UNIVERSITY OF GHANA

ADOPTION OF AN ECOSYSTEM-BASED ADAPTATION (EbA) APPROACH IN THE FACE OF CLIMATE CHANGE: IMPROVING LIVELIHOODS IN FRINGE COMMUNITIES AROUND THE WOROBONG SOUTH FOREST RESERVE

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DECLARATION

I, Conrad Kyei-Mensah, hereby declare that except for references to other authors and their works which I have duly acknowledged, this is the result of my research carried under the supervision of Dr Rosina Kyerematen of the Climate Change and Sustainable Development, University of Ghana.

I further affirm that this thesis has neither in whole nor part been previously presented elsewhere for the award of another degree.

…….. DATE……..

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…… DATE……

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SUPERVISOR

DEDICATION

This work is dedicated to my wife, Laura Kyei-Mensah Dzitorwoko, my father, Mr Alphonse Kofi Nyame, sisters: Benedicta Nyame, Mrs Patience Ofori-Appiah Nyame, and Mrs Anastasia Tetteh Nyame, brothers: Gerald Nyame Bonsu and Andrew Sawiri Nyame. I further dedicate it to my late mother, Helen Abena Kefe Odoom.

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LIST OF ABBREVIATIONS

AfDB	African Development Bank
CO_2	Carbon Dioxide
CRIG	Cocoa Research Institute of Ghana
CFMP	Community Forest Management Programme
CI	Conservation International
CBD	Conservation of Biological Diversity
DA	District Assembly
DFID	Department for International Development
EBA	Ecosystem Based Adaptation
EPA	Environmental Protection Agency
ELAN	Ecosystems and Livelihoods Adaptation Network
EU	European Union
EEA	European Environment Agency
FIP	Forest Investment Programme
FC	Forestry Commission
FAO	Food and Agriculture Organisation
FGD	Focus Group Discussion
FLEGT	Forest Law Enforcement, Governance and Trade
GDP	Gross Domestic Product
GSGDA	Ghana Shared Growth and Development Agenda
GEF	Global Environment Facility
GSA	Global Significant Area
GHG	Green House Gas
GLSS	Ghana Living Standard Survey

GMET	Ghana Meteorological Agency
GOG	Government of Ghana
IPCC	Inter-governmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
LULUCF	Land Use, Land Use Change and Forestry
MA	Millennium Ecosystem Assessment
MESTI	Ministry of Environment, Science, Technology and Initiative
MOFA	Ministry of Food and Agriculture
NAMAs	Nationally Appropriate Mitigation Actions
NDUFR	New Dabaga Ulongambi Forest Reserve
NGOs	Non-governmental Organisations
NTFPs	Non Timber Forest Products
REDD+	Reducing Emissions from Deforestation and Degradation
SNC	Second National Communication
SPSS	Statistical Package for the Social Science
TEEB	The Economics of Ecosystems and Biodiversity
UNDP	United Nation Development Programme
UNEP	United Nation Environment Programme
UNFCCC	United Nation Framework Convention on Climate Change
VPA	Voluntary Partnership Agreement
WB	World Bank
WSFR	Worobong South Forest Reserve
WRI	World Resources Institute

ABSTRACT

Extreme human activities couple with climate change have the potential to reduce the resilience of communities whose livelihoods depend on the forest ecosystem services. As a way of building resilience of society using the same resource also has the capacity to derive co-benefits for the forest ecosystem upon which livelihoods activities operate. To this end, the study sought to adopt the Ecosystem-based adaptation (EbA) to identify Ecosystem services of the Worobong South Forest Reserve (WSFR), assess how these services have been impacted by climate variability or change, the vulnerability of fringe communities and proposed the appropriate EbA strategies needed to improve their livelihoods while enhancing the ecosystem. The study selected five communities around the Worobong South Forest Reserve (WSFR). Questionnaires were administered to 250 respondents, one focus group discussion was held, and three key informant interviews with officers of the Forestry Commission (FC), and Ministry of Food and Agriculture (MoFA) and a chief were also conducted. As part of the findings, the respondents perceived changes in rainfall and temperature which corroborated the time series data from GMeT, and these, probably may have affected crop production, supply of bush meat, freshwater, barks, leaves among others which they identified as ecosystem services. To build resilient livelihoods and ecosystem, locals suggested provision of irrigation facilities, enhanced agroforestry with a benefit sharing regime, change of planting time and enforcement of forest regulations. It is recommended that, capacity building efforts and effective stakeholder engagements should be a continuous exercise, while as part of the benefit-sharing scheme for agroforestry, participants can be given 15% of the 40% right to trees planted ahead of maturity as motivation and this will resolve the apprehension of waiting for several years before deriving the full benefits and this can sustain EbA initiatives.

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

Climate change is a defining challenge of our time (Wanjiru, 2011). This phenomenon may be threatening the long term provision of ecosystem goods and services, of the world, but it also presents an opportunity to get our global accounting system "right" (United Nation Environment Programme, 2010). The Inter-governmental Panel on Climate Change can project with high confidence that the arid and semi-arid lands in Africa will increase by 5 to 8% (Inter-governmental Panel on Climate Change, 2007), as a result of extreme weather condition.

It is also estimated that after 2040, with a mean average global temperature of 1.5°C, the economic costs of climate change will be equivalent to 1.7 percent of Africa's Gross Domestic Product (GDP), while at 2.2°C by 2060 will cost 3.4 per cent; and with a temperature rise of 4.1°C by the end of the century will cost just under 10 per cent of the continent's GDP (Clements, 2009). In response to this complex situation, the IPCC (2003) recommends mitigation and adaptation as the approaches towards global climate challenges. Quite apart from the ecosystems, people are also vulnerable to climate change particularly natural resources-dependent communities for food, water and shelter (Ecosystem and Livelihoods Adaptation Network, 2014). Africa is among the most vulnerable regions in the world (African Development Bank, 2011), and adaptation is considered an intervention for the most vulnerable regions. What adaptation is able to do under such circumstance is to reduce vulnerability of people and restore ecosystem services in order to build the resilience of both systems (Kinnaird *et al*, 2003). Climate change actions can contribute to local sustainable development initiatives and bring multiple potential benefits in environmental quality, economic savings, and social equality aspects (Zhenghong *et al*, 2010).

In ensuring that the best adaptation works for ecosystem-dependent communities whose livelihoods are organised around these resources, UNEP (2009), introduced the Ecosystem-Based Adaptation (EbA) approach that discharges the natural system as a way to buffer the worst impacts of climate change and other drivers of ecosystem loss, maintain the resilience of the natural ecosystem, their services and the species that support them and help people adapt

to changing conditions. According to a report by Conservation International (2011), Cambodia implemented this type of adaptation approach which resulted in increased field sanctuaries in the Tonle Sap Lake by as many as 50,000 hectares and restored 1,000 hectares of illegally logged forests. This report again revealed the increase in fish population, reduction in erosion and stabilised water supply in the same region.

Agriculture remains an important part of the West African economy (Toulmin and Gueye, 2003), contributing 30-50% to GDP in most countries and a major source of income and livelihoods for 70-80% of the population. Trend analysis over the period revealed that, some economies may be diversifying into other activities in response to adverse environmental conditions but, farming is more likely to remain of central significance to incomes and livelihoods (Fafchamps, *et al* 2001). Agriculture, one of the major ecosystem-dependent livelihood activities is sensitive to climate change. For instance, Dinar *et al*, (2008) indicated that, temperature increase to 2.5°C in Baukina Faso could lead to a 46% fall in net agricultural revenue, while 5°C increase would lead to a decline in revenue of 93%. Many more of such natural resources including wildlife, water bodies, medicinal plants, and fuel wood faces a lot of threat and the concomitant food insecurity, health dangers that requires interventions such as EbA to address some of the burgeoning challenges. This approach according to the UNEP is comparatively a cost-effective one considering that, the African Development Bank report, 2011 on the cost of adaptation to climate change in Africa puts it between US$ 20-30 billion per annum over the next 10 to 20 years to reduce its climate vulnerability to an acceptable level.

Ghana has ratified a number of international conventions related to the environment (Second National Communication, 2007). Recent global environmental challenge is climate change, and Ghana's economy is sensitive to this phenomenon (SNC, 2007). This is because agriculture constitutes about 55% of GDP and requires the services of ecosystems to ensure production (Ghana Shared Growth and Development Agenda, 2010). It is estimated that, in Ghana, climate change will cause a reduction in real household consumption of 5 - 10% in 2050, and reduction in real GDP of 1.9 - 7.2% (AfDB, 2011). According to a report by the Forestry Commission (2015), natural forest areas were set aside after discovering some bad practices in the use of their services. The report makes reference to the past when 188 natural areas were reserved (125 forest reserves, 16 protected areas and 6 RAMSAR sites). As a result of agricultural practices, off-reserve areas have seen a lot of degradation. The Forestry Commission has implemented a number of strategies towards sustainable management of the forest ecosystems and its services, which include; Voluntarily Partnership Agreement (VPA) with European

Union (EU), Global Environment Fund (GEF) support, designated areas formally under logging converted into Globally Significant Areas (GSA), Reducing Deforestation and Forest Degradation in Developing countries plus carbon stock conservation, enhancement and sustainable forest management (REDD+) programme under World Bank (WB) facility, Plantation programme (10,000Ha/year), Coastal Wetland programmes, Forest Improvement Programme (FIP), International Union for Conservation of Nature and Natural Resources (IUCN) programme for assessing the contribution of forest conservation to national development, Trans-boundary natural resources management with Ivory Coast, Togo, Ecosystem services such as carbon sequestration and watershed protection (FC, 2015). Sustainable management of the ecosystem and a well-planned agricultural system, enhance food production and contribute to climate change mitigation (Verchort, 2008).

The state of the Worobong South Forest Reserve (WSFR) is symptomatic of the larger problems of deforestation in most of the country's reserved areas (Kyere *et al*, 2006), particularly, because of its significance to the fringe-communities for livelihoods. Communities around the reserve have severely impacted the resources through their livelihood activities such as farming and hunting leading to forest fires, illegal logging among others. Incidentally, the ecosystem is sensitive to climate change, thereby putting both the forest (WSFR) ecosystems and the peoples' livelihoods at risk. As noted, the EbA approach, which is a critical link between climate change, biodiversity, ecosystem services and sustainable resources management (UNEP, 2003), is intended to be used as part of an overall adaptation strategy for communities around the WSFR and enhance the forest ecosystem, which will build the ecosystem's resilience against the impacts of climate change.

1.1 Statement of Problem

There is the global understanding that, the interaction between the natural systems, ecosystems, human beings and societies is paramount to the course of action for mitigation and adaption to the impact of climate change. Extreme human activities such as bush burning, (Figure1.0) over exploitation, illegal logging, and farmland expansion renders the landscape and communities very vulnerable and reduces their resilience to impacts of their actions. There has been a decline in wildlife (i.e., snails, tortoise, antelopes, and cane rats and other animals) than it used to be, including the various Non-Timber Forest Products (NTFPs) like mushrooms, bitter kola, walnuts (Adekunle *et al*, 2011). Such uncontrolled practices coupled with the incidence of

climate variability, poses dire risk to the ecosystem (for instance, Forest Reserve), upon which the communities depend for livelihood.

By managing, protecting and enhancing the ecosystem services, it will support livelihoods, maintain local safety nets, increase the buffering capacities of local ecosystem and explain the range of options for building resilience and adapting to disruptive shocks and trends (Berkes and Folke, 1998). Actions of the residents brings to the fore, lack of appreciation of the extent of the challenge that illegal logging, severe bush burning and dwindling forest cover will pose to the socio-economic activities especially, when these problems will be exacerbated by climate change. There is also limited information on the vulnerability assessment of these farmers, appropriate policy design and adaptation options, improvement in capacity for resilient communities.

In effect, Ghana's effort to ensure a climate proof economy have been unsuccessful due to limited capacity both technical and financial (GSGDA, 2010). Forest Reserves in Ghana are to some extent limited by management and use of the forest ecosystems and generating any credible basis for assessing the real value of the forest in terms of its supporting, provisioning, cultural and regulating functions.

The Worobong South Forest Reserve, a part of Ghana's deciduous forest with two major stocking associations; *Celtis-Triplochiton* (15.6%) and *Antiaris-Chlorophora* (11.3%) (MoFA, 2011) is over 80 years old, and it was created with the view to protecting and conserving natural and especially forest and wildlife resources, however, as a result of the significance of the Forest Reserve to the people and the State, its resources have been abused (Kyere *et al*, 2006). The WSFR fringe communities are predominantly farming communities who rely extensively on the services the forest offers to undertake their livelihood activities. In order to sustain the ecosystem services in the face of climate change, this study seeks to assess the perception of people regarding services the forest offers, the impact of climate variability or change on the forest and livelihoods, other non-climatic stressors that tends to degrade the forest, and identify the appropriate interventions to help the communities engage in sustainable livelihood activities with less or zero impact on the forest reserve, as well as improve understanding of benefits of the forest ecosystem. In other words, it is to overcome the gap in knowledge production and to contribute to the local and national climate solution.

Figure 1.0: A burnt portion of the WSFR.
Source: Photo by Author, 2016

1.2 Justification

According to the GSGDA (2010), adaptation is the principal way to address the potential impacts of climate change. It is a mechanism that allows the management of risks; adjust development, that include the economy, environment, and socio-cultural activities to reduce vulnerability of the national economy, population and ecosystems to the impact of climate change in order to achieve national development and economic growth. Ghana's medium term development policy direction is not the only motivation for improving resilience to climate change impact through adaptation. Indeed the essence of adaptation to countries in the tropics is fundamentally as a result of their vulnerability to climate change (IPCC, 2007). In the late 1970s and early1980s for example, severe droughts and bush fires destroyed forests and farms resulting in massive crop failure and hunger, livestock losses, malnutrition and increased health risks in Ghana (Amisah *et al*, 2009). The global significance of such forests in terms of carbon sequestration, watershed protection, and wildlife conservation will be affected if no intervention is made. Based on the aforesaid, the outcome of this study may bring to the fore the status of, and trends in livelihood activities which affects the WSFR in the face of climate change, the significance of an EbA approach for sustainable livelihoods and ensure forest conservation as well as serve as a good model to be replicated for other ecosystems which are also sensitive to climate change and exposed to abuse.

1.3 Objectives of the Study

The main objective of the study is to look at the ecosystem services provided by the Worobong South Forest Reserve (WSFR), how they are impacted by climate variability or change, the vulnerability of fringe communities and the interventions needed to improve their livelihoods.

Specific Objectives:

- Identify the ecosystem services provided by the WSFR
- Conduct vulnerability assessments of fringe communities of the WSFR to impacts of climate variability or change.
- Determine the human activities that affects the ecosystem services of the WSFR.
- Propose the appropriate EbA strategies to improve livelihoods.

1.4 Research hypothesis

- Climate variability or change does not affect the ecosystem services of the WSFR
- Fringe communities of the WSFR are not vulnerable to climate variability or change.
- There is no significant effect of human activities on the ecosystem services of the WSFR
- There is no significant relationship between proposed EbA strategies and the improvement on livelihoods.

