although the field plots stored more C. In terms of age of land-use, the three age groups were not significantly different in carbon stock, but the medium plots stored the most C (9.59 Mg ha^{-1}). The second component of the research was to find out the policies formulated by Ghana in response to the UNFCCC international agreements and their impact on shea production in Ghana. The findings show that Ghana has responded appropriately to these international agreements and has implemented policies for the mitigation and adaption of climate change and boosting shea production in the country. In the third component, a study was conducted in the study area to identify the strategies and practices used by farmers in managing shea trees and their perceived impact on the local communities. Results of the research indicate that farmers managed shea trees using practices such as raising seedlings by natural regeneration and creation of fire-belts around farms and trees. These improved growth and yields of trees and accrued many benefits such as income, sheabutter and other shea products. The fourth aspect of the research was to find out shea farming systems that could be developed into shea carbon project models suitable for the international carbon markets. In line with the criteria of the international carbon markets, five shea carbon project models were developed. The findings also show that carbon stored in these shea project models could be significantly enhanced if the recommended tree densities and agroforestry practices are adopted. With the required policies, if these models are implemented they would help conserve shea trees to yield carbon credits that could be traded on the international forest carbon markets and the accruing incomes paid to farmers to motivate them to continue managing and protecting the shea trees. In the end, it would be a win-win situation for all; shea parklands would be conserved to store carbon to mitigate climate change for the benefit of all while cash incomes from traded shea carbon credits would be paid to the farmers to improve their livelihoods.

CHAPTER ONE

INTRODUCTION

1.1 The Background

This research aims to identify the potential for global international agreements on climate change to bring benefits to Ghanaian communities involved in shea production through carbon trading and/or REDD+ policy. The shea production system serves as a major source of livelihoods for shea-growing communities in Ghana as shea products are locally harvested, processed, some consumed while the rest are sold to generate income for households. There is a high aggregate value of shea production throughout the region, and it has some margin of profit to the farmer at the local village level. However, in comparison to returns from crop-based agriculture, these benefits are inadequate to compensate for the costs of managing the shea trees as well as meeting daily financial needs of farming households. This is due to low incomes obtained from shea products, which are usually bought at low prices by businessmen and women and companies trading in the raw shea nuts and locally manufactured shea products. Owing to this, the shea trees are in general not well-managed. They are cut down and used for fuelwood, mostly for sale to generate cash income, and shea parkland is converted to agriculture[1]. Nevertheless, there are benefits in addition to shea production. Apart from providing vegetative cover and diversifying farmer incomes in a region of climatic fluctuation, shea trees also serve as sinks for carbon. This study seeks to identify the possibility of generating additional income for farmers through the sale of carbon credits on the international carbon market. The hope is that this will motivate communities to conserve shea parklands, which will also assist in sequestering atmospheric carbon to mitigate climate change for global environmental benefits as well as generating economic benefits through the sale of carbon credits and shea products from the parklands to improve livelihoods of shea-growing communities.

Shea trees grow naturally throughout the Sudano-Sahelian region of Africa, stretching from Senegal up to the slopes of the Ethiopian highlands (White, 1983; Sanou and Lamien, 2011; Tree Aid, 2013; Natural Homes, 2014) being found in uninterrupted belt nearly 5,000 km long by 500 km wide (IPGRI, 2006). The region contains a number of tree species of high economic importance. The shea tree (Vitellaria paradoxa C.F. Gaertn., Sapotaceae) is characteristic of the woody flora in the savanna woodland of West Africa (Hall *et al*., 1996), and is the most significant tree species of the agroforestry parklands (Boffa, 2000; Lovett PN and Haq, 2000). Shea has 2 subspecies; subsp. paradoxa extends from Senegal eastwards to the Central African Republic while subspecies nilotica is found in southern Sudan, Ethiopia, Uganda and northeast Zaire (Boffa, 1999 and Ferris *et al.*, 2001). It is adapted to a broad range of environmental conditions. The tree can be found in plains and mountains and occurs in almost pure stands in the Sudanian savannahs, from Senegal to Uganda, between latitudes 9° and 14°N in West Africa, 7° and 12° N in Central Africa

[1] When shea parkland trees are cut down, the land is initially used for agriculture and after a number of years when crop yields begin to decline as a result of low soil fertility the land is allowed to fallow for some years to replenish the depleted soil nutrients. During the fallow period, the land can also be used as a grazing land.

and 2° and 8° in East Africa. This zone matches with wetter central and southern parts of dry countries such as Burkina Faso, Mali and Niger and the drier northern part of wetter countries (Benin, Cameroon, Côte d'Ivoire, Ghana, Nigeria, Togo and Uganda) (Sanou and Lamien, 2011). The species grows naturally throughout most of the Sudano-Sahelian region and has been recorded in 21 countries; Benin, Burkina Faso, Chad, Cameroon, Central African Republic, Cote d'Ivoire, Ethiopia, Gambia, Ghana, Guinea, Guinea Bissau, Mali, Niger, Nigeria, Senegal, Sierra Leone, South Sudan, Sudan, Togo, Uganda and Democratic Republic of Congo (Lovett PN, 2000). The shea tree is a prominent tree species in the West African parklands, and produces essential products and ecological services to the semi-arid region (Teklehaimanot, 2004). The dominance in many areas of the tree probably results from it being retained as a semi-domesticated tree in the savannah production system for millennia due to its economic importance (PN Lovett and Haq, 2000).

In Ghana, shea trees grow plentifully in the wild and on managed parklands in nearly half of the country, occurring throughout northern Ghana, covering a land area of more than 77670 km^2 in Western Gonja, Central Gonja, Western Dagomba, Southern Mamprusi, Lawra, Tumu, Wa and Nanumba, with Eastern Gonja having the densest stands. It is also reported that in Ghana, it occurs extensively in the Guinea Savannah and less abundantly in the Sudan Savannah (FAO, 1988a). In Ashanti, Brong-Ahafo, and the Eastern and Volta regions in the south of the country, the shea tree population is far less (Fobil, 2007).

The Shea industry in Ghana dates back centuries and has inter-generational development implications. Almost anyone brought up in rural northern Ghana has come into contact with and benefitted in one way or the other from the shea tree and its products. At the moment, the industry is dominated by women and children who harvest and process shea fruits into nuts for sale directly, or for processing into butter on a small scale. In recent years the industry has developed large scale commercial processing with the arrival of buyers and exporters who have discovered the high value of shea on the international market. Collection of nuts and processing of shea for this industry offers some level of employment to about 85 percent of the people of northern Ghana (Kavaarpuo, 2010; Kwode, 2010; Tree Aid, 2013 and Natural Homes, 2014). The trees have the potential of generating one hundred tons of shea nuts worth approximately 100 million US dollars per annum for Ghana alone (Dogbevi, 2009).

The trees are so important that they form part and parcel of the lives of the people living in the shea-growing areas of Ghana and the other 20 African countries where shea occurs. This is because, in Ghana, virtually every part of the tree is needed and used. The fresh fruits and butter are eaten as food; the leaves are used as fodder to feed livestock; the bark, roots and leaves are used in medicinal preparations for curing ailments; the ash from the waste of the butter is used to make soap (Lovett and Haq, 2000; Dogbevi, 2009; Hatskevich, 2011).

The butter from shea has essential fatty acids and is naturally rich in vitamins A, E, and F, and other vitamins and minerals (Hatskevich, 2011). Vitamins A and E help to keep the skin smooth and hydrated to prevent skin dryness. They also provide skin collagen acting as anti-agents for wrinkles and other signs of ageing. Shea butter is a perfect dry skin moisturizer and is an effective product in a form of cream for revitalizing dull or dry skin on the body or scalp. It is a good agent for skin renewal, increases circulation, and accelerates wound healing and for the treatment of many other conditions. Similarly, shea butter is used as protection against sunburn and is a component of many post sun-exposure products. In the northern parts of Ghana, it is used as pre-warm bath cream for babies to promote smooth supple skin (Hatskevich, 2011). Shea butter's property of remaining solid at room temperature and its stability in formulations makes it suitable as a base for certain traditional ointments for the treatment of fractures and broken bones (Dogbevi, 2009).

Apart from the fact that there is a growing demand for shea nuts, the industry is dominated by rural women who are normally the most economically disadvantaged group due to their limited access to productive assets (Hatskevich, 2011; Tree Aid, 2013 and Natural Homes, 2014). Many scientists, including Julius Yeboah, a Shea Biologist at Cocoa Research Institute of Ghana (CRIG) in Bole, Ghana, have acknowledged that *the shea tree is a 'golden tree', and that shea can do what cocoa can do, but cocoa cannot do what shea does, and yet little attention is given to shea* (Kavaarpuo, 2010).

Due to the major contribution of shea in the socio-economic lives of people, it is therefore not surprising that shea parklands in Africa continue to occupy about 2.5 million km^2 of land in the semi-arid and seasonal zone south of the Sahara (IPGRI, 2006). They represent a traditional land use system in which harvesting of the tree is combined with agriculture and pastoralism. The parklands also provide a range of ecosystem goods and services that are important locally, regionally, nationally and globally. These include stabilization of soil through maintenance of permanent woody vegetation cover, storage and sequestration of carbon, and maintenance of biodiversity through retaining indigenous species in the agricultural system. Although local farmers, and in particular the women who harvest the shea nuts, benefit from the direct economic outputs from the shea parkland system, they, however, do not currently receive compensation for the ecosystem goods and services that the system provides. Thus, there is the potential for an environmental market failure in which the farmers switch to a production system that might bring in greater direct financial returns, but which does not provide the same level of ecosystem goods and services. This thesis explores the potential for compensating the farmers for carbon storage and sequestration by first estimating the carbon stock of Shea woodlands in Ghana, and then investigates the possibilities for the farmers to receive payments for reduced losses of carbon stock or for increases in carbon stock that they manage.

The environment provides a wide range of ecosystem services from which people benefit. These services include provision of food, fuel, shelter and clothing (Bond *et al.,* 2009). It is therefore crucial that environmental resources are utilized in a manner that should pave the way for sustainable development to take place. According to Drexhage and Murphy (2010), since the Rio Earth Summit in 1992, sustainable development has become a new paradigm of development, integrating economic growth, social development and environmental protection as interdependent and mutually inter-related components of long-term development. Sustainable development also places much emphasis on a participatory, multi-stakeholder approach to policy formulation and implementation, pooling public and private resources together for development and utilizing the knowledge, skills and energy of all social groupings concerned with the future of the planet and its people.

The United Nations Agenda 21, the global bond for the 21st Century, signed by 179 nations at the UN Conference on *Environment and Development in Rio de Janeiro in 1992, binds governments around the world* to the UN plan, which among other things called for a Global Biodiversity Assessment (GBA) of the state of the planet. The GBA, a creation of the United Nations Environmental Programme (UNEP), provided the UN leaders with the needed "information" and "science" to check their global management system. With a prediction of a gloomy future for the global environment, the GBA strongly recommended for a reduction in human population and consumption, and a return to living standards that will sustain the environment and human life (Lafferty and Eckerberg, 2013).

The Millennium Declaration and the Millennium Development Goals (MDGs), although now replaced by the Sustainable Development Goals (SDGs) (UN, 2015), provided a new impetus for monitoring the progress of countries towards ensuring environmental sustainability, which has proven to be challenging for most countries. Environmental sustainability is very central in the Millennium Declaration, which was adopted by 147 Heads of States in September 2000 and the global agenda of eight development goals and multiple time-bound targets contained in it. Achieving progress towards MDG7 ('Ensure environmental sustainability') entails examining human welfare and ecosystem health, as well as the interrelationship between the two. Indeed, the Road Map for implementing the Millennium Declaration warns that if we do not act to contain existing environmental hazard and mitigate future peril, we will inflict irreversible damage to the ecosystems that support human life, livelihoods, and well-being, and thus compromise our ability to achieve the other MDGs, particularly MDG1 which aims at eradicating extreme poverty and hunger (UNDP Report, 2005).

According to the United Nations (2011), the Millennium Development Goals (MDGs) are:

- *Goal 1: Eradication of extreme poverty and hunger*
- *Goal 2: Achievement of universal primary education*
- *Goal 3: Promotion of gender equality and empowerment of women*
- *Goal 4: Reduction in child mortality rates*
- *Goal 5: Improvement of maternal health*
- *Goal 6: Combatting HIV/AIDS, malaria, and other diseases*
- *Goal 7: Ensuring environmental sustainability*
- *Goal 8: Development of a global partnership for development*

According to the UN Millennium Development Goals Report (2007), Ghana's efforts at achieving the MDG targets were very promising, even with overall national development being more ambitious than the 2015 targets of the MDGs. Thus, the country made good progress in achieving the MDGs since the year 2000, by maintaining a period of economic stability, with income poverty levels declining from 39.5 per cent in 1999 to around 28.5 per cent in 2006. This steady decline of poverty and increased access to basic social services throughout the country have been as a result of mainstreaming the MDGs into the broad development policy framework of the country known as the Growth and Poverty Reduction Strategy (GPRS).

The aim of the GPRS is to enable Ghana address critical issues of poverty based on growth-inducing policies and programmes to support wealth creation and poverty reduction. It is also aimed at pursuing continued macroeconomic stability, accelerated private sector-led growth, vigorous human resource development and good governance and civic responsibility (NDPC, 2005). A joint report by the Government of Ghana and the United Nations Country Team in Ghana (MoH, 2011) indicates that Ghana has made satisfactory progress towards achieving all the MDGs; with efforts made at completely achieving MDGs 1, 2, 3, 6 and 8, while significant attempts have also been made towards realizing MDGs 4, 5 and 7 before 2013. A recent report by the EU-Ghana (2012) also indicates that given the necessary support, Ghana has the potential of achieving all the MDGs, including MDGs 4 and 5.

Ghana Statistical Service also reports that MDG 1A target of reducing extreme poverty by 50% and MDG7B of halving the proportion of people who have no access to safe drinking water have been attained ahead of time. MDG1C of decreasing the proportion of those who suffer from hunger by half; MDG2 of attaining universal basic education; MDG3 of eliminating gender inequality in school for both boys and girls; MDG4 of cutting down on under-five mortality; MDG6 of terminating and reversing the spread of HIV/AIDS and malaria; MDG8 of securing debt sustainability are achievable targets. Although five targets – MDG1B of achieving full and productive employment and decent work; MDG3 of achieving equal share of women in wage employment in non-agriculture sector; MDG5 of decreasing maternal mortality; and MDG7 target of reversing the loss of environmental resources and address sanitation problems are considered to be difficult to attain, efforts are being made to ensure that they are achieved (Ghana Statistical Service, 2013).

The Shea industry contributes significantly to Ghana's economy as its products (mainly sheanuts and sheabutter) are ranked as the highest non-traditional export commodities which generated about 29 million US dollars in 2005 alone to the country (GEPC, 2006), apart from the industry playing a major economic role in the livelihoods of rural people who do not have access to other forms of income generation. The steady progress towards realizing the MDGs by Ghana has been due to external donor assistance as well as domestic contributions from many sectors of the economy, including the shea industry. This means that the shea industry has significantly contributed (and still continues to contribute) to the realization of all the 8 MDGs. Various reports demonstrate the roles played by the shea industry that are all directly or indirectly linked to the 8 MDGs. In this regard, shea contributes significantly towards the eradication of extreme poverty and hunger by respectively generating incomes as supplements to annual household budgets and provision of edible shea products for human consumption (Soladoye *et al.,* 1989; Hall *et al.,* 1996; DFSC, 2000; Lovett and Haq, 2000; Schreckenberg, 2000; Saul *et al.,* 2003; Fobil, 2007; Moore, 2008; Carette *et al.,* 2009 and Dogbevi, 2009).

At the UN Conference on Sustainable Development (Rio+20) in Rio, Brazil in 2012, one of the key issues discussed and agreed on by the UN member states was a new set of Global Sustainable Development Goals (SDGs) designed to lay out a plan towards sustainable development in the post-2015 world. The goals are a universally-shared global vision proposed for the well-being of all humans on earth. The goals and targets comprise tasks for both developed and developing countries depending on their current level of development and other national situations (Osborn *et al*., 2015). The Rio+20 Outcome Document (UN, 2012) states that the goals are "action-oriented, concise and easy to communicate, limited in number, aspirational, global in nature and universally applicable to all countries, while taking into account different national realities, capacities and levels of development and respecting national policies and priorities". The goals, as indicated in

Table 1.1, are supposed to concentrate on areas that require urgent attention for sustainable development (Osborn *et al*., 2015).

Table 1.1 Sustainable Development Goals (SDGs)

Sustainable Development Goal	
1	End poverty in all its forms everywhere
2	End hunger, achieve food security and improved nutrition, and promote sustainable agriculture
3	Ensure healthy lives and promote well-being for all at all ages
4	Ensure inclusive and equitable quality education and promote life-long learning opportunities for all
5	Achieve gender equality and empower all women and girls
6	Ensure availability and sustainable management of water and sanitation for all
7	Ensure access to affordable, reliable, sustainable, and modern energy for all
8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9	Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10	Reduce inequality within and among countries
11	Make cities and human settlements inclusive, safe, resilient and sustainable
12	Ensure sustainable consumption and production patterns
13	Take urgent action to combat climate change and its impacts
14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17	Strengthen the means of implementation and revitalize the global partnership for sustainable development

Source: ICSU and ISSC (2015b)

Following the Rio+20 conference, Heads of State and Government and High Representatives at a meeting in New York from 25-27 September 2015, as the UN celebrates its seventieth anniversary, decided on and adopted the new global Sustainable Development Goals which it described as "comprehensive, far-reaching and people-centered set of universal and transformative Goals and targets". The UN member states pledged to work towards the complete implementation of the SDGs by 2030 (The UN, 2015).

The UN recognizes that "*eradicating poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development*". It is therefore keen on realizing sustainable economic, social and environmental development; - in a balanced and coordinated manner. It "*will also build upon the achievements of the Millennium Development Goals and seek to address their unfinished business. We resolve, between now and 2030, to end poverty and hunger everywhere; to combat inequalities within and among countries; to build peaceful, just and inclusive societies; to protect human rights and promote- gender equality and the empowerment of women and girls; and to ensure the lasting protection of the planet and its natural resources. We resolve also to create conditions for sustainable, inclusive and sustained economic growth, shared prosperity and decent work for all, taking into account different levels of national development and capacities*". The 17 Sustainable Development Goals (Table 1.1) and 169 targets demonstrate the way forward and scope of this new universal Agenda (The UN, 2015).

Shea can contribute to meeting all the 17 SDGs in many respects. The key issues running through all the 17 SDGs are on poverty alleviation, food security and improved nutrition, sustainable agriculture, environmental protection and climate change, quality education and gender equality, access to good water and energy, social, economic and infrastructural development and global partnership for sustainable development. Shea can contribute immensely to meeting all these issues in the SDGs. Shea is already known to be playing enormous roles in all the issues contained in the SDGs. It is however envisaged that if shea farmers are motivated and supported to conserve shea trees as well as improve on existing parklands, benefits from shea in the form of higher incomes from the sale of shea products could translate into improved income levels and better living conditions of farmers and their households as well as other people along the marketing and value chains in the shea industry (Fobil, 2007; Carette et al., 2009; Dogbevi, 2009; Moore, 2008, Lovett PN, 2010; Bup, 2010; Bup *et al*., 2014).

Shea is already significantly contributing to the national purse through foreign exchange earnings from increased shea exports (GEPC, 2006; Moore, 2008, Lovett PN, 2010; Bup, 2010; Bup *et al*., 2014. These can thus contribute to ending poverty in SDG1, ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture in SDG2, ensuring healthy lives and promoting well-being for all at all ages in SDG3, ensuring inclusive and equitable quality education and promoting life-long learning opportunities for all in SDG4.

Widely acknowledged as “The Northern Cocoa” in Ghana owing to its production only in the northern part of the country, an estimated 1 million farmers (women and men) are directly engaged in shea nuts picking, processing and marketing. Their collective contributions together with foreign demand for the commodity contribute about US$18 million dollars annually to the country’s economy or GDP (Savannah News, 2013). This significantly contributes to meeting the social, economic and infrastructural development issues in both the MDGs and SDGs.

Presently, shea is among the top ten Non-Traditional Exports of Ghana. Thus, the country considers the shea industry to be a significant contributor to its national budget (in meeting the targets of the MDGs and SDGs as well as other national needs) due to the income and foreign exchange the country earns from the exportation of shea products (Boffa, 2000; Akosah-Sarping, 2003; Saul *et al*., 2003; Chalfin, 2004; Carette *et al.*, 2009; Dogbevi, 2009; Moore, 2008; Hatskevich *et al.*, 2011). Incomes from shea (Soladoye *et al.*, 1989; Hall *et al*., 1996; 2000; Schreckenberg, 2000; Moore, 2008) are also used to take care of education of children, thereby contributing towards achieving universal primary education (Kwode, 2010). Shea also indirectly contributes to the household budget because household items needed for daily use, which could have otherwise been bought, are obtained from shea (Boffa *et al.*, 2000; CRIG, 2002; Dogbevi, 2009). Hence, part of the already insufficient household budget for purchasing such items is saved and used for other purposes to take care of household needs.

Shea is also considered to be an economic industry mostly for the rural woman, as the harvesting and processing stages are mostly undertaken by women (Elias and Carney, 2007; Moore, 2008; Kwode, 2010). This therefore helps in the promotion of gender equality and empowerment of women and girls (as contained in SDG5) through the provision of jobs in the shea industry as well as economic empowerment for women for supporting their families.

In meeting MDG6 and SDG3 (ensuring healthy lives and promote well-being for all at all ages), shea also plays a major role in the treatment of several ailments such as malaria, and other diseases (Millee, 1984; Soladoye *et al.*, 1989; Hall *et al.*, 1996; CRIG, 2002; Fobil, 2007; Dogbevi, 2009; Moore, 2008; Hatskevich *et al.*, 2011), as well as during pregnancies and child deliveries by women, thereby reducing child mortality rates and improving maternal health (Moore, 2008). The shea industry also serves as a source of income for most women and the youth in shea-growing areas of Ghana, thus reducing contraction of HIV/AIDS and other deadly infectious diseases due to actions taken as a result of poverty. This is because, poverty has been intrinsically linked with the prevalence of HIV/AIDS due to the fact that poverty has the potential of making people, in their quest to get money to survive, vulnerable to unsafe sexual relationships (Campbell and Ntsabane, 1996; Fako and Linn, 2003; Madise *et al.*, 2007; Tagoe and Aggor, 2009 and Fako *et al.*, 2010).

Shea also plays key roles in food security, sustainable agriculture, climate change and environmental protection/sustainability (SDG2, 6, 7, 13, 14 and 15) as the trees have the capacity to ameliorate the microclimate and improve soil fertility in savanna woodlands. With the aid of their roots, the trees are capable of stabilizing soils and check soil erosion with the help of the roots. They also serve as wind breaks against strong devastating winds. In sustaining the environment, shea trees also serve to be very important in climate change mitigation through sequestration of atmospheric carbon (Rao *et al.*, 2007; Okiror *et al.*, 2012).

The shea industry in Ghana plays a major economic role in the provision of shea nuts, butter and other products which are exported to many countries around the world for industrial uses (Boffa, 2000; Schreckenberg, 2000; Laird and Guillén, 2002; Saul *et al*., 2003; Akosah-Sarping, 2003; Hatskevich *et al.*, 2011) including France, Great Britain, the Netherlands, Denmark, North America and Japan (Elias and Carney, 2007) as well as its role in carbon sequestration, which all go a long way in establishing global partnership (SDG16 and 17) between Ghana and the rest of the world for development (Moore, 2008 and Okiror *et al.*, 2012).

1.2 The Research Problem

The 2005 Millennium Ecosystem Assessment shows that nearly two-thirds of the world's ecosystems are now under threat. The emergence of the concept of payments for ecosystem services has raised expectations among many stakeholders that ecosystems can be conserved through payments to ecosystem service providers rather than through unpopular and difficult to enforce measures of command and control. The basic logic is simple: those that provide ecosystem services, by forgoing alternative uses of the land, should be compensated by the beneficiaries of that service. The principle is increasingly being applied in broader contexts beyond conservation, including the maintenance of cultivated landscapes, water supply and – most recently – for mitigating climate change. Tropical deforestation occurs due to the fact that it is more profitable to cut down forests than to take care of them. However, the emissions from deforestation and degradation of forests, mainly from tropical countries, make up close to 20% of the global emissions of greenhouse gases (Bond *et al.*, 2009). Although this estimate has been reviewed downward to 12% to reflect corrected FAO data (or 15% when peat degradation is added), deforestation is still ranked the second largest anthropogenic source of carbon dioxide to the atmosphere, after fossil fuel combustion (van der Werf *et al.*, 2009). Other results suggest the emission rates to be 25 to 50% of the original estimate (Harris *et al.*, 2012).

Due to the social and economic importance of shea trees, they are deliberately protected, conserved and raised by most farm families in northern Ghana by allowing natural regeneration, prevention of people from cutting them down and other management practices such as protecting them against bushfires and weeding around them (Okiror, *et al*., 2012). As a result of the decreasing population of shea trees, farmers have realized the need to grow and intensively manage shea trees to provide greater economic returns from the sale of shea products such as shea nuts and shea butter (Yidana, 2005). These efforts for protecting and conserving shea trees will ultimately result in the avoidance of the problems of carbon emissions from deforestation and degradation since farming households and communities prevent the shea trees from being cut down or burnt by bushfires.

At UNFCCC CoP13 in Bali in December 2007, the Parties to the UNFCCC discussed a policy known as REDD (Reduced Emissions from Deforestation and Degradation) in Developing Countries (UNFCCC, 2007). The REDD policy is aimed at compensating countries that are able to reduce their rates of deforestation, with compensation in proportion to the amount of carbon that is saved (Tollefson, 2008). The details of the mechanism are being negotiated but it is proposed to operate at national level; in contrast to CDM, which is project-based (Moutinho and Schwartzman, 2005).

For REDD funds to be released to a developing country, past rates of forest loss and a reference scenario for each participating country needs be made, against which achievements in reducing deforestation can be measured. Countries would have to commit to retain forests, and not to let their deforestation rates increase in periods that follow. Each country will have to decide as to which policies and strategies it selects and promotes to achieve its reductions. Benefits of carbon credits would be based on the entire country's net reductions in rate of loss of forest biomass over the relevant accounting period compared to the reference scenario. Although involvement would be voluntary, each participating country would benefit from funds derived either from sale of carbon credits in a global market, or from a special fund managed by a multi-lateral organization (Skutsch and Ba, 2010).

According to the Millennium Ecosystem Assessment (MA), ecosystem services (ES) can generally be defined as "the benefits people obtain from ecosystems" (MA, 2003, 2005). In the period spanning 1960 and 2000, the demand for ecosystem services rose considerably as world human population increased by two-fold and the global economy grew by more than six fold. Simultaneously, the assessment showed that almost two-thirds of global ecosystem services are in decline (MA, 2005).

Payments for ecosystem services are capable of creating incentives for reducing emissions from deforestation and degradation. A critical issue is the entire national and forest governance framework. These ideas are being implemented globally, and these are worth successfully pursuing further on much broader scales. The concept of REDD in developing countries is a vital part of a global climate policy framework. This has created global awareness that it is a cost-effective way of mitigating climate change (IPCC, 2007a; Stern, 2006). As a result, having joined and effected strategies in readiness for the execution of the REDD policy in the country, Ghana completed and submitted the final draft of the R-PP to the FCPF in 2010. This report (FCPF, 2010), among other things, indicates that *"In Ghana, the agro-forestry/tree crops/agriculture sector is as important as the forest sector itself in defining options for REDDplus, because much of the process of deforestation relates to agricultural or agro-forestry conversion… The cocoa sector presents particularly interesting opportunities in relation to REDDplus, with potentially major impact given its dominant position in the high forest zone. The COCOBOD and Cocoa Research Institute might be invited to lead this work, in association with the Ministries of Land and Natural Resources, Food and Agriculture, and Local Government".*

This clearly shows Ghana's determination to link the agro-forestry/tree crops/agriculture sector into the REDD policy. In addition, plans are far advanced to get the 3 sectors under COCOBOD (Cocoa, Shea and Coffee) into the REDD project as well, with farmers in southern Ghana expected to benefit from cocoa and coffee sectors while shea will derive significant additional cash benefits for farmers in northern Ghana.

Furthermore, during the 2010 field research for this thesis in which interviews were conducted with policy-making institutions in Ghana, Robert Bamfo (The National Coordinator for REDD Project in Ghana and also Head, Climate Change Unit, Forestry Commission, Accra, Ghana), indicated that "*Ghana provides component funding in addition to external funding, such as benefits under REDD, for the implementation of policies on conservation of shea trees. We still want to promote the forest industry so as to conserve carbon. If by planting shea trees with other trees will lead to the sequestration of carbon then we are all for it. This will be in line with low carbon development".*

In response to issues of climate change and the need to embark on pragmatic efforts to mitigate the undesirable effects, Ghana signed the United Nations Framework Convention on Climate Change in 1992, ratified it in 1995 and acceded to the Kyoto Protocol in 2002. It subsequently established a CDM Designated National Authority (DNA) at the Environmental Protection Agency (EPA) of the Ministry of Environment, Science, Technology and Innovation (MESTI) in Accra. The CDM project offers a distinctive prospect for project developers and other interested parties to develop the capacity to formulate and implement CDM-type projects. Sectors that may qualify for CDM projects include energy, industrial processes, solvent and other product uses, waste and land use, land use change and forestry (EPA, 2008).

When calculating the amount of C sequestered by forests or trees, it is necessary to determine the context in which a forest is defined. Such forest definitions differ from country to country. As a result, Shea CDM carbon projects could be considered under the forestry types of projects. This stems from the fact that in recognition of the general definition of a forest by the UNFCCC (2008) "*as one with a minimum tree crown cover of 10 - 30%, a minimum land area of 0.05 - 1 ha and a minimum tree height of 2 - 5 m*", each country is required to include information in its initial report on specific parameters related to the definition of a forest under the Kyoto Protocol. Thus, EPA (2007) defined a forest in the Ghanaian context as "*a piece of land with a minimum area of 0.1 hectares, with a minimum tree crown cover of 15% or with existing tree species having the potential of attaining more than 15% crown cover, and the trees should have the potential or have reached a minimum height of 2.0 meters at maturity in situ*".

FCPF (2010) also reports that "*how a country defines its forest cover depends on national circumstances as was agreed to under the Kyoto Protocol. It is likely that international agreements will allow for such definitions to be decided by a country within certain guidelines. In the Ghana case, it makes sense for REDDplus related activities to use the current Marrakesh Accords guidelines for defining forest cover. Various sub-national definitions could be developed that correspond to (for example) different vegetation zones (such that forest is defined in the high forest zone as having a canopy cover greater than 30% while forest cover in the savannah and transition zones could be defined as having a canopy cover greater than 15%)".*

Thus, from the above definitions of a forest, shea parklands could qualify as forests in the Ghanaian context because, to a greater extent, shea parklands generally form part of the dominant tree species in the transition and savannah zones of northern Ghana. Furthermore, findings of this research indicate that shea trees of the study area, by estimation, have a crown cover of more than 20%, although in some places shea tree densities are much lower and more planting of the trees is needed to get the percentage cover up to the required level, and cover several hectares of land area with the trees measuring 8.35 m as the mean height per tree.
For a forest project to be eligible as an AR-CDM project, then the woody vegetation should not have surpassed the forest threshold for more than 50 years (afforestation) or at the end of 1989 (reforestation). Additionally, it should not surpass this threshold in future, e.g. stable grass- or shrubland. Agroforestry only qualifies as an AR CDM project if the project measures convert long term non-forest land to forests. Enrichment plantings or forest conservation measures do not qualify under the current CDM setting as these activities focus on areas already covered with forests (UNFCCC, 2013).

However, under the UNFCCC policy on REDD+, compensation can be paid for forest emission reductions under deforestation and degradation, and forest carbon enhancement. It is nevertheless possible to separate the accounting of these three due to the fact that the local designation of credits would be easier for carbon enhancement, and perhaps reduced degradation, than for reduced deforestation, since carbon gains can be measured locally in the first two cases. It is therefore possible to design a rewards and incentives system in which both landowners and communities managing forests and local government agencies will receive a share of the financial flows from REDD+. By this separation, baselines can be set for degradation and forest enhancement at the parcel or management unit level, while the baseline for reduced deforestation will be applicable at the regional level. This type of splitting or separating accounting will enable the autonomous designation of carbon enhancement and reduced degradation to local landowners and communities. Thus, it will increase participation by providing equitable rewards for all the stakeholders involved (Balderas and Skutsch, 2012). To be able to pay individual farmers, Ghana would have to develop an internal system based on local baselines within the country and determine how much farmers should be compensated under its local REDD+ policy.

The parklands are not homogeneous; some parts are well-managed while in other areas the parklands are degraded. For this reason, parts of the shea parklands that cannot be regarded as forests (either as afforestation or reforestation), could qualify as AR-CDM projects, while the remaining parklands that need to be managed to claim credits for reduced deforestation, reduced degradation and enhancement could qualify as REDD shea projects.

Ghana has put in place measures in readiness for implementation of the REDD policy. The Readiness Preparation Proposals (R-PP) is a roadmap towards achieving REDD Readiness. It indicates what activities could be undertaken and it provides a guide to how these activities can be undertaken and what resources would be needed. Ghana began developing its R-PP in April 2009 and submitted the final R-PP to the FCPF's Participants' Committee – made up of representatives from those countries participating in the FCPF – in October 2009 (Forestry Commission of Ghana Report, 2009).

Since the start of discussions on the REDD concept, it has evolved from a highly specific mechanism to tackle deforestation and degradation to one that addresses a broader set of forest management issues, becoming REDD+. At present the REDD+ concept as defined in the Bali Action Plan (UNFCCC Dec 1/CP.13) and the next CoP decisions have a bearing on reducing emissions from deforestation and degradation, the role of conservation, sustainable management of forests and enhancement of forest carbon stocks all within developing countries. A REDD+ strategy can involve market or non-market-based instruments, and hinge on performance according to established criteria or based on greenhouse gas quantification. Ghana has taken a proactive role to initiate analysis and discussion regarding how the REDD+ concept could be applied to bolster its efforts to better manage its forest sector. Ghana is one of the first African countries to initiate the development of a national strategy on REDD+ and also participates within negotiations on the development of international mechanisms on REDD+ (Forestry Commission of Ghana Report, 2009).

The Forestry Commission of Ghana (2014) reports that:

"The country's long-term vision, or Ghana-Vision 2020, as set out in the 1995 National Development Policy Framework, is to achieve a balanced economy and a middle-income status by the year 2020. The Ghana Shared Growth and Development Agenda (GSGDA) identified medium-term objectives for the country and represented the government's development blueprint for the period 2010-2013. Within this period, accelerated agricultural modernization and effective natural resource management were seen as the pre-conditions for economic growth and poverty reduction.

To address environmental degradation, Ghana has developed a number of national programmes; notably, the Natural Resources and Environmental Governance Programme (NREG) and the National Forest Plantation Development Programme (NFPDP), which together aim to arrest and reverse deforestation rates in the country and to take steps to increase the national forest cover. Recognizing the anticipated social and economic impacts arising from climate change, and the associated development challenges, the Government of Ghana is committed to mainstreaming climate change into key planning processes at the national, regional and local level, and in early 2010 the government initiated the development of a National Climate Change Policy (NCCP). A key objective of the NCCP is low carbon growth. REDD+ and other initiatives within the forestry sector have been identified as key aspects of this policy.

Ghana's M&E Framework for the REDD+ readiness process defines five intermediate impacts or long-term results of the readiness process:

- *Reduced Pressure on Forest Ecosystems;*
- *Sustainable Management of Forests;*
- *An institutional and legal/regulatory framework that supports sustainable management of forests and protects the rights of local communities;*

- *New and additional resources for climate- and forest-friendly projects;*
- *Integration of learning by development actors active in REDD+.*

Faced with one of the highest rates of forest cover loss on the continent and degradation of its forest estates, which form a major backbone of the national economy, Ghana subscribed to the REDD+ mechanism as a feasible pathway to addressing this threat.
In 2007, the Government of Ghana submitted its REDD+ Readiness Plan Idea Note (R-PIN) to the Forest Carbon Partnership Facility (FCPF) of the World Bank which was subsequently approved in July, 2008, paving the way for the signing of a Preparation Grant Agreement on 1st April, 2009 for the sum of US$ 200,000. This came as financial support for the preparation of a REDD+ Readiness Preparation Proposal (R-PP) for the country. After an elaborate process of consultations and analytical studies involving a wide range of stakeholders and experts, both local and international, Ghana's REDD+ R-PP was submitted to the FCPF in December, 2009 which was assessed and approved by the FCPF PC at the PC5 in Gabon as per Resolution PC/5/2010/3 of March, 2010 subject to revision.
The revised R-PP was submitted to the FCPF in accordance with the PC5 resolution in December, 2010. In early October, 2011, the FCPF Readiness Grant preparation process 7 which included fiduciary arrangements, World Bank due diligence and preparation of the R-PP Assessment Note were completed culminating in the signing of a Readiness Grant Agreement of USD 3.4 million to support the implementation of the R-PP in late October, 2011. This brought the total contribution of the FCPF to the REDD+ process in Ghana to $3.6M. The formal launch of the REDD+ Readiness Programme took place in Accra on the 26th of April 2012; however it is worth noting that some initial preparatory work had begun prior to the signing of the grant agreement and formal launch.
Ghana's R-PP presents a three-step approach towards REDD+ readiness, including the development of a REDD+ strategy, as well as technical, policy, legal, management, and monitoring arrangements necessary for full participation in the evolving REDD+ mechanism. The implementation of the R-PP covers the period of 2011-2014".

Among the priority areas, as part of the national strategy to tackle the problem of environmental degradation is the arid northern savannah zone (SZ), which constitutes one-third of the land area of Ghana. Optimal management of its resilient natural resource base is essential if the people of this impoverished region are to secure for themselves a better future. Farming is the main occupation of the people, a greater proportion of which involves shea production. Most of the people are poor and live on less than one-dollar a day and depend largely on shea as the main source of their livelihoods. The mature trees are protected and well-kept during land clearance for farming and thus form part of the indigenous farming system (Masters *et al.*, 2004) and the shea industry serves as the main source of income for women whose livelihoods and that of their families largely depend on the shea trees.

In Ghana, the population of shea trees growing naturally has been estimated to be about 20 million, most of which are in the dry northern Savannah areas (8°-11°N), although there are smaller populations in the other parts of the country (Dr. Peter N. Lovett, Personal communication, July 28, 2011). There are however fears that if pragmatic efforts are not made to protect and conserve these trees, their numbers will reduce drastically they are being cut down for use as fuelwood and other products, as well as to pave the way for agricultural production, road construction and industrial establishments, in spite of the trees playing a pivotal role in climate change mitigation through carbon sequestration. This is based on the fact that the trees, as reported by Okiror *et al.* (2012), are reliable sinks for carbon as they can last for over a hundred years, thus playing a vital role in climate change mitigation through carbon sequestration. With funds from REDD to governments, Ghana could develop an internal system based on local baselines within the country and determine how much shea tree farmers should be compensated under its local REDD+ policy, and disburse money to shea tree farmers for additional sinks, or if the farmers could prove that without REDD there would be loss of stock. As a result, this could serve as an incentive for motivating them to manage and conserve the trees to serve as additional sinks.

Under the UNFCCC policy on REDD+, developing countries can claim compensation for the calculated national forest emission reductions. For this to happen, there is the need for them to prove that they have cut down on the total national rate of emissions from deforestation and/or degradation, and/or enhanced forest carbon stocks (increased the rate of carbon sequestration in forests). Similarly, for shea farmers to qualify to benefit from such compensations there is the need for them to manage and protect existing shea trees to prevent the release of CO_2 from the parklands through burning and decaying of the trees. They will also need to plant more shea trees or enhance natural regeneration of the trees to increase C stocks and the potential for increased C sequestration. As a result, there have been urgent calls and campaigns by governmental and non-governmental organizations, concerned groups and individuals to develop the shea industry and conserve the shea trees (Yidana, 2004; Moore, 2008; Sanou and Lamien, 2011). Recognizing that shea has been rated for many years now as the principal non-traditional agricultural export in Ghana (GEPC, 2006; and Savannah News, 2013) as well as playing an important role in climate change mitigation through carbon sequestration and providing incomes for households in northern Ghana through the sale of shea products, the Government of Ghana has enacted policies and programmes to develop the shea industry as well as manage and conserve the shea trees. Such policies and programmes have been channeled through the Ministry of Forestry, Lands and Mineral Resources; Ministry of Environment, Science and Technology; Ministry of Local Government and Rural Development; Forestry Commission; Forest Services Department; Environmental Protection Agency; COCOBOD; CRIG as well as other allied ministries, departments, commissions, agencies for implementation to ensure that shea trees and adequately managed and conserved (Oppong-Kyekyeku, National Climate Change Coordinator of Ghana, Personal Communication, October 20, 2010). Specific institutions under the Government of Ghana, such as COCOBOD, CRIG and SADA, have also been mandated to oversee the conservation of shea trees and have therefore been working on the ground to ensure that the trees are protected, conserved and propagated to increase their populations (SADA, 2010; COCOBOD, 2012 and COCOBOD, 2016). With these calls, campaigns and policies enacted, it is expected that the shea industry will be boosted and the shea trees adequately managed and conserved for the benefit of the nation as well as for the socio-economic benefits of the local people. In addition, based on the global international agreements and policies on climate change, it is expected that individuals and communities will manage and conserve shea trees to receive incentive packages in the form of payments for carbon credits as compensation for conserving the trees and for environmental benefits through carbon sequestration and ultimately mitigation of climate change either directly from international sources under CDM or Verified Carbon Standard (VCS) projects or REDD funds through the Ghana Government. There is however no documented information on these issues, particularly on how the management and conservation of shea trees could enhance the livelihoods of households in northern Ghana as well as improve the global environment.

It is therefore worth researching into and finding out the carbon sequestration potential of shea trees in Ghana and the extent to which the implementation of global international agreements and policies on climate change could enhance the improvement of livelihoods of people involved in shea production in Ghana and the management and protection of the global environment as a whole.

1.3 The Theoretical Framework

This research is based on the assertion that all forms of life depend on the environment for sustenance and survival (Bond *et al.*, 2009). This means that any adverse effect on the environment will ultimately impact negatively on human development. Thus, the environment and human development are intricately linked and affect each other either negatively or positively. As the environment of shea-growing savannah and the Sahel regions are dynamic, it is critically important that measures are put in place in this type of system to enhance natural and social resilience. This can then minimize the adverse impact of the environment on human development, and vice versa. All these negative, positive and negligible impacts of one on the other would, however, significantly depend on human interventions (Figure 1.1); human influences that would eventually impact on the very survival of humans themselves. In this context, such possible influences by humans can impact on the environment either positively or negatively. Positive human impacts or influences could lead to the desired human development and the favourable environment that everyone is yearning for. Negative human influences could however result in disastrous consequences, which adversely affect the environment resulting, for example, in climate change resulting in fluctuations in environmental conditions. Thus, these effects could eventually translate into adverse impacts on human development, as shown in the theoretical framework in Figure 1.2. The theoretical framework scenario of this dissertation is based on the assumption of maintaining a balance between human development and the environment. In so doing, humans can exploit environmental resources on a sustainable basis for the overall development and improvement of human livelihoods without causing any adverse impacts on the environment.

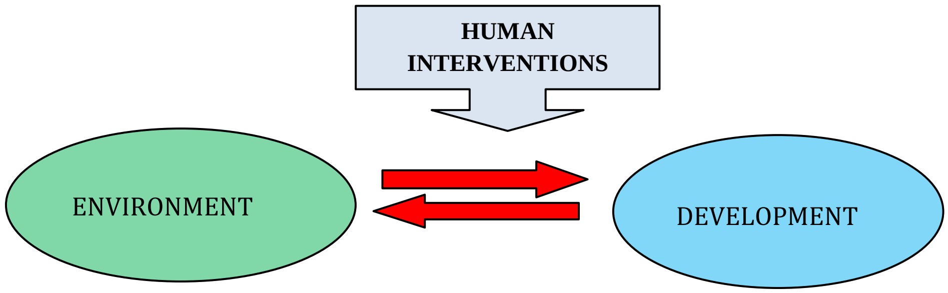


Figure 1.1 Theoretical framework for the research showing the relationship between the environment, development and human interventions

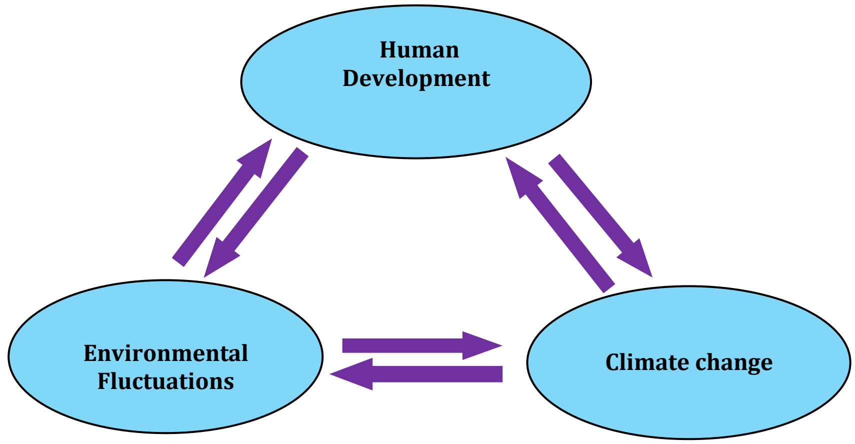


Figure 1.2 Theoretical framework for the research showing the relationship between climate change, environmental fluctuations and human livelihoods

1.4 The Conceptual Framework for this research

The 2005 Millennium Ecosystem Assessment indicates that almost two-thirds of the world's ecosystems are now under threat, and this has led to the urgent call for the institutionalization of payments for ecosystem services to encourage people to conserve ecosystems (Bond *et al.*, 2009). Thus, this dissertation research explores the possibilities of addressing critical issues relevant to how to conserve shea parklands in the West African Savannah region in general and Ghana in particular, in view of the fact that shea parklands play critical roles as forest systems in sequestering carbon from the atmosphere in addition to their key role in the livelihoods of local people. It will also help to conserve shea parklands from gradual degradation due to the alarming rates at which shea trees are lost every year. In addressing the need to conserve shea parklands, it is however necessary to consider the bigger picture that involves some major stakeholders in the climate change and the shea industry; from the UNFCCC international policy perspective through national policy formulation and implementation to field research and community/household participation in the management of shea parklands. As a result, this dissertation research seeks to address the following research questions (RQs), as illustrated in the conceptual framework in Figure 1.3, based on the Conceptual Interactions Theory (Bressers, 2004 and Bressers and O'Toole, 2005), which proposes the combination of both fundamental and actor-interaction scopes to policy analysis:

1. *RQ 1:- What carbon stocks do the various types of shea parklands, in terms of agro-ecological zones, land-use systems and ages of land-use systems, in the West African Savannah contain and how much carbon can they sequester?*

This research question seeks to bring to the fore the significant contribution that shea parklands make to the amelioration of the overall global climate change through the amounts of carbon stored and sequestered. Here, it is worth mentioning, however, that only above ground carbon was measured. Thus, in addressing the research question, field research was conducted and data taken on shea trees in purposively selected plots in the shea parklands within the northern savannah agro-ecological zones of Ghana as a case study in the West African savannah region. In all, a total of 54 plots were assessed for the study.

2. *RQ 2:- How are UNFCCC international agreements on adaptation and mitigation of climate change related to shea production in Ghana?*

In addressing this research question, a component of the research was conducted at both the international and national levels. At the international level, the UNFCCC international agreements on climate change in general and afforestation/reforestation/LULUCF in particular of which shea production is a part, were identified and analyzed. At the national level, a study was conducted in Ghana, where a total of forty officers of Governmental policy-making institutions (Ministries, Departments, Agencies and Commissions) were interviewed on the various policies, programmes, projects and measures formulated, and implemented by Ghana in response to the international climate change agreements and how they address climate change and shea production concerns in Ghana were identified and analyzed.

3. *RQ 3:- How does community shea parkland management benefit the shea trees, the livelihoods of people in the local communities in Ghana as well as on the global environment?*

To answer this research question, a study was conducted in shea-growing areas of northern Ghana to find out the strategies and practices used by households to manage shea trees and their impact on livelihoods of people in the local communities and the global environment. To obtain the required data, a multi-stage sampling design was used to select respondents at the national, regional, district, community, household and gender levels. Thus, a total of five hundred and forty 540 (3 x 3 x 30 x 2) farmers were chosen for the socio-economic study, in which both males and female farmers constituted 50% each, due to the fact that both men and women play diverse but vital roles in the shea industry; because in each household males carry out management practices to conserve shea trees while women are basically involved in the processing of the shea products.

4. *RQ 4:- How can shea fit into the international carbon markets to improve the livelihoods of people in northern Ghana as well as conserve shea parklands there for the purposes of combating climate change?*

This part of the research was conducted, in addressing the research question, to determine models of shea projects in Ghana suitable for the carbon markets within the backdrop of the international climate change agreements. The study was divided into two stages; the first stage involved a detailed analysis of the amount of sequestered carbon dioxide equivalent sequestered (CO_2e) per hectare per year by shea parklands in Ghana and how to enhance the carbon sequestration potential of the shea trees as way of increasing carbon credits for farming households for the improvement of their livelihoods. The second segment of this part of the general dissertation research was to develop shea project models for the international carbon markets.

1.5 Objectives of the study

1.5.1 Aim of the research

The aim of the research is to investigate the potential for global international agreements on climate change to bring benefits to Ghanaian communities involved in Shea production through carbon trading and/or REDD policy so that the Shea production system is not replaced by an alternative that is less-equitable and produces less ecosystem goods and services.

1.5.2 The specific objectives

The objectives of the research were to:

1. Address the problem of how to best link global needs to local action in a way that meets all three sustainability criteria: social, economic and environmental;
2. Address the problem of implementation of carbon trading and REDD policy in a sustainable way so that it provides a range of environmental improvements and also brings economic and social benefits with a focus on dry woodlands and the livelihoods of poor and marginalized people and;
3. Assess the potential for intervention in the management of shea woodlands, which are currently being managed through mechanized agriculture and depleted through firewood collection, by introducing a system of payments for carbon sequestration

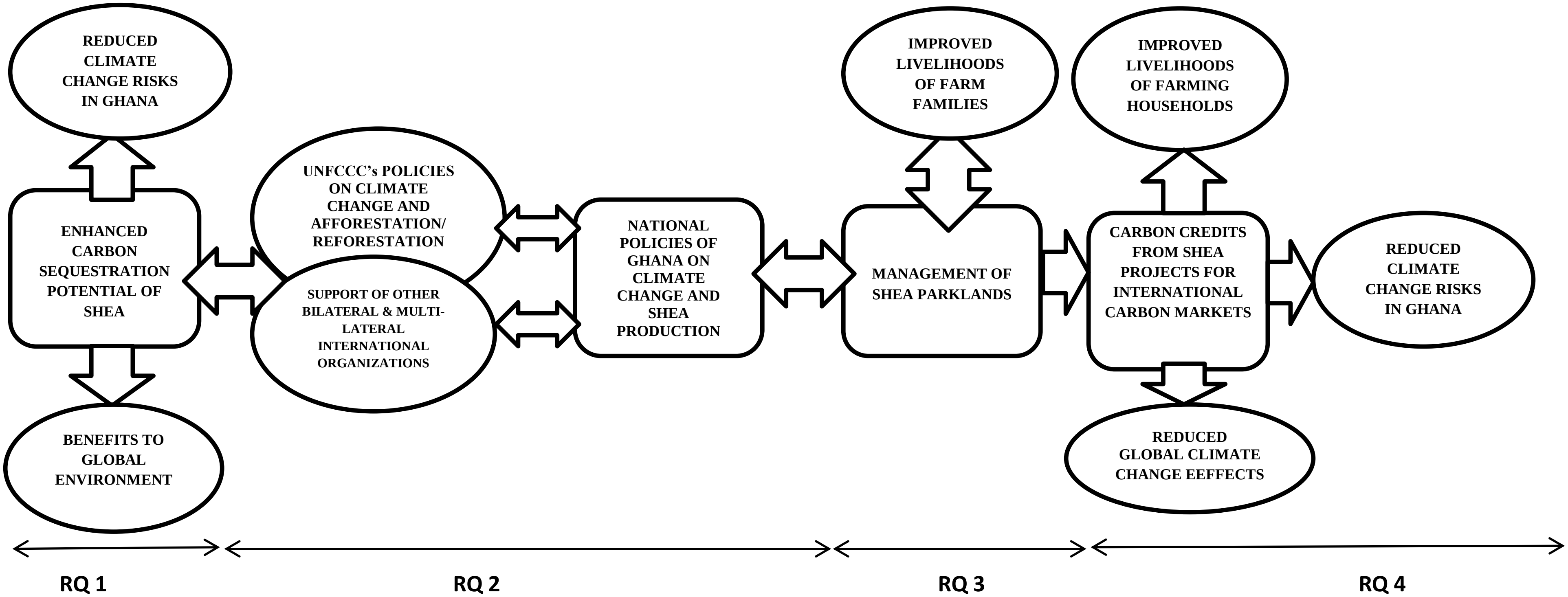


Figure 1.3 Conceptual framework of the research depicting the various segments covered by the four research questions.

1.6 Overview of the thesis

This thesis is presented in eight chapters. Chapter 1 gives a general overview of the thesis, objectives and research questions of the study. Chapter 2 presents the literature review and identifies knowledge gaps in the estimated carbon stocks and sequestration potential of shea in Ghana. In addition it reviews policies formulated in response to international agreements of the UNFCCC and their implementation and impacts on shea production in Ghana. Strategies and practices used by households to manage shea trees and their impact on livelihoods of people in the local communities and the global environment, and shea systems that could be developed into shea forest carbon project models suitable for the international carbon markets, and the cash revenue realized paid directly to the people as a motivation to conserve the trees are also presented. Chapter 3 describes the study area and presents details of methodology and approach to the objectives and research questions of the study. Chapter 4 presents results of the assessment study on carbon stocks and carbon sequestration potential of the various types of shea parklands in Ghana; how much carbon stocks the agro-ecological zones, land-use systems and ages of land-use systems in the West African Savannah contain and how much carbon they can sequester, using Ghana as a case study. Chapter 5 identifies the various policies formulated by Ghana in response to international agreements of the UNFCCC and the extent of implementation and impacts of these policies on shea production in Ghana. Chapter 6 presents findings of the research on the strategies and practices used by households in Ghana to manage shea trees and their impact on livelihoods of people in the local communities and the global environment. Chapter 7 identifies shea systems that could be developed into shea forest carbon project models suitable for the international carbon markets, and the cash revenue realized paid directly to the people as a motivation to conserve the trees. Finally, Chapter 8 presents the key findings of the dissertation, draws conclusions on the results of the overall research and also discusses the recommendations for the adoption, implementation of the results and the way forward in enhancing the conservation and productive capacity of shea parklands in Ghana for improving the livelihoods of local communities as well as for the benefit of the global environment.

CHAPTER TWO

LITERATURE REVIEW

The aim of this thesis is to investigate the potential for farmers managing Shea parklands to be compensated for the ecosystem services that they provide, in particular carbon storage and sequestration. In so doing, it is hoped that the market failure that stimulates farmers to convert Shea trees into fuelwood and charcoal and replace the parklands with other forms of land use involving either tree-less production systems or exotic woody species, will be corrected. Carbon storage and sequestration by woody vegetation is now globally recognized as an important means of mitigating anthropogenically-induced climate change through removal of the greenhouse gas carbon dioxide (CO_2). A range of mechanisms that have either already been implemented or are being negotiated are designed to capture that value.

Climate change has become an important issue and a serious concern for everyone due to the severe threat it poses to life and property globally. Carbon (C) sequestration and preventing more CO_2 from being released by avoiding deforestation and degradation, has in the recent past been a fiercely debated and widely studied topic. There are now numerous studies on carbon stocks, the carbon sequestration potential of the trees, policies formulated to address climate change, strategies and practices used to manage forests and their impact on livelihoods of people and the global environment as well as payments for ecosystems services. These have yielded results on how to sustainably manage forests for tackling climate change in general and carbon sequestration in particular. The review of literature in this chapter is focused on the above-mentioned issues that are most relevant to the current study.

The chapter begins with an assessment of studies on carbon stocks and carbon sequestration potential of trees and forests. Then various policies formulated in response to international agreements of the UNFCCC and the extent of implementation and impacts of these policies on climate change are reviewed. Following this are findings of the research on the strategies and practices used by households in Ghana to manage shea trees and their impact on livelihoods of people in the local communities and the global environment. Finally, the literature is reviewed to identify payment mechanisms that are suitable for ecosystems services.

2.1 Carbon stocks and carbon sequestration potential of trees

Global warming is incontrovertibly one of the main environmental issues of this century. This phenomenon is having adverse impacts on the global climate through increases in the temperature of the earth. This phenomenon is caused mainly by the increase in atmospheric concentrations of greenhouse gases (GHGs) (IPCC, 2014), the most common of which is carbon dioxide (CO_2). In 2012 alone, global CO_2 emissions recorded were 34.5 billion tonnes (PBL, 2013). The rates of emissions of CO_2 continue to surge, with increased concentrations reaching their fastest rate for 30 years in 2013, regardless of the warnings given by the world’s scientists to reduce emissions in order to stop increases in global temperatures. The experts gave strong warnings that the world was “running out of time” to reverse the escalating levels of CO_2 to solve the climate change

According to the UNFCCC (2012):

"In Article 2, sub-paragraphs 1(a) (ii) as well as (iii), Annex I Parties, in meeting their emission reduction commitments under Article 3, shall implement and/or further elaborate policies and measures to protect and enhance sinks and reservoirs of greenhouse gases (GHGs) not controlled by the Montreal Protocol, promote sustainable forest management, afforestation and reforestation and sustainable forms of agriculture".

"Annex I Parties must report emissions by sources and removals by sinks of GHGs resulting from LULUCF activities, in accordance with Article 3, paragraphs 3 and 4. Under Article 3.3 of the Kyoto Protocol, Parties decided that net changes in GHG emissions by sources and removals by sinks through direct human-induced LULUCF activities, limited to afforestation, reforestation and deforestation that occurred since 1990, can be used to meet Parties' emission reduction commitments. Under Article 3.4 of the Kyoto Protocol, Parties could choose additional human-induced activities related to LULUCF specifically, forest management, cropland management, grazing land management and revegetation, to be included in their accounting of anthropogenic GHG emissions and removals for the first commitment period. Upon election, this decision by a Party is fixed for the first commitment period. The changes in carbon stock and GHG emissions relating to LULUCF activities under Article 3, paragraphs 3 and 4 must be reported for each year of the commitment period, beginning with the start of the commitment period, or with the start of the activity, whichever is later. When LULUCF activities under Articles 3.3 and 3.4 result in a net removal of GHGs, an Annex I Party can issue removal units (RMUs) on the basis of these activities as part of meeting its commitment under Article 3.1".

"In addition, under Article 3, paragraph 7, for the purpose of calculating the assigned amount, an Annex I Party for which land-use change and forestry constituted a net source of GHG emissions in 1990 shall include in their 1990 emissions base year or period the aggregate anthropogenic carbon dioxide equivalent emissions by sources minus removals by sinks in 1990 from land-use change (according to paragraph 5(b) in the annex to 13/CMP.1, this refers to: all emissions by sources minus removals by sinks reported in relation to the conversion of forests (deforestation)".

"Two of the flexible mechanisms of the Kyoto Protocol make provisions for the implementation of LULUCF project activities by Parties. The clean development mechanism (CDM) under the Kyoto Protocol (Article 12) allows for the implementation of LULUCF project activities, limited to afforestation and reforestation, in non-Annex I countries. These project activities assist Annex I Parties in achieving compliance with their emission reduction commitments under Article 3, while simultaneously assisting non-Annex I Parties to achieve sustainable development. Under joint implementation (Article 6), an Annex I Party may implement projects that increase removals by sinks in another Annex I country. The emissions reduction units (ERUs) generated from such a project can be used by the former to meet its emission reduction target Any project under Article 6 aimed at enhancing anthropogenic removals by sinks shall conform to definitions, accounting rules, modalities and guidelines under Article 3, paragraphs 3 and 4, of the Kyoto Protocol".

problems (The Guardian, 2014). According to the IPCC's Fifth Assessment Report (AR5) (IPCC Report, 2014), between the period 1970 - 2010 total anthropogenic emissions have been on the increase; greater absolute increases having occured between 2000 and 2010 with estimated anthropogenic emissions in 2010 reaching 49 ± 4.5 $GtCO_2$-eq yr^{-1}.

With such increasing trends of CO_2, there are fears that its concentration in the atmosphere will be doubled by the close of the 21st century (Saha *et al.*, 2008). Findings of a research for the 2000s that apply the book-keeping model show that the mean net emissions from tropical land-use change is 1.3 and 1.0 Pg C yr^{-1} (Pan *et al*., 2011 and Baccini *et al*., 2012). A further improved approach using satellite observations of gross forest cover loss and a map of forest carbon stocks of the most recent studies projected gross carbon emissions in tropical regions between 2000 and 2005 to be 0.81 Pg of carbon per annum (equivalent to 3 gigatonnes of CO_2 emissions per year) within the range of 0.57 to 1.22 Pg of carbon per annum (Harris *et al.*, 2012).

The international response to climate change began in earnest with the setting up of the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. Five years later, 159 countries signed an agreement known as the Kyoto Protocol, which places an obligation on the 38 signatory developed countries to cut their combined greenhouse gas (GHG) emissions by not less than 5% compared to the 1990 level by the period 2008 – 2012. The agreement became operational on February 16, 2005, subsequent to its ratification by Russia on November 18, 2004. As of April 2007, a total of 169 countries and other governmental entities had endorsed the treaty. A distinctive feature of the Kyoto protocol is that it permits the amount of CO_2 sequestered by forests to be calculated towards emission targets (Takimoto *et al.,* 2007). This distinctive feature is contained in the number of Articles in the Kyoto Protocol that make provisions for the inclusion of land use, land-use change and forestry activities by Parties with regards to their efforts aimed at implementing the Kyoto Protocol and contribute to the mitigation of climate change (UNFCCC, 2012b). These Articles are: Article 2, sub-paragraphs 1(a) (ii) and (iii), Annex I Parties; Article 3.1; Article 3.3; Article 3.4; Article 3, paragraph 7; Article 6; Article 12. The first commitment period of the Kyoto Protocol ended in 2012. A second commitment period from 1 January 2013 to

31 December 2020 was agreed in Doha, Qatar, in December 2012, though the list of signatories to the second period is not the same as the first.

In order to reduce the GHGs in the atmosphere, two key activities are relevant (IPCC, 2014): reduce the anthropogenic emissions of CO_2, and create or promote carbon (C) sinks in the biosphere. The second option proposes storing atmospheric C in the biosphere, and in that regard, land-use systems such as agroforestry are of considerable importance (Saha *et al.*, 2008).

2.1.1 Role of trees in amelioration of climate change

Forests, and for that matter trees, provide ecosystem services such as climate change mitigation and adaptation, hydrological services, help in agricultural productivity, combat erosion, improve wildlife habitat and wood or availability of other forest resources. Hence, losses and degradation of forest can result in impacts like floods and landslides, on the local environment, as well as wider impacts such as global climate change (TEEB, 2010). Forests, thus, play a key role in climate change through global carbon cycle due to the large amount of carbon they are able to store in vegetation and soils (Pan *et al.*, 2011 and Ciccarese *et al.*, 2012). Furthermore, trees are able to exchange large amounts of CO_2 with the atmosphere through natural processes and biotic and abiotic disturbances. They serve as sources of carbon by releasing CO_2 and non-CO_2 gases to the atmosphere, once total respiration or oxidation of plants, soil and dead organic matter go beyond net primary productivity. Trees can also function as carbon sinks and absorb CO_2 from the atmosphere when agricultural land and pastures are left to fallow and convert to forests, or are returned to forests or plantations by enrichment planting of forests (Ciccarese *et al*., 2012).

Terrestrial ecosystems are able to store approximately 2100 Gt C in living organisms, litter and soil organic matter, and this is almost three times as much carbon as is in the atmosphere. Among these terrestrial ecosystems, tropical and boreal forests serve as the largest stores. Thus, to be able to enhance amelioration of climate change there is the urgent need to consider the maintenance of existing carbon reservoirs as one of the highest priorities (Trumper *et al.,* 2009). It is in this light that it is becoming increasingly critical to not only conserve forest ecosystems, but also restore them (Roberts *et al.*, 2009a; Lambin and Meyfroidt, 2011) for continued amelioration of climate change for global benefits. This is the reason why the UNFCCC and its Kyoto Protocol (KP) included forestry and land-based activities – known as land use, land-use change and forestry (LULUCF) – in the international climate change context as they play key roles in ameliorating climate change (Ciccarese *et al.,* 2012).

2.1.2 The role of shea in climate change amelioration

Closed tropical forest ecosystems contain enormous amounts of carbon stocks. As a result, a lot of attention has been concentrated on them (Lewis *et al.*, 2009) and their role in maintaining biodiversity. Drier forest ecosystems however offer higher potential for active management of carbon together with improvements in livelihoods (Skutsch, 2010) because they cover a large land area with a larger population of people living there. For example, the Sudano-Sahelian region of

Africa, extends from Senegal to the foothills of the Ethiopian highlands (White, 1983) and found in unbroken belt approximately 5,000 km long by 500 km wide from Senegal to Uganda and Ethiopia (IPGRI, 2006). The region contains a number of tree species of high economic importance. The shea tree is one of the numerous economically-valued trees (Okullo *et al.,* 2004; Byakagaba *et al.,* 2011). The species grows naturally throughout most of the region and has been recorded in 21 African countries. It has high socio-economic and environmental importance in areas where it grows. The most highly treasured product is shea butter extracted from the dried kernels (Teklehaimanot, 2004), used as a mono-product or whose products are useful materials in the multi-billion dollar international confectionery, cosmetic and pharmaceutical markets (USAID, 2004).

In Ghana, shea trees grow in the northern savannah regions which according to the Ghana Statistical Service (2011), these regions cover an area of almost 12 million ha of land (Ghana Statistical Service, 2011),. These shea parklands can significantly contribute to addressing climate change in Ghana through the sequestration of carbon from the atmosphere due to the fact that the trees are reported to be reliable long-term sinks for carbon (Okiror *et al.,* 2012) and are capable of living for over 500 years (Dr. Peter N. Lovett, Personal communication, November 21, 2011). However, given the relatively low rate of economic returns on the trees, they are not always protected and preserved because people are not willing to invest time and resources in managing them. Coupled with lack of support to provide labour, inputs such as the needed working tools and equipment, as well as the prevalence of high poverty levels in the shea-growing regions always render these valuable trees at the mercy of the adverse effects of annual bushfires, felling during land preparation for food crop cultivation, logging for sale as fuelwood and charcoal to generate immediate income, and roofing houses (as their wood is resistant to termite attack). Yidana (2004) reports that adverse effects of the indiscriminate annual bush burning, competition for moisture, nutrients and other resources by weeds and parasitic epiphytes that grow on the shea trees significantly decrease the yields and destroy many of the trees, and as a result the number of trees has considerably reduced over the years and decades. Thus, tangible benefits such as financial rewards from the sale of carbon credits will encourage communities to protect, conserve, improve and manage the shea trees. These are only feasible if concrete data on the carbon stocks and sequestration potential of the trees are known and documented, which at the moment such information is very scanty. Such limited studies include those done by Takimoto *et al*. (2007), Aitken *et al*. (2010) and Nair (2013) for carbon storage generally by trees in the entire ecological zone and non-existent specifically for shea in the West African Savannah. A study to gather data on carbon stocks and sequestration potential by shea trees in the parklands of the West African Savannah is very much needed.