1.5 Limitation of the Study

A couple of challenges were encountered in the course of collecting data. It was a difficult task to access accurate, up- to-date, and time series data from the Forestry Commission, Ghana Meteorological Agency and Ministry of Food and Agriculture as well as Cocoa Research Institute of Ghana (CRIG) to assist with data on cocoa production for the District. There was also the issue of accurately translating certain technical words that could be understood easily by respondents in their native language.

1.6 Organisation of the Study Report

This study and the report are organised under Six (6) chapters. These include; Chapter one, which constitutes introduction and background to the study, statement of the problem, justification, research objectives and hypotheses, as well as limitations of the study. Also, Chapter Two captured theoretical basis and conceptual frame work of the study under literature

review, while Chapter Three tackled the profile of the study area in terms of the population outlook, sampling, data collection, and method of analysis. The findings of the study were presented in Chapter Four, while chapter five constituted the discussions section. Finally, Chapter Six presented the conclusion, as well as recommendations. Additionally, a list of references and appendices are attached to the report.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter underscores the theoretical works, principles as well as concepts in order to identify existing literature dealing specifically with climate change impacts, mitigation and adaptation measures used by various researchers and projects. It looks at the definition of concepts, Identification of forest ecosystem services, vulnerability assessment of forest fringe communities, human activities and impact on ecosystem services, vulnerability of forest-fringe communities, appropriate EbA strategies for communities, forest governance issues, theoretical foundation, and conceptual framework for this study.

2.1 Definition of Concepts

To provide a reasonable basis for this study, concepts such as climate change, and ecosystem services are thoroughly defined and explained in order to properly situate their use within the object of this work.

2.1.1 Climate Change

Climate Change refers to a statistically significant variation in either the mean state of the climate or in its variability, persisting for an extended period, typically decades or longer (IPCC, 2001). In introducing the anthropogenic aspect to the phenomenon, the United Nations Framework Convention on Climate Change (UNFCCC), refers to it as a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods. Natural and anthropogenic substances and processes that alter the Earth's energy budget are drivers of climate change (IPCC, 2013), however, anthropogenic processes has been identified as the main drivers of the change.

2.1.2 Ecosystem Services

Ecosystem services are defined as the contributions that ecosystems make to human well-being (European Environmental Agency, 2011). The term "services" encompass both the tangible and the intangible benefits humans obtain from ecosystems, which are sometimes separated into "goods" and "services" respectively, culminating in provisioning, regulating, cultural and

supporting services classifications (The Economics Ecosystem and Biodiversity, 2009). Boyd and Banzhaf (2007), assert that the MA categorisation is problematic. Perhaps this informed a new category 'habitat services'. Meanwhile other typologies are also being debated (Costanza, 2008; Fisher and Turner, 2008). However, for the purpose of this study, the widely used and acceptable classification is considered. Forests ecosystem regulate local and global climate, ameliorate weather events, regulate the hydrological cycle, protect watersheds and their vegetation, water flows and soils, and provide a vast store of genetic information much of which has yet to be uncovered (Pearce and Pearce, 2001). Based on the categorisation of the services, each of them is examined independently.

2.1.2.1 Regulating services

The services include all the ways in which ecosystems control or modify biotic or abiotic parameters that define the environment of people (i.e. 'ambient' environment). These are ecosystem outputs that are not consumed but affect the performance of individuals, communities and populations and their activities. For the forest ecosystem, its regulating function is carbon sequestration. In a report authored by Ven der Werf *et al*. (2009), 12% of global Green House Gas (GHG) emissions are attributable to deforestation, therefore forest degradation has a negative implication on its properties making the regulating services such an important one.

2.1.2.2 Provisioning services

These are material and energetic outputs from ecosystems; they are tangible things that can be exchanged or traded. Millennium Ecosystem Assessment (2005) captures the indispensable forest asset succinctly that 'No tool or agricultural implement could be fashioned, no fence made to protect crop or stock, no baskets made of any strength, no mine sunk below ground, no machinery devised for milling, draining, spinning, weaving that did not utilise wood. In effect, some of the provisioning services include; fuel wood, game, tree bark, timber, mushrooms and others.

2.1.2.3 Cultural services

The Millennium Ecosystem Assessment (MA) (2005), defined cultural ecosystem services as "the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences" (Sarukhán and Whyte 2005). Of significant recognition is the intangibility of the service. Some traditional forest

dwellers believe that trees are central to life to the extent that, the spirits in the trees reveal themselves at night after serving as shelter. Practitioners and scientists alike recognize at least some cultural ecosystem services as contributors to human wellbeing (Milcu *et al*, 2013). Ecotourism, also a cultural service, is a growing activity and constitutes a potentially valuable non-extractive use of tropical forests. There are over 205 million visits per year to National Forest Service lands for hiking, fishing, hunting, skiing, and camping (Food and Agriculture Organisation, 2005), making cultural service such a big thing. Cultural significance may even grow with the emerging issues of climate change and the key roles of forests for mitigation purposes (for instance, REDD +).

2.1.2.4 Supporting Services

Providing living spaces for plants or animals and maintaining a diversity of plants and animals are 'supporting services' and the basis of all ecosystems and their services (FAO, 2005). In essence, supporting services are those that are necessary for the production of all other ecosystem services. Examples of supporting services are primary production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat. They differ from provisioning, regulating, and cultural services in that their impacts on people are either indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people.

2.2 Identification of Forest Ecosystem Services

Unprecedented changes are taking place in the ecosystems of the world (Naeem *et al*, 1999), including species losses through local extinctions. Studies have analysed the social value of ecosystems services (García-Nieto *et al*, 2014), and determined the spatial scale at which these ecosystem services were valued by different people.

In Tanzania, households consumed forest products directly as part of their food intake, and earned 42% of their total income from selling wild fruits, firewood, timber, and charcoal (Pramova, 2012). Kashaigili *et al* (2014) in a study, confirmed peoples' perception of availability of forest ecosystem services, with 47% and 17% of respondents in Bunyina and Chamika respectively sourcing fuel wood and charcoal from the forest as well as wild fruits, mushrooms, building poles, fodder for livestock. Elsewhere, the most demanded ecosystem service was nature tourism, followed by timber, erosion control, recreational hunting, mush room harvesting, and beekeeping (García-Nieto *et al*, 2012). Similarly, people's perception

that climate is changing with the effect on drying of perennial rivers, declining agriculture production of traditional crops, increased crop diseases and declining soil fertility was revealed by the same report (Kashaigili *et al*, 2014).

To understand the values that reside in forests arise from the estimated rates of loss of forest area and, hence, in biological diversity (Pearce and Pearce, 2001). The forest has the potential to deliver co-benefits when the EbA approach is the adaptation option. Forest ecosystems provide more carbon sinks than the entire atmosphere (Greenfacts, 2007). Ghana's GHG emission represents about 0.05% of the total global emissions and is ranked 108 in the world (SNC, 2011). Therefore removal of vegetation in any typical region can lead to reduction not only by evapotranspiration (Sud and Smith, 198), but also its sink potential. It explains why eight out of the 55 Nationally Appropriate Mitigation Actions (NAMAs) submitted by Ghana in 2010, addressed land use, Land Use Change and Forestry (LULUCF), including sustainable forest management, REDD+, and plantation development programmes, and rehabilitation of degraded lands.

2.3 Vulnerability Assessment of Forest Fringe Communities

Livelihood comprises the capabilities, assets (including both material and social resources) and activities used by a household for means of living (Chambers and Conway, 1992). A livelihood pathway can be seen as the result of a series of livelihood choices that have emerged over time. The capacities and assets available for a choice underpin how fulfilling one becomes in such a choice. It has been explained that, livelihoods activities, particularly the natural resources dependent ones (e.g., forest) are exposed to several pushbacks. As a way out of a total emasculation of peoples' sources of survival, concepts and theories have been developed. Out of the lot came the sustainable livelihood concepts or framework. In assessing sustainable livelihoods, it is prudent to draw on the Environmental Impact Assessment (EIA) model and the Sustainable Livelihoods Framework (SLF), a logical, user-friendly process that help users better appreciate the link between climate-related risks, and people's livelihoods activities. A household's livelihood is secure when it can cope with and recover from stresses and shocks, and maintain or enhance its capabilities and productive asset base.

Vulnerability of societies to climate variability or change, particularly those in the tropics according to IPCC is uncontested, and more exposed is the continent of Africa, because of lack of adaptive capacity (IPCC, 2003). The propensity or predisposition to be adversely affected by climatic change (IPCC 2012), is for Africa to face for instance, increase water scarcity and

stress with a subsequent potential increase of water conflicts as almost all of the 50 river basins in Africa are trans-boundary (Ashton 2002, De Wit and Jacek 2006). Furthermore, climate change will cause a general decline in most of the subsistence crops, e.g. sorghum in Sudan, Ethiopia, Eritrea and Zambia; maize in Ghana; Millet in Sudan; and groundnuts in Gambia (Fischer *et al*. 2002).

Across the world, smallholder farmers are considered to be disproportionately vulnerable to climate change because changes in temperature, rainfall and the frequency or intensity of the extreme whether events directly affect their crop and animal productivity as well as household's food security, income and well-being (Vignola *et al*, 2015). Forest stakeholders face challenges related to Ecosystem degradation which undermines food production and the availability of clean water, among other ecosystem services, thereby threatening human health, livelihoods, and ultimately societal stability (Munang *et al*, 2013). This is particularly the case when 61.8% of respondents in forest fringe community (Kamenyanga) in Tanzania, describes farming as the major economic activity supported by the forest ecosystem services in a study by Majule and Mary in (2009). According to the IPCC Fourth Assessment Report (2007), drought stress has affected vegetation and reduced gross primary production by as much as 30% in southern Europe, resulting in a net carbon source, particularly during the heat wave of 2003 (Fischlin *et al*. 2007). The changes to the environment associated with agriculture affect a wide range of ecosystem services including food and materials for human consumption, water quality and quantity, soil quality, air quality, carbon sequestration, pollination services, seed dispersal, pest mitigation, biodiversity, habitat change and habitat degradation (Dale and Polasky, 2007).

In view of the role of the forest to agriculture and livelihoods, people are expanding their activities contributing to deforestation. It has been established that, any increase in farm sizes implies additional clearing of forest areas to make extra land available for further cultivation (Mohammed, 2014). Changes in rainfall pattern, particularly drought have considerably affected agriculture production (Kashaigili *et al*, 2014). This situation is worrying when farmers are not just the poorest in Ghana, but are also contributors to the poverty situation in Ghana (Ghana Living Standard Survey, 2013). Effectiveness of ecosystem services in reducing vulnerability to climate is influenced by characteristics, such as topography, geology, soils, ecosystem diversity and structure (Pramova *et al*, 2012). There are three factors that contribute to the overall vulnerability of a species to climate change: exposure, sensitivity and adaptive capacity (Glick *et al*. 2011). It is the degree to which a system is susceptible to or unable to

cope with, the adverse effects of climate change, including climate variability and extremes (IPCC 2007), which determine the overall vulnerability.

2.3.1 Climate Variability or Change (temperature and rainfall)

Africa is characterised by a wide variety of climate systems, ranging from humid equatorial systems through seasonally-arid-topical, to sub-tropical Mediterranean type of climate (IPCC, 2001). The IPCC indicates that a decrease in precipitation has occurred over the twentieth century, particularly after the 1960s in the subtropics and the tropics from Africa to Indonesia. Precipitation changed over land from 1900-2000. The report found a decrease in precipitation by about 2.4± 1.3 per cent per decade in tropical rain forest regions of Africa since the mid-1970s. It further states that, this rate was faster in West Africa (-4.2 ± 1.2 percent per decade) and in North Congo (-3.2 ± 2.2 per cent per decade).

Temperature and rainfall variations perceived by respondents and observed data from a meteorology station in Tanzania in a study, reveals the consistency in the two data sets. Extreme temperature events were observed from the analysis of the Julius Nyerere International Airport for 30 years whiles the seasonal rainfall and the total number of seasonal rain days for the same station and Kisarawe indicated declining trend, in the most recent decade of 2000-2010 (Kashaigili *et al*, 2014).

2.3.2 Climate Variability and Forest Ecosystems Services

Forest and woodland in Africa occupy 16.8 per cent of the global forest (FAO, 2000). The Food Organisation estimates that, a total of 650 million hectares or 21.8 per cent of the land area in Africa constitutes its forest. This natural resources provides livelihood opportunities directly or indirectly (Shretha, and Gautan, 2014), such as NTFPs, Timber, Fuel wood, Fodder, Agriculture, Forest-based entrepreneurship (sawmill, furniture shops) services to the people. Demand for NTFPs around NDUFR, in Tanzania has gone high with use pattern ranging from food, primary health care and income more than it used to be 30 years ago (Msalilwa *et al*, 2013).

The predicted climate change in Africa may have a wide range of direct effects on species. According to Tunde, (2011), Cocoa which is the leading crop in the Ondo-State, Nigeria has the highest yield in the year 2004, decreased in 2005, increase again in 2006 but decreased in 2007. The changes were attributed to alterations in the climate of the study area. Some examples include: changes in rainy and dry seasons, altered species distribution and habitat, shifts in breeding season and changes to population growth rates (Chidumayo 2011).

Communities' perception of climate variability and change include decreasing rainfall, increasing incidences of droughts, unpredictable rainfall patterns, disappearance of wetlands and failure to predict the on-set of rainy season using traditional indicators and indigenous knowledge (Kashaigili *et al*, 2014). A change of climate is attributed directly or indirectly to human activity (IPCC, 2007).

To ascertain the true impact of climate change on ecosystem services, it is good to compare scientific data and local perceptions of climate seasonality, variability, and change (Boissiere *et al*, 2013). Several reports have been published on local perceptions on long-term changes in temperature and rainfall. In Kamenyanga village, as many as 63.8% respondents and 73.8% from Kintinku village accepts that there has been an increase in temperature over the past 10 years as contained in a report by Mary and Majule, (2009), although years of assessment is less than 30 years when the standard year to draw conclusion is for the mean state of climate or its variability to persist for an extended period, typically decades or longer (IPCC, 2001), it is still useful for understanding the issues. Similar results were reported by Maddison (2006) whereby a significant number of farmers in eleven African countries believed that temperatures had increased and that precipitation had declined. According to IPCC (2007), increase in average temperature will adversely affect crops, especially in semi-arid regions, where heat is a limiting factor of production. This situation is analogous to the Northern Region of Ghana when annual mean temperature of Wa for instance, is projected to increase by 2.3◦C and 4.2◦C between 2081 and 2100 (Tachie-Obeng *et al*, 2014) which would lead to severe crop failure.

Generally, agriculture in Africa is highly dependent on rainfall (over 95 per cent), as a result of this, the sector is highly vulnerable to variability in climate, seasonality shifts, and precipitation patterns (Water Resource Institute, 1996). In essence, a model results from Hadley Centre, CSIRO, Canadian Climate Centre, and NCAR indicate that only 80,000km2 of agricultural land in sub-Saharan Africa with currently severe environmental constraints are expected to improve with climate change, whereas more than 600,000km2 currently classified as moderately constrained would migrate to the class of severe environmental limitations (Fischer *et al*, 2002). To state the obvious, climate change is not the only factor for all the environmental issues. It is to be mentioned, that both climatic and non-climatic stressors stimulate and have different impacts in community and ecosystem, leading to loss of alternative livelihood opportunities (Mohammed, 2014).

According the Heinz Centre (2012), wildlife species are threatened much more severely by factors other than climate change, and this is an indication that, non-climatic factors are grave. To this end, illegal harvesting and poaching continue to threaten such dangerously imperilled

species (Heinz Center. 2012). According to Desanker (2002), Africa is under environmental threat from a number of natural as well as human induced pressures. Over the past 50 years, humans have changed ecosystems more rapidly and extensively than in any comparable period of time in human history, largely to meet rapidly growing demands for food, fresh water, timber, fibre, and fuel (MA, 2005). About half of South Africa's wildlife habitats were lost by 1986 without the right attribution in terms of cause. Maybe, IPCC (2007) point that climate change is an additional stressor to the existing environmental problems explains the South African dilemma. In spite of the established consequences, Sedjo (2010) indicates that, not all the news on climate change is gloomy. This is because, according to the report, in a warming world, global forest area could increase by 5 to 6 percent by 2050. It argues that, as a botany lesson, trees require CO2 to grow, so the increased levels of C02 that are contributing to climate change are a boon to them, and this is the referred to as *''carbon fertilization effect''*.

These changes have considerably affected agriculture production in the study communities due to soil moisture stress, which has also resulted in the disappearance of hippopotamus, and fish because river Mzinga which was perennial in the past has become seasonally most recently, according to the report.

The trend of annual temperature and rainfall Mean in the Oyo State, Nigeria shows a large variability in the amount of rainfall from year to year, and a slim variability in temperature value from year to year which affects crops production such as Yam (Adewuyi *et al*, 2014). These changes explained the kind of significant relationship existing between yields, for example, in maize and seasonal mean precipitation (Rowhani *et al*, 2011). The perception of people on climate variability or change runs contrary to the observed data in some cases. For instance, Metaweja community perception of March to May and September to October rainfall variation did not appear in the climate data analysis (Boissiere *et al*, 2013). In other words, precipitation may not change necessarily because that is the peoples' verdict.

The climatic change leaves in its wake debilitating images like crop failure, influence local seasonal and annual water balances (Fischer *et al*, 2002). The impacts of climate change on Africa's agricultural systems will most likely result from increased intra-annual (seasonal) and inter-annual climate variability and from an increased frequency of extreme events than from changes in mean climatic conditions (Padgham, 2009).

2.4 Human Activities and Impact on Ecosystem Services

Other aspects of human-induced change in rainforests are visible in deforestation, among the most important of these is hunting, whether for bush meat or for international trade in wildlife

parts such as ivory and skins (Malhi *et al*, 2013). Bushfires are not excluded, it is not the high-intensity fires that burn across the landscape, but the very low-intensity fires that are no longer as easy to suppress or self-extinguish naturally because of the change in the fire weather over time with climate change (Cary, 2004). Many other non-climatic stressors can be mentioned. Forest cover in Ghana for instance, fell from 8.2 million hectares in the 1980s to about 2 million hectares in contemporary times (Hawthorne and Abu Juam, 1995) and further declined to 1.2 million (Ministry of Food and Agriculture, 2011), through deforestation and degradation. Forest degradation affects soil organic matter, nutrients and soil respiration which influence atmospheric CO_2 concentration (Adekunle *et al*, 2011). These services are impacted by population pressure, over exploitation, expansion of farms among others. Peoples' livelihoods depend on the direct extraction and utilisation of the services, individual significance of various aspects including trees, shrubs, rivers, lakes, and fauna.

2.5 Appropriate EbA Strategies for Communities

Response to impact of climate variability or change is important, paying close attention to a broader spectrum of options that go beyond words into actions with potential for informing and guiding policy practices are needed (Munang *et al*, 2013). To help counter the climatic stressors is to implement what are known as adaptation strategies (Heller and Zavaleta 2009). Based on this, several adaptation options exist in the coastal, marine and terrestrial zones. The motivation for adaptation is either purposeful or unintentional (Kashaigili *et al* 2014), thus not all adaptation strategies are sustainable. Some practitioners perceive adaptation as counterproductive, and lead to other multiple effects on the environment and contribute to climate variability and change. Adaptation responses, however, have to be tailored to local conditions and needs, since the nature of risks and the affected livelihood groups vary from one ecosystem to another (MA, 2005). The ecosystem-based adaptation (EbA), a fairly recent approach which has gained acceptance in the scheme of adaptation strategies to tackle the impact of climate change to help people and communities adapt to the negative effects of climate change, using biodiversity and ecosystem services is an option UNEP acknowledges will be a better intervention. Evidence points to the fact that, EbA is flexible in implementation, cost effective and broadly applicable alternative for building robust livelihood systems and climate resilient society. A number of countries in West African sub region adopted this strategy. Munang *et al*, (2013), reported that Togo rehabilitated water reservoirs in the savannah regions with opportunities in brick production, market gardening, and fisheries leading to a more prosperous community. Similarly, Uganda integrated tree crops (barrier crop

use) and agriculture to improve the fertility of soils and increased yields. As an adaptation strategy, Msalilwa (2013), in a study, reveals that, local communities (87%) around New Dabaga Ulongambi Forest Reserve (NDUFR) reported to engage in livestock keeping mainly pigs, chicken, goats and cows. In the same report, about 57% of the respondents reported that the existing coping strategies were effective.

However, there is a need for the government to develop the local coping strategies of communities to allow them adapt effectively with the situation. Baukina Faso planted its barren, degraded land (restoration) with nutrient fixing plants to improve the soil fertility for crop production by adopting this strategy. In responding to the needs of vulnerable forest fringe communities, their choice of strategy is based on preferences showed in table 2.1. High on such choices are agroforestry, cultivation of fast-growing indigenous timber species and cultivation of short-rotation exotic timber species (Acheampong *et al*., 2014).

Additionally, Yeboah and Ameyaw, (2004), assessed community participation in sustainable forest management, type of strategy to adopt and motivation for doing same among the community members. Apparently, planting food crops and trees, greenbelt establishment, combating illegal chainsaw and fire according to the report, were the choice of adaptation (Table 2.1); while the motivation for this decision was built on the future income to be derived from a 40% share of trees planted and supply of farm inputs such as cutlasses, farming boots and rain coats. Blench (2003) found that farmers minimize or spread risks by managing a mix of crops, crop varieties and sites; staggering the sowing/planting of crops; and adjusting land and crop management to suit the prevailing conditions.

A study in the River Offin area, assessed the natural, physical, social, financial, and human resources of river and the riparian forest to communities in the Offin river basin and placed the resources in category that provides safety needs for farmers in that catchment area. Another study in Ghana by Foli *et al*, (2009) revealed that, 54% of the people were aware of the alternative livelihood activities in their communities, yet only 20% had actually engaged in these activities, such as plantation development, grass cutter rearing, snail and mushroom cultivation.

However, people have series of difficulty to adaptation, among which are lack of information on adaptation methods, no access to effective adaptation methods, lack of money or access to credit facilities, shortage of labour, shortage of land and poor capability for irrigation Apata (2011). The extents to which these resources enable the people to conduct their livelihoods and

cope with climate hazards were assessed and formed the baseline for knowing the vulnerability of the communities to potential climate change and variability.

Table 2.1: Reasons for choice of forest-based alternative livelihood options

Alternative Livelihood Option	**Reasons for preferring option**
Agroforestry	• Provision of food • Provision of extra income to support the family • Restoration of lost forest
Cultivation of Fast-growing indigenous timber species	• Extra income to support the family • Restoration of the lost forest • Provision of construction materials • Supply of lumber to the domestic market • It will serve for construction purposes • It will provide us housing and furniture materials
Cultivation of Short-rotation exotic timber species	• Provision of construction materials • Supply of lumber to local market • Provision of extra income to support the family • Restoration of the lost forest • It will serve as an insurance for my children in the future • The trees grow very fast • It will serve for construction purposes • It will provide us housing and furniture materials • Provision of poles for electrification projects • The trees can coppice after harvesting • The trees can resist fire
Establishment of fruit plantation	• Provision of food • Provision of extra income • Restoration of forest cover • It will help my children in the future
Cultivation of Non-timber forest products	• Provision of food • Extra income to support our livelihoods • It will help to restore the forest
Establishment of woodlot/fuel wood plantation	• Provision of extra income to support the family • Restoration of the lost forest

Source: Adapted from Mckeown, 2015.

Further examination of the concept reveals that, the process has the potential of destroying the very resources supporting the livelihoods. It is explained that, habitat destruction, unsustainable farming practices, inadequate livelihood support systems, and weak institutional capacity to support conservation and production, forms the basis for this situation (UNDP, 2014). The dilemma is that, the livelihoods of forest-dependent communities in Ghana are still linked to miss-use of resources and this is partly because of structural flaws (Mckeown *et al*, 2015), therefore for forest based adaptation strategies to be on point, it is significant to balance poverty reduction initiatives and reducing illegal logging for instance. Reducing deforestation and encouraging re-afforestation will restore degraded riparian vegetation to improve climatic conditions and invariably, enhance livelihoods in the forest fringe communities (Amisah *et al*, 2009).

2.6 Forest Governance Issues

There is no single or broadly accepted definition of 'Governance' even though several disciplines use it (Davis *et al*, 2009). This notwithstanding, the principle behind it is to ensure transparency, participation and accountability, as a foundation for achieving positive social, environmental, and economic outcomes. In several cases of forest governance, the divergence between the forest as a provider of means to rural people and governance mechanisms that have predominantly focused on national economic activities and political priorities (World Bank, 2009), which has led to weak governance, non-compliance and often blamed for poverty and unsustainable levels of natural resource depletion. Forest degradation is high, according to FAO, and estimates 50–60% of total logging activities in Cameroon, Mozambique, Equatorial Guinea and Ghana; 70% for Gabon; and 80%–90% for Benin and Nigeria (World Bank, 2009). This is accentuated possibly because, as FAO reveals very little is seen about forest governance in Africa, particularly the quality of the laws being passed and enforced. There are continuous conflicts between economic operators and local populations due to unclear rights basis and conflicting interest over land use (Tieguhong and Schure, 2015).

To ascertain the challenges of illegal timber harvesting in Tanzania, for example, a TRAFFIC Report of Illegal Timber in 2007, was issued and found out that, Massive revenue shortfalls, unsustainable rates of harvesting, collusion among influential players, and irreplaceable losses of biodiversity are challenges that constituted strong wakeup call for government, civil society and the nation (Jambiya, 2012). Issue of governance cannot be overlooked, for instance, there is a long history of Forest laws and policies in Ghana. Contribution of policy weakness is a

major threat in Ghana's forest governance regime over the years. This confusion, according to Teye (2011), is as a result of forest managers' attitude of ignoring the principle of good governance which recognises local community rights over trees and creating incentives for sustainable forest management in the past. This right arise because forest lands were forcibly included in the forest reservation process and that actually accounted for forest conflicts (Derkyi, 2012). Over the period, changes to these governance mechanisms have included;

Timber Protection Ordinance No. 20 of 1907,
Forest Bill and Ordinance, Land and Native Right and Forest Ordinance (CAP157),
Concessions Ordinance (136 section 30 and Timber Restriction Order, No.55),
The Forest and Wildlife Policy and Trees and Timber Ordinance No.20 of 1948 (CAP 158),
Administration of Lands Act, Act 123,124, 125,
Trees and Timber Decree 1974 (NRDC 273),
Constitution of Ghana,
The 1994 Forest and Wildlife Policy,
Interim Measures to Control Illegal Timber Harvesting (FC, 2015).

Not only did the regulations made for the on-reserve areas, but also the call for effective management of the forest outside the direct control of the state. In response to this came the;

Timber Resources Management Act (547),
Timber Resources Management Regulations (L.I. 1649),
Timber Resources Management Act (amendment) (Act 617),
Timber Resources Management (Amendment) L.I. 1721.

With the view to streamline the activities of the forest resources users and the fight against degradation, some amendments were made. Earlier, the main interests of colonial forest policies was not focused on indigenous communities involvement and benefit-sharing but on timber exploitation and export, as well as to reconcile the competing land and forest demands of farmers and loggers (Wiggins *et al*., 2004; Asante, 2005). These policies took rights from communities in the management and use of the forest (Alhassan, 2010). Ownership rights of land are relevant in analysing the forest governance regime in Ghana, for instance. Therefore issue of people having no secure rights and tenure over the lands and resources affects the possibility of promoting activities in the forest sector that are aimed at mitigating climate change (Insaidoo *et al*, 2014). Contemporary laws and policies recognise community participation in all stages of development and implementation of forest conservation actions.

To derive the best outcomes of a particular forest governance regime Davis *et al* (2009) recommended three different components of forest governance, namely; Actors, Rules, and Practice. When these are fed into decentralization of forest management, it can lead to improving the effectiveness of public forest institutions by matching the demand for public forest services with their supply by local governments (World Bank, 2006). The concept of decentralisation of forest governance essentially is one that enhances closeness to local people, their demands, and priorities, and thereby offers opportunities for government to become more relevant to local conditions.

Support towards achieving sustainable management of natural resources including forest in Ghana saw the European Union (EU) under Voluntary Partnership Agreement (VPA)/ Forest Law Enforcement, Governance and Trade (FLEGT), and the World Bank (FIP) in regulating timber trade and building and rebuilding institutions for the management of timber production and NTFPs as well as biological diversity conservation and water-shed management as well as recognising the role of the local people. A good test case is REDD+ whose primary rationale is to ensure enhancement of carbon sink (mitigation) but with inherent co-benefits for adaptation in Ghana (World Bank, 2006). Some of the different governance arrangements which inure to forest fringe communities in terms of afforestation are institutional framework that is livelihood friendly, tenure security for land and tree planted, marketing of harvested trees, benefits sharing and alternative livelihoods enhancement. A good ecosystem governance mechanism has the potential to promote adaption options such as EbA, therefore as an essential element, it cannot be avoided anytime any of the strategies are considered for adoption.

2.7 Challenges of Ecosystem-based Adaptation (EbA) Adoption

The EbA does not postulate a honky dowry, problem-free approach to reducing vulnerability. Some challenges exist, key amongst them are governance structures, participation, measure of effectiveness, and appropriate financial mechanisms (Ojea, 2015). The rest include the implementation challenge, lack of information, uncertainties in future climate change projections, ecological vulnerability and economic growth, exacerbated by general paucity of information from monitoring and evaluation of interventions. According to Acheampong *et al* (2014), alternative livelihood activities such as grass cutter rearing, snail rearing and mushroom cultivation usually required some level of training and initial capital and this could be the reason why most community members do not involve themselves in these activities. Other challenges, as stated by Baig *et al* (2016) are identified at the national level, such that,

coordinating the management functions of diverse stakeholders who oversee different aspects of the ecosystem services (for instance, Ministry of Lands and Natural Resources, Ministry of Water Resources, Works and Housing, Ministry of Environment Science, Technology and Innovation, Ministry of Food and Agriculture and others) at times become difficult. It further pointed out that, EbA is an emerging adaptation option therefore, the fear of unknown factor allows people to think it is going to introduce new financial and technical burden to the already precarious situation they find themselves and the assumption that, it can only lead to re-naming already existing ecosystem management practices is an indication that, people have not appreciated the important principles of EbA in addressing the gaps in what the know in the face of climate change. In spite of the challenges, the overarching objective is always to reduce the vulnerability of people towards the effects of climate change and restore ecosystems if damaged.