2.2 Policies formulated to address climate change

Considering how climate change has become a major concern worldwide and a threat to the very existence of humans and other living organisms, UNFCCC (2008) reports that it is increasingly being recognized as one of the most critical challenges ever to confront humans and suggests that as a global problem it requires a global response embracing the needs and interests of all countries. UNFCCC (2007) also asserts that the impacts of climate change range from increase in sea level, melting of ice caps and glaciers, along with increased incidences of drought and flooding, leading already to reduction in agricultural production, threatened water security and the spread of vector-borne diseases.

As the “defining challenge of our age” (UNFCCC, 2008) and undoubtedly the worst environmental challenge facing the world in this century, the phenomenon is more about serious disruptions of the entire world’s weather and climate patterns, including impacts on rainfall, extreme weather events and increase in sea level, rather than just moderate temperature increases. The developing world faces more serious threats than the developed world, both in terms of the impacts of climate change and the capacity to respond to it (DEAT, 2004 and IPCC Report, 2014).

Human activities produce huge amounts of greenhouse gases (GHGs), predominantly made up of carbon dioxide (CO_2), which significantly add to the causes of global warming. The use of fossil fuels and loss of trees and forest degradation also contribute GHG emissions (CBO, 2012). Together with projected global temperature increases, precipitation patterns and quantities possibly change, and the rate and intensity of key natural threats, such as droughts, heat waves, floods and fires are likely to increase. In West Africa, agriculture, which is mostly rain-fed, is the main economic activity that provides food and income for the people. It is however the most vulnerable sector to climate change (Roudier *et al.,* 2011).

2.2.1 Impact of climate change in Ghana

Ghana is affected by the adverse impacts of climate change. Generally, Ghana is projected to become hotter and wetter during the wet season and drier during the dry season, with increased sea level rise and storm surges on the coast (The World Bank Group, 2011). As an agrarian-based economy, dependent on food and cash crops, the country is vulnerable to the impacts of climate change. Ghana is highly vulnerable to floods, especially in the northern Savannah belt, and faces associated risks of landslides. Excessive rainfall occurrence has increased within the 1986-1995 period, including a high number of 24-hour maximum rainfall events - a trend that has continued in the last decade. The equivalent upsurges in temperature across all river basins propose that the observed intensification in flood frequency may not be just a cyclical variability. Thus, the recurrence of both floods and droughts in the northern Savannahs is becoming a common phenomenon, often associated with high temperatures and extreme heat (The World Bank Group, 2011).

Climate change, together with land degradation, give rise to decreasing yields and crop failures in northern Ghana and have caused further impoverishment of Ghana’s poorest region, where the majority of the people live in abject poverty. As a result, farmers have devised survival strategies and diversified their livelihoods to adapt to uncertain environmental conditions in various ways (Laube, 2012).

Initial assessments suggest that Ghana is very vulnerable to climate change impacts, particularly in the savannah zones. Climate change is anticipated to worsen land degradation problems, reducing the land’s capacity to buffer further climate change impacts. Decreased rainfall, increased variability of rainfall, and temperature rises could have negative impacts on agricultural productivity, increase the incidence of droughts and floods, and exacerbate desertification, particularly in the northern savannah (The World Bank Group, 2011).

Due to the fact that Ghana's economy is predominantly based on agriculture, it will suffer severe economic consequences from climate change. Adverse agricultural productivity impacts become more pronounced over time. Relative to the baseline projection for the middle of the 21st century, agricultural GDP is estimated to decline by 3 to 8 percent (The World Bank Group, 2010). A policy shift is needed - from support for coping strategies for climate shocks at the household level, to transformative adaptation strategies that can increase resilience at the household and area level. The poorest are particularly vulnerable to climate shocks, as they do not have stored assets to use during times of stress. A pro-poor approach to climate change adaptation would look not only at reducing shocks to households, but also engage in transformative adaptation strategies that increase resilience and overcome past biases in subnational investment (The World Bank Group, 2010).

Ghana is among the most vulnerable countries in Africa to the impacts of climate change due to the fact that most of its people depend on agriculture and principally rain-fed agriculture. Over the past 40 years, Ghana's average temperature increased by 1^0C, with the rate of increase being more rapid in the northern sector than in the south. Over the past years, Ghana experienced concrete signs and direct effects of climate change, with the northern floods in 2007 directly affecting 317,000 people, destroying 1,000 km of roads and 210 schools, damaged 45 health facilities and contaminated 650 drinking water facilities. In October 2010, numerous districts were severely flooded in five out of the ten regions of Ghana while in December 2013, Teshie, a suburb of Accra, was flooded which led to loss of lives and some properties (Doe, 2014).

Despite these, it is expected that climate change will have effects on vital water resources, supply of energy, food security ad production of crops in Ghana (Cameroon, 2011). There are even more fears that if this trend continues without any interventions the situation could get worse.

The worst scenario of these adverse impacts of climate change is in northern Ghana, which is made up of three regions considered to be the poorest in the country. They constitute approximately 30% of Ghana's total population and 70 percent of its poor population (NDPC/GoG and UNDP-Ghana, 2010 and 2012).

Even though climate change impacts on energy would be both positive and negative, the negative impacts are more likely to dominate. Renewable energy resources, in the form of hydropower, are expected to be more sensitive to climate change since they depend on factors such as hydrology, wind regimes, weather patterns and solar radiation (MEST, 2011).

2.2.2 How Ghana is dealing with climate change

As a result of these developments there is obviously the urgent need to put in measures to contain the situation locally in Ghana as well as, to a large extent, globally. At the local level, Ghana has responded appropriately by developing initiatives to address the climate change problem. This is due to the concern and commitment exhibited by the leadership of the country towards meeting the challenges of climate change and reversing the trends of the impacts that affect the poor most. This is even more serious and should be seen as a priority due to the fact that certain segments of Ghanaian society are already severely impoverished, particularly in northern Ghana where according to GSS (2007) the 3 northern regions have the highest percentages of extremely poor people; each person surviving on less than one dollar per day.

Ghana has exhibited extraordinary economic growth over the past decades, but future progress is endangered by its high vulnerability to climate change. Although according to the latest government statistics, Ghana has lately attained lower middle-income country status, but the majority of its people still depend on small-scale agriculture and other key economic resources threatened by climate change, such as the coastal zone and water resources. There is already an observed increase in temperatures across all ecological zones in Ghana whereas rainfall patterns are becoming less predictable. In the northern regions, where high average temperatures and low rainfall predominate, the incidence of poverty is currently highest. Projected climate pressure (higher temperatures and changing rainfall patterns) is expected to aggravate the poverty issues. In addition, a rise in the number of floods in recent years threatens settlements, such as Keta, close to the coastline (MEST, 2010a).

In view of these events, the Government of Ghana (GoG) recognizes the social and economic impacts and the development challenge arising from climate change. Thus, GoG is committed to mainstreaming climate change into key planning processes on the national, regional and local level (MEST, 2010a). The response of Ghana to climate change is very good or excellent, against the backdrop of its preparedness and commitment in signature and in documentation to meeting the requirements of the international climate change agreements (Cameroon, 2011). The country is politically stable with relatively good governance structures, and has shown stable growth rates over the past years. Real GDP growth was 5.8% annually between 2003 and 2008 (Rabobank, 2009) and these positive trends appear to be improving further year after year. Ghana, therefore, is an attractive nation for international donor activities, including climate change associated initiatives. Besides, for years Ghana has had an influential position in the international climate negotiations as an opinion maker within the G77 group, and this has further raised the country's international image (Würtenberger *et al.*, 2011).

Stanturf *et al* (2011) reports that the task for developing, coordinating, and executing Ghana's climate policy is clearly shared among a number of governmental organizations. The Environment and Natural Resources Advisory Council (ENRAC), which functions at the Cabinet level, coordinates climate change activities among ministries. Each Ministry is in turn responsible for coordinating certain specific climate change programmes and activities. The Ministry of Environment, Science and Technology (MEST) serves as the main institution for climate change and UNFCCC activities in Ghana and hosts the National Committee on Climate Change (NCCC). The NCCC, which consists of representatives from relevant ministries, universities, research institutions, the private sector, and non-governmental organizations, among other tasks, is responsible for formulating a National Climate Change Policy for Ghana. The Environmental

Protection Agency (EPA) within MEST is charged with oversight responsibilities over NCCC, and has responsibility for developing national climate change policy and integrating priorities into sectoral plans and strategies. The EPA is the main Country Implementing Institution (CII) for technical coordination of climate change programmes and activities, the United Nations Framework Convention on Climate Change (UNFCCC) and some other environmental conventions endorsed by Ghana. The EPA is made of several units, including the Energy Resources and Climate Change Unit, where the National Climate Change Coordinator is located. This Unit serves as the technical focal point for climate change and related matters in Ghana, as well as technical aspects for Clean Development Mechanism (CDM) projects. The Ministry of Lands and Natural Resources (MLNR) is the lead national body tasked with the general coordination and management of REDD+ activities in Ghana. The National REDD Steering Committee, formed in 2009, offers assistance to MLNR. MLNR also has representation at the National Climate Change Committee (NCCC). The REDD+ secretariat at the Forestry Commission, in partnership with the National REDD+ Steering Committee enhanced Forest Carbon Partnership Facility (FCPF) process, which was supported by the World Bank. The Ministry of Finance and Economic Planning (MoFEP) is also represented at the NCCC and has been selected to function as the fiduciary administrator of the Adaptation Fund in Ghana. MoFEP is also leading an inter-ministerial collaboration under the Forest Investment Programme (FIP) initiative by the World Bank to support REDD+ implementation in Ghana. The Natural Resource Governance desk at MoFEP centrally coordinates the budget support programme under Natural Resource, Environmental Governance (NREG) programme and the Forest Investment Programme Initiatives. Climate change is being integrated into Ghana's Shared Growth and Development Agenda (GSGDA) and coordinated by the National Development Planning Commission (NDPC). Climate change was earmarked for assistance from Donor Partners under the NREG programme.

For the past ten years, Ghana has played host to several climate change related activities, initiated by international donors or research organizations, or by representatives of the Ghanaian government, academia or civil society. Comparatively, many of these measures and initiatives have been on a small-scale, and coordination across sectors, ministries or regions has often been lacking. At the moment, there is an urgent need to organize and improve on all these efforts. Ghana's economy is at crossroads with the advent of oil and gas production from the recently discovered Jubilee oil field off its coast. Besides, there is a growing pressure on the country's natural resources and energy system due to economic growth and a growing population which lead to increased demand for both traditional wood fuels and for electricity (Würtenberger *et al.,* 2011).

The Government of Ghana, through the Ministry of Environment, Science and Technology (MEST) developed a list of 55 actions and policies to reduce GHG emissions. These Nationally Appropriate Mitigation Actions (NAMAs) were added to Ghana's proposal to the Copenhagen Accord. Most of the NAMAs are among the development priorities in the Ghana Shared Growth and Development Agenda 2010 (GSGDA), while others relate to energy issues. Out of the 55 NAMAs, 8 address land use, land use change and forestry including sustainable forest management, REDD+, plantation development, and rehabilitation of degraded lands. In addition, Ghana has embarked on some specific programmes and projects with the view to combating climate change. Among these are REDD+, Voluntary Partnership Agreement, Clean Development

Mechanism, Forestry Investment Programme, National Forest Forum, Modified Taungya Systems and Non-Legally Binding Instrument (Stanturf *et al*., 2011).

Having identified REDD as one of the effective ways for mitigating climate change (UNFCCC, 2007), the international community invested a lot of resources into getting tropical countries, including Ghana, ready to partake in it to conserve or increase forest carbon stocks. The Forest Carbon Partnership Facility of the World Bank and the United Nations REDD (UNREDD) programme have been the 2 mechanisms through which funding has been streamed for the REDD programme. Others are the voluntary carbon markets and the Clean Development Mechanism/Afforestation and Reforestation mechanism (Westholm *et al.*, 2009). On November 20, 2009, a Voluntary Partnership Agreement (VPA) was signed between the Government of Ghana and the European Union (EU). The aim of this programme was to address sustainability, particularly illegal logging, by governing trade between Ghana and the EU; timber that has been legally produced and exported to the EU would be identified by a license issued in Ghana. VPA also entails preventing unlicensed Ghanaian timber from entering into the EU (Ochieng *et al*., 2012).

The Forestry Investment Programme (FIP) was created to constitute as a segment of the Strategic Climate Fund (a multi-donor Trust Fund within the Climate Investment Funds) with the overall objective of FIP mobilizing funds to reduce deforestation and forest degradation as well as support sustainable forest management. The idea is that FIP will support REDD-efforts with funds for readiness reforms and investments, considering opportunities to adapt to the impacts of climate change on forests, contribute to the conservation of biodiversity, and improve rural livelihoods. Ghana is one of eight countries (one of three in Africa) chosen to pilot the FIP. The Minister of Lands and Natural Resources is the FIP Focal Point and the expanded NREG Technical Coordination Committee provides overall guidance of the FIP. A New National Plantation Development Programme was commissioned in January 2010 by the Forestry Commission with a target of planting trees on 30,000 ha per annum (Stanturf *et al*., 2011).

Civil society platforms such as Forest Forums are existing structures used for disseminating REDD+ information to people in forest communities. The Forestry Commission is collaborating with the United Nations Food and Agriculture Organization (FAO) to assist in addressing the bottlenecks in implementing Ghana’s national forest programme in collaboration with all stakeholders. As a result, the Forestry Commission established a National Forestry Forum (NFF) at the national, regional and district levels as a common civil society organization to contribute to developing, implementing, and monitoring key policies in the sector. Having been inaugurated in November 2007 in Accra, the aim of the NFF is to provide a national platform for forest stakeholders to discuss critical issues on forest governance, share information and interact with forest managers and policy makers on the most effective ways of managing forest resources (Stanturf *et al*., 2011).

In September 2001, the President of Ghana launched the National Forest Plantation Development Programme with the objective of planting 20,000 hectares annually using a number of approaches. One approach was the Modified Taungya System (MTS) in which small-scale farmers could team up with the Forestry Commission to establish and manage tree plantations in degraded forest reserves and qualify to enjoy financial benefits accruing from the tree crop. Under the current phase of the National Forest Programme partnership with FAO, a priority is accomplishing plantation development by consolidating the benefits due to farmers engaged in the Modified Taungya System. An estimated 100,000 hectares of MTS plantations have been established across the country through the involvement of over 100,000 rural farmers since its launch (Kalame, 2009). In 2008, Ghana became the first country to methodically implement the Non- Legally Binding Instrument (NLBI) on all types of forests with FAO and the German Agency for Technical Cooperation (GTZ) providing technical support as well as funding coming from the German Federal Ministry for Economic Cooperation and Development (BMZ). The aim is to provide a far-reaching plan for national action and international collaboration for sustainable forest management (Stanturf *et al*., 2011).

Ghana has also joined the global committee of nations that produce fossil fuels. Major new commercial oil production in the country started in December 2010 contributing revenue of over $1 billion per annum (DFID Ghana, 2012). Presently, the country has the potential of billions of barrels of crude oil, and based on current proven reserves, production from the Jubilee field is expected to peak from 2013-2015 at 120,000 barrels of oil per day. More oil discoveries are, however, being made along the country's coastal areas and these will add up to the current estimates. This has the potential to generate up to USD 1.8 billion per annum at peak production (van der Ploeg *et al*., 2012). As a result, Ghana has a responsibility to invest part of these oil revenues in carbon offsetting through forestry, especially in the light of the fact that fossil fuels serve as the largest contributor to climate change (IPCC, 2014). Therefore, some of the revenue from the oil fields should be reinvested in the carbon sequestration services of trees, such as shea trees, which have been proven to play a significant role in carbon sequestration. This is based on the fact, as asserted by FIP (2012) that, with the current total carbon stocks having reduced and the forest being degraded at a negative basal area of 0.13 m^2/ha/yr, Ghana faces difficult choices if it is to support rational and optimal use of the remaining forest resource. As a result, the obvious solution is to invest in the forestry sector by planting more trees.

Ghana, being a signatory to the UNFCCC and the Kyoto Protocol, has for years been an active participant in the Conferences of the Parties (CoP), with a considerable degree of participation and has collaborated with the Copenhagen Accord. Ghana has signed all the three Rio Conventions (climate change, biodiversity and desertification) as well as produced 55 Nationally Appropriate Mitigation Actions (NAMAs) which are presently being reduced to 5 NAMAs. These 5 priority NAMAs include those for cooking fuel as well as for sustainable forest management. The country has also submitted its Second National Communication to the UNFCCC and finalized its Green House Gas (GHG) inventory (Cameroon, 2011).

Recent extreme global environmental happenings in the form of heat waves, floods, droughts, wildfires and cyclones have been established as some of the adverse impacts of climate change on ecosystems and humans (IPCC Report, 2014), with the poor being the worst affected as they are increasingly becoming vulnerable to such environmental threats that adversely impact on their livelihoods. Sadly, the effects of climate change are expected to plunge millions of into poverty and kill millions more (Agbeve *et al.,* 2011). With Ghana having tasted its share of climate change related disasters, including the 2007 energy crisis and the frequent patterns of droughts and floods in recent years, are clear signals of imminent climate change threats and catastrophes. These have, thus, attracted a lot of attention and mainstreamed into the Ghanaian development agenda. As a result, for the past couple of years, a number of stakeholders have been having consultative discussions and working round the clock to help address these looming effects of climate change (Agbeve *et al.,* 2011).

As a result of the 2008 elections and the consequent change in government, the Ministry of Environment, Science and Technology (MEST) was reconstituted and endowed with greater responsibility for coordinating climate change activities across Ministries, Departments and Agencies (MDAs). Besides, the Ministry of Finance and Economic Planning (MoFEP) has become very much involved in supervision of climate related finance flows, driven partly by participation in international REDD initiatives, which have started to attract significant international funding. With the reorganization of MEST, the National Climate Change Committee (NCCC) was also strengthened and given the mandate to advise MEST on climate change policy-related questions. In early 2010, the NCCC was given the mandate to initiate the process of developing a National Climate Change Policy Framework (NCCPF) which, among other things, was to create a policy framework for climate resilient and low carbon economic growth that is compatible with and integrated into national development plans and budgeting processes (Würtenberger *et al.,* 2011).

This process led to the publication of a discussion document by MEST in advance of the international climate change conference in Cancun, Mexico, in November 2010 (MEST, 2010a). The discussion document elaborates the fundamentals for the comprehensive development of the NCCPF in Ghana (Würtenberger *et al.,* 2011). Subsequently, Ghana was also able to submit its Second National Communication to the UNFCCC ahead of the November-December 2011 CoP17 Climate Change conference in Durban, South Africa.

There have been many other policies, measures as well as initiatives undertaken by Ghana to keep climate change in check in response to the UNFCCC international agreements. There is therefore the need to identify and document the most important of these policies and other measures as well as find out the stakeholders or actors involved and how they function together in developing adaptation and mitigation strategies for dealing with climate change in Ghana.

2.3 Strategies and practices for managing forests

2.3.1 Biodiversity conservation

Human societies and economic systems exist within the environment and all these are closely inter-related and depend on one another. The environment is thus defined and shaped by humans and their economic systems. Humans, usually dictated to by these economic systems and considerations, manage the environment with the view to deriving economic and other types of benefits. As such efforts aimed at managing and conserving biodiversity should not be focused only on protected areas but also on economically productive landscapes that contain many of the world's important species (Lovett JC and Ockwell, 2010). One of such important species is shea, which grows in Africa, covering millions of hectares of land stretching from Senegal across Africa south of the Sahara to Ethiopia. These shea parklands support livelihoods of millions of households, providing useful products and services such as food, income, shelter and medicines to people as well as generating foreign exchange revenue from the exportation of shea products for countries in which the trees grow. In view of this, the trees are usually protected and conserved on farms during land preparation for crop cultivation, near or within communities and on fallow lands. Due to this, lands on which shea trees grow are generally better managed and protected against bushfires, deforestation and forest degradation, and this in turn impacts favourably on other forms of biological resources as they also benefit from such protection and conservation efforts. Consequently, such protected farms and fallow lands tend to have more biological resources compared to areas without shea trees.

Community-based natural resource management has impacted positively on the social-economic development as well as conservation of biodiversity in some human societies. An example is the Wechiau Community Hippo Sanctuary in Ghana. An assessment of the first 10 years of this project using an evaluation framework that considers socioeconomic and ecological outcomes, as well as resilience mechanisms, showed positive results. Based on traditional restrictions on the killing of hippopotami, this intervention has endeavoured to conserve an imperiled large mammal, protect biodiversity and alleviate abject poverty amidst a bush meat crisis and complex ethnic diversity. Results indicate that the Sanctuary has improved local livelihoods by stimulating economic diversification and infrastructure development rates 2 - 8 times higher than in surrounding communities. At the same time, there have been reduced threats to biodiversity and these have maintained populations of the hippopotami. Bird species have also increased in numbers in the riparian habitats of the Sanctuary compared to neighbouring areas. In addition, people living within that catchment area have realised the numerous socio-economic, ecological and other benefits they derive from the project (Sheppard *et al.,* 2012).

One of the key environmental challenges of this century is biodiversity conservation (CBD, 2006; UNEP, 2012). Biodiversity offers invaluable ecosystem services to sustain human life, and effective strategies must be implemented to conserve biodiversity in this world, which is becoming increasingly unstable (Loreau *et al.,* 2002; Díaz *et al*., 2006; CBD, 2006; Ives and Carpenter, 2007). 'Biodiversity' is a contracted word for 'biological diversity', and it includes all forms of life on earth; including plants and animals. There are several definitions for biodiversity, but the most widely accepted one was proposed by the US Congressional Biodiversity Act, HR1268 (1990) which explains biodiversity as: "biological diversity means the full range of variety and variability within and among living organisms and the ecological complexes in which they occur, and encompasses ecosystem or community diversity, species diversity, and genetic diversity" (The State of California, 2000).

Biodiversity refers to an assortment of plants, animals, and other organisms, the habitats in which they live, and the ways that these organisms interact with one another and with the environment (Rapid Assessment Programme, 2007). The term biodiversity is the shortened form for biological diversity and it is defined by Article 2 of the Convention of Biological Diversity (CBD) as: "*the variability among living organisms from all sources including terrestrial, marine and other* *aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystem*" (CBD, 1992).

The local and global extinction of species of plants, animals, fungi and microbial organisms, that we are witnessing on this planet constitute a major environmental problem that requires urgent attention. As a result, the planet earth has been experiencing an unprecedented loss of biological diversity. The major aim of biodiversity conservation is to make sure that the utilization of biological resources does not reduce the diversity of genes and species, or destroy vital habitats and ecosystems globally. As a country Ghana is very much interested and keen on protecting and conserving biological resources, of the 157 countries Ghana became the 12th member and a signatory of the Convention of Biological Diversity (CBD) during the Earth Summit in June 1992, as well as other Multilateral International Environmental Agreements to develop strategies for the conservation and sustainable use of biodiversity. Subsequently, she has since August 29, 1994 ratified the Convention on Biological Diversity and therefore under obligation to develop a national strategy for the sustainable use of the country's biological resources (MEST, 2002).

In line with her programme for implementation of the Convention, a Biodiversity Country Study was undertaken. Apart from providing the baseline data on the biological diversity of the country, the research also identified a number of measures that have to be put in place to ensure the conservation and sustainable use of the country's biological resources. Following this, the country instituted a Biodiversity Country Study, a National Environmental Action Plan (NEAP) and a National Biodiversity Strategy and Action Plan. As a result, both in situ (involving the use of traditional and scientific methods – sacred groves and protected areas), and ex situ (the use of gene banks, zoological and botanical gardens) methods have been employed in biodiversity conservation in Ghana. However, the success and efficiency of the in situ approach have diminished in recent times due to factors such as fast increases in human population, urbanization, human migration and resettlement, human encroachment, deforestation and poaching. Among these, the outstanding challenge facing biodiversity conservation in Ghana currently is rapid population growth and its accompanying urbanization, over-exploitation of forests and need for more agricultural land (Attuquayefio and Fobil, 2005).

MEST (2012) reports that 16% of Ghana's land surface area has been set aside to conserve representative samples of her natural ecosystems in the form of forest reserves, national parks and other wildlife reserves including various traditional forms of conservation. Article 6 of the Convention makes provision for countries to develop national strategies for the conservation and sustainable use of their biological diversity. This document, the National Biodiversity Strategy for Ghana, has been prepared in fulfillment of this provision. It is an indication of the plans envisaged for activities that have to be undertaken by the country to achieve the goal of conservation and sustainable management of the country's biological diversity. Ghana's policies relating to the conservation of biodiversity and the sustainable utilization of biological resources are guided by the three objectives of the Convention on Biological Diversity, namely:

- *the conservation of biological diversity;*
- *the sustainable utilization of biological resources; and*
- *the fair and equitable sharing of benefits arising from the use of genetic resources*

Food production and agricultural systems are also represented in the CBD working policy document for Ghana, The National Biodiversity Strategy for Ghana. This is spelt out in one of the policy objectives of Strategy as "*To optimize utilization of the component of biological diversity for sustainable socio-economic benefits to ensure long-term food, shelter and health security".*

As such, the Strategy enjoins the people in Ghana to embark on practices that will enhance sustainable food and agricultural production, without compromising on biodiversity conservation.

2.3.2 Management of shea parklands

Parklands are landscapes that consist of scattered mature trees on farms or fallow lands that have been made to lie idle for the restoration of soil nutrients (Boffa, 1999). These Agroforestry parklands play an important role as agricultural systems (Boffa, 1999). Important tree species such as *Tamarindus indica, Adansonia digitata, Ziziphus. Mauritiana and Vitellaria paradoxa* that grow in these systems form key sources of livelihoods of rural communities (Dawson *et al*., 2009). Parklands also play an important role in preserving ecological sustainability (Boffa, 1999). They are progressively becoming important because they provide ecological services that make the ecosystem resilient and tolerant to extreme environmental conditions (Dawson *et al*., 2011) under increasing temperatures (Boko *et al*., 2007; Christensen *et al*., 2007) and varying amounts of rainfall (Christensen *et al*., 2007; Meehl *et al*., 2007) as determined by climate change models for the region which is subjected to drought stress and human pressure (Bourou *et al.,* 2012).

According to Huston and Marland (2003) the ecological functions of multiple species can reduce the effects of environmental instabilities and so that ecological stability is retained under different conditions. In agreement with this, Loreau *et al*. (2002) stated that high diversity should reduce temporal fluctuations caused by climate change and other disturbances. On the other hand, it is widely agreed that more carbon is sequestered in systems with lesser disturbance (Six *et al.*, 2002). For that reason, it might be logical to conclude that species-rich systems can stimulate C sequestration through mitigating the effects of disturbance. Kirby and Potvin (2007) argued that as more species are added to a system, more complete use of resources occurs and the system becomes more efficient. On the other hand, they also indicated that spontaneous addition of functionally essential species in diverse collections actually results in an upsurge in productivity rather than just an increase in diversity.

There are lots of environmental problems that plague different parts of the world. Some of these are pollution, deforestation, indiscriminate bush burning and natural wild fire, drought, desertification, climate change, rain and windstorms, flood, earthquake, volcanicity and erosion. These environmental problems are caused either by unsustainable human activities, nature, or both, leading to environmental hazards or disasters (Odjugo, 2012). Transition zones tend to be very sensitive to those sorts of environmental challenges and these pave the way for conducting assessment studies into the woody species dynamics (Sop and Oldeland, 2011). There are several causes of such environmental problems, and these are basically natural and man-made causes.

Poverty has been identified as both a cause and consequence of man-made environmental degradation in Africa (UNDP, 1997; Mwambazambi, 2011). Accordingly, it is important to take into consideration this multidimensional poverty as one reason to "attack Africa's environmental problems head on, both for present and future generations and for the whole world. In essence, poverty is not only about economic disempowerment, but also involves political, social, environmental and cultural disempowerments" (World Resources Institute *et al*., 2005). This therefore means that poverty and environmental degradation can be tied together, as one can be the cause of the other. Poverty drives people to over-exploit environmental resources for survival, which can lead to environmental degradation. Environmental degradation leads to destruction of such resources, making them scarce, and hence only a minute percentage of people get access to these resources while a huge percentage is deprived of them. Consequently, such deprived people in turn become further impoverished, and hence out of desperation and the urgent need to survive, they further over-exploit the left-overs of the scarce environmental resources. This is a kind of cyclic process.

However, environment and development are linked; environmental protection can be used as a poverty reduction strategy (Huge and Hens (2009) in Africa. This is due to the fact that the poor in sub-Saharan Africa, many of whom live in rural areas, rely upon resources obtainable from their immediate environment for sustenance, and hence, are severely affected by environmental degradation. As Kante (2004) notes; "for the poor, nature offers a series of goods of inestimable value, on which they depend absolutely. That sums up their life".

The problems of environmental degradation and severe drought as a result of climatic and environmental change in the West African Sahel, particularly in the 1970s and 1980s, attracted a lot of scientific research (West *et al*., 2008). Findings of numerous studies, mostly based on data gathered by remote sensing indicate that the vegetation in the Sudano-Sahelian zone of Burkina Faso (Hountondji *et al*., 2006) as well as in other Sahelian areas of Africa has recovered (Anyamba and Tucker, 2005; Olsson et al., 2005). Transition zones are known to be highly sensitive to environmental changes and thus make an interesting case study for assessing dynamics of woody species (Sop and Oldeland, 2011).

It is expected that other areas such as the Sahelian countries that highly sensitive to changes in the environment will be among the regions worst hit by climate change impacts in the form of drier and hotter, fluctuations in rainfall patterns as well as land degradation. A report from the UNDP shows there could be severe droughts in sub-Saharan Africa dryland areas. Up to half of the agricultural potential of countries such as Senegal, Mali and the Sudan could be lost (Cline, 2007; Leighton, 2011 and Hummel et al., 2012). The West African Sahel in particular is however well-known to have movements and migration of people across the region (Hummel et al., 2012). According to the UNDP (2009: 18), there could be drought in 90 million ha of sub-Saharan Africa drylands.

Drylands of sub-Saharan Africa, including woody species or forests, perform multiple functions such as agroforestry, pastoralism, food and energy supply, climate change mitigation, control of erosion and desertification. These are crucial services and can only be sustained when the diversity of components is adequately managed and maintained. Biodiversity is an important basis for successful adaptation to climate change. Approximately, two-thirds of people in Africa dwell in rural areas, depending largely on the environment for almost everything; for farming, food and income. Due to this, any adverse changes in the environment have a tremendous impact on the lives of the people. Land degradation, deforestation, lack of access to safe water, erosion, desertification and loss of biodiversity, compounded by climate variability, are among the major concerns (FAO, 2010).

The threat posed by desertification is particularly acute in Africa, one of the continents most affected by the processes and impacts of land degradation and the deterioration of the communities' living conditions. As a result of these worrying trends, a lot of attention has been focused on the establishment of projects involving woody species to combat environmental problems and land degradation issues such as drought, desertification and erosion in Africa, particularly in the Sahelian and Savanna regions which are the worst affect areas. Such projects included the "Greenbelt" and the "Green Dam" projects in the 1950s, long before the United Nations Conference on Combating Desertification (Nairobi, 1977). The best known projects are the greenbelt in Niamey (1965), the green dam in Algeria (1971) and the greenbelt in Nouakchott (1975). In the other countries, reforestation and dune fixation activities were often carried out with the assistance of the forestry departments. Considered as infrastructure, these undertakings provide a public environmental service. Their implementation is carried out by the State (OSS, 2008).

Juxtaposing these arguments to conservation of environmental resources, there is the need to manage and conserve biodiversity, particularly in areas where the threat of climate change is more serious. In such areas, the presence of more biological resources, or 'natural capital', such as trees, can help alleviate the adverse effects of climate change. As there is a serious threat of climate change in Ghana, there has been the urgent call for the proper management and conservation of shea trees, since they play a significant role in both mitigating and ameliorating the effects of climate change such as through carbon sequestration. One of tree species that offers socio-economic returns, environment protect and carbon sequestration potential is the shea tree.

The shea tree is native to the semi-arid zone of sub-Saharan Africa, stretching from Senegal in the west to Uganda (Lovett and Haq, 2000a) or Ethiopia (Okollu *et al*., 2004) in the east. It has a wide-ranging list of local, national and international uses and as a result is greatly valued by the local communities in which it grows (Moore, 2008). In northern Ghana and in many parts of Western Africa, shea butter is the major edible oil and it is the highest leading source of glycerol and fatty acids in their food (Saul *et al*., 2003). The tree is an integral and essential part of the local people's lives and source of revenue, mainly because the ripening of the fruits coincides with the hunger period when availability of food is very limited. The ripe fruit pulp is eaten (even sometimes as a full meal) during periods of food scarcity, and the kernel provides important raw material for cooking and other uses. After the fatty matter has been extracted from the kernel, the residual residue is mixed with mud for plastering traditional mud huts, and also used as excellent biomass fuel for heating and cooking (IOI Group, 2011). So no part of shea is wasted; everything is put to good use.

Dating back to the colonial period in Ghana, nuts from the shea tree have enjoyed international recognition and usage. They were first acknowledged as vital export products for West Africa since 1920s when they were being used in European chocolate, cosmetics and soaps (Saul *et al.,* 2003). Increasingly, shea nuts are being exported for use in the cosmetics industry as a constituent in lotions, makeup, baby ointments, hair care products and soaps (Akosah-Sarping, 2003). Shea butter is generally less expensive than cocoa butter and it also increases durability in chocolate, making it solid and more firm (Chalfin, 2004).

The shea tree regenerates itself naturally, though it may be assisted by suitable land management, such as protection from fire or grazing livestock, it is not usually planted (Kristensen & Lykke, 2003). Shea parklands have been reported to be increasingly degrading, leading to decreases in tree density and vegetation cover and reductions in soil fertility (Ouédraogo, 2006). The population of shea trees is declining at a fast rate owing to rapid human population growth, increases in land fragmentation, and high demand for wood fuel, particularly charcoal. To reverse this trend will depend on the involvement of rural communities in planting, enabling natural regeneration, and nurturing the shea trees on farms (Okiror *et al*, 2012). The tree is also confronted with a rampant felling, selection, and natural death resulting in decreases in density (Kelly *et al.,* 2004) as well as attack by pests and diseases (CRIG, 2002; Dwomoh 2003, Dwomoh 2004; and Carette *et al.*, 2009 and Okiror *et al.*, 2012).

In Ghana, in spite of the importance and uses that the shea tree and its products are put to, there have been concerns about the gradual and perhaps drastic reductions in the shea tree populations owing to low regeneration rates of the trees, destruction of older trees through bushfires; use as fuelwood, carving and construction; loss of natural woodlands as a result of urban expansion and replacement for exotic cash crop agriculture such as mango plantations. At present, the population of mature shea trees growing naturally in Ghana has been reducing as they are being destroyed by annual bushfires and other causes (Yidana, 2004). There is therefore the need to reverse these trends, particularly as the tree serves as a major source of livelihoods for households in most communities in northern Ghana, where people live in abject poverty compared to situations in southern Ghana.

There has been regional disparity in Ghana for a long time been and it still remains pronounced. Inequality, particularly between the north and south regions attracts much interest (Shepherd & Gyimah-Boadi, 2004). With the large proportion of valuable natural resources such as gold and diamonds situated in the mid-southern regions, most of the development, such as industry, road networks, electricity, potable water supply, schools and hospitals has also been concentrated in these southern regions. The naturally less-endowed northern Ghana (formerly known as the "Northern Territories") was not under British colonial government administration until 1902, and there was limited investment (Lund, 2003). Consequently, there has been how to bridge developmental gaps between southern and northern Ghana. Attention has been focused on several fronts, including the development of the shea industry to economically empower people of northern Ghana who, to a greater extent, depend on the shea tree for sustenance. Thus, the dwindling numbers of shea trees has been a major concern for stakeholders since the development of the area is linked to the survival of the shea trees.

Shea is highly rated in Ghana and abroad and the nuts produced are ranked among the top 8 agricultural products in Ghana (Saungweme, 2012). In considering non-traditional exports in

Ghana, shea is ranked as the most significant in terms of both quantity produced and contribution to Ghana's economy (Al-hassan, 2012). For many years, shea has been ranked as the leading non-traditional agricultural export in Ghana (GEPC, 2006).

Ghana is still grappling with poverty issues in most of her rural communities. The situation is even worse in the northern Ghana, where ironically, majority of the shea trees grow. Although the country has made tremendous improvement in reducing poverty for the past two decades, northern Ghana still records the highest levels of poverty, with up to 70% of the people living in abject poverty (GSS, 2008). Shea has therefore been targeted for promotion as one of the key cash crops in the North for alleviating poverty. This is expected to create more income for rural households in the shea-growing communities in northern Ghana (MoFA, 2010). In accordance with alleviating poverty in rural communities, Ghana's agricultural sector has therefore earmarked policy and investment necessary to boost incomes for the poverty and lift them out of poverty (Breisinger *et al.*, 2008). To help address these poverty issues and bridge the economic yawning gap between the north and south in the country, the Government of Ghana has formulated a number of policies. One of such policies specifically aimed at addressing the socio-economic problems is the Savannah Accelerated Development Authority (SADA).

The ultimate goal of SADA is "*to double per capita incomes of northern Ghanaians and reduce the incidence of poverty to 20 percent and achieve a Forested North within 20 years in the Northern Savannah Ecological Belt".* Six unique features of this development initiative undertaken to realize this goal include the Development of a Comprehensive Regional Strategy that operates within a national development framework which is *"to provide direct opportunities for communities, private sector and civil society to gain needed inputs in order to transform the natural resources into sustained incomes and assets"*; A model for the modernization of agriculture *"that starts from generating a market impetus as the main catalyst for stimulating farmers to produce, with improved technology and timely inputs. By this strategy, farmers do not wait to find markets after they have produced; rather the market defines their production targets and quality; and a vigorous private sector initiative that strengthens existing private operators, as well as attract new investments in the manufacturing, processing, transport and tourist services in the North of Ghana".* All these strategies involve developing income-generating sectors such as the shea industry in order to generate more income and reduce poverty in the North through increased improved technology of shea production, enhanced marketing for shea products as well as improved production-and-market-driven processes along the shea value chain that help maximize economic benefits for household communities in northern Ghana (SADA, 2010). This means that farming households will be given fair deals and fair prices for their shea products.

Shea is also a target for development by the Government of Ghana through other policy frameworks such as the Growth and Poverty Reduction Strategy (GPRS I & II). The overall aim of GPRS is "*to create wealth by transforming the nature of the economy to achieve growth, accelerated poverty reduction and the protection of the vulnerable and excluded within a decentralized, democratic environment*". This is founded on certain thematic areas aimed at "*Ensuring and sustaining macroeconomic stability*" and "*Accelerated agricultural* *modernization and natural resource management*" and geared towards supporting important sectors of the Ghanaian economy and local production systems such as the shea industry through provision of technical and financial assistance to farming households to step up shea production and improved marketing for shea products (GPRS I, 2003; and NDPC, 2010a).

With these and other forms of support to boost the shea industry, it therefore stands to reason that not only would the suffering of the people in shea-growing areas be alleviated and their livelihoods improved but the country would also benefit from increases in revenue from shea exports if the aforementioned and other related policies and measures are implemented to enhance the conservation of shea trees for improving livelihoods of farming households and forestall the impact of climate change through carbon sequestration and protecting the soil.

In recent times, there have been increasing on-going studies and discussions about how to deal with the issue of decreasing shea tree populations and one of the identified possible panaceas lies in the conservation of the trees through farm management practices. Such farm management practices have been identified to be useful for both the farmer and the environment. Since most farmers in northern Ghana already have at least a little idea about the relevance of agroforestry practices, with the needed technical education on the importance of farm management practices together with other forms of logistical support given to the farmers, they will be willing to manage the shea trees. Poudyal (2009) reports that farmers in northern Ghana are more likely to conserve and manage valuable trees like shea on their agroforestry farms to maximize economic and other benefits from both trees and food crops.

Management practices carried out on farms have been reported to have had positive impact on shea. Djossa *et al.* (2007) assert that traditional management of shea trees, which involves selection and retention of trees based on size, age, and yield, on lands cleared for crop cultivation results in a relatively higher-yielding and larger trees on farm lands than those on fallow lands and in the bush. Results of studies conducted by Lovett and Haq (2000) in Northern Region of Ghana also indicate that farm management practices impacted significantly on composition and population of important trees such as shea. The results show that shea trees on farms were generally larger and greater in number compared to trees growing on fallow lands and in the bush. Similar results reported by Kelly *et al*. (2004) indicate that shea trees managed on farms in Mali generally had larger girth than those in older fallows and in the bush.

Presently, the majority of shea tree populations grow in the wild and these should be conserved as they have enormous economic potential. While ensuring environmental sustainability and improved livelihoods, research programmes should aim at assisting local communities to undertake interventions such as multiplication of shea tree germplasm, regeneration of the trees and motivating farmers to manage and protect trees that regenerate naturally. National governments and local and international conservation organizations should motivate farmers to conserve and manage shea trees on farms. There is also the need to propagate shea trees by both vegetative means and using seed. If interventions are not made, with time, shea parklands could completely be degraded or even lost (Buyinza and Okullo, 2015).

Shea and its products are listed among the top ten Non-Traditional Exports of Ghana. In Burkina Faso, it is the fourth most important export crop after gold, cotton and livestock and makes a contribution of about 6 million USD to the national economy. Shea is presently the second most important oil crop in Africa after the palm nut tree (Bup, 2014). In West Africa alone, there are at least 500 million shea trees, which produce about 2.5 million tonnes of dry kernel per annum, based on 5 kg dry kernel per tree (Maranz and Wiesman, 2003). These can earn West African Sahel-Savannah rural communities approximately US$ 150 million every year (Lovett PN, 2010).

Some farmers protect and manage shea parklands owing to the numerous benefits that are derived from shea trees. Such protection and management practices usually take the form of pruning, lopping, weeding, intercropping shea with shade-tolerant crops, managing and protection against bushfires. If farmers are assisted with inputs such as planting materials, they will be willing to plant and manage shea trees on their farms and in other places such as in parklands (Okullo et al, 2012). In most shea-growing areas, shea trees are protected through participatory management practices comprising an intricate blend of traditions and customs (Gwali et al, 2012). These usually entail the enactment and enforcement of local bye-laws that mobilize members of communities to protect and manage shea trees as well as implementation of punitive measures against people who flout such bye-laws and destroy shea trees.

Shea trees are usually the most common and widespread woodland species in Sub-Saharan agricultural parklands. These parklands serve as important fields for cultivating crops, where shea trees grow in-between the crops. In Ghana, shea is of considerable importance for the rural people, particularly in northern Ghana, as it contributes significantly to the household budget. For instance, in the Upper West Region of Ghana, the contribution of shea to the total annual household budget is between 25% and over 50%. With its high nutritional value shea also serves as an important source of fats and vitamins (Carette *et al.,* 2009). Management of shea trees will therefore not only help to conserve and increase shea tree populations to enhance the sequestration of atmospheric carbon, but would also considerably improve yields of shea trees to boost the shea industry in northern Ghana. This will lead to the creation of job opportunities in the shea-growing areas especially for the youth who, according to GSS (2007), migrate every year to southern Ghana in search of non-existent jobs, with average seasonal migration of young men and women from the Upper West and East Regions to the Greater Accra region alone exceeding 551,000.

It thus imperative to step up efforts to reverse these trends of fast declining shea tree populations (Teklehaimanot, 2004) as shea products are presently exported to many countries around the world including France, Great Britain, the Netherlands, Denmark, North America and Japan. The shea industry is capable of generating income, particularly for women, due to the fact that the industry is traditionally regarded as women's business (Elias and Carney, 2007).

A growing number of reports recognize the traditional management of the parklands as a major solution to this problem. Mature trees are preserved during each cycle of land preparation for farming and that these form a major part of the indigenous farming system. The trees benefit from agronomic practices, such as weeding and management of soil fertility employed for annual crops (Masters *et al.,* 2004). What is lacking in these reports, though, is the extent to which these farming practices have impacted on the livelihoods of local households in the shea-growing communities as well as on the global environment. Thus, it is imperative to conduct a study on the impact of the management of these trees on the livelihoods of people in the local communities in Ghana as well as on the global environment.

2.4 Payment mechanisms suitable for ecosystems services

2.4.1 Payment for ecosystems services

Payments for ecosystem services (PES) constitute one of the major means by which a market for ecosystem services can be formulated. As such, PES can basically be defined in terms of payments to land managers and others who provide such services to embark on actions that improve the quantity and quality of needed ecosystem services from which specific or general users, to some extent, benefit (DEFRA, 2010).

According to Pagiola (2006), payment for ecosystems services (PES) is a mechanism designed to enhance the supply of indirect environmental services, as shown in Figure 1.4, in which:

- Those who provide environmental services get paid for doing so ('provider gets')
- Those who benefit from environmental services pay for their provision ('user pays')
- Payments are conditional
- Participation is voluntary

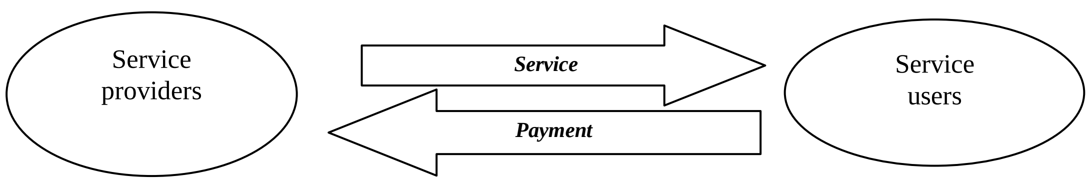


Figure 2.1 The relationship between service providers and service users in a typical PES scenario.
Source: Adapted from Pagiola (2006) of the Environment Department of the World Bank.

Forest Trends *et al.* (2008) assert that ecosystems offer a broad array of services to society. These services range from continuous flows of good clean water to fertile soil and carbon sequestration. These services, as shown in Table 2.1 below, are extremely useful and humans, companies and communities depend on them for raw material inputs, production processes, and for regulating the climate.

In a typical PES, payment arrangements are made in such a manner that service users pay for the ecosystems services that are useful to them while service providers receive payments for such ecosystem services they provide using meaningful and quantifiable means to sustainably produce them (Greiber, 2006).

Table 2.1 Types of Ecosystem Services

	Forests	***Oceans***	***Cultivated/Agricultural Lands***
Environmental Goods	• Food • Fresh water • Fuel • Fibre	• Food	• Food • Fuel • Fibre
Regulating Services	• Climate regulation • Flood regulation • Disease regulation • Water purification	• Climate regulation • Disease regulation	• Climate regulation • Water purification
Supporting Services	• Nutrient cycling • Soil formation	• Nutrient cycling • Primary production	• Nutrient cycling • Soil formation
Cultural Services	• Aesthetic • Spiritual • Educational • Recreational	• Aesthetic • Spiritual • Educational • Recreational	• Aesthetic • Educational

Source: Millennium Ecosystem Assessment (2005)

Smith *et al.* (2006) identified 4 different forms of possible PES schemes. These are:

1. private payment schemes
2. cap-and-trade schemes, under a regulatory cap or floor
3. certification schemes for environmental goods
4. public payment schemes, including fiscal mechanisms.

Smith *et al.* (2006) further explain these 4 different forms of possible PES schemes as:

- ***Private payment schemes***

These types of PES schemes have the least government involvement. They have features of ownership that include two heterogeneous groups; privately-owned, profit-oriented companies, such as shea agroforestry farms and hydropower companies as one group, while the second group consists of private individuals or groups of individuals, whose main objective (e.g. consumers) is not making profit. In such systems, private bodies agree among themselves to provide payments or rewards in return for, for example, carbon sequestration by shea parklands.

- ***Cap-and-trade schemes***

Under this type of scheme a limit or cap is set for, for instance, the emission of pollutants. The cap is then the cumulative maximum amount of pollution emitted by participating entities. Pollution credits can then be given by dividing up the permissible overall total among polluters. Companies or industries can then sell permits that are not relevant to them to other participants who necessarily require more than what has been allocated to them.

Shea afforestation/reforestation and agroforestry CDM projects can benefit from the Cap-and-trade schemes. This is due to the fact that, as asserted by Menne *et al*. (2011) that, the CDM is one of the ways by which developed countries can mitigate their greenhouse gas emissions and meet targets for reducing emissions. Thus, through the CDM, developed countries can claim to "offset" their emissions, by paying to support developing country projects that either reduce GHG emissions, or sequester carbon dioxide. The majority of CDM funding are in Asia and Latin America, and Africa should also be receiving CDM project funding from developed country investments.

- ***Certification schemes of environmental goods***

These are schemes for watershed goods and services that also enhance water production in both quality and appropriate quantity. Transactions take place between private parties. Traded products paid for by service users include certified timber, fish or organic produce. The service users specifically want products from suppliers who adhere to verifiable environmental standards. There are intermediaries who play a major role in this type of scheme, either as the certification agency or as traders in licensed products.

Certification schemes of environmental goods also occur in the forestry sector, and are applicable in the shea afforestation/reforestation/agroforestry CDM projects as well. The concept of forest certification, as reported by CPI (2009), "*was spawned by the 1992 United Nations Conference on Environment and Development (UNCED) where a number of Forest Principles aimed at halting the deforestation of tropical rainforests were agreed. This was the first global attempt to define (by awarding equal status to environmental, social and economic criteria) and to achieve sustainable forest management*".

- ***Public payment schemes***

These are the most common schemes and have the highest level of participation by public agencies. Service users include are public authorities such as municipalities or national governments who need to provide safe drinking water or regulation of river flows. Mechanisms for payment in these schemes include user fees, purchase of land and land easement, which constitute rights to particular use of land belonging to other people. Public payment schemes could also include Shea afforestation/reforestation/agroforestry projects under REDD (national based system) if the carbon credit benefits will be coming from the national level (accredited national institutions) for the benefit of people at the national, regional, district, or community level.

Forests generally play a key role in reducing the concentration of carbon dioxide (CO_2) from the atmosphere by absorbing it during photosynthesis and storing it. This significant role played by trees contributes meaningfully to ameliorating the impact of climate change. On the other hand, deforestation and forest degradation, such through burning of forests results in the release of the stored carbon. For instance, emissions from tropical deforestation contributes as much as 10% of net annual CO_2 emissions globally (Harris *et al.,* 2012). Removing this C from the atmosphere and storing it in the terrestrial biosphere is, therefore, one possibility for mitigating the emission of this

GHG. Baccini *et al.* (2012) suggest that between the period 2000 and 2010 alone, forest land use and land-use change produced an estimated 2.2 Pg C yr-1 (8.1 $GtCO_2$) gross emissions of carbon.

In view of this, it is necessary to manage and conserve forests so as to continue maintaining this mitigation potential for absorbing carbon from the atmosphere. There is however the need to compensate this service, which is one of the numerous services that forests provide. De Gryze *et al*. (2009) asserts that as forests generally supply a range of these ecosystem services, in recent times, however, these services have less direct cash-generating value but have substantial indirect economic significance. The absence of such direct cash payments for these services results in deforestation and forest degradation, usually with devastating environmental and social consequences. Forest resources would however be properly managed and conserved if direct cash compensations are paid for those ecosystem services. Schneck *et al*. (2011) also report that carbon credits, which are among the numerous services provided, could be captured for the carbon markets. Fears about the adverse effects of climate change have accelerated the development of these carbon markets ahead of markets for other environmental or ecosystem services, thus currently making carbon markets the central point for buyers with a broad range of objectives, including buyers who value the non-carbon benefits of forests alongside any associated carbon benefits.

2.4.2 Types of Markets for Environmental Services

Types of markets for environmental services differ in geographic scope, the competitiveness, strength and structure of demand, the number of transactions and nature and price of commodities sold. PES schemes have been set up for four types of environmental services (Table 2.2): Watershed Services, Carbon Sequestration, Biodiversity Services and Landscape Beauty (Mayrand and Pacquin, 2004).

Table 2.2 Types of PES and types of existing markets

Type of PES	**Type market**
Carbon	*REDD and REDD Plus through Voluntary Carbon Standard*
Biodiversity	*Climate, Community and Biodiversity (CCB)*
Energy products and changes in agriculture practices	*Clean Development Mechanism (CDM)*
Water	*Local Government Authorities*
Forest Products (timber and non-timber forest products)	*Traditional grant and local bank credits. Certification programmes*

Source: USAID and EnterpriseWorks/VITA (2015)

Markets for Watershed Services

Markets for watershed services are typically local in nature and scope, with most dealings taking place at the watershed level. Markets for watershed protection normally do not entail trading commodities such as water quantity or quality, but instead financing land uses that create watershed benefits (Pagiola *et al.* 2002). Demand for water services in most cases come *from users at the downstream water such as farmers, hydroelectric producers and users of domestic water in urban areas (FAO, 2000b).* With a local demand and a limited number of beneficiaries (e.g. water or hydroelectric services, irrigation commissions), it is comparatively not difficult to organize downstream beneficiaries and include them in PES schemes (Mayrand and Pacquin, 2004).

Watershed-based services are usually financed through user fees to pay for improved management of the protected zone upstream (Pagiola, 2003). Hence it is necessary to develop sophisticated hydrological models to connect conservation practices with the generation of water quality and quantity services so as to ensure that the PES system is rendering the services beneficiaries are paying for (Mayrand and Pacquin, 2004).

Markets for Carbon Sequestration

Carbon markets are basically global in scope and most transactions are made up of international buyers. Carbon sequestration markets are well-established and highly competitive. The competition involved enables service providers to reduce transaction costs and reduce the risk related to how reliable carbon credits are. The two environmental risks linked with the creation of carbon markets are: the risks making sure that native forests are replaced by tree plantations or of funding conservation where first and foremost there is no deforestation taking place (the baseline issue). In the first scenario, carbon markets would create inappropriate incentives to deforest and afforest with monocultures that sequester carbon most quickly, while in the second instance, they would have no real value-addtion in forest conservation, due to the fact that the forests were protected without payments. In view of this, carbon sequestration projects should be properly defined to prevent such perverse occurences (Mayrand and Pacquin, 2004).

Markets for Biodiversity Services

Markets for biodiversity services occur at local, national and international scales. Thus, they can look like carbon or watershed markets, or a combination of the two. The array of biodiversity services creates a variety of demands that increase the complication of creating payments systems. Just like watershed services, biodiversity services are not directly sold. Rather, specific land uses that are supposed to protect species, ecosystems or genetic diversity are sold (Pagiola *et al.* 2002).

Demand for biodiversity conservation is occasionally local but more frequently global. Key buyers of biodiversity conservation services are international organizations, foundations and conservation NGOs. Also involved in markets for biodiversity services are pharmaceutical companies (Mayrand and Pacquin, 2004).

Markets for Landscape Beauty

Of all the markets for environmental services, markets for landscape beauty are the least developed. Demand for these services is both at national and international levels. One of the main potential beneficiaries is the ecotourism industry, which therefore demands landscape beauty services. Presently, governments have been the principal providers of landscape beauty services through the establishment of protected zones or the demarcation and protection of natural or cultural heritage sites (Landell-Mills and Porras, 2002b). Nevertheless, local communities and indigenous people increasingly provide landscape beauty services as the concept of landscape beauty can also comprise cultural practices, traditional land uses or architectural features (Mayrand and Pacquin, 2004).

2.4.3 Economic potential of trees in the forest carbon markets

In terms of volume, carbon markets constitute the biggest category of environmental market in the world. The value of global carbon market increased from US$63 billion in 2007 and US$135 billion in 2008 to US$144 billion in 2009. Majority of these dealings take place in regulatory markets associated with cap–and–trade mechanisms implemented by governments. For farmers in Africa, it is rather unfortunate that the regulatory carbon markets focus on sectors in industry and energy (Shames and Scherr, 2010). As of June 11, 2012, the total number of UNFCCC registered CDM projects globally was 4,201; of which forestry-types were merely 39, representing less than even 1% (0.93%) of all the UNFCCC registered CDM projects worldwide (Forest Carbon Asia, 2012). The world's leading regulatory scheme, the European Union Emission Trading Scheme (EU ETS), does not include land use carbon. The Kyoto Protocol specifies that for Clean Development Mechanism (CDM) project types in the land-use area to be eligible they must fall within the afforestation and reforestation categories, thus not including agricultural or forest management, degradation or avoided deforestation as well as carbon storage in soils in developing countries. In addition, the CDM offers temporary carbon credits for activities in afforestation/reforestation that can be swapped with other traded carbon credits. This means CDM land use projects are mostly scarce and only reduced methane and other emissions from agricultural wastes in agricultural projects and reduced energy emissions in industrial processing projects are eligible (Shames and Scherr, 2010).

Management of forest carbon must be an essential component of any international agreement on climate change. Forest carbon flows comprise a significant part of overall global greenhouse gas emission (Plantinga and Richards, 2008). Although global forests generally serve as a net sink (Nabours and Masera, 2007), 20% of all greenhouse gas emissions emanate from global emissions as a result deforestation (UNFCCC, 2009) and this has recently been reviewed downwards to 7-14% (Harris *et al.*, 2012). Presently, C stock in the world's forests is generally estimated to be 861 Pg C, with 471 Pg C (55%) stored in tropical forests alone. The annual rates of emissions from tropical land-use change is 1.3 Pg C year^{-1}, and this consists of a yearly gross tropical deforestation emission of 2.9 Pg C year^{-1}. This is however compensated for by a carbon sink in tropical forest regrowth of 1.6 Pg C year^{-1}. Collectively, the fluxes make up a net global forest sink of 1.1 Pg C year^{-1} (Pan *et al.,* 2011). Global carbon cycle has a huge potential effect on anthropogenic and natural changes in forests (Plantinga and Richards, 2008).

Developing forest carbon projects is complicated and usually daunting for project proponents; whether they are from the private sector, government, or civil society. Successful project development requires complying with rigorous standards of analyzing and documenting carbon benefits, working through an array of legal, business, and community relations issues, and actually carrying out the challenging work of reforestation in addition to forest and land management activities that go beyond business as usual in order to create carbon benefits (Olander and Ebeling, 2011).

An effective international system for forest carbon management must not only provide landowners and governments incentives to protect and expand stocks of carbon, but must also encourage countries to participate in discussions and international agreements on forest conservation. In this context, the present international UNFCCC regime, the Kyoto Protocol, is not effective. There are some key problems associated with this. One such problem is that Kyoto has been unable to provide non-Annex I countries with motivations to reduce carbon emissions through forest management. Net gains in carbon credits that are forestry-related in non-Annex I countries, also included under the Clean Development Mechanism (CDM) of Article 12, are restricted only to afforestation and reforestation projects (Santilli *et al.,* 2005).

Thus, the CDM does not include projects that are potentially beneficial, including those that are capable of reducing deforestation. Furthermore, it is difficult to quantify the carbon effects of individual forestry projects. This does not make the CDM a good tool for providing incentives for individual forestry projects, although the cumulative potential of such projects is important. Lastly, the current approach under the Kyoto Protocol may actually speed up deforestation by shifting timber harvesting from Annex I to non-Annex I countries (Silva-Chavez 2005). Leakage between countries cannot be resolved by a system that does not include global accounting of changes in forest use. As the Kyoto Protocol ends in 2012, there is the need to re-examine *how the global community can tackle issues on forest carbon management within the framework of a climate change agreement. There are increasing interests in finding a mechanism that will recognize avoided deforestation in the tropics under the Kyoto Protocol or one that comes after it (Skutsch, et al. 2007; Nepstad et al., 2007; Meyers, 2007; Gullison et al., 2007).*

A proposition for "compensated reduction" (CR) in deforestation was made at the COP9 meeting by some non-governmental organizations from Brazil (Santilli *et al*., 2005) and this was supported by Costa Rica and Papua New Guinea (UNFCCC, 2005). In furtherance to this, at the COP11 meeting, participants initiated a two-year study on reduced emissions from deforestation and degradation (REDD) to consider the possibility of including this major source of emissions into the Kyoto Protocol (Sanchez, 2007; UNFCCC, 2005). The 2007 Bali Climate Change Conference adopted the Bali Road Map, which involves a number of forward-looking resolutions aimed at reaching a secure climate future. The Bali Road Map includes the Bali Action Plan, which plans the course for a new negotiating process designed to tackle climate change with the aim of completing this by 2009, along with a number of other decisions and resolutions (UNFCCC, 2012a).

Key among these decisions is Decision 2/CP.13, which recognizes efforts and actions already being taken to reduce deforestation and to maintain and conserve forest carbon stocks in developing countries. It also affirms the urgent need to take additional important action to reduce emissions from deforestation and forest degradation (REDD) in developing countries. The REDD policy is expected to operate at the national level and is meant to provide compensation for emission reductions from deforestation and forest (UNFCCC, 2008). Subsequently, there have been numerous other attempts to address this critical issue of "compensated reduction". As a result, as recent as 2011 at the UNFCCC conference in Durban, South Africa, a major decision was made on the "Under the Kyoto Protocols Clean Development Mechanism", where participating countries adopted procedures to allow in carbon-capture and storage projects. These guidelines are expected to be reviewed every five years to ensure environmental integrity (UNFCCC, 2012b). And it is therefore expected that concerns about forest carbon management would be addressed as the guidelines are reviewed.

With appropriate policies and good project development, these markets have the potential to speed up climate-friendly and resilient small-holder agricultural development in Africa (Shames and Scherr, 2010). It is therefore imperative for African countries to take advantage of this opportunity and act appropriately by managing and conserving their forest resources that would possibly halt or minimize the risks and devastating impacts associated with climate change as well as yield carbon credits for sale on such carbon markets.

2.4.4 Potential of shea in the forest carbon markets

Ghana has developed a number of policies and implemented many climate-change related initiatives with the view to complying with the international climate change agreements aimed at combating climate change. Although some of these initiatives seek to benefit the entire nation and invariably the rest of the world in general, communities and farmers in particular look forward to receiving direct cash benefits for managing forest resources which provide the much-needed ecosystem services. Among these forest resources are shea parklands in Ghana in the Sudan, Guinea and the Transitional savannah zones of Ghana which, according to the GSS (2011), cover almost 12 million ha of land. These shea parklands significantly contribute to addressing climate change in Ghana through carbon sequestration. The shea trees grow mainly in northern Ghana; an area beset, ironically, with abject poverty "in the midst of plenty" of these useful and potential money-making trees. And as Dzah (2012) indicates that about 50% of the people are poor and live on less than one dollar per person per day.

Although the trees provide certain tangible benefits such as fruits, nuts, butter, revenue from the sale of shea products, and other intangible benefits including provision of shade, such benefits are considered by the people as woefully inadequate to meet their financial needs; thus there is little motivation for the people to continue protecting and conserving the trees. They rather prefer clearing and cutting down the trees to make way for food crops to feed their households. Besides, out of necessity and in their urgent quest to tackle those critical financial problems, the people have no alternative in such desperate circumstances than to fell the trees for fuelwood and charcoal for sale, in spite of the ban on the felling of such trees. To further worsen the situation is the unwillingness of the people to plant more of the tress to at least replace the felled ones, with reasons such as lack of resources to grow the trees and the long juvenile growing period from seedling to fruiting (which takes at least nine years) to be too long, and therefore cannot wait for such a long time as they need to immediately solve their urgent financial difficulties.

It is therefore imperative to turn this situation around, by taking action to improve livelihoods of the people and also prevent the shea parklands from disappearing as the trees are presently being cut down at alarming rates. One such possible action is direct cash payment to the people for carbon credits from their shea parklands. This will help solve the financial challenges of the people, which in turn will motivate them to prevent the felling of shea trees, and instead properly manage and conserve them. Unfortunately, however, at the moment there are no such arrangements, in terms of well-structured shea projects in Ghana that have been developed to meet the requirements of the international carbon markets. If such projects are developed, not only would they significantly help to conserve shea parklands in Ghana to combat climate change for the benefit of Ghana and the world as a whole, but they would also present opportunities for farmers in the shea-growing areas of the country, who to a greater extent depend on shea for their livelihoods, to receive direct cash compensation for carbon credits from their shea parklands. In these contexts, it is worth identifying the possibilities and opportunities of fitting shea into the international carbon markets to improve the livelihoods of people in northern Ghana as well as conserve shea parklands there for the purposes of combating climate change.

2.5 Identified gaps in knowledge in this research

Global climate change has had and continues to have impact on life and property worldwide and efforts are being made to adapt to and/or mitigate this phenomenon (FAO, 2008; Allen *et al*., 2010; Lobell *et al*., 2011; IPCC, 2015 and Leggett, 2015). Such efforts include the endorsement of the UNFCCC international climate change agreements and their implementation at global, national and local community levels in managing and conserving forests or trees in order to sequester atmospheric C as well as reduce emissions from deforestation and forest degradation. There is also research information on C stocks and C sequestration potential of forests and many tree species. What is inadequate or completely lacking is similar information on shea in all areas that it grows, particularly in Ghana. The trees form part and parcel of the lives of millions of people living in such shea-growing areas of Ghana, as in the rest of the 20 African countries, considering the numerous tangible and intangible benefits that the trees provide and the crucial socio-economic roles they play in the livelihoods of the people. For some years now, there have worrying concerns about the fast decreases in the numbers of these important trees, and it has become critically important to check the situation, with several causes and panaceas having been identified to reverse these trends.

One of the most effective mechanisms to ensure proper management and conservation of forest ecosystems is to make direct cash payments for carbon credits provided by the trees (Greiber, 2006; Pagiola, 2006; Smith *et al.*, 2006; DEFRA, 2010; Milder *et al*., 2010). By implementing this payment mechanism, the livelihoods of the people will be improved and they will be motivated to manage and conserve the shea parklands. This will in turn improve the shea tree populations to sequester more atmospheric carbon to mitigate climate change for the benefit of the global environment.

As a result, this research dissertation sought to find out how feasible this can be in the case of shea. To do this, the study reviewed the UNFCCC international climate change agreements to ascertain how they could help improve shea tree management and conservation when implemented in Ghana. The study also sought to fill the knowledge gap by identifying the specific national policies formulated by Ghana in response to these international agreements and how these policies address climate change and shea production in Ghana as well as motivate local communities to manage shea trees for local economic and global environmental benefits. Finally, the research sought to find out the carbon stocks and sequestration potential of shea parklands and how they could be used to mitigate climate change and increase resilience in both the social and economic systems of the Shea parklands in Ghana.

CHAPTER THREE

3.1 Introduction

This chapter presents an overview of the methodology used in the thesis in order to demonstrate how the methods used are derived from the gaps in knowledge identified in Chapter 2 to answer the research questions posed in Chapter 1. A wide variety of methodological approaches are used, from quantitative assessment of the Shea carbon stock and estimation of carbon sequestration rates, to household questionnaires and key informant interviews. The chapter explains how these techniques are linked together to create a coherent approach to the research aim of the thesis as a whole.

The chapter also describes in detail the locations, climatic, demographic and other environmental conditions of the study areas. The entire research was conducted in Ghana but was subdivided into four segments. These four segments were:

1. *Technical fieldwork;*- this segment of the study was conducted to find out the carbon stocks of shea in the Sudan, Guinea and Transitional Savannah agro-ecological zones of Ghana. This involved studies conducted in purposively-selected communities based on the set criteria for the different categories of shea parklands. These criteria were:

i. *Agro-ecological zones (3):- The 3 agro-ecological zones covered were Sudan savannah, Guinea savannah and Transitional forest-savannah selected along the North-South climatic gradient.*

ii. *Land-use systems (2):- The 2 land-use systems used were field (land under crop cultivation) and fallow (land previously under crop cultivation but left to rest for its fertility to be restored).*

iii. *Age of land-use systems (3):- Each land-use system from ii (field and fallow) was subdivided into three age groups, and these were:*

- *new (where the land has been under crop cultivation or fallow for 1-5 years);*
- *medium (where the land has been under crop cultivation or fallow for 6-10 years)*
- *old (where the land has been under crop cultivation or fallow for over 10 years).*

Following the above criteria, 6 plots (2 land-use systems x 3 age groups of land-use systems) were purposively selected in each agro-ecological zone using the above criteria. These were then replicated 3 times, which summed up to 18 plots in each agro-ecological zone. Thus, a total of 54 plots (2 land-use systems x 3 age groups of land-use systems x 3 agro-ecological zones) were purposively selected in all the 3 agro-ecological zones.
Data were taken on 763 trees from the 54 purposively-selected plots, with each plot measuring 0.25 ha (50 m x 50 m).