2.8 Theoretical Foundation

This study is theoretically underpinned by the concept of Ecosystem-based Adaptation (EbA), which is a United Nation Environment Programme's flagship climate response mechanism and very useful in diverse ecosystem settings, including mountains, river basins, dry-lands and low-lying coasts (Raasakka, 2013). The emergence of EbA hinged on the Millennium Ecosystem Assessment report, (2005), to satisfy the growing concerns regarding threats to ecosystems globally, and identify what options exist to manage the ecosystem sustainably and build resilience under extreme climatic variability. What ecosystem based adaptation seeks to do fundamentally is to use biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change (CBD, 2009). This concept is relatively new and its adoption equally low. Therefore, the governing bodies of the convention of biological diversity and United Nation Framework Convention on Climate Change (UNFCCC) are encouraging parties to adopt ecosystem-based adaptation approaches.

The essence of this concept is that, EbA has a key defining features that targets the immediate adaptation needs of the poorest and most vulnerable communities who are adversely affected by climate change (Chong, 2014). In effect, the concept seek to achieve a balance between livelihoods and ecosystem services sustainability within the context of effectiveness and cost efficiency. The results of this adaptation option are classified into provisioning, supporting, regulating and cultural benefits as determined by Millennium Ecosystem Assessment (2005); food security, habitat, preservation of genetic materials, water security, soil health, barriers to

disaster, erosion prevention, conservation of biodiversity, drought prevention, and regeneration of natural resources. The rest are empowerment of the rural resources, empowerment of the rural poor, incorporation of indigenous knowledge, and holistic approaches to development. Additionally, it provides numerous opportunities for natural solutions to manage the impacts of climate change. In general it ensures social, economic, environmental co-benefits, following land use practices such as afforestation, reforestation, natural regeneration of forests, silvicultural systems and agroforestry in reducing CO_2 (IPCC, 2007), as well as inherent participatory**,** transparent, and culturally appropriateness while embracing gender and equity issues.

With this background, the study will draw on the concept to identify the forest ecosystem services in the various classification, assess the vulnerability of community members to extreme climatic conditions, determine human activities that affects ecosystem services, and propose the appropriate EbA strategies for the communities.

2.9 Conceptual Framework

Many conceptual frameworks provide the context for livelihoods and environmental impact analysis. In particular, the indicators for assessing forest-based livelihoods and its vulnerability to climate variability or change as well as non-climatic stressors are not extremely different. Department for International Development's (DFID) sustainable livelihood assessment and the UNEP's ecosystem-based adaptation (EbA) approach are some of the concepts. This study adapts the EbA as the most suitable approach since it is relevant fundamentally because, forest fringe communities rely on natural resources and ecosystems for their livelihoods (Reid, 2011). It is therefore a way to minimize the impacts of climatic and non -climatic stresses on livelihood and enhance the resilient capacity of vulnerable people and restore ecosystem (Shretha, and Gautan, 2014).

Ecosystem based Adaptation is an emerging field of study and only a few organizations have some projects or activities carved in the frame of EbA (UNDP, 2014). EbA operationalise sustainable management, conservation and restoration of ecosystems (Reid, 2011), and when destroyed or there is decline in delivering benefits which negatively affects people's livelihoods. This process is cost-effective (Pramova *et al*, 2012), and it allows for the structural definition of the core multidisciplinary teams as a function of conceptualisation and implementation of the EbA strategy. DFID has adapted this approach and built a comprehensive model with all the elements included to make it an easy-to-use process. The

process ensures community-level participation to identify the ecosystem services and boundaries as well as potential climatic threats of the area.

As part of the process, peoples' livelihood activities are assessed within the scope of their vulnerability to climatic and non-climatic impacts. A decision is then taken on the choice of appropriate strategies to address the gap between human and environmental systems for the improvement of livelihoods. Figure 2.1 underscores the principles and concepts of sustainable management to the extent that, a two way relationship is established. Benefits are derived from either way within the system without compromising themselves. This framework shows how ecosystem goods and services of the forest could be identified as the basis for ensuring resilient society in the face of climate change, (arrow 1). When extreme human activities are not subjected to proper management, (arrow 2), sustainability of ecosystem services as well as resilience of society will be compromised.

Additionally, climatic changes will exacerbate the vulnerability of both society and ecosystems as the framework suggests. Much the same way, when ecosystem is properly managed and utilised, it increases the resilience of the ecosystem, thereby promoting mutual benefits. In essence, the framework indicates that, for ensuring that forest contribute to the adaptation of society (arrow 1), sustainable management must first be achieved (arrow 2). So therefore, when immediate pressures on forest are addressed, a longer term perspective and climate change can considered. At the heart of this therefore is for society to adopt the right strategies within the context of EbA that reduces the vulnerability of society to climate change, through a multi sectorial and multi scale framework with the aim to also reducing the vulnerability of ecosystems, increase their services, and building resilience to different threats, including climate change and land-use change.

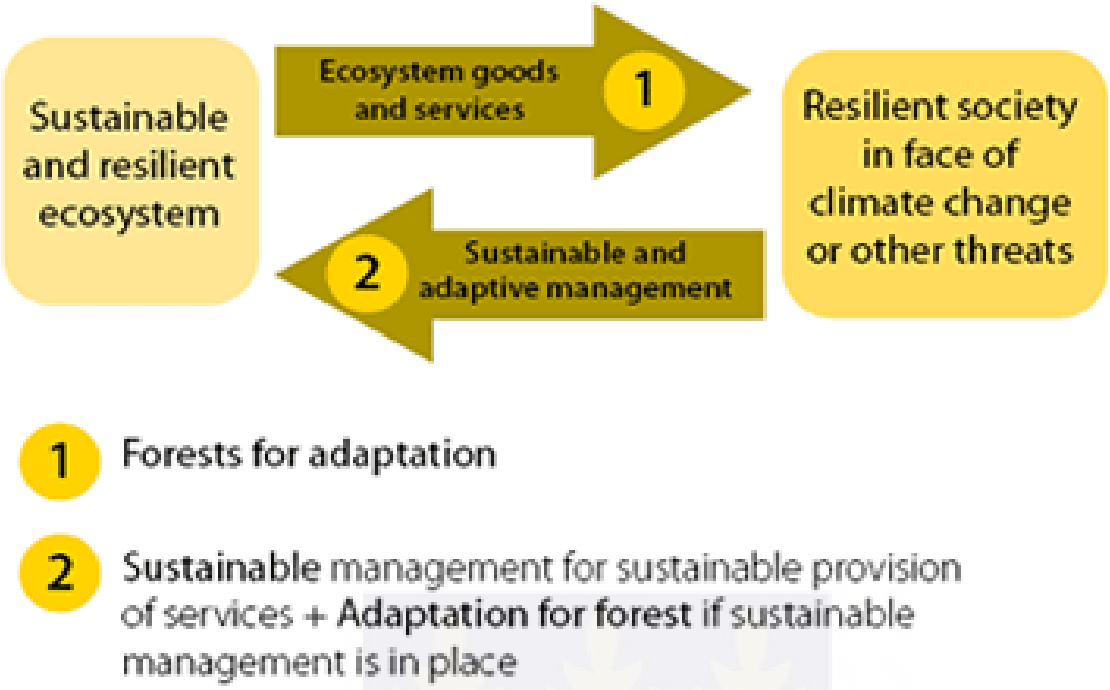

Figure2.1: EbA framework for forest ecosystem
Source: Adopted from Locatelli *et al*, 2008

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The study area, population, sample and sampling procedure, data collection, and data analysis constitute the research methodology in this chapter. The methodology provides a chronology of activities and processes that gives the study an insight into where the study is taking place, who it surveys, how it does that and by what means data is analysed.

3.1 Study Area

The Worobong South Forest Reserve is one of the initial natural forest areas created in the Fanteakwa District in the Eastern Region of Ghana. It is located south of Begoro in the Eastern Region of Ghana and covers an area of 109.35km2. The reserve is situated in a Semi-deciduous Forest zone and lies between Latitude 4° 30'N and 6° 24'N, and Longitude 0° 35'W and 0° 21'W, and a mean annual rainfall of between 1250mm – 1500mm. There are a number of forest fringe-communities in the area that includes; Akwansrem, Akwumu Kotoko, and Feyiase. Others are; Peseator, Amokrom, Ahomahomaso, Kyrepong, Kronkronso and Ayigbetown. The rest are; Bonsakor/Kumfere, Asarekrom, Esaase, Akoradarko, Kukurutu, Apaa Opare and Beseboam. The choice of the study site was based on the high levels of species diversity. The area has natural resources-dependent communities engaged in crop farming, such as cassava, maize and plantain. Other crops include cocoa, and oil palm. The area is also noted for logging, extensive forest encroachment due to farmland expansion and the advertent setting of forest fires. The study focused on Feyiase, Mianya, Miaso, Komfere, and Akwansrem communities (Figure 3.1), since these communities have characteristics similar to the other communities.

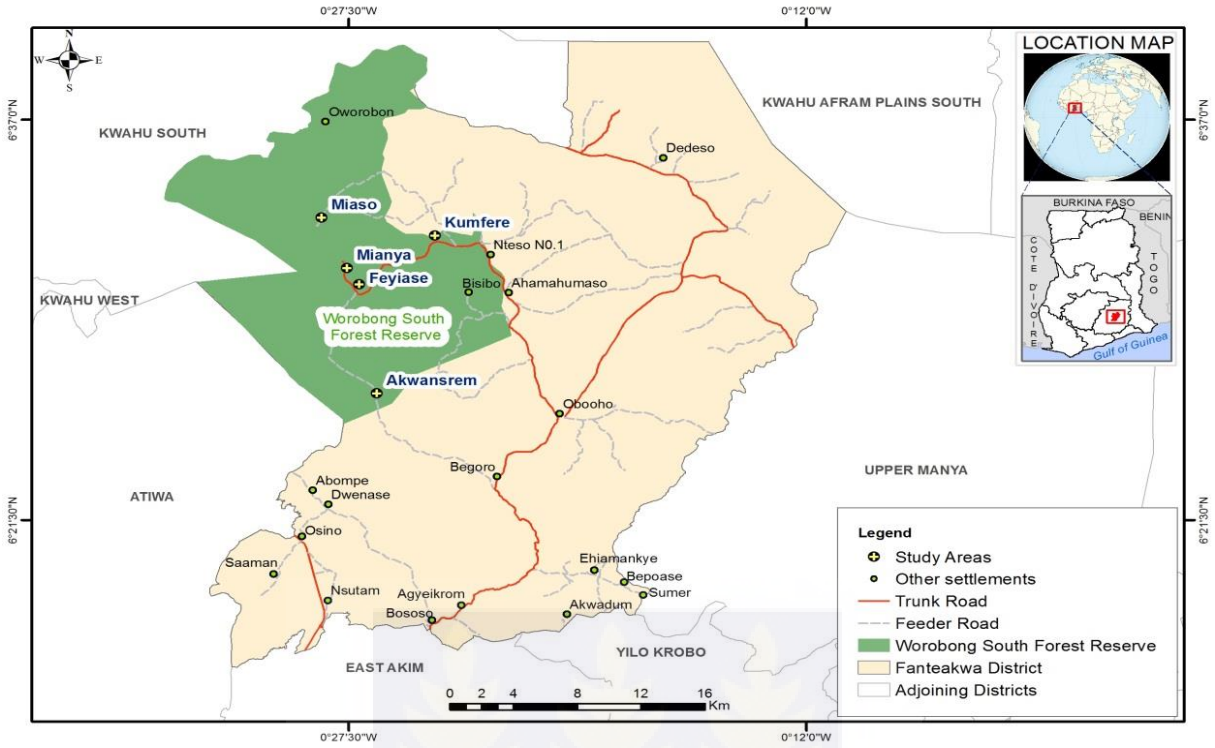

Figure 3.1: Map showing Fanteakwa District, WSFR and fringe communities
Source: CERGIS, 2016

3.2 Population

The population size of the five communities is 3,205 (Forestry Commission's Management Plan, 2009). The breakdown includes; Feyiase (1,129), Mianya (225), Kumfere (634), Akwansrem (599), and Miaso (618). Out of this population, 250 respondents, representing about 7.8% of the population constituted the sample size for the study. This number was chosen due to resources constraint and time factor.

3.3 Sampling

Each of the five communities were assigned a percentage of the sample size (i.e., 250) based on each community's population estimates, and this came up to; Feyiase, 88 respondents, and Mianya, 17 respondents. 50 respondents were from Miaso, while Komfere, and Akwansrem had 47 and 48 respondents respectively. Individuals whose main livelihood activities or other source of income is dependent on the forest ecosystem constituted the sample frame, out of which respondents were selected for each quota using systematic sampling method that allows for the determination of the sample frame and respondents concurrently. The heads of the households or their representatives were the respondents. A team of 12 members including a chief, farmers, student, hunter who were male or female, old or young were chosen for a Focus Group Discussion (FGD).

3.4 Data Collection

3.4.1 Primary data

The study used the mixed methods for data collection (Creswell, 2009). A semi-structured with both closed-ended and opened ended research questionnaires were used to determine in-depth knowledge of the respondents (indigenous knowledge) of the ecosystem services provided by WSFR, climate variability or change (temperature and rainfall), and their effects on their livelihoods. The questionnaire was grouped into six (6) sections (A-Z), with section A, looking at the socio-economic data of the respondents which included; community, age, source of livelihoods, number of dependents and levels of income, among others. Section B, determined the in-depth knowledge of respondents concerning what constitute ecosystem services provided by WSFR. Also, section C explored the impact of climate change on forest ecosystems by examining peoples' knowledge of climate change, and whether temperature and rainfall have changed over a period, and what evidence of forest impact have been observed or experienced. Again, section D dealt with the vulnerability of fringe communities by finding out whether sources of livelihood have changed and to what extent these changes have occurred. Section E, assessed the various livelihood activities which may have impacted on the ecosystem services using the frequency of use of the services as the bases, and whether the services have declined in quantity and quality over the period. Finally, section F, explored the coping strategies adopted and if not adopted, examine the reasons for non-adoption, and looked at proposals of interventions or strategies expected to achieve sustainable livelihoods and enhance ecosystem services.

A pilot test was conducted with a small group of the population to assess the validity of the questionnaires. Respondents were asked to fill out the questionnaire to seek respondents understanding of the questions which informed the revisions made based on the feedback, comments and recommendations from the respondents. A single focus group discussion (FGD) with 12 members was held, which drew the individual members from the five communities to a single location and made provision for all strands of livelihood activities undertaken within the communities as presented in Table 3.1., to set climate and livelihoods contexts of the communities and suggest interventions for improving the livelihoods as well as enhancing the ecosystem services. Additionally, key informant interviews were conducted for the Forestry Commission's District Officer, and the MoFA District Officer at Begoro, as well as the chief of Feyiase on climate change knowledge and adaptation measures.

Table 3.1: Members of the focus group discussion

Livelihood activity	Community	Age	Gender
Farmer	Miaso	54	Male
Farmer	Feyiase	52	Male
Farmer	Feyiase	63	Male
Farmer/Chief	Feyiase	44	Male
Farmer	Miaso	52	Female
Farmer/Queen mother	Kumfere	51	Female
Student/chainsaw operator	Kumfere	22	Male
Hunter/farmer	Mianya	48	Male
Farmer/Assemblyman	Akwansrem	58	Male
Farmer	Feyiase	40	Male
Farmer/trader	Akwansrem	31	Female
Farmer/hunter	Akwansrem	60	Male

Source: Author generated 2016.

3.4.2 Secondary data

The sources for secondary data included on-line journals, published research papers and reports. Others were students' thesis, books and relevant reports. Data on rainfall and temperature from the Ghana Meteorological Agency (GMeT) was used to determine annual maximum and minimum temperatures and precipitation over the period of 1985-2015. Records of harvested economic timber species in the WSFR from the Forestry Commission and data from MoFA's district office at Begoro indicating the state of major crop production were also obtained. This was used to validate the perception of respondents in identifying ecosystem services, livelihood activities and its impact on the ecosystem services and their assessment of climate variability or change on their livelihoods. Satellite images of the Worobong South Forest Reserve showing the changes in the forest structure over a 10 year period were also obtained from Centre for Remote Sensing and Geographic Information System (CERGIS).

3.5 Data Analysis

To analyse the quantitative data from respondents, SPSS (version-21) was used. Descriptive analysis of socio-economic characteristics of respondents were analysed to determine frequencies of distribution. Cross tabulation was used in matching the socio-economic characteristics of the respondents and the various ecosystem services identified and available to respondents, while the chi square test of association was performed to test the hypothesis stated. Pearson product moment coefficient of correlation was used to determine the significance of relationship between climate data (temperature and rainfall) and crops (cassava,

cocoyam, plantain, and tomatoes) production over a period. For the interviews and focused group discussion, NVIVO software, a qualitative analysis tool was also used to capture the salient assessment of the interviewees. Data (temperature and precipitation) from Ghana Meteorological Agency (GMeT) were analysed to establish historical trends, (Amisah, *et al*, 2009). Additionally, Microsoft excel was used to generate graphs for the presentation of findings.

CHAPTER FOUR

RESULTS

4.0 Introduction

This chapter looks at the findings of the study. Data from the field have been collated and analysed using SPSS, while presentation of results in bar graphs and curves were done using excel in Microsoft. Others were also presented in tables. The findings are divided into five main segments, namely; Demographic imperatives, ecosystem services of the WSFR, Vulnerability assessment of fringe communities, human activities that affect the forest ecosystem, and proposed appropriate EbA strategies for communities.

4.1 Results

4.1.1 Summary of Socio-economic Descriptive Statistics of Respondents

Similarities in the five communities selected for this study relative to their socio-demographic outlook was underscored in the respondents choice of main livelihood activities. Out of the 250 respondents, 86.4% were engaged in farming (mainly plantain, cocoyam, cabbage, and tomatoes), with the lowest number of respondents engaged in food vending and palm wine tapping, which constituted 0.4% (Table 4.1).

There was a near split in the gender representation as females made up 41.6% of the sample size, whiles the rest were males. Mianya was the only community where females (58.8%) respondents were more than males (41.2%) respondents. In the communities, three major social groups in terms of incomes were identified; the high income, middle income, and low income. Majority of the respondents (63.2%) fell within the low income bracket, while the least number of 17.2% were within the high income category earners.

Respondents who attained JHS/Middle school education constituted 33.6% and 27.6% of the respondents did not have any formal education. With respect to age categories of the respondents, 30.8% were within the ages of 35-44, while 24.8% of respondents were in the age bracket, (45-55).

Table 4.1: Socio-Demographic Description

	Frequency	Percentage (%)
	Gender	
Male	146	58.4
Female	104	41.6
Total	**250**	**100.0**
	Age	
15-24	19	7.6
25-34	50	20.0
35-44	77	30.8
45-54	62	24.8
55-64	29	11.6
65>	13	5.2
Total	**250**	**100.0**
	Community	
Feyiase	88	35.2
Miaso	50	20.0
Akwansrem	48	19.2
Komferi	47	18.8
Mianya	17	6.8
Total	**250**	**100.0**
	Level of education	
No formal education	69	27.6
Primary	77	30.8
JHS/Middle school	84	33.6
Secondary	17	6.8
Tertiary	3	1.2
Total	**250**	**100.0**
	Main sources of livelihood	
Farming	216	86.4
Hunting	2	0.8
Chainsaw operating	2	0.8
Food vending	1	0.4
Artisan	11	4.4
Trading	14	5.6
Palm wine tapping	1	0.4
Fuelwood collecting	3	1.2
Total	**250**	**100.0**
	Annual/seasonal income (Gh₵)	
Low income (<500)	158	63.2
Middle income (501-800)	49	19.6
High income (>801)	43	17.2
Total	250	100
Total	**250**	**100**

Source: Field work, 2016

4.2 Identification of Ecosystem Services of WSFR

Perceptions and experiences of respondents form the basis for identifying services derived from the forest reserve boarded by the five communities. Table 4.2 shows the degree of importance attached to the services the forest provides. The provisioning services represented the category with the most approval rating relative to respondents' livelihood activities. In this category, freshwater (97.6%), bush meat (96.0%), chewing sticks (91.6%), pestles (91.2%), and fuel wood (90.8%) were among the major services respondents found useful to their livelihoods. Meanwhile, 92.4% of the respondents believed that the forest provides a regulating service of improving soil fertility for crop production. Similarly, 93.6% of the respondents considered the forest's ability to regulate the air in the area. In rating the supporting category of services provided by the forest, respondents considered pollination (55.6%), carbon sequestration (52.8%), and seed dispersal (52.4%) as the major services they derived from the forest. For the cultural services, 31.0% of the respondents thought that, the forest can serve as a resource for recreational. This data suggests that, the provisional services dominates all other services, particularly the cultural services.

Table 4.2: Identified forest ecosystem services by people from the five fringe communities of the WSFR

Ecosystem services		Frequency	Percentage (%)
Provisioning	Freshwater	244	97.6
	Bush meat	240	96.0
	Chewing stick	229	91.6
	Pestles	228	91.2
	Fuel wood	227	90.8
	Leaves	227	90.8
	Snails	226	90.4
	Timber	223	89.2
	Mortar	222	88.8
	Seeds	216	86.4
	Roots	204	81.6
	Sponges	185	74.0
	Mushroom	176	70.4
	Fruits	142	56.8
	Honey	121	48.4
	Cola nut	121	48.8
	Essential oil	94	37.6
	Spices	91	36.4
	Mats	84	33.6
	Fish	76	30.4
	Wooden tray	67	26.8
Regulating	Air quality	234	93.6
	Fertile soil for food	231	92.4
	Regulate climate	221	88.4
	Water purification	203	81.2
	Prevention of erosion	135	54.0
	Pest regulation	231	92.4
Supporting	Pollination	139	55.6
	Carbon sequestration	132	52.8
	Seed dispersal	131	52.4
Cultural	Spiritual value	179	71.6
	Habitat for gods	167	66.8
	Recreation	78	31.0
	Royal burial grounds	167	27.6

Source: Field work, 2016.

4.3 Vulnerability Assessment of Forest Fringe Communities

4.3.1 Major Exposures of livelihoods

A cross tabulation analysis of some socio-demographic characteristics of the respondents and the indicators of vulnerability (Table 4.3) was conducted. Respondents were asked to rate the indicators based on the degree of exposure in their activities. Out of the 250 respondents, males

(127) and females (86) rated decline in income higher than depletion of wildlife, spread of infectious diseases, among others. On the basis of livelihood activities of the respondents, farmers (190) who are dominant in this category also indicated that, their vulnerability was evident in the decline of their income. The next most rated exposure by respondent who were farmers was, reduction in crop yield (182), followed by decline in forest resources (175), increase in soil depletion (156), and depletion of wildlife (134). The spread of infectious diseases was the least rated indicator by respondents - farmers (31). To compare communities in analysing their degree of vulnerability, 88.6% of respondents in Feyiase were the only community that rated decline in income higher, while Miaso (88.0%), and Akwansrem (85.4%), rated reduction in crop yield, and decline in forest resources respectively higher than the remaining indicators. The majority of the respondents (133) within the low income earning indicated that, decline in income constituted the highest rated aspect of their lives that makes them vulnerable. Respondents in this category of income earners (19) also rated spread of infectious diseases as the least of the indicated aspects of their lives which were exposed.

Table 4.3: Community's livelihood vulnerability to impacts of climate change

	Indicators of Vulnerability							
Characteristics	**DII**	**RCY**	**SID**	**RUM**	**ISD**	**DW**	**INF**	**DFR**
Gender								
Male	127	122	21	53	109	93	29	123
Female	86	85	17	36	66	56	19	73
Livelihood Activity								
Farming	190	182	31	82	156	134	39	175
Hunting	2	2	1	1	2	1	1	2
Chainsaw operating	2	2	0	0	2	2	1	2
Food vending	1	1	0	1	1	1	1	0
Artisan	5	7	2	2	5	4	2	7
Trading	11	11	3	2	8	5	4	8
Palm wine tapping	1	1	0	0	0	1	0	1
Community								
Feyiase	78	70	16	14	69	64	25	76
Miaso	43	44	7	5	31	25	15	32
Akwansrem	38	36	2	37	34	33	0	41
Komferi	41	43	4	29	36	23	4	48
Mianya	13	14	9	4	5	6	4	7
Income levels (Ghc)								
Low	133	129	19	57	115	93	22	129
Middle	41	40	11	14	29	32	13	38
High	39	38	8	18	31	24	13	29

*Scale: DII=Decline in Income, RCY=Reduction in Crop Yield, SID=Spread of Infectious Diseases, RUM=Rural-Urban Migration, ISD=Increase in Soil Depletion, DW=Depletion of Wildlife, INF=Increase in Fertilizer, DFR=Decline in Forest Resources.
Source: Field work, 2016

4.3.2 Climate Variability, Ecosystem services and Livelihoods

To ascertain the extent of vulnerability of both natural and human systems to climate variability or change, about 78.4% and 77.6% of respondents believe their livelihoods have been affected because of change in temperature and decline in rainfall levels respectively. A relationship between the supply of ecosystem services to the respondents and the change in temperature as well as rainfall determined. The outcome was that, out of 250 respondents, 196 and 194 respondents who indicated that temperature and rainfall respectively have changed over the period of 20-30 years also maintained that, this has led to the change in their livelihoods over the past 10-20 years.

Relating respondents' climate assessment to the Ghana Meteorological Agency's (GMeT) data, annual Rainfall values have consistently recorded variability in the WSFR area over a period of 35 years (1980-2015). Monthly levels have declined since September, 1987 which recorded

the highest average rainfall of 621.7mm. Beyond 1997, which comes close in terms of the monthly levels, all other recordings indicated variability, (Figure 4.1). Statistical analysis of rainfall from January to December showed all year recording of rainfall.

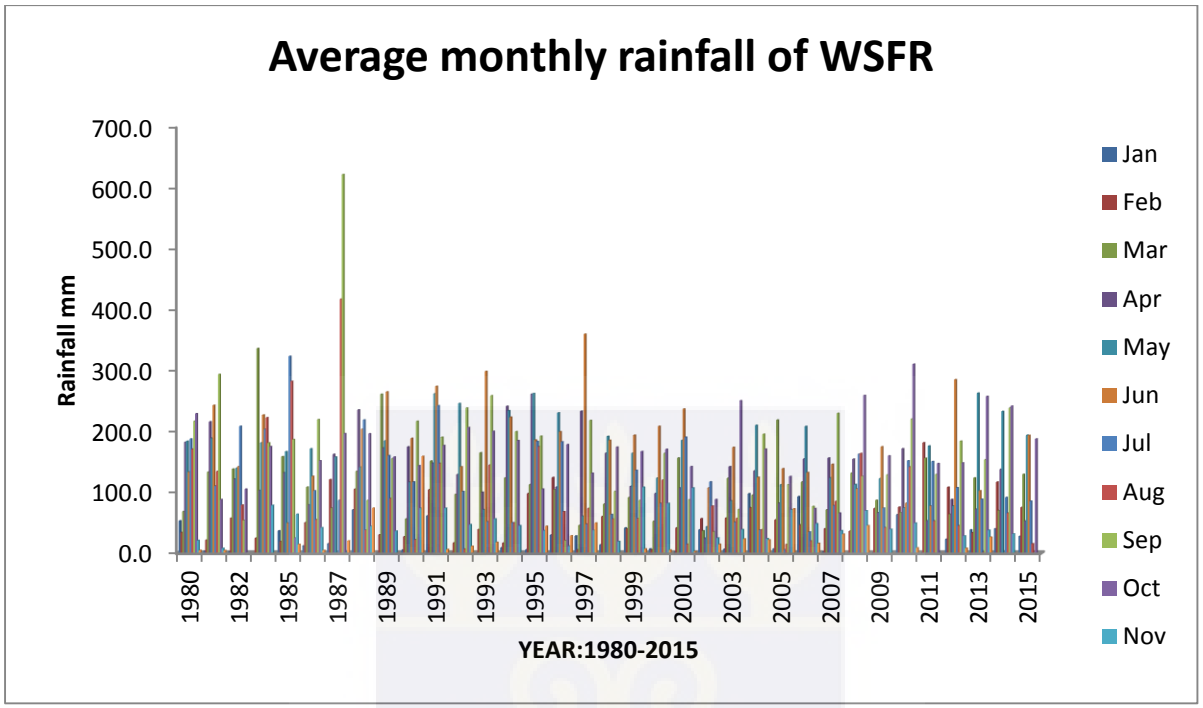

Figure 4.1: Average monthly temperature of WSFR
Source: GMeT, 2016

The highest amount of rainfall was recorded in 1986 with the value of 3204.80mm and the lowest recorded 776mm in 2002, (Figure 4.2). The mean and standard deviation of the rainfall recording for 1980-2015 was 1644.39mm and 748.54 respectively, (table 4.4).
The most recent decade (2002-2012), provides the record of decreased rainfall with more changes occurring in short rains in the major season. There is a strong annual variability of rainfall across the study area with a decreasing trend. By this trend, it could be suggested that, rainfall variability is quite rapid at the local level.