2. *National study:*- this was undertaken to identify the ministries, departments, agencies, commissions, boards and other governmental and non-governmental organizations involved in climate change and shea production policy formulation and implementation, the different kinds

of policies they formulate and how they function together in a form of actor-network in implementing these policies. The research was mostly conducted in Accra, where most of these organizations were located, 15 of whom were purposively selected and interviewed. From the data gathered, 14 policies and policy-related initiatives as well as several other programmes and projects were identified as having been implemented or being implemented to address climate change and shea production issues by the organizations;

3. *Regional survey:-* this segment of the research was done to identify organizations, institutions, agencies and other bodies involved in the implementation of policies on climate change and shea production. The study was conducted in Tamale, Bolgatanga and Sunyani, which are the administrative regional capitals of the three purposively-selected northern regions of Ghana. These regions are Northern, Upper East and Brong-Ahafo regions, representing Guinea, Sudan and the Transitional Forest-Savannah zones respectively. The key organizations involved in the implementation of policies on climate change and shea production at the regional levels were purposively selected and data gathered from them using key informant interviews. These organizations involved in the implementation of climate change and shea production policies and initiatives at the regional level were:

i. *Environmental Protection Agency (EPA), under Ministry of Environment, Science and Technology*
ii. *Forest Services Department (FSD) under Forestry Commission, Ministry of Lands, Forestry and Mines*
iii. *Ministry of Food and Agriculture (MoFA).*

In addition, there were some other organizations that were identified to be playing supporting roles. These were Northern Ghana Rural Growth Project in the Northern region; Women in Agricultural Development (WIAD), Ministry of Food and Agriculture and Association of Widows and Orphans, Bolgatanga in the Upper East Region, Ghana; and Action Aid, in Sunyani, Brong-Ahafo Region.

4. *Community level: Household key informant interviews on shea:-* this was conducted in shea-growing communities in Ghana to identify the practices and strategies used by farmers to manage and conserve shea trees. Household surveys were conducted and a simple random technique was used to select 540 farmers (270 males and 270 females) in 9 communities in the 3 agro-ecological zones of northern Ghana. Key informant interviews were conducted using semi-structured questionnaires to gather data from the farmers.

With the field data gathered on the above segments of the study, the results were used to constitute this thesis, which is divided into four research chapters (Chapters 4, 5, 6 and 7). Thus, the general methodology of this thesis is based on the individual methodologies of the research chapters, as illustrated in the conceptual framework of the thesis in Figure 5 below:

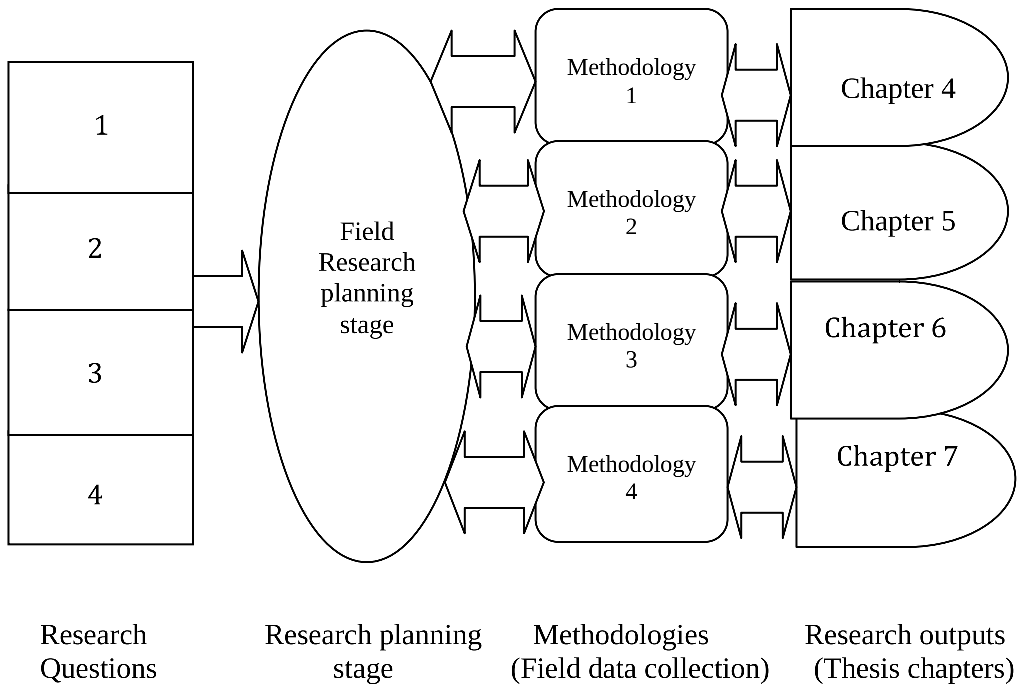


Figure 3.1 Conceptual framework of the research showing the entire dissertation research process

3.2 Study sites

The entire research was conducted in Ghana, and this started from Paga in the north-most part of the country and ended in Accra in the south-most part. The study, as indicated in Section *3.1 Introduction*, was done at four different levels. The *National study* was done in Accra, the administrative national capital, and the data gathered covers the entire country. The other 3 levels (Technical fieldwork, Regional surveys and Community level) of research were conducted in the 3 agro-ecological zones in northern Ghana. Thus, there will be 2 sets of descriptions; description of Ghana (as the study site for the *National study*) and a description of the northern Ghana agro-ecological zones (as the study site for the *Technical fieldwork, Regional surveys and Community level*)

3.3 Description of the study area and land-use systems of Ghana

The segment of the research on climate change and shea production policies covered the entire country (Ghana). Thus, the description of the study area in this segment will focus on Ghana as a whole. As such, the description of the study area will cover the entire country and will dwell on the geography, climate, agriculture, demography and topography of Ghana as reported by MEST (2011).

3.3.1 Geography and climate

Ghana is located in West Africa, with the Gulf of Guinea to the south, Cote d'Ivoire on the west, Togo on the east and Burkina Faso on the north. The country lies between latitudes 4.5°N and 11.5°N and longitude 3.5°W and 1.3°E (Figure 6) and has a total land area of 239,460 km^2 and 8,520 km^2 of water. The total land boundaries are 2,094 km (Burkina Faso 549 km, Cote d'Ivoire 668 km, Togo 877 km). Ghana has large water bodies such as the Lakes Volta and Bosomtwe, which cover 3,275 m^2, while lakes that are seasonally flooded occupy another 23,350 km^2.

According to MEST (2011), numerous models and forecasts have been examined to evaluate the vulnerability status of Ghana with respect to climate change. Even though their conclusions extremely differ they confirm Ghana's vulnerability and indicate that climate change impacts are already occurring. First of all, there are clear indications of warming in all models. A rise of 1°C has been observed over the past 30 years. One recent forecast projected temperature increases of 1.7°C to 2.04°C by 2030 in the northern savannah regions, with mean temperatures increasing to as high as 41°C. The climate of Ghana is naturally unpredictable and the country can anticipate more extreme weather events, such as very heavy rains, extreme heat and severe dry winds due to climate change.

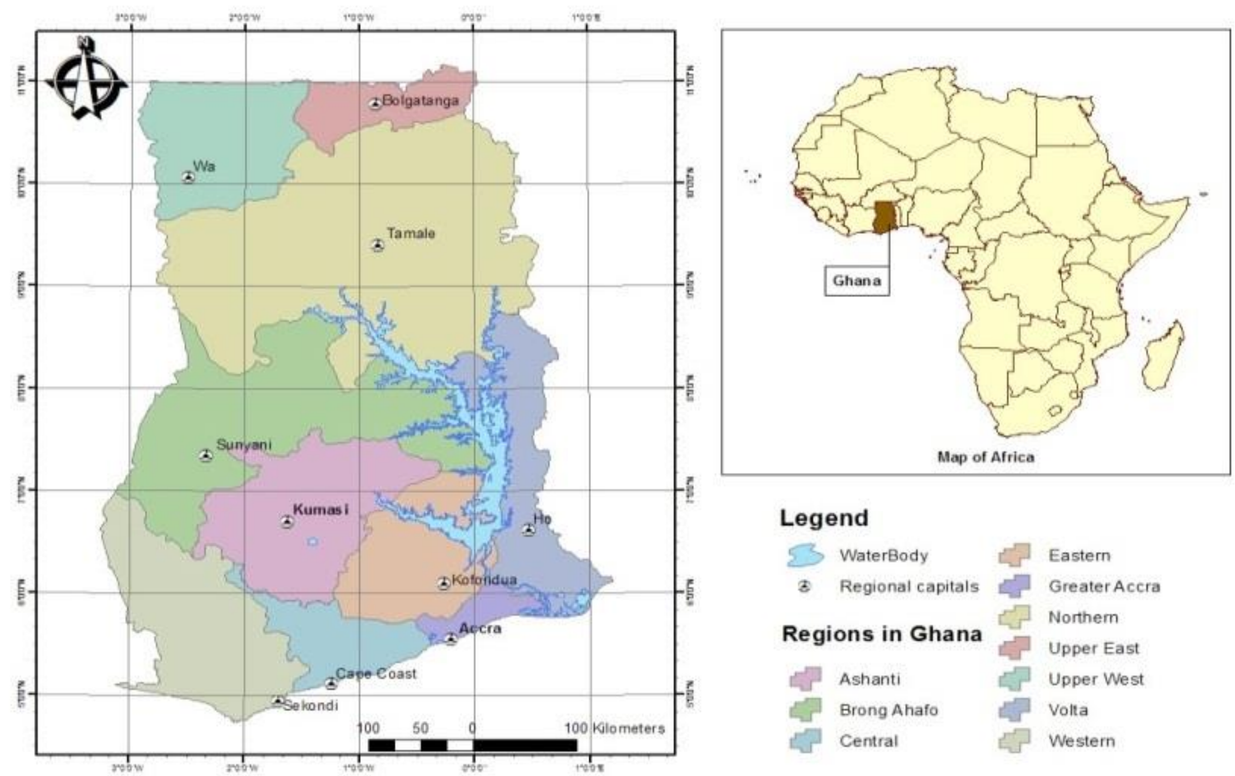


Figure 3.2 Map of Africa showing the geographical location of Ghana

Ghana's terrain is composed of mostly low plains with dissected plateau in the south-central area and altitude extremes of between the coast of the Atlantic Ocean to Mount Afadjato (880 m) being the highest point. The country is divided into five different geographical regions. Coastal plains stretching across the southern part of the country, featuring low sandy beaches interspersed with saltwater lagoons. A forested plateau region made up of the Ashanti uplands and the Kwahu Plateau are found inland, in southwest and south central Ghana. The rest of the evergreen rainforest is situated in the southwestern part of the country. The hilly Akwapim-Togo Ranges stretch along the north-south direction of the country's eastern border. The Volta Basin occupies most of central Ghana. Lastly, high plains typify the northern third of the country.

Temperatures all over the country are usually high. The average annual temperature is mostly above 24°C, a result of the low latitude position of Ghana and the lack of high altitude areas. Mean temperatures are between 24°C and 30°C even though temperatures ranging from 18°C to 40°C or more are usually in the southern and northern parts, respectively. Spatial variation in temperature is observed in daily and annual ranges due to distance from the effect of the sea breeze. Rainfall in Ghana generally decreases from south to north, with the extreme southwest being the wettest area where rainfall is about 2000 mm per annum. In the extreme north, however, the annual rainfall is less than 1100 mm. The driest part of Ghana is the wedge-like strip from east of Sekondi-Takoradi, extending eastward up to 40 km where rainfall is about 750 mm per annum. The country has two main rainfall regimes: double maxima regime taking place south of latitude 8°30`N. The two highest periods are from April to July and from September to November in Southern Ghana. The single maximum regime is in the north of latitude 8°30`N where there is only one rainy season from May to October, and this is followed by a long dry season from November to May.

The dry conditions in the south-eastern coastal belt are anomalous and due to the coastal alignment and upwelling of cold water. The seasonal distribution of rainfall determines ecology and land use. Ghana has a warm and relatively dry south-east coast; hot and humid in southwest; hot and dry in north tropical. Ample evidence has been collected in Ghana on the long-term changes and variability in the weather. Based on a 20-year observed data, temperatures in all ecological zones in the country are rising, while rainfall levels have been declining and patterns progressively becoming erratic (MEST, 2011).

3.3.2 Drainage

The drainage of Ghana is made up of several water bodies, which include rivers, streams and lakes. All the key rivers in Ghana flow into the sea. The only area of internal drainage in the country is found around Lake Bosomtwe, where only streams flow from the surrounding highlands into the lake. River valleys show different characteristics. Terraces showing the earlier width and height of the rivers border the valleys of all the major rivers. A number of the valleys are led in their direction by major features of relief. For example, the Morago River runs east-west alongside the foot of the Gambaga escarpment. The two leading sources of water supply for the rivers are rainfall and springs. In areas with single rainfall maximum as in the north, the flow of rivers is erratic. In areas with high and well-distributed rainfall in the year, however, the rivers flow in the entire year. It is also significant to add that progressively, water bodies are either diminishing or drying up throughout the country (MEST, 2011).

3.3.3 Population and demography

Ghana's human population as at 26 September 2010 was approximately 25 million with the yearly intercensal growth rate in 2010 as 2.5 percent (GSS, 2013a). The country's human population structure is estimated as follows: females are 12.6 million, constituting 51.2% while males are 12.0 million, constituting 48.8%. The age structure is as follows: 0-14 years; 9.5 million constituting 38.3% (male 4.8 million/female 4.7 million), 15-64 years; 14.0 million constituting 57.0% (male 6.7 million/female 7.3 million) and 65 years and over; 1.2 million constituting 4.7% (male 0.5 million/female 0.7 million). The estimated life expectancies of Ghanaians are 60 years for males and 63 years for females. The country's population density has risen from 79 in 2000 to 103 in 2010 (GSS, 2013a).

Presently, the population of Ghana is largely urban with 56.2% living in urban areas, whereas 43.8% reside in rural areas. The high urban population growth of 4.2% indicates that many people are migrating to urban areas (GSS, 2014). The significant upsurge in rural-urban drift additionally compounds the problem of overstretched infrastructure and service in urban areas. This means agricultural productivity reduces as more people migrate from rural areas to urban centres (MESTI, 2015).

3.4 Description of the study area and land-use systems of northern Ghana

The three segments of the research that covered the technical fieldwork, regional surveys and the household key informant interviews were at the field, regional and community levels, were all carried out in shea parklands in the Sudan, Guinea and the Transitional savannah zones of Ghana (Figure 7). There will therefore be a common description for the general study area.

Located between 33^0 and 34^0 E longitude and 10^0 to 30^0N latitude, the climate of the zones is dominated by distinct dry and rainy seasons. The dry season begins in November and ends in April while the wet season is between May and October with a peak in September (Nathan Consortium, 1970; cited in Gyau-Boakye and Tumbulto, 2006). The average air temperature is 28°C and the mean relative humidity rises to about 80% in September and decreases to about 20% in January (Gyau-Boakye and Tumbulto, 2006). Annual rainfall is 900-1300 mm in 150-220 days. These conditions, particularly the warm and dry conditions, tend to favour the growth and survival of shea trees in the northern savannah zones of Ghana. The shea occurrence zone is characteristically within the zone of 600 and 1400 mm of rainfall per annum (DFSC, 2000). Comparatively, Vitellaria is a very adaptable species, as demonstrated by its wide geographical distribution in Africa. It however requires optimum conditions for fast and healthy growth. Although the trees can survive on a variety of soil types, they tend to do better on dry, sandy soils with a good humus cover, (Hall *et al*., 1996). Soils are Fragiudults (USDA Soil Taxonomy)/fine sandy loam, siliceous,

semi-active, thermic (SRID, 2001). These conditions are characteristic of the West African savannah as a whole.
Shea trees grow widely in non-coastal areas of the dry savannas, forests, and parklands of the Sudan zone of Africa (Boffa *et al*., 1996). Its rooting system is extensive and shallow, which enables it to be well-adapted to tolerate prolonged dry seasons up to 8 months and intermittent droughts that are typical of conditions in the savannah zone (Vermilye, 2004). Being indigenous to the savannah zone, the shea tree is fairly a photophilic tree and grows in abundant sunlight (Boffa, 1999). The tree appears to tolerate competition from other sources and therefore can possibly grow well in a competitive environment. This occurs in a situation where grazing animals prefer to feed on shea trees even while Mangifera indica (Mango) and other species are available. Like majority of species of trees and other forms of vegetation, at their sapling stage shea trees are extremely susceptible to being trampled upon by grazing animals. Thus, to increase their chances of growing into bigger and tough trees, they need more densely-vegetated environment (Hall *et al*., 1996; Kristensen and Lykke, 2003).

As indicated in (Table 3.1), the three northern savannah zones (Transitional, Guinea and Sudan zones) of Ghana where this research was conducted cover approximately 140,000 km^2 with a human population of approximately 5,539,000 (GSS, 2013a). The area is characterized by wide and almost flat plains in its lower parts and by undulating hills at elevations of between 60 and 80 m in its upper section. According to the Ghana classification system based on the Charter's Interim Scheme (Brammer, 1956; cited in Gyau-Boakye and Tumbulto, 2006) the prevailing soils are savannah ochrosols, groundwater laterite and groundwater laterite-ochrosols and acid gleisols (Gyau-Boakye and Tumbulto, 2006). As a result of a higher build-up of biomass, the savannah area has greater accumulation of organic matter in the soil. The area has numerous igneous, metamorphic and sedimentary rocks that have affected the nature and properties of the soil. Generally, the soils are low in organic matter (less than 2% in the topsoil), but have high levels of iron concretions and are prone to severe erosion. As a result, well-drained upland parts have a tendency to be droughty and when exposed to severe incident sun scorch, tend to develop cement-like plinthite. Due to such conditions, it is necessary to regularly incorporate manure into the soils for agriculture (MoFA, 1998).

Being a perennial woody species that on a yearly basis sheds its leaves, the shea tree performs a key part in the recycling of nutrients through the decomposition of its leaves and fine roots at the surface of the soil (De Bie *et al.*, 1998; Bayala *et al.*, 2006). The litter from shea is also decays at a slow rate (Bayala *et al*., 2005), which has a more sustainable effect on soil fertility (Bayala *et al.*, 2006).

These properties of the savannah are ideal for tree growing, and the permanent presence of trees and their canopies shield the soils from the scorch sun. The roots of trees will also serve as good anchorage and help hold soils together to reduce the effects of erosion. Thus, soil protection can be enhanced by growing economic trees such as shea in the form of the shea traditional parkland system which involves growing annual crops in-between to conserve shea trees on the same piece of land; a sort of agroforestry system. It will also lower the costs of purchasing and adding fertilizers to improve the fertility status of the soil since biomass, in the form of litter fall from leaves and dead parts of the trees will further add organic manure to the soil (Rao *et al.*, 2007). It is therefore more prudent to practise the shea traditional parkland system rather the annual cropping system.

Cotton and tobacco are also important in the northern sector, while the food crops cultivated are mainly sorghum, maize, millet, rice, cowpeas, groundnuts and yam. Although the majority of rural households keep some sort of livestock, livestock farming is an adjunct to crop farming. Poultry production is low, while cattle production is high. Sheep and goat production is generally widespread throughout the savannah areas (MoFA, 1998).

Table 3.1 Population density (Number of persons per km^2), from 1984 – 2010, of the study area in the Transitional, Guinea savannah and Sudan savannah zones of Ghana

Site	***Agro-ecological zone***	***Area (km^2)***	***1984***		***2000***		***2010***	
			Population	***Density***	***Population***	***Density***	***Population***	***Density***
Kawampe	Transitional	40,000	1,207,000	31	1,815,000	46	2,311,000	58
Nyankpala	Guinea	70,000	1,165,000	17	1,821,000	26	2,479,000	35
Paga	Sudan	9,000	773,000	87	920,000	104	1,047,000	118
Ghana		239,000	12,296,000	52	18,912,000	79	24,659,000	103

Source: GSS (2013a).

Table 3.2. Rainfall, temperature and length of crop growing period of the Transitional, Guinea and Sudan savannah zones of Ghana

Site	***Agro-ecological zone***	***Approximate mean annual temperature (^oC)[1]***	***Approximate mean annual rainfall (mm)[1]***	***Length of crop growing period days)[2]***
Kawampe	Transitional savannah	26	1300	250 – 300
Nyankpala	Guinea savannah	28	1100	200 – 250
Paga	Sudan savannah	29	1000	150 – 200

Sources:

1. Environmental Protection Agency (EPA) Accra-Ghana (2003)[1]
2. Franke *et al*. (2011)[2]

In Ghana, shea trees are found mainly in the Upper East, Upper West and Northern regions (8^o-11^oN). Small populations are also found in the Brong-Ahafo, Ashanti, Eastern and the Volta regions in the south. In northern Ghana, where the majority of Ghana's shea tree population grows, the natural vegetation is savannah woodland and grassland (Yidana, 1994). A growing number of reports recognize the traditional management of the parklands, for example, Masters *et al*. (2004) report that mature trees are preserved during each cycle of land preparation for farming and that they form a major part of the indigenous farming system. The trees benefit from agronomic practices, such as weeding and management of soil fertility, employed for annual crops. In spite of the importance and uses that the shea tree and its products are put to, there are growing concerns about low regeneration rates of the trees, destruction of older trees through bushfires; use as fuelwood, carving and construction; loss of natural woodlands due to urban expansion and replacement for exotic cash crop agriculture (e.g. mango plantations and biofuels).

And as the human population densities increase as indicated in the increasing trends in Table 2, there are concerns of their adverse effects on the growth and survival of shea trees. Okiror *et al*. (2012) report that the number of shea trees is rapidly declining due to rapid human population growth. This means a higher human population density results in a decrease in the shea tree populations due to the fact that more people cut down the trees for use as fuelwood, carve them into stools and other items as well as for charcoal production.

Another school of thought postulates that humans and animals such as bats help to propagate shea. Seed dispersal by humans, cattle and birds are some of the methods of natural regeneration of shea. On their way to work and school, farmers and school children often eat shea fruits and throw away the seeds. This contitutes localized dispersal of shea seeds (Fujita, 1991; Hall *et al.,* 1996; Bollen *et al*., 2004; Djossa *et al.*, 2008).

3.4.1 Agro-ecological zones

The division represents a north-south climatic gradient (mainly rainfall and temperature). The three climatic or agro-ecological zones (Figures 3.3 and 3.4) of shea-growing areas in Ghana from driest to wettest, as are indicated in Table 3.3 below:

Table 3.3. Site characteristics of the study areas in Ghana

Zone	***Name of community***	***Position***	***Elevation (m)***	***Land-use***	***Size of plot***
Transitional or Southern	Kawampe (Kawampe area)	$08^0$25.635'N $001^0$33.736'W	168	Field and fallow	50 m x 50 m (0.25 ha)
Guinea Savannah or Middle	Zuolanyili-Cheyohi (Nyankpala area)	$9^0$25.848' N. $1^0$00279'W	160	Field and fallow	50 m x 50 m (0.25 ha)
Sudan Savannah or Northern	Paga-Badunu (Paga area)	$10^0$57.015'N, $01^0$04.952'W	215	Field and fallow	50 m x 50 m (0.25 ha)

A total of 54 plots was selected for the study. The selection of plots was done at three stages:
The first stage involved the selection of sites in the three northern savannah zones of Ghana. The three sites selected were Transitional, Guinea and Sudan savannah zones. The second stage entailed the selection of two phases of landuse (field and fallow) in each site. In the third stage, three different ages of landuse (new, medium and old) were selected in each phase of landuse. This gave rise to a total of six treatments (plots) selected in each site. These six treatments were then replicated three times in each site, resulting in the selection and assessment of 54 plots in all the three sites as illustrated below:

3 (sites) x 2 (phases of landuse) x 3 (ages of landuse) x 3 replications = 54 plots

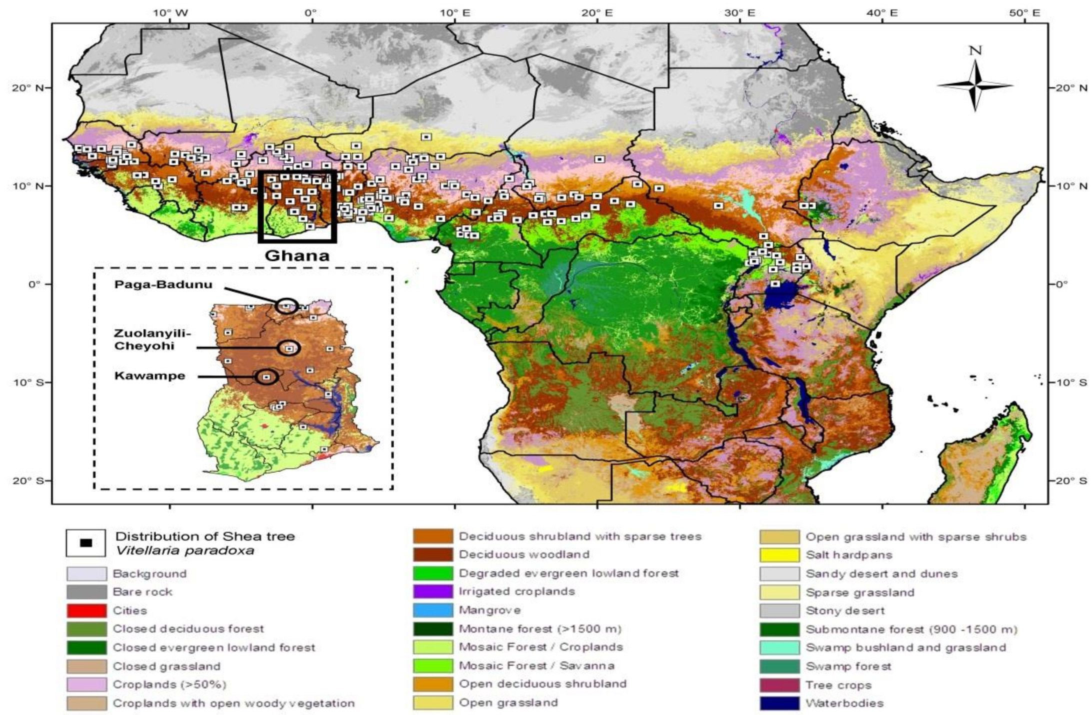


Figure 3.3 Distribution of shea parklands across Africa. At the continental scale, the distribution is constrained by the Sahara Desert to the north and tropical rainforests to the south. Inset is the map of Ghana showing the three agro-ecological sites where data on shea carbon were taken from the research plots.
Source: Platts *et al*., (2010).

Figure 3.4. Map of Ghana showing the ecological zones including the Transitional, Guinea and Sudan savannah zones where the study was conducted
Source: Benneh and Agyapong (1990); Antwi-Agyei (2012).

3.5 Research Questions

To address issues on climate change and shea production in Ghana, a number of research questions were set to serve as guides for the study. These research questions were:

3.5.1 Research Question 1

The objective of this first segment of the thesis dissertation (Chapter 4) was to determine the amount of biomass carbon stored by shea trees in Ghana and their possible potential for sequestering carbon. The following research question was used to find answers to that objective:

How much carbon stocks do shea parklands in the West African Savannah contain and how much carbon could they potentially sequester?

To help answer the above research question, the following sub-question was used:

what amounts of carbon are stored by shea trees in the agro-ecological zones, land-use systems and ages of land-use systems in the West African Savannah?

3.5.2 Research Question 2

The second segment of the study (Chapter 5) was to assess Ghana's response to the UNFCCC's international climate change agreements and how it impacts on shea production in Ghana. To be able to realize this objective, the following research question was used to provide answers to this segment of the study:

What are the UNFCCC international climate change agreements and how are they related to climate change and shea production issues in Ghana?

To help in the discourse of the research, the following sub-questions were used to identify and discuss the climate change and shea production issues that the research sought to address:

i. *Which are the UNFCCC international climate change agreements and how are they addressing climate change and shea production concerns?*
ii. *What national policies are formulated by Ghana in response to these international agreements and how are these policies addressing climate change and shea production concerns in Ghana?*
iii. *Which actors are involved in addressing these climate change and shea production concerns in Ghana and how do they interact or work together to address these issues?*

3.5.3 Research Question 3

The objective of the third segment (Chapter 6) of this overall research was to identify the local strategies used in managing shea parklands in Ghana and how they contribute to the provision of global environmental benefits and improvement of livelihoods of people in the local communities. The study was therefore conducted using the following research question as a guide:

- *How does community shea parkland management impact on the shea trees, the livelihoods of people in the local communities in Ghana as well as on the global environment?*

The following sub-questions were used to help address the research question:

i. *How are lands acquired for farming shea, and which practices are undertaken by farmers at the local community level to manage shea parklands in Ghana?*
ii. *What benefits are derived from the management of shea trees and how do these benefits impact on the livelihoods of people in the local communities*
iii. *What constraints and socio-demographic and management factors influence the conservation of shea in Ghana?*

3.5.4 Research Question 4

The objective of the fourth and last segment (Chapter 7) of the dissertation research was to identify the local strategies used in managing shea parklands in Ghana and how they contribute to the provision of global environmental benefits and improvement of livelihoods of people in the local communities using the following research question:

How can shea fit into the international carbon markets to improve the livelihoods of people in northern Ghana as well as conserve shea parklands there for the purposes of combating climate change?

The following sub-questions were used in an attempt to answer the research question:

i. *How are lands acquired for farming shea and which practices are undertaken by farmers at the local community level to manage shea parklands in Ghana?*
ii. *What benefits are derived from the management of shea and how do these benefits impact on the livelihoods of people in the local communities*
iii. *What constraints and socio-demographic and management factors influence the conservation of shea in Ghana?*

3.6 Methodology

3.6.1 Methodologies for Chapter 4

(Estimation of Carbon Stock of Shea Parklands in the West African Savannah)

This component of the research was aimed at determining the carbon stocks of shea trees in Ghana.

Materials and methods of the study

The research was conducted in shea parklands of the three northern savannah agro-ecological zones of Ghana; the Sudan, the Guinea and the Transitional savannah. Methodologies were designed and used to gather data from the field in the three sites.

Treatments for the study

The research was undertaken based on the following three treatments:

- ***Agro-ecological zones;*** under this treatment, consideration was given to the division made across the agro-ecological zones along the north-south climatic gradient. The major climatic factors considered in the study under this treatment were rainfall and temperature as they are quite distinct as one moves from the northern to the southern sector of the country. The three agro-ecological zones were Sudan savannah, Guinea savannah and Transitional Forest/Savannah zones.

- ***Land-use systems***: *field* (land under crop cultivation) and *fallow* (land that was earlier under crop cultivation but presently allowed to 'rest' for a couple of years to restore its fertility) were the 2 land-use systems taken into account under this treatment.

- ***Age of land-use*****:** The 2 land-use systems were categorized into age groups, with each land-use system (field and fallow) subdivided into three age groups. These 3 age groups were:

  new (where the land has been under crop cultivation or fallow for 1-5 years);
  medium (where the land has been under crop cultivation or fallow for 6-10 years); and
  old (where the land has been under crop cultivation or fallow for over 10 years).

3.6.2 Methodology for Chapter 5

(Ghana's response to the UNFCCC international agreements and the impact of the policies on climate change and shea production in Ghana)

This chapter is based on a study of the UNFCCC international agreements and how they are linked to policies on climate change and shea production in Ghana. The chapter explains how international climate change agreements play out in Ghana and the national policies that are formulated and implemented with the view to ameliorating climate change for local and global environmental benefits as well as for the improvement of livelihoods of shea farmers.

In this chapter, diagrammatic presentations and explanations of policies and programmes on climate change constitute the methodology used in the presentation of results of the study. These represent the UNFCCC international agreements and how they are linked to policies on climate change and shea production in Ghana.

Data collection

Both quantitative and qualitative data and other additional information on the UNFCCC international agreements and Ghana's policies on climate change mitigation and adaptation and shea production in Ghana were gathered from interviews with key officers of the Government of Ghana policy-making institutions and the other organizations, analysis of policy documents and extensive search for additional literature on the internet (including websites of the UNFCCC, the policy-making institutions and in Ghana).

In the first part of the research, the various UNFCCC international agreements on climate change in general and afforestation/reforestation/LULUCF in particular of which shea production is a part, were identified and analyzed. During the research, both primary and secondary data on UNFCCC international agreements that address climate change and shea production concerns were gathered. Resource persons working in the field of climate change in Ghana and abroad were purposively selected with the view to finding out the UNFCCC international agreements that address climate change and shea production concerns in Ghana. Primary data were then gathered from these resource persons by using interviews through the administration of semi-structured questionnaires as well as through formal and informal discussions with them. Semi-structured questionnaires and informal discussions were used to gather other additional bits of information that could not otherwise have been covered by the structured and/or formal discussions. Secondary data were obtained from the internet such as from UNFCCC website, climate change and shea policy documents and other material from libraries.

The objective of the second part of the study was to find out which national policies, programmes, projects, measures, of Ghana were embarked upon in response to the international climate change agreements and how they address climate change and shea production concerns in Ghana. Both primary and secondary data were collected during the study. Primary data were obtained from purposively-selected policy makers in Ghana for interviews and discussions on the policies formulated to address climate change and how they impact on shea production in Ghana. Such policy makers from Ministries, other governmental organizations such as Departments, Boards, Commissions, Agencies, non-governmental organizations involved in addressing climate change and shea production concerns in Ghana were purposively selected and interviewed through administration of semi-structured questionnaires. Both formal and informal discussions were held with them with the view to identifying the national policies of Ghana that are formulated in response to the UNFCCC international agreements to address climate change and shea production concerns in Ghana. These governmental and non-governmental organizations were asked questions such as Ghana's vision, goals, policies and other initiatives in response to the UNFCCC international agreements and their impact on climate change and shea production in Ghana.

Secondary data for this part of the study were also obtained from websites of the policy-making institutions in Ghana, libraries, policy documents and other sources.

Data Analysis

The findings of this study were compiled and presented as a review of policies and programmes of UNFCCC international agreements on climate change and shea production in Ghana.

3.6.3 Methodology for Chapter 6

(Management of shea parklands and the impact on local livelihoods and the global environment)

Data collection

The study was conducted at household level on land/tree tenure, land/tree ownership, management strategies and practices, conservation, utilization and impact of shea on the global environment and livelihoods of the local people in the shea-growing areas of Ghana. Key-informant interviews were conducted to gather data from farmers at household level in nine communities using semi-structured questionnaires.

Sampling techniques: multi-stage sampling design

A multi-stage sampling design suited for large-scale sampling involves multiple stages of sub-sampling. Selection of units is done in stages and the design has the advantages of being less expensive compared to other sampling designs. Multi-stage designs are used for a number of practical reasons; one common motivation is for administrative convenience (Preston, 2009 and Schwarz, 2011). As such, the multi-stage sampling design was used to select representative sampling units from the three savannah zones of northern Ghana. At the first stage, the three regions within the ecological zones of shea-growing areas in northern Ghana were purposively chosen. The second stage involved selecting a total of nine districts from the three regions; three districts from each region. The selection procedure at this second stage involved using simple random sampling technique to select two districts in each region, while a third district in which the first segment (carbon research) of the study was purposively selected in each region. The third stage consisted of selecting (using simple random sampling technique) three communities in each district. The fourth stage of the sampling design involved using simple random sampling technique to select 30 households per community for interview while the fifth and final stage comprised purposively selecting two persons (a male and a female) in each household. The research was gender-sensitive because both men and women play varied but vital roles in the shea industry; as such, in each household, a man and a woman involved respectively in the management and processing of shea were selected for interview. Thus, a total of five hundred and forty 540 people (3 x 3 x 30 x 2) people at the local community household level were chosen for the socio-economic study.

In summary, the multi-stage sampling technique involved the following:

i. Stage 1 (Regional level): 3 regions were selected representing 3 the zones
ii. Stage 2 (District level): 3 districts per region were selected
iii. Stage 3 (Community level): 3 communities per district were selected
iv. Stage 4 (Household level): 30 households per community
v. Stage 5 (Individual level): 2 persons (a male and a female) per household were selected

Statistical analysis and interpretation and presentation of results

Statistical Package for Social Scientists (SPSS) programme and Microsoft Excel were used to analyze the responses of the administered questionnaires. Correlation, logistic regression analysis and cross-tabulation in SPSS were used to test the relationship between socio-demographic factors and willingness to manage shea trees (Okiror *et al.,* 2012). Interpretation and presentation of results of analyzed data were done in the form of tables, histograms, pie-charts, cumulative curves.

3.6.4 Methodology for Chapter 7

Chapter 7 constitutes the segment of the research that was conducted to determine models of shea projects in Ghana that could be suitable for carbon markets within the context of the international climate change agreements.

Data collection

The study consisted of two stages. The first stage involved an in-depth study and analysis of the quantum of carbon stored per hectare by shea parklands of Ghana and the way forward towards optimizing carbon credits in the study area, while the second part was to develop shea project models suitable for the international carbon markets.

The first part of this study was conducted to determine the possibility of optimizing the amount of carbon stored by shea parklands of Ghana based on their current sequestration rates. Shea carbon (C) data gathered during a previous study (as part of an overall research on shea including the current one) in the Sudan, Guinea and the Transitional savannah zones of Ghana were used for the first part of this current research. The results from the study in Chapter 4 were used in Chapter 7.

For the second part of the study, existing systems involving shea trees were identified in shea parklands of the Sudan, Guinea and the Transitional savannah zones of Ghana. These systems were analyzed and a number of suitable models were then developed for the shea systems in line with the requirements of the various payment mechanisms of the international carbon markets. These basically involved the use of primary data gathered from the research on existing shea systems in Ghana as well as socio-economic survey data gathered from farmers and juxtaposing them with the requirements of payment mechanisms of the international carbon markets. Three regions (Upper East representing Sudan Savannah, Northern region representing Guinea Savannah and Brong-Ahafo representing the Transitional Savannah zone) in the shea-growing areas of Ghana were purposively selected for the study. In each region, three districts were randomly selected while in each district three communities were also chosen randomly. Thus, a total of nine communities were randomly chosen for the study in which five shea systems were identified and five shea forest project models were developed for the international forest carbon markets. Information on payment mechanisms of the UNFCCC international carbon markets constituted secondary sources of data which were obtained from relevant published works and other UNFCCC-recommended documents on the internet and in libraries.

3.7 Conclusion

The methodologies, which involved both qualitative and quantitative research methods, used in this study facilitated the collection and analysis of field data and the interpretation of the results in a manner that answered the research questions for the various four research chapters.

The next four chapters (Chapters 4, 5, 6 and 7) are the research chapters. Chapter 4 presents findings on the estimation of carbon stocks of shea parklands of the three agro-ecological zones in northern Ghana. Chapter 5 researches into the policies established by Ghana in response to the UNFCCC international agreements on climate change and to what extent these policies have been implemented to address climate change and shea production issues in Ghana. The following chapter, Chapter 6, is on a study that dwells on the strategies and practices by households in Ghana to manage and conserve shea trees and their impact on people's livelihoods in shea-growing communities in Ghana and the global environment. Finally, Chapter 7 finds out shea systems that have the capacity to be developed into shea carbon projects that could attract cash revenue on the international carbon markets for the benefit of shea farmers.

CHAPTER FOUR

Estimation of carbon stock and carbon sequestration of shea parklands of northern Ghana

This chapter discusses the assessment of carbon stocks of the different types of shea parklands in Ghana, that is, how much carbon stocks the agro-ecological zones, phase of landuse and ages of phase of landuse in the West African Savannah have and makes an estimate of how much carbon they can sequester.

4.1 Introduction

The traditional shea parkland system involves both agroforestry and fallow systems. In the shea parkland agroforestry system, shea trees are deliberately conserved in association with annual/seasonal crops (sometimes together with animals) in a spatially dispersed arrangement with both ecological and economic interactions between shea trees and other components of the system. The agroforestry system can last for a number of years until crop yields begin to decline and the land is allowed to 'rest' for a number of years without any crop cultivation. This becomes a shea parkland fallow system wich is characterised by shea trees that are allowed to grow on the land that has been left to idle to restore soil fertility before the cultivation of annual/seasonal crops are re-introduced. The fallow system can also run for a number of years (Okia *et al.*, 2005; Okiror *et al.*, 2012) depending on factors such as increases in human population, scarcity of land for farming and other uses (Poudyal, 2009). In Ghana, as in the other 20 shea-growing countries in Africa, landuse involving shea trees, basically involves shea trees growing with annual crops (farming system of land-use) and shea trees growing on land that has been allowed to lie idle for a number of years for its soil nutrients to be restored (fallow system).

To be able to estimate increases in carbon stocks derived from tree biomass in both farm and fallowland, there is the need to follow certain guidelines. As a result, (IPCC, 2003) suggests that estimates of an area and annual increment of total biomass for each forest or landuse type and climatic zone in each country should be taken into account. Kramer (1982), Brown (1997), Lowe *et al.* (2000) and Koehl (2000) also recommend that the type, age, growing conditions, stand density of trees and the climate within the forest or tree stands should generally be considered when assessing the basic wood density (D) and biomass expansion factors (BEF). These have a direct correlation with carbon stock and sequestration of trees or forests. As a result, these elements should be considered when estimating carbon stock and sequestration of trees.

Although most attention has been focused on closed tropical forest ecosystems because of their high carbon stocks (Lewis *et al.*, 2009) and their role in maintaining biodiversity; drier forest formations offer greater potential for active management of carbon in combination with livelihood improvements (Skutsch, 2010). The region contains a number of tree species of high economic importance. Among such trees is shea, which grows naturally in 21 African countries, including Ghana.

Tangible benefits such as direct financial rewards from the sale of carbon credits will encourage communities to protect, conserve and manage forest ecosystems for intangible global environmental benefits including carbon sequestration. And with the availability of the REDD and

A/R CDM and other windows of opportunity, shea could reap a lot of additional cash benefits for farmers, since shea parklands within the savannah and transitional zones with "*a canopy cover greater than 15%"* could be defined as forests and are therefore being considered under the REDD programme in Ghana's R-PP (FCPF, 2010). There is, however, no information on carbon stocks and sequestration potential of shea parklands in Ghana and very scanty data in the West African Savannah such as those done by Takimoto *et al.* (2007), and Aitken *et al.* (2010), Luedeling and Neufeldt 2012, Nair (2013) and PKR Nair and VD Nair (2013) for carbon storage by trees in the entire ecozone. This research was therefore undertaken to determine the carbon stocks and carbon sequestration potential in the three agro-ecological zones of Ghana (Guinea, Savannah and the transitional forest/savannah zones) that differ in terms of climatic factors (mainly temperature and rainfall) resulting from differences in agro-ecological conditions. The research also focused on differences in carbon stocks in the 2 phases of landuse (farm and fallow) as well as the 3 different ages (new, medium and old) of the phases of landuse. Thus, the study was conducted with the following research question:

How much carbon stocks do shea parklands in the West African Savannah contain?
The sub-question used to address the research question was:

What amounts of carbon are stored by shea trees in the agro-ecological zones, phases of landuse and ages of the phases of landuse in the West African Savannah?

4.2 Objectives of the study

The general objective of the study was to determine the impact of agro-ecological location, phases of landuse and ages of phases of landuse on shea carbon stocks and estimate carbon sequestration potential in the West African Savannah.

The specific objective was to:

determine the differences in shea carbon stocks in the agro-ecological zones as well as phases of landuse and ages of phases of landuse in the northern savannah of Ghana.

4.3 Materials and methods

The research was done in collaboration with INNOVKAR (Innovative Tools and techniques for Sustainable Use of the Shea Tree in Sudano-Sahelian Zone). The partner countries involved in the INNOVKAR research project included United Kingdom (UK), The Netherlands, France, Denmark, Germany and five partner African countries (Ghana, Mali, Burkina Faso, Senegal and Uganda) where the project was concurrently conducted. INNOVKAR was funded by the European Union (EU). The results presented here are from the Ghana component of the project.

4.3.1 Study location and phase of landuse

The study was carried out in shea parklands of the Sudan, Guinea and the Transitional savannah agro-ecological zones of Ghana.

4.3.2 Materials and methods of the study

Following a recommendation by IPCC (2003), the non-destructive tree method involving the estimation of tree biomass from diameter at breast height (DBH) measurements and an allometric equation was used to assess carbon stocks. Estimated mean C stock in shea trees per plot were extrapolated on per ha basis in each agro-ecological zone. Means of C stock and were also estimated for each land-use system and phase of landuse.

4.3.3 Sampling design and setting up of treatment plots and data collection

The Shea woodlands were sampled at three sites in Ghana using a series of 50 m x 50 m plots. Each site was located in a different agro-ecological zone. At each site two land use systems of three different ages were assessed. Therefore, at each of the three sites, 18 plots were assessed and these gave rise to a total of 54 plots that were set up in all the 3 sites. Reading and recording of field data (Figure 4.1) were subsequently done in each of the 54 plots.

Figure 4.1 Setting up treatment plots as well as reading and recording field data

4.3.4 Treatments for the study

The study was conducted using treatments (Figure 4.2 and Table 4.1) as explained below:

- ***Agro-ecological zones;*** a division was made across the agro-ecological zones along a north-south climatic gradient (with rainfall and temperature being the main factors under consideration). As indicated in Table 4.1, the 3 agro-ecological zones of shea-growing areas in Ghana from driest to wettest along the climatic gradient are agro-ecological zones, phase of landuse and age of land-use (as indicated below) are:

- ***Phase of landuse***: the 2 phases of landuse considered were *field* (land under crop cultivation) and *fallow* (land previously under crop cultivation but allowed to 'rest' for a couple of years for the restoration of its fertility).

➢ ***Age of land-use*:** Estimated age of each land-use system was determined using information (the number of years the farm or fallow system has been operating) provided by the farmers. With this information, the 2 phases of landuse were categorized into 3 age groups, with each land-use system (field and fallow) subdivided into three age groups and these are also indicated below as;

i. new (where the land has been under crop cultivation or fallow for 1-5 years),
ii. medium (where the land has been under crop cultivation or fallow for 6-10 years)
iii. old (where the land has been under crop cultivation or fallow for over 10 years).

The general schematic figure below depicts the graphical format of the treatments for the INNOVKAR project, and adopted for the component study in Ghana:

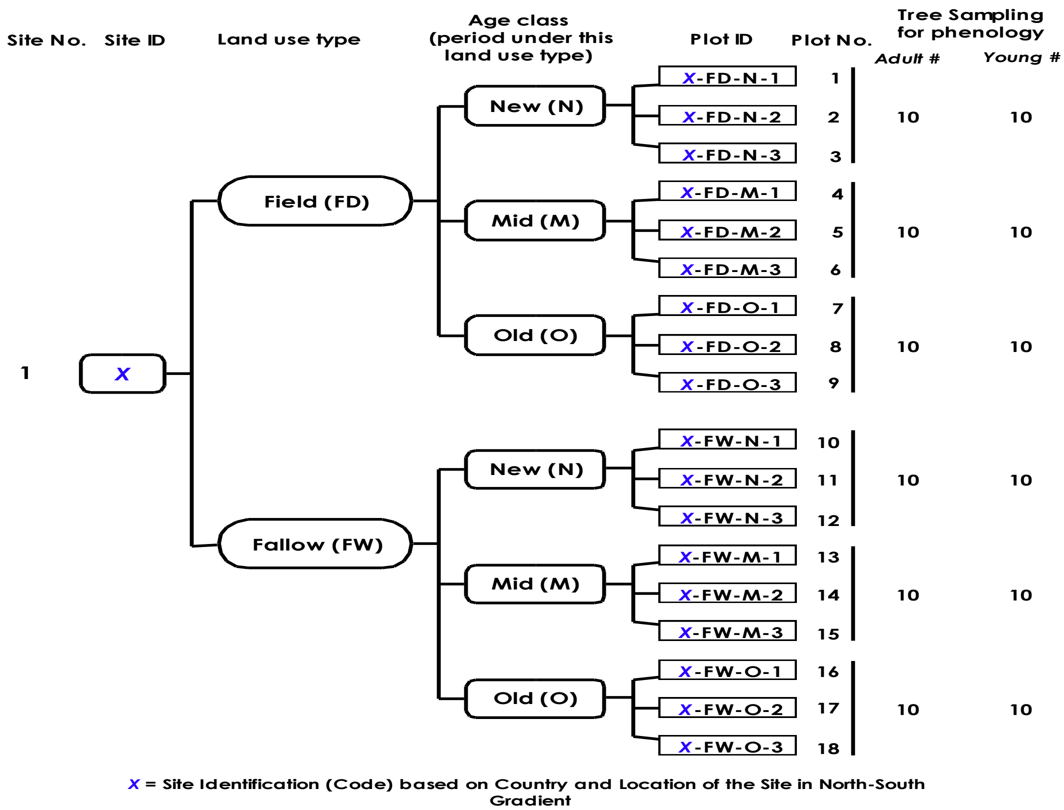


Figure 4.2 The general schematic figure showing the number of sample plots for the INNOVKAR project
Source: INNOVKAR Project (Adopted for the component study in Ghana)

Table 4.1 Experimental treatments for assessing carbon stocks of shea parklands in Ghana

	Agro-ecological zone	*Site*	*Phase of landuse*	*Age of landuse*	*Number of replications*	*Number of plo per site*
1	Sudan savannah	Paga	Field	New	3	18
				Medium	3	
				Old	3	
			Fallow	New	3	
				Medium	3	
				Old	3	
2	Guinea savannah	Nyankpala	Field	New	3	18
				Medium	3	
				Old	3	
			Fallow	New	3	
				Medium	3	
				Old	3	
3	Transitional forest-savannah	Kawampe	Field	New	3	18
				Medium	3	
				Old	3	
			Fallow	New	3	
				Medium	3	
				Old	3	
			Total number of plots for all the three sites			***54***

4.3.5 Data collection

To quantify above-ground biomass, tree diameters were recorded at 1.3 m from the ground (DBH) in the fifty-four 50 m x 50 m plots. In each plot, diameters of all trees with a DBH that fell within the range of 15-53 cm were recorded.

Field data collection was carried out at the end of each of the 2 seasons in the year; rainy season (October/November 2008) and dry season (April/May 2008) for all the 18 plots (6 plots with 3 replications) in each site, totalling 54 plots in all the 3 study sites. Data were taken on trees of at least 1.5 m in height. Data were gathered on the following parameters of each 0.25 ha (50 m x 50 m) plot:

i. Number of trees per plot
ii. Height of each tree (in metres)
iii. Diameter at breast height (DBH) each tree (in centimetres)
iv. Crown diameter (both on East-West and North-South orientations) of each tree (in metres).

4.3.6 Estimation of biomass carbon

The study area can be categorized under the managed forest land that is subject to periodic or on-going human interventions through management practices as indicated in the IPCC (2003) Guidelines.

To estimate the amount of carbon stored, first the DBH (in cm) of the trees were measured, and these were then converted into biomass using an allometric equation. The calculated biomass was then converted into stored carbon.

As there were no specific allometric equations for shea in the study area, an allometric equation proposed by Peltier *et al.* (2007) for *Vitellaria paradoxa* (shea) was used to estimate the above-ground biomass (AGB) of the shea parkland trees:

Above-ground biomass of tree (kg) = 0.08*(X2^(2.46))

where *X* = diameter at breast height (DBH in centimetres)

The above allometric equation is used for *Vitellaria paradoxa* in Mafa Kilda, Cameroon, which has a mean annual rainfall of 997 mm. This can be applied to regions with similar climatic conditions such as shea-growing areas of Ghana. The equation is also used for shea trees which fall within the DBH range of 15-53 cm.

The carbon fraction rate of 0.5, as proposed in the UNFCCC guideline (Takimoto *et al.*, 2008 and Escobedo *et al.*, 2009), was used to calculate carbon in the biomass.

Determination of ages of the shea trees

There are a number of methods that can be used to determine the ages of trees. One of such methods, developed by the International Society of Arboriculture, involves multiplying the measured diameter of a tree by its growth factor (Mulligan, 2012). The problem associated with this method, however, is that growth factors of certain tree species, such as shea, have not yet been established. As a result, it is difficult or somehow impossible using this method to determine the age of shea trees in the study area.

One other method is ‘growth ring counting’ method usually used by foresters to determine ages of trees. This method involves counting the growth rings of a severed tree stump. Another method is by the use of the increment borer to take a small (0.51 cm diameter) straw-like sample from the bark to the pith of the tree. The rings are then counted near the base (ground) of the tree. Although the hole bored into the stem of the tree is small, it can still introduce decay in the trunk. Thus, these and other methods, known as invasive or destructive methods, involve destroying or injuring the trees in order to determine their ages. There are however non-invasive or non-destructive methods for estimating ages of trees. The commonest and most convenient method is by comparing ages of trees of the same species growing under similar conditions (Nix, 2012).

This method of age estimation does not involve causing any damage to trees as it relies on comparison with trees of known ages. Thus, ages of trees can be determined by comparing known ages of trees of the same species in different locations on particular site types. Cross-referencing between individual trees is credible due to the fact that trees of the same species predictably develop through well-defined patterns of growth (White, 1998; Bruscke, 2014).

This age comparative method was used to estimate the ages of shea trees in the study area. This was because shea trees in the INNOVKAR research plots have no data on their ages and therefore it was not possible to estimate their carbon and carbon sequestration rates. As a result, available data were obtained from the Savannah Agricultural Research Institute (SARI) and the Ghana Airforce on the known ages of conserved shea tree plantations in Nyankpala and the Tamale Airport Junction respectively. Information from the Ghana Airforce in Tamale indicates that the shea trees at the Tamale Airport Junction were planted in 1978, and that means the shea trees were 34 years old as of 2012. The growing conditions, especially moisture, at the Savannah Agricultural Research Institute (SARI) and the Ghana Airforce, Tamale Airport Junction, are similar to the growing conditions in the research study area. Hence, the shea trees at SARI and the Tamale Airport Junction have characteristics similar to shea trees in the study area, and their ages were therefore used as a basis to estimate the ages of the shea trees in the research plots by comparing the sizes of their DBHs.

Determination of the range of uncertainty of the DBH of the shea trees

To determine the range of uncertainty of the DBH of the shea trees at the Tamale Air Force shea plantation, the following formulae and procedure were used:

First, the standard deviation and standard error of the mean (SEM) were calculated.

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2},$$

Where:
s= the standard deviation,
x_1, x_2, ……X_N are the observed values of the sample items, and
$\overline{x}$ is the mean value of these observations, while the denominator
N stands for the size of the sample

The standard error of the mean, SEM, is the standard deviation of the sample-mean's estimate of a population mean (Table 4.2), which can also can also be said to be the standard deviation of the error in the sample mean relative to the true mean, since the sample mean is an unbiased estimator. SEM is usually estimated by the sample estimate of the population standard deviation (sample standard deviation) divided by the square root of the sample size (assuming statistical independence of the values in the sample):

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

Where:
s is the sample standard deviation (i.e., the sample-based estimate of the standard deviation of the population); and
n is the size (number of observations) of the sample.

Table 4.2 Tabulated values for the DBH, Deviation, Variance, Standard deviation and standard error of the mean (SEM) of the Tamale Air Force Base Shea Trees

		DBH of shea trees at the Tamale Airforce Base (m)	Deviation about the mean (x-$\bar{x}$)
	1	18.47	2.03
	2	19.11	2.66
	3	18.79	2.35
	4	23.89	7.44
	5	23.57	7.12
	6	18.79	2.35
	7	23.57	7.12
	8	18.15	1.71
	9	21.66	5.21
	10	26.43	9.99
	11	10.83	-5.62
	12	12.10	-4.34
	13	11.78	-4.66
	14	14.01	-2.43
	15	17.83	1.39
	16	12.42	-4.02
	17	10.51	-5.93
	18	17.20	0.75
	19	22.61	6.17
	20	10.83	-5.62
	21	14.65	-1.79
	22	13.06	-3.39
	23	12.42	-4.02
	24	13.06	-3.39
	25	12.42	-4.02
	26	14.01	-2.43
	27	14.65	-1.79
	28	16.24	-0.20
	29	15.29	-1.16
	30	14.97	-1.48
Sum		493.31	0.00
Number of observations	n	30	30
mean	$\bar{x}$	16.44	
Variance	s^2		
Standard deviation (s)	s		
Standard error	e		

To calculate the range of uncertainty of the gathered data on the measured DBH of the shea trees at the Tamale Air Force Shea plantation, the lower limit of at 95% confidence interval was determined by using the formula below:

$$Lower\ endpoint = \bar{X} - 1.96\frac{\sigma}{\sqrt{n}},$$

or

Lower 95% Limit = $\bar{x} - (SE \cdot 1.96)$.

where $\bar{x}$ is equal to the sample mean, SE or σ is equal to the standard error for the sample mean, and 1.96 is the .975 quantile of the normal distribution

Similarly, the upper limit was determined using the following formula:

Upper 95% Limit = $\bar{x} + (SE \cdot 1.96)$,

or

$$Upper\ endpoint = \bar{X} + 1.96\frac{\sigma}{\sqrt{n}}.$$

Table 4.3 Range of uncertainty of the DBH of the shea trees at the Tamale Air Force Shea plantation

Mean ***($\bar{x}$)***	***Number of observations*** ***(n)***	***Standard deviation*** ***s***	***Standard error*** ***(SE or σ)***	***Lower limit*** ***(L)***	***Upper limit*** ***(U)***
16.44	30	4.29	0.78	14.91	17.98

Thus, using the above formulae, the range of uncertainty was calculated to be between 14.91 cm and 17.98 cm with a mean DBH of the trees as 16.44 cm and a standard deviation of 4.29 at 95% confidence interval (Table 4.3).

The growth pattern of shea trees can generally be divided into four phases (Dr. Peter N. Lovett, Personal communication, November 21, 2011), and these four phases are:

i. 0 – 25 years: period of active growth until flowering
ii. 25 – 100 years: young but productive years
iii. 100 – 500 years: middle age
iv. 500+ years: stable but old age

Comparing the sizes (in terms of DBH) of the shea trees at the Tamale Airport Junction and the INNOVKAR research plots, using 16.44 cm as the mean DBH for the 34 year-old shea plantation at the Tamale Airport Junction, Dr. Peter N. Lovett recommended that ages of shea trees of the INNOVKAR research plots for DBH classes above 20 cm should be triples of 34 years, and quadruples of 34 years for DBH classes above 40-60 cm. The growth phases, growth habits and estimated ages of the shea trees were thus used to model a growth curve, from which a sigmoid-type of growth curve (Figure 4.3) was obtained when the DBH vs. estimated ages (Table 4.4) were plotted.

Table 4.4 DBH classes of shea trees in the study area and their corresponding estimated ages

DBH classes (cm)	***Estimated age of trees (years)***
1 - 20	34
21 - 40	102
41 - 60	136
61 - 80	204
81 - 100	272
101 - 120	408
120 and above	544

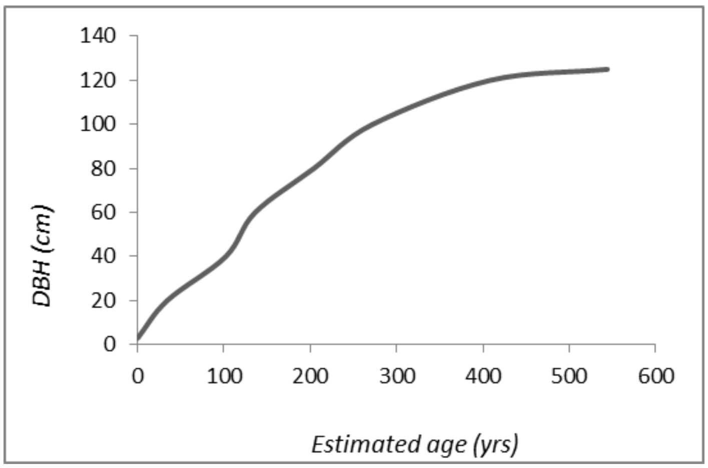


Figure 4.3 The relationship between age and diameter of shea trees in Ghana

The average C stock and C sequestered per shea tree were then extrapolated from per plot basis to per ha and subsequently used to represent the study area, as spelt out in the IPCC (2003) Guidelines for estimating the C stock and C sequestered.

To estimate for below-ground biomass, the suggested general root/shoot ratio of 0.25 for trees was used (Takimoto *et al.,* 2008; Kolozs and Facsko, 2012).

C stock of a tree is the absolute quantity of C contained in the tree at the time of taking the inventory (Takimoto *et al*, 2008) while, C sequestration is the process of removing carbon from the atmosphere and putting it in a reservoir (UNFCCC, 2006). Through the natural process of photosynthesis trees are able to remove carbon dioxide from the atmosphere and store the carbon (C) component in their leaves, branches, bark and roots. Benefit of C sequestration can be assessed by determining the difference in the mean carbon stock between the previous land use and the forest or plantation (Primefacts, 2010). This implies C sequestration can be determined between two land uses or between two periods of time by knowing the difference in C stocks of the two land uses or periods.

4.3.7 Data analysis

In analyzing the gathered data, Analysis of variance (ANOVA) by SAS PROC MIXED and Tukey-Kramer multiple comparison test were used to compare the biomass carbon stocks of the study area. Presentations of data were also done using Microsoft Excel and Statistical Package for Social Sciences (SPSS).

4.4 Results

4.4.1 Carbon stock of shea trees

Factors affecting growth, carbon stocks and sequestration potential of shea trees

A number of factors, as depicted in Table 4.5, have been identified as affecting the growth, carbon stocks and sequestration potential of trees in general. In shea trees, it has been reported that these factors have either positive or negative impacts on the growth, carbon storage and sequestration. Factors such as availability of nutrients, favourable climatic conditions (precipitation, temperature, wind), absence of bushfires, useful animals such as pollinating bees as well as good land/tree management practices enhance the growth, carbon storage and sequestration potential of shea trees. The absence of these aforementioned factors or when they become unfavourable (either in inadequate or in excessive amounts), they impact negatively on the growth, carbon storage and sequestration potential of the trees.

Although, the above-mentioned factors generally affect the growth, yield and size of shea trees, results gathered from the study generally show that age has much more influence on the size of the trees than other factors. This is because different sizes of trees were found in the 3 different agro-ecological zones (sites), the 2 different landuse systems and the 3 different phases of landuses in this study. This therefore means that it is extremely difficult to attribute size of shea trees to specific factors. What is however certain, as the interviewed farmers in the study areas explained, is that the age is the key single most influential factor that generally impacts on the size of the shea trees. This means that bigger shea trees are more likely to be older than smaller trees; a case of the bigger the tree the older it is.

Table 4.5 Factors affecting growth, carbon stocks and sequestration potential of shea trees

	Factor	***Effect***
1	Nutrient requirements	growth and yield
2	General climatic factors (mainly rainfall and temperature)	significant influence on yield
3	bush fires	significant influence on yield; damages flowers, fruits; tree kills trees and saplings (affects tree regeneration)
4	insects and parasites	significant influence on yield; retards growth and reduces yield
5	drought	wrinkling of seed, abortion of shea fruit, growth and yield
6	strong winds	make flowers drop down

7	heavy rain shower	make flowers drop down
9	Mistletoe (a parasitic plant)	Reduces fruit yield, if too many can kill the tree
10	Caterpillar species	Defoliation and damage to fruits
11	Bees	responsible for the pollination of the fruits
12	Animals e.g. monkeys and bats.	dispersal of the seed
13	Climatic influences (rainfall and temperature)	type and density of vegetation (including shea trees)
14	Age of trees	the sequestration rate is higher in young trees than in old trees.
15	Land-use management practices	have direct effect on growth and yield; these in turn impact on carbon stock and carbon sequestration rates of trees
16	human disturbance/pressure	has negative effects on growth, yield, carbon stocks and carbon sequestration rates

Estimation of carbon dioxide sequestered by shea trees at the Tamale Airport Junction

Carbon sequestration can also be expressed in terms of 'time-averaged-quantities' (Mg C/year) (Palm *et al*., 2004; Roshetko et al., 2002 and Trees For The Future, 2015). In other words, carbon sequestration can be estimated by dividing carbon stored over time (such as the age of the tree).

Carbon sequestration can therefore be expressed as = carbon stored/age of the tree

Thus, to estimate the C sequestration rates of the shea trees at the Tamale Airport Junction, their C stocks were calculated (using an allometric equation and their DBHs), and these were then divided by their age of 34 years.

On the international carbon market, the price of carbon is usually quoted in carbon dioxide equivalent per tonne (tCO_{2e}). To obtain the tCO_{2e}, the calculated carbon sequestered (0.11 tons ha^{-1} yr^{-1}) by shea trees at the Tamale Airport Junction was multiplied by a factor of 3.67, as explained below:

Molecular mass of C = 12

Molecular mass of CO_2 = 44

The ratio, Molecular mass of CO_2 /Molecular mass of C = 44/12 = 3.67

A mean of 0.40 tCO_{2e} ton/yr was estimated as the carbon dioxide sequestered by shea trees at the Tamale Airport Junction when the Carbon sequestered (Cseq) by the tree was multiplied by 3.67

Cseq by shea trees = 0.11 tons ha^{-1} yr^{-1}

tCO_{2e} by shea trees = 0.11 x 3.67 = 0.40 tCO_{2e} tons ha^{-1} yr^{-1}

Therefore, the mean carbon dioxide sequestered per year by the shea trees at the Tamale Airport Junction is 0.40 tCO_{2e} tons ha^{-1} yr^{-1}.

Site

The density data below (Table 4.6) shows characteristics of shea trees in the research study area.

Table 4.6 Characteristics of shea trees in the Transitional, Guinea savannah and Sudan savannah zones of Ghana.

Zone	***Site***	***Number of trees ha^{-1}***	***Height per tree (m)***	***DBH[1] per tree (cm)***	***Biomass (Mg ha^{-1})***	***Carbon stock (Mg ha^{-1})***	***Carbon stock per tree (Mg)***
Transitional savannah	Kawampe	48.67 (22.26)[a]	9.66 (1.66)[a]	26.17 (6.47)[a]	11.53 (5.99)[a]	5.77 (2.99)[a]	0.14 (0.08)[a]
Guinea savannah	Nyankpala	87.78 (48.52)[b]	7.00 (1.41)[b]	19.78 (5.69)[a]	9.55 (4.52)[a]	4.77 (2.26)[a]	0.07 (0.05)[a]
Sudan savannah	Paga	33.11 (17.02)[a]	8.40 (2.10)[ab]	47.43 (14.62)[b]	32.40 (19.11)[b]	16.20 (9.56)[b]	0.62 (0.57)[b]
Means		56.52 (39.32)	8.35 (2.03)	31.13 (15.32)	17.83 (15.62)	8.91 (7.81)	0.28 (0.41)

Note: Figures in parenthesis are standard deviations
Means that have different superscripts within a column are significantly different ($p<0.05$).
DBH[1] = Diameter at breast height
Confidence interval = 95%

From the research results, the individual trees were categorized into DBH classes according to their measured DBHs as shown in Table 4.7.

Table 4.7 DBH classes and amounts of C stored per shea tree and per ha in the Savannah Parklands of Ghana.