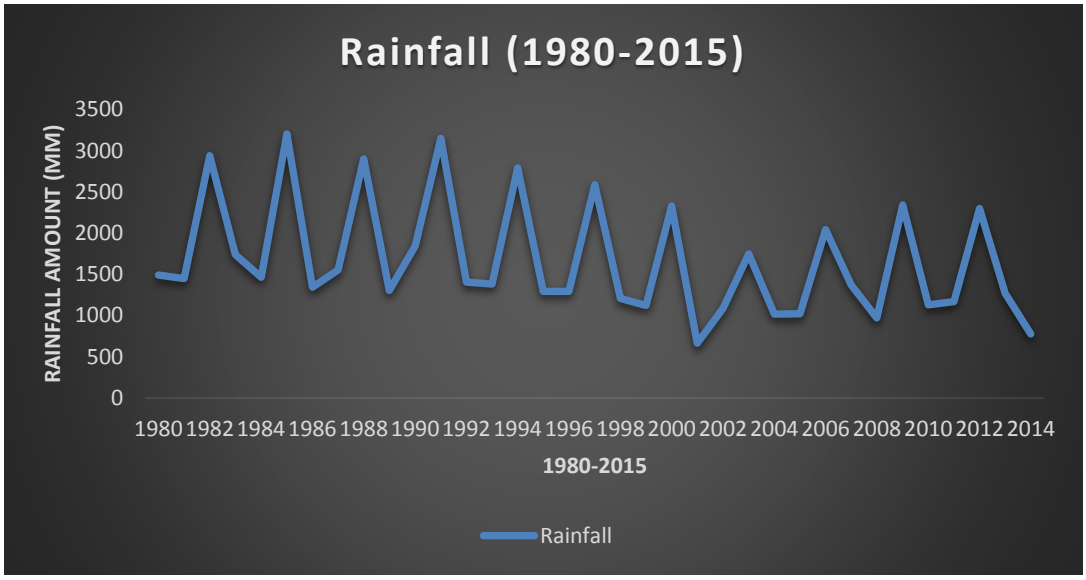

Figure 4.2: Average annual rainfall of WSFR
Source: GMeT, 2016

The analysis of annual average temperature over a period of 35 years (1980-2015) in some cases and 27 years (1980-2007) in the Worobong South Forest Reserve area shows two outputs of minimum and maximum levels. The inter-annual variability of recorded time-series is relatively minor with recordings as low as 0.1^{o}C sometimes.

Annual average temperatures of the study area in Figure 4.3, indicates a gradual increase between 1980 and 2006, with average increase of about 1.1^{o}C, and the minimum temperature (20.1°C) recorded in 1986, while the maximum temperature of 27.7°C was recorded in 2006. Also, temperature recorded for 1980-2006 have mean and standard deviation values 24.51°C and 2.1 respectively, (Table 4.4).

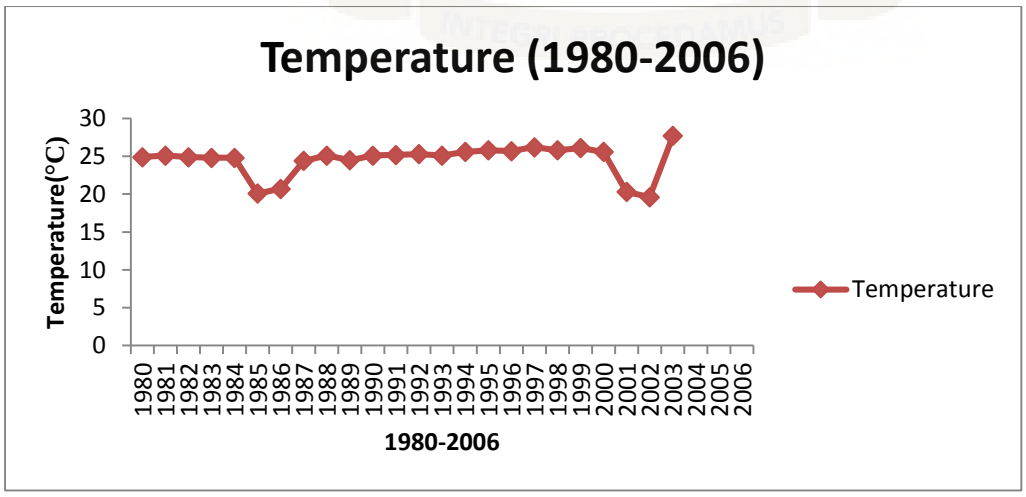

Figure 4.3: Average annual temperature of WSFR
Source: GMeT, 2016

Table 4.4: Trend Analysis on rainfall (1980-2015) and temperature (1980-2006)

	Rainfall (mm)	Temperature (°C)
Mean	1644.40	24.51
Standard deviation	748.54	2.10
Correlation coefficient	0.19	0.69

Significant at 1%
Field work, 2016

To that extent, the study assessed respondents' knowledge of the threat to the forest resources as a result of their activities outside the incidence of temperature and rainfall. In doing so, respondents' sources size of household was matched against the number of years respondents have been engaged in their livelihood activities by running a Pearson coefficient of correlation to determine their relationship. There was a positive correlation between size of household (M=6.7320 SD=2.97718) and the years in undertaking livelihood activities (M=3.1880 SD=1.11608), r = 0.541, n = 250, P = 0.000≤0.01.

Hypothesis Testing

To determine whether Fringe communities of the WSFR are not vulnerable to climate variability or change as the first hypothesis stated, at a 0.05 level of significance**,** the chai square analysis indicated the following socio-economic characteristics of the study; Community of respondents (χ^2= 16.291, df = 4, p = 0.003 ≤ 0.05), Livelihood activities (χ^2=17.350, df=7, p=0.015≤0.05), Income earned (χ^2=21.900, df=10, p=0.016≤0.05), were significantly associated with change of livelihoods over the past 10-20 years as a result of possible climate variability or change. With this findings, the hypothesis was rejected since respondents were vulnerable to the impacts of climate change relative to where they live (communities), their livelihood activities (farming, hunting etc), income earned.

As a way of assessing the vulnerability of livelihoods of the people under climate variability, some livelihood activities such as farming was considered. In this case, some selected crops cultivated within the area were used. The findings of the yearly crop output within the Fanteakwa agro-ecological zone showed a downward trend (Figure 4.4), except tomato production. Cassava production in 2003 was about 14,000 mt/ha compared to cocoyam and plantain which recorded 10,000 mt/ha and 10,700 mt/ha respectively over the same year. Just like cassava which has recorded some steady decline from 2003 to 2015 with a percentage decline of about 16.7%, cocoyam and plantain are no different. Cocoyam recorded a decline of 17.3%, while plantain also recorded about 10.1% over the same period (2003-2015) for both

crops production. Tomatoes on the other hand recorded rather steady increase of 3,650mt/ha in 2003 to 6,620 mt/ha in 2015. Unlike cassava, cocoyam and plantain productions which were in decline, tomatoes saw about 28.9% increase in production for 2003 and 2015.

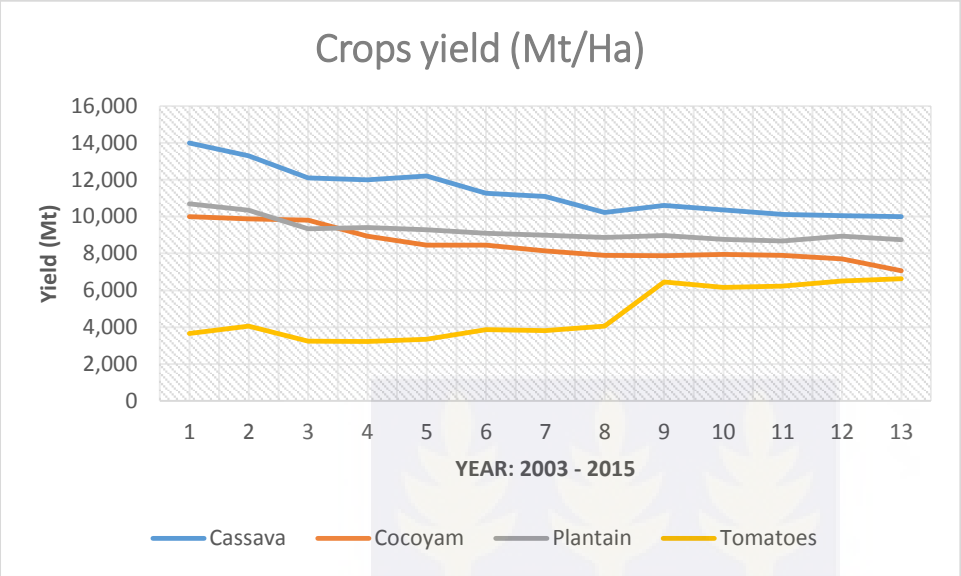

Figure 4.4: Selected Crops Yield in Fanteakwa District
Source: MoFA-Begoro, 2016

The correlation coefficient analysis carried out for some of the major crops (cassava, cocoyam, plantain, and tomatoes) cultivated in the Fanteakwa District and two climatic variables (rainfall and temperature) shown in Table 4.5, revealed that, rainfall negatively correlated with all the crops; cassava (-0.466), Cocoyam (-0.431), Plantain (-0.274), except tomatoes (0.417). Similarly, changes in the minimum temperature had a negative coefficient of correlation with all the crops; cassava (-0.406), cocoyam (-0.333), plantain (-0.462), and tomatoes (-0.453).

Table 4.5: Correlation Analysis: Climatic Variability and Crop Yield (2003-2015)

Crops	Rainfall (°C)	T_{max} (mm)	T_{min} (mm)
Cassava	-0.466	-0.696	-0.406
Cocoyam	-0.431	-0.775	-0.333
Plantain	-0.274	-0.858	-0.462
Tomatoes	0.417	0.116	-0.453

Source: Field work, 2016

To test the second hypothesis which states that climate variability or change has no effect on the ecosystem services of the WSFR, by using respondents' perception of climate variability within the context of gender, age, community, income household, and livelihoods on the changes in the vegetation of the forest reserve. The chi square analysis with a significant level of 0.05, (Table 4.6) shows that, Community of respondents (*p-value<0.000*), and Income

earned (*p-value<0.005*), were significantly associated and perceived changes in the vegetation of the forest. The claim is therefore rejected with regards to communities of the respondents and income earned but not for gender, age, household and livelihoods.

Table, 4.6: Socio-economic characteristic of respondents and the perceived changes in the vegetation of the WSFR as a result of climate change.

Characteristic	Calculated(χ^2)	df	p-value	Decision
Gender	1.671	2	0.373	Not significant
Age	5.961	10	0.819	Not significant
Community	61.715	8	0.000	Significant
Income	40.296	20	0.005	Significant
Household	15.430	22	0.843	Not significant
Livelihood	20.798	14	0.107	Not significant

Source: Field work, 2016

4.4 Livelihood Activities and Impact on Ecosystem Services

Relative to the peoples' activities that impact the WSFR and its ecosystem services, respondents rated all the human activities high (Table 4.7). Furthermore, over 77% of the respondents had no doubt that bushfires were a major threat to the forest. Also, overexploitation (70%), land/bush clearing (55.6%), indiscriminate hunting (45.6%), collection and use of fuel wood (35.2%) and over use and abuse of river systems (34.0%) were among some of the human activities that got high ratings by the respondents in terms of the severity of impact these activities have on the WSFR (mean scores of 3.4, 3.3, 3.1, 2.6 respectively on a 4 point scale of assessing severity of human activities on WSFR). Meanwhile improper chemical use had a mean score of 1.6 indicating less severity of this activity on the forest. This data suggests that, more of the human activities have severe impacts on the WSFR.

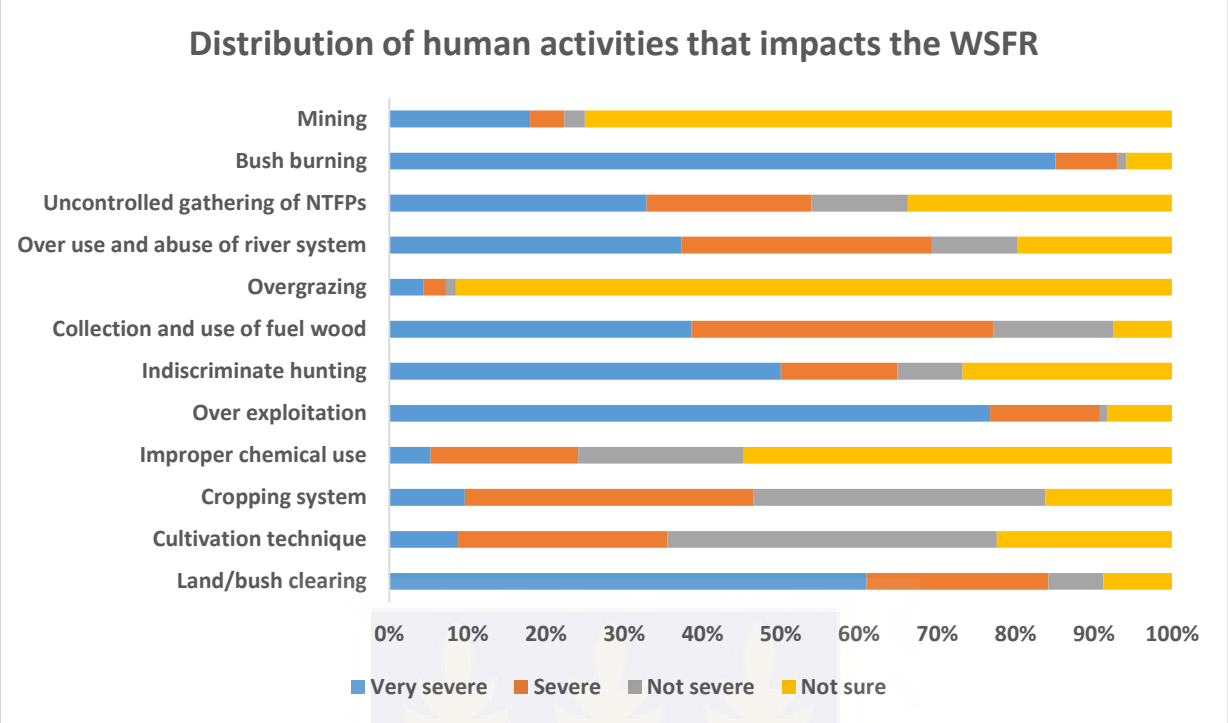

Figure 4.5: Distribution of human activities that impacts the WSFR
Source: Field work, 2016

Further analysis of human impact on the WSFR in terms of utilising its provisional services revealed that, the Forest Reserve had 12 ‘‘admitted farms’’ at the time of its reservation. Subsequent to that, farmers and other users of the forest have expanded their activities leading to the change in the forest cover of the area.

In finding out the scientific basis for this impacts, the WSFR satellite images captured the state of the Reserve in three temporal units (Tu) of five years (5) interval, 2000, 2005, and 2015. The first temporal unit showed much better and bigger area of closed forest (deep green colour) and spots of areas with incidence of bush fires (orange colour) in Figure 4.8. Similarly, patches of degraded lands (grey colour) as well as small settlements (deep brown) within the forest reserve. The situation could be seen to have changed as presented on the 2005 year imagery of the WSFR (Figure 4.7) where settlements appeared to have expanded, and larger portions of the reserve seemed to have suffered severe bushfires. Same was noticed even as recent as 2015 (Figure 4.6) which shows a rather pervasive and elucidating decline in forest cover.

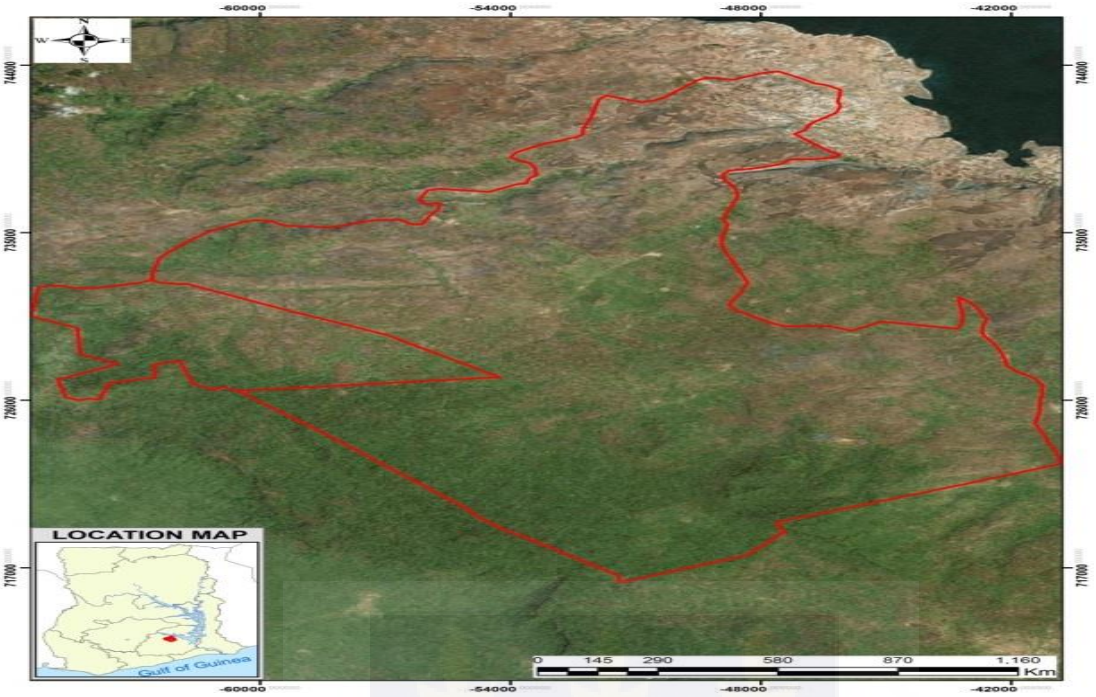

Figure 4.6: Status of WSFR in 2015
Source: Center for Remote Sensing and Geographic Information System, (CERGIS) 2016.

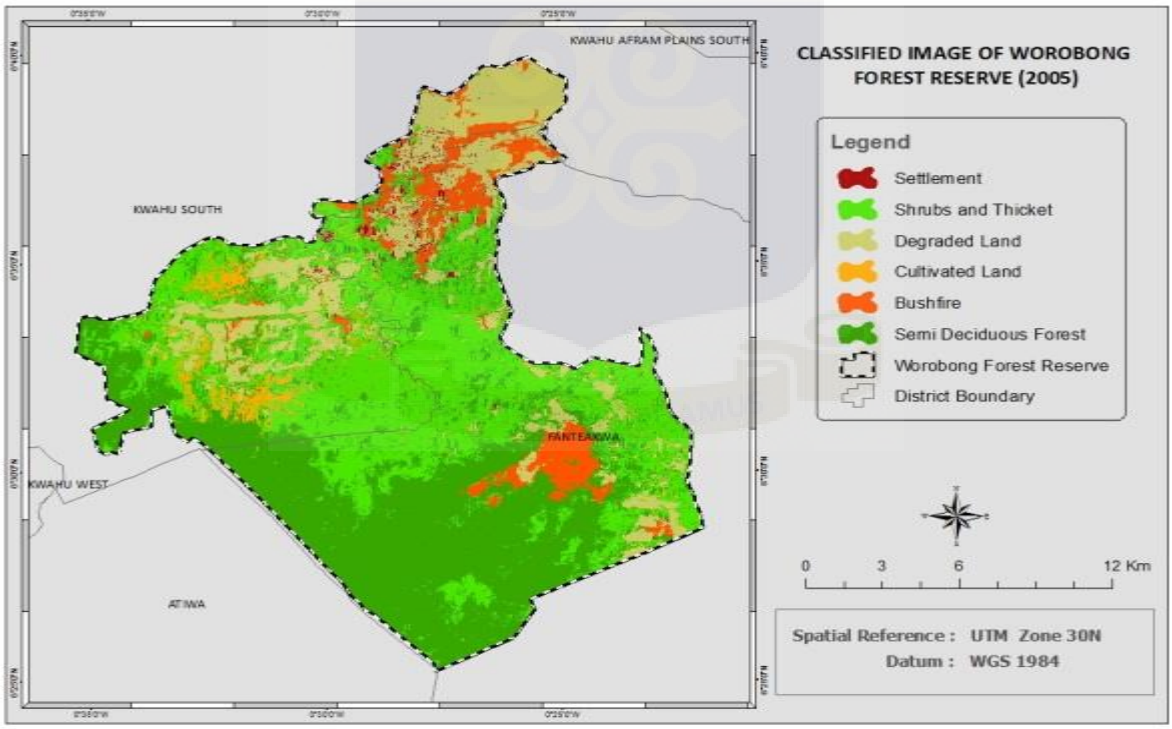

Figure 4.7: Status of WSFR in 2005
Source: CERGIS, 2016

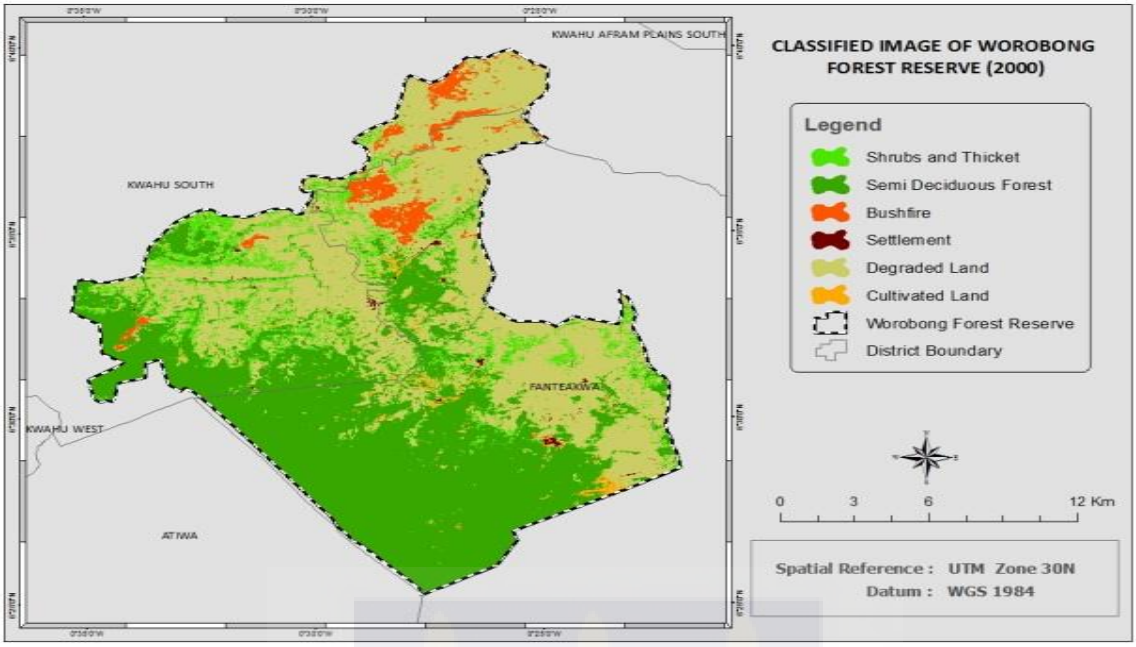

Figure 4.8: Status of WSFR in 2000
Source: CERGIS, 2016

The third hypothesis to determine whether any association exist between human activities and its impact on the ecosystem services was conducted. The chi square analysis of 0.05 significant level reveals that, land/bush clearing *($p<0.000$)*, cultivation technique (*$p<0.000$*) and improper use of fertilizer *($p<0.023$)* were among the many human activities in Table 4.8 which were significantly associated with the perceived effects of these activities on the ecosystem services. However, cultivation technique, cropping system, and over grazing showed that, they did not significantly affect the ecosystem services of the forest reserve.

Table 4.7: Results of chi square analysis between activities of communities and the extent of perceived effects on the ecosystem services of the WSFR.

Activities of communities	χ^2	df	p-value	Decision
Land/bush clearing	38.604	12	0.000	Significant
Cultivation technique	45.359	12	0.091	Not significant
Improper application of fertilizer	23.577	12	0.023	Significant
Cropping system	51.300	12	0.183	Not significant
Over exploitation of timber	46.789	12	0.000	Significant
Indiscriminate hunting	82.050	12	0.000	Significant
Collection and use of fuel wood	52.059	12	0.000	Significant
Over grazing	52.208	12	0.162	Not significant
Over use and abuse of river system	55.271	12	0.000	Significant
Uncontrolled gathering of NTFPs	95.376	12	0.000	Significant
Bush burning	32.147	12	0.000	Significant
Mining	42.145	12	0.000	Significant

Source: Field work, 2016

4.4.1 Communities' Experience of Climate Threats and Preferred Remedies

To ascertain how local people perceived and share experiences of the impacts of climate events on individually livelihoods and their communities as a whole, as well as the opportunity to make proposal for other measures in their own view constitutes solution, a focus group discussions was held, and a couple of interviews also conducted. Most of the participants in the FGD, for instance enumerated timber (*Esa, Wawa, Danta, Dahoma*), bush meat (*Otwe, Kusie, Apese, Akrantie*), fuel wood, pestles, foodstuff, and leaves as services they derived from the forest. The discussions revealed the relevance of indigenous knowledge in the conduct of livelihood activities. For example, a predator bird referred to as *Asakwa* served as predictor of planting time in the past and this has never failed until the birds disappeared due to the peoples' wanton felling of trees, bushfires they have subjected the forest to in recent times. The group demonstrated knowledge of climate change through personal and collective experiences when they were asked about it. Participants in the discussion lamented over their circumstances and maintained that, ''rainfall has declined, and it is also late in coming''. The group recounted their experience in this statement: ''growing up, the rains started latest in March, but now, even as late as May not enough is recorded to sustain our work''. They explained that, certain species of trees responsible for rainfall have been harvested leading to prolonged drought and its attendant bushfires for which they take responsibility. This was in response to how their activities impacted the forest and its services.

Another perspective to the discussion was brought to bear when the group stated that, ''because women are no longer tolerating polygamous lifestyles of their husbands which was not the case

in the past, this is leading to excessive jealousy and sometimes end up in murder''. ''We are paying for these sins through the unbearable heat and less rainfall''. To find out what workable and sustainable solutions or interventions would be acceptable in resolving these challenges, some of the suggestions included; technical assistance from state institutions (Forestry Commission, MoFA, Fanteakwa District Assembly, and NGOs) in order to expand the agroforestry (i.e., fast growing tree species and food crops), projects which would increase the stocking of timber species as well as the opportunity to derive livelihood in the form of food crops. They strongly suggested that in addressing the issues, a collaborative effort was very relevant and the benefit-sharing mechanism espoused by Government for tree planting is a good one but it will take too long to derive benefit, therefore it should be done in good faith and the modalities very transparent to illicit broad acceptance and participation from the people.

An interview with a Forestry Commission officer, the District MofA officer, a Chief, and District Assembly member within the Fanteakwa District provided a lot of insight into the challenges, threats, opportunities and solution to the natural resources (WSFR) which served as the basis for community survival.

The FC's officer indicated that the WSFR is managed under four thematic areas as published in the Forestry Commission's management plan 2011-2020 for the reserved area – production, conversion, protection, and plantation. Production involves; exploitation of natural timber, plantation timber (teak/cedrella), collection of NTFPs (particularly *sawe* and leaves). Only authorised exploitation is allowed under this arrangement. Conversion/Plantation: Undertake afforestation in degraded areas through community participatory approaches (community-centred). Protection: To secure plant protection areas (e.g., *Kokrodua*), hill sanctuaries, research areas, (e.g., Permanent Sample Plots), and areas under convalescence. 'As managers of the forest, the office had and continuous to encounter a lot of challenges', according to the officer. These they categorised into logistics (lack of vehicles for patrols, Personal Protective Equipment (PPE), tools, very low staff strength) and Security (attacks on field staff by nomadic herdsmen and illegal loggers for daring to enforce the forest and wildlife laws which bans such activities particularly in the forest reserve). In an attempt to curb the threats and challenges the office had adopted for instance, a collaborative effort with communities and development partners.

Under the Community Forest Management Project (CFMP), tree plantations have been developed with support from the African Development Bank (AfDB). Again under this project,

some alternative livelihood activities were introduced which empowered the women in soap, tie and dye making, and grass cutter rearing. To a very limited extent these projects were successful in terms of coverage, however, sustaining it became difficult once funding stops coming, and the locals return to their old ways of survival.

A national policy on forest plantation programme had also been carried out. The Taungya system (i.e., agroforestry) was introduced but it was later modified to include the benefit sharing element which was not part of the initial agroforestry programme. This project allows for the release of portions of forest reserve lands (mostly degraded areas) for agricultural crop cultivation alongside planting of seedlings supplied by the state (FC) and some incentives in the form of cash remuneration for peg cutting, pegging and planting of the seedlings. Tending however forms part of the cultural practices required for their crops therefore no payment is made for such an activity.

European Union support for chainsaw operators to develop plantations was also introduced. This helped to build the capacity of these men, encouraged them to form cooperatives and became beneficiaries of SME loans facility, free cocoa seedlings and more, ostensibly to reduce the impact of their illegal activity on the forest. In spite of the interventions, capacity to sustain the EU support system after the project life was expended has become a big challenge, according to the FC's officer. For this reason, problems associated with forest degradation persist without limits. ''We need to find other sources of support to sustain such programmes when the main donor is no longer available'', the officer added. In the opinion of the officer, the sustainability of the forest and its dependants, is sine qua non and will go a long way to resolving issues if they promote alternative livelihoods that have market value and not just anything at all.

An increase in awareness creation and encouraging private plantation development to feed the timber industry is another sure way to sustainability. The WSFR is under serious threat, human activities such as bushfires, hunting, farmers, and nomadic herdsmen, illegal logging, (Table 4.9), are unabated, according to the officer. Insufficient record and data management regime of the Forestry Commission could only provide a limited update on the illegal lumbering activities in the area. Despite this major blot, year- on –year detection and confiscation of illegal lumber and logs from the WSFR keeps increasing, even with all the interventions adopted however limited they are. ''At this rate, the only outcome is a total degradation of the forest reserve if extra efforts are not implemented'', the officer added.