DBH classes (cm)	***Number of trees***	***C stored (kg/tree)***		
		Above-ground	***Below-ground***	***Above and below ground***
1 - 20	375	11.54	2.88	14.42
21- 40	282	172.10	43.02	215.12
41-60	82	604.68	151.17	755.85
61- 80	19	1383.57	345.89	1729.46
81-100	2	2567.42	641.85	3209.27
101-120	2	4206.16	1051.54	5257.70
120+	1	6343.96	1585.99	7929.95

In general, results of the research show that the mean DBHs of the shea trees in all the three sites were within the range of 15-53 cm and had an overall mean DBH of 31.13 cm, as shown in Table 4.6. The three sites differed significantly ($p<0.05$) in tree size (in terms of DBH), although the difference was between the Sudan savannah and the other two sites (Sudan savannah and the Transitional savannah). Sudan savannah recorded the largest mean size of 47.43 cm per tree, followed by Transitional savannah 26.17 cm per tree, while Guinea savannah had the smallest tree size of 19.78 cm per tree. Since the amount of carbon stocks were derived from the corresponding DBHs of the trees using an allometric equation, the same trend was observed. As a result, Sudan savannah which differed significantly ($p<0.05$) from the other two sites recorded the most carbon stocks (0.62 Mg per tree), while Transitional savannah and Guinea savannah had 0.14 Mg per tree and 0.07 Mg per tree respectively.

On per hectare basis, the field research results indicate that shea tree densities were significantly different ($p<0.05$) among the three sites (Table 4.6). Nevertheless, the difference was only significant between Guinea savannah and the other two sites. Guinea savannah zone had the highest number of trees (87.78 ha^{-1}), followed by Transitional Savannah (48.67) while Sudan savannah registered the least number of trees (33.11 ha^{-1}). The reverse was the case for biomass carbon, in which the Sudan savannah differed significantly from Transitional Savannah and Guinea savannah. Sudan savannah registered the highest value of 16.20 Mg ha^{-1}, Transitional Savannah had (5.77 Mg ha^{-1}) while Guinea savannah stored the least carbon (4.77 Mg ha^{-1}).

These differences were as a result of two factors; that is, number of trees per ha (density) and size (DBH) of the trees per ha. A regression analysis was done to separate out whether the difference is due to size of trees (DBH) or number of trees (density). The results show that size of trees (DBH) differed more significantly at 95% confidence level (R^2 of 0.853 and R^2 of 0.784.. Number of trees per ha however had a less significant effect on carbon stock; with R^2 of 0.180 and level of significance of 0.001 for carbon stock per ha as indicated in Table 4.8. This means that the differences in the 3 study zones (in terms of their carbon stocks) were due to the sizes (DBHs) of their trees. And this could be as a result of management of the trees, because when few trees are allowed to grow, they tend to grow bigger and therefore produce larger DBHs and more carbon stock.

Table 4.8 Regression analysis of independent factors (DBH and Number of trees) each ran against the dependant factors (carbon stock per ha ha)

Dependent factor	**Independent factor**			
	DBH (cm)		***Number of trees***	
	R^2	Level of significance	R^2	Level of significance
Carbon stock (ha)	0.853	0.000	0.180	0.001

Pearson correlation, which was used to establish the correlation between the independent factors (DBH and number of trees) and the dependent factors (carbon stock), has the following formula:

$$r = \frac{\sum_{i=1}^{n}(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}}$$

where:

r is Pearson's correlation coefficient and may also be known as the *sample Pearson correlation coefficient* or the *sample correlation coefficient.*

or

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{X_i - \bar{X}}{s_X}\right)\left(\frac{Y_i - \bar{Y}}{s_Y}\right)$$

where:

$$\frac{X_i - \bar{X}}{s_X}, \bar{X}, \text{ and } s_X$$

are the standard score, sample mean, and sample standard deviation, respectively,

(X_i, Y_i) are sample of paired data.

An analysis with Pearson correlation showed that the number (density) of trees had a negative correlation (-0.318) with carbon stock (Table 4.9). The implication of this is that, generally, as the trees increased in number, the amount of carbon stock decreased (Figure 4.4), showing an indication of competition for growth factors such as moisture, soil nutrients and sunlight among the increasing number of trees as well as the DBH (sizes) of the trees (Figure 4.5).

Table 4.9 Pearson correlation between independent factor (Number of trees) ran against the dependant factor (carbo stock per ha)

		Number of trees per ha
Number of trees per ha	Pearson Correlation	
	Sig. (2-tailed)	
	N	54
DBH (cm)	Pearson Correlation	-0.613**
	Sig. (2-tailed)	0.000
	N	54
Carbon stock per (Mg/ha)	Pearson Correlation	-0.318*
	Sig. (2-tailed)	0.019
	N	54

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

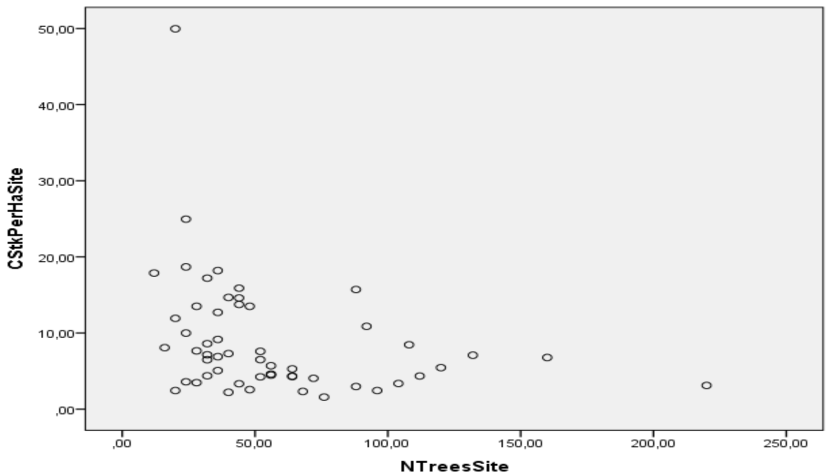


Figure 4.4 Scatter diagram showing the relationships between the number of trees and carbon stock (Mg/ha) between number of trees.

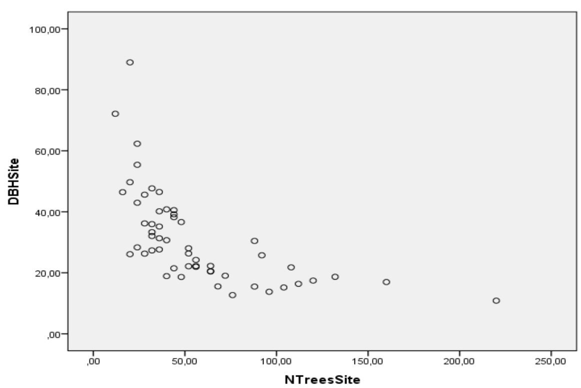


Figure 4.5a

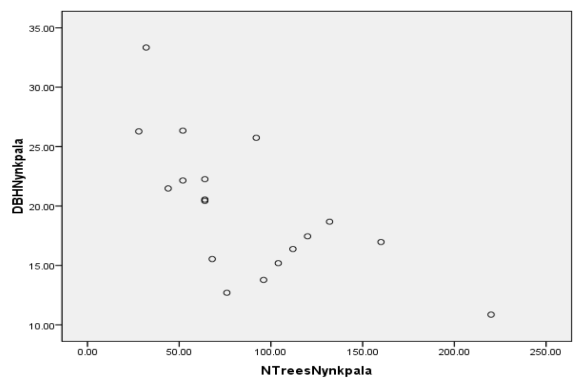


Figure 4.5b

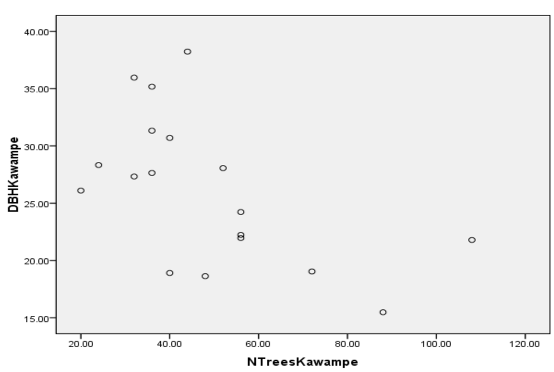


Figure 4.5c

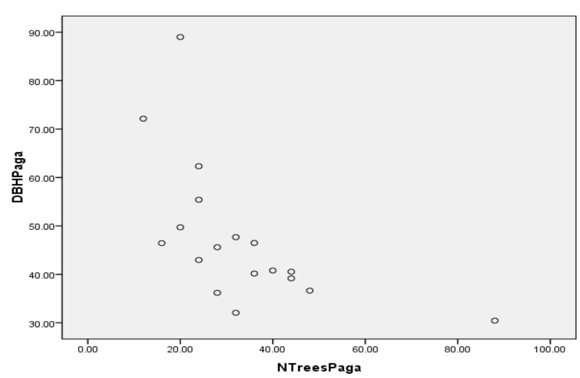


Figure 4.5d

Figures 4.5a, 4.5b, 4.5c and 4.5d. Graphs showing inverse relationships between DBH (size in cm) and number of trees of the entire study area (Figure 4.5a), Guinea savannah (Figure 4.5b), Transitional Forest (4.5c) and Sudan savannah (4.5d) zones.

As shown in the generalized graph (Figure 4.5a) above of the entire study area, analysis of the data gathered shows an inverse relationship between the number of shea trees and their DBHs (sizes). This means that as the number of trees increases, the trees decrease in sze. As can be inferred from the graph, areas with the least numbers of trees have largest trees and vice versa, while areas with average of 30-60 trees per ha produced trees with average size of 20-40 cm in DBH.

The same can be said of the individual study sites as their specific graphs follow the same trend; there is an inverse relationship between the number of shea trees and their sizes. This indicates that as the number of trees increases, their sizes decrease (Figures 4.5b, 4.5c and 4.5d). There is however a slight difference in the graphs, in terms of the numbers and sizes of the trees. In terms of the upper limit of the number of trees, Guinea savannah (Figure 4.5b) recorded the highest number of trees (220 trees/ha, majority between 50-130 trees/ha) followed by the Transitional Forest zone (108 trees/ha, majority having 30-60 trees/ha), while the Sudan savannah had the least (88 trees/ha, majority having 20-45 trees/ha).

With regards to size, the reverse is the case. Sudan savannah had the largest trees (highest DBH of 90 cm) (largest size), with an average of 20-50 trees/ha producing trees of average size of 35-60 cm in DBH. This was followed by Transitional Forest zone which recorded the largest trees of 38 cm in DBH, with average of 30-60 trees/ha producing trees of average size of 18-35 cm in DBH. Guinea savannah produced the smallest trees of size of about 34 cm in DBH, with average of 50-140 trees/ha producing trees of average size of 12-26 cm in DBH

With good farming and silvicultural practices, however, it is possible to increase the number of trees to 100-400 trees per ha.

Land-use system

The phase of landuse also differed significantly ($p<0.05$) in shea tree densities, with the fallow plots recording a higher value of 69.04 trees ha^{-1} while 44.00 trees ha^{-1} were counted in the field plots (Table 4.10a). This was probably due to the fact that some of the shea trees were cleared to make way for the cultivation of crops. Thus, this reduced the number of shea trees in the field plots compared to the higher number of trees in the fallow plots. Thus, in the fields, some trees are removed to make way for crop cultivation, but more shea tree seedlings begin to grow up in place of the removed shea trees, either by vegetative means (from the stumps) or from germinated fallen shea seeds. By the time these seedlings attain the required minimum height of 1.5 m to be considered as trees or tree saplings (which usually takes a couple years of crop cultivation), however, the land would have been allowed to fallow to replenish lost soil nutrients. This cycle of cutting down some of the shea trees to make way for crop cultivation in farms and the regeneration of more trees during the fallow periods respectively reduces shea tree density in fields and increases shea tree density in fallows.

The same trend was observed in the individual zones (as indicated in Tables 4.10b, 4.10c and 4.10d) in terms of density of trees. In all the 3 zones, field and fallow plots also diffrered significantly in most of the parameters studied, particularly in DBH, C stock per tree, C stock per ha, sequestered C and CO_2e, except in the Guinea savannah zone where the field and fallow plots did not significantly differ in C stock per ha, sequestered C and CO_2e.

When the sizes (DBHs) of the trees were plotted against their density (number of trees per ha), an inverse relationship was observed; the higher the number of trees the smaller their sizes (Figures 4.6a and 4.6b). Fallow plots (Figure 4.6a) recorded 220 trees/ha as the highest number of trees/ha than Field plots (Figure 4.6b) which recorded 120 trees/ha as their highest density of trees. Conversely, Field plots registered the largest trees with DBH of 89 cm, while Fallow plots had 72 cm DBH as their largest trees. On the average, 30-120 trees/ha of Fallow plots produced trees of average size of 10-40 cm in DBH while 20-60 trees/ha of Field plots produced trees with average size of 20-50 cm in DBH.

Good field management practices by farmers and the availability of adequate growth factors (such as soil moisture, soil nutrients, sunlight) impacted positively on the fewer trees in the field plots and thus enabled them to grow bigger (higher DBH values) compared to the high numbers of trees in the fallow plots that had insufficient growth factors (due to competition among the more densely populated trees) and received less or no management practices. Since bigger trees generally have more carbon stocks, the field plots with bigger shea trees stored a slightly higher C (9.16 Mg ha^{-1}) in the trees compared to the fallow plots (8.66 Mg ha^{-1}). The two phases of landuse did not however differ significantly in C carbon stocks, as can be seen in Figure 4.7.

Thus, the larger sizes (DBHs) of trees (although fewer) in the field plots was due to the trees responding well to the access of adequate growth factors and farming/management practices to both the crops and the trees, and these enabled the trees to grow bigger, compared to the trees on fallow plots that received less growth factors and little or no management practices. The effect of size of the trees in the field plots was more pronounced than their small number of trees (low density); meaning that the fewer trees in the field plots were able to grow bigger and produced more biomass carbon, sequestered carbon and sequestered carbon dioxide than the smaller but more trees in the fallow plots did. Size therefore had more pronounced effect than number of trees on the biomass carbon, sequestered carbon and sequestered carbon dioxide.

Table 4.10a General characteristics of shea trees in the two phases of landuse (field and fallow plots) of the Transitional, Guinea savannah and Sudan savannah zones of Ghana.

Land-use type	*Number of trees ha*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass ($Mg\ ha^{-1}$)*	*Carbon stock ($Mg\ ha^{-1}$)*	*Carbon stock per tree (Mg)*
Field	44.00 (23.51)^a	8.79 (2.18)	33.15 (15.26)	18.33 (18.37)	9.16 (9.19)	0.31 (0.47)
Fallow	69.04 (47.67)^b	7.91 (1.81)	29.12 (15.40)	17.33 (12.63)	8.66 (6.31)	0.24 (0.31)
Means	**56.52 (39.32)**	**8.35 (2.03)**	**31.13 (15.32)**	**17.83 (15.62)**	**8.91 (7.81)**	**0.28 (0.41)**

Note: Figures in parenthesis are standard deviations
Means that have different superscripts within a column are significantly different ($p<0.05$).
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.10b Characteristics of shea trees in the two phases of landuse (field and fallow plots) of the Guinea savannah zone of Ghana.

Land-use type	*Number of trees ha*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass (Mg ha^{-1})*	*Carbon stock (Mg ha^{-1})*	*Carbon stock per tree (Mg)*
Field	54.22 (24.67)^{a}	8.78 (0.95)^{a}	22.92 (3.99)^{a}	9.32 (4.19)	4.66 (2.09)	0.09 (0.04)^{a}
Fallow	115.11 (50.67)^{b}	6.21 (1.00)^{b}	17.72 (5.19)^{b}	10.40 (5.67)	5.20 (2.83)	0.05 (0.04)^{b}
Means	**84.67 (49.76)**	**7.50 (1.63)**	**20.32 (5.23)**	**9.86 (4.87)**	**4.93 (2.43)**	**0.07 (0.04)**

Note: Figures in parenthesis are standard deviations
Means that have different superscripts within a column are significantly different ($p<0.05$).
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.10c Characteristics of shea trees in the two phases of landuse (field and fallow plots) of the Transitional zone of Ghana.

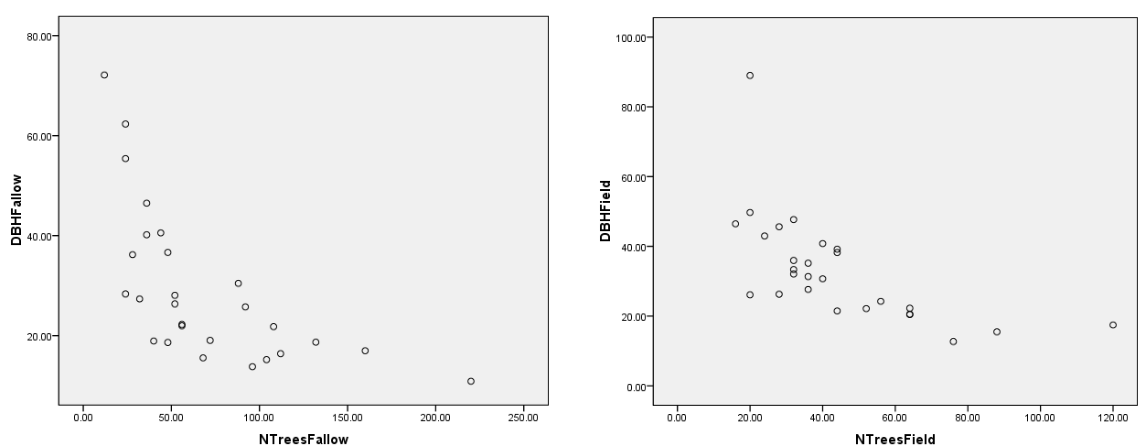
Land-use type	*Number of trees ha*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass (Mg ha^{-1})*	*Carbon stock (Mg ha^{-1})*	*Carbon stock per tree (Mg)*
Field	60.44 (27.46)^{a}	7.78 (1.36)	21.85 (5.69)^{a}	8.69 (3.11)	4.35 (1.56)^{a}	0.09 (0.06)^{a}
Fallow	37.78 (21.83)^{b}	8.72 (1.96)	46.71 (13.80)^{b}	32.26 (9.55)	16.13 (4.78)^{b}	0.58 (0.44)^{b}
Means	**49.11 (26.74)**	**8.25 (1.71)**	**34.28 (16.38)**	**20.48 (13.95)**	**10.24 (6.97)**	**0.34 (0.40)**

Note: Figures in parenthesis are standard deviations
Means that have different superscripts within a column are significantly different ($p<0.05$).
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.10d Characteristics of shea trees in the two phases of landuse (field and fallow plots) of the Sudan savannah zone of Ghana.

Land-use type	*Number of trees ha*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass (Mg ha^{-1})*	*Carbon stock (Mg ha^{-1})*	*Carbon stock per tree (Mg)*
Field	28.44 (9.48)^{a}	8.07 (2.30)^{a}	48.16 (16.20)^{a}	32.54 (26.17)^{a}	16.27 (13.09)^{a}	0.66 (0.70)^{a}
Fallow	43.11 (19.37)^{b}	10.53 (1.79)^{b}	29.43 (7.02)^{b}	13.75 (6.90)^{b}	6.87 (3.45)^{b}	0.18 (0.09)^{b}
Means	**35.78 (16.60)**	**9.30 (2.37)**	**38.80 (15.48)**	**23.14 (20.93)**	**11.57 (10.47)**	**0.42 (0.54)**

Note: Figures in parenthesis are standard deviations
Means that have different superscripts within a column are significantly different ($p<0.05$).
DBH[1] = Diameter at breast height
Confidence interval = 95%



Figures 4.6a and 4.6b Graphs showing inverse relationships between DBH (size in cm) and number of trees in the Fallow (Figure 4.6a) and Field (4.6b) of the study area.

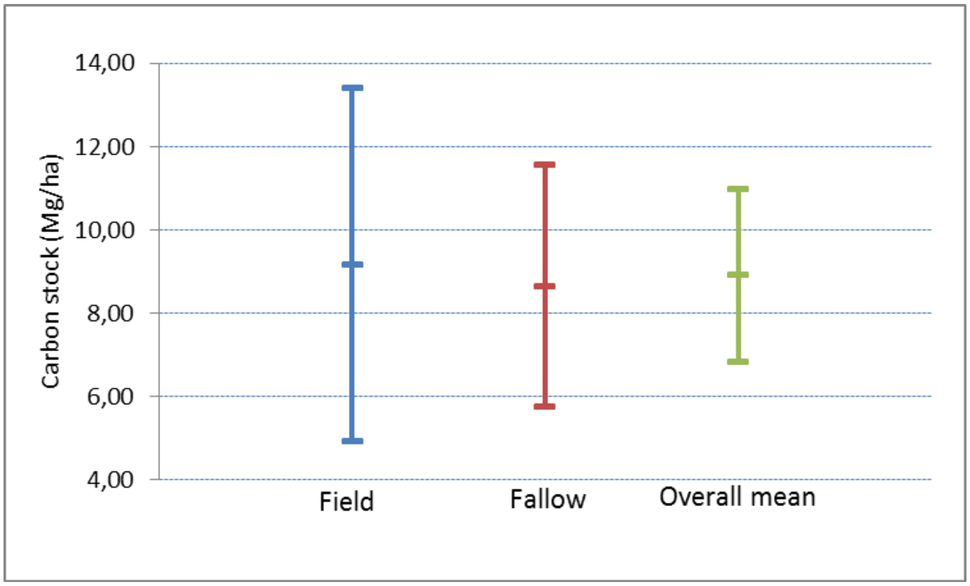


Figure 4.7 A graph showing the confidence intervals of amounts of carbon stocks stored in the field and fallow plots and the overall mean of the plots. The graph also shows that there is no significant difference (at 95% level of significance) between the field and fallow plots since the the error bars of their means overlap.

Phase of landuse

The three age groups of shea parklands did not differ significantly ($p<0.05$) in all the parameters studied. The old plots however recorded the highest tree density of 67.78 trees ha^{-1}, followed by the new plots (54.00 trees ha^{-1}), while the medium plots registered the lowest density (47.22 trees ha^{-1}). Reasons for these trends were given by the farmers interviewed. The farmers explained that the old plots had the highest density of shea trees because of over 10 years of continuous regeneration of shea. This resulted in the gradual and continuous increases in the numbers of shea trees. As these numbers increased, some of the shea trees were removed to make way for either crop cultivation or for other purposes such as for use as fuelwood, which ended up as new plots (immediately after crop cultivation) with fewer trees in the short-term (1-5 years). Continuous removal of trees for a relatively longer period of 6-10 years resulted in the medium plots having the least density of trees. Realizing the drastic reduction of the trees in the medium plots, the farmers explained that, they would then put in measures to ensure that the remaining trees are conserved and allowed to regenerate. Thus, continuous conservation and regeneration of trees for over 10 years result in greatest numbers of shea compared to the new and medium plots.

However, the medium plots stored C most (9.59 Mg ha^{-1}) due to their largest DBH (32.11 cm) and least number of trees, compared to the other two age groups, while the new plots stored the least amount of C (8.07 Mg ha^{-1}).

The same trend was also observed in the individual zones, as the phase of landuse systems did not differ significantly in all the parameters studied, except in the Transitional Forest zone where the phase of landuse differed significantly in Biomass and C stock per ha

Table 4.11a Characteristics of shea trees in age groups (new, medium and old) of the Transitional, Guinea savannah and Sudan savannah zones of Ghana.

Age group of land-use	***Number of trees ha^{-1}***	***Height per tree (m)***	***DBH^1 per tree (cm)***	***Biomass (Mg ha^{-1})***	***Carbon stock (Mg ha^{-1}***	***Carbon stock per tree (Mg)***
New	54.00 (36.85)	8.17 (1.91)	31.13 (16.46)	16.14 (12.43)	8.07 (6.21)	0.29 (0.40)
Medium	47.22 (24.98)	8.59 (2.01)	32.11 (17.78)	19.18 (22.42)	9.59 (11.21)	0.32 (0.58)
Old	67.78 (51.14)	8.29 (2.26)	30.15 (11.95)	18.16 (9.93)	9.08 (4.97)	0.22 (0.17)
Means	**56.52 (39.32)**	**8.35 (2.03)**	**31.13 (15.32)**	**17.83 (15.62)**	**8.91 (7.81)**	**0.28 (0.41)**

Note: Figures in parenthesis are standard deviations
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.11b Characteristics of shea trees in age groups (new, medium and old) of the Guinea savannah zone of Ghana.

Age group of land-use	***Number of trees ha^{-1}***	***Height per tree (m)***	***DBH^1 per tree (cm)***	***Biomass (Mg ha^{-1})***	***Carbon stock (Mg ha^{-1})***	***Carbon stock per tree (Mg)***
New	96.67 (37.64)	7.00 (0.98)	20.80 (4.88)	10.41 (6.29)	5.21 (3.15)	0.08 (0.04)
Medium	98.67 (70.77)	7.06 (1.04)	20.52 (4.04)	8.99 (2.76)	4.50 (1.38)	0.07 (0.03)
Old	68.00 (29.50)	6.94 (2.17)	18.04 (8.04)	9.24 (4.58)	4.62 (2.29)	0.06 (0.08)
Means	**87.78 (48,52)**	**7.00 (1.41)**	**19.78 (5.69)**	**9.55 (4.52)**	**4.77 (2.26)**	**0.07 (0.05)**

Note: Figures in parenthesis are standard deviations
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.11c Characteristics of shea trees in age groups (new, medium and old) of the Transitional Forest zone of Ghana

Age group of land-use	***Number of trees ha^{-1}***	***Height per tree (m)***	***DBH^1 per tree (cm)***	***Biomass (Mg ha^{-1})***	***Carbon stock (Mg ha^{-1})***	***Carbon stock per tree (Mg)***
New	54.00 (23.43)	8.97 (1.62)	22.42 (8.59)	9.91 (4.44)^a	4.29 (1.68)^a	0.10 (0.09)
Medium	37.33 (11.78)	9.78 (1.43)	25.44 (4.27)	8.62 (3.72)^a	4.31 (1.87)^a	0.12 (0.04)
Old	54.67 (27.64)	10.23 (1.92)	30.24 (7.23)	17.39 (5.92)^b	8.70 (3.00)^b	0.19 (0.10)
Means	**48.67 (22.26)**	**9.66 (1.66)**	**26.03 (7.31)**	**11.97 (6.00)**	**5.77 (3.00)**	**0.14 (0.08)**

Note: Figures in parenthesis are standard deviations
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.11d Characteristics of shea trees in age groups (new, medium and old) of the Sudan savannah zone of Ghana

Age group of land-use	***Number of trees ha^{-1}***	***Height per tree (m)***	***DBH^1 per tree (cm)***	***Biomass (Mg ha^{-1})***	***Carbon stock (Mg ha^{-1}***	***Carbon stock per tree (Mg)***
New	27.33 (12.24)	8.56 (2.50)	49.75 (15.24)	29.42 (12.44)	14.71 (6.22)	0.68 (0.49)
Medium	37.33 (26.49)	8.94 (2.43)	50.38 (20.62)	39.93 (20.22)	20.00 (15.11)	0.78 (87)
Old	34.67 (8.26)	7.69 (1.37)	42.18 (4.40)	27.85 (8.40)	13.92 (4.20)	0.41 (0.11)
Means	**33.11 (17.02)**	**8.40 (2.10)**	**47.44 (14.62)**	**32.40 (19.11)**	**16.20 (9.56)**	**0.62 (0.57)**

Note: Figures in parenthesis are standard deviations
DBH[1] = Diameter at breast height
Confidence interval = 95%

Combined age and land-use type

Although there were no significant differences among the six combined categories of age and phase of landuse in all the parameters studied, old fallow registered the highest number of trees (86.67) per ha, followed by new fallow with 64.00 trees ha^{-1} and medium field recording the least (39.11 trees ha^{-1}). Conversely, medium field had the highest values for height (9.38 cm), DBH (36.17 cm), biomass (22.51 Mg ha^{-1}) and carbon 11.26 Mg ha^{-1}) and carbon (0.45 Mg tree^{-1}). Old fallow recorded the least values for DBH (26.67 cm) and C (0.17 Mg tree^{-1}), but due to its highest tree density it registered higher values for biomass (16.88 Mg ha^{-1}) and carbon (8.44 Mg ha^{-1}) on per hectare basis than medium fallow and new field. The amounts of sequestered C and CO_2e per ha decreased in the order of Medium field > Old field > New fallow > Old fallow > Medium fallow > New field, despite all the combined categories registering no significant differences among each other (Tables 4.12a and 4.13).

When similar analysis were done on individual zone basis, all the six combined categories of age and phase of landuse in the Guinea savannah zones differed in all the parameters studied (Figure 4.6b). The same was observed in the transitional zone, except that the combined categories did not differ significantly in terms of tree height (Figure 4.6c). In Sudan savannah, except in DBH per tree, all the combined categories did not differ in all the parameters studied (Figure 4.6d).

Table 4.12a General characteristics of shea trees in the combined age and land-use type categories of the Transitional, Guinea savannah and Sudan savannah zones of Ghana.

Combined categories of age and phase of landuse	*Number of trees ha^{-1}*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass ($Mg\ ha^{-1}$)*	*Carbon stock ($Mg\ ha^{-1}$*	*Carbon stock per tree (Mg)*
New fallow	64.00 (46.78)	8.56 (2.06)	32.62 (20.94)	19.25 (15.77)	9.63 (7.88)	0.36 (0.53)
Medium fallow	56.44 (28.67)	7.80 (1.66)	28.05 (12.84)	15.85 (12.30)	7.93 (6.15)	0.20 (0.24)
Old fallow	86.67 (61.81)	7.36 (1.66)	26.67 (12.08)	16.88 (10.56)	8.44 (5.28)	0.17 (0.17)
New field	44.00 (21.73)	7.79 (1.79)	29.64 (11.49)	13.03 (7.60)	6.51 (3.80)	0.21 (0.20)
Medium field	39.11 (18.31)	9.38 (2.10)	36.17 (21.68)	22.51 (29.87)	11.26 (14.94)	0.45 (0.78)
Old field	48.89 (30.58)	9.21 (2.49)	33.63 (11.43)	19.44 (9.72)	9.72 (4.86)	0.27 (0.16)
Means	**56.52 (39.32)**	**8.35 (2.03)**	**31.13 (15.32)**	**17.83 (15.62)**	**8.91 (7.81)**	**0.28 (0.41)**

Note: Figures in parenthesis are standard deviations.
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.12b Characteristics of shea trees in the combined age and land-use type categories of the Guinea savannah zone of Ghana.

Combined categories of age and phase of landuse	*Number of trees ha^{-1}*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass ($Mg\ ha^{-1}$)*	*Carbon stock ($Mg\ ha^{-1}$*	*Carbon stock per tree (Mg)*
New fallow	116.00 (38.16)^{b}	6.55 (1.27)^{ab}	18.83 (6.19)^{a}	13.38 (8.43)^{ab}	6.70 (4.22)^{ab}	0.06 (0.04)^{a}
Medium fallow	48.00 (24.00)^{ab}	8.75 (1.28)^{ab}	22.00 (5.49)^{a}	6.80 (1.52)^{a}	3.40 (0.76)^{a}	0.09 (0.04)^{a}
Old fallow	28.00 (18.33)^{a}	10.36 (1.65)^{b}	57.04 (18.33)^{b}	37.56 (11.55)^{c}	18.78 (5.78)^{c}	0.94 (0.61)^{b}
New field	77.33 (31.07)^{ab}	6.39 (1.08)^{a}	19.42 (6.01)^{a}	8.78 (4.18)^{a}	4.39 (2.09)^{a}	0.06 (0.05)^{a}
Medium field	46.67 (12.22)^{ab}	9.04 (1.12)^{ab}	22.73 (4.26)^{a}	7.38 (2.56)^{a}	3.69 (1.28)^{a}	0.09 (0.04)^{a}
Old field	49.33 (34.02)^{ab}	7.99 (1.81)^{ab}	42.01 (12.58)^{ab}	31.40 (5.96)^{bc}	15.70 (2.99)^{bc}	0.44 (0.31)^{ab}
Means	**60.22 (37.83)**	**8.18 (1.86)**	**30.34 (17.01)**	**17.55 (13.83)**	**8.78 (6.92)**	**0.28 (0.41)**

Note: Figures in parenthesis are standard deviations.
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.12c Characteristics of shea trees in the combined age and land-use type categories of the Transitional savannah zone of Ghana.

Combined categories of age and phase of landuse	*Number of trees ha^{-1}*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass ($Mg\ ha^{-1}$)*	*Carbon stock ($Mg\ ha^{-1}$*	*Carbon stock per tree (Mg)*
New fallow	152.00 (60.53)^{b}	5.70 (0.78)	14.91 (3.92)^{a}	9.03 (4.46)^{a}	4.52 (2.22)^{a}	0.03 (0.02)^{a}
Medium fallow	72.00 (31.24)^{ab}	8.55 (0.81)	24.03 (3.50)^{a}	13.78 (4.04)^{ab}	6.89 (2.02)^{ab}	0.10 (0.04)^{ab}
Old fallow	36.00 (8.00)^{a}	7.82 (1.81)	41.08 (5.17)^{b}	27.82 (11.10)^{b}	13.91 (5.55)^{b}	0.38 (0.12)^{bc}
New field	45.33 (18.04)^{a}	7.44 (0.45)	22.77 (3.08)^{a}	7.43 (1.09)^{a}	3.72 (0.55)^{a}	0.09 (0.03)^{a}
Medium field	60.00 (26.23)^{a}	9.18 (2.19)	23.68 (7.94)^{a}	10.38 (4.01)^{a}	5.19 (2.01)^{a}	0.11 (0.08)^{ab}
Old field	26.67 (6.11)^{a}	6.76 (1.77)	42.46 (9.23)^{b}	21.28 (7.37)^{ab}	10.64 (3.68)^{ab}	0.43 (0.21)^{c}
Means	**65.33 (50.02)**	**7.56 (1.69)**	**28.15 (11.54)**	**14.95 (9.14)**	**7.48 (4.57)**	**0.19 (0.18)**

Note: Figures in parenthesis are standard deviations.
DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.12d Characteristics of shea trees in the combined age and land-use type categories of the Sudan savannah zone of Ghana.

Combined categories of age and phase of landuse	*Number of trees ha^{-1}*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass (Mg ha^{-1})*	*Carbon stock (Mg ha^{-1})*	*Carbon stock per tree (Mg)*
New fallow	60.00 (6.93)	7.73 (0.44)	21.61 (1.03)[a]	9.21 (1.18)	4.60 (0.60)	0.08 (0.01)
Medium fallow	32.00 (10.58)	10.52 (1.50)	28.15 (2.34)[ab]	9.86 (4.85)	4.93 (2.43)	0.15 (0.03)
Old fallow	25.33 (12.86)	9.89 (2.96)	58.75 (26.35)[b]	48.46 (45.94)	24.23 (22.52)	1.12 (1.19)
New field	76.00 (44.00)	8.18 (2.56)	21.16 (10.81)[a]	9.44 (5.70)	4.72 (2.85)	0.10 (0.11)
Medium field	37.33 (6.11)	11.91 (0.40)	36.45 (1.59)[ab]	21.01 (5.65)	10.50 (2.83)	0.28 (0.03)
Old field	33.33 (10.07)	7.55 (1.16)	43.28 (4.26)[ab]	27.87 (7.31)	13.93 (3.66)	0.43 (0.11)
Means	**44.99 (24.96)**	**9.30 (2.23)**	**34.90 (16.86)**	**20.98 (21.61)**	**10.49 (10.80)**	**0.36 (0.56)**

Note: Figures in parenthesis are standard deviations.

DBH[1] = Diameter at breast height
Confidence interval = 95%

Table 4.13 Confidence intervals of Characteristics of shea trees in the combined age and land-use type categories of the Transitional, Guinea savannah and Sudan savannah zones of Ghana

Combined categories of age and phase of landuse	*Number of trees ha^{-1}*			*Height per tree (m)*			*DBH[1] per tree (cm)*			*Biomass (Mg ha^{-1})*			*Carbon stock (Mg ha^{-1})*			*Carbon stock per tree (Mg)*		
	M	***L***	***U***	***M***	***L***	***U***	***M***	***L***	***U***	***M***	***L***	***U***	***M***	***L***	***U***	***M***	***L***	***U***
New fallow	64.00	33.44	94.56	8.56	7.21	9.91	32.62	18.94	46.30	19.25	8.95	29.55	9.63	4.48	14.78	0.36	0.01	0.71
Medium fallow	56.44	37.71	75.17	7.8	6.72	8.88	28.05	19.66	36.44	15.85	7.81	23.89	7.93	3.91	11.95	0.2	0.04	0.36
Old fallow	86.67	46.29	127.05	7.36	6.28	8.44	26.67	18.78	34.56	16.88	9.98	23.78	8.44	4.99	11.89	0.17	0.06	0.28
New field	44.00	29.80	58.20	7.79	6.62	8.96	29.64	22.13	37.15	13.03	8.06	18.00	6.51	4.03	8.99	0.21	0.07	0.35
Medium field	39.11	27.15	51.07	9.38	8.01	10.75	36.17	22.01	50.33	22.51	2.99	42.03	11.26	1.50	21.02	0.45	0.16	0.74
Old field	48.89	28.91	68.87	9.21	7.58	10.84	33.63	26.16	41.10	19.44	13.09	25.79	9.72	6.54	12.90	0.27	0.09	0.45
Grand Means	56.52	30.83	82.21	8.35	7.02	9.68	31.13	21.12	41.14	17.83	7.62	28.04	8.91	3.81	14.01	0.28	0.10	0.46

KEY:

M = Mean
L = Lower limit
U = Upper limit

4.5 Discussion

4.5.1 Biomass carbon stock and carbon sequestration of shea trees

Site

Results of the study indicate that the Savannah zones were significantly different ($p<0.05$), with regards to carbon (C) stored in the trees, with Sudan savannah recording the largest amount of C (16.20 Mg ha^{-1}), an indication that shea trees there significantly stored more C than shea trees in the other two sites. This is because of the larger tree sizes of the area, in terms of their mean tree diameter (DBH of 47.43 cm) being about twice the mean diameter of trees in the other two savannah zones. Biomass C estimated from these larger DBH figures of the Sudan savannah were then extrapolated to obtain the relatively larger amounts of stored carbon.

United Nations Framework Convention on Climate Change (UNFCCC) defines C sequestration as the process of removing C from the atmosphere and depositing it in a reservoir (UNFCCC, 2010c) such as trees, because trees are capable of capturing C from the atmosphere through the stomata of their leaves during the process of photosynthesis and store the captured carbon in the form of carbohydrates in their plant tissues. C sequestration is expressed over time and therefore calculated or estimated such as on per yearly basis. C stock refers to the absolute quantity of C held at the time of inventory (Takimoto *et al.*, 2008). Generally, young trees sequester carbon at faster rates than old trees due to the fact that young trees grow more quickly and therefore their CO_2 uptake during photosynthesis is greater (O'Laughlin and Mahoney, 2008). It is however argued that, in overall quantitave terms, larger trees sequester more carbon than smaller ones and the sequestered carbon is expressed as CO_2 equivalents (Escobedo and Zipperer, 2009).

In general, density of vegetation (including trees) decreases from southern to northern Ghana due to decreasing amounts of rainfall, which has an influence on the length of growing periods of crops and other forms of vegetation (Franke *et al.*, 2011). This because there is a decreasing trend in rainfall amounts as one moves from the south to the north, with the Kawampe, Nyankpala and Paga sites having 1300 mm, 1100 mm and 1000 mm of rainfall respectively (EPA, 2003). As shea trees thrive best in areas with relatively low rainfall, they are thus ubiquitous in the northern savannahs and are increasingly dominant tree species from the south to the north, and form over 80% of woody vegetation in northern Ghana (Lovett & Haq, 2000a).

With annual rainfall in the study area ranging between 900-1300 mm, these relatively dry optimum conditions favour the growth and survival of shea trees in the northern savannah zones of Ghana as the trees typically grow best within the 'Shea Convergence Zone' of 600 and 1400 mm of rainfall per year (DFSC, 2000). The trees are very adaptable species and thrive best on dry, sandy soils (Hall *et al.*, 1996). The trees grow well in dry savannas, forests, and parklands of the Sudan zone of Africa (Boffa *et al.*, 1996). This is due to the fact that the tree has an extensive and shallow rooting system which enables it to be well-adapted to tolerate prolonged dry seasons up to 8 months and intermittent droughts that are typical of conditions in the savannah zone (Vermilye, 2004). So although rainfall generally affects growth rates of trees, shea tends to grow best in drier sites and therefore produces highest yields of shea fruits and shea butter. As a result, the Sudan savannah being the northmost and driest area of the three sites, it had shea trees constituting the most dominant species of the vegetation (even though the area had the least number of shea trees per ha), followed by Guinea savannah (in the middle zone), while shea trees formed the least dominant tree species among the vegetation of the Transitional Savannah zone. The dominance and size of shea trees can also be explained in terms of their adaptability to such areas. Hence, the more adapted the trees are to their environment the better their chances of survival and ultimately their ability to grow larger. It is probably for these reasons that the Sudan savannah had the largest shea trees, because the trees were among the well-adapted and most-dominant trees in the area. Furthermore, results of the research showed an inverse relationship between density and size of trees (Niklas *et al.*, 2003) where the density of the shea trees was inversely proportional to their DBH (Table 4.6). The low density of shea trees in the Sudan savannah zone is probably due to the low soil moisture and poor soil fertility to support growth and survival of more trees (Yidana *et al.*, 1993), since shea trees require deep fertile well-drained soils. Hence, the fewer trees that were able to survive in the area grew bigger as they were able to make efficient use of adequate space and limited moisture and soil nutrients.

Guinea savannah zone had the highest density of shea trees (87.78 trees/ha) probably because of availability of growth factors (such as moisture, soil nutrients and light) and good agroforestry practices by farmers in protecting the shea trees. However, with a large number of shea trees per ha competing for limited resources could have led to reduced growth rate among the trees. Therefore, in spite of the high density of shea trees in Guinea savannah, the trees were smaller (relatively shorter trees with smaller DBH). The Transitional savannah zone, however, had higher tree density (48.67 trees ha^{-1}) than trees in the Sudan savannah because of the availability of relatively adequate levels of growth factors. Compared to the Guinea savannah, the Transitional savannah zone had fewer trees due to the area having a higher diversity and prevalence of other tree species. The other reason for the low density of shea trees in the Sudan savannah zone could be as a result of intensive and continuous harvesting of shea trees over the years for use as fuelwood (due to scarcity of other trees in the already dry environment with sparse vegetation). Thus, as species richness is dependent on maintaining a disturbance regime to which the vegetation is adapted (Lovett JC *et al.*, 2000), it would be prudent to maintain a balance between harvesting and growing of shea trees, particularly in the Sudan zone where shea trees are fewer but have the largest carbon stocks (Table 4.6). Therefore, efforts should be geared towards growing more shea trees in shea-growing areas in general or at least conserve them as in the Community-based Forest Management (CBFM) tree-growing projects in Tanzania where existing trees are maintained (Zahabu, 2006 a & b) as well as in other areas. This is because, if well-planted and properly managed, the current mean density of 57 shea trees per ha in the study area could be increased significantly to an optimum density. And this could increase the amounts of stored C, sequestered C and CO_2e by several folds more than what has been obtained in this research. This is because, findings of this study indicate that it is possible to obtain an optimum density of 100 – 400 shea trees ha^{-1} at a spacing of 5–10 m x 5–10 m, or approximately 204 shea trees ha^{-1} from an optimum spacing of 7 m x 7 m by vegetative propagation (Dakwa, 1985; Frimpong & Adomako, 1987; Tawiah, 1994; Yidana, 1994) or 100 shea trees ha^{-1} from 10 m x 10 m (Kavaarpuo, 2010). Furthermore, Boffa (1995) also reported that research stations in countries like Ghana achieved a higher optimum shea tree density of 400 shea trees ha^{-1} through natural regeneration. As such, similar tree densities could be considered, adopted and implemented when establishing shea plantations.

In overall terms, the three savannah zones recorded 8.91 Mg ha^{-1}. Farmers can therefore earn financial benefits on the CO_2 sequestered. And considering the proposed 2015 price for CO_2 per Mg or tonne of approximately $37.00 as Carbon Tax recently arrived at by the U.S. government in places such as in the United States of America (Zeller Jr, 2015 and Nuccitelli, 2016), it therefore means that this will incentivize farmers to conserve existing stocks of shea trees as well as grow more to derive increased financial benefits from the shea trees, which presently cover hundreds of thousands of hectares, not only for the fruits and other additional economic benefits but also for the carbon credits. In that regard, a farmer can therefore realize, for example, a minimum of $1,480 every year from his 100 ha[2] shea parkland (at the CO_2e sequestration rate of 0.40[3] Mg ha^{-1} yr^{-1}, and at the minimum rate of $37.00 per tonne of CO_2e). It will therefore be a win-win situation for all, since, as asserted by Albrecht and Kandji (2003) the financial cost of C sequestration through agroforestry appears to be much lower than through other CO_2e mitigating options. Thus the costs of managing such trees could easily be offset by the monetary benefits from agricultural products and trading in C credits.

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[2] This is based on the information gathered during the research as the average size of shea parkland (farm and mostly fallowlands) owned by a household in the study area.

[3] An estimate from shea trees of the Tamale Airport Junction.

Therefore, policies geared towards the conservation of trees should be formulated, and with shea trees being good candidates for C sequestration, shea farmers should be able to obtain additional financial rewards from the sale of carbon credits from their shea trees, in addition to benefits from the sale of shea nuts as well as other tangible and intangible benefits from their shea parklands. Eventually, all these substantial benefits would serve as huge incentives to protect and conserve their shea trees for both local and global benefits.

Land-use system

In spite of the fact that the two phases of landuse did not significantly differ ($p<0.05$) in biomass carbon stocks in addition to sequestered C and CO_2e, the field plots performed better than the fallow plots in almost all the parameters studied. This could be attributed to the attention given to shea trees growing on fields intercropped with food crops (Fatubarin, 1987). Farming practices, such as control of pests and diseases, soil fertility improvement and supplementary irrigation carried out on the field to boost crop yields invariably impacted positively on shea trees, which enabled the trees to grow bigger in size (33.15 cm DBH), taller (8.79 m) and stored more C (9.16 Mg ha^{-1}) than the fallow plots (Tables 4.10a, 4.10b, 4.10c and 4.10d). Compared to shea trees growing on farms (fields), those growing on fallow lands depended solely on natural conditions (rainfall, available soil nutrients, etc.), with little or no positive human intervention. Besides, the smaller size of shea trees on fallow lands could be as a result of the destructive effects of annual bushfires and indiscriminate bush burning which retarded the growth of the trees. On farms, however, farmers usually prevent bushfires from destroying their crops and shea trees (Yidana, 1994) and other useful plants by making fire-belts around their trees and farms. Thus, such continuous management and protective measures, for up to over 10 years, could have significantly improved the growth and eventually increased the sizes of shea trees on farms. Furthermore, controlled bush burning is done on farms, particularly during land preparations in order not to destroy shea trees and other useful plants. Moreover, due to lack of or inadequate care given to shea trees on fallow lands, the trees are under the mercy of people who either completely cut down some of the trees (Abbiw, 1990) or persistently prune their branches for use as fuelwood, leading to slow growth rates thereby reducing their sizes. These in turn adversely affect their biomass carbon stocks and potential to sequester atmospheric C and CO_2. On the other hand, shea trees on farms are protected and managed (Osei-Bonsu *et al.*, 1993) to grow bigger to provide larger canopies which serve as shade for farmers. Such mature shea trees are usually preserved during land preparation for farming and thus form part of the indigenous farming system (Masters *et al.*, 2004). The trees therefore benefit from the agronomic practices such as weeding and management of soil fertility which are employed primarily for the benefit of annual crops. As shea trees on farms are owned by farmers and their families, they usually ensure that the trees are allowed to increase in size and grow more branches so as to produce more shea fruits for them. Moreover, as asserted by Dombro (2011), well-managed trees generally produce more wood biomass than do natural forests, resulting in higher carbon C stocks and C sequestration rates per hectare. This is due to the fact that in a managed forest plantation, good management practices are carried out to ensure that trees are adequately protected and conserved. And these enable the trees to grow at a faster rate and produce more biomass carbon for storage in the tissues of the trees.

There was however a significant difference ($p<0.05$) between the field and fallow phase of landuse in terms of density of shea trees, with the fallows recording 69.04 trees ha^{-1} while the fields had a lower figure of 44.00 trees ha^{-1}. The lower density of shea trees on farms (fields) could be attributed to seasonal land preparations of field plots for crop cultivation which usually result in the gradual killing of some of the trees, particularly in areas where tractors are used to plough and harrow fields. Such machines destroy roots of shea trees and the wounded roots are attacked by insects and fungi. These result in infections in the wounded areas of the roots which eventually kill the affected trees. Besides, a lot of young seedlings and saplings, which should have grown to replace dying or dead trees or even increase the density of existing healthy trees, are destroyed during weeding and land preparation on farms. All these reduce the number of shea trees on farms. As land preparations are not done on fallow lands, there is minimal or virtually no disturbance of shea trees, seedlings and saplings. Shea trees, seedlings and saplings that are able to withstand or tolerate bush fires later grow in large numbers. As such, these help to increase the density of shea trees on fallow lands. The net effect of all these, however, is that the fast growth rate of shea trees on farms (due to farm management practices from which the shea trees also benefit) tends to make up for their relatively low density. This therefore accounted for larger values for their DBH, stored biomass carbon and sequestered C and CO_2e. As C storage in plant biomass is mainly possible in the perennial agroforestry systems (Albrecht and Kandji, 2003), a farmer would thus gain additional financial benefits from the sale of carbon credits yielded by the trees on his agroforestry farm (in addition to the harvested crops, fruits and other products), as he would be conscious of the fact that sequestered C and CO_2e could bring in more financial benefits than only shea trees on fallow lands would.

Phase of landuse

Although there were no significant differences ($p<0.05$) among the three land-use age groups in all the parameters studied (Tables 4.11a, 4.11b, 4.11c and 4.11d), shea parklands on medium plots had relatively more biomass carbon stocks (9.59 Mg ha^{-1}) followed by old parklands (9.08 Mg C ha^{-1}), with least amounts of biomass carbon registered by new parklands (8.07 Mg C ha^{-1}). Medium plots also sequestered more C (0.12 Mg ha^{-1} yr^{-1}) and CO_2e (0.143 Mg ha^{-1} yr^{-1}) than the other two age groups of phase of landuse. This was probably due to new plots recovering from previous years' continuous intensive cultivation. Hence, the first few years, from 1-5 years (representing new plots), may not have been adequate to replenish utilized soil nutrients. The period, 6 to 10 years (medium), may be enough for the soil to have regained its fertility and supported shea tree growth (Yidana *et al.*, 1993), leading to increase in DBH and height, and consequently larger carbon stocks and higher amounts of sequestered C and CO_2e. However, for periods exceeding 10 years (old field and old fallow), most soils would have exhausted their nutrients, particularly if the lost nutrients were not replenished. This might have led to a slight decrease in the rate of growth of the trees, which resulted in a less build-up of carbon stocks and sequestered C and CO_2e. In terms of density of trees, however, an inverse relationship was observed between density and size of trees. Hence, the old plots recorded relatively the highest value of 67.78 trees ha^{-1}, due probably to an increase in the number of shea trees over a long period of over 10 years but compromised on the sizes of trees, resulting in smallest sizes of the trees. This was followed by new plots with 54.00 trees ha^{-1}, with medium plots recording the lowest density of 47.22 trees ha^{-1} but with largest tree sizes and carbon stocks and sequestered C and CO_2e. These trends could stem from the fact that high density of trees led to competition for growth factors (moisture, soil nutrients, light, etc.) resulting in small trees, low carbon stocks and sequestered C and CO_2e. In addition, results of the interviews with farmers in the study area also generally indicate that, in both field and fallow plots, the old plots had the highest density of shea trees because, through regeneration for a continuous period of over 10 years, saplings and seedlings of shea were able to grow into trees. This resulted in the gradual and continuous increases in the numbers of shea trees. Some of the shea trees were however removed to make way for either crop cultivation or for other purposes such as for use as fuelwood, which resulted in the new plots having fewer trees. Continuous removal of trees for a relatively longer period of 5-10 years resulted in the medium plots having the least density of trees. At a certain point, as explained by the farmers, when the shea trees were observed to be declining to very low levels, the farmers put in place conservation measures to ensure that most of the remaining shea trees were protected and allowed to regenerate. Thus, with continuous protection and regenertation of the trees for periods of over 10 years, there were gradual and continuous increases in tree numbers wich resulted in highest densities for the old plots. These cyclic increases and dereases in tree densities correspond with the dynamics of land use changes over time.

4.6 Conclusion

Generally, there was an inverse relationship between density and size of trees with regards to all the three main treatments of the research (zone/site, land-use system and age of land-use). Consequently, areas with high density of shea trees had small trees and vice versa. with Sudan savannah recording the highest carbon stocks (16.20 Mg ha^{-1}. This means Sudan savannah had the largest carbon stocks and highest potential for sequestering carbon as a result of the large sizes of the trees there. There was however no significant difference between the two phases of landuse, but the field plots stored more C than the fallow plots. In terms of age of land-use, the three age groups were not significantly different in the biomass carbon stock and C sequestered, but the medium plots stored the most C stocks (9.59 Mg ha^{-1}). These results show that the savannah shea parklands areas have appreciable biomass carbon stocks, with Sudan savannah, field plots and medium age plots being the most productive treatments in their respective categories for C storage. On the average, the shea parklands stored 8.91 Mg ha^{-1}.

CHAPTER FIVE

Ghana’s response to the UNFCCC international agreements and the impact of the policies on climate change and shea production in Ghana

5.1 Introduction

This chapter reviews the various policies formulated by Ghana in response to international agreements of the UNFCCC and discusses the extent of their implementation and impacts on shea production in Ghana. The chapter outlines how international climate change agreements play out in Ghana and the national policies formulated and implemented in line with these agreements aimed at ameliorating climate change for local and global environmental benefits, as well as for the improvement of livelihoods of shea farmers.

5.1.1 Background to the research

Over the last ten years, Ghana has hosted numerous climate change related activities, initiated by international donors or research organizations, or by representatives of the Ghanaian government, academia or civil society. However, many of these initiatives have been on a relatively small-scale, and coordination across sectors, ministries or regions has often been lacking. Today, there is an urgent need to harmonize and upscale these efforts. Ghana’s economy is at crossroads with the advent of oil and gas production from the recently discovered Jubilee oil field off its coast. Moreover, there is an increasing pressure on the country’s natural resources and energy system due to economic growth and a growing population, which lead to increased demand for both traditional wood fuels and electricity (Würtenberger *et al.*, 2011).

Ghana’s economic development is vulnerable to anthropogenic climate change as a result of the country depending heavily on rain-fed agriculture, hydro-power, and unsurfaced rural roads. Climate change continues to impact negatively on national welfare, with the worst affected being the poor, urban households and northern Ghana. Investments of resources in agricultural research and extension as well as improved roads are efficient ways of mitigating most of the climate change adverse impacts in Ghana (Arndt, 2014).

Ghana is a signatory to the UNFCCC and the Kyoto Protocol and has been an active participant in the Conferences of the Parties (CoP) over a number of years, with a reasonable range of participation and has associated itself with the Copenhagen Accord. It has signed all three of the Rio Conventions (climate change, biodiversity and desertification) *and has also come out with a list of fifty-five Nationally Appropriate Mitigation Actions (NAMAs)* and it presently working to prioritize down to an expected 5 NAMAs, including for cooking fuel and sustainable forest management. It has also recently drafted its Second National Communication to the UNFCCC and completed its Green House Gas (GHG) inventory (Cameroon, 2011).

The Government of Ghana and its development partners, in 2007, signed the Ghana Joint Assistance Strategy (G-JAS). The strategy came out with a medium-term proposal for collaborative efforts between the Ghana Government and the donors. It provides a framework for the Ghana Shared Growth and Development Agenda (GSGDA) 2010-2013 (which functions as the Medium Term Development Framework) (Cameroon, 2011).

As a result of the 2008 elections and the consequent change in government, the Ministry of Environment, Science and Technology (MEST) was reconstituted and endowed with greater responsibility for coordinating climate change activities across Ministries, Departments and Agencies (MDAs). Also, the Ministry of Finance and Economic Planning (MoFEP) has become more strongly involved in supervision of climate related finance flows, driven partly by participation in international REDD initiatives, which have started to attract significant international funding. With the reorganization of MEST, the National Climate Change Committee (NCCC) was also strengthened and given the mandate to advise MEST on climate change policy-related questions. In early 2010, the NCCC was given the mandate to initiate the process of developing a National Climate Change Policy Framework (NCCPF) which, among other things, was to create a policy framework for climate resilient and low carbon economic growth that is compatible with and integrated into national development plans and budgeting processes (Würtenberger *et al.*, 2011).

This process led to the publication of a discussion document by MEST in advance of the international climate change conference in Cancun, Mexico, in November 2010 (MEST, 2010a). The discussion document elaborates the fundamentals for the comprehensive development of the NCCPF in Ghana (Würtenberger *et al.*, 2011). Subsequently, Ghana was also able to submit its Second National Communication to the UNFCCC ahead of the November-December 2011 COP17 Climate Change conference in Durban, South Africa. UNFCCC (2015) reports, that Ghana has submitted its Third National Communication to the UNFCCC. This is an opportunity to educate Ghanaians and improve their understanding on the impacts of climate change and the efforts, policies and measures put in place by the Government to address those impacts.

There have also been lots of other policies, measures as well as initiatives undertaken by Ghana to keep climate change in check in response to the UNFCCC international agreements. There was therefore the need to identify and document them as well as find out the stakeholders or actors involved and how they function together in the form of functional networks in their quest to develop adaptation and mitigation strategies for dealing with climate change issues in Ghana.

5.1.2 Aim, objectives and scope of the study

This study was therefore conducted with the aim of assessing Ghana's response to the UNFCCC's international climate change agreements and how it impacts on shea production in Ghana.

Specifically, the objectives of the study were to identify:

i. the impact of climate change on Ghana and on shea production
ii. the UNFCCC international climate change agreements and how are they addressing climate change and shea production concerns;
iii. national policies formulated by Ghana in response to these international agreements and

how they are addressing climate change and shea production concerns in Ghana and;

iv. the actors involved in addressing these climate change and shea production concerns in Ghana and how they interact or work together to address these concerns.

5.1.3 Research Question

The study was conducted to address the following research question:

- *How are UNFCCC international agreements impacting on adaptation and mitigation of climate change and shea production in Ghana?*

To help in the discourse of the research, and related to the objectives of the study, the following sub-questions were used as a guide to unearth climate change and shea production issues that the research sought to address:

i. Which are the UNFCCC international climate change agreements and how are they addressing climate change and shea production concerns?

ii. What national policies are formulated by Ghana in response to these international agreements and how are these policies addressing climate change and shea production concerns in Ghana?

iii. Which actors are involved in addressing these climate change and shea production concerns in Ghana and how do they interact or work together to address these issues?

5.2 Methodology

The research aimed to elucidate how the individual actors within a network act together to formulate and implement climate change policies in Ghana in line with the UNFCCC international agreements.

The study involved two stages:

i. identification of UNFCCC international agreements that address climate change and shea production concerns and;

ii. identification of national policies of Ghana in response to the UNFCCC international agreements and how they impact on climate change and shea production in Ghana.

5.2.1 Data Collection

Data and other additional information on the UNFCCC international agreements and Ghana's policies on climate change mitigation and adaptation and shea production in Ghana were gathered from interviews with key officers of the Government of Ghana policy-making institutions and the other organizations (Table 5.1), analysis of policy documents and extensive search for additional literature on the internet (including websites of the UNFCCC, the policy-making institutions and NGOs in Ghana).

Table 5.1 List of officers (who have given permission for their interviews to be reported in this thesis) interviewed for information on policies and other initiatives in Ghana on climate change.

ORGANIZATION	***NAME OF OFFICER***	***POSITION/STATUS***
Environmental Protection Agency, Ministry of Environment, Science and Technology, Accra	Oppong Boadi Kyekyeku	National Climate Change Coordinator
Forestry Commission, Ministry of Lands, Forestry and Mines, Accra	Robert Bamfo	Head, Climate Change Unit, Forestry Commission, Accra
Ministry of Finance and Economic planning, Accra	Fredua Agyemang	Technical Director/Advisor, Economic Planning Division, Natural Resources, Environment and Climate Change Unit
Ministry of Environment, Science and Technology, Accra	Raymond Babanawo	Project Technical Assistant, Ghana Environmental Conventions Coordinating Authority, MEST, Accra
Environmental Protection Agency, Ministry of Environment, Science and Technology, Accra.	Daniel Tutu Benefoh	Senior Programme Officer, Energy Resource and Climate Change
Cocoa Research Institute of Ghana - Ghana Cocoa Board, Accra	G.J. Anim-Kwapong	Senior Research Officer
Savannah Accelerated Development Authority	Sulley Gariba	Development Policy Advisor on Savannah Accelerated Development Authority (Office of the President of Ghana)
Ministry of Food and Agriculture, Accra	Della	Senior Agricultural Officer
Ministry of Food and Agriculture, Accra	Bernice Addo	Assistant Agricultural Officer
Ministry of Local Government and Rural Development, Accra	Demedeme Naa	Acting Director, Environmental Health and Sanitation Directorate, Ministry of Local Government and Rural Development, Environmental Health and Sanitation Unit, Accra
National Development Planning commission, Accra	Sandra Amankwah Kesse	Planning Analyst of NDPC (Environmental Management)
National Development Planning commission, Accra	Winfred A. Nelson	Principal Analyst (Policy Analysis and Planning, Climate Change mainstreaming and Poverty reduction) formerly at the National Development Planning Commission but now at Energy Commission, Ministry of Energy, Accra.
Environmental Protection Agency, Ministry of Environment, Science and Technology	Zinabu Wasai-King	Regional Director, Bolgatanga, Upper East Region
Environmental Protection Agency, Ministry of Environment, Science and Technology	Abu Iddrisu	Regional Director, Tamale, Northern Region
Environmental Protection Agency, Ministry of Environment, Science and Technology	Isaac Osei	Regional Director Sunyani, Brong-Ahafo Region
Ministry of Food and Agriculture, Regional Office, Sunyani	John Ayie Jatango	Regional Agricultural Extension Officer
Ministry of Food and Agriculture	Emmanuel Asante Krobea	Regional Director, Sunyani, Brong-Ahafo Region
Forestry Commission	Daniel Donkor	Assistant Regional Forestry Manager, Sunyani, Brong-Ahafo Region
Ministry of Food and Agriculture	Ofosu Dankyira	Regional Crops Officer, Sunyani, Brong-Ahafo Region
Ministry of Food and Agriculture	Emmanuel Eledi	Regional Director, Bolgatanga, Upper East Region
Ministry of Food and Agriculture	Ahmed Yussif	Regional Crops Officer, Tamale, Northern Region
Ministry of Food and Agriculture	Mr. Kweku Antwi	Regional Monitoring and Evaluation Officer, Regional Office, Tamale
Ministry of Food and Agriculture, Regional Office, Bolgatanga, Upper East	Sylvester Logo	Regional PPRS Officer, Bolgatanga, UER

Region		
Ministry of Food and Agriculture, Crops Services Division, Regional Office, Bolgatanga, Upper East Region	Beni Joseph Walier	Regional Crops Officer, Ministry of Food and Agriculture, Regional Office, Bolgatanga, Upper East Region
Women in Agricultural Development (WIAD), Ministry of Food and Agriculture , Regional Office	Edna Lucy Awedagha	Regional Coordinator, Bolgatanga, Upper East Region
Forestry Commission, Tamale, Northern Region	Eben Jabilite	Regional Forestry Officer, Tamale
Northern Ghana Rural Growth Project	Roy Ayariga	Project Coordinator, Tamale
Widows and Orphans, Bolgatanga, Upper East Region, Ghana.	Jemimah Aarakit	Volunteer
Ministry of Food and Agriculture , Bolgatanga, Upper East Region	Drah Edgar	Regional Animal Production Officer,
Action Aid, Sunyani, Brong-Ahafo Region	Solomon Tawiah Banasam	Programme Officer for Food Rights and Climate Change
Kumasi Institute of Technology and Environment (KITE), Accra	Prince Owusu Agyemang	Projects Officer

Table 5.2 Policy documents analyzed during the study

	Policy document analyzed	***Coordinating Policy-making Institution***
1	Ghana Shared Growth and Development Agenda (GSGDA)	National Development Planning Commission (NDPC)
2	Natural Resources, Environmental Governance (NREG) programme	Ministry of Environment, Science and Technology
3	National Climate Change Policy Framework	Ministry of Environment, Science and Technology
4	The National Environmental Policy	Ministry of Environment, Science and Technology
5	Science, Technology and Innovation Policy (STIP)	Ministry of Environment, Science and Technology
6	REDD Readiness Plan Development	Ministry of Forestry, Lands and Mineral Resources
7	Food and Agriculture Sector Development Policy (FASDEP)	Ministry of Food and Agriculture
8	National Energy Policy	Ministry of Energy
9	COCOBOD Policy	Ministry of Food and Agriculture
10	Environment and Natural Resources Advisory Council (ENRAC) policy	National inter-Ministerial advisory body at Cabinet level
11	Ghana Environmental Conventions Coordinating Authority	Ministry of Environment, Science and Technology
12	Clean Development Mechanism	Ministry of Environment, Science and Technology
13	Savannah Accelerated Development Authority (SADA)	SADA Board

In the first part of the research, the various UNFCCC international agreements on climate change in general and afforestation/reforestation/LULUCF (Table 5.3) in particular of which shea production is a part, were identified and analyzed. During the research, both primary and secondary data on UNFCCC international agreements that address climate change and shea production concerns were gathered. Resource persons working in the field of climate change in Ghana and abroad were purposively selected with the view to finding out the UNFCCC international agreements that address climate change and shea production concerns in Ghana. Primary data were then gathered from these resource persons through interviews by administering semi-structured questionnaires as well as through formal and informal discussions with them. Semi-structured questionnaires and informal discussions were used to gather other additional bits of information that could not otherwise have been covered by the structured and/or formal discussions. Secondary data were obtained from the internet such as from UNFCCC website, climate change and shea policy documents and other material from libraries (Table 5.2).

Table 5.3 List of UNFCCC international agreements on climate change studied and analyzed in the research

YEAR	TITLE OF DOCUMENTS STUDIED AND ANALYZED
2011	NOV-DEC: COP 16 UNFCCC Conference in Durban, South Africa
2010	NOV-DEC: COP 16 UNFCCC Conference in Cancun, Mexico
2009	DEC: COP 15 UNFCCC Conference in Copenhagen, Denmark
2008	DEC: COP 14 UNFCCC Conference in Poznan, Poland
2007	DEC: COP 13 and CMP 3 (Bali, Indonesia) SEP: High-level Event on Climate Change, UN Headquarters (New York, USA)
2006	NOV: COP 12 and COP/MOP 2 (Nairobi, Kenya)
	Nairobi Work Programme on Adaption
2005	NOV/DEC: COP 11 and COP/MOP 1 (Montreal, Canada) FEB: Entry into force of Kyoto Protocol
2004	DEC: COP 10 (Buenos Aires, Argentina)
	Buenos Aires Programme of Work on Adaption and Response Measures
2002	OCT/NOV: COP 8 (New Delhi, India) Delhi Declaration
	AUG/SEP: Progress since 1992 reviewed at World
	Summit on Sustainable Development
2001	OCT/NOV: COP 7 (Marrakesh, Morocco), Marrakesh Accords JUL: COP 6 resumes (Bonn, Germany), Bonn Agreements APR: IPCC Third Assessment Report
2000	NOV: COP 6 (The Hague, Netherlands),
	Talks based on the Plan break down
1998	NOV: COP 4 (Buenos Aires, Argentina),
	Buenos Aires of Plan of Action
1997	DEC: COP 3 (Kyoto, Japan), Kyoto Protocol adopted
1995	MAR/APR: COP 1 (Berlin, Germany), Berlin Mandate
1994	MAR: Convention enters into force
1992	JUN: Convention opened for for signature at Earth Summit
1992	MAY: INC adopts UNFCCC text
1991	First meeting of the INC
1990	IPCC and second WCC call for global treaty on climate change
	SEP: United Nations General Assembly negotiations on a framework convention
1988	IPCC established
1979	First World Climate Conference (WCC)

The objective of the second part of the study was to find out which national policies, programmes, projects and measures of Ghana were embarked upon in response to the international climate change agreements and how they address climate change and shea production concerns in Ghana. Both primary and secondary data were collected during the study. Primary data were obtained from purposively-selected policy makers in Ghana for interviews and discussions on the policies formulated to address climate change and how they impact on shea production in Ghana. Such policy makers from Ministries, other governmental organizations such as Departments, Boards, Commissions and Agencies, non-governmental organizations involved in addressing climate change and shea production concerns in Ghana were purposively selected and interviewed through administration of semi-structured questionnaires. Both formal and informal discussions were held with them with the view to identifying the national policies of Ghana that are formulated in response to the UNFCCC international agreements to address climate change and shea production concerns in Ghana. These governmental and non-governmental organizations were asked questions such as Ghana's vision, goals, policies and other initiatives in response to the UNFCCC international agreements and their impact on climate change and shea production in Ghana.

Secondary data for this part of the study were also obtained from websites of the policy-making institutions in Ghana, libraries and policy documents.

5.3 Results

The assessment of the impact of climate change in Ghana and the projections made can be based on a series of interconnections through complex feedback loops (Figure 5.1). Therefore, a multidisciplinary and multi-sectoral approach is needed to significantly minimize the impacts of climate change on the capacity of human adaptations to them (MEST, 2011).

In the interviews with the policy-making institutions in Ghana, they explained that climate change has had significant impacts on people and property in the country. Such impacts include scarcity of water as a result of reduced amounts of rainfall, desertification caused by a number of factors including deforestation, bushfires, overgrazing, etc. These result in the removal of the vegetative cover from the soil and expose the soil surface to the mercy of the weather. Continuous exposure leads to gradual destruction of biodiversity, which eventually makes the soil bare. All these result in biodiversity loss; accelerated soil erosion, decreased crop yield; overall diminished productive capacity of the land; increased human health hazards, all of which have negative implications for human livelihoods and welfare.

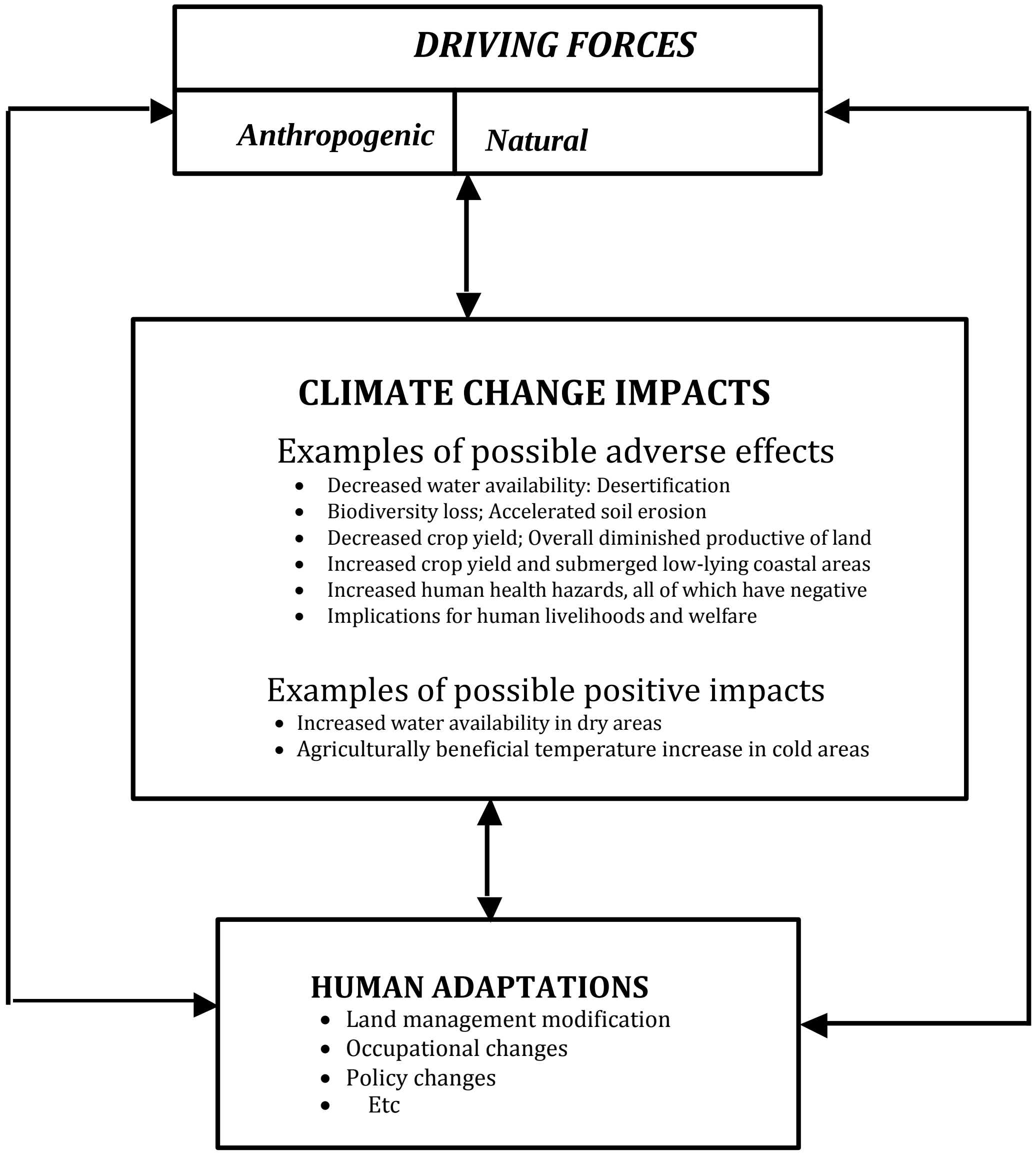

Figure 5.1 A simplified diagrammatic representation of Climate Change and possible associated problems and human Adaptations Source: MEST (2011).

5.3.1 Implementation of the UNFCCC International Agreements in Ghana

Conscious of the adverse impact of climate change on the country and the global community as a whole, Ghana is responding to the UNFCCC international agreements by vigorously formulating and implementing appropriate policies and other initiatives to address climate change issues. It is therefore expected that all these climate change mitigation and adaptation efforts will pay off to minimize the adverse impacts and more importantly result in the country's sustainable socio-economic development. In this regard, Ghana endorsed the United Nations Framework

Convention on Climate Change (UNFCCC) in September 1995 and has formulated policies and other initiatives for those international agreements to be implemented.

Subsequently, Ghana has put in place policies and other initiatives to contain the situation. In adapting to climate change to help minimize the impacts, the Government of Ghana and other multi-national and international agencies invested heavily in sectors such as health and agriculture as can be seen in Table 5.4.

Table 5.4 Adaptation to Climate Change Incremental Cumulative Investment in Ghana
Source: MEST (2011)

Sector	*Year*	*Budget*		
		Business As Usual (in millions of dollars)	***Climate Change Scenario (in millions of dollars)***	***Amount Needed (in US Dollars) (in millions of dollars)***
*Health (Whole Sector)***	2006	3,000	2,875	151
	2020	6,994	6,644	350
	2050	7,042	6,690	352
Malaria alone under Health sector*	2003	67	63	3
	2020	151	143	8
	2050	150	143	8
*Agriculture (Whole Sector)***	2006	2,892	2,748	145
	2020	6,685	6,350	334
	2050	6,726	6,389	336
*Coastal Zone Management****	2006	50	47	2
	2020	115	109	6
	2050	116	110	6

Note:
* estimations based on costing of malaria in 2003 by Asante *et al*. (2005).
** estimations based on government budgetary allocation in 2006 for the sector.
*** estimations are based on the Ada Coastal Protection Works Report by the World Bank (2007).

According to MEST (2011), Ghana is pursuing programmes to enhance the adaptation to Climate Change in all sectors and across the various national planning levels. The types of policies and measures selected depend on the general priority impacts sectors, based on the outcome of the analysis of the cross-sector impact studies done in Ghana. At the upstream level, Ghana is formulating the National Climate Change Adaptation Strategy (NCCAS) to provide strategic ties with prioritized impact sectors. This is supported by the Ghana Country Office of the UNDP and the Climate Change Adaptation and Development Initiative (CCDARE). The aim of these efforts is to make sure that Climate Change adaptation programme is well-implemented at the project level and realize the set objectives. The incorporation of climate change into national planning has already begun on a pilot scale in 10 districts in the country, with the support of the UNDP country office in Ghana. This resulted in the formulation of a “guide or tool” for incorporating Climate Change and disaster risk reduction into national development, policies and planning in the country. At the downstream level, from the top ten programmes identified from multi-sector impacts analysis, two received funding from the Japanese Government and UNDF-GEF for executing resilient-building project in early warning system and health. The two projects are currently underway.

Ghana has also drawn up medium to long-term ten prioritized adaptation programmes (Table 5.5), with funding possibly coming from the Adaptation Fund, Multilateral, Bilateral, other

Donors, Government of Ghana and other sources which are related to climate change (DARE, 2010).

Table 5.5 Medium to long term budget summary of the ten prioritized adaptation programmes
Source: DARE (2010)

No	Programmes
1	Increasing resilience to climate change impacts : identifying and enhancing early warning systems
2	Alternatives Livelihoods : Minimizing impacts of climate change for the poor and vulnerable
3	Enhancing national capacity to adapt to climate change through improved land use management
4	Adaptating to climate change through enhanced research and awareness creation
5	Development and management of of environmental sanitation strategies to adapt to climate change
6	Managing water resources as climate change adaptation to enhance productivity and livelihoods
7	Minimizing climate change on socio-economic development through agricultural diversification
8	Minimizing Climate change impacts on human health through improved access to health care
9	Demand and supply side measures for adapting the national energy system to impacts of climate change
10	Adaptation to climate change sustaining livelihoods through enhanced fisheries resources management

Programme No.	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2016*	*2017*	*2018*	*2019*	*2020*
	$m	*$m*	*$m*	*$m*	*$m*	*$m*	*$m*	*$m*	*$m*	*$m*	*$m*	*$m*
Programme 1	30	36	43	52	62	75	90	99	102	108	109	111
Programme 2	20	24	30	36	44	54	66	80	98	103	105	107
Programme 3	25	30	36	43	52	62	75	90	99	103	104	107
Programme 4	33	40	48	57	68	82	99	101	94	99	104	106
Programme 5	40	44	48	53	59	64	71	78	86	87	91	93
Programme 6	45	47	57	68	82	98	108	86	91	92	93	95
Programme 7	40	46	53	61	70	80	93	88	92	97	102	104
Programme 8	20	25	28	37	48	62	81	89	98	99	101	103
Programme 9	60	64	67	71	76	80	85	90	96	101	102	103
Programme 10	65	66	68	69	70	72	73	75	76	78	79	81
Total	378	422	478	548	631	730	839	875	932	967	991	1009

5.3.2 Implementation of the Kyoto Protocol in Ghana

At its twenty-fifth meeting on 26th November 2002, the Parliament of the Republic of Ghana approved a resolution to ratify the Kyoto Protocol. The last instrument of ratification was submitted at the United Nations Headquarters in New York in March 2003, hence permitting Ghana to comply with the Kyoto Protocol and therefore becoming a Party to it. The Kyoto Protocol was finally enforced worldwide on 16th February 2005. In fulfillment of its commitment under Kyoto Protocol and in accordance with Decision 17/CP.7, Ghana established its Designated National Authority (DNA) under a ministerial decree and selected the Environmental Protection Agency as the host. The EPA has formed a Governing Council for the Designated National Authority for the Clean Development Mechanism (CDM), for the purpose of protecting and improving on the quality of the environment, in terms of the implementation of the Kyoto Protocol (MEST, 2011).

Following this, Ghana has developed a number of policies to help combat climate change since the phenomenon impacts adversely on its socio-economic development. With funding from both the Government of Ghana (GoG) and its bilateral and multi-lateral partners (within and outside the country) a number of areas have been earmarked and attention has been focused on the specific measures for minimizing and adapting to the impacts of climate change as well as, possibly, mitigating climate change through reducing emissions. As a result, each policy-making institution has established a Climate Change Unit and charged with the responsibility of developing policies or measures, in line with the mandate of that institution, to help address climate change situations in the country. All such individual Climate Change Units of the various policy-making institutions liaise with the National Climate Change Unit located at EPA, MEST, Accra, to harmonize plans and efforts geared towards ameliorating the phenomenon's impacts. It must be noted, however, that each policy is formulated and directed towards dealing with a specific natural resource or area that is more likely to be vulnerable to climate change. For instance, REDD, which specifically deals with forestry-related issues, is being coordinated by the Forestry Commission in Ghana but the policy framework is made up of a number of representatives of instutions within its Composition of the National REDD+ Steering Committee (NRSC). As a result, all these institutions share ideas and bring on board expertise from their respective institutions on how to tackle the climate change phenomenon in the country. Similarly, climate change policies under the coordination of other institutions are also made up of representatives of other institutions from different backgrounds with different expertise on how to tackle climate change issues. These compositions of memberships of representatives from the various policy-making institutions on different climate change policy frameworks in Ghana therefore result in a complex web of networks of policy frameworks. It is gratifying to note, however, that such criss-crossing of institutions in different climate change policies result in the laying of empahasis and concentration of effeorts in tackling climate change in the country as well as globally (MEST, 2011).

Information gathered from the interviews I conducted in Ghana in 2010 with the National Climate Change Coordinator, Oppong Boadi Kyekyeku, the Senior Programme Officer (Energy Resource and Climate Change), Daniel Tutu Benefoh, both of the Environmental Protection Agency (EPA) of the Ministry of Environment, Science and Technology, Accra, as well as other Climate Change Officers of the policy-making institutions in Ghana, also reported by MEST (2011), indicate that some studies were carried out in some pilot areas in Ghana to determine the effects of climate change scenarios (Figure 5.2) on temperature, rainfall, human health, fisheries, agriculture, land management, including land degradation, wildlife and biodiversity, in addition to linkages with poverty. The findings showed adverse impacts of climate change on all the parameters studied. These therefore served as warning signals for the country to undertake pragmatic measures to contain the situation in order to minimize such adverse impact on life and property.

5.3.3 The inter-relationships between Climate Change and other Multilateral Environmental Conventions in Ghana

Ghana has made great strides in fulfilling its international commitments under the several multilateral environmental conventions, treaties and protocols. It has ratified the three Rio Conventions and engaged in attempts at meeting its obligations. Subsequently, Ghana did a comprehensive and participatory capacity assessment, the National Capacity Self- Assessment (NCSA), which is needed to implement the three Rio Conventions. These three Rio Conventions are the United Nations Framework Convention on Climate Change (UNFCCC), the United Nations Convention on Biological Diversity (UNCBD) and the United Nations Convention to Combat Desertification (UNCCD). Following the findings of these assessments, it was recommended that Ghana should consider the possibility of putting together all multilateral environmental agreements (MEAs) under the proposed national conventions coordinating authority, and this resulted in the UNDP-GEF funded project forming an effective and sustainable framework for implementing multilateral agreements (MEST, 2011).

5.3.4 National Policies and other initiatives by Ghana in response to the UNFCCC international agreements

A number of national policies and other initiatives formulated by Ghana in response to the international agreements to address climate change and shea production concerns in Ghana were identified during the research. These national policies and other initiatives and the funding institutions are shown in Table 5.6.

Table 5.6 Climate Change Mitigation Initiatives in Ghana

Source: MEST (2011)

Status	***Keywords***	***Description***	***Recipient***	***Start Date***	***End Date***	***Funding Institution***	***Amount***	***Currency***
Completed	Renewable energy	Renewable Energy-Based Electricity for Rural, Social and Economic Development in Ghana (RESPRO)	Ministry of Energy	01-Feb-99	30-Mar-01	Government of Ghana	600,000	USD
						GEF	2,472,000	USD
						Total funding:	3,072,000	USD
	Energy efficiency	Transformation of lightning market from incandescent to CFL bulbs	Energy Commission	01/01/2007	31/12/2007	Ministry of Energy	15,200,000	USD
	Forestry and land use	A Review of Forestry and Wildlife Policies and Laws	Forestry Commission			NREG		
	Forestry and land use	Growing Forest Partnership (GFP)	IUCN					
	Forestry and land use	Peoples' Diagnostic Study	IUCN	01-May-09	31-Jul-09	GFP		
	Forestry and land use	Community Resource Management Areas (CREMA)	Forestry Commission			NREG		
	Forestry and land use	Forest Resources Use Management Project (FORUM)	Unknown		31-Dec-08	GTZ	12,500,000	EUR
	Transport	Vehicle emissions programme	EPA	01-Jun-05		DANIDA		
	Carbon finance	Capacity building for CDM in Ghana	Unknown		31-Aug-09	UNDP		
On-going	Forestry and land use	Ghana Readiness Preparation Proposal (R-PP)	Forestry Commission		31-Jan-10	FCPF	786,000	USD
	Energy efficiency	Promoting of Appliance Energy Efficiency and Transformation of the Refrigerating Appliances Market in Ghana	UNDP	01-Jan-11	31-Dec-13	World Bank	5,672,727	USD
	Renewable energy	Ghana Energy Development and Access Project GEDAP (formerly) Development of Renewable Energy and Energy Efficiency	ECG	26-Jul-07	30-Nov-13	GEF	5,500,000	USD
						IDA	90,000,000	USD
						Africa Catalytic Growth Fund	50,000,000	USD
						AfDB	18,250,000	USD
						Switzerland	11,000,000	USD

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On-going						Global Partnership on output based aid	6,250,000	USD
						Government of Ghana	29,500,000	USD
						Total Funding:	210,500,000	USD
	Renewable energy	Integration of renewable energy sources into the national energy grid mix (in preparation)	Unknown	2011		World Bank		
	Renewable energy	Solar PV Systems to Increase Access to Electricity Services in Ghana	Government of Ghana	10-Oct-08	31-Dec-11	Global Partnership on output based aid	4,350,000	USD
	Transport	Ghana Urban Transport	MRH	21-Jun-07	31-Dec-12	FDA	20,000,000	USD
						Global Environment Facility (GEF)	7,000,000	USD
						IDA	45,000,000	USD
						Government of Ghana (GoG)	18,000,000	USD
						Total funding:	90,000,000	USD
	Transport	Transport Sector Project	Government of Ghana	30-Jun-09	30-Jun-15	IDA	225,000,000	USD
	Climate strategy	Natural Resource and Environmental Governance Program (NREG)	Government of Ghana	01-Sep-08	30-Sep-12	FDA	4,100,000	USD
						EU	5,474,000	USD
						IDA	40,000,000	USD
						Dutch Embassy	28,739,000	USD
						DfID	6,440,000	USD
						Total Funding:	84,753,000	USD
	Forestry and land use	Ghana Natural Resource and Environmental Governance – DPO	Government of Ghana	03-Jun-10	30-Jun-11	Dutch Embassy	11,160,000	USD
						EU		
						Government of Ghana	2,000,000	USD
						FDA	1,590,000	USD
						IDA	10,000,000	USD

						Total Funding:	24,750,000	USD
	Forestry and land use	Chainsaw Milling Project	Forestry Commission	01-Jan-07	31-Dec-12	EU	2,200,000	EUR
	Forestry and land use	Growing Forest Partnership (GFP)	IUCN			World Bank		
	Forestry and land use	Chainsaw Milling Project	Forestry Commission	01-Jan-07	31-Dec-12	Tropenbos International	600,000	EUR
	Forestry and land use	Non-legally Binding Instruments on all types of forest in Ghana (UNFF/NLBI)	Forestry Commission	01-Dec-08	30-Nov-10	BMZ	400,000	USD
	Forestry and land use	Forest Investment Program (FIP)	Unknown	01-Jul-09		World Bank	70,000,000	USD
	Forestry and land use	Voluntary Partnership Agreement (VPA)	MLNR	2009		EU, DfID, Dutch Embassy		
	Forestry and land use	REDD+ R-PP Implementation	Forestry Commission	01-Jan-10	31-Dec-13	FCPF	200,000	USD
On-going	Forestry and land use	Forest Conservation with emphasis on Mitigation and Adaptation to Climate Change	Forestry Commission			JICA	7,800,000	USD
	Forestry and land use	National Forestation Plantation Development Program (NFPDP)	Forestry Commission	10-Jan-10		Government of Ghana	40,000,000	GHC
	Forestry and land use	Ghana Cocoa Carbon Initiative	NCRC/KG			Cadbury		
	Forestry and land use	Towards Pro-Poor REDD	IUCN	01-Jan-09	31-Dec-13	DANIDA		
	Forestry and land use	Ghana Cocoa Carbon Initiative	NCRC/KG			Rockefeller Foundation		
	Climate strategy	Technology Needs Assessment (TNA) update	UNDP	01-Nov-09	30-Apr-12			
	Climate strategy	Second National Communication to UNFCCC (to be finalized)	EPA			UNDP	420,000	USD
	Carbon finance	Carbon Finance Project (in preparation)	MoFEP			World Bank	30,000,000	USD

5.3.5 Some key policies by Ghana in response to International Climate Change Agreements

The research identified the following as some of the major policies formulated by Ghana to tackle Climate Change and Shea production concerns in Ghana.

Table 5.7 Policies on Climate change in and the Institutions that coordinate them

	Policy	*Coordinating Policy-making Institution*
1	Ghana Shared Growth and Development Agenda (GSGDA)	National Development Planning Commission (NDPC)
2	Natural Resources, Environmental Governance (NREG) programme	Ministry of Environment, Science and Technology
3	National Climate Change Policy Framework	Ministry of Environment, Science and Technology
4	The National Environmental Policy	Ministry of Environment, Science and Technology
5	Science, Technology and Innovation Policy (STIP)	Ministry of Environment, Science and Technology
6	REDD Readiness Plan Development	Ministry of Forestry, Lands and Mineral Resources
7	Food and Agriculture Sector Development Policy (FASDEP)	Ministry of Food and Agriculture
8	National Energy Policy	Ministry of Energy
9	COCOBOD Policy	Ministry of Food and Agriculture
10	Environment and Natural Resources Advisory Council (ENRAC) policy	National inter-Ministerial advisory body at Cabinet level
11	Ghana Environmental Conventions Coordinating Authority	Ministry of Environment, Science and Technology
12	Clean Development Mechanism	Ministry of Environment, Science and Technology
13	Savannah Accelerated Development Authority (SADA)	SADA Board

The policies listed above in Table 5.7, together with other initiatives, programmes, projects, activities, measures, etc, all either exclusively at addressing or have sections that address climate change and shea production concerns in Ghana. Generally, mention is usually made of initiatives that are aimed at addressing climate change and the strategies involved in conserving and protecting the environment, biodiversity and forests including shea parklands in Ghana.

Results of the interviews conducted with the policy makers in Ghana in 2010 indicate that each of these policies is coordinated by a Ministry, Commission, Department, Agency, Board or an inter-Ministerial body taking into consideration the specific climate change issues that are supposed to be tackled and under which relevant institution these issues fall. For instance, if the focus of a policy is on forestry, then that policy is put under the Ministry of Forestry, Lands and Mineral Resources and executed by the Forestry Commission. Each of the policy-making institutions is also represented in either a single policy framework or in a number of policy frameworks. So it is like a network of networks; with one network representing a policy framework, which is interlinked with other policy frameworks. The results also indicate that, in view of the importance Ghana attaches to climate change, in each of these policy-making institutions, there is a Climate Change Unit that deals with climate change issues. As such, each policy network has representations from all or some of the policy-making institutions, and they all coordinate their efforts, with the mandated policy-making instution in-charge of a particular policy serving as the central coordinating body. The other representative institutions serve as other actors within the policy network and are assigned varied roles (according to the expertise they bring on board from each institution), which are all geared towards the realization of the set goals, aims and objectives of a particular policy. Therefore, to achieve the overall aim of ameliorating climate change in Ghana, all these climate change policies are harmonized and organized by the Environmental Protection Agency, which serves as the national coordinating institution in-charge of all climate change issues in the country.

5.3.6 Ghana Shared Growth and Development Agenda (GSGDA)

According to MEST (2011), attention on climate change in Ghana is gaining firm ground at both the highest political level and across all the sectors of the economy. At the highest political level (policy level), climate change is being mainstreamed into core national development, particularly, into Ghana's Shared Growth and Development Agenda (GSGDA), coordinated by the National Development Planning Commission (NDPC).

The GSGDA is a medium-term development framework developed and being implemented by the Government of Ghana (GoG) for the general sustainable socio-economic development of the country. The institutional arrangements and how all the key actors are interconnected in a form of a network and their various roles under GSGDA are shown in Figure 5.3.

On recognizing that climate change is a great concern and a national issue, the Government of Ghana, through GSGDA (a medium-term development framework), is responding *to an injunction in the constitution which demands that the state implements policies for establishing a just and free society. GSGDA pursues to address the hurdles and challenges of previous* policies and programmes. It is also planned to tackle climate change and expedite action on job creation and income generation for poverty reduction and shared growth through conservation of important tree crops such as shea under the Accelerated Agricultural Modernization and Natural Resource Management programme of the GSGDA from 2010 to 2013 (NDPC, 2010). In this regard, a total of US$906.354 million has been allocated to that sector (Table 5.8).

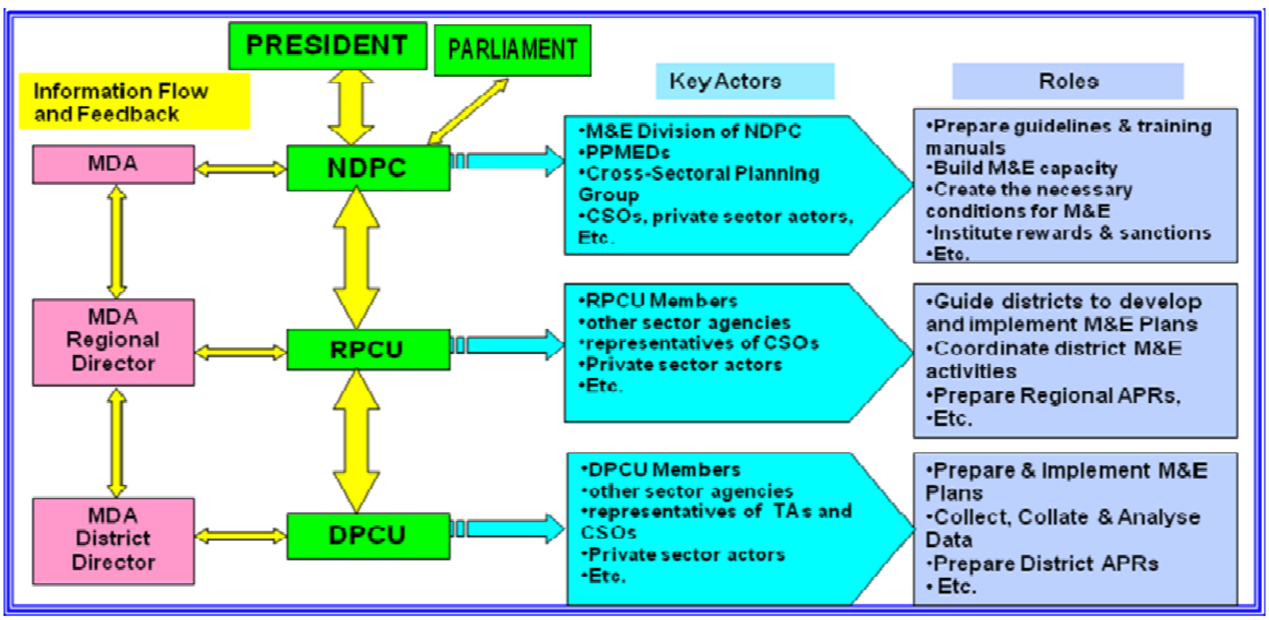

Figure 5.3 Institutional arrangements under GSGDA
Source: NDPC (2010).

Key:

APRs Annual Progress Reports

CSOs	Civil Society Organizations
DPCU	District Planning Coordinating Unit
MDAs	Ministries, Departments and Agencies
M&E	Monitoring & Evaluation
NDPC	National Development Planning Commission
PPMEDs	Policy Planning, Monitoring and Evaluation Divisions
RPCU	Regional Planning Coordination Unit
TAs	Traditional Authorities

Table 5.8 Cost of GSGDA allocation according to thematic area
Source: NDPC (2010)

Thematic Area	**GH¢ (millions)**	**US$ (millions)**	**%**
Ensuring and sustaining macroeconomic stability	729.17	502.87	2.10
Enhanced competitiveness of Ghana's private sector	2,764.01	1,906.21	
Accelerated agricultural modernization and natural resource management	1,314.21	906.35	3.79
Infrastructure and human settlements development	13,656.70	9,418.42	39.42
Oil and gas development	5,222.09	3,601.44	15.07
Human development, employment and productivity	8,727.18	6,018.75	
Transparent and accountable governance	2,229.26	1,537.42	6.44
TOTAL	**34,642.62**	**23,891.46**	

According to NDPC (2012), "*the National Development Planning is a constitutional body created by Articles 86 and 87 of the 1992 Constitution of the Republic of Ghana and established by The National Development Planning Commission Act, 1994 (Act 479). Its function is to advise the President of the Republic of Ghana (and Parliament upon request) on development policy and strategy, to prepare and ensure the effective implementation of approved national development plans and strategies and coordinate economic and social activities country wide in a manner that will ensure accelerated and sustainable development of the country and improvement in the standard of living for all Ghanaians. The Commission also coordinates and regulates the decentralized national development planning system in accordance with the National Development Planning System Act, 1994 (Act 480)".*

In an interview with Sandra Amankwah Kesse, a Planning Analyst (Environmental Management) of the National Development Planning Commission, Accra, Ghana, she explained that as the NDPC is concerned about sustainable socio-economic development of the country, it sees climate change as a development challenge. Therefore, the NDPC has taken on board issues on climate change and coopted them into the GSGDA. Mrs Kesse further explained that, as a result of the coordinating role assigned to the NDPC, it generally coordinates all activities within the GSGDA policy network. At the uppermost part of the GSGDA policy network, the Commission plays a leading role in the planning, information flow and feedback, and serves as the main link between the Executive (The Presidency) and the Legislature (Parliament) on one hand, and the Ministries, Departments and Agencies (MDAs), the Regional Planning Coordination Units (RPCUs) as well as the key actors in the GSGDA network on the other hand (Figure 5.3***).*** The key actors involved in the GSGDA policy framework include the Monitoring & Evaluation Division of NDPC, Policy

Planning, Monitoring and Evaluation Divisions (PPMEDs) of the various policy-making institutions such as the Ministries, Cross-Sectoral Planning Group, Civil Society Organizations an the Actors from the Private Sector. These key actors in turn play various roles in the GSGDA policy implementation. Such roles include the preparation of guidelines and training manuals, building of the Monitoring and Evaluation (M&E) capacity, build and creat the necessary conditions for M&E to function and work more effectively as well as institute rewards for job well-done and sanctions for non-performance. The actual implementation of the GSGDA policy is done at the regional and district levels. At the regional level, the NDPC links up with the Regional District Directors of MDA as well as the Regional Planning Coordination Units (RPCUs) for dissemination of information and feedbacks on GSGDA policy issues, and the RPCUs in turn link up with the key actors to execute GSGDA activities, including guiding the districts in the development, preparation and implementation of the M&E plans. Within the network, there is a two-way information flow and feedback on GSGDA between RPCUs and the DCPUs from the regional to the district level. At the district level, the District Planning Coordinating Units (DPCUs) link up with the key actors to prepare and implement the M&E plans; collect, collate and analyze data; as well as prepare annual progress reports (APRs).

Included in the GSGDA M&E plans are critical issues on climate change. As reported by NDPC (2010), "*the key policy measures to achieve the objective of adapting to the impacts of, and reduced vulnerability to climate variability and change include identifying and enhancing early warning systems; enhance national capacity to adapt to climate change through improved land use management; and adapt to climate change through enhanced research and awareness creation".*

5.3.7 Natural Resources, Environmental Governance (NREG) programme

In response to the UNFCCC international agreements, Ghana has put in place policies and other initiatives in the country to minimize or if possible prevent the adverse impact of climate change locally in Ghana and to a large extent to also invariably benefit the rest of the global community. In furtherance to this, the Government of Ghana recognized the need to seek other ways of minimizing such adverse impact. In this regard, MEST (2011) reports that the "Natural Resources, Environmental Governance" (NREG) programme was instituted and placed under the environmental sector of the Ministry of Environment, Science and Technology (MEST) to coordinate natural resources and environmental activities in Ghana. MEST serves as the principal organization for coordinating climate change and UNFCCC activities in the country at the strategic level (Figure 5.4) and also acts as the host for the National Committee on Climate Change (NCCC). The NCCC is made up of representatives from relevant Ministries, Universities, Research Institutions, the Private sector and Non-Governmental Organizations (NGOs), and has been mandated under a Ministerial directive among other things to:

"1. Prepare a National Climate Change Policy for Ghana that takes into account mitigation and adaptation actions necessary for sustainable national development and ensure that the policy is integrated into planning processes at national, regional and district levels.

2. Envision for Ghana, mitigation and adaptation strategies for implementing the climate Change

Policy or otherwise review any existing sector strategies and associated action plan(s).

3. Recommend for the consideration of the Minister of Environment, Science and Technology (MEST), relevant area(s) of study that could provide a sound basis for comparative analyses of climate change adaptation strategies.
4. Identify skills deficiencies within sectors and propose training needs for particular sectors, training modules and institutions for action by the sectors.
5. Develop harmonized Climate Change programmes from all sectors especially in the key sectors of finance and economic planning, forestry, agriculture, land and water, health, energy and coastal zones management to ensure coherence and building of synergies among these sectors.
6. Source and utilize funding for the implementation of Climate Change mitigation and adaptation activities, and strengthen financial mechanisms for sustainable implementation.
7. Develop a communication strategy for Climate Change related matters in Ghana.
8. Formulate a common Ghanaian position in relation to the on-going Climate Change negotiations. Such a position should as far as possible be consistent and feed adequately into the overall African position, and ultimately the Group of 77 and China but highlighting national areas of difference.
9. Offer strong technical backstopping to the political leadership, Cabinet and Parliament in particular, to share the common African vision on efforts made to combat Climate Change in general and on the African climate platform".

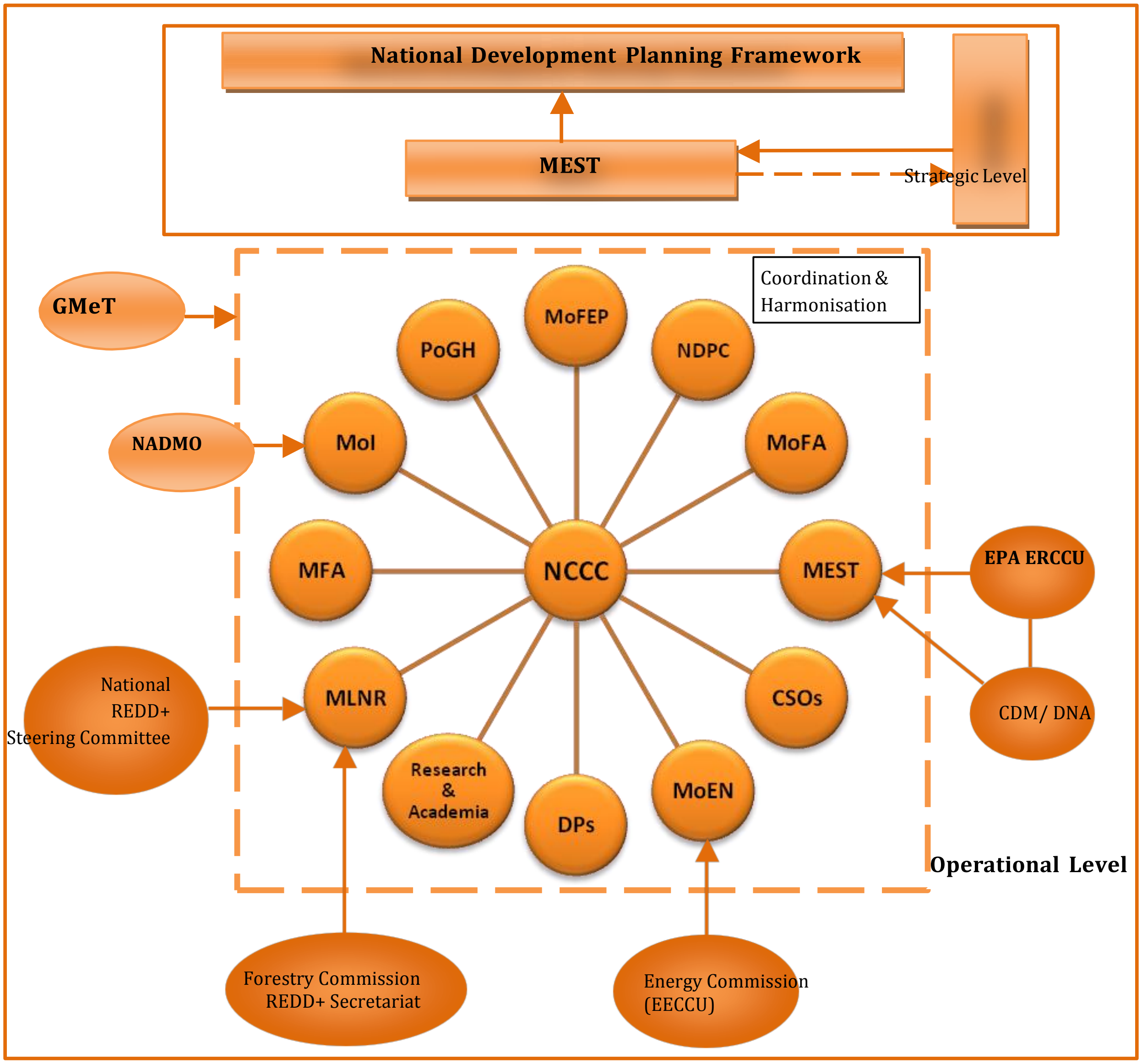

Figure 5.4 Institutional arrangement for coordinating Climate Change activities in Ghana
Source: MEST (2011)

Key:

NCCC – National Climate Change Committee, MoFeP: Ministry of Finance and Economic Planning, NDPC: National Development Planning Commission, MLNR: Ministry of Lands and Natural Resources, MoFA: Ministry of Agriculture, MEST: Ministry of Environment, Science and Technology, CSOs: Civil Society Organizations; ERCCU: Energy Resources & Climate Change Unit, EECCU: Energy Efficiency and Climate Change Unit, CDM/DNA: Clean Development Mechanism/Designated National Authority, MoEn: Ministry of Energy, DPs: Donor Partners, MFA: Ministry of Foreign Affairs, PoGH: Parliament of Ghana, MoI: Ministry of the Interior, NREAG: Natural Resource and Environment Advisory Group, GMeT: Ghana Meteorological Agency

Note: *This institutional arrangement does not represent the hierarchical flow of functions and roles within the national development planning process. The various institutions, particularly those involved in the processes of coordination and harmonization are only a representation of their respective institutions and contributions to the national climate change activities.*

5.3.8 National Climate Change Policy of Ghana

Another major policy implemented by the Government of Ghana (GoG) to handle climate change issues in the country is the National Climate Change Policy. The formulation of the policy was however done through the GoG sector ministry, the Ministry of Environment, Science and Technology (MEST). MEST serves as the main Climate Change Coordinating Unit in Ghana between the strategic level (policy-making) and the operational level (policy implementation) and all the other organizations (both governmental and non-governmental) serve as supporting units (Figure 5.4).

According to MEST (2010a), the National Climate Change policy document was produced under the guidance of the National Climate Change Committee (NCCC). The NCCC, which plays a central role and links up with all the other actors (as shown in Figure 5.4) at the coordination and harmonization level, is represented by the following organizations:

i. Ministry of Environment, Science and Technology;
ii. Ministry of Finance and Economic Planning;
iii. National Development Planning Commission;
iv. Ministry of Food and Agriculture;
v. Ministry of Foreign Affairs;
vi. Ministry of Energy;
vii. Energy Commission;
viii. Ministry of Health;
ix. Environmental Protection Agency;
x. Forestry Commission;
xi. Centre for Scientific and Industrial Research - Forestry Research Institute of Ghana;
xii. Ghana Health Service;
xiii. National Disaster Management Organization;
xiv. Ghana Meteorological Services;
xv. the UK Department for International Development;
xvi. the Dutch Embassy;
xvii. ENAPT Centre, Conservation International Ghana;
xviii. Friends of the Earth Ghana;
xix. Abantu for Development.

The National Climate Change Policy Framework – *Analysis of impact on Climate Change mitigation and adaptation and Shea production in Ghana*

The aim of the National Climate Change Policy Framework (NCCPF) of Ghana is to *"Ensure a climate resilient and climate compatible economy while achieving sustainable development and equitable low carbon economic growth for Ghana"*. This complements and enhances the purpose of the Ghana Shared Growth and Development Agenda (GSGDA) 2011–2014, which is: *"to foster high and equitable levels of growth going towards middle income status".* The GSGDA determines the direction for any other medium-term frameworks and plans, and the

NCCPF works in accordance with many of its themes. The Ghana Government considers climate change as part and parcel of the development agenda, acknowledging that climate change must be mainstreamed into policies and into the daily lives of Ghanaians if the country is to achieve its development targets. The NCCPF has to necessarily make sure the required actions on adaptation and social development that are needed for national development, to support Ghana in harnessing the opportunities from low carbon growth, and incorporate climate change into the main planning processes at national, regional and district levels (MEST, 2010a).

5.3.9 The National Environmental Policy of Ghana

According to MEST (2010c), Ghana's involvement in the Stockholm Conference in 1972 significantly demonstrated the beginning of the country's wish and preparedness to make determined and conscious efforts at managing its environment. Twenty years later at the Earth Summit in Rio, Ghana and the world took a giant step further to realizing the objective of living in harmony with the environment by signing the Rio Conventions. By signing the Conventions, Ghana and the world in general recognized the fact that development and environmental issues and goals are one and the same. Ironically however, since Rio, environmental problems have been on the rise, leading to a worsening situation. These range from general environmental pollution, urban congestion, loss of biodiversity to climate change. In view of this, the Government of Ghana has instituted a number of measures to resolve these environmental challenges. One of these measures is the formulation of the National Environmental Policy of Ghana in 1995.

MEST (2010c) further reports that, the vision for the environmental management policy is based on an integrated and holistic management system for the environment in Ghana. It is aimed at sustainable development now and in the future. The vision for the environmental policy, therefore, is: *"To manage the environment to sustain society at large."* The Environmental Protection Agency (EPA), the official government institution that is under the Ministry of Environment, Science and Technology (MEST), is mandated to be responsible for the implementation of the policy and its associated programmes and projects. The policy statement primarily *"takes account of the national environmental priorities while sufficient attention is also given to longer-run sustainability concerns. Government ownership of the national environmental objectives is indeed important, but ministries, departments and agencies, as well as other institutions including non-governmental organizations must buy into the policy implementation process to ensure overall success."* The policy therefore aims at:

"

- reversing the current insufficient commitment to environmental objectives, policies and interventions
- reversing rapid population growth, economic expansion, persisting poverty, poor governance and institutional weaknesses and failures
- improving quality and flow of information
- creating an understanding of the nature and causes of environmental problems
- establishing a clear definition of the national environmental agenda and its links to economic growth and poverty reduction and weak legal, regulatory, financial, technical, human and

institutional capacity

- mainstreaming international relations into the national environmental agenda
- improving the current environmental quality control programme by which prior environmental impact assessments of all new investments that would be deemed to affect the quality of the environment are undertaken.
- taking appropriate measures, irrespective of existing levels of environmental pollution and extent of degradation to control pollution and the importation and use of potentially toxic chemicals.
- taking appropriate measures to protect critical ecosystems, including the flora and fauna they contain against destructive practices".

Some of the interventions that have already been put in place by the Government of Ghana to take care of climate change-related concerns in the country are shown in Table 5.9 below, while the other environmental challenges and the current emerging environmental issues and the interventions implemented to manage them are in appendices A.3 and A.4.

Table 5.9 Interventions by Ghana to deal with the prominent environmental challenges in Ghana
Source: MEST (2010c)

ISSUE	CHARACTERISTICS	INTERVENTIONS
1. Climate Change	Global problem with local implications Changes in rainfall pattern and impact on agricultural production, unprecedented floods and disasters Increased coastal erosion due to sea level rise Drought in Sahelian region resulting in southward migration of people and animals Climate change and associated health problems	Guidebook to facilitate the integration of climate change and Disaster Risk Reduction into National Development Policies and Planning prepared Ghana is party to the UN Framework Convention on Climate Change (UNFCCC) Studies on measures to abate climate change through forestry and Land-use using the Comprehensive Mitigation Analysis Process (COMPAP) model. A needs assessment report prepared in fulfillment of decisions of the COP of the UNFCCC A report with the assistance of the Climate Technology Initiative (CTI) of the OECD lists a number of desired technologies based on national set of criteria: Energy Efficient Lighting, Industrial Energy Efficiency and Land fill Methane Gas Recovery

5.3.10 National Science, Technology and Innovation Policy (STIP)

Another policy formulated by GoG is the National Science, Technology and Innovation Policy (STIP). MEST (2010b) reports that the STIP is aimed at building a strong Science, Technology and Innovation **(**STI) capacity in Ghana to support the social and economic developmental needs of a middle-income country. Ghana intends to make progress and move from the low science and technology-poor practices and worldview associated with tradition-bound society to an STI and knowledge-based society with an economy centered on high levels of production, processing, industrialization and manufacturing. The STI policy pursues for the country a future whose STI capacity and ability would support it to produce and process maximally the natural resources that she is blessed with and also has the knowledge base to participate actively in the production of higher technology goods and services for local consumption and for export. The STI policy is to be fully integrated into a national development strategy which completely makes use of Ghana's science and technology potential to realize national objectives for wealth creation, poverty reduction, and competitiveness of enterprises, sustainable environmental management and industrial growth. The basic objectives of the Science, Technology and Innovation Policy should therefore be to:

- facilitate mastering of scientific and technological capabilities by a critical mass of the products of all institutions;
- provide the framework for inter-institutional efforts in developing STI and programmes in all sectors of the economy to provide the basic needs of the society;
- create the conditions for the improvement of scientific and technological infrastructure for research and development and innovation;
- ensure that STI supports Ghana's trade and export drive for greater competitiveness; and;
- promote a science and technology culture.

The sustainable environmental management component of this policy will include the conservation, protection and management of the environment, which includes the nation's natural resources such as forests, shea parklands as well as measures to adapt to and mitigate climate change.

There is also another aspect of the STIP that deals with agriculture. In realizing food security in Ghana, agriculture plays a crucial role and it presently continues to provide employments for over 60% of the workforce and produces 40% or more of the country's GDP. Agricultural productivity at every stage of the chain of production, processing, packaging and marketing would be made to benefit from quality relevant research and development. It will require the knowledge and technical abilities of scientists of many specializations, engineers and technologists, and many social scientists such as economists, sociologists, geographers and statisticians, etc (MEST, 2010b).

The policy implication of the STIP is that it will help enhance productivity in all sectors of the Ghanaian economy by paving the way and ensuring that environmentally-sustainable and technologically-improved systems and methods are employed in productive processes. These will consequently impact positively on the environment and the country's natural resources including the shea parklands.

5.3.11 REDD Readiness Plan of Ghana

Another major policy aimed at managing and controlling climate change and shea production concerns in Ghana is the REDD-plus. By 2016, Ghana activities and programmes to cut down on deforestation, and in following five to ten years, will scale-up and broaden these interventions (FC, 2015).

Global climate change endangers the livelihoods of people throughout the world. The international community is developing a mechanism to provide motivations (mostly in the form of funding) to assist developing countries reduce emissions from deforestation and forest degradation (REDD), and to support conservation, sustainable forest management, and the development of forest carbon stocks (these three being the + in REDD plus). This mechanism is being discussed against the backdrop of an international climate agreement that will complement the UNFCCC and the Kyoto Protocol. Ghana is actively participating in these negotiations. A future REDD+ mechanism offers the prospect of funding for Ghana to stimulate policies and activities that will decrease further deforestation and forest degradation. This funding is scheme performance-based and comes as payment for the provision of an environmental service in the form of carbon in land uses. At the moment, Ghana is getting funds form the Forest Carbon Partnership Facility (FCPF) to prepare for the participation in a future mechanism for REDD+. The first major phase of this is the development of the R-PP or Readiness preparation proposal which specifies what activities could be carried out for REDD+ and offers a guide to what needs to be done to assess these activities, and find out a comprehensive national strategy for REDD+, which will guide activities and procedures at both the national and international levels (FC, 2010).

FC (2015) reports that the Government of Ghana intends to implement the R-PP “towards a sustainable future REDD+ administration and implementation” using a ‘Strategy Development’. Under this, the Ghana REDD+ implementation has been formulated into three phases:

“Phase I: Preparation and Design Phase (2008-2015), where Ghana will complete its REDD Readiness Preparation and submit its R-Package in late 2015 for international approval.

Phase II: Early Implementation, Monitoring, Performance Based Payments, Scaling Up (2016-2030), which will focus on implementing the Cocoa Forest REDD+ Program and associated activities with an initial monitoring is proposed for 2018 and

Phase III: Performance Based Payments, Consolidation, Determining Future of REDD+ (2021-2036), which marks the end of the Cocoa Forest REDD+ Program, as currently articulated”.

In Ghana, the Ministry of Lands and Natural Resources (MLNR) is the lead national institution responsible for REDD+ activities. The National REDD Steering Committee, established in 2009, provides support to MLNR. The Ministry is also represented at the National Climate

Change Committee. The Ministry of Finance and Economic Planning (MoFEP) also plays an active role in the Climate Change agenda. Apart from their representation at the NCCC the Ministry has also been active in the national processes (Figures 5.5, 5.6 and 5.7) to mainstream climate change into national development planning. In the light of this, MoFEP has been chosen for accreditation as the National Operating Entity (NOE) to the Adaptation Fund Board (MEST, 2011).

According to FCPF (2012), the 'Implementation Framework' for the REDD programme in Ghana has been divided into phases and planned for up to 2013 and beyond as follows:
"Phase 1 (2009 – 2011): REDD+ Readiness – Development of national plan or strategy, policies and measures and capacity building are ongoing
Phase 2 (2011 – 2012): Implementation of REDD+ Strategy - Implementation of national plan, policies and measures and further capacity building, technology development and transfer, and results-based demonstration activities or pilots
Phase 3 (2012 – 2013): Implementation of Performance-based actions - Results-based actions with full measurement, reporting and verification (MRV)"

Composition of the National REDDplus Steering Committee (NRSC)

According to FC (2010), the National REDDplus Steering Committee (NRSC) is made up of the following:

- Ministry of Lands and Natural Resources (MLNR)
- Forestry Consultant from the Institute of Renewable Natural Resources (IRNR) of the Kwame Nkrumah University of Science and Technology
- Ghana Timber Millers Association
- Tropenbos International - Ghana
- Forestry Commission
- Environmental Protection Agency (EPA)
- Forestry Research Institute of Ghana (FORIG)
- Ministry of Lands and Natural Resources (MLNR)
- Forestry Commission (FC), Wildlife Division
- Ministry of Energy
- Ministry of Local Government & Rural Development (MLGRD)
- Ghana Meteorological Agency
- Forestry Commission (FC)
- Ministry of Food and Agriculture (MoFA)
- Civic Response
- Ministry of Finance and Economic Planning (MoFEP)
- Netherlands Embassy
- National House of Chiefs
- National Forest Forum
- GTMO
- Ministry of Environment, Science and Technology (MEST)
- Minerals Commission
- Attorney General's Department

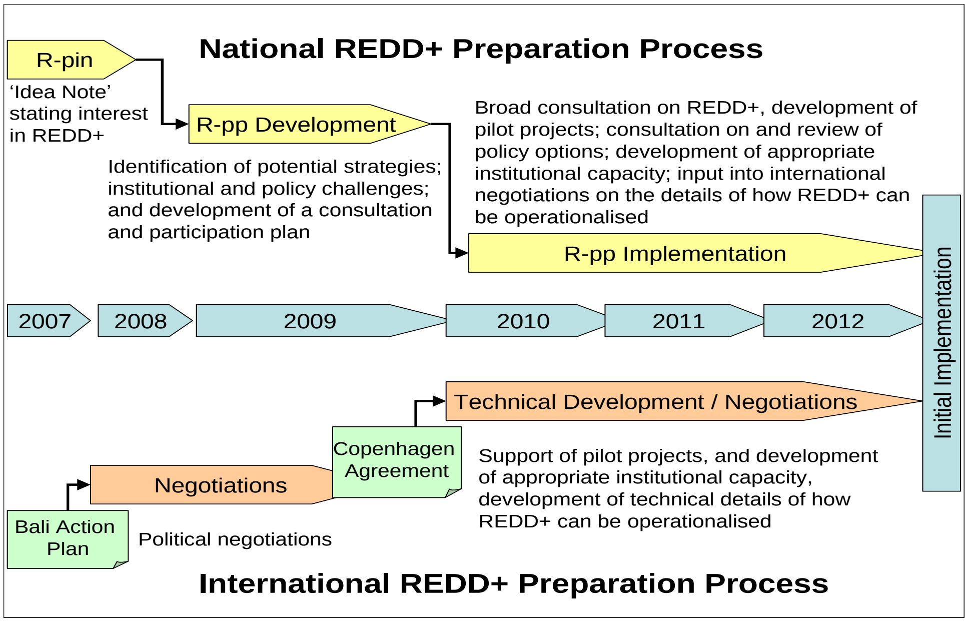

Figure 5.5 National and International Preparations for REDDplus
Source: FC (2010).

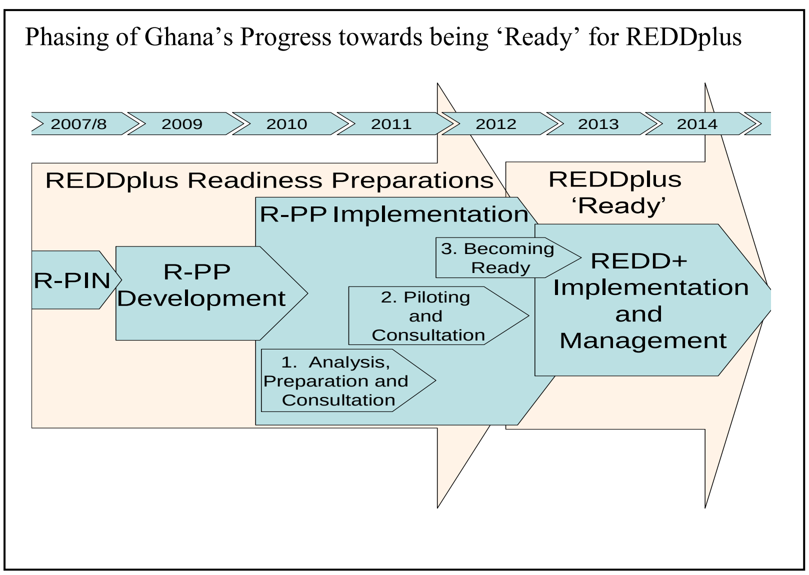

Figure 5.6 Ghana's Progress towards being 'Ready' for REDD+
Source: FC (2010)

The Ghanaian forest sector has been a priority area for Government, Development Partners and Civil Society groups for many years. A focus on consultation and participation within several key initiatives has increased the capacity of stakeholder groups and Government to organize, advocate and consult, when compared to other sectors within the country. Examples of these developments are the elaboration of Ghana's Voluntary Partnership Agreement (VPA) with the EU and the country's Natural Resource and Environmental Governance (NREG) Sector Budget Support Programme (NREG), with both having made use of a consultative process. The VPA consultation process was identified as one of the highest worldwide successful VPA consultation processes with good levels of information sharing and effective multi-stakeholder decision-making. As a result, a number of lessons have been learned from the process (Figure 24) which other initiatives can make use of in further developing and improving multi-stakeholder consultation and decision-making within Ghana. Considerable success has been achieved in developing the NREG structure for establishing the consultative process by creating a framework around which stakeholders can deliberate and identify priorities for the sector in a coordinated way (FC, 2010).

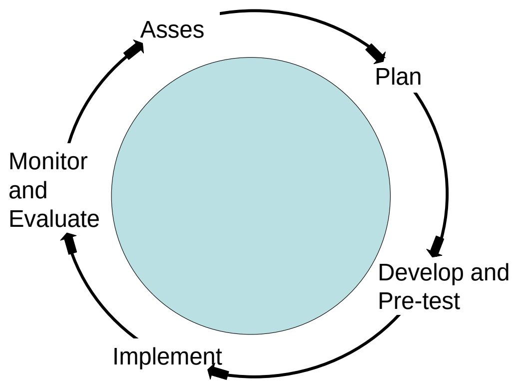

Figure 5.7 Consultation and Participation Design and Development
Source: FC (2010)

The R-PP

The Readiness Preparation Proposal (R-PP) aims to assist Ghana to prepare itself for reducing emissions from deforestation and forest degradation (REDD), and become 'ready' for the implementation of an international mechanism for REDD. The document provides a roadmap of preparation activities needed and will remain a living document throughout the preparation process. In this R-PP, REDD is taken to include all the elements mentioned in the Bali Action Plan, Section 1(b), and officially known as 'REDD plus', namely "*policy approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries, and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries*" (FC, 2010).

Ghana has already been involved in conservation and sustainable production and utilization of forest resources in the country since 2009, as outlined in Figure 5.8.

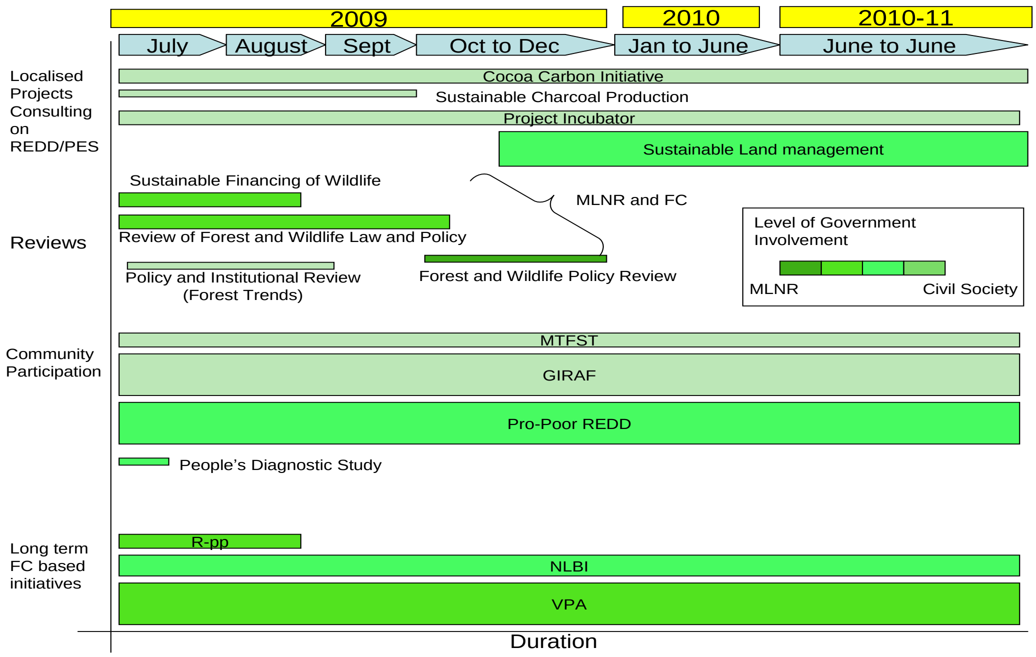

Figure 5.8. Example of ongoing initiatives in the forest sector
Source: FC (2010)

The condition of Ghana's forests, including shea parklands, has been reducing for many years, particularly since the 1970s. Many forest reserves are heavily encroached and degraded, and the off-reserve stocks are being rapidly depleted. These are triggered by immediate causes such as policy/market flops in the timber sector, growing human populations in rural and urban areas, rising local demand for agricultural and wood products, increased demand for wood and forest products on the international market, huge reliance on charcoal and wood fuel for rural and urban energy, low level of technology in farming and the seasonal 'slash and burn' methods of farming. As a result, the Government of Ghana has implemented a number of initiatives to tackle deforestation and forest degradation in the country. The most prominent of these initiatives are the Forest Law Enforcement, Governance and Trade (FLEGT) Initiative, and the multi donor sector budget support through the Natural Resources and Environmental Governance Program (NREG) (FC, 2010).

5.3.12 Food and Agriculture Sector Development Policy (FASDEP)

FOSADEP (2007) reports that the Government of Ghana formulated the Food and Agriculture Sector Development Policy (FASDEP) as a GEPC working document to guide development and interventions in the agriculture sector in the country. The initial Food and Agriculture Sector Development Policy (FASDEP) was developed in 2002 as an outline for the implementation of strategies to modernization of the agricultural sector. The strategies in that policy were centered on the Accelerated Agricultural Growth and Development Strategy (prepared in 1996), and were planned to forge linkages in the value chain. After nearly four years of its implementation, and the development of sub-sector policies and strategies to guide implementation, it became necessary to revise FASDEP to reflect lessons learned and to respond to the changing needs of the sector. This revised policy (FASDEP II) emphasizes the sustainable utilization of all resources and commercialization of activities in the sector with market-driven growth in mind.

The national vision for the food and agriculture sector is a modernized agriculture resulting in a structurally transformed economy and evident in food security, employment opportunities and reduced poverty. This is linked to the national vision in the Growth and Poverty Reduction Strategy (GPRS II) and the Comprehensive Africa Agriculture Development Programme (CAADP) of the New Partnership for Africa's Development (NEPAD). Based on the role of agriculture in the national development framework, the objectives for the food and agriculture sector policy are as follows:

- Food security and emergency preparedness
- Improved growth in incomes
- Increased competitiveness and enhanced integration into domestic and international markets
- Sustainable management of land and environment
- Science and Technology Applied in food and agriculture development
- Improved Institutional Coordination

The *Science and Technology Applied in food and agriculture development* and *sustainable management of land and environment* components deal with issues on improved agricultural production, environmental protection, climate change and conservation of natural resources including shea parklands. As a result, these components of the FOSADEP policy invariably impact positively on climate change and shea production.

5.3.13 National Energy Policy of Ghana

The National Energy Policy outlines the Government of Ghana's policy direction regarding the current challenges facing the energy sector. The document provides a concise outline of the Government's policy direction in order to contribute to a better understanding of Ghana's Energy Policy framework. Ghana has a huge potential to grow and transform its economy through industrialization with a view to creating jobs and ensuring equitable distribution of wealth. The fundamental goal of the Government of Ghana's development agenda is to achieve macro-economic stability and grow the economy to a middle-income status by 2020. Ghana's total energy supply must increase significantly if the development agenda is to be achieved. In 2008, Ghana's biomass energy consumption was 11.7 million tonnes, while petroleum products and electricity consumption were 2.01 million tonnes and 8,059 GWh, respectively. In terms of total energy equivalents, biomass (fuelwood and charcoal) constituted 65.6%, with petroleum products and electricity accounting for 26.0% and 8.4%, respectively (Figure 5.9). Biomass usually serves as the main source of energy for Ghanaians, and in 2008 alone it constituted 65.6% of the energy needs of the country. In the form of fuelwood and charcoal from trees including shea, this type of energy is used in cooking, heating, etc. In northern Ghana, shea serves as an excellent source of biomass energy due to the high quality of fuelwood and charcoal it produces. A lot of people, either in desperate moves to make quick money or because they need wood energy, turn to shea trees and fell them for use as a source of energy (MoEn, 2010).

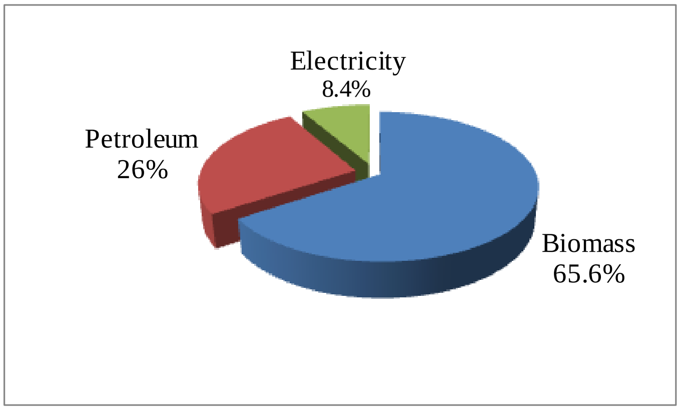

Figure 5.9 Ghana's energy sources in 2008
Source: MoEn (2010)

According to MoEn (2010), the energy sector's vision is to develop an "Energy Economy" that would guarantee secure and reliable supply of high quality energy services for all segments of the Ghanaian economy, and to become a net exporter of oil and power by 2012 and 2015, respectively. Within this vision, the goal of the energy sector is to make energy services universally accessible and readily available in an environmentally sustainable manner. The consequence of the production and usage of energy on the environment is obvious and varying in its extent. The use of biomass energy can cause deforestation, while the use of fossil fuels results in carbon dioxide emissions. Also the utilization of inferior cooking equipment has harmful health impacts. The production and transport of crude oil and petroleum products and the flaring of natural gas related to petroleum production have accompanying environmental dangers. As a result, it has the goal of *"ensuring that energy is produced and utilized in an environmentally sound manner"*. Therefore, the challenge is to:

"• *Mitigate the environmental hazards of energy production, transportation and use.*

• *Build capacity to adapt and mitigate the effects of climate change*

• *Regulate all activities in the energy sector to protect the environment".*

The Policy Direction of the Government of Ghana in addressing this challenge, as MoEn (2010) reports, is to:

"• Promote the use of environmentally friendly energy supply sources such as renewable energy (solar, wind, waste) in the energy supply mix of the country;
• Encourage a shift from oil to gas wherever gas is a technically feasible alternative;
• Promote the use of improved wood fuel burning equipment for cooking in households and other commercial activities;

• Support and actively participate in international efforts and cooperate with International organizations that seek to ensure sustainable delivery of energy to mitigate negative environmental impacts and climate change;
• Encourage and enable all relevant entities engaged in activities in the energy sector to explore and access international environmental financial mechanisms and markets to overcome investment, technology and other relevant barriers;
• Ensure effective disposal of all hazardous substances and materials associated with the production, transportation and use of energy; and
• Facilitate environmental protection awareness programmes".

Hence, the policy aims at ensuring that the production, supply and utilization of energy will take into consideration issues bordering on environmental sustainability, climate change, conservation of natural resources, etc. All these ultimately have positive impacts on the management of forest resources including shea parklands.

5.3.14 COCOBOD

According to COCOBOD (2012), the mission of COCOBOD is to boost and enhance the production, processing and marketing of good quality cocoa, coffee and sheanuts in all forms in the most efficient and cost-effective way, and sustain the best mutual industrial relations with its objectives.

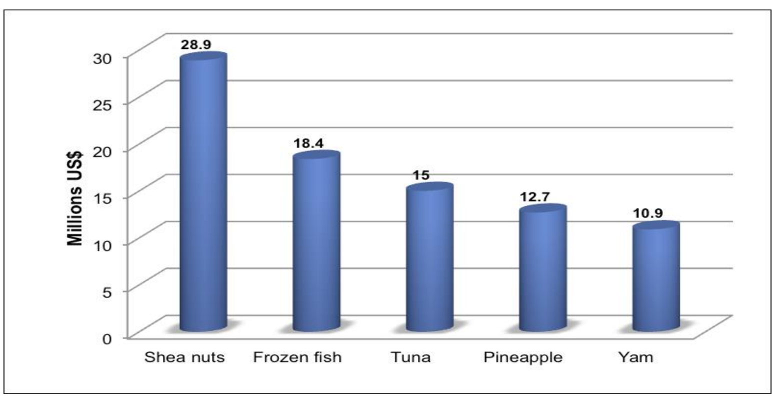

Figure 5.10 Leading non-traditional agricultural export in 2005
Source: Ghana Export Promotion Council, GEPC, (2006)

As shea is a very important crop, it is the policy of COCOBOD to facilitate its production, processing and marketing of quality kernels and butter, together with cocoa and coffee. Over the past years, shea has been gaining much attention as the leading non-traditional agricultural export earner for Ghana and earned US$28.9 million in 2006 (Figure 5.10). In terms of production, Ghana is ranked as one of the top producers in the world, with annual exports of about 45,000 metric tonnes and 15,000 metric tonnes of the kernels and butter respectively (Table 5.10), although the country has much potential to produce more. As a result of these significant contributions of shea to Ghana's economy, COCOBOD developed a policy to facilitate the conservation and increased production of shea in the country, and has therefore set up a research institute, Cocoa Research Institute of Ghana (CRIG), at Bole, among other things, to be responsible for shea with the aim of facilitating its conservation, production and propagation. This is aimed at increasing the populations of the trees in shea-growing areas. This impacts positively on the environment since the trees play a meaningful role in climate change mitigation through carbon sequestration.

Table 5.10 Shea Kernel Production and Utilization (metric tons per annum)

Country	*Est. Total Potential Production (tones)*	*Est. Actual Collection*	*% share of Actual Shea kernel production in West Africa*	*Estimated Consumption*	*Total Exports*	*Exports as shea kernels*	*Export as Shea Butter*
Mali	250,000	150,000	28.03	97,000	53,000	50,000	3,000
Nigeria	250,000	100,000	18.69	80,000	20,000	20,000	0
Ghana	200,000	130,000	24.29	70,000	60,000	45,000	15,000
Cote d'Ivoire	150,000	40,000	7.47	15,000	25,000	15,000	10,000
Burkina Faso	150,000	75,000	14.01	35,000	40,000	37,000	3,000
Benin	80,000	40,000	7.47	14,900	35,100	35,000	100
Total	1, 130,000	535,000	100	321,900	263,100	217,000	46,100

Source: Lovett PN (2004).

5.3.15 Environment and Natural Resources Advisory Council (ENRAC) policy

Ghana's economy depends largely on the utilization of natural resources, particularly forestry, wildlife and the mining, and these account for nearly 15% of Ghana's Gross Domestic Production (GDP). About 70% of the nation's human population depends on natural resources for their livelihood (food, water and energy requirements). In the face of increasing population, there is enormous pressure on the environment and natural resources. For the natural resources to continue supporting economic growth there is the need to strengthen environmental governance through the improvement of the policy, regulatory and institutional framework. This calls for the establishment of a national inter-ministerial advisory body consisting of stakeholders representing government, labour, business and civil society to discuss environmental and natural resource issues and provide strategic direction on matters concerning environmental and natural governance and management prior to decision-making (FC, 2010).

Framework for Environment and Natural Resources Advisory Council

The National Climate Change Committee (NCCC), led by the Ministry of Environment, Science and Technology has developed national strategies on Climate Change Mitigation and Adaptation for forestry, agriculture and energy in line with the national climate change policy development. The NCCC is a multi-stakeholder committee made up of government, civil society (NGOs), and development partner representatives. The need for concerted efforts among Ministries, Departments and Agencies to come up with and implement programmes to resolve environmental concerns such as climate change and the negative impacts of human activity on the environment and vice-versa was mentioned in the Budget Statement and Economic Policy of the Government of Ghana (GoG) for the 2009 Financial Year that was presented to Parliament on 5th March 2009. The Environmental Protection Agency has introduced a consultative process for mainstreaming climate change in Ghana Government plans and programmes by formulating policy briefs for distribution to Parliamentarians, Cabinet, Ministers and the Council of State members. To demonstrate its seriousness and commitment to tackling climate change and other environmental issues, the Government of Ghana has constituted a national inter-ministerial advisory body at Cabinet level known as the Environment and Natural Resources Advisory Council (ENRAC) (FC, 2010). To be able to most effectively tackle climate change and other environmental issues in Ghana, ENRAC has linkages with other stake-holders, as shown in Figure 5.11, and all these bodies and groups team up at the various levels and jointly coordinate their efforts with the view to realizing the ultimate goal.

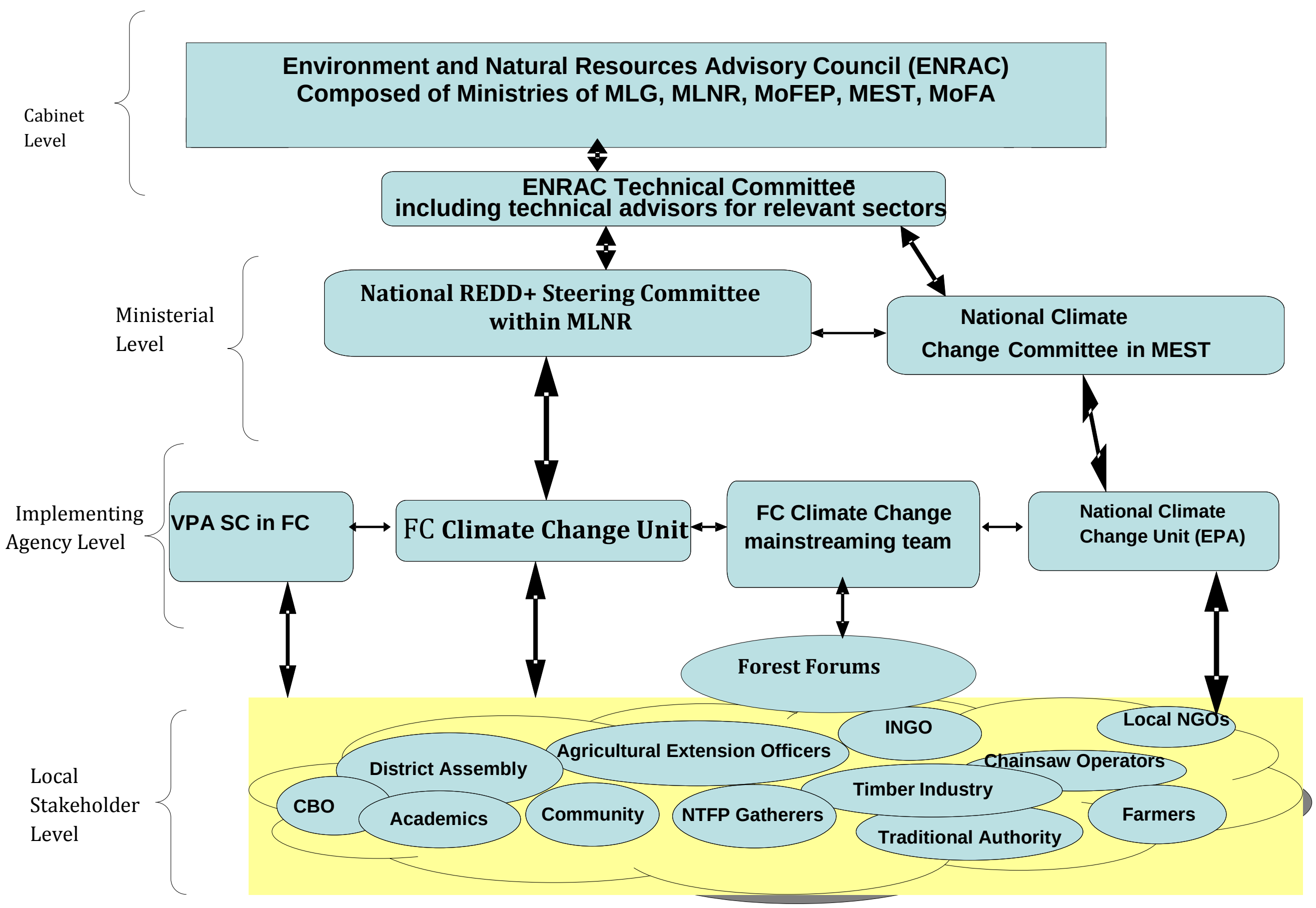

Figure 5.11 Schematic linkages between ENRAC and other stake-holders in tackling climate change in Ghana

Source: FC (2010).

5.3.16 Ghana Environmental Conventions Coordinating Authority (GECCA)

MEST (2011) reports that the GECCA project which was established in 2009 with the theme "Establishing Effective and Sustainable Structure for Implementing Multilateral Agreement" is funded by UNDP-GEF and hosted by the Ministry of Environment, Science and Technology (MEST). The project is a follow-up on the priority recommendation from the NCSA process to assess the possibility of bringing all multilateral environmental agreements (MEAs) under the proposed national conventions coordinating authority, and a Secretariat to service the GECCA. The GECCA and its Secretariat is backed up by a national Law and budget allocation. The GECCA and its Secretariat are envisaged as the entry point for all international, national and local bodies. It is designed in order to respond flexibly to the political and technical requirements under each Convention, whilst maintaining a sound structure and interactions across the Conventions. The second pillar of the strategy is 'capacity-building by doing' for the structure while the third pillar of the project strategy recognizes that, eventually, the most important Convention stakeholders are at the local level. The GECCA is made up of relevant MDAs, NGOs and others that are currently members of the UNCBD, UNFCCC and UNCCD Committees/Commissions (Figure 28). The first year operations had been mostly financed by GEF, and have from then been primarily financed by Government of Ghana. Subsequently, a detailed business plan has been developed for the Secretariat. The plan forms its structure, staffing, activities, targets, financing and monitoring. The Secretariat is expected to, by the end of the project, have performed the following tasks and functions:

- Housing the Focal Points for GEF and the three Rio Conventions;
- Taking the lead in mainstreaming Rio Conventions into sectoral activities and practices;
- Overseeing data collection, storage, dissemination and clearing.

According to GECCA (2012), The GECCA's vision is to provide dynamic leadership in coordinating efforts of all stakeholders towards addressing environmental challenges in Ghana to ensure sustainable development. Its mission is to provide a common platform for various stakeholders to build consensus and pool resources towards addressing developmental and environmental challenges facing Ghana and the global community through capacity building, awareness creation, facilitating access to data and information and support for project implementation. The GECCA is mandated to develop the institutional structure and capacity to harmonize and manage, at the national level, efforts being made by various stakeholders (Figure 5.12) into concrete action(s) for dealing with the environmental and developmental concerns facing Ghana and the global community. In that regard, the GECCA is:

- Reviewing the provisions of environmental conventions to identify programmes and projects and provide- action plans for their implementation
- Identifying and establish a network of stakeholders (NGOs and governmental institutions) whose activities seek to address the provisions of the environmental conventions
- Strengthening cooperation among various stakeholders working on the environmental conventions
- Building the capacity of target local communities for efficient implementation of projects

and activities aimed at implementing the provisions of the conventions

- Bringing to attention of stakeholders emerging issues relating to global environmental concerns and the provisions of environmental conventions
- Encouraging gender equity at the local level in connection with participation in programs and projects to address environmental and developmental concerns
- Establishing data and information network for sound decision making at the local, national and regional levels and to enable the effective participation of the public in the decision making process in the implementation of the conventions.

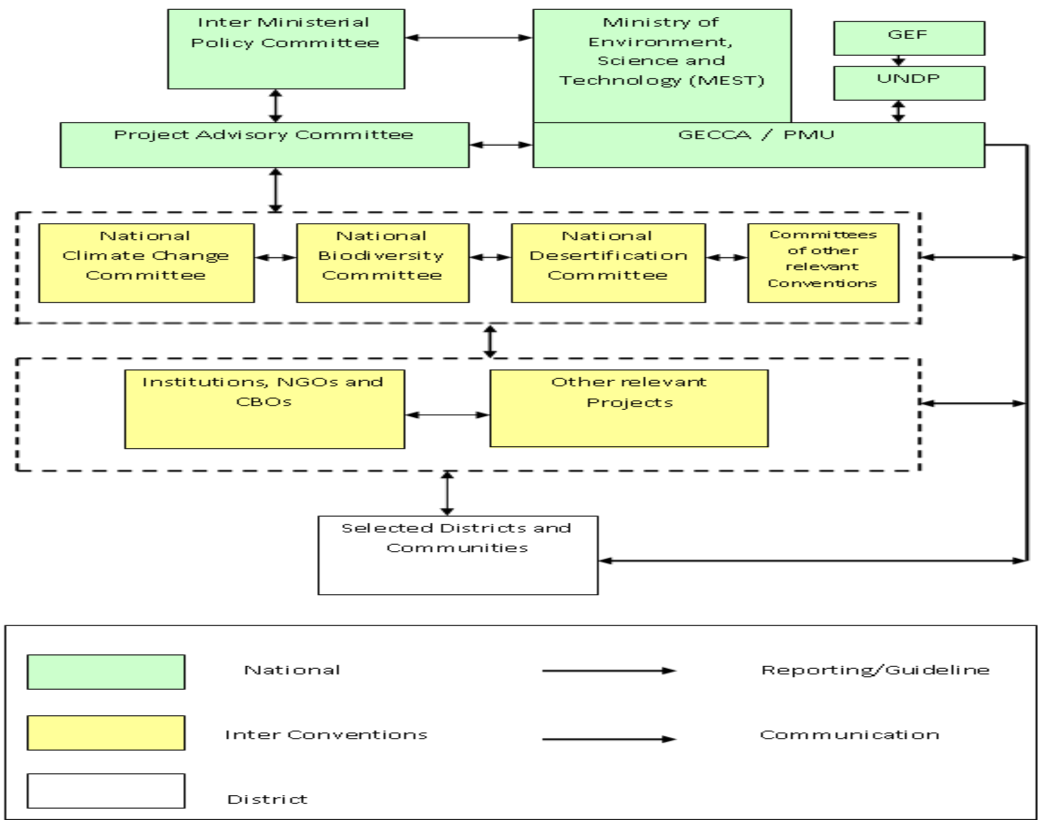

Figure 5.12 The organogram of Ghana Environmental Conventions Coordinating Authority (GECCA) showing the various stakeholders are interlinked in the project.
Source: MEST (2012).

5.3.17 Clean Development Mechanism (CDM)

According to MEST (2011), Ghana's Parliament approved a resolution to endorse the Kyoto Protocol at its twenty-fifth sitting on 26th November 2002. The last instrument of approval was submitted at the United Nations Headquarters in New York in March 2003, thereby permitting Ghana to comply with the Kyoto Protocol and becoming a Party to it. The Kyoto Protocol became functional globally on 16th February 2005. In fulfilling its commitment to the Kyoto Protocol and in accordance with Decision 17/CP.7, Ghana established its

Designated National Authority (DNA) under a ministerial directive and nominated the Environmental Protection Agency to be the host. The EPA has constituted a Governing Council for the Designated National Authority for the Clean Development Mechanism (CDM) for the purpose of protecting and improving on the quality of the environment, in terms of the implementation of the Kyoto Protocol. The members of the DNA governing council were drawn from the following institutions:

- Executive Director (Environmental Protection Agency) - Chairman
- Chief Director (Ministry of Environment and Science) - Member
- Chief Director (Ministry of Energy) - Member
- Chief Director (Ministry of Lands and Forestry) - Member
- Director (External Resource Mobilization Division, Ministry of Finance and Economic Planning) -Member
- Chief Director (Ministry of Trade and Industry) -Member
- Climate Change Focal Point (Environmental Protection Agency) -Member, Secretary

CDM Capacity Development Initiatives in Ghana

National Clean Development Mechanism (CDM) approval guidelines were formulated to assist in assessing how CDM projects contribute to sustainable development. The DNA with support from the United Nation Development Programme (UNDP, Ghana Office) undertook a number of capacity building and CDM promotion programmes for potential project developers, relevant government institutions, businesses, particularly, financial institutions. The capacity building programmes were aimed at facilitating CDM development in Ghana. In terms of international support for institutional capacity development, Ghana has benefited from a number of CDM capacity development initiatives. Ghana was among the list of countries that received capacity development support for Clean Development Mechanism Projects currently implemented by the United Nations Environment Programme (UNEP), through its UNEP RISOE Centre in Denmark (URC) with financial support from the Government of the Netherlands (MEST, 2011).

The project aimed at generating a broad understanding of the opportunities offered by the CDM in participating developing countries, and developing the necessary institutional and human capabilities to formulate and implement projects under the CDM. The DNA and two private entities, namely Kumasi Institute for Technology and Environment (KITE) and Energy Foundation in Ghana collaborated on this project. Apart from building the capacities of the DNA and other partners, the project supported development, launching and maintenance of CDM web portal for Ghana. Ghana also benefited from the Green Facility Project among a number of African countries where CDM projects are heavily underrepresented. The DNA and ENAPT Centre undertook the Green Facility Project in collaboration with UNEP RISOE Centre (URC) and financial support from the Government of Denmark through DANIDA. Under the phase 1 of the project, two project developers, Zoomlion Ghana Limited and Ghana Water Company Limited, were assisted (technical and financial) to prepare project idea notes (PINs) for two CDM projects on waste to compost in Accra and energy efficiency on the

Kpong water supply system in Greater Accra. Phase II of the Green Facility Project is intended to support project developers to further develop the PIN into project design document (PDD) toward final registration. It supported processes for matchmaking project developers with potential financiers. The DNA and the Energy Commission received training from the government of Austria through Energy Changes Projektentwicklung GmbH to develop and update national grid emission factor in 2008 and 2009, respectively. The training focused on the calculation of combined margin emission factor of Ghana's electric power system according to the UNFCCC Methodological tool (tool to calculate the emission factor for an electricity system). Though some level of success has been recorded in institutional, systemic and individual capacity development, Ghana intends to focus on scaling up involvement of the private sector, increase the technical capacity for project development and above all provide the needed policy and technical environment for CDM projects development (MEST, 2011).

CDM Project Development in Ghana

There have been deliberate national efforts to facilitate CDM development in Ghana as there are a number of projects at different stages of the CDM pipeline. For example, there is one reforestation project at validation stage, and four afforestation and reforestation methodologies proposed. There are also five CDM projects at the Project Development Document (PDD) stage and many other Project Idea Notes (PINs). UNFCCC (2015) reports of two approved CDM projects in Ghana registered at the UNFCCC. These are ZOOMLION Ghana Ltd Composting of Municipal Solid Waste in Accra area and Project Asona - CCGT in Takoradi.

According to the World Bank, Ghana has the potential to generate $45 m–100 m worth of carbon revenues per annum especially in the areas of: fuel switch, energy efficiency, avoidance of gas flaring, renewable energy and transport. However, the development of CDM projects targeting voluntary carbon markets has been comparatively forward-looking across sectors. Ghana faces a number of challenges in the development of CDM. Though the challenges border largely on under capacity, high upfront transaction costs and above all, risks, they could be categorized under: institutional, policy, data management and financial (MEST, 2011).

5.3.18 Savannah Accelerated Development Authority (SADA)

Savannah Accelerated Development Authority (SADA) is a major policy of the Government of Ghana aimed at bridging the developmental gap between northern and southern Ghana, with the North registering significantly higher levels of poverty than the Southern export economy (as indicated in Table 5.11). This is based on the findings of the 2005 International Comparison Program (ICP), which sets a new poverty line in developing countries at US$1.25 a day (ICP, 2008). The policy has a vision based on the concept of a *"Forested North and Green North"* where agricultural production is modernized and oriented towards a larger market. The policy thus contains strategic directions for sustainable development of the northern savannah. It is a decisive policy directive from the Government of Ghana, contained in the 2008 Budget Statement and Economic Policy, mandating the formulation of a long-term sustainable development plan (Figure 5.13) to reverse the trend of decades of neglect of northern Ghana. The 2008 Budget Statement also proposed the establishment of the Northern Ghana Development Fund, with an amount of 25 million cedis as seed capital. At the moment, with commitment of the Government of Ghana, an extension has been made to cover the entire Northern Savannah Ecological Belt, and a new law, SADA Act 805, 2010, being passed with the view to targeting the Northern Savannah as a distinctive development area. Thus, the strategy has been incorporated in Ghana's Medium-term Development plan prepared by the National Development Planning Commission, NDPC (SADA, 2010).

Table 5.11 Percentage of poverty of population by administrative region (1991/1992 to 2005/2006) in Ghana
Source: GSS (2007)

Region	***% of Poverty***		***% of Extreme Poverty***	
	1998/99	***2005/2006***	***1998/99***	***2005/2006***
Western	27.3	18.4	13.6	7.9
Central	48.4	19.9	31.5	9.7
Greater Accra	5	11.8	2.4	6.2
Volta	37.7	31.4	20.4	15.2
Eastern	43.7	15.1	30.4	6.6
Ashanti	27.7	20.3	16.4	11.2
Brong-Ahafo	35.8	29.5	18.8	14.9
Northern	69.2	52.3	57.4	38.7
Upper East	88.2	70.4	79.6	60.1
Upper West	83.9	87.9	68.3	79.0
All	38.5	28.5	26.8	18.2

With the SADA's policy vision of a *"Forested North and Green North"* where agricultural production is modernized and oriented towards a larger market, the policy plans to use environmentally-friendly, sustainable and improved methods to boost agriculture, including shea production, since the shea industry serves as one of the main sources of employment for the people in northern Ghana. Attention is also focused on conserving natural resources such as forests, trees including shea parklands in the area. This would not only help in realizing the policy's but would also boost shea production and facilitate addressing climate change and general environmental degradation, particularly desertification, deforestation, rampant bush burning, etc, of which the area is vulnerable to.

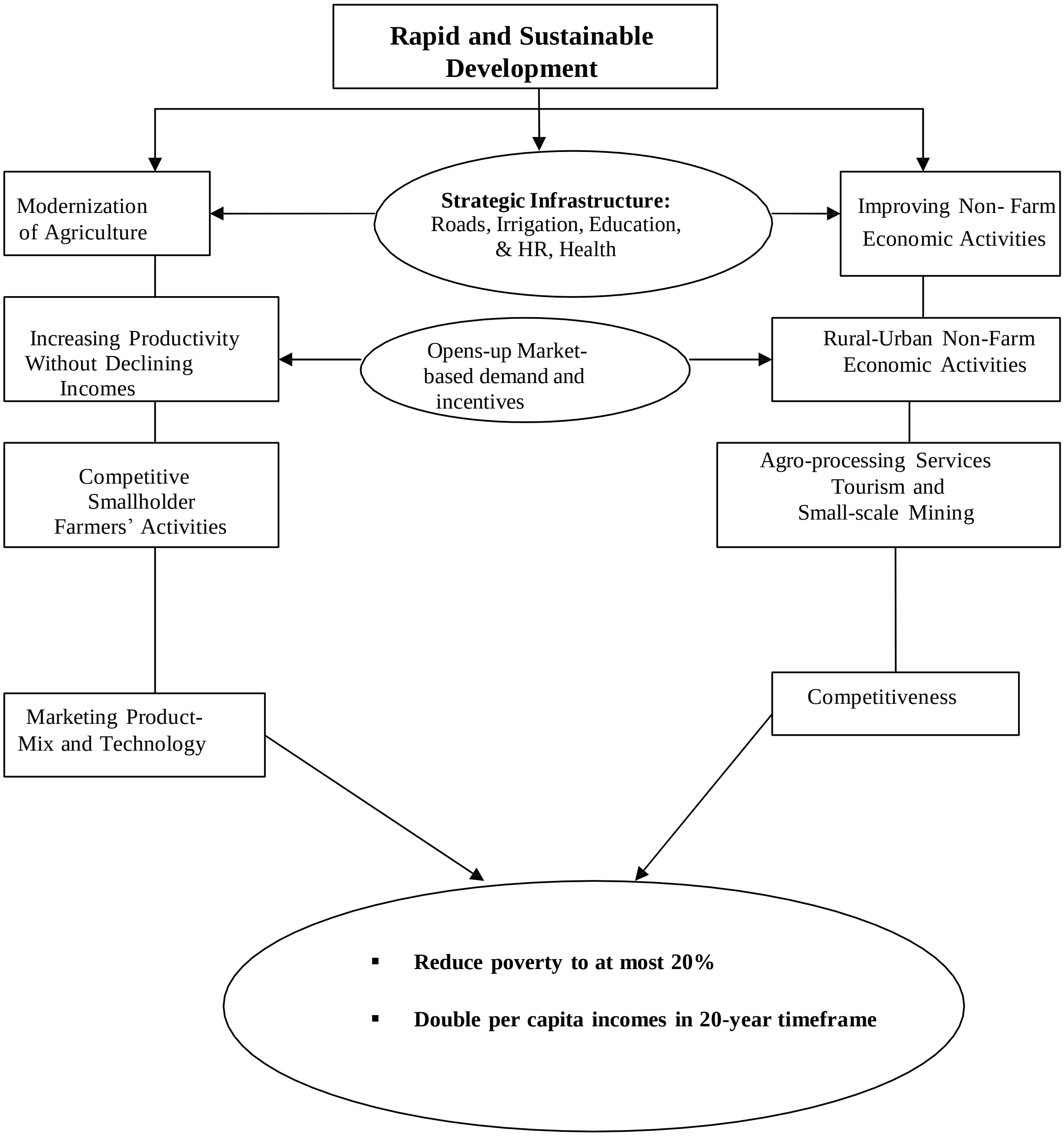

Figure 5.13 Framework of Accelerated Development in Northern Savannah
Source: SADA (2010)

5.4 Analysis and discussion

The study identified several policies and other initiatives put in place by Ghana in response to the UNFCCC international agreements. An analysis of this shows the seriousness and commitment which Ghana attaches to climate change issues as there is overwhelming evidence of its occurrence in the country, having caused much havoc leading to destruction of property and in some cases, human lives. For instance, there have some collaborative efforts among various ministries, departments and agencies in tackling deforestation, which to a large extent affects shea trees. As one of the key approaches to tackling climate change is to reduce deforestation, there is need to provide alternative fuelwood supply to people in shea-growing communities in Ghana most of them cut down shea trees for use as fuelwood. As a result, concerns have been expressed that if this trend continues, the shea industry could be adversely affected. In view of this, there have been concerted efforts by the Ministries of Petroleum, Power, Food and Agriculture, Forestry and Natural Resources, Environment Science, Technology and Innovation, Local Government and Rural Development in tackling the problems of deforestation, lack of fuel for domestic uses and food production. MESTI (2015) reports that the Government of Ghana, through Ministries of Petroleum and Power and other allied departments and agencies, has embarked upon “50% LPG penetration targets in urban and rural households” in the country. This is to provide an alternative source of fuel for cooking to curb the cutting down of shea trees for similar purposes. At the same time, the Ministries of Forestry and Natural Resources, Food and Agriculture have been raising and supplying seedlings of fast-growing tree species such as *Senna siamea, Gliricidium sepium, Leucaena leucocephala* farmers to grow for multi-purpose uses such as in using their branches as fuelwood and also their leaves as fodder for their livestock. Seedlings of shea (including grafted ones) are also raised and supplied to farmers to grow in their farms. The Ministry of Information, together with other ministries, departments, agencies, non-governmental organizationa and individuals have been embarking upon public campaigns against deforestation, indiscriminate bush burning, all in attempts to help protect shea trees and mitigate climate change.

The study also shows how much resources have been committed to the several policies and other initiatives to adapt to and mitigate climate change and how a good number of actors (governmental and non-governmental organizations, individuals, traditional rulers, communities, banks and other financial institutions, corporate bodies, religious groups, civil society groups, individuals, etc) have all teamed up at different levels and in different policy networks to tackle climate change in Ghana. The preparedness of these actors to get involved and actively participate in such important measures demonstrates how climate change impacts on every sector of the Ghanaian socio-economic environment. Analysis of the results of the study also shows that participation in climate change issues takes place at all levels in Ghana; from the President, through Cabinet, Ministerial, Implementing agency to local stake-holder level. This means climate change concerns are expressed and discussed appropriate measures are taken right from the national, regional, district, zonal, community and household level up to the individual level.

The main problem, however is that, at the community level, shea trees are cut down for use as fuelwood and in making charcoal to generate immediate income. Although such actions contravene the laws and bye-laws on deforestation, people sneak into farms and other parklands and cut down shea trees belonging to other farmers and sell them to take care of their immediate financial needs. Furthermore, farmers complained that they are not compensated for their investments into the management of shea trees. Some farmers therefore become less willing to continuously invest their time, energy and resources into managing shea trees instead of using such lands for cultivativating food crops which in their opinion yield immediate and more incomes. In addition, results of interviews with farmers such as those belonging to the Ghana Sheanuts Farmers and Pickers Association suggest that they wished COCOBOD, which is the umbrella governmental organization that oversees the affairs of cocoa, coffee and sheanuts could be made to give more attention to the shea industry just like cocoa and coffee. The famers complained that COCOBOD unfortunately appears to be too skewed towards cocoa in particular and to some extent coffee, thereby paying less attention to shea. Thus, policies formulated by COCOBOD seem to be more in favour of cocoa since it is a major foreign exchange earner. As a result, the sheanuts farmers wished the shea industry could be separated and made independent of COCOBOD so as to focus more on the affairs of shea and the management of shea trees.

5.4.1 Ghana's commitment and contribution to International Climate Change Process

Apart from the numerous policies and other initiatives formulated and being implemented or to be implemented in Ghana in line with the international climate change agreements, analysis of the research findings also show the level of commitment and contribution of Ghana to the international climate change process at the global level. MEST (2011) reports that Ghana has also made significant contribution to the international Climate Change process such as:

"

- **Climate Change Negotiations**: At the UNFCCC, regional and the sub-regional levels, Ghana is an active participant in the Climate Change negotiations. Especially at the level of UNFCCC, Ghana has made very significant contributions to the development of a number of climate resolutions and mechanisms, which aim at enabling implementation of the convention. Ghana has made enormous contributions to the Africa Group level by leading negotiations on behalf of the Africa Group, especially on Technology Transfer, REDD+ and Climate Change Adaptation. At the regional and sub-regional levels, Ghana has contributed to the formulation and advancement of common Africa position on various negotiation issues, as well as participating in activities to formulate common climate change framework for the ECOWAS sub-region. Ghana is also a member of the ECOWAS climate change committee.
- Ghana was and continuous to be a member or an alternate member of the following "groups" of the convention:

a. Adaptation Fund Board (ADF) –Alternate member
b. Consultative Group of Experts on National Communications from Parties not included in Annex I to the Convention (CGE) – Member
c. Expert Group on Technology Transfer (EGTT) – Former Member

- **Inter-governmental Panel on Climate Change (IPCC):** Ghana is fully represented at the IPCC and has served on a number of working groups and tasks force. Ghanaian scientists are working in Working Group II (WG II) and Working Group (WB III), under the Firth Assessment report (AR5), as lead and contributing authors. In addition, a Ghanaian scientist contributed to the IPCC Special Report on Renewable Energy Resources and Climate Mitigation (SRREN)".

5.4.2 Actor-networking and participation of private sector

Findings of the research also demonstrate the extent and level of participation of the actors. It was heart-warming to discover, during the study, that the degree of commitment and active involvement of the actors was commendable and satisfactory, with some serving on a number of committees, policy formulation and implementation, as well as assessment/evaluation of the policies and other initiatives. At several levels on a particular policy formulation, these actors work together and are linked in a sort of actor-networks, with inputs moving in a hierarchical or in multiple directions but in a coordinated manner. All the policies and other initiatives identified during the study work in a coordinated network fashion such as in the Ghana Shared Growth and Development Agenda (GSGDA), National Climate Change Policy Framework, REDD Readiness Plan Development. Notwithstanding all these efforts put in place to tackle the problems of deforestation, land degradation and other environmental and climate change problems, there is the need to tackle the core issue of poverty in all sectors of the economy since it is the driving force that compels people to do acts that tend to pose a danger to the environment.

It was also noticed that there were issues of multiple representation and duplication of efforts. For instance, an actor could be playing multiple roles in different capacities in a particular policy framework or initiative or a number of policies virtually having the same aims, objectives, strategies, etc. A situation of duplication of efforts could arise since the same activity is being done under different policies or initiatives. This could, however, be an added advantage as when such common activities are well-organized and well-coordinated they could lead to the realization of the set aims and objectives of the different policies or initiatives. A case in point is the setting up of a climate change unit in almost every ministry to deal with climate change issues in the country. Although it may seem like duplication of efforts, every climate change unit is tasked to deal with specific programmes and projects within the mandates of its ministry. Ultimately, however, all the various units of the ministries harmonize their programmes and projects together through networking to achieve the main objectives of tackling national and global climate change problems.

In the networking, however, challenges could emerge if an actor fails to carry out its tasks in a particular policy framework. For instance, in a chain-command network or hierarchical network if an actor, for some reasons, is unable to perform its responsibility or task the networking could adversely be affected since that task that has not been performed could break that chain of responsibilities, unless appropriate measures are taken by other actors in the network to fill in the gap. In the Institutional arrangement for coordinating Climate Change activities in Ghana, if Ministry of Energy (now split into Ministries of Petroleum and Power) and other allied bodies are for instance are unable to supply the proposed LPGs to rural and urban communities for cooking and other domestic uses, the objective of curbing the felling of trees for use as fuelwood will not be realized. If Misnistries of Food and Agriculture, Lands and Natural Resources, Environment, Science, Technology and Innovation, Information, etc, are unable to supply tree seedlings or effectively dessiminate information to educate people on the hazards of deforestation, land degradation, etc, then the ultimate goal of tackling the felling of shea trees and climate change will not be realized.

Private sector participation was also noticed during the research, with hundreds of non-governmental organizations, private civil society groups, private individuals, etc, actively participating in policy formulation and implementation at various levels in the adaption and mitigation of climate change processes in Ghana. Private sector participation in climate change activities in Ghana are in several forms including making contributions and inputs intellectually, financially, logistically/provision of physical resources, etc. Examples are Kumasi Institute for Technology and Environment (KITE) and Energy Foundation that have been very active and instrumental in this regard. These two private organizations have served as the DNA for the National Clean Development Mechanism (CDM) in Ghana. In collaboration with the United Nation Development Programme (UNDP, Ghana Office), KITE and Energy Foundation organized capacity building and CDM campaign programmes and activities for prospective project developers, appropriate government institutions, business organizations such as financial institutions. These capacity building programmes were designed towards enhancing the development of CDM in Ghana.

5.4.3 Organization and coordination

Interviews and discussions conducted during the study as well policy documents analyzed show how well-organized and coordinated the policy frameworks were, with actors assigned their roles and responsibilities in different capacities. Each policy or initiative is also coordinated by an institution and/or serves as the coordinating unit for the formulation and/or implementation of its assigned policy. Findings of the study also indicate the level of commitment and well-laid-out plans that have been developed in each policy framework, leading to harmonization, organization and coordination of policy implementation. All these efforts by the various actors involved in climate change activities will yield fruitful results if the living conditions of the vast majority of Ghanaians are improved through poverty alleviation programmes. With their living conditions improved, the people will stop cutting down the shea trees or resorting to other means of survival that lead to deforestation and environmental degradation. This will help reduce deforestation and motivate them to fully appreciate and participate in the protection of shea trees and the environment in general as well as in climate change mitigation and adaptation programmes.

5.4.3 Funding of Climate change activities

Ghana is a lower middle-income economy and yet it is still grappling with poverty and other under-development issues. The country has, however, devoted a substantial percentage of its financial and other resources to deal with climate change issues, in addition to contributions from multi-lateral countries and agencies as well as other donor and funding national and international institutions. Examples of such projects, programmes and other initiatives costing millions of dollars, fully or partly funded by the Government of Ghana (GoG) are those on renewable energy such as Renewable Energy-Based Electricity for Rural, Social and Economic Development in Ghana (RESPRO), Transformation of lightning market from incandescent to CFL bulbs, Ghana Energy Development and Access Project GEDAP (formerly) Development of Renewable Energy and Energy Efficiency, Ghana Urban Transport; forestry and landuse sector such as Ghana Natural Resource and Environmental

Governance, National Forestation Plantation Development Program (NFPDP), as well as several other initiatives.

5.4.4 Focus on Shea

As shea has been very important to Ghana, in terms of being the leading non-traditional agricultural export (GEPC, 2006) and contributing significantly to the growth of the economy as well as being a major source of revenue for households and individuals in shea-growing areas in Ghana, all the policies and other initiatives formulated and implemented or to be implemented eventually impact on shea, or have modules that are aimed specifically at the management and production of shea as well as conservation of shea parklands in Ghana. Examples are COCOBOD's policy on shea (COCOBOD, 2012) which aims at the development, production, protection/conservation and management of shea parklands in Ghana; SADA's policy vision of a "*Forested North and Green North*" which aims at improving and modernizing agricultural production, including development and increased production of shea.

5.5 Conclusion

Findings of the research clearly demonstrate the magnitude of the impact of climate change on Ghana, particularly on life and property. The research results also show the extent to which Ghana has responded to the various international agreements on climate change of the UNFCCC; with several policies and other initiatives having been formulated and implemented or planned to be implemented to manage or deal with the climate change concerns. It also shows the quantum of resources (financially, intellectually, logistically, etc,) that Ghana has invested into climate change adaptation and mitigation policies and initiatives. Participation of the actors in the various policy planning and implementation has been remarkable, judging by the extent to which set targets and objectives of the policies and other initiatives are being achieved. Results of the research also show how these policies and other initiatives have implications for the shea industry in Ghana if properly implemented, with some stakeholders interviewed expressing satisfaction at the formulation of the various policies and initiatives. Additionally, if concerns of shea farmers could be addressed and more attention paid to the shea industry and more resources invested in compensating and motivating farmers to manage shea trees, the shea industry could thrive better. Thus, farmers will be willing to manage existing shea trees and even grow more to earn them additional incomes through the sale of carbon credits from their shea parklands. This in the long run will help in mitigating climate change through carbon sequestration by the shea trees.

CHAPTER SIX

6. Management of shea parklands and the perceived impact on livelihoods of farmers

This chapter presents findings of a study on the strategies and practices farmers adopt and use to manage shea trees and their impact on the livelihoods of people in shea-growing communities of Ghana as well as on the global environment.

6.1 Introduction

6.1.1 Background to the study

The shea tree is a multipurpose tree crop native to sub-Saharan Africa. It is immensely valued for the oil that is produced from its nuts and used locally and worldwide in cosmetics, pharmaceutics and in chocolate formulations (Bup *et al.,* 2014). The shea tree is generally considered to be one of the most important tree species in the West African parklands. Its uses range from provision of income to environmental services in the semi-arid region (Teklehaimanot 2004; Okullo *et al.,* 2004; Byakagaba *et al.,* 2011). The edible fruit pulp of the tree is consumed by both humans and animals while the butter is generally used in cooking food as well as in the pharmaceutical and confectionery industries for the production of useful products such as body creams and lotions and other body healthcare products (Lamien, 2007). The tree serves as the bedrock on which most households in northern Ghana depend for survival as it provides jobs for nearly 85% of the people in that area.

Despite all these benefits, over the past decades the trees have been cut down for various uses, including clearing them to create space for the cultivation of food crops as well as for fuelwood for domestic uses and for sale. These have resulted in drastic reductions in the shea tree populations in Ghana. Most of the trees could have been conserved and managed alongside food crops, but insecure land and tree tenure serve as a disincentive for tenant farmers in particular to manage trees (McDermott and Schreckenberg 2009, 163), and this has contributed to the declining numbers of shea trees in Ghana. As a result, a lot of concerns have been expressed as to how to reverse these worrying trends as the populations of shea trees have significantly dwindled over the past decades. In view of this, in recent times there have increasingly been on-going studies and discussions on how to deal with these disturbing developments of decreasing shea tree populations (Okiror *et al*., 2012, Okullo *et al.,* 2012 and Buyinza and Okullo, 2015). One of the identified promising panaceas lies in the conservation of the trees through farm management practices (PN Lovett and Haq, 2000; Takimoto *et al*., 2008; Okiror *et al*., 2012; Okullo *et al.,* 2012 and Buyinza and Okullo, 2015).

The traditional management of shea parklands usually involves the use of farming strategies and practices to manage and conserve shea trees, and these have been identified as the most effective way of tackling the problem of the decreasing shea tree populations. During such management activities, mature trees are preserved during each cycle of land preparation for farming and constitute a major part of the indigenous farming system (Tabuti *et al.,* 2009). The trees profit from agronomic practices such as weeding and management of soil fertility carried out for annual crops (Masters *et al.,* 2004) and increase in growth and yield. Ultimately, these trickle down to improve the livelihoods of households and communities that manage the trees, and in turn help to conserve trees (Bigombe Logo, 2004; Oyono *et al.,* 2006) since farmers are able to derive financial and other benefits from the trees. As there is scanty or no data on such impacts in shea-growing areas of Ghana, it is worth considering the extent to which these management practices have impacted on the shea trees, the farmers and as well as on the global environment. As such, this study was conducted to find out the strategies and practices used by farmers in Ghana in managing shea parklands and how these impact on their livelihoods and on the global environment.

6.1.2 Research Questions and Objectives of the research

This study was therefore conducted to address the following research question:
Research Questions to the study

- *How does community shea parkland management impact on the shea trees, the livelihoods of people in the local communities in Ghana as well as on the global environment* ***?***

Sub questions

The following sub questions were used to help address the research question:

i. How are lands acquired for farming shea and which practices are undertaken by farmers at the local community level to manage shea parklands in Ghana?
ii. What benefits are derived from the management of shea and how do these benefits impact on the livelihoods of people in the local communities
iii. What constraints and socio-demographic and management factors influence the conservation of shea in Ghana?

6.2 Methodology

6.2.1 Study location and land-use systems

The study was conducted in the shea-growing area of northern Ghana; the three northern savannah agro-ecological zones of Ghana. One region in each zone was selected for study. Thus, three regions, Upper East region (representing Sudan savannah zone), Northern region (representing Guinea savannah zone) and Brong-Ahafo region (representing the transitional forest/savannah zone) were selected for the research.

6.2.3 Data collection

Sampling techniques

The study was done at 2 levels; the local community and household levels. Specific key-informant interviews and personal observations were used to gather the required information. The focus of the study was on land/tree tenure, land/tree ownership, management strategies and practices, conservation, utilization and impact of shea on the global environment and livelihoods of the local people in the shea-growing areas of Ghana.

The multi-stage sampling design

Multi-stage sampling designs involve multiple stages of sub-sampling and are appropriate for large-scale sampling. They are recommended for a number of practical reasons including for administrative convenience. Selection of units is done in stages and the design has the advantages of being less costly compared to other sampling designs. For these reasons, a multi-stage sampling design was used in this study as it covered a fairly large study sample from a relatively large geographical area. The multi-stage sampling design was therefore used to select representative sampling units from the three savannah zones of northern Ghana.

1. At the first stage (Regional level), purposive sampling technique was used to select the 3 regions within the ecological zones of shea-growing areas in northern Ghana.

2. The second stage (District level) involved using a simple random sampling technique to select 3 districts in each region.

3. At the third stage (Community level), a simple random sampling technique was used to select 3 communities in each district.

4. The fourth stage (Household level) of the sampling design entailed using a simple random sampling technique to select 30 households per community for interview.

5. The fifth and final stage (Individual level) comprised purposively selecting 2 persons (a male and a female) in each household.

Due to the fact that the shea industry involves the active participation of both men and women in the management and processing of shea respectively, both men and women were selected for interview. Consequently, based on the selection criteria described above (3 regions x 3 districts x 30 households x 2 persons), a total of five hundred and forty 540 people (Table 6.1) were chosen using the multi-stage sampling technique.

Table 6.1 Selection of respondents using the multi-stage sampling design for the study

	Zone	***Region***	***District***	***Community***	***No. of Households***	***Respondents***	
						Male	***Female***
1	*Transitional savannah*	*Brong-Ahafo*	*Kintampo North*	*Kawampe*	*30*	*30*	*30*
2			*Tain*	*Old Longoro*	*30*	*30*	*30*
3			*Pru*	*Yeji*	*30*	*30*	*30*
4	*Guinea*	*Northern*	*East Gonja*	*Fuu*	*30*	*30*	*30*
5			*Tamale*	*Nyeshei*	*30*	*30*	*30*
6			*Kumbungu*	*Cheyohi*	*30*	*30*	*30*
7	*Sudan*	*Upper East*	*Kassena-Nakana East*	*Paga-Badunu*	*30*	*30*	*30*
8			*Kassena-Nakana West*	*Gia*	*30*	*30*	*30*
9			*Bolgatanga*	*Kulbia*	*30*	*30*	*30*
Total numbers of respondents					***270***	***270***	***270***
Overall total number of respondents selected for the study						***540***	

6.2.4 Statistical analysis and interpretation and presentation of results

Responses of the questionnaires that were administered in the research were analyzed using

Microsoft Excel and Statistical Package for Social Sciences (SPSS) programme. Logistic regression analysis, Pearson correlation and cross-tabulation in SPSS were used to investigate the relationship between socio-demographic factors and willingness to manage shea trees. The analyzed data were then interpreted and the results were presented in the form of tables, histograms, pie-charts and cumulative curves.

6.3 Results

6.3.1 Socio-economic characteristics of respondents

A total of 540 respondents (50% males and 50% females (Table 6.2) were selected for the study. About 17.59% of them were in the young age group (below 30 years), 55.56% were within the middle group (30-49 years), 25.19% were in the ageing group (50-69) while 1.67% were in the aged category (>69 years). About 92% of the respondents were natives in their communities, while a little over 7% said they were non-natives. All the respondents indicated that they have been residing in the communities for decades now, with only occasional short duration visits to other communities to attend to personal, household and other matters. Almost 93% of the respondents said they were married, about 3% were widowed, almost 3% were single while about 1% were divorced. Approximately 40% had a household size of 1-5, about 50% had 5–9 people in their households, while approximately 9% had a household size of more than 10. Approximately 65% indicated that were muslims, almost 19% were Christians while about 16% practised the African Traditional Religion. Almost 74% of the respondents had never had any formal education while about 26% had at least studied up to basic education level. The majority (almost 77%) of the respondents were peasant farmers while about 21% were traders. Approximately 62% had up to 4 ha of shea parkland farms and almost 38% had more than 4 ha of shea farms.

Table 6.2 Socioeconomic characteristics of respondents

Factor	**Sex**		**Total**	**Percentage**
	Male	***Female***		
Age (years)				
<30	25	70	95	17.59
30-49	149	151	300	55.56
50-69	91	45	136	25.19
>69	5	4	9	1.67
Native or non-native				
Native	253	247	500	92.59
Non-native	17	23	40	7.41
Marital status				
Married	261	241	502	92.96
Single	9	6	15	2.78
Widowed	0	17	17	3.15
Divorced	0	6	6	1.11
Gender				
Male	270	-	270	50.00

Female	270	-	270	50.00
Household size				
1-5	109	-	109	40.37
6-10	136	-	136	50.37
>10	25	-	25	9.26
Religion				
Islam	174	178	352	65.19
Christianity	46	56	102	18.89
African Traditional Religion	50	36	86	15.93
Educational status				
None	192	206	398	73.70
Basic*	50	55	105	19.44
Secondary	16	2	18	3.33
Tertiary	1	2	3	0.56
Others**	11	5	16	2.96
Primary occupation				
Farming	262	153	415	76.85
Trading	5	113	118	21.85
Civil service	2	0	2	0.37
Teaching	1	0	1	0.19
Dress making	0	2	2	0.37
Hair dressing	0	2	2	0.37
Farm size (ha)* **				
<3	65	-	65	24.07
3-4	103	-	103	38.15
>4	102	-	102	37.78

According to the Ministry of Education of Ghana (2012), *Basic education or Universal Basic Education in Ghana is 11 years, made up of:

i. 2 years of Pre-primary school (nursery/kindergarten);
ii. 6 years of Primary School: Primary 1 to Primary 6
iii. 3 years of Junior High School.

**"Others" here refers to other forms of education such as Non-formal education, Arabic education, etc.

*** Traditionally, women do not necessarily own land in the study area. Lands they farm on are in the name of male members of their families (such as their husbands, family heads, clan heads, big brothers, etc).

6.3.2 Land and tree tenure

As indicated in Table 6.3, almost 98% of the respondents indicated that they own[4] the farmland that they were working on together with the shea trees growing on them, while approximately 2% said they did not own their farmlands. About 81% of the farmers explained that they inherited the farmlands together with the shea trees while 16.30%, 1.48% and 0.74% indicated that the modes of land acquisition were respectively by gift, renting and by purchase. Almost 61% indicated that they had authority over the land they were working on, while about 21%

[4] The respondents said they own the land (that belongs to their clans and families) and can sell it but with the consent of the heads of their clans, families and the chief of the community

said the chief of the community possessed the authority[5] on the affairs of the farmlands they were working on.

Table 6.3 Land and shea tree tenure in Ghana

Factor	Sex		Total	Percentage
	Male	*Female*		
Ownership of land and trees				
Yes	264		264	97.78
No	6		6	2.22
How land was acquired				
Inherited	220	-	220	81.48
Gift	44	-	44	16.30
Renting	4	-	4	1.48
Purchased	2	-	2	0.74
Authority over land				
Self	164	-	164	60.74
Chief	58	-	58	21.48
Clan	18	-	18	6.67
Traditional Chief Priest	16	-	16	5.93
Family	12	-	12	4.44
Landlord	2	-	2	0.74

6.3.3 Farmers' strategies for managing shea trees

Approximately 92% explained that they carried out management practices on the shea trees while almost 8% indicated that they did not manage the trees. Nearly 90% of the respondents said they travelled up to 6 km from home to manage the shea trees on their farms while about 10% indicated that they covered a distance of more than 6 km from home to manage the trees on their farms (Table 6.4).

Table 6.4 Farmers' strategies for managing shea trees

Factor	Sex		Total	Percentage
	Male	*Female*		
Do you manage the shea trees				
Yes	249	-	241	92.22
No	21	-	21	7.78
Distance of farm from home (km)				
<3	135	-	135	50.00
3-4	74	-	74	27.41
5-6	35	-	35	12.96
>6	26	-	26	9.63

[5] The Chief has authority over lands in his community. He serves as the custodian of lands for and on behalf of the people of his community.

Do you manage the shea trees				
Yes	264	-	264	97.78
No	6	-	6	2.22
Would you have preferred cultivating only food crops on your farm?				
Yes	56	-	56	20.74
No	214	-	214	79.26
Are you planning to remove the shea trees from your farm and cultivate only food crops?				
Yes	9	-	9	3.33
No	261	-	261	96.67

The identified shea systems being practised in the study area were shea agroforestry; shea trees intercropped with food crops; shea parklands on fallow lands with other trees but dominated by shea trees; shea parklands dominated by other tree species and other forms of vegetation; shea home gardens. e.g. backyard gardens, vegetable/crop gardens, etc. and; small pockets of shea trees within communities. e.g. by schools, etc.

Results of the study revealed that almost all (more than 90%) of the households in the northern savannah agro-ecological zones of Ghana said, realizing how shea trees are destroyed through activities such as logging and bush burning they do their best in raising and protecting shea trees deliberately on farm by allowing natural regeneration, creation of fire-belts around farms and trees, weeding around shea trees alongside other crops during cultivation, discouraging other people from felling the trees and mounding soil around trees to cover their exposed roots. The farmers explained that, although their efforts are not so much in significantly increasing populations of shea trees, they try their best to protect the existing ones. They appealed for assistance in the form of financial support, farm inputs such as working tools and equipment as well as pesticides for the protection and conservation of the shea trees. Up to 80% of the respondents indicated that they employed other management strategies such as planting and using other tree species as substitutes for fuelwood, pruning branches of shea trees, planting of shea trees on farms, control of insect pests and diseases and manure application (Table 6.5).

Table 6.5 Local strategies by farming households for managing and conserving shea trees in Ghana.

Management practice	**Response**	
	Frequency	***Percentage***
Creation of fire-belts around farms and trees	269	99.63
Preventing people from cutting down shea trees	268	99.10
Management of young trees to grow well by natural regeneration	263	97.10
Mounding of soil around exposed roots of trees	247	91.48
Weeding around shea trees	245	90.74
Planting/using other tree species as substitutes for fuelwood	213	78.89
Pruning branches of trees	174	64.44
Planting of shea trees on the farm	41	15.19
Control of insect pests and diseases	18	6.67
Manure application	11	4.07

6.3.4 Benefits derived from shea and the impact on the livelihoods of farming households

Benefits derived from shea

All the respondents indicated that they derived benefits from the shea trees in one way or the other. When each of the respondents was asked to rank and mention one single most important benefit derived from shea, approximately 47% of the farmers mentioned income as primary benefit derived from shea. This was followed by sheabutter (43.70%), fuelwood (5.19%), shea litter fall as manure for crops (1.11%), wood for roofing houses (0.74%) and shade (0.37%) in a descending order (Table 6.6).

Apart from identifying the single most important benefit derived from shea, another round of questioning was done to find out from respondents other benefits derived from shea. In this "other benefits" category, sheabutter was ranked by almost 93% of the respondents as first, while up to about 49% identified "other benefits" such as shea fruits, fuelwood and income (Table 6.7).

Azara Nindow, a female farmer in Nyeshei in the Tamale Metropolis of the Northern Region said:

"We the women process the shea nuts we harvest from our farms into shea butter. We sell the shea butter to get income to take care of our families and support our children in school. The sad thing is that the shea trees are fast decreasing in numbers because some people are destroying them. Please, we need help. Our husbands are doing everything they can to protect and manage the trees but they need help to manage and protect the trees very well"

Table 6.6 Ranking of the primary (first single most important) benefits from shea trees in Ghana

Most important benefit*	**Response**	
	Frequency	***Percentage***
Income	126	46.67
Sheabutter	118	43.70
Shea fruits	14	5.19
Fuelwood	6	2.22
Shea litter fall as manure for crops	3	1.11
Wood for roofing local houses	2	0.74
Shade	1	0.37

*****Each farmer was requested to name the single most important benefit from shea.

Table 6.7 Farmers' responses on other important benefits from shea trees in Ghana

Other important benefits	**Response**	
	Frequency	***Percentage***
Shea butter	169	92.59
Shea fruits	132	48.89
Fuelwood	115	42.59
Income	59	21.85
Soap	32	11.85
Shade	28	10.37
Roots for medicinal preparations	11	4.07
Sheabutter residue used as manure/compost	4	1.48
Leaves as fodder for domestic animals	4	1.48

Gum	3	1.11
Windbreaks	2	0.74
Sheabutter waste used as fuel material	2	0.74
Wood used to carve mortars, pestles, etc	2	0.74
Sticks used as stakes to support yam vines	2	0.74
Branches used as roofing materials	2	0.74

Quantity of sheanuts harvested per household per year

The responses of this part were obtained from women since they are basically responsible for the harvesting, processing and marketing of shea products (mostly shea butter). Other harvested products were usually consumed locally at home and/or given out as gifts to other extended family members, friends, neighbours, traditional authorities and other community leaders.

Harvesting of shea nuts, processing and marketing of the products are the responsibilities of the wives and other females in the household. As a result, to determine the quantity of sheanuts harvested per household per year, all the 270 women were interviewed during the research in the study area; one in each household. Of the 270, the majority (87%) of the women said they harvested up to 5 bags per year, while 7% indicated that they harvested 6-10 bags, 3% (more than 15 bags), 3% (less than 5 bags) and 1% harvested 11-15 bags per household per year (Figure 6.1).

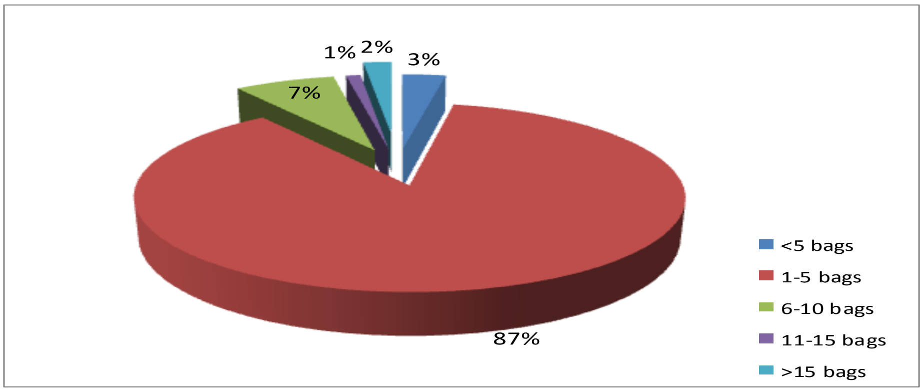

Figure 6.1 Quantity of sheanuts harvested in Ghana per household per year

Impact of benefits of shea on the livelihoods of farming households

Generally, the research identified the rural shea industry as a two-phase industry in the farming households in the study area; management and conservation aspects being done by men while harvesting, processing and marketing being the preserve of women. After selling the shea products, women therefore keep the accrued income and use it in taking care of the economic needs of their households. As such, as indicated in Figure 6.2, of the 270 women interviewed, majority of them (74%) indicated that the general income realized from shea constituted up to 20% of the total income of the household per year, while 25% and 1% said income from shea respectively formed 21-40% and 41-60% of their total household income per year.

Income from shea

In terms of cash income, majority (74%) of the farmers interviewed indicated that income from shea constituted up to 20% of their total household income per year while 25% and 1% said income from shea represented 21-40% and 41-60% of total household income per annum respectively (Figure 6.2).

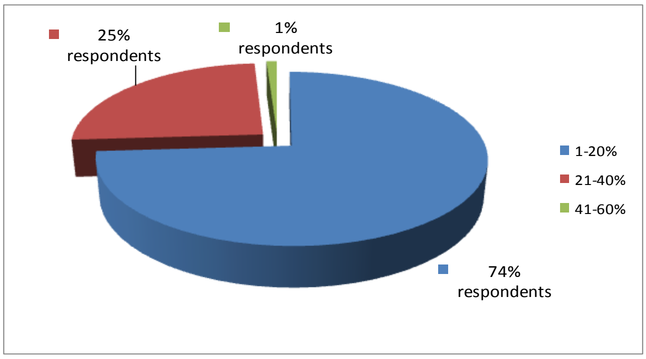

Figure 6.2 Percentage contribution of shea income to total annual household income in Ghana.

This was valued in terms of how much shea contributes to the family budget in order to answer the question: *of what percentage is shea revenue to the total annual household budget?*

Income from other shea products

Apart from the main shea products (sheanuts, sheabutter and shea fruits) all the 540 respondents explained that other shea products also played significant roles in the economic needs of their households. As a result, of all the other shea products mentioned, 43% of the 270 female respondents said soap (made from sheabutter) was the highest income-earner in the "other shea product income-earners" category, while fuelwood, charcoal and shea by-products constituted 29%, 14% and 14% respectively (Figure 6.3). Shea by-products included shea 'waste water' obtained after extracting the butter. The 'waste water' is used during construction of houses, particularly in plastering walls and floors of rooms and houses. Such by-products, when requested for, are sold to generate additional income for the household.

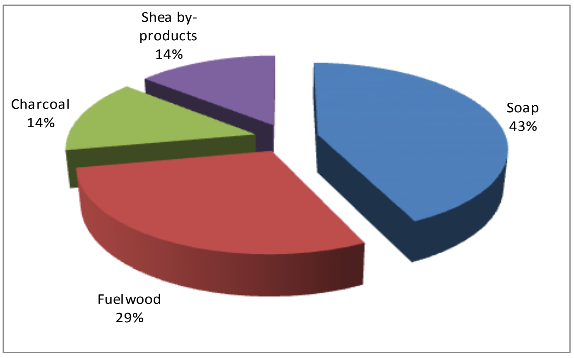

Figure 6.3 Percentage income contribution of other shea products in the "other shea product income-earners" category in Ghana.

Uses of economic benefits from shea trees in Ghana

On the question of uses of economic benefits from shea, about 52% said they used such benefits for the general upkeep of their households while payment of wards' school fees was mentioned by nearly 38% of the farmers. Purchase of clothing, cooking utensils & other household items, food for the household, investing into farming, medical bills and other general health needs of household as well as investment into livestock as household property ranged from about 17% to 0.74% of the farmers' responses (Table 6.8).

Table 6.8 Uses of economic benefits from shea trees in Ghana

Use of economic benefits from shea	**Response**	
	Frequency	***Percentage***
For general upkeep of household	141	52.22
Payment of wards' school fees	102	37.78
Purchase of clothing for household	45	16.67
Purchase of cooking utensils & other household items	38	14.07
Purchase of food for the household	35	12.96
Used to increase farm size & hire farm labour	21	7.78
Payment of medical bills & other general health needs of household	19	6.99
Investment in livestock as household property	6	2.22
Investing in roofing and repair of house	2	0.74
Investments in other items as property for children	2	0.74

6.3.5 Management constraints of shea trees in Ghana

High labour demand, lack of funds, lack of working tools and planting material, lack of strict implementation of laws against deforestation, injuries from working tools and chemicals, burns from bushfires, risks of snake bites, scorpion and bee stings during management of the shea trees were the major constraints mentioned by all (100%) the respondents (Table 6.9). Up to 94% of the farmers also identified low education on the growing and management of shea trees, destruction of seedlings, young trees and roots of trees by wind, running water, bushfires and pests and diseases as the management constraints they encountered.

Table 6.9 Management constraints of shea trees in Ghana

Management constraints	**Response**	
	Frequency	***Percentage***
Labour intensive & less attention for trees due to other responsibilities	270	100.00
Financial constraints & inadequate working tools, planting material, etc.	270	100.00
Lack of strict implementation of laws against deforestation in Ghana	270	100.00
Injuries from working tools and chemicals, burns from bushfires	270	100.00
Danger of snake bites, scorpion stings, bee stings during tree management	270	100.00
High cost of labour & inadequate labour	254	94.07
Low education on the growing and management of shea trees	254	94.07
Seedlings, young trees and roots of trees destroyed by winds, running water, etc	251	92.96
Trees felled for fuelwood, charcoal, ceremonial activities, etc	248	91.85
Destruction by bushfires and pests and diseases	243	90.00
Lack of interest in growing/managing the tree as it takes a long time to mature	230	85.19
Complaints about the adverse shading effects on crops	219	81.11
Low interest in growing/managing shea due to long gestation period & low returns	216	80.00
Land/tree tenure problems and scarcity of land	192	71.11
Inadequate market for shea products	189	70.00
Inadequate knowledge/skills on tree management	184	68.15
Socio-cultural & religious beliefs	149	55.19

6.3.6 Authority over the land and the shea trees

Who has the authority in making decisions on the management of Shea Trees in communities in Ghana?

Men are regarded as heads of families in the communities and they have authority over land, farms and shea trees and make decisions on how to manage them. From the study, farmers and the chiefs (traditional leaders in the communities) were identified as the main authorities and formed 60% and 20% of the main decision makers in the shea tree management within the communities sampled. Other identified decision makers were traditional chief priests (7%), Clan heads (6%), family heads (5%) and landlords (2%) (Figure 6.4).

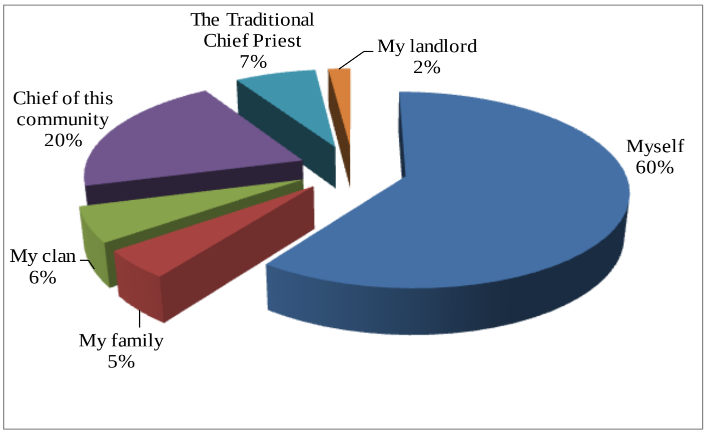

Figure 6.4 Who has the authority to decide on management of shea trees in communities in Ghana?

6.3.7 Management of Shea Trees by Farming Households

Of the main socio-demographic and shea tree management characteristics that influence continuous management of shea trees by farmers studied, cross-tabulation analysis shows that respondents' continuous management of shea trees is significantly influenced by whether one is a *native* to the village *or non-native, mode of land acquisition, distance of farm from home, ownership of the farmland and shea trees, authority over land and shea trees and benefits from the shea trees* (Table 6.10).

With regards to whether one is a native or a non-native, natives said they want to continue (84.8%) managing shea trees than non-natives (6.7%). Land acquisition also influenced attitudes towards continuous management of shea trees. A cross-tabulation (Table 6.10) shows that farmers with farmlands acquired through inheritance had the highest interest (56.7%) in the management of shea trees. Farmers with shea trees of less than 3 km from their homes were also more willing to manage the trees (53%). With regards to ownership and authority over the land and the shea trees, farmers who own the land together with the trees (58.5%) and those who have authority over the shea trees (58.9%) said they want to continue managing the trees.

Table 6.10 Cross-tabulation of indigenousness, how land was acquired, distance of farmland, ownership and authority over the land, owned against respondents' willingness to manage shea trees (N = 270).

	Percentage of farmers who want to continue managing shea trees		
Variable	**Yes**	**No**	**Total**
Native			
Native	84.8 (229)	6.7 (18)	91.5 (247)
Non-native	7.4 (20)	1.1 (3)	8.5 (23)
How farmland was acquired			
Purchased	17.0 (46)	0.0 (0)	17.0 (46)
Inherited	56.7 (153)	5.2 (14)	61.9 (167)
Gifted	14.4 (39)	2.2 (6)	16.7 (45)
Rented	4.1 (11)	0.4 (1)	4.5 (12)
Distance of farm from home			
< 3 km	53.0 (143)	1.1 (3)	54.1 (146)
3 - 4 km	21.9 (59)	4.8 (13)	26.7 (72)
5 - 6 km	9.6 (26)	1.1 (3)	10.7 (29)
> 6 km	7.8 (21)	0.7 (2)	8.5 (23)
Who owns the land with the shea trees			
Myself	58.5 (158)	1.1 (3)	59.6 (161)
My family	8.1 (22)	-	8.1 (22)
My clan	7.8 (21)	0.7 (2)	8.5 (23)
Chief of this community	7.4 (20)	3.0 (8)	10.4 (28)
This community	5.2 (14)	2.6 (7)	7.8 (21)
Myself & the chief	0.4 (1)	0.4 (1)	0.7 (2)
The Traditional Chief Priest	2.6 (7)	-	2.6 (7)
My family & Chief	1.5 (4)	-	1.5 (4)
My landlord	0.7 (2)	-	0.7 (2)
Who has authority over the shea trees			
Myself	58.9 (159)	1.1 (3)	60.0 (162)
My family	4.4 (12)	0.4 (1)	4.8 (13)
My clan	5.6 (15)	0.4 (1)	5.9 (16)
The Chief	14.8 (40)	5.6 (15)	20.4 (55)
The community	0.7 (2)	-	0.7 (2)
The Traditional Chief Priest	5.9 (16)	0.4 (1)	6.3 (17)
My landlord	1.9 (5)	-	1.9 (5)

6.4 Discussion

6.4.1 Acquisition of land for farming shea and practices undertaken by farmers at the Local community level for managing shea in Ghana

Almost all (98%) the respondents indicated that they own the farmlands they were working on together with the shea trees growing on them, with only 2% indicating that they did not own the farmlands and the trees. Due to the fact that shea trees form an integral and crucial part of the lives and livelihoods of the local people (IOI Group, 2011), the trees are cherished and valued and therefore inherited from generation to generation. This accounts for the reason why majority of the respondents (81%) said they inherited the trees from their parents or from members of their clans. Being a tree species of high priority for African genetic resources

(Teklehaimanot, 2004), traditional leaders in most communities consider shea trees as not only individual, family or clan properties but as community properties as well. Thus, although 60% of the farmers indicated that they had authority over their farmland shea trees, traditional leaders such as chiefs and traditional chief priests played active roles in overseeing the management and conservation of the shea trees in their communities and hence were reported to be among those who wielded authority over the trees. Chiefs usually serve as the traditional political heads of their communities while the traditional chief priests basically function as the spiritual leaders and are responsible for the spiritual well-being of the people and all other resources in their communities.

The various identified shea systems (shea agroforestry, shea parklands and shea home gardens) were all managed in the study area with more than 90% of the respondents indicating that they raised and protected shea trees deliberately on their farms and fallowlands by allowing natural regeneration, creation of fire-belts around farms and trees, weeding around shea trees alongside other crops during cultivation, discouraging other people from felling the trees and mounding soil around trees to cover their exposed roots. This affirms the assertion by Kristensen and Lykke (2003) that although shea trees are not traditionally planted they grow through natural regeneration. And if the seedlings are protected *from fire and grazing animals and properly taken of through other suitable land management practices, the seedlings could grow into big and robust mature trees.*

One of the farmers in Fuu in the East Gonja District of the Northern Region, Yakubu Saaka said:

"We do our best to protect the shea trees because we derive a lot of benefits from them. It however seems our best is not enough because people continue to cut down the shea trees. We sometimes arrest such people and hand them over to the Chief or the police for punishment. Some of theose those people mostly hide and cut down the trees. We know it is poverty that compels them to cut down the trees to sell as fuelwood or use them to produce charcoal for sale. So we wish something could be done about this to stop people from cutting down the shea trees. We also need help in the form of financial support and farm tools and equipment to protect and manage the trees".

Marthin Awuni, one of the farmers in Kulbia in the Bolgatanga Metropolis of the Upper East Region said:

"Let me ask you, is it not strange that we conserve and protect the shea trees, because a lot of them are occupying fertile farmlands which we use for cultivating food crops? And you know land is becoming scare these days. I hope we will get some compensation for our efforts for not removing some of the trees to cultivate our food crops. As for us, we will continue in our small way to protect and manage the trees because they are important to us".

6.4.2 Benefits derived from the management of shea and how the benefits impact on the livelihoods of people in the local communities in Ghana and the global environment

All the farmers indicated that the various strategies and practices they embarked upon for their annual crops, as well as managing and conserve shea trees in their farms and fallow lands, impacted positively on the shea trees through improved growth and yield, and protection of the trees. The farmers explained that such positive impacts had been noticed over the past years through critical observations on the growth and yields as well as the survival rates of the shea trees. Thus, the trees benefitted from such management practices, as postulated by Masters *et al.* (2004). Such improved survival rates, growth and yields of shea translated into numerous benefits such as income, sheabutter and fuelwood mentioned by the farmers, with the majority (87%) of the households harvesting up to 5 bags of sheanuts while others harvested up to over 15 bags per annum. As shea is a multi-purpose tree used every day by rural African communities (Diarrassouba (2009), all the households said they derived numerous benefits from shea, with income being ranked as the number one benefit and formed up to 60% of the total household income, although the majority (74%) of the households indicated that revenue from shea constituted up to 20% of the total household income. As previously reported by Okullo *et al.* (2004) and Byakagaba *et al.* (2011) that shea is one of valuable trees in parkland landscapes in Sudano-Sahelian belt of Africa which generate economic gains for the local people, such significant economic gains from shea used to take care of households and other financial needs are a major incentive for farmers to continue managing and conserving the trees in communities where the trees grow.

Joshua Awudu, one of the male farmers in Paga-Badunu in the Kassena-Nakana East District of the Upper East Region said:
"*We get some income from the sale of shea butter, which our women here extract from shea nuts. We wish we could get more income from shea trees, but the fast rate at which we are losing our shea trees is quite alarming! What can we do to save the situation? We are doing our best to protect the shea trees, but we need help to continue doing this because we are poor farmers. We have limited resources, tools and equipment to continue protecting the shea trees".*

6.4.3 Constraints and socio-demographic and management factors influencing conservation of shea in Ghana

Constraints to management of shea

As shown in Table 6.9, the highly labour intensive nature of working with shea, less attention for trees due to other responsibilities, lack of working capital, lack of working tools and planting material, failure to strictly implement laws against deforestation, injuries from working tools and chemicals, burns from bushfires, risk of snake bites, scorpion and bee stings during management of the shea trees were the main constraints mentioned by all (100%) the respondents.
Management of shea was mentioned by all the farmers as a labour intensive activity which requires input of a lot of time and resources. However due to the fact that the turn-over from shea is woefully inadequate, the farmers complained that they have no option but to focus on more rewarding activities that bring in quick economic returns. This made the farmers pay less attention to the shea trees. These findings are line with a report by Lovett PN (2004) that among the major shea management constraints is the inadequate traditional protection for shea trees, particularly as a result of low financial returns on production in addition to the management of the trees being labour intensive, requiring a lot investment of resources which the farmers lacked. Hence, the farmers naturally had to divert their attention to other more rewarding economic ventures to be able to take care of their households.
Financial constraints and lack of working tools and planting materials were also identified as

major management constraints in the study. The naturally less-endowed northern Ghana (Lund, 2003) has already been grappling with poverty issues, with the average household struggling to get food and other basic necessities to survive. Thus, investing into the management and conservation of shea trees go beyond the capability of the people. These result in low morale in caring for the trees. Additionally, the farmers said they consider the cultivation of annual food crops to feed their households to be more important[6], and coupled with shortage of land, then obviously the people will have less interest in managing the trees but rather concentrate on producing food crops.

Another important constraint identified in the study area was the destruction of trees and seedlings by pests, diseases, bushfires, and running water after heavy rains. All the farmers reported these as major hindrances to their efforts in management the trees. Although the Ghana COCOBOD is mandated with the over-sight responsibility of, among others, encourage the production of cocoa, coffee and shea as well as undertake the cultivation of the crops and control pests and diseases of the crops (Ghana COCOBOD, 2012), farmers in the study area mentioned the prevalence of the parasitic mistletoe plant, which is very common on shea trees and and is reported to reduce overall shea yields (CRIG, 2002 and Carette *et al.*, 2009). Farmers also complained about caterpillars defoliating leaves of shea trees from seedlings to mature trees. These caterpillars were identified as *Cirina butyrospermii* as earlier reported (Dwomoh 2003, Dwomoh 2004 and Carette *et al.*, 2009) similar to reported cases in the Amuria District in Eastern Uganda (Okiror *et al.*, 2012). Other constraints mentioned were the damage caused by bushfires, which destroyed flowers, fruits and/or the entire shea trees. Farmers said the effects of the bushfires were severest during the dry seasons when grasses, leaves, some branches of shrubs and twigs became dry and easily combustible, thereby causing intense fires upon the least fire outbreaks, which terribly damaged shea trees, as earlier reported by Carette *et al.* (2009). Another constraint affecting adversely shea trees is the destructive impact of strong winds and fast running water on shea trees. Farmers explained that their shea trees were pulled down by strong winds and fast running water, particularly during and after heavy rains.

Another key management constraint mentioned by the farmers was the felling of the trees by other people for use as fuelwood, charcoal production[7], roofing houses, carving mortars, pestles, stools and other domestic wooden items[8]. These were reported in all communities in the study area, but most of these activities, particularly in some communities in the transitional savannah where charcoal production had caught on well with the people as a very profitable economic activity, were said to doing much more damage to the shea trees and drastically reducing their numbers. As shea produces excellent charcoal, the trees were felled by other people other than the farmers themselves for the production of charcoal. As such, several bags of charcoal could easily be seen in most of the communities along the Tamale-Kintampo-

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[6] The farmers said they get an average of GH¢20,000 (US$5,263) ha^{-1} yr^{-1} as income from crops compared to an average of Gh₵10,000 (US$2,632) ha^{-1} yr^{-1} as income from shea trees. This is at the exchange rate of $1.00 = GH¢3.800 (Bank of Ghana, 2015) as of Wednesday 30th December 2015 at 03.08 hours GMT.

[7] Most of the felling of shea trees is done by other people. Such people stray into farmers' fields and cut down shea trees for charcoal production. Usually farmers only prune branches of shea trees on their farms and trees felled during land preparation for fuelwood and charcoal production.

[8] These activities are carried out by natives to the communities and non-natives; usually farmers do not carry out these activities.

Kumasi road. Truckloads of charcoal could also be spotted daily along that road, and the charcoal being carted to urban centres for sale. These activities resulted in reduced numbers of shea trees in the study area, confirming a report by Ouédraogo (2006) that the felling of shea trees is the single most important cause of the degradation of shea parklands, resulting in decreasing tree density and vegetative cover.

Low education in the growing and management of shea trees was also another major constraint identified in the study area. Most of the farmers explained that despite the fact that they lacked the needed resources to manage trees and grow more, they had limited knowledge and technical know-how in tree growing. They explained that they wish they could get more technical training from experts in tree growing than they had been doing for generations. Thus, they wished they had some training so that they could implement that in their farms and fallow areas to grow additional shea trees since the shea trees they had were few.

As explained by Anumu Zakariah, one of the male farmers from Kawampe in the Kintampo North District of the Brong Ahafo Region*:*

"We know shea trees are very important because we derive a lot of benefits from them. That is why we see it important managing and protecting them. We however lack a lot of things to use in managing the shea trees. If we get these things we can properly manage and protect the shea trees very well. For instance, we do not have the technical know-how on how to manage the shea trees so that they can grow very well. Also, we do not have the appropriate tools and equipment to use in managing and protecting the trees. We are appealing to the Agricultural and Forestry Extension Officers to be helping us with resources and technical training on the management of the shea trees".

This confirms the findings of Okiror (2012) who reported that inadequate extension services were a hindrance to management of shea in the Amuria District in Uganda.
The management of shea parklands is usually associated with a lot of risks such as snake bites, scorpion and bee stings and fire burns. As a result, most of the farmers try to contain such situations by adopting certain methods which in turn present additional problems. All the farmers interviewed explained that such risks serve as constraints to managing the shea trees, and that sometimes they have no alternative than to adopt measures to prevent and/or control such dangers. As a result, some of the farmers said they normally resort to burning the bush in and around their famers to get rid of such dangers, particularly snakes, scorpions and bees. In the end, if such fires get out of control, they stray into other areas and destroy crops, trees and other valuable property. This confirms earlier reports by Carette *et al.* (2009) that in attempt to get rid of snakes and other dangerous animals, farmers resort to the use of fires to do controlled burning of bushes within and around farms, which occasionally got out of hand and caused damage to crops, trees and other items.

At Cheyohi in the Kumbungu District of Northern Region, one of the farmers, Afa Yakubu said:

"Shea trees are very important to us. Unfortunately, the trees are drastically reducing in numbers because they are cut down and used as fuelwood and for producing charcoal. We always try our best to protect the trees but we are poor farmers. We lack so many things. How can we protet these trees if we do not have the means to do so? So we need financial and logistical support to take better of the trees"

Azara Awudu, one of the female farmers in Gulumpe in the Kintampo North District of the Brong Ahafo Region said:

"We derive a lot of benefits from the shea trees. We harvest shea fruits from the trees. We process the shea nuts into shea butter which we sell to get money to support our husbands to take care of ourselves and our children. We wish we could get help our husbands to protect the trees better we do now. People are cutting down those important trees. It is very sad!"

Socio-demographic and management factors influencing shea conservation in Ghana

Notwithstanding the fact that there are many constraints associated with the management of shea trees, almost all the farmers (95%) were willing to continue managing the shea trees. A cross-tabulation (Table 6.10) indicates that the farmers' desire to continue managing and conserving shea trees is influenced by whether the farmers are natives or non-natives, how the land was acquired, distance of farm from home, ownership of the farmland and shea trees, authority over land and shea trees and benefits from the shea trees.

Cross-tabulation of the factors (Table 6.12) indicated that majority (84.5%) of the natives were more willing to continue managing shea trees than non-natives. This could be as a result of the recognition of the shea trees being of high priority for African genetic resources (Teklehaimanot, 2004) and economically valuable (Okullo *et al.,* 2004; Byakagaba *et al.,* 2011). As a result, to ensure that such trees are conserved to provide them with benefits, most farmers who are natives in their communities usually manage their trees, which significantly benefit from agronomic practices, such as weeding and management of soil fertility employed for annual crops (Masters *et al.*, 2004).

Farmers who inherited farmlands were more willing to continue managing shea trees owing probably to the fact that they considered the trees to be an integral and crucial part of their lives and livelihoods (IOI Group, 2011). Therefore, to preserve their cultural heritage, customary practices and traditions meant that they needed to manage the shea trees to continue surviving on their lands. In addition, most of the farmers who acquired their farms by inheritance said they have the spiritual belief that there are links between their ancestors and the properties (including the shea trees) they bequeathed to the current and subsequent generations. Therefore, apart from the shea trees providing several vital products (Teklehaimanot, 2004) and numerous benefits, the farmers believed that to continue to appease their ancestors meant that they needed to manage the trees, and also ensure that they conserved the trees for posterity as well.

With regards to cross-tabulation of willingness to continue managing the trees with distance of farmlands and trees from homes of farmers, it can be deduced that willingness to manage shea diminished with distance; meaning the closer (less than 3 km) the farm was to the farmer's home the more he was willing to manage the trees. Conversely, the further away (3 km or more) the farm was from his home the more the farmer was unwilling to manage the trees. This is obviously due to the additional challenge of covering distances of more than 6 km to provide protection for the trees (Lovett PN, 2004), apart from the numerous management constraints such as financial constraints and lack of working tools and planting materials, particularly with farmers from the naturally less-endowed northern Ghana (Lund, 2003).

With regards to ownership of land and trees, farmers who personally owned their farms together with the shea trees were the most willing to continue managing the trees probably as a result of their multiple uses (Teklehaimanot, 2004) and economic value (Okullo *et al.*, 2004; Byakagaba *et al.*, 2011). It is a tree species of high priority for African genetic resources (Teklehaimanot, 2004) and the ripe fruits are eaten as food during periods of food scarcity (Lamien, 2007). In addition, farmers who owned lands managed the trees so that they could use the presence of the trees to continue to lay claim to the ownership of their lands. Farmers who did not own the land on which they were farming or the trees were unwilling to manage the trees most probably due to insecure land and tree tenure.

Decisions on willingness to continue managing shea trees were mostly made by farmers who had authority over their farmlands together with the shea trees growing on them. Similar to ownership, farmers who had authority over their farmlands could make independent decisions on issues related to the land and the trees and were the most willing to manage the trees since they valued the presence of the trees on their farmlands most. This is because trees are used as symbols of ownership and authority over land since the claim of ownership of land is tied to the ownership of land, and vice versa. The choice of trees as a claim of ownership, though symbolic, is the main reason for conserving shea trees in particular on farmlands is as a result of the tree providing the main edible oil for the people (Saul *et al*., 2003). It is a tree species of high priority for African genetic resources with multiple uses in most communities (Teklehaimanot, 2004) as well as generating income (Okullo *et al.*, 2004; Byakagaba *et al.*, 2011) due to its multi-purpose tree nature.

6.5 Conclusion

Results of the research show that the farmers manage the shea trees by raising seedlings through natural regeneration, creating fire-belts around farms and trees, weeding, discouraging other people from felling the trees, mounding soil around trees to cover their exposed roots, pruning branches of trees, controlling insect pests and diseases and applying manure. These were considered by farmers to improve survival rates as well as growth and yields of the trees, which in turn accrued numerous benefits such as income, sheabutter, edible fruits, fuelwood, shea litter fall as manure for crops, wood for roofing houses, and provision of shade for the farming households. Income generated from the sale of shea products and used to take care of most of the household needs was ranked highest, and formed up to 25% of the total annual income of 74% of the households. On a global scale, the impact of these management strategies and practices could be realized worldwide through the positive role shea trees play in mitigating climate change and reducing global warming effects. This is due to the fact the potential of shea trees to sequester carbon could be enhanced if they are better managed.

Almost all the farmers who were willing to continue managing shea trees were natives in their communities and had inherited their farmlands together with the shea trees from their parents and other family or clan members. These farmers own and have authority over the lands and shea trees but are however more willing to manage trees that are less than 3 km away from their homes compared to trees that are 3 km or farther away from their homes. Willingness to manage and conserve shea trees is significantly ($p \leq 0.05$) influenced by whether the farmers are natives or non-natives, how the land was acquired, distance of farm from home, who owns the farmland and the shea trees, who has authority over the land and the shea trees and benefits derived from the trees. Therefore, in seeking ways of conserving shea trees in the study area, these factors should be taken into consideration since they play critical roles in determining the willingness of farmers to manage shea trees.

CHAPTER SEVEN

Payment Mechanisms for Shea Carbon: Developing Shea Projects in Ghana for the Carbon Markets

This Chapter identifies shea systems that could be developed into shea forest carbon project models suitable for the international carbon markets, and the cash revenue realized paid directly to the people as a motivation to conserve the trees.

7.1 Introduction

As by size, carbon markets (Figure 7.1) are the biggest global environmental market, and they, for instance, in 2009, escalated to US$144 billion from US$135 billion in 2008 and US$63 billion in 2007. Most of these transactions are taking place in regulatory markets, associated with the cap–and–trade mechanisms imposed by governments. The European Union Emission Trading Scheme (EU ETS), which is the world's principal regulatory scheme, regrettably does not include any type of land use carbon. The Kyoto Protocol puts a limit to the eligible Clean Development Mechanism (CDM) project categories in the land-use area to afforestation and reforestation, unequivocally leaving out any crediting for agricultural or forest management, avoided deforestation or degradation, and soil carbon storage in developing countries. In addition, CDM awards afforestation/reforestation activities only temporary carbon credits that have limited opportunities of being exchanged with other traded carbon credits. As a result, land use projects mostly are extremely few in the CDM, and agricultural projects have been restricted to those that reduce methane and from other agricultural wastes emissions and those that cut down on energy emissions in the industrial processing area (Shames and Scherr, 2010).

International agreements on climate change should necessarily include management of forest carbon as forest carbon flows constitute an important portion of the general global greenhouse gas emission (Plantinga and Richards, 2008). Global forests may generally serve as a net sink (Nabours and Masera, 2007); they can also contribute 12% of all greenhouse gas emissions through deforestation (van der Werf *et. al*., 2009). Compared to the yearly global carbon emissions from the industrial sector being about 6.3 GtC (gigatonnes of carbon), the total global carbon pool in forest vegetation is approximately 359 GtC (IPCC, 2000). Natural and anthropogenic changes in forests both have a huge possible influence on global carbon cycle (Plantinga and Richards, 2008).

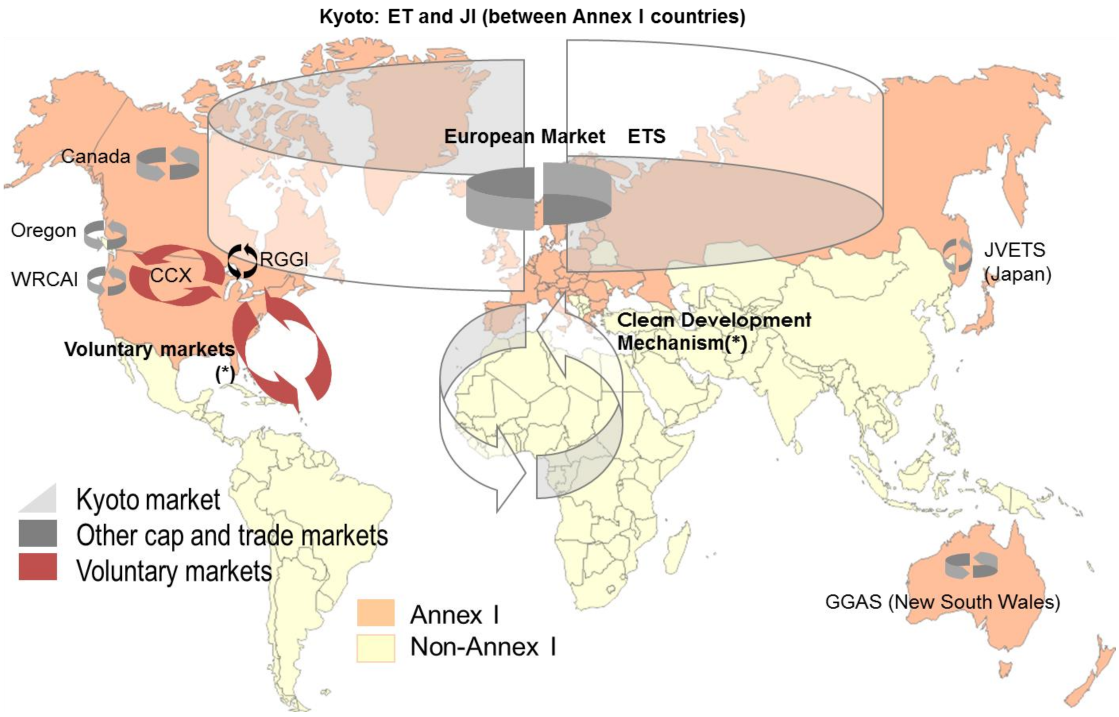

Figure 7.1 Types of carbon markets
Source: USAID (2009)

Developing forest carbon projects can be difficult as it entails fulfilling certain requirements to create carbon benefits (Olander and Ebeling, 2011). Forest carbon management should be backed by an operationally well-organized international system to give landowners and governments the needed compensations to protect and increase carbon stocks, as well as encourage countries to participate in discussions and international agreements on forest conservation. The current international UNFCCC system, the Kyoto Protocol, cannot, however, be said to be efficient as it has not been able to motivate non-Annex I countries to cut down on their carbon emissions through forest management activities. Forestry-related net gains in carbon credits in non-Annex I countries, also included under the Clean Development Mechanism (CDM) of Article 12, are limited only to afforestation and reforestation projects (Santilli *et. al*., 2005). As a result, the CDM has not been included in projects that could be beneficial, together with the ones that can possibly reduce deforestation. Although the general impact of forestry projects is significant, yet the CDM has not been regarded as a good tool for providing incentives for individual forestry projects. This because of the problem associated with assessing the carbon impacts of individual projects that are forestry-related. Finally, the current system under the Kyoto Protocol could speed up deforestation through the movement of harvesting of timber from Annex I to non-Annex I countries (Silva-Chavez, 2005).

It is necessary to re-consider and tackle the issue of forest carbon management in post-Kyoto Protocol and find a worthy replacement that will include avoided tropical deforestation. Due to this, major discussions were held on a proposal for "compensated reduction" (CR) in deforestation, reduced emissions from deforestation and degradation (REDD) as a major source of emissions to be included in the Kyoto Protocol. Following these, at the UNFCCC conference in Durban, South Africa in 2011, participating countries around the world made a major decision on the "Under the Kyoto Protocols Clean Development Mechanism", which entailed allowing in carbon-capture and storage projects. It is the expectation that these guidelines will be reviewed every five years for the purposes of achieving ensure addressing issues on forest carbon management for environmental sustainability. According to UNFCCC (2013), the Doha Amendment, an amendment to the Kyoto Protocol and adopted in Doha, Qatar on 8th December 2012, launched a second commitment period which began on 1st January 2013 and will end in 2020.

As climate change unleashes its devastating effects throughout the world, African farmers sadly tend to bear the greatest brunt of these adverse impacts. Increasing temperatures and unreliable rainfall patterns exacerbate existing vulnerabilities to land degradation, floods, and drought in Africa, and these challenge farmers to make major changes in farming systems. One-third of the people in Africa already live in areas prone to droughts and face severe risks of food insecurity and famine. Droughts are more frequent in drylands, and rainfall higher in some rainforest regions, making food production even more difficult. With temperature changes, the growing seasons for crops are shrinking by more than 20% in several countries in the continent. Crop yields may decline by 50% in some countries by 2020. Climate change would also put ecosystems at risk, with over 4,000 African plant species projected to lose critical habitats, undermining the livelihoods of many Africans who depend on wild species for food, fuel, fodder and medicinal plants (Shames and Scherr, 2010). Other reports also indicate that climate change has or expected to worsen conditions or have adverse impacts in Africa on pastoralists and livestock populations particularly in semi-arid grassland regions (Gardener, 2012), scarcity of water in rivers and other water sources, agricultural productivity, biodiversity (Mwingira, 2011), food security, temperature, rainfall, agricultural production, human health, floods and droughts (UNEP, 2011).

If there is any glimmer of hope in this disturbing and gloomy situation, particularly for the deprived rural farmer in Africa, then the remedy lies in his participation in the management of trees that could yield carbon credits on the international carbon markets. These markets are capable of enhancing climate change-resilient agricultural development in Africa if the right policies are put in place to facilitate the effective implementation of appropriate, well-formulated projects. It is therefore imperative for African countries to take advantage of this opportunity and act appropriately by managing and conserving their forest resources that would possibly halt or minimize the risks and devastating impacts associated with climate change as well as yield carbon credits for sale on such carbon markets.

As the winds of hope are blowing, and following these recent events and expectations, climate resilient development has become Ghana's main priority in terms of addressing climate change, as low carbon growth options present additional opportunities such as direct economic and social benefits of these options, and increased access to available international support in the form of financial and technical assistance as well as capacity building (Würtenberger *et al.*, 2011). To take advantage of these happenings and realize these ambitions, Ghana became a party to the United Nations Framework Convention on Climate Change after ratification in September 1995 and has since engaged in policies and measures to facilitate its implementation (MEST, 2011).

In line with this, Ghana has developed a number of policies and implemented many climate-change related initiatives with the view to complying with the international climate change agreements aimed at combating climate change. Although some of these initiatives seek to benefit the entire nation and invariably the rest of the world in general, communities and farmers in particular look forward to receiving direct cash benefits for managing forest resources which provide the much-needed ecosystem services. Among these forest resources are shea parklands in the Sudan, Guinea and the Transitional savannah zones of Ghana cover millions of hectares of land. These shea parklands significantly contribute to addressing climate change in Ghana through carbon sequestration. The shea trees grow mainly in northern Ghana; an area beset, ironically, with abject poverty "in the midst of plenty" of these useful and potential money-making trees. The majority of the people there live on less than one dollar per person per day. Although the trees provide certain tangible benefits such as fruits, nuts, butter, revenue from the sale of shea products, etc, and other intangible benefits including provision of shade, etc, such benefits are considered by the people as woefully inadequate to meet their financial needs; thus there is motivation for the people to continue protecting and conserving the trees. They rather prefer clearing and cutting the trees down to make way for food crops to feed their households. Besides, out of necessity and in their urgent quest to tackle those critical financial problems, the people have no alternative in such desperate circumstances than to fell the trees for fuelwood and charcoal for sale, in spite of the ban on the felling of such trees. To further worsen the situation is the unwillingness of the people to plant more of the tress to at least replace the felled ones, with reasons such as lack of resources and the long juvenile growing period, from seedling to fruiting (which takes at least nine years), to be too long, and therefore cannot wait for such a long time as they need to immediately solve their urgent financial difficulties. It is therefore imperative to turn this gloomy situation around, by taking urgent actions to improve the livelihoods of the people and also prevent the shea parklands from disappearing as the trees are presently being cut down at alarming rates. One of such major actions needed to be taken is direct cash payments to the people for carbon credits from their shea parklands. This will drastically help solve the financial challenges of the people which in turn will motivate them to prevent the felling of the shea trees, and rather properly manage and conserve them. Unfortunately, however, at the moment there are no such arrangements, in terms of well-structured shea projects in Ghana that have been developed to meet the requirements of the international carbon markets. If such projects are developed, not only would they significantly help to conserve shea parklands in Ghana to combat climate change for the benefit of Ghana and the world as a whole, but they would also present opportunities for farmers in the shea-growing areas of the country, who to a greater extent depend on shea for their livelihoods, to receive direct cash compensations for carbon credits from their shea parklands. In these contexts, the aim of this research was to develop suitable shea project models for carbon markets using the following research question as a guide.

7.1.2 Research questions and objectives of the study

Research questions for the study

How can shea fit into the international carbon markets to improve the livelihoods of people in northern Ghana as well as conserve shea parklands there for the purposes of combating climate change?

The following sub questions were used to help address the research question:
i. which are the existing models of shea systems in Ghana;
ii. which are the existing international carbon markets and how do they operate; and

iii. how can suitable models of shea systems be developed to meet the requirements of the international carbon markets.

7.2 Methodology

This research was conducted to determine models of shea projects in Ghana suitable for the carbon markets within the context of the international climate change agreements. The study involved two stages. The first stage involved an in-depth analysis of the quantum of sequestered carbon dioxide equivalent sequestered (CO_2e) per hectare per year by shea parklands of Ghana and the way forward towards optimizing carbon credits in the study area, while the second part was to develop shea project models for the international carbon markets.

The first part of this study was done to determine the possibility of optimizing the amount of carbon stocks stored by shea parklands of Ghana based on their current sequestration rates. Shea carbon (C) data gathered during a previous study (as part of an overall research on shea including the current one) in the Sudan, Guinea and the Transitional savannah zones of Ghana were used for the first part of this current research. In each of the three sites, field and fallow cultivation were subdivided into new (land under crop cultivation or fallow for 1-5 years), medium (land under crop cultivation or fallow for 6-10 years) and old (land under crop cultivation or fallow for over 10 years). C stock and C sequestered by shea were estimated from tree DBH (diameter at breast height) of up to 53 cm. In each site, six plots of shea trees (each plot measuring 50m x 50m) were randomly selected and replicated three times, giving a total of eighteen plots per site. Thus, an overall total of 54 shea plots (18 plots x 3 sites) were randomly selected for the study. On each plot, data on the number of shea trees and DBH were taken. An allometric equation was used to determine the amount of biomass contained in each tree, and this was converted into carbon stock by multiplying by a factor of 0.5.

For the second part of the study, existing systems involving shea trees were identified in shea parklands of the Sudan, Guinea and the Transitional savannah zones of Ghana. These systems were analyzed and a number of suitable models were then developed for the shea systems in line with the requirements of the various payment mechanisms of the international carbon markets. These basically involved the use of primary data gathered from the research on existing shea systems in Ghana as well as socio-economic survey data gathered from farmers and juxtaposing them on the requirements of payment mechanisms of the international carbon markets. Three regions (Upper East representing Sudan Savannah, Northern region representing Guinea Savannah and Brong-Ahafo representing the Transitional Savannah zone) in the shea-growing areas of Ghana were purposively selected for the study. In each region, three districts were randomly selected while in each district three communities were also chosen randomly. Thus, a total of nine communities were randomly chosen for the study in which five shea systems were identified and five shea forest project models were developed for the international forest carbon markets. Information on payment mechanisms of the UNFCCC international carbon markets constituted secondary sources of data which were obtained from relevant published works and other UNFCCC-recommended documents on the internet, in libraries, etc.

7.3 Results

7.3.1 Existing models of shea systems in Ghana

An overview of current carbon sequestration potential of shea parklands in Ghana

The first part of this study was done to analyze the implications of the quantum of carbon stocks in both fields and fallows of shea systems (Table 7.1) of a previous research (in Chapter 4) conducted in shea parklands of the Sudan, Guinea and the Transitional savannah zones of Ghana, as well as to determine ways of optimizing shea carbon yields for the international carbon markets. This part of the research was conducted to assess the carbon sequestration potential of shea parklands. Apart from provision of fruits, nuts, butter, fuelwood and other numerous tangible and intangible benefits derived from shea, the tree also plays a very significant role in combating climate change through carbon sequestration.

Table 7.1 Stocking density of shea trees on field and fallow plots

Land-use type	*Number of trees ha^{-1}*	*Height per tree (m)*	*DBH[1] per tree (cm)*	*Biomass ($Mg\ ha^{-1}$)*	*Carbon stock ($Mg\ ha^{-1}$)*	*Carbon stock per tree (Mg)*
Field	44.00 (23.51)[a]	8.79 (2.18)	33.15 (15.26)	18.33 (18.37)	9.16 (9.19)	0.31 (0.47)
Fallow	69.04 (47.67)[b]	7.91 (1.81)	29.12 (15.40)	17.33 (12.63)	8.66 (6.31)	0.24 (0.31)
Grand means	**56.52 (39.32)**	**8.35 (2.03)**	**31.13 (15.32)**	**17.83 (15.62)**	**8.91 (7.81)**	**0.28 (0.41)**

Generally, results of the research indicate that the Savannah regions had an average shea tree density of 57 trees ha^{-1} and an average DBH of 31.13 cm within the mean DBH range of 21 – 40 cm. The shea trees stored an average of 18.90 C Mg ha^{-1} of carbon (Table 7.2). With good agroforestry and agronomic practices, however it is possible to increase the stocking density to a recommended rate of 100 – 200 trees ha^{-1} which can then sequester approximately 33.07 – 66.43 CO_2 Mg ha^{-1} yr^{-1}.

Table 7.2 Stocking densities of shea trees in Ghana and CO_2 sequestered

DBH class (cm)	*Number of trees*	*Carbon stored (Mg ha^{-1})*	*Proposed number of trees ha^{-1}*	*Carbon stored (Mg ha^{-1})*
21- 40	57	18.90	100 – 200	33.07 – 66.43

Identified existing shea systems in Ghana

Results of the research conducted show the existence of the following systems involving shea trees in the study area:

- Shea agroforestry projects - shea trees intercropped with food crops;
- Shea parklands on fallow lands with other trees but dominated by shea trees;
- Shea parklands dominated by other tree species and other forms of vegetation;
- Shea home gardens. e.g. backyard gardens, vegetable/crop gardens, etc. and;

- Small pockets of shea trees within communities. e.g. by schools, etc.

Shea agroforestry projects - shea trees intercropped with food crops

Agroforestry is the inclusion of woody perennials, such as trees within farming systems. This has been both a traditional land-use practice developed by subsistence farmers in the tropics, and a livelihood preference supported by land-use managers and international development efforts. Agroforestry systems range from subsistence livestock and pastoral systems to home gardens, alley intercropping, and biomass plantations with a wide diversity of biophysical conditions and socio-ecological characteristics (Zomer *et al.*, 2009).

Agroforestry was the commonest system of farming identified during the research as being practised by all the farmers throughout the study area. The system involves the cultivation of food crops and/or animals together with shea trees on the same piece of land. All the farmers (respondents) interviewed indicated that they undertake this system of farming, which according to them, involves simple forestry and agronomic practices that are easier to carry out. Such farms are easier to manage and the farmers cultivate food crops such as root and tuber crops (e.g. yams, cassava, sweet potatoes, etc), cereals (e.g. maize, guinea corn, millet, etc.), vegetables (e.g. tomatoes, lettuce, onions, garden eggs, leafy vegetable, etc), legumes (e.g. soya beans, cowpea, Bambara beans, groundnuts, etc) in between naturally-growing shea trees on their lands. Here, the mean density of shea trees was 44 trees ha^{-1}, which was found to be quite low. In this regard, the number of trees could be increased for more yields of carbon credits.

Shea parklands on fallow lands with other trees, but dominated by shea trees

The research identified shea parklands in the study area in which naturally-growing shea trees were on the same parcels of fallow lands together with other tree species and other forms of vegetation. These other tree species identified in this type of shea parklands included dawadawa (*Parkia biglobosa*), mahogany (*Khaya senegalensis*), mango (*Mangifera indica*), silk cotton (*Ceiba pentandra*), baobab (*Adansonia digitata*), Neem *(Azadirachta indica),* etc. as well as other shrubs. The other forms of vegetation were grass species such as elephant grass (*Pennisetum purpureum*), spear grass *(Imperata cylindrica*), etc. In these parklands, shea trees formed between 60 - 90% of the tree species.

Such parklands were usually within about 0.5 – 5 km radius of communities where the non-shea tree species were intermittently harvested for use as fuelwood, roofing materials, construction of mortars, etc, while the shea trees were conserved and protected for their commercial value (nuts collected and processed into butter for sale, some pruned branches for sale as fuelwood, etc.) and other tangible benefits (e.g. ripe fruits harvested for consumption, extracted butter and some harvested fuelwood for domestic uses, leaves used as fodder for ruminant domestic animals, medicinal preparations from selected leaves, barks, roots, etc.) and intangible benefits (shade, etc). The density of shea trees in such parklands was on the average

69 trees ha^{-1}. Such parklands were generally found in the Guinea and Sudan savannahs due to the shea trees there being tolerant and able to withstand the relatively harsh environmental conditions such as low humidity, low soil moisture, high temperatures, relatively high incidences of bushfire outbreaks, etc, compared to other tree species. Such harsh environmental conditions exist, particularly during the annual dry season (November – March), and typical resilient savannah species such as shea are able to tolerate and survive – *a kind of "survival of the fittest"* – during such periods due to its hard bark which, to a certain extent, can withstand those tough conditions within tolerable limits. The transitional savannah seemed to have relatively low densities of shea trees per hectare relative to the other tree species as a result of the existing local environmental conditions (such as relatively high humidity, high soil moisture, low temperature, low incidences of bushfire outbreaks, etc.) being favourable and tolerable for the other tree species.

Shea parklands dominated by different tree species and other forms of vegetation

The other shea parklands identified during the research was the type dominated by non-shea tree species and other forms of vegetation. Shea trees were estimated to form between 10 – 40% of the tree species. This type of shea parklands were mostly found in the transitional forest zone where the local climatic and other environmental conditions (such as relatively high humidity, high soil moisture, low temperature, low incidences of bushfire outbreaks, etc.) encourage the growth and survival of many other tree species as well as beyond 5 km radius of most communities in the Guinea and Sudan savannahs.

In addition to the presence of environmental conditions favourable for the growth and survival of tree species other than shea in the transitional savannah zone, information gathered from respondents in communities such as Gulumpe, Kawampe and Kpagto, for reasons for the low density of shea trees in such areas were that the trees were usually cut down and converted into charcoal for sale since they serve as good combustible fuelwood and produce excellent flames for cooking and heating. Other reasons included the low turn-over (high investments of time, work, energy and other resources and low outputs of shea products), lack of market for shea products (eg. butter, nuts, etc), etc. On the average, the density of shea trees in such areas was less than 69 trees ha^{-1}. Similar reasons were given in the Guinea and Sudan savannah zones for the low density of shea trees in some areas; and these included trees burnt by bushfires, conversion of shea parklands into cropping farms, felling of the shea trees for fuelwood or charcoal production.

Shea home gardens

Home gardens are common and sustainable agroforestry systems in the tropics (Saha *et al.*, 2009) and in other parts of the world. They are diverse in nature with regards to species composition, size, and age (Mohan *et al.*, 2007). As composite systems, home gardens consist of close, multistory collections of various trees and crops, sometimes in relationship with domestic animals, around the homesteads (Kumar and Nair, 2004). Kirby and Potvin (2007) suggested that plant collections with high species-diversity may boost more effective utilization of resources in comparism with those of lower species diversity and hence result in greater overall primary production.

In terms of their role in the combat against climate change, home gardens are said to have high C sequestration potential due to the fact that they seem to have the structure and composition of a forest (Kumar, 2006). Biodiversity conservation and climate change mitigation have recently become two key environmental challenges, and thus home gardens are better placed to address these concerns as they are sustainable agroforestry systems with high species diversity and high C sequestration potential.

Findings of this study in the northern savannah zone of Ghana showed the existence of home gardens in every community. They are either by houses (backyard gardens) or within the communities near schools and other public places. Such home gardens usually supply daily household food needs; fruits and vegetables, and in some cases cereals, roots and tubers, etc. Some home gardens were intensively-managed for commercial purposes (commercial home gardens); products from such home gardens were sold out to generate income to meet household needs. In such home gardens, food crops such as cereals (maize, millet, guinea corn, etc), fruits and vegetables (including tomatoes, cucumbers, cabbage, carrots, salads, Amaranthus, *Corcorus olitorius,* etc.) were intensively-cultivated in-between shea trees near homesteads and within communities. It was also observed that farmers in all the communities of the study area included shea trees in their home gardens due to the importance of such trees in providing fruits, shade, fuelwood, nuts, and above all income from the sale of nuts, fuelwood, butter, tree barks for medicinal preparations, etc. As was the case of agroforestry farms in which farmers selectively cut down some shea trees during land preparation to create more space for the cultivation of food crops or some shea trees eventually sometimes wither, dry up and die due to inadvertent destruction of their roots by tractors and other heavy farm machinery during land preparation, the density of shea trees was found to be relatively low; with a mean density of 44 trees ha^{-1}.

There is therefore the need to increase the density of shea trees in home gardens due to the fact that, as asserted by Montagnini and Nair (2004) and Takimoto *et al.* (2008), trees play a significant part in soil C sequestration since an increase in the number of trees (high tree density) in a system will lead to a corresponding increase in the total biomass production per unit area of land, which in turn may increase C storage in soils. Haile *et al.* (2008) and Nair *et al.* (2009) confirmed that there is higher soil C stock under deeper soil profiles in agroforestry systems compared to agricultural or pasture systems without trees under identical ecological conditions.

Small pockets of shea trees within communities

Small pockets of shea tree populations, in the form of woodlots, also existed in all the communities in the northern savannah zone of Ghana. Such pockets of shea trees, which were near schools, social and recreational centres, etc were managed by the local community members due to the numerous benefits that the people derived from the trees. Some of these benefits were provision of shade, fruits, fuelwood, etc. from the trees. As food crops were not cultivated in such small pockets of shea trees which existed as woodlots, the shea trees have closer spacing and therefore have a relatively higher density of 69 trees ha^{-1}.

7.3.2 Existing international carbon markets

According to Simula (2009), there are three types of carbon markets: (1) the market that aims at achieving the commitments under the Kyoto Protocol (Kyoto regulated market); and (2) the regulated market outside the Kyoto Protocol, and (3) the market that is trading voluntary emission reductions. Both (2) and (3) markets are however categorized as voluntary markets (Figure 7.2). In each market, two modes of trading possibilities can be distinguished: (i) permits or allowance trading, and (ii) project-based trading. Forest-related mitigation opportunities are categorized under the Kyoto-regulated market (CDM A/R) as well as under the voluntary market (planting forests and avoiding deforestation).

As such, shea carbon credits could be traded in the Kyoto-regulated market and the Voluntary market since shea projects could qualify as A/R or forest-related mitigation projects. As forests serve as a net sink for carbon (Nabours and Masera, 2007) and have an enormous potential impact on the global carbon cycle of both natural and anthropogenic changes (Plantinga and Richards, 2008), it is imperative that direct cash rewards be paid for ecosystems services if forest resources are to be properly managed and conserved (De Gryze *et al.,* 2009). Such services include carbon credits that can be traded on the carbon markets such as the Kyoto-regulated market and the Voluntary market.

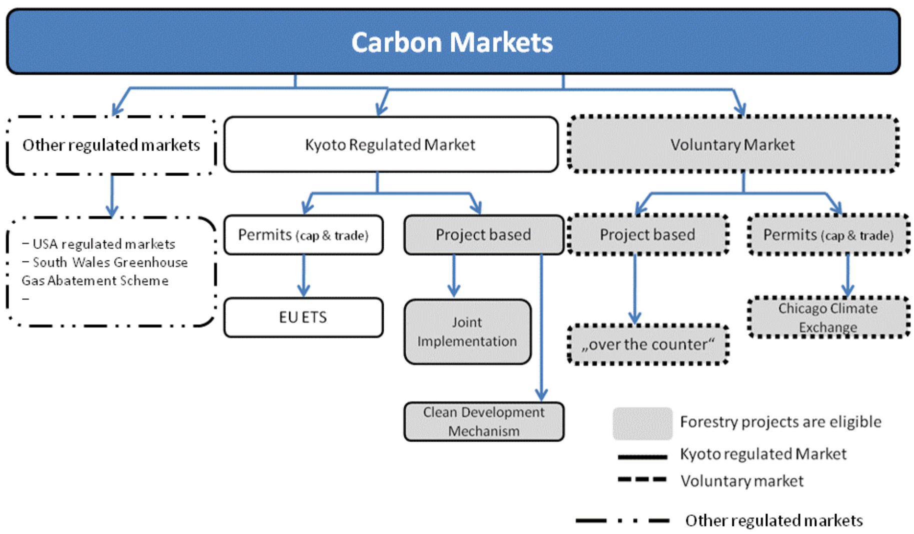

Figure 7.2 Types of carbon markets
Source: Simula (2009).

7.3.3 Recommended models of shea projects for carbon markets

Based on the identified existing forest and agroforestry systems involving shea trees in communities in the study area, the following models of shea systems are recommended for the carbon markets:

- Shea agroforestry model
- Sole shea parkland model
- Shea plantation on degraded lands model
- Shea home garden model
- Community shea woodlots model

Shea agroforestry model

As agroforestry was identified as the commonest system of farming practised by farmers throughout the study area, it is recommended that one model that could be accepted and readily adopted by farmers should involve the integration of food crops in shea farming. In this system, which is already being practised and familiar to the farmers in the study area, the density of the shea trees should however be increased from the stocking density of 44 trees ha^{-1} which stored 11.40 C Mg ha^{-1} to 100 trees ha^{-1} to store 25.85C Mg ha^{-1} (Table 7.3). At the recommended density of 100 trees ha^{-1}, 10 m x 10 m spacing between trees could be adopted and food crops planted in-between the shea trees in the form of alleys (rows of trees followed by rows of food crops) or mixed trees and food crops. This wide spacing of the shea trees is required because food crops that would be grown between the trees would need sunlight and other growth factors; these would be possible with the recommended wide spacing between the shea trees.

Table 7.3 Stocking densities of shea trees on field plots and amounts of CO_2 sequestered

Type of Shea project model	***Mean DBH (cm)***	***Recorded field data***		***Recommended for the developed model***	
		Stocking density of shea trees (no. of trees ha^{-1})	***Carbon stored (Mg ha^{-1})***	***Stocking density of shea trees (no. of trees ha^{-1})***	***Carbon stored (Mg ha^{-1})***
Agroforestry farms	33.15	44	11.40	100	25.85
Sole Shea parklands	29.12	69	10.84	100 - 400	15.84 – 62.81
Shea plantation on degraded lands	29.12	69	10.84	100 - 400	15.84 – 62.81
Shea home gardens	33.15	44	11.40	100 – 150	25.85 – 38.91
Community shea woodlots	29.12	69	10.84	100 - 400	15.84 – 62.81

Sole shea parkland model

It was observed during the research that the existing shea parklands were mostly degraded as a result of the following:

- felling of the trees (deforestation/logging) by the people for fuelwood, roofing houses, construction of mortars, pestles, stools, etc;
- destruction by bushfires;
- conversion of portions of shea parklands into croplands, roads, houses, etc;
- presence of hard pans or concretions below the soil surface, etc;
- etc.

As can be seen in Table 7.3 above, to maximize income from the sale of carbon credits, it is recommended that, for the proposed model of improved degraded shea parklands or sole shea parkland model (only shea trees in the parklands), the stocking density of 69 trees ha^{-1} which stored 10.84 C Mg ha^{-1} should be increased to 100 – 400 trees ha^{-1} at a spacing of 5–10 m x 5–10 m. The corresponding range of C storage of these ranges of tree densities and inter-tree spacing would be 15.84 – 62.81C Mg ha^{-1}. Closer spacing between trees should be used because the parklands should be fallows; no food crops required in this type of shea system, only the shea trees (sole shea parklands). Secondly, to encourage the shea trees to grow vertically straight, taller and bigger (with good forestry practices), there is the need to use closer spacing for the trees such as 5 m x 5 m. This will create avenues for more C to be stored since such bigger trees would have more surface areas (broader canopies and wider surface areas for the leaves of the trees). Later, if it becomes necessary, some of the trees could be thinned out to widen the spacing of up to 10 m x 10 m. Closer spacing could however be maintained but selected branches of the trees could be pruned if the branches of the trees grow broader canopies.

Shea plantation on degraded lands model

Closer observations made during the research revealed that lots of parcels of land in the northern areas of Ghana were left to idle without any plans to put them to any meaningful use for agricultural production or for any other productive ventures. Such lands were not in use due to the fact that either they were unproductive for agricultural production as a result of several years of continuous cropping, presence of hard pan or rock concretion below the soil surface, the soils being unsuitable for cultivation of food crops (Figure 7.3), etc. Such degraded or unproductive lands could be used for the establishment of new shea plantations, and just like the case of the sole shea parkland model, the tree density and the spacing could respectively be 100 – 400 trees ha^{-1} (Table 7.3 above) at a spacing of 5 – 10 m x 5 – 10 m to sequester 15.84 – 62.81C Mg ha^{-1}.

Figure 7.3 Land degraded by annual bushfires at Paga-Badunu

Shea home garden model

For home gardens, since shea trees are conserved and food crops cultivated in-between the trees, it is possible to encourage farmers to increase the density of the shea trees in their gardens from 44 trees ha^{-1} which sequesters 11.40 C Mg ha^{-1} to 100 – 150 trees ha^{-1} to sequester 25.85 – 38.91 C Mg ha^{-1} (Table 7.3 above) for more CO_2 credits. It was also observed that there was intensive cropping in home gardens in the study area as the home gardens were in communities and within reach, just by homes. They were also intensively manured or fertilized, thereby significantly improving the soil fertility. As such, increasing the tree density from existing 44 trees ha^{-1} up to 100 – 150 trees ha^{-1} would be appropriate as the fertile soils would be able to support the growth of both the shea trees and the food crops. Subsequently, with good agroforestry practices the trees, through litter fall, etc, could further improve the fertility of the soil.

Community shea woodlots model

In the community shea woodlots model, the stocking density of the small pockets of shea woodlots, could also (as in the case of the shea parklands with similar characteristics) be increased from 69 trees ha^{-1} to 100 – 400 trees ha^{-1} at a spacing of 5 – 10 m x 5 – 10 m to sequester 15.84 – 62.81 CO_2 Mg ha^{-1} yr^{-1} (Table 7.3 above). This would yield more C credits and generate more income for farmers.

7.3.4 Suitable models of shea systems for international carbon markets

According to Chenost *et al.* (2010), different types of forestry and timber projects can be used to combat climate change to claim carbon payments. These forestry and timber projects can be categorized along the value chain from upstream to downstream as shown in Figure 38 below:

Upstream → *Downstream*				
Land-use change and existing forests			Timber products	
Reducing emissions from deforestation and forest degradation (REDD)	Afforestation and reforestation (AR)	Improvements in forest management (IFM)	Biomass to energy	Wood product materials development

Figure 7.4 Types of forest projects along the value chain
Source: Chenost *et al.* (2010)

Shea project models under REDD

Global deforestation constitutes about 18% of all greenhouse gas emissions, or approximately 5.8 billion tonnes of CO_2 equivalent emitted into the atmosphere annually. This is more than global transport and aviation put together. The Stern Review indicates that reducing deforestation is the "single largest opportunity for cost-effective and immediate reductions of carbon emissions". This is where REDD (Reducing Emissions from Deforestation and Degradation) comes in. REDD is an international framework put in place to stop deforestation. In addition, the mechanism could help combat poverty while conserving biodiversity and sustaining important ecosystem services (Holloway and Giandomenico, 2009).

From the time when the idea of reducing emissions from deforestation (RED) was introduced at COP 11 in 2005, it has been expanded to include forest degradation, making it Reducing Emissions from Deforestation and forest Degradation (REDD), and then to REDD plus the role of conservation, sustainable management of forests (SMF) and enhancement of forest carbon stocks (REDD+). In addition, there are other proposals that emissions from agriculture and other land uses should be considered, as part of a broader AFOLU (agriculture, forestry and other land use) programme. This approach is known as REDD++ (Minang *et al.*, 2009).

Deforestation, which is the conversion of forest land to non-forested land, is caused by human activities. These result in the emission of substantial quantities of stored carbon and other GHGs into the atmosphere by combustion or decomposition. REDD is defined in terms of a "mosaic" when it is effected in different places, as in the case of slash-and-burn farming. The term "frontier" is used when REDD occurs on a pioneer front, for example when lands are deforested for large-scale agriculture. To combat deforestation and forest degradation, there is the need to implement projects, conservation activities, etc, such as establishment of protected areas or activities, reforestation, sustainable agricultural production, sustainable forest management, improvements in household energy efficiency, etc. (Chenost *et al.*, 2010).

To compute for the amount of carbon sequestered by forests, it is essential to follow the UNFCCC's definition of a forest as having a minimum tree crown cover of 10 - 30%, a minimum land area of 0.05 - 1 ha and a minimum tree height of 2 - 5 m, as well as that of Ghana as "a piece of land with a minimum area of 0.1 hectares, with a minimum tree crown cover of 15% or with existing tree species having the potential of attaining more than 15% crown cover, and the trees should have the potential or have reached a minimum height of 2.0 meters at maturity "in situ".

As shea parklands also have at least 15% crown cover and cover several hectares of land area and have a mean height of 8.35 m, they also qualify as forests. Since the five recommended models of shea projects (mentioned in section 7.3.3 on page 164) all aim at combating deforestation and forest degradation as well as sustainable agricultural production and sustainable forest management, they qualify as REDD projects for the carbon market. These five shea project models are *Shea agroforestry, Sole shea parkland, Shea plantation on degraded lands, Shea home garden and Community shea woodlots.*

Afforestation and Reforestation Projects (AR)

UNFCCC (2008) reports that a*fforestation and reforestation* (AR) involve the conversion of "non-forested" lands to "forested" lands. Both afforestation and reforestation aim at increasing the amount of carbon stored in forest biomass and soils. Afforestation means the human-induced conversion to forest of land that has been non-forested for at least 50 years at the time of conversion while reforestation refers to the conversion to forest of land that has been non-forested for a shorter period of time (less than 50 years). The difference between afforestation and reforestation is the length of time during which the terrain contained no forest: over 50 years in the case of afforestation and less than 50 years in the case of reforestation. Since the methodologies for estimating emissions and removals from afforestation and reforestation are identical, the two activities are treated as one for reporting and accounting purposes under the Kyoto Protocol. AR projects may include:

- Commercial AR, often on a large scale and mainly targeted at the production of timber or non-timber forest products (rubber, etc.);
- Community and peasant AR, often on a small scale and providing goods and services to local communities;
- AR on degraded lands with the main aim of restoring and preserving soils; and
- Agroforestry AR, combination of forestry and agricultural production.

Types of Shea AR project models for the carbon markets

On the basis of the above AR project specifications and categorizations, shea could clearly fit into the various AR projects for the carbon markets. Examples of such possible shea projects that could fit into their corresponding AR categorizations are indicated in Table 7.4 below:

Table 7.4 Types of AR projects and their recommended equivalent shea projects

	Afforestation/Reforestation (AR) project	*Recommended equivalent Shea project*
1	Commercial AR, often on a large scale and mainly targeted at the production of timber or non-timber forest products (rubber, etc.)	*Sole shea parkland* *Shea plantation on degraded lands*
2	Community and peasant AR, often on a small scale and providing goods and services to local communities	*Shea home gardens* *Community shea woodlots*
3	AR on degraded lands with the main aim of restoring and preserving soils	*Shea plantation on degraded lands*
4	Agroforestry AR, combining forestry and agricultural production	*Shea agroforestry* *Shea home gardens*

Improved Forest Management (IFM) Projects

Chenost *et al.* (2010) asserts that, IFM projects are executed in "forests" that are planned to remain as such. The purpose is to increase the C stock in the area or to decrease C emissions from forest activities and their effects through better forestry practice. Examples of IFM projects include the following:

- Switching from conventional forest exploitation methods to low-impact or sustainable forest management;
- Establishing a previously-logged forest as a conservation area; and
- Increasing the duration of rotations (i.e. the interval between felling operations in the same forest parcel).

In these contexts, some recommended shea projects could also be considered within the set criteria for the IFM project categories, examples of which are shown in Table 7.5 below:

Table 7.5 Improved Forest Management (IFM) projects and recommended equivalent shea projects

	Improved Forest Management Project	*Recommended equivalent Shea project*
1	Switching from conventional forest exploitation methods to low-impact or sustainable forest management	*Shea agroforestry* *Sole shea parkland* *Shea plantation on degraded lands* *Community shea woodlots*
2	Establishing a previously-logged forest as a conservation area	*Sole shea parkland* *Shea plantation on degraded lands* *Community shea woodlots*
3	Increasing the duration of rotations (i.e., the interval between felling operations in the same forest parcel	*Sole shea parkland* *Shea plantation on degraded lands* *Community shea woodlots*

Shea projects and uses of tree products

The Inter-Governmental Panel on Climate Change (IPCC) indicates that 1 m^3 of timber products can store an average of 1 tCO_2. Tree products play an important role in combating climate change. Firstly, they prolong the period during which C is stored in wood. When a tree is cut down, the C in it is concealed in the marketed products for some time, the duration of which depends on the type of wood product. Secondly, the use of wood to manufacture alternative products also assists to decrease fossil fuel needs (which is known as the 'substitution effect'). The manufacture of wood products usually involves the expenditure of less energy than producing materials like aluminum, concrete, or cement (Chenost *et al.*, 2010).

Taking this into account, there could also be additional projects for shea along the value chain during the conversion of culled shea trees into wood products. Findings of a socio-economic study in Ghana (of which this research forms part) indicate that all the 540 farmers interviewed said they usually select some shea trees for use as roofing materials for their houses, for carving mortars, pestles, stools, etc. It is therefore possible to increase the length of storage of carbon in such products if the people are properly educated on the relevance of such practices as they eventually impact on climate change. The urge to embrace and adopt these *'long-duration of C storage in wood'* practices would be boosted if people in such communities are motivated and somehow adequately compensated. This would not only help prolong the life-spans of the wood products and eventually decrease the need to fell more trees for such wood products, but they would ultimately also help to conserve trees and forests to sequester more C to combat climate change.

Shea biomass energy projects

According to Junginger *et al.* (2008), in recent years the trade in biomass energy (or bioenergy) has increased very fast. Trade in residues from the forestry and agricultural sectors such as wood chips, pellets and briquettes as well as liquid biofuels and biodiesel are significantly increasing for applications in electricity production (e.g. in gas- and coal-fired power plants), transportation fuels and as residential space heating. This trade occurs at high levels in national, regional and global energy markets. The reason for this increase in the trade and utilization of bioenergy is its potential in the provision of an affordable and practical renewable source of energy for climate change mitigation, energy security, and rural development.

Thus, Chenost *et al.* (2010) report that the sustainable and prudent use of wood for biomass energy or a source of fuel is almost carbon neutral. This is due to the fact that the amounts of CO_2 emitted when wood is burnt are counterbalanced by the amounts of CO_2 sequestered by growing forests. Biofuel replaces fossil fuels and thus avoids the corresponding CO_2 emissions. This energy substitution effect may involve heat production (industrial or domestic) or combined heat and power production (CHP).

In the same vein, shea serves as an excellent bioenergy source because, during the research, wood and oil/butter from shea[9] were identified and used as biofuel. As a result, when shea parklands are properly and sustainably managed for the provision of bioenergy, the amounts of CO_2 emitted when its wood and oil/butter are burnt as biofuels would be compensated for by the amounts of CO_2 sequestered by growing trees in shea parklands.

7.4 Discussion

7.4.1 Identified shea systems and developed models for carbon markets and the roles played in addressing climate change

Five shea systems were identified in the study area. These were shea agroforestry projects, shea parklands on fallow lands dominated by shea trees, shea parklands dominated by other tree species, shea home gardens and small pockets of shea trees within communities. The most prominent systems identified were the shea agroforestry system and shea home gardens which were practised by all the farmers interviewed as they involved the cultivation of food crops in-between shea. The other three shea systems were also existent in the communities in the study but basically, they were shea trees protected and allowed to grow on either fallow lands on in the communities.

Although it is quite difficult developing forest carbon projects due to the need to comply with rigorous standards (Olander and Ebeling, 2011), it became necessary to develop models out of the existing shea systems to meet the requirements of the international carbon markets. As a result, five models were developed for the carbon markets. These are the shea agroforestry model, sole shea parkland model, shea plantation on degraded lands model, shea home garden model and the community shea woodlots model. With the structuring and development of these models and the accompanying recommended cultural practices, it is expected that, if selected and implemented, the tree density, as suggested in each model, should be increased to improve the carbon sequestration potential of the shea parklands. This would translate into the production of more carbon credits for the markets, which would in turn yield more cash revenue for direct payment to communities and individuals for proper management and protection of shea parklands. In the end, the livelihoods of communities and individuals would be improved as the people will profit from direct cash benefits from the sale of their shea carbon credits, leading to improved carbon sequestration by shea trees to combat climate change.

This ability of shea to combat climate change through carbon sequestration, apart from all the other tangible and intangible benefits derived, is the single most important benefit that can change the gloomy future of shea trees in Ghana, which presently are disappearing at an

[9] Oil/butter from shea is used as a biofuel for lighting in lamps at night (in the absence of electricity) in most communities in the study area. In addition, after extracting the oil/butter, the shea butter waste is used to supplement the fuelwood used in producing the oil/butter. It saves some significant amount of energy needed to produce shea oil/butter.

alarming rate due to logging, annual bushfires, etc. This singular role would tremendously benefit the people in those shea-growing areas as they would obtain direct cash benefits through the sale of carbon credits from their shea farms and parklands. Thus, this could serve as a major incentive to the people to willingly and readily manage and conserve the trees which, from results of gathered field data in Ghana, have high potential in sequestering carbon and hence very good at combating climate change. Thus, as asserted by Chenost *et al.* (2010), attention should be paid to such forest ecosystems since play critical roles in the balance of the earth's climate; in terms of maintaining the equilibrium of the earth's climate. Globally, greenhouse gas (GHG) emissions emanating from land uses and Land Use, Land Use Change and Forestry (LULUCF) or Agriculture, Forestry and Other Land Uses (AFOLU) boil down to 17.4% of all Greenhouse Gas (GHG) emissions, making forestry sector the third largest source of GHG emissions – only next to the energy sector (25.9%) and industry (19.4%), with the agriculture (13.5%) and transport (13.1%) sectors ranked as fourth and fifth respectively. In spite of deforestation contributing very much to anthropogenic GHG emissions, forest ecosystems also help to combat climate change by absorbing large quantities of CO_2 via photosynthesis. Worldwide terrestrial ecosystems absorb approximately 2.6 Pg C per annum, which is greater than the total emissions from deforestation (1.6 Pg C per year). The overall "net" effect of forests is thus positive, at about 1 Pg per year.

At the local level, shea parklands in Ghana, which constitute part of the terrestrial or forest ecosystems, also play a significant role in addressing climate change through carbon sequestration, with the capacity, based on findings of this research, to sequester as much as 1.19 – 2.39 CO_2 Mg ha^{-1} yr^{-1} at a stocking density of 100 – 200 trees ha^{-1}, which compare favourably with the sequestration rates of other tree species, and even to stretch it further, shea does better and could even do a lot more. Thus, this indicates that shea is an excellent candidate for climate change mitigation through carbon sequestration, and has brighter chances of gaining grounds in the international carbon markets.

According to Chenost *et al.* (2010), forests or trees affect climate in different ways:

- When forests are growing (new growth and young forests), they absorb CO_2 from the atmosphere in large quantities and store it in the form of carbon chains in tree trunks, branches, and roots, as well as in soil and litter;
- When forests are in equilibrium, their stores of carbon remain intact and the impact on climate change is relatively neutral (low emissions from natural mortality of certain individuals, low absorption by tree growth).
- When forest trees are felled and replaced by crops (e.g. oil palms in Indonesia, soya beans in Brazil, cash or subsistence crops in Africa) or grazing land (cattle ranching in Amazonian), the stored carbon is released into the atmosphere. And finally;
- Wood products may be used as a substitute for fossil fuels or energy intensive materials, thus avoiding GHG emissions when these products are from sustainably-managed forests.

Similarly, shea trees, like other forest tree species, play significant roles in combating climate change. To be able to obtain the desired net "positive gain" of sequestered CO_2 from the atmosphere there is the need to ensure that activities that contribute to absorption of CO_2 far outweigh those that lead to emissions of CO_2. In this regard, it is important to identify and establish shea projects that would significantly lead to reducing GHGs emissions while at the same time increase carbon sequestration from the atmosphere; that is precisely what the developed models of shea are expected to do. Shea trees are particularly important in carbon sequestration due to the fact that the trees are capable of surviving for more than six hundred years if properly managed and protected. With adequate care, in terms of appropriate forestry, agronomic, cultural and other tree and field management practices, the tree can live for hundreds of years; this means hundreds of years of sequestering carbon! Although the same argument could be made for other species of trees, shea trees are unique because of the value people attach to them. During the socio-economic survey on shea in Ghana, the words of one of the respondents who happened to be the Chief of Kawampe (Figure 7.5), one of the prominent traditional leaders in the shea-growing areas, summed up the general comments by all the other 539 respondents interviewed:

"*Shea trees are everything to us. They form part and parcel of our lives, our tradition, our culture; in fact our very existence. They are a major source of our food, medicine and our income. We therefore wonder how we can survive without shea trees. That is why you see them everywhere; on our farms, on our fallow lands, in our communities and even in our houses. We cherish and protect them wherever they grow because they form part of our lives. We inherited them from our forefathers and we have to hand them over to our children, grandchildren and those who will come after them. But the sad thing is that we are gradually losing these trees because people have been felling them for fuelwood and charcoal production for sale. We have been enforcing strict bye-laws to stop these from happening but we sometimes helplessly look on while these things happen. To some extent, we cannot blame those who flout these bye-laws because economic hardships drive them into cutting down the trees. The people need to survive. You know, people will do anything to survive. You will be sad when you see the conditions in which they live with their families. They need to solve their financial problems immediately by selling the trees in the form of fuelwood and charcoal. We always warn them but the recalcitrant ones will not listen. We wish we had the resources to employ vigilante groups to patrol and protect the shea trees, but where is the money to pay them to do so? So we are excited about this idea of 'direct cash payments for the management and protection of the trees'. We therefore welcome this great idea and look forward to its implementation. We will support it and gladly and willingly help to implement it as well as properly manage and protect the trees, because my people would eventually be rewarded with these direct cash payments; that will be a great incentive for protecting the trees".*

Figure 7.5 An interview with the Chief (Traditional ruler) of Kawampe in Ghana on conservation of shea.

7.4.2 Availability of markets for Shea carbon

By the UNFCCC (2008) and EPA (2007) respective general and specific definitions of forests, shea parklands could also be considered as forests as they fulfill the requirements of forests. Shea forests or parklands thus offer numerous ecosystem services including carbon sequestration, and therefore have the prospects of gaining grounds in the international carbon markets for the sale of their shea carbon credits since the trees generally have a high potential for sequestering carbon. There is therefore the need, as argued by De Gryze *et al.* (2009) for direct cash payments for these services and this will ensure that shea parklands are properly managed and conserved. As Schneck *et. al*. (2011) observed that there are presently ready markets for forest carbon credits owing to worries about adverse effects of climate change that have accelerated the development of such carbon markets, the resultant impact of traded shea carbon credits on the conservation of shea parklands would be considerable.

Carbon markets are large enough for these ecosystem services including forest carbon credits, and in terms of volume, such markets are the largest type of environmental market in the world (Shames and Scherr, 2010). Hence, there is the need to take advantage of the existence of these markets and adequately manage and conserve forest resources that will yield carbon credits for sale on these markets. To this end, all the farmers in the shea-growing communities of Ghana pledged their support and readiness to help protect the shea trees as they all stand to derive financial gains from the generated carbon credits. They see this as a good platform to derive financial gains through the sale of carbon credits in the Kyoto-regulated market and the Voluntary market since the developed shea project models qualify as A/R or forest-related mitigation projects. In this regard, if the fight against climate change is to be won, there is the urgent need to make available avenues for carbon credits from forests (including shea parklands) to be traded in these markets and the generated cash revenues paid directly to communities and individuals to ensure that shea parklands and the other types of forests are properly managed and conserved.

7.4.3 Ghana's preparedness for shea carbon projects

Having had practical experiences of climate change and realized the damaging impact it has had and still continues to have on the livelihoods of the people, the socio-economic development agenda as well as virtually everything within the country, the phenomenon of climate change has kept everyone in the country alert and busy trying to figure out the needed measures to put in place to address the phenomenon in order to reduce the impact or possibly prevent it from happening. In this regard, projects that would help realize these dreams are warmly embraced and welcomed by all in Ghana. As shea has high prospects of addressing climate change, the Government of Ghana and indeed everyone is well-prepared to ensure that shea carbon projects, if implemented, succeed for the benefit of all, as they would help improve the livelihoods of the people by way of the direct cash payments that they would get from carbon credits as well as in the combat against climate change through carbon sequestration.

In Ghana, climate change is becoming an increasing threat to social and economic development as well as to the livelihoods of the people. The Government of Ghana (GoG) is completely committed to addressing these concerns, and preparing actions to adapt to these changes. Being a tropical country with substantial forest reserves, it is recognized that appropriate policies and actions should be implemented as both mitigation and adaptation measures to reduce deforestation and forest degradation in the country (Forestry Commission, 2012). The REDD initiatives in Ghana consider C conversion in farming systems for emission reduction (Nketia *et al.,* 2009). Climate resilient development has become Ghana's main priority as efforts aimed at addressing climate change present additional opportunities such as direct economic and social benefits and increased access to available international support in the form of financial and technical assistance as well as capacity building. To be able to realize these, the Government of Ghana (GoG) has developed and implemented appropriate policies and measures soon after becoming a party to the UNFCCC in September 1995.

In addition, in response to issues of climate change and the need to embark on pragmatic efforts to mitigate the undesirable effects, on signing the UNFCCC on Climate Change in 1992 and ratified it the GoG established a CDM Designated National Authority (DNA) at the Environmental Protection Agency (EPA) in 1995. It subsequently acceded to the Kyoto Protocol in 2002. The CDM project was to provide a unique opportunity for project developers and other interested parties to develop the capacity to formulate and implement CDM-type projects. Sectors that qualified for the CDM projects included energy, industrial processes, solvent and other product uses, waste and land use, land use change and forestry (EPA, 2008).

However, as it became increasing clear that CDM projects were extremely difficult to establish in the country due to challenges such as individuals and groups lacking or unwilling to invest the adequate initial capital (seen as very substantial) to invest into such projects, other opportunities emerged. One of such opportunities is the REDD project which is expected to take off in 2012. As REDD is a direct initiative to be implemented at the national level and financed through GoG, it is expected that shea carbon projects would be included in forest projects and given the needed attention. A report by Forestry Commission (2009) confirms that Ghana has also joined and implemented measures in readiness for the implementation of the REDD policy. The Readiness Preparation Proposals (R-PP) is a roadmap towards achieving REDD Readiness. It indicates what activities might be embarked on and it provides a guide to how these activities can be carried out and what resources may be needed. Since its incorporation into discussions the REDD concept has advanced from a highly definite tool to address deforestation and degradation to one that tackles a wider set of forest management issues – which is known as REDD+. At the moment, the REDD+, concept as defined in the Bali Action Plan (UNFCCC Dec 1/CP.13) and ensuing CoP decisions, relates to reducing emissions from deforestation and degradation, the role of conservation, sustainable management of forests and enrichment of forest carbon stocks all in developing countries. A REDD+ strategy can involve market or non-market-based instruments, and centre on performance according to established standards or based on greenhouse gas quantification. Ghana has taken a proactive role to initiate analysis and discussion regarding how the REDD+ concept could be applied to bolster its efforts to better manage its forest sector, including shea parklands. Ghana is one of the first African countries to initiate the development of a national strategy on REDD+ and also participates within negotiations on the development of international mechanisms on REDD+.

Ghana is thus well-prepared for such forest projects, and with the promise shea holds for the country, in terms of its capacity to sequester carbon, the livelihoods of the people would dramatically be improved once they get direct cash payments for their carbon credits. This would to some extent, help reduce the GoG's heavy responsibility of providing financial assistance to better the standard of living of the people. Furthermore, at the local community level, results of the socio-economic studies conducted indicate that the people in the shea-growing communities are well-prepared and ready to welcome and participate in the shea carbon projects. Their expectation of getting direct cash payments from the sale of shea carbon credits is gearing them up for this sort of projects. All the 540 respondents interviewed in the shea-growing areas look forward to the implementation of such shea carbon projects and are very excited at the thought of getting direct cash compensations for managing and conserving shea trees.

7.5 Conclusion

Based on results of the study, the five identified shea systems already have a high potential for sequestering carbon, and following the requirements of the international carbon markets, five models (shea agroforestry model, sole shea parkland model, shea plantation on degraded lands model, shea home garden model and the community shea woodlots model) were developed. It is expected that there would be significant increases in the carbon sequestration potential of these shea models if the recommended tree densities and appropriate agroforestry, agronomic and forestry practices are implemented to yield more carbon credits for the carbon markets. The study also identified three types of carbon markets: (1) the market that aims at achieving the commitments under the Kyoto Protocol (Kyoto regulated market); and (2) the regulated market outside the Kyoto Protocol, and (3) the market that is trading voluntary emission reductions. However, as forest-related mitigation opportunities are categorized under the Kyoto-regulated market (CDM A/R) and voluntary market (planting forests and avoiding deforestation), shea carbon credits could be traded in these markets since shea projects qualify as A/R or forest-related mitigation projects. With the necessary policies and measures put in place in the country by the Government of Ghana, and the enthusiasm and willingness with which the farmers are ready to participate in these models of shea projects, it can be appropriately said that all is now set for the implementation of these projects which would significantly improve the livelihoods of the people through direct cash payments to them for traded shea carbon credits on the forest carbon markets as well as help to manage and conserve shea parklands for addressing climate change.

CHAPTER EIGHT

8. General Conclusions and Recommendations

8.1 Introduction

The dissertation study investigated how the potential for global international agreements on climate change could bring benefits, through carbon trading and other mechanisms including REDD policy, to Ghanaian communities involved in Shea production. The study was done in Ghana in the West African Savannah and was divided into the following four segments:

1. *Technical fieldwork;*- this segment of the study was conducted to assess the carbon stocks and carbon sequestration potential of shea parklands in the Sudan, Guinea and Transitional Savannah agro-ecological zones of Ghana. Data were taken on 763 trees from 54 randomly selected plots each measuring 0.25 ha (50 m x 50 m) in the Guinea, Sudan and the Transitional Savannah agro-ecological zones of Ghana in the West African Savannah.

2. *National study;*- this was undertaken to identify the Ministries, Departments, Agencies, Commissions, Boards and other Governmental and Non-governmental organizations involved in climate change and shea production policy formulation and implementation, the different kinds of policies they formulate and how they function together in a form of network for implementing these policies. 31 people from a range of organizations were interviewed. The research was essentially conducted in Accra, where the national headquarters of most of these organizations are located. The research identified more than 14 major policies and several other initiatives on climate change and shea production formulated and implemented by organizations, both Governmental and Non-governmental,

3. *Regional survey;*- this segment of the research was done to identify organizations, institutions, agencies and other bodies involved in the implementation of policies on climate change and shea production. The study was conducted in Tamale, Bolgatanga and Sunyani, which are the regional administrative capitals of the three sampled northern regions of Ghana. These regions are Northern, Upper East and Brong-Ahafo regions, and are located in the Guinea, Sudan and the Transitional Savannah zones respectively.

4. *Socio-economic survey on shea at the community level*;- this was conducted in shea-growing communities in Ghana to identify the practices and strategies used by farmers to manage and conserve shea trees. A total of 540 farmers (50% males and 50% females) were randomly selected from 9 communities of the 3 agro-ecological zones of northern Ghana in the West African Savannah.

The studies aimed to answer the following four key research questions:

1. *How much carbon stocks do the various types of shea parklands (in terms of agro-ecological zones, land-use systems and ages of land-use systems, in the West African Savannah) contain and how much carbon can they sequester?*
2. *How are UNFCCC international agreements impacting on adaptation and mitigation of climate change and shea production in Ghana?*
3. *How does community shea parkland management impact on the shea trees, the livelihoods of people in the local communities in Ghana as well as on the global environment?*

4. *How can shea fit into the international carbon markets to improve the livelihoods of people in northern Ghana as well as conserve shea parklands there for the purposes of combating climate change for the benefit of the global environment?*

8.2 Main findings of the research

The key findings of this dissertation research are the field results of the research objectives and answers to the research questions set for the studies. These are:

8.2.1 Conclusion and recommendations to Research Question 1

In pursuit of answers to Research Question 1, field results of the study show that all the three sites significantly differed ($p<0.05$) with regards to carbon stocks and CO_2e, with Sudan savannah recording the largest amounts of carbon stocks (16.20 Mg ha^{-1}). The two land-use systems did not differ significantly, but the field plots stored more C. In terms of age of land-use, the three age groups were not significantly different in the biomass carbon stock, but the medium plots stored C stocks most (9.59 Mg ha^{-1}). These results demonstrate that the savannah shea parklands areas have substantial biomass carbon stocks with Sudan savannah, field plots and medium age plots being the most productive treatments in their respective categories for C storage. On the average, the shea parklands stored 8.91 Mg ha^{-1}. Increasing the density of shea trees through planting and natural regeneration will lead to greater sequestration of carbon.

Due to the fact that Sudan savannah, field and medium plots stored the largest C stocks and sequestered the most C and CO_2e in all the different categories of plots studied, the determining factor however is the management of the trees. It is therefore recommended that shea parklands be properly managed for the trees to store and sequester most C since it is evidently clear that managed shea trees on farms (field) yield better than unmanaged ones (fallow). And considering the global attention given to the need to use forests and agroforestry systems to mitigate climate change through carbon sequestration, farmers stand to derive additional financial benefits from the conservation of shea trees on their farms as the carbon price per ton, which is presently at $37.00 per ton of CO_2e. Thus, it is a very lucrative area to venture into since it is the cheapest way to sequester carbon dioxide from the atmosphere for personal, family, community, national and global environmental benefits.

8.2.2 Conclusion and recommendations to Research Question 2

The findings show Ghana's response to the numerous international agreements on climate change of the UNFCCC; with several policies and other initiatives having been formulated and implemented or yet to be implemented in managing or dealing with climate change issues. The results also illustrate the considerable amount of resources (financially, intellectually, etc,) that Ghana has invested into climate change adaptation and mitigation policies and initiatives. The country has also collaborated with a number of foreign countries and foreign organizations in both bilateral and multilateral agreements with the view to tackling climate change in Ghana. The involvement of the actors in the various policy planning and implementation has been significant, considering the extent to which aims and objectives of the policies and other initiatives are being achieved. They have been involved in public education on the need to protect the environment, protect and conserve trees and to desilt drains and stop dumping waste into them to allow free flow of water during heavy rains. This has caught on well with the people and the trend is beginning to change after some disasters in the recent past. The research findings also indicate how these policies and other initiatives have impacts on the shea industry in Ghana if appropriately executed, with some stakeholders interviewed expressing contentment at the design of the various policies and initiatives.

Although findings of the research show how committed Ghana is towards climate change mitigation and adaptation, the impact of the various policies and other initiatives on shea so far has not been significantly felt as expected since most farmers at the moment are yet to enjoy compensations and incentive packages for conserving shea trees on their farms instead of reducing their density to pave way for more food crops to be cultivated. This is because, prior to this research there were earlier studies in shea-growing communities and the farmers interviewed complained about decreases in food crop yields due to the shading effects of shea trees on their crops. Therefore, if adequate compensation is given to farmers to purchase additional food for their families they would be motivated enough to conserve shea trees, which would form part of the efforts aimed at adapting to and mitigating climate change as well as improving the incomes of the people in northern Ghana whose livelihoods depend, to a large extent, on the shea industry.

8.2.3.1 Conclusion and recommendations to Research Question 3

The research findings show that the farmers manage the shea trees by raising seedlings through natural regeneration, creating fire-belts around farms and trees, weeding, discouraging other people from felling the trees, mounding soil around trees to cover their exposed roots, pruning branches of trees, controlling insect pests and diseases and applying manure. These significantly helped to improve survival rates as well as growth and yields of the trees which accrued several benefits such as income, sheabutter, edible fruits, fuelwood, shea litter fall as manure for crops, wood for roofing houses, and provision of shade for the farming households. Income made from the sale of shea products and used to take care of most of the household needs was ranked highest by the farmers, and constituted up to 25% of the total annual income of 74% of the households. The positive impact of these management strategies and practices could be realized worldwide through the positive role shea trees play in mitigating climate change and reducing global warming effects. This is as a result of the shea trees having a high potential to sequester carbon through increasing the density of shea trees and this could be enhanced if they are better managed.

The study also found out that almost all the farmers who were willing to manage shea trees were natives in their communities and had inherited their farmlands together with the shea trees from their parents and other family or clan members. These farmers own and have authority over the lands and shea trees but are however more willing to manage trees that are less than 3 km away from their homes compared to trees that are 3 km or farther away from their homes. Willingness to manage and conserve shea trees is significantly ($p \leq 0.05$) influenced by whether the farmers are natives or non-natives, how the land was acquired, distance of farm from home, who owns the farmland and the shea trees, who has authority over the land and the shea trees and benefits derived from the trees. Therefore, in seeking ways of conserving shea trees in the study area, these factors should be taken into consideration since they play crucial roles in determining the willingness of farmers to manage shea trees.

Shea parklands identified as playing a significant part in carbon sequestration. It is thus recommended that these developed shea project models be considered for implementation to save shea trees, which at present are under serious threat as they are constantly being logged and burnt by bushfires in every minute every day. If these models are considered, they would help conserve the shea parklands and ultimately produce carbon credits which could be transacted on the international forest carbon markets and the accumulating cash revenues directly paid to farmers in the study area as cash payments to inspire them to continue managing and protecting the shea trees. To the end, it would be a win-win situation for all; shea forests would be conserved for addressing climate change for the benefit of all while cash revenues from traded shea carbon credits would be paid directly to the farmers to improve their livelihoods.

8.2.4 Conclusion and recommendations to Research Question 4

The research findings indicate that the five identified shea systems already have a high potential for sequestering carbon through increasing the density of shea trees, and following the requirements of the international carbon markets, five models (shea agroforestry model, sole shea parkland model, shea plantation on degraded lands model, shea home garden model and the community shea woodlots model) were developed. It is thus the hope and expectation that there would be significant increases in the carbon sequestration potential of these shea models if the recommended tree densities and suitable agroforestry, agronomic and forestry practices are applied to yield more carbon credits for the carbon markets. Three types of carbon markets were identified during the study. These were: (1) the market that aims at achieving the commitments under the Kyoto Protocol (Kyoto regulated market); and (2) the regulated market outside the Kyoto Protocol, and (3) the market that is trading voluntary emission reductions. Nevertheless, as forest-related mitigation opportunities are categorized under the Kyoto-regulated market (CDM A/R) and voluntary market (planting forests and avoiding deforestation), shea carbon credits could be traded in these markets since shea projects qualify as A/R or forest-related mitigation projects. With the requisite policies and measures implemented in the country by the Government of Ghana, and the interest and preparedness with which the farmers are all set to participate in these models of shea projects, it can be fittingly said that all is now set for the execution of these projects which would significantly improve the livelihoods of the people through direct cash payments to them for traded shea carbon credits on the forest carbon markets as well as help to manage and conserve shea parklands for addressing climate change.

As there is the need to look for pragmatic ways of addressing climate change, with shea parklands identified as playing a significant part in carbon sequestration, it is recommended that these developed shea project models be considered for implementation to save shea trees, which at present are under serious threat as they are constantly being logged and burnt by bushfires in every minute every day. If these models are considered, they would help conserve the shea parklands and ultimately yield carbon credits which could be traded on the readily available international forest carbon markets and the accruing cash revenues directly paid to farmers in the study area as compensation to motivate them to continue managing and protecting the shea trees. In the end, it would be a win-win situation for all; shea forests would be conserved for addressing climate change for the benefit of all while cash revenues from traded shea carbon credits would be paid directly to the farmers to improve their livelihoods.

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APPENDICES

Appendix 1a. Climate change-related activities: Policy Framework of GSGDA on Climate Variability and Climate Change in Ghana, 2010-2013
Source: NDPC (2010).

KEY FOCUS AREA	ISSUES	POLICY OBJECTIVE	STRATEGIES	IMPLEMENTING AND COLLABORATIVE AGENCIES
Climate Variability and Change	• Lack of awareness on climate change and its impact • Variability in ecological zones that make predictions of climate change impacts complicated • High dependence on natural resources • Poor and inadequate infrastructure to cope with the impacts of climate change • Limited human resource	1. Adapt to the impacts and reduce vulnerability to Climate Variability and Change	1.1 Increase resilience to climate change impacts through early warning systems 1.2 Alternative livelihoods: minimize impacts of climate change for the poor and vulnerable 1.3 Enhance national capacity to respond to climate change through creation of a Climate Centre at the Institute of Environment and Sanitation Studies, Legon 1.4 Adapt to climate change through enhanced research and awareness creation 1.5 Develop and implement environmental sanitation strategies to adapt to climate change 1.6 Manage water resources as a climate change adaptation	MEST, NDPC, Regional Planning & Coordinating Units, Cross Sectoral Planning Groups (CSPGs), District Planning & Coordinating Units, Universities
		2. Mitigate the impacts of Climate Variability and Change	2.1 Promote energy efficiency in all aspects of social and economic life 2.2 Promote energy efficient transport services and facilities 2.3 Promote sustainable forest management and implement forest governance initiatives 2.4 Promote various mitigation options in the agricultural sector including education and efficient management practices 2.5 Improve waste management mechanisms	

	capacity • Weak sub-regional network • Inadequate financial resources/low budgetary allocations • Poor control of water level for the generation of hydropower	3. Use Low Carbon Growth (LCG) as a specific approach to integrate the link between climate and development	3.1 Develop a long-term national LCG approach based on a clear scientific and economic assessment 3.2 Develop an appropriate response to climate challenges through linkages between and among research, industry and the Government machinery 3.4 Prioritize technical and systemic innovation initiatives in the most pressing areas and those areas with the most potential	
			for rapid cost-effective results 3.5 Involve a wide range of stakeholders so as to understand and negotiate tradeoffs and achieve broad consensus for a package of LCG policies for sustainable development 3.6 Identify the technical, human and financial capacity needed to achieve long-term Low Carbon Growth 3.7 Create the knowledge base that would allow the nation to enter international negotiations with a clear understanding of the potential for emission abatement, and the financing needs of the country	

Natural Disasters, Risks and Vulnerability	• High vulnerability of environmental natural resources to natural disasters • Poor management of the impacts of natural disasters and climate change • Earthquakes and minor tremors in Accra district and some coastal areas • Occasional droughts – most severe in 1982/3 with disastrous effects on livelihoods • Increasing frequency and impact of droughts, floods, forest fires, and other natural hazards	1. Mitigate and reduce natural disasters and reduce risks and vulnerability	1.1 Invest in early warning and response systems 1.2 Create awareness on climate change, its impacts and adaptation 1.3 Increase capacity of NADMO to deal with the impacts of natural disasters 1.4 Equip the key seismological monitoring stations in Ghana 1.5 Reduce impacts of natural disasters on natural resources using a multi-sectoral approach 1.6 Introduce education programmes to create public awareness 1.7 Integrate watershed management to combat desertification 1.8 Enforce bye-laws restricting structures in flood-plains, water-ways, wetlands, etc	MWRWH, MLGRD, MMDAs, TCPD, NADMO, Private Sector, NGOs

Appendix 1b. Climate change related initiatives in Ghana: Overview of the initiatives related to adaptation in Ghana
Source: Würtenberger *et al.* (2011)

	Keyword	Name	Recipient or implementing organization	start date	end date	Initiative sponsor	Amount	Currency
ongoing	Adaptation	Sustainable Land Management in Ghana (no specific climate change focus)	MEST	Jun-10	Oct-15	AfDB, IDA, GoG	129.2 mln.	USD
		CARE Adaptation learning programme for Africa (ALP)	CARE	Jan-10	Dec-14	DFID, DANIDA, Ministry of Foreign Affairs Finland,	5 mln.	GBP
		Innovative Insurance Products for Adaptation to Climate Change (IIPAC)	GTZ	Dec-09	Jun-13	German Federal Ministry of the Environment	2.25 mln.	EUR
		Vodafone - Raising awareness for climate change	EPA	Jul-10	Jul-12	Vodafone Ghana	150 000	GHC
		Regional Science Service Centres (RSSC)	Unknown	Jul-10	Jun-12	German Federal Ministry of Education and Research	2.9 mln.	EUR
		URAdapt: Managing water in the urban-rural interface for climate change resilient cities	CSIR/ WRI	2009	2012	International Development Research Centre (IDRC) of Canada, DFID	480 000	USD
		Climate Change Adaptation in Northern Ghana	WRC	Jan-08	Dec-11	DANIDA	884 000	USD
		Africa Adaptation Programme	UNDP	Dec-08	Dec-11	JICA	2.7 mln.	USD
		Climate Airwaves	Ghana Community Radio Network					

	Keyword	Name	Recipient or implementing organization	start date	end date	Initiative sponsor	Amount	Currency
completed	Adaptation	CC DARE – Climate Change and Development Adapting by Reducing Vulnerability	UNDP/EPA	Aug-09	Nov-10	DANIDA, UNDP, UNEP	150 000	USD
completed	Adaptation	Economics of Adaptation to Climate Change	World Bank	Dec-07	Mar-10	DFID, Switzerland, NL	4.4 mln.	EUR
completed	Adaptation	Netherlands Climate Assistant Programme (NCAP) Ghana Phase Two	ETC International	Jan-04	Dec-07	Dutch Ministry of Foreign Affairs	180 000	EUR
completed	Adaptation	Netherlands Climate Change Studies Assistant Programme (NCCSAP) Ghana Phase One	IVM	Jan-96	Dec-00	Dutch Ministry of Foreign Affairs		
ongoing	Disaster risk management	Ghana North- Sustainable Development, Disaster Prevention, and Water Resources Management (GFDRR)	NADMO	Jan-08	Dec-11	World Bank	660 000	USD
completed	Disaster risk management	Enhancing National Strategies for Effective Disaster Risk Reduction in Ghana	Unknown	Jan-08	Dec-08	UNDP	140 000	USD
ongoing	Social development and health	Integrating Climate Change into the Management of Priority Health Risks	MoH	Oct-10	Dec-13	GEF	1.8 mln.	USD
						(co-financing of 55.8 mln. USD through general health sector funding, e.g. by DANIDA)		
ongoing	Social development and health	Climate Change and Human Health in Accra, Ghana	Regional Institute for Population Studies	Sep-09	Jun-12	International Development Research Centre (IDRC) of Canada, DFID	340 000	USD
ongoing	Social development and health	Ghana Community-Based Rural development (no specific climate change focus)	MLGRD - Ministry of local government and rural development	Jul-04	Jun-11	IDA, GoG, Local governments	74 mln.	USD

	Keyword	Name	Recipient or implementing organization	start date	end date	Initiative sponsor	Amount	Currency
ongoing	Water management	Ghana Sustainable Rural Water and Sanitation Project (no specific climate change focus)	Community Water and Sanitation Agency (CWSA)	Jun-10	Jun-16	World Bank, GoG	77.3 mln.	USD
		Ghana Urban Water Project (no specific climate change focus)	Ghana Water Corporation	Jul-04	Dec-12	IDA, GoG, Nordic Development Fund	120 mln.	USD
completed	Water management	Sustainable Development of Research Capacity in West Africa based on the GLOWA Volta Project (no specific climate change focus)	Unknown	Jun-09	Nov-10	German Federal Ministry of Education and Research	566 000	EUR
		GLOWA Volta Project (no specific climate change focus)	University of Bonn	May-00	May-09	German Federal Ministry of Education and Research	11 mln.	EUR
		Water resource management principles	WRC	Jan-01	Dec-07	DANIDA		

	Keyword	Name	Recipient or implementing organization	Start date	End date	Initiative sponsor	Amount	Currency
ongoing	Carbon finance	Ghana Cocoa Carbon Initiative	NCRC			Moore Foundation, Rainforest Foundation, Cadbury		
completed	Carbon finance	Capacity building for CDM in Ghana	Unknown		Aug-09	UNDP		
		MEND - Moving towards emission neutral development	Ecosecurities Ltd	Aug-00	May-02	DFID	206 000	GBP
ongoing	Climate strategy	Climate Change Enabling Activity (Additional Financing for Capacity Building in Priority Areas)	EPA			UNDP	100 000	USD
		Technology Needs Assessment (TNA) update	EPA	Nov-09	Apr-12	UNDP	200 000	USD
		UNDP Annual Workplan Ghana	EPA			UNDP		
		Ghana Environmental Conventions Coordinating Authority (GECCA)	MEST			UNDP, GEF		
completed	Climate strategy	Second National Communication to UNFCCC	EPA		Dec-2010	UNDP	420 000	USD
		National Mitigation Strategies for Forestry and Agriculture	EPA		2010	UNDP		
		Initial National Communication (INC)	UNDP	Dec-97	Jan-01	UNDP	95 000	USD
Ongoing	Energy efficiency	Promoting of Appliance Energy Efficiency and Transformation of the Refrigerating Appliances Market in Ghana	EC, Ministry of Energy	Jan-11	Dec-13	GEF, UNDP, GoG	6.1 mln.	USD

Status	Keyword	Name	Recipient or implementing organization	Start date	End date	Initiative sponsor	Amount	Currency
completed	Energy efficiency	Transformation of lighting market from incandescent to CFL bulbs	Electricity Company of Ghana	Jan-07	Dec-07	GoG	15.2 mln.	USD
planned	Renewable energy	Integration of renewable energy sources into the national energy grid mix (in preparation)	Unknown	2011		World Bank		
ongoing	Renewable energy	Ghana Energy Development and Access Project GEDAP (formerly Development of Renewable Energy and Energy Efficiency)	Ministry of Energy	Jul-07	Nov-13	GEF (total program costs of 46.77 mln. USD including not directly renewable energy related project components)	5.5 mln.	USD
		Solar PV Systems to Increase Access to Electricity Services in Ghana (part of GEDAP)	GoG	Oct-08	Dec-11	Global Partnership on output based aid	4.35 mln.	USD
		Geographic information system (GIS) tools to support RE planning in Ghana	REEEP	2009	2011	Energy Commission (EC)	130 000	USD
completed	Renewable energy	Renewable Energy-Based Electricity for Rural, Social and Economic Development in Ghana (RESPRO)	Ministry of Energy	Feb-99	Mar-01	GoG, GEF	3.1 mln.	USD
ongoing	Transport	Transport Sector Project (no specific climate focus)	GoG	Jun-09	Jun-15	IDA	225 mln.	USD
		Ghana Urban Transport Project	MRH	Jun-07	Dec-12	GEF (plus 83mio USD of co-financing by other institutions)	7 mln.	USD
completed	Transport	Vehicle emissions programme (part of the Transport Sector Program support (TSPS) II funded by DANIDA)	EPA	Jun-05	2008	DANIDA		

	Keyword	Name	Recipient or implementing organization	Start date	End date	Initiative sponsor	Amount	Currency
ongoing	Forestry & land use	Forest Investment Program (FIP)	GoG	Jul-09		World Bank/AfDB/development partners	70 mln.	USD
		REDD+ R-PP Implementation	Forestry Commission	Jan-10	Dec-13	FCPF	4.4 mln.	USD
		Towards Pro-Poor REDD	IUCN	Jan-09	Dec-13	DANIDA		
ongoing	Forestry and land use / Climate strategy	Natural Resources and Environmental Governance Program (NREG) and the NREG development policy operation (DPO)	GoG	Sep-08	Sep-12	FDA	4.1 mln.	USD
						EU	5.5 mln.	USD
						IDA	40 mln.	USD
						Dutch Embassy	28.7 mln.	USD
						DFID	6.2 mln.	GBP
						Total Funding:	84.8 mln.	USD
	Forestry & land use	Chainsaw Milling Project	Forestry Commission	Jan-07	Dec-12	Tropenbos International, EU	600 000	EUR
		National Forestation Plantation Development Program (NFPDP) (no specific climate change focus)	Forestry Commission	Jan-10		GoG	40 mln.	GHC
		Voluntary Partnership Agreement (VPA) (no specific climate focus)	MLNR	Jan-09		DFID, EU, Dutch Embassy		
		Afforestation schemes (no specific climate change focus)	Unknown			AfDB, GoG		

	Keyword	Name	Recipient or implementing organization	Start date	End date	Initiative sponsor	Amount	Currency
completed	Forestry & land use	Ghana REDD Readiness Preparation Proposal (R-PP)	Forestry Commission		Jan 10	FCPF	790 000	USD
		Non-legally Binding Instruments on all types of forest in Ghana (UNFF/NLBI)	Forestry Commission	Dec-08	Nov-10	BMZ	400 000	USD
		Peoples' Diagnostic Study	IUCN	May-09	Jul-09	GFP		
		Wildlife Sustainable Financing Study	Forestry Commission		Dec-09	EU		
		Forest Resources Use Management Project (FORUM) (no specific climate change focus)	GoG		Dec-08	GTZ	12.5 mln.	EUR
		ODA-KOTOAMSO COMMUNITY AGROFORESTRY PROJECT (OCAP)	Local community	Jan-07		GTZ, Samartex		
		Community Forest Management Project (CFMP)	MLNR	Dec-03		AfDB		
		Forest Conservation with emphasis on Mitigation and Adaptation to Climate Change	Forestry Commission			JICA	7.8 mln.	USD
		Forest trends Incubator Project	NCRC			Moore Foundation, US Aid		
		Sustainable Charcoal Production	NCRC			EU		
		Review of Forestry and Wildlife Policies and Laws	Forestry Commission, MLNR			NREG		
	Forestry & land use	Legal and Institutional Review - with regard to carbon projects	Forest trends (FT)			Moore Foundation		
		Community Resource Management Areas (CREMA)	Forestry Commission			NREG		
		CREMAs	Forestry Commission			NREG		
		Conservation of Forest Reserves	Forestry Commission			NREG		
		Benefits of REDD on cocoa farming	IUCN			Unknown		
		Growing Forest Partnership (GFP)	IUCN			World Bank		
		Dedicated Forests	Forestry Commission			DFID		
		KASA Forum	Local community					
		Production Reserves	Forestry Commission			GoG		
		Amanzouri Ecotourism Project	Unknown			Dutch Embassy		

Appendix 1c. Environmental challenges in Ghana and the management activities put in place to deal with them

ENVIRONMENTAL CHALLENGE	CHARACTERISTICS	MANAGEMENT ACTIVITES
1. Land degradation	• Results in declining productivity • Traditional and modern agricultural practices have led to declining soil quality, deforestation, accelerated erosion, reduced crop yields, increasing desertifying conditions.	• Preparation of land use and land cover plans • Mapping and environmental information systems of Natural Resources Management Programme (NRMP) • National Soil Fertility Action Plan • National Forest Plantation Development Programme (NFPDP) 2001 • Ratification of UN Convention to Combat Desertification (UNCCD) • National Action Programme to Combat Drought and desertification (EPA, 2000) • Ghana Environmental Management Project (3 Northern Regions)
2. Deforestation	• Marked deterioration of the condition and status of forest • Forest resources mainly utilized for production of logs for export, fuel-wood extraction, charcoal production and agriculture, the main cause of deforestation • Inadequate system for monitoring the rate and extent of deforestation • Forest destruction through mining, bush fires and other poor silvicultural management practices • Estimated annual forest cover decline of about 70,000 ha.	• Forestry Commission since 1970 has been implementing comprehensive forest protection strategy to restore forest reserves • About 30 areas (121,156 ha) of protected forests re-designated as Globally Significal Biodiversity Areas (GSBAs) • Forestry Commission and Private Sector engaged in cultivation of forest plantations (about 94,00 ha in 2004) • Community-protected areas (CPAs) also called "sacred groves" are available in many communities. EPA has recorded 145 CPAs in Ghana. • Forest and Wildlife Policy (1994) encourages community involvement in protecting forest resources
3. Biodiversity Loss	• Biological diversity is an indispensable component of natural resource base • Rich biodiversity in different parts of Ghana – mammals, birds and plants • Changes in the environment, drought and climate variability are proximate drivers of biodiversity loss	• Various domestic policies, laws and regulations related to conservation and use of biodiversity, e.g. Forestry and Wildlife policy, water resources policy • Designation of "protected areas" – Six Resource Reserves, Two wildlife Sanctuaries, Seven National Parks, Six Ramsar Sites and many community based sanctuaries • Ghana is party to many international conventions on biodiversity. - Convention on Biological Diversity (CBD)

	• Economic development and urbanization have resulted in rapid loss of biological diversity • Current harvest of wildlife for meat is estimated between 225 and 385,000 tons annually	- CITES • Projects to conserve biodiversity: - Northern Savanna Biodiversity Conservation Project - National Biodiversity Strategy and Action Plan
4. Water Pollution	• Major sources include: domestic and municipal wastes, agricultural and industrial wastes and other improper land use practices • Water pollution creates major environmental health problems – spread of disease pathogens which create water-borne diseases • Marked variation in river water quality for urban and rural settlements due to disposal of liquid and solid waste into water courses	• Awareness creation campaigns for protection of watersheds by government agencies and NGOs • Impoundments to improve water availability for different uses • The Community Water and Sanitation Agency (CWSA) is assisting communities in the provision of water and sanitation facilities • The African Development Bank (AFDB) has sponsored the Rural Water Supply and Sanitation Project • Provision of safe water in guinea worm endemic communities
5. Marine and Coastal Degradation	• Marine and coastal areas are under pressure due to: intensive agricultural production, industrial development, salt production, mining and quarrying and urban development • Sources of pollution are municipal and industrial effluents, agricultural runoffs • Sea erosion, e.g. Keta and Ada	• Direct investment in control structures, e.g. Keta Sea Defence Project • Gabions and boulder revetments to arrest erosion • Mangrove replanting and planting of other vegetative cover, e.g. at Winneba • Regulatory incentives – fines for illegal mining • Policy reforms in land use planning and coastal zone management • Investments in waste treatment and small scale waste collection
6. Mining and Industrial Development	• Mining has been an important industrial activity in the economy of Ghana • Small-scale mining for gold and diamond has also been important • Main environmental challenges include land devastation, soil degradation, water and air quality deterioration, noise, visual intrusion and social dislocation	• Mineral Policy and Fiscal Regime • EIA Procedures • Reclamation Bonds • Performance Disclosure Rating System • Minerals Commission • NREG Project

7. Urbanization	• Rapid population growth rate (2.2 % pa) • Regular north-south, rural-urban migration • Very high housing demand needs • Impact of over-crowding on human health, poor sanitation, absence of sewage treatment plants • Lack of planning leading to inordinate growth of cities, e.g. Accra, Kumasi, Tamale • Encroachment on reserved open spaces and waterways • Proliferation of unapproved settlements	• Policies and programmes to improve living conditions in rural areas to contain rural-urban migration • Improvement in urban transport • Affordable housing projects in the main cities • Draft Urban Policy in place • Draft Housing Policy • Cabinet approval of Environmental Sanitation Policy • Northern Region Small Towns Water and Sanitation Project

Appendix 1d. Emerging environmental issues that have assumed prominence in Ghana and the interventions implemented to manage them

ISSUE	CHARACTERISTICS	INTERVENTIONS
1. Climate Change	• Global problem with local implications • Changes in rainfall pattern and impact on agricultural production, unprecedented floods and disasters • Increased coastal erosion due to sea level rise • Drought in Sahelian region resulting in southward migration of people and animals • Climate change and associated health problems	• Guidebook to facilitate the integration of climate change and Disaster Risk Reduction into National Development Policies and Planning prepared • Ghana is party to the UN Framework Convention on Climate Change (UNFCCC) • Studies on measures to abate climate change through forestry and Land-use using the Comprehensive Mitigation Analysis Process (COMPAP) model. • A needs assessment report prepared in fulfillment of decisions of the COP of the UNFCC • A report with the assistance of the Climate Technology Initiative (CTI) of the OECD lists a number of desired technologies based on national set of criteria: Energy Efficient Lighting, Industrial Energy Efficiency and Land fill Methane Gas Recovery
2. Natural Disasters	• Accra district and some coastal areas have previously experienced earthquakes and continue to experience minor tremors • Occasional droughts – most severe in 1982/3 with disastrous effects on livelihoods • Devastating annual floods throughout the country, especially in Greater Accra	• National Disaster Management Organization (NADMO) in place • Seismological stations installed at Weija, Shai Hills, Kukurantumi and Accra • Educational programmes to create public awareness • Integrated watershed management to combat desertification • Korle Lagoon Ecosystem Restoration project • Byelaws restricting structures in flood-plains, water ways, wetlands, etc. • Ghana has ascribed to the Hyogo Framework for Action (HFA) which aims to reduce substantially loss of life as well as the social economic and environmental losses resulting from disasters • NADMO spends more than 85% of its resources to address issues related to hydro-meteorological disasters
3. Urban Noise	• Motor vehicle congestion and increasing noise levels from sirens and horns • Commercial activities in markets and at lorry parks • Industrial noise: factories, mining	• EPA guidelines on permissible ambient noise levels for the country • Noise levels for residential, educational, commercial and places or worship • Inability of Municipal/Metropolitan Assemblies to enforce the guidelines

	operations, quarries • Noise at entertainment and social gatherings – e.g. parties, churches, mosques • Equipment and engine noise, e.g. generators, corn mills and block moulding machines in residential areas, itinerant musical shops, etc.	
4. Oil and Gas Industry (Petroleum Exploration)	• Oil and Gas industry is new as a result of the Oil discovery in the Jubilee Field (Western Region) • Areas of concern include - Oil spills at sea and on land - Pollution of air, water and land - Transportation – pipelines, tankers • International relations • Coastal ecosystem destruction	• Petroleum Exploration bill before Parliament • EPA guidelines on petroleum exploration (EIA, ESIA, SEA) • "Strengthening Environmental Governance of the Oil and Gas Sector in Ghana" programme (EPA) • Act before Parliament to manage oil resources and income from oil • GNPC in place • Ghana is member of Oil for Development (OFD) programme (Norway) • Jubilee Field EIA • SEA of Petroleum Sector
5. Invasive Alien Species	• Occur in large water reservoirs – Oti arm of Volta Lake, Tano Basin • Obstruction water use: fisheries, hydropower generation, transportation	• Invasive Aquatic Weeds Management Project (EPA) • EPA Water-weed Management in West Africa • Integrated Management of the Volta River Basin
6. E-Waste	• Sources are: used equipment in the form of computers, copying machines, television sets, mobile phones and electronic equipments • Rejected in the country of origin and imported into Ghana without regard to their age and degree of usefulness • No guidelines/manuals on disposal techniques • No e-waste collection or recycling programme • Burning of e-waste to retrieve useful parts	• Ghana is signatory to the Base Convention and Kyoto Protocol as well as other global treaties for the protection of environment • EPA Act 1994 (Act 490) provides the principles and mechanisms for integrating good environmental management into all developing activities. • EPA Act provides framework for waste management through the principles that refer to avoidance or minimization and remediation of pollution, including waste reduction re-use, recycling and proper waste disposal.

	• Consequent emissions and toxins cause detrimental impacts on human health and the environment	
7. Chemicals (PCBs)	• Covers all chemicals – except pharmaceuticals • Increasing use of agro chemicals – pesticides, weedicides, fertilizers • Potential to cause considerable health and environmental problems – production to end use • Presence affects the quality of air, soil and water	• The Factories Offices and Shops Act 328 (1970) • Draft Policy on Occupational Safety and Health • Mercury Law (1989) • Prevention and Control of Pests and Diseases of Plants (Act 307) Infectious Disease Ord. Cap 78 • Licensing of all chemical dealers

Appendix 2. List of *officers from policy-making organizations and other institutions interviewed for information on policies and other initiatives in Ghana on climate change*

ORGANIZATION	***NAME OF OFFICER***	***POSITION/STATUS***
Environmental Protection Agency, Ministry of Environment, Science and Technology, Accra	Oppong Boadi Kyekyeku	National Climate Change Coordinator
Forestry Commission, Ministry of Lands, Forestry and Mines, Accra	Robert Bamfo	Head, Climate Change Unit, Forestry Commission, Accra
Ministry of Finance and Economic planning, Accra	Fredua Agyemang	Technical Director/Advisor, Economic Planning Division, Natural Resources, Environment and Climate Change Unit
Ministry of Environment, Science and Technology, Accra	Raymond Babanawo	Project Technical Assistant, Ghana Environmental Conventions Coordinating Authority, MEST, Accra
Environmental Protection Agency, Ministry of Environment, Science and Technology, Accra.	Daniel Tutu Benefoh	Senior Programme Officer, Energy Resource and Climate Change
Cocoa Research Institute of Ghana - Ghana Cocoa Board, Accra	G.J. Anim-Kwapong	Senior Research Officer
Savannah Accelerated Development Authority	Sulley Gariba	Development Policy Advisor on Savannah Accelerated Development Authority (Office of the President of Ghana)
Ministry of Food and Agriculture, Accra	Della	Senior Agricultural Officer
Ministry of Food and Agriculture, Accra	Bernice Addo	Assistant Agricultural Officer
Ministry of Local Government and Rural Development, Accra	Demedeme Naa	Acting Director, Environmental Health and Sanitation Directorate, Ministry of Local Government and Rural Development, Environmental Health and Sanitation Unit, Accra
National Development Planning commission, Accra	Sandra Amankwah Kesse	Planning Analyst of NDPC (Environmental Management)
National Development Planning commission, Accra	Winfred A. Nelson	Principal Analyst (Policy Analysis and Planning, Climate Change mainstreaming and Poverty reduction) formerly at the National Development Planning Commission but now at Energy Commission, Ministry of Energy, Accra.
Environmental Protection Agency, Ministry of Environment, Science and Technology	Zinabu Wasai-King	Regional Director, Bolgatanga, Upper East Region
Environmental Protection Agency, Ministry of Environment, Science and Technology	Abu Iddrisu	Regional Director, Tamale, Northern Region
Environmental Protection Agency, Ministry of Environment, Science and Technology	Isaac Osei	Regional Director Sunyani, Brong-Ahafo Region
Ministry of Food and Agriculture, Regional Office, Sunyani	John Ayie Jatango	Regional Agricultural Extension Officer
Ministry of Food and Agriculture	Emmanuel Asante Krobea	Regional Director, Sunyani, Brong-Ahafo Region
Forestry Commission	Daniel Donkor	Assistant Regional Forestry Manager, Sunyani, Brong-Ahafo Region

Ministry of Food and Agriculture	Ofosu Dankyira	Regional Crops Officer, Sunyani, Brong-Ahafo Region
Ministry of Food and Agriculture	Emmanuel Eledi	Regional Director, Bolgatanga, Upper East Region
Ministry of Food and Agriculture	Ahmed Yussif	Regional Crops Officer, Tamale, Northern Region
Ministry of Food and Agriculture	Mr. Kweku Antwi	Regional Monitoring and Evaluation Officer, Regional Office, Tamale
Ministry of Food and Agriculture, Regional Office, Bolgatanga, Upper East Region	Sylvester Logo	Regional PPRS Officer, Bolgatanga, UER
Ministry of Food and Agriculture, Crops Services Division, Regional Office, Bolgatanga, Upper East Region	Beni Joseph Walier	Regional Crops Officer, Ministry of Food and Agriculture, Regional Office, Bolgatanga, Upper East Region
Women in Agricultural Development (WIAD), Ministry of Food and Agriculture , Regional Office	Edna Lucy Awedagha	Regional Coordinator, Bolgatanga, Upper East Region
Forestry Commission, Tamale, Northern Region	Eben Jabilite	Regional Forestry Officer, Tamale
Northern Ghana Rural Growth Project	Roy Ayariga	Project Coordinator, Tamale
Widows and Orphans, Bolgatanga, Upper East Region, Ghana.	Jemimah Aarakit	Volunteer
Ministry of Food and Agriculture , Bolgatanga, Upper East Region	Drah Edgar	Regional Animal Production Officer,
Action Aid, Sunyani, Brong-Ahafo Region	Solomon Tawiah Banasam	Programme Officer for Food Rights and Climate Change
Kumasi Institute of Technology and Environment (KITE), Accra	Prince Owusu Agyemang	Projects Officer

Appendix 3. Research team involved in the field data collection

NAME	***QUALIFICATION***
Shu-aib Jakpa Sumaila	PhD Researcher
Mahesh Poudyal	PhD
Abagale Kofi	PhD
Francis Chimsah	Master's Degree
Adu Kofi Hanson	Bachelor Degree
Ayipio Emmanuel	Bachelor Degree
Alhassan Mahamadu	Bachelor Degree
Oppong Arthur James Jnr.	Bachelor Degree
Abugah Gordon	Bachelor Degree
Augustina Abugah	Bachelor Degree
Kafayat Karim	Bachelor Degree
Mary Adita	Bachelor Degree
Elijah Sayibu	Bachelor Degree
Saani Yussif	Bachelor Degree
Akibu Hardi	Bachelor Degree
Lansa Anumu Adam	Bachelor Degree
Henrietta Abugah	Bachelor Degree
Memuna Abdulai	Bachelor Degree
Gifty Ali	Bachelor Degree

APPENDIX 4*: Questionnaires*

Appendix 4a. Questionnaire for policy makers

UNIVERSITY OF TWENTE, ENSCHEDE, NETHERLANDS
PhD PROGRAMME 2008 - 2010

GLOBAL TO LOCAL SUSTAINABILITY: INTERNATIONAL CLIMATE CHANGE AGREEMENTS AND SHEA PRODUCTION IN GHANA

QUESTIONNAIRE FOR POLICY MAKERS
AT MINISTRIES, DEPARTMENTS, AGENCIES, COMMISSIONS, ETC. IN GHANA

1. Name of officer…………………………………………………………………………......
2. Ministry/Department/Agency/Commission…………………………………………….......
…………………………………………………………………………………………..
3. Position/status in the Ministry/Department/Agency/Commission………………………….........
…………………………………………………………………………………………..
…………………………………………………………………………………………..
4. In Ghana, which Ministries, Departments, Agencies, and/or Commissions, etc. are tasked to handle Climate Change issues?..
5. What are Ghana's vision and goals with regards to the UNFCCC's policy on Climate Change?
…………………………………………………………………………………….....................
…………………………………………………………………………………………………
…………………………………………………………………...
6. What are the national laws of Ghana on environmental protection?...
…………………………………………………………………………………………………
…………………………………………………………………………………………
7a. In Ghana, are there laws on Climate Change?...
7b. If yes, what are these laws?...
………………………………………………………………………………………………
7c. If no, please explain...
8. What is Ghana's position or policy in the UNFCCC?..
9. What is the national policy of Ghana on Climate Change?..
……………………………………………………………………………………………..........
10. What is your Ministry/Department/Agency/Commission's policy on Climate Change?
…………………………………………………………………………………………...........
11. What programmes or activities have been lined up towards Climate Change mitigation?
…………………………………………………………………………………………………
12a. Is Shea part of your Ministry/Department/Agency/Commission's policy on Climate Change mitigation?..
12b. If yes, what are these policies on Shea?...
…………………………………………………………………………………………………
…………………………………………………………………………………………………
12c. If no, please explain...
…………………………………………………………………………………………………
……………………………………………………………………
13a. Are there laws, policies, measures or incentive packages for the conservation of forests or trees by communities in Ghana?...
13b. If yes, which are these?...
13c. If no, please explain..
………………………………………………………………….............................
14a. Are there laws, policies, measures or incentive packages for the conservation of Shea trees by communities in Ghana?..

14b. If yes, which are these?...
14c. If no, please explain..
…………………………………………………………………………..................................
15. What type of payment system(s) for the mitigation of Climate Change does Ghana prefer?….
……………………………………………………………………………………………...........
16a. Is there any commitment by Ghana Government to carbon/carbon sequestration?..................
16b. If yes, please what are these commitments?..
……………………………………………………………………………………………………
…………………………………………………………………………...................................
16c. If no, please explain..
……………………………………………………………………………………………………
…………………………………………………………………………..................................
17a. Would there be funding from Ghana, or is Ghana totally relying on external funding for the implementation of policies on Climate Change mitigation?...
17b. If yes, please explain...
…………………………………………………………………………...................................
17c. If no, please explain?...
18a. Would there be funding from Ghana, or is Ghana totally relying on external funding for the implementation of policies on conservation of trees and forests?...
18b. If yes, please explain...
18c. If no, please explain?...
19a. Would there be funding from Ghana, or is Ghana totally relying on external funding for the implementation of policies on conservation of Shea trees?...
....
19b. If yes, please explain...
19c. If no, please explain?...
20a. Would there be funding from Ghana, or is Ghana totally relying on external funding for the implementation of policies on the development of the Shea industry?..................................
....
20b. If yes, please explain...
20c. If no, please explain?...
21. How is Ghana Government dealing with issues of carbon loss from fires and land use change in Ghana?...
22a. Is there compatibility with Ghana's existing laws?...
22b. If yes, please what are these commitments?..
22c. If no, why?..
23. Any additional comments?..
……………………………………………………………………………………………………
……………………………………………………………………………………………………
……………………………………………………………………………………………

Appendix 4b. Questionnaire for male farmers in the communities managing shea parklands

GLOBAL TO LOCAL SUSTAINABILITY: INTERNATIONAL CLIMATE CHANGE AGREEMENTS AND SHEA PRODUCTION IN GHANA

PhD PROGRAMME
UNIVERSITY OF TWENTE, ENSCHEDE, NETHERLANDS

MANAGEMENT OF SHEA (*Vitellaria paradoxa*) PARKLANDS IN GHANA

QUESTIONNAIRE FOR MEN IN THE COMMUNITIES

SAVANNAH ZONE:

HOUSEHOLD NUMBER:

SECTION A: BACKGROUND OF RESPONDENT

1. Name of farmer…………………………………………………………………………
2. Age:…………………………………………………………………………………..
3. Sex: Male□ Female□
4. Community……………………………………………………………………………
5. District………………………………………………………………………………...
6. If you are not from this community, then where do you come from?
Community…………………………………………………………………………...
Region………………………………………………………………………………..
Country……………………………………………………………………………….
7. Educational status: No education□ Primary□ JSS□ SSSCE□ Tertiary□
Others (*specify*)……………………………………………………………………………..
8. Religion Islam□ Christianity□ Traditional African Religion□
9. Others (*specify*)…………………………………………………………………………….
10. Marital status: Single□ Married□ Widowed□ Divorced□
11. Primary occupation: Farming□ Civil service□ Trading□
Others (*specify*)……… .....……………………………………………………………….

SECTION B: OWNERSHIP OF LAND AND SHEA TREES AND REDD-TYPE PAYMENT

12. Do you own land with shea trees on it? Yes□ No□
13. If yes, how did you acquire the land? Purchased□ Inherited□ Gifted□ Rented□
14. How distant is the land from your house? 1-2km□ 3-4km□ 5-6km□ 7km+ □
15. What is the size of the farm? 1 acre□ 2 acres□ 3 acres□ 4 acres□ 5 acres +□
16. Who owns the shea trees on your farm? Myself□ My family*□ My clan**□
Chief□ Community□ Others (*specify*)……………………………………………

17a. Who has authority over the shea trees with regards to whether the number of trees should be reduced, increased or maintained? Myself□ My family*□ My clan**□
Chief□ Community□ Others (*specify*)……………………………………………

17b. Explain………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………………...

SECTION C: SOCIO-ECONOMIC BENEFITS

18a. What is the most important benefit you derive from shea trees on your farm(s)?
………………………………………………………………………………………

18b. What other benefits do you get?
…………………………………………………………………………………………………
…………………………………………………………………………

19a. Are you required to share these benefits from the shea trees? Yes□ No□
19b. If yes, with whom are you required to share the benefits? My family*□ My clan**□ Chief□ Community□ Others (*specify*)…………………………………………..
19c. Why should you share these benefits?
…………………………………………………………………………………………………
……………………………………………………………………………
19d. Do you really share these benefits? Yes□ No□
19e. If no, why?..
……………………………………………………………………………………..……………
…………………………………………………………………………..
19f. What proportion (in %) of the shea nuts do you share?...
19g. What proportion of the shea butter extracted do you share?
……………………………………………………………………………………………
19h. What proportion of the timber or wood harvested from the shea trees do you share?
……………………………………………………………………………………………
19i. What proportion of the other products of the shea trees do you share?
i.…………………………………………………………………………………………
ii…………………………………………………………………………………………
iii…………………………………………………………………………………………

SECTION E: MANAGEMENT PRACTICES ON SHEA PARKLANDS

26a. Do you want the shea trees on your farm? Yes□ No□
26b. Give reasons for your answer………………………………………………………..
………………………………………………………………………………………………..
………………………………………………………………………………………………..
28a. Do you see it necessary to manage shea trees? Yes□ No□
28b. Give reasons………………………………………………………………………………...
…………………………………………………………………………………………………
……………………………………………………………………………………………… 29a. Do you manage the shea trees on your farm? Yes□ No□
29b. Do you carry out the following management practices on or around the shea trees?
i) Weeding……………………………….,,Yes□ No□
ii) Pruning………………………………… .Yes□ No□
iii) Control of insect pests and diseases……..Yes□ No□
iv) Creation of fire-belts……………………. Yes□ No□
v) Fertilizer/manure application……………, Yes□ No□
vi) Others (*specify*)…………………………………………………………………………
………………………………………………………………………………………………..
30. Who carries out these management practices?
i) Weeding…………………………………………………………………………………….
ii) Pruning…………………………………………………………………………………..
iii) Control of insect pests and diseases…………………………….……………………….
iv) Creation of fire-belts……………………………………………………………………….
v) Fertilizer/manure application……………………….…………………………………
vi) Others (*specify)* ……………………….…………………………………………………….
………………………………………………………………………………………………..
31a. Which management practices do you carry out during the wet season?
..……………………………………………………………………………………………
………………………………………………………………………………………………..
31b. Why do you carry out the management practices in the wet season?
…...…………………………………………………………………………………………..
…...………………………………………………………………………………………..
32a. Which management practices do you carry out during the dry season?
……………………………………………………………………………………………….
.……………………………………………………………………………………………..

32b. Why do you carry out the management practices in the dry season?
…...………………………………………………………………………………………………..
…...………………………………………………………………………………………………..

33. What tools do you use in the management practices?
i) Weeding……………………………………………………………………………….
………………………………………………………………………………………………..
ii) Pruning……………………………………………………………………………………..
………………………………………………………………………………………………..
iii) Control of insect pests and diseases…………………………….…………………………
………………………………………………………………………………………………..
iv) Creation of fire-belts……………………………………………………………………….
………………………………………………………………………………………………..
v) Fertilizer/manure application…………………………….……………………….
………………………………………………………………………………………………..
vi) Others (*specify)* …………………………….………………………….
………………………………………………………………………………………………..

34. How much time and money do you spend on these activities, and what impact do they make on the production level of sheanuts?

	ACTIVITY	***TIME/DAYS PER YEAR***	***COST PER YEAR***	***DIFFERENCES/IMPACT MADE***
1	Weeding			
2	Pruning			
3	Control of insect pests and diseases			
4	Creation of fire-belts			
5	Fertilizer/manure application			
6				
7				

35. What problems do you encounter during:
i) Weeding……………………………………………………………………………….
……………………………………………………………………………………………
ii) Pruning……………………………………………………………………………
……………………………………………………………………………………………
iii) Control of insect pests and diseases…………………………….……………………
………………………………………………………………………………………………..
iv) Creation of fire-belts……………………………………………………………….
……………………………………………………………………………………………
v) Fertilizer/manure application…………………………….……………………………...
……………………………………………………………………………………………

vi) Others (*specify*) ……………………………….……………………………………..
…………………………………………………………………………………………

36a. Are the shea trees (*only one option must be selected)*

i. Reducing in number □
ii. Increasing in number □
ii. or the same in number □?

36b. Explain…..……………………………………………………………………………..
……………………………………………………………………………………..
……………………………………………………………………………………..

If the trees are reducing in number, then proceed to 36c, 36d, 36e and 36f.

36c. If the trees are reducing in number, what are the possible causes of the reduction?
………………………………………………………………………………………………
………………………………………………………………………………………………

36d. Have you taken any preventive measures to check the decline? No□ Yes□

36e. If yes, what preventive measures have you taken to check the decline?
……………………………………………………………………………………
……………………………………………………………………………………
…………………………………………………………………………………….

36f. If no, why have you not taken any measures to check the decline?
……………………………………………………………………………………
……………………………………………………………………………………
…………………………………………………………………………………….

37a. Do you cultivate food crops? Yes□ No□

37b. If yes, which crops do you cultivate?...
………………………………………………………………………………………
………………………………………………………………………………………
………………………………………………………………………………………

38a. Do you intercrop shea trees with food crops? Yes□ No□

38b. If yes, why do you intercrop shea trees with the food crops?
…………………………………………………………………………………………………
…………………………………………………………………………………………………
……………………………………………………………………

38c. Would you have preferred cultivating only food crops on your farm(s) instead of intercropping shea trees with the food crops? Yes□ No□

39. What do you use the economic benefits derived from shea trees for?..
…………………………………………………………………………………………………
…………………………………………………………………………………………

40a. Are you planning to remove the shea trees on your farm to grow food crops? Yes□ No□

40b. If yes, why?..
…………………………………………………………………………………………………
…………………………………………………………………………

40c. How much more income (in %) do you expect to get as a result of doing this?

40d. If no, why?...
…………………………………………………………………………………………………
…………………………………………………………………………

41a. Is anyone else likely to cut down the shea trees on your farm? Yes□ No□

41b. If yes, why would anyone do this?...
…………………………………………………………………………………………………
…………………………………………………………………………

41c. What is the economic benefit to them for doing this?..
…………………………………………………………………………………………………
…………………………………………………………………………

41d. If no, what could be the reason(s)?...
…………………………………………………………………………………………………
………………………………………………………………………………
42a. Is one allowed to plant/grow shea trees in this community? Yes□ No□
42c. If yes, how many shea trees are planted per acre?
42c. Who is allowed to plant shea trees in this community?..
42d. Are the following practices carried out to manage such planted shea trees
i) Weeding……………………………..…Yes□ No□
ii) Pruning………………………………….. Yes□ No□
iii) Control of insect pests and diseases……..Yes□ No□
iv) Creation of fire-belts……………………. Yes□ No□
v) Fertilizer/manure application……………. Yes□ No□
vi) Others (*specify*)………………………………………………………………………
………………………………………………………………………………………………..
42e. Have you ever planted a shea tree or shea trees? Yes□ No□
42f. If Yes/No, any reasons?....................………………………………………………………
…………………………………………………………………………………………………
…………………………………………………………………………………………………
42g. Do you plant/grow shea trees now? Yes□ No□
42h. If Yes/No, any reasons?....................………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………………………
42i. How many trees per acre do/did you plant?..
42j. Did/do you consider the optimal density for the shea trees? Yes□ No□
42k. If Yes/No, any reasons?....................………………………………………………………
…………………………………………………………………………………………………
………………………………………………………………………………………………
42l. If you have ever planted shea trees, do you carry out the following management practices?
i) Weeding…………………………………..Yes□ No□
ii) Pruning………………………………… .Yes□ No□
iii) Control of insect pests and diseases……..Yes□ No□
iv) Creation of fire-belts……………………. Yes□ No□
v) Fertilizer/manure application…………… .Yes□ No□
vi) Others (*specify*)………………………………………………………………………
………………………………………………………………………………………………..
43a. Are there shea trees growing in the wild in this area?
Yes□ No□
43b. If Yes, who owns such trees?...
43c. Who has rights to them?..
43d. Who has rights to harvest their products?...
43e. Are such trees managed? Yes□ No□
43f. If Yes, are the following practices undertaken to manage them?
i) Weeding…………………………………..Yes□ No□
ii) Pruning………………………………….. Yes□ No□
iii) Control of insect pests and diseases……..Yes□ No□
iv) Creation of fire-belts……………………. Yes□ No□
v) Fertilizer/manure application…………… .Yes□ No□
vi) Others (*specify*)………………………………………………………………………
………………………………………………………………………………………………..
43g. Who manages such trees?...
44a. Are there shea trees growing in this community on communal lands?
Yes□ No□
44b. If Yes, who owns such trees?...
44c. Who has rights to them?..
44d. Who has rights to harvest their products?...

44e. Are such trees managed?   Yes□   No□
44f. If Yes, are the following practices undertaken to manage them?
i) Weeding…………………………………..Yes□   No□
ii) Pruning…………………………………. .Yes□   No□
iii) Control of insect pests and diseases……..Yes□   No□
iv) Creation of fire-belts……………………. Yes□   No□
v) Fertilizer/manure application……………. Yes□   No□
vi) Others (*specify*)……………………………………………………………………………
………………………………………………………………………………………………..
44g. Who manages such trees?...

*My family** refers to the person and his/her spouse & children
*My clan*** refers to a group of people regarded as being descended from a common ancestor such as the person's siblings, parents, uncles, aunts, grandparents, cousins, etc)

Appendix 4c. Questionnaire for women in the communities involved in processing of shea products

GLOBAL TO LOCAL SUSTAINABILITY: INTERNATIONAL CLIMATE CHANGE AGREEMENTS AND SHEA PRODUCTION IN GHANA

PhD PROGRAMME
UNIVERSITY OF TWENTE, ENSCHEDE, NETHERLANDS

MANAGEMENT OF SHEA (*Vitellaria paradoxa*) PARKLANDS IN GHANA

QUESTIONNAIRE FOR WOMEN IN THE COMMUNITIES

SAVANNAH ZONE:

HOUSEHOLD NUMBER:

SECTION A: BACKGROUND OF RESPONDENT

1. Name of farmer………………………………………………………………………………
2. Age:…………………………………………………………………………………………..
3. Sex: Male□ Female□
4. Community……………………………………………………………………………
5. District…………………………………………………………………………………...
6. If you are not from this community, then where do you come from?
   Community…………………………………………………………………………...
   Region…………………………………………………………………………………..
   Country………………………………………………………………………………….
7. Educational status: No education□ Primary□ JSS□ SSSCE□ Tertiary□
   Others (*specify*)………………………………………………………………………………..
8. Religion Islam□ Christianity□ Traditional African Religion□
9. Others (*specify*)……………………………………………………………………………….
10. Marital status: Single□ Married□ Widowed□ Divorced□
11. Primary occupation: Farming□ Civil service□ Trading□
    Others (*specify*)……… ......…………………………………………………………….

D. BENEFITS AND PROCESSING OF SHEA NUTS

20a. Do you sell the nuts that you have gathered? Yes□ No□

NB// *If the answer to Question 20a is yes, then proceed to 20b, 20c, 20d and 20e but skip 20f.*

20b. If the nuts are sold directly, who sells them in your family? Men□ Women□

20c. Do you sell all the nuts? Yes□ No□

20d. If you do not sell all the nuts, what proportion (in %) is sold?
………………………………………………………………………………

20e. If you do not sell all the nuts, what do you do with the remaining nuts not sold?

i.………………………………………………………………………………………

ii………………………………………………………………………………………

iii………………………………………………………………………………………

iv.……………………………………………………………………………………...

NB// *If the answer to Question 20a is no, then skip 20b, 20c, 20d and 20e and proceed to 20f.*

20f. If you do not sell the nuts directly, does anyone in your family process the nuts into butter? Yes□ No□

21a. If the butter is made, do you use all of it within the family? Yes□ No□

21b. If no, what happens to the remaining butter?..
………………………………………………………………………………………

……………………………………………………………………………………………

21c. If you do not use all, what proportion is sold?..

21d. Who sells the butter in your family? Men□ Women□

22a. Is sheanuts/butter business women's business? Yes□ No□

22b. If it is women´s business, is the income from the sales considered to belong to the women? Yes□ No□

23a. Are any other products sold? Yes□ No□

23b. If yes, which are they?

…………………………………………………………………………………………
………
…………………………………………………………………………………

24. What proportion of your family income (out of total income from farming, cattle-keeping, other employments, etc) comes from shea products?………………………………………

25a. If women sell shea products, do they have any other major sources of income?
Yes □ No □

25b. If yes, what are the other major sources of income?………………………………………
………
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BRIEF BIOGRAPHY OF THE AUTHOR

Shu-aib Jakpa Sumaila is a lecturer of the University for Development Studies, Tamale, Ghana. Since 1997 when he completed his Bachelor degree and was retained by the university and started working as a Teaching Assistant, Research Assistant, Demonstrator (Junior Lecturer) and subsequently as a Lecturer from 2003 onward, he has been involved in teaching several courses, but his passion has been in agriculture, horticulture and environmental conservation.

How did it all start? Although born and bred in Kumasi, Ghana, where he lived with his parents and four brothers and one sister, Jakpa and his siblings used to enjoy spending school holidays with their grandparents in rural areas such as Kpembe, Makango, Kitoe and Kayireso in northern Ghana where their grandparents owned farms and fruit tree plantations. It was during these years of Jakpa's young life that he developed interests in agriculture, tree planting and environmental protection. These interests began as hobbies but later became great passions for him, and they permeated throughout his life from primary school to the university. Back in the city, as a boy, he replicated what he learnt in the villages and grew a number of crops and fruit trees in their family garden, and 'jealously' guarded and protected them from being destroyed by humans and livestock. He showed enormous interests and worked hard in school farms in taking care of crops and trees. Even as a school leader (Senior School Prefect/President) in the schools he attended later, Jakpa always took time off and visited school farms to help in taking care of the crops and trees. He fully participated in planting and growing trees, contrary to the fear particularly in the rural communities then that *if a young person planted a tree he will die before the tree grew to maturity*. He used to jokingly say: "*I rather prefer to die as a grower and protector of trees than to live and see trees die and none planted".*

His passion for trees was so amazing that he always expressed deep interests in doing research on trees. This formed the basis for his interests to work on topics involving trees for his BSc, MSc and PhD theses. So he has grown from being a '*little tree boy*' to a '*tree man*'! Whenever, particularly during his research, he visited his study sites and noticed that a tree had been cut down, he felt very sad as if it was a human being that had been cut down, because he saw trees as living beings. Jakpa is a member of several local and international organizations working for the promotion of tree growing and environmental protection both in Ghana and worldwide and he is a strong advocate for the strict adherence to the protection against deforestation, forest degradation and environmental destruction. He always reiterates the importance of trees and re-ehoes the late Indira Gandhi's saying that *if the last tree dies the last man dies!* He therefore cherishes the idea of promoting the conservation of trees in general, and shea trees in particular, not only as cash tree crops for farmers but also as reliable sinks for carbon sequestration and mitigation of climate change for the benefit of humanity.

Between 1997 and 2000, then as a BSc. student and later as a Teaching/Research Assistant in the university, Jakpa worked as a radio producer/host of a number of programmes at Radio Savannah in Tamale. One programme he liked hosting was an environmental programme known as 'PACIPE'. This earned him an award and a lot of admirers among listeners due to the passion with which he used to host the programme on tree growing and environmental protection.

Jakpa has worked on several funded projects within and outside the university together with his colleagues and other organizations (such as the World Bank, JICA, SNV, CEDEP, GoG/VIP, GETFUND, OIC, DfID/GOAN, ASIP, AgSSIP, CBUD, ACDEP and INNOVKAR) in agriculture, tree growing and environmental management. For the first part of his PhD research, he worked on a EU-sponsored project, INNOVKAR (Innovative Tools and Techniques for Sustainable Use of the Shea Tree in Sudano-Sahelian Zone), focusing on improvement of shea production, biodiversity conservation and carbon sequestration in shea parklands of Ghana. Although he was officially enrolled to start his PhD programme at CSTM in October 2008, due to some funding hitches (through no fault of his), he actually had to conduct his research in 2010-2012 to supplement the data gathered in the INNOVKAR project. His research, titled "*Global to Local Sustainability: International Climate Change Agreements and Shea Production in Ghana*", was supervised by Prof. Dr. Jon C. Lovett and Dr. Samuel Donkoh.

Through the sponsorship of the university, Jakpa did a Master's degree programme in Agroforestry at the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana, and a BSc. Agricultural Technology programme at the University for Development Studies, Tamale, Ghana. He has worked in various capacities, including teaching and research in a number of subject areas in universities and other institutions (both local and foreign).

His research interests include:

- Climate change policy, mitigation, adaptation and carbon sequestration
- Improvement in shea production and carbon storage in shea parklands
- Horticulture and sustainable agricultural production
- Agroforestry, biodiversity conservation and environmental management