Table 4.8: Quantity of confiscated trees felled illegally in the WSFR

				SPECIES/QUANTITY				
YEAR	**Chainsaw cases**	**Reported cases**	**Arrest/ prosecution**	**Esa**	**Dahoma**	**Wawa**	**Cedrela**	**Emire**
2012	17	17	5	3	12	4	1	7
2013	23	23	11	1	11	-	63	9

Source: FC-Begoro, 2016

The chief interviewed, also recounted the threats their livelihoods had been exposed to. The impact in the form of severe drought, low rainfall, bush fires, and late start of rainfall, have resulted in low harvest, high application of chemicals, low incomes, extra effort used for farming, according to the chief. As a traditional authority, they had deployed customs, tradition and norms in the form of Taboo days (every Wednesday) to conserve/preserve the forest and prevent the use of torchlight at night in the forest to limit excessive killing of wild animals, which has not been too effective. Going forward, according to the chief, some form of cooperative or association was needed so people could access technical and financial assistance as a group in alternative livelihood activities such as goat/sheep rearing, women in 'Gari' processing to supply to schools and companies. This would go a long way to improving their livelihoods. The chief was of the opinion that, enforcing the law to ensure that only legal timber firms were certified to harvest timber with the guarantee to employing members of the community, especially the youth was another way of sustaining livelihoods and the forest ecosystem services.

The District MoFA Officer bemoaned the extent of decline in agricultural activities especially the production of food crops as a result of several factors. The MoFA District Officer explained that, farming in the area is predominantly rain-fed and the recent variability in rainfall and prolonged drought had affected the yield. Other factors account for the decline, including bad agricultural practices and the menace of nomadic herdsmen, however, the availability of extension agents to resolve the issues are being implemented. Unlike cassava, cocoyam, and plantain, vegetable production has seen an increase and this is as a result of the irrigation option adopted by farmers. The continuous increase in tomato production is primarily due to the irrigation facilities.

4.5 Appropriate Ecosystem-based Adaptation (EbA) Strategies

4.5.1 Current Coping Strategies Adopted

As part of the study, respondents were asked to provide their current coping strategies having indicated that resources from the WSFR, upon which they depend, had declined over the years. As many as 62.8% said their standard of living have declined, yet had done nothing in coping with the situation, while 8.8% of the respondents indicated that, they engaged in trading (off-farm activity) as a way of adjusting to the impacts of climate change. Some of the respondents (4.8%) indicated that, they worked extra hours than they did previously, while 4.0% revealed that, storage of food for domestic use as well as waited for high prices for their produce in the future before offering them for sale was the preferred option, and another 3.2% indicated that they planted the crops on time as a coping strategy. Additionally, 3.2% of the respondents preferred to reduce their livelihood activities as another form of response to climate impacts in their community. Meanwhile, 1.6% of the respondents saw the need to withdraw their children from school to work on the farms.

4.5.2 Community's Knowledge of Existing Adaptation Strategies

In responding to whether the people know about adaptation strategies available, the most prominent ones rated were change of planting time, tree planting as a paid activity, crop diversification, and irrigation. This was expressed by respondents in Feyiase (59), Miaso (16), Akwansrem (16), Mianya (19), and Komferi (7) who indicated their awareness of changing the planting time as a way of adjusting to the impacts of climate change (Table 4.10). Respondents (50) also thought that, reducing exploitation of timber was another strategy they were aware of, while reducing the number of livestock as a strategy had the least number of respondents (32), who had knowledge in the strategy.

Table 4.9: Respondents Knowledge of existing EbA strategies

CODE	STRATEGIES	SELECTED COMMUNITIES					
		Feyiase	Miaso	Akwansrem	Mianya	Komferi	TOTAL
a	Irrigation	28	16	19	34	6	103
b	Crop diversification	27	19	12	17	8	83
c	Change of planting time	59	16	16	19	7	117
d	Tree planting	50	22	30	15	4	121
e	Application of fertilizer	16	7	1	13	5	42
f	Reduce livestock	10	6	10	5	0	31
g	Reduce exploitation of timber	19	7	15	9	0	50
h	Engage in handicraft activities	13	8	9	9	1	40
i	Snail farming	16	9	8	5	1	39
j	Grasscutter rearing	16	7	9	6	1	39

Source: Field work, 2016

If respondents were familiar with the types of EbA strategies existing, their opinion in terms restraining adoption factors was tested and the respondents said lack of knowledge, finance, and trust in the strategy among others were the pushbacks likely to affect adoption of any of the strategies as explained in Table 4.11. A significant number of respondents did not actually have any reason not to adopt any of the strategies. Indeed 69.6% of the respondents did not find the need to undertake tree planting to restore portions of the degraded forest. For irrigation, 26.0% indicated that lack of knowledge was the hindrance, as 23.3% thought it was lack of finance, and 42.7% of the respondents did not have any reason for not considering the adoption of the strategy.

On the account of reducing exploitation of timber as an adaptation strategy, 68.3% could not indicate why such strategy would not be adopted, while to reduce the number of livestock they own as one of the adaptation options, 25.5% of the respondents indicated that, lack of money would be the setback for adoption of this strategy. Meanwhile, 13.6% had no believe in the strategy. Engaging handicraft activities, snail farming, and grass cutter rearing were not strategies for adoption as 58.9%, 62.1%, and 61.5% of respondents respectively were convinced that lack of knowledge is the reason this option would not be considered.

Table 4.10: Community's non-adoption of adaptation strategies and reasons

Indicators	(%)	Reason for non-adoption				
		Lack of knowledge	Lack of finance	Don't trust strategy	No land	No reason
Irrigation	58.8	26.0	23.3	4.0	4.0	42.7
Crop diversification	66.7	19.0	3.1	8.6	0.6	68.7
Change of planting time	53.0	17.8	3.7	7.4	1.5	69.6
Tree planting	51.4	13.5	13.5	2.3	13.5	57.2
Application of fertilizer	83.1	7.4	37.4	6.4	1.5	47.3
Reduce livestock	87.6	25.5	5.0	13.6	0.5	55.5
Reduce exploitation of timber	80.0	25.7	3.0	1.5	1.5	68.3
Engage in handicraft activities	84.0	58.9	6.2	3.8	1.0	30.0
Snail farming	84.4	62.1	11.7	5.1	1.4	19.6
Grass cutter rearing	84.4	61.5	10.3	4.2	1.4	22.5

Source: Field work, 2016

Respondents were allowed to outline what in their view will constitute the most appropriate strategies for adoption. Out of the eleven strategies listed by respondents, controlling bushfires (28.4%) was the most considered intervention. A lot of respondents from the five communities (23.2%) rated intensive agroforestry as another intervention necessary for adoption. Law enforcement (13.2%), provision of incentives (7.6%), and irrigation (6.0%) were also proposed for adoption. To ensure that indiscriminate and illegal felling as well as sawing of timber is curbed, respondents from the five communities, except Mianya, wanted the laws strictly enforced to deter people from engaging in it, (Figure 4.8).

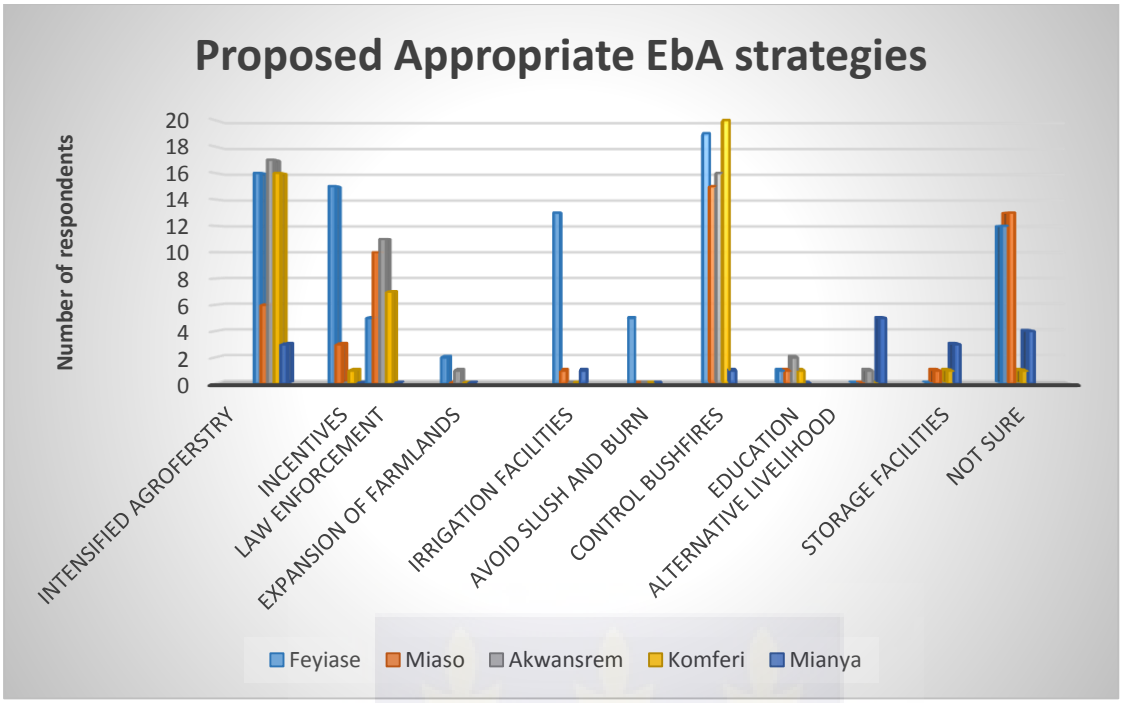

Figure 4.9: Proposed adaptation strategies to reduce impacts of climate change
Source: Fieldwork, 2016.

In testing the significant relationship between EbA strategies to be adopted and the improvement on livelihood activities while enhancing forest ecosystem services**,** the chi square analysis at a 0.05 significant level revealed that, irrigation ($p<0.000$), crop diversification ($p<0.009$), change of planting time ($p<0.000$), tree planting ($p<0.009$), engaging in handicraft activities ($p<0.030$), snail farming and grass cutter rearing were all significantly associated with the livelihood activities of respondents. While, the rest were not significantly associated with their livelihood activities, (Table 4.12).

Table 4.11: Chi square analysis between respondents' livelihood activity and choice of EbA strategy

EbA Strategy	χ^2	df	p-value	Decision
Irrigation use	26.467	7	0.000	Significant
Crop diversification	18.789	7	0.009	Significant
Change of planting date	37.822	7	0.000	Significant
Tree planting	18.784	7	0.009	Significant
Adoption of fertilizer usage	11.249	7	0.128	Not significant
Reduce livestock	5.203	7	0.635	Not significant
Reduce exploitation	11.750	7	0.109	Not significant
Engage in handicraft activities	15.543	7	0.030	Significant
Snail farming	13.686	7	0.057	Significant
Grass cutter rearing	13.063	7	0.071	Significant

Source: Field work, 2016

CHAPTER FIVE

DISCUSSION

5.0 Introduction

This chapter discusses the findings with reference to the objectives, reviewed literature and inferences were made from the results. The discussions were grouped under, identified forest ecosystem services of WSFR, vulnerability of fringe communities to impacts of climate change, human activities and impacts on ecosystem services of the WSFR, and the appropriate EbA strategies for communities.

5.1 Identification of Ecosystem Services of WSFR

Consistent with the theoretical context of the Millennium Ecosystem Assessment (MA) (2005), as well as research from other jurisdiction (Kashaigilli *et al*, 2014), the study shows that forest ecosystem services mapped out are at the heart of peoples' livelihoods. Among the services from the forest ecosystem, freshwater for irrigation, domestic use and the collection of fuel wood, supply of bush meat are among benefits derived in all the communities bordering the WSFR. Other services the WSFR offers grouped under regulating, supporting, and cultural are a key feature in the literature, (Ven der Werf *et al*., 2009: Sarukhan and Whyte, 2005). Since the four categories of ecosystem services are integral in the concept of ecosystem-based adaptation, it can be explained that, these services are capable of becoming a derivative for improving fringe communities' livelihoods and enhance the same ecosystem Milcu *et al*, 2013: García-Nieto *et al*, 2012). Meanwhile, recreation and burial grounds were weakly identified as services derived from the WSFR by fringe communities, despite the increase in several approaches to sustainable forest management.

5.2 Vulnerability Assessment of Forest Fringe Communities

Consistent with the Ghana Living Standard Survey figures of 2013, the high percentage of male respondents explains the dominance of males in the socio-cultural dynamics of people in a typical rural setting, culminating in the pertinent role they play as household heads. Nonetheless, in recent times, more females are taking up similar roles following the dynamics

in the cultural, environmental, social and economic trajectory the world is faced with. Just like their male counterparts, farming is the main livelihood activity for the females and collectively they form the majority group of famers compared to the other activities, an indication of the active involvement of women in the utilisation of the services of the forest ecosystem. As many females as males engaged in farming also fell within the low (<500) seasonal or yearly income level category that can be described as inadequate for sustaining lives. Agriculture in general is sensitive to climate change therefore to have a lot of the people involved in farming is an indication of the nature of humanitarian crises the likely negative impacts of some activities, and exacerbated by climate change would have on their livelihood activities. Income levels are low a suggestion that, not enough is derived from their activities, at least not the majority. With over 55% of the people within the age bracket of 35-55, they were better placed to explain the changes, or variability in climate, and the implications for farming activities and general ecosystem services of the forest.

5.2.1 Decline in ecosystem services

The changes in the forest ecosystem services affect the quality of lives of people who depend on it for livelihoods. The supply of ecosystem services becomes irregular owing to climatic factors and other considerations such as uncontrolled utilisation of the forest resources. This way, forest dependent communities bear the brunt. Incomes from the activities of the people are the defining link for social and economic emancipation from poverty and exclusion. Therefore, it explains the basis for the majority of the respondents finding the decline in income as the first most important threat posed by the vagaries of climate on the ecosystem services. Evidence of threat posed by decline of forest resources was the significant number of both male and female with low income, who are also engaged in farming.

5.2.2 Wildlife and Forest Resources

To the extent that respondents are aware of the decline in their livelihoods underscores similar findings in a study by Msalilwa (2013). To suggest that climate change has the potential of increasing the forest stock and for that matter it services, was disputed by the respondents. Meanwhile, Sedjo's (2010) report which says in a warming world, global forest could increase by 5 to 6 percent by 2050 contrasts the thinking of the people which somewhat explains that, such phenomenon is not within their ''knowledge reach'' for that reason not the entire body of knowledge is available by way of traditional knowledge to ensure conservation and

sustainability of the resources. Hunting as a livelihood activity was minimal, however to gauge the perception of respondent about availability, wildlife was rated higher particularly by farmers, indication that, aside from the main livelihood activity in crop cultivation, either they benefitted from the wildlife accidentally or as a plan endeavour.

5.2.3 Crop Production and Soil Fertility

The ability of soil to sustain crop production is determined by its nutrient. By helping to prevent soil erosion, forests act as a crucial protector of soil resources, and underpins agriculture's resource base. This establishes the respondents' knowledge to the effect that, over the period, they have witnessed decline in their crop yield (Cassava, cocoyam, and plantain) which are linked to the utter depletion of crop production support systems such as the forest ecosystems. This is significant for discussion particularly when majority of the respondents are engaged in farming, a very sensitive livelihood activity. It would not be the entire crop reduction that could be attributable to climate variability or forest resources decline since other factors existed long before the phenomenon of climate change. This confirms the agriculture managers within the area (MoFA) who suggested crop production in tomatoes for example is increasing because a lot more of the farmers are using irrigation facilities. It is perhaps safe to place the assumption with *medium confidence level* that there is crop switch rather than recorded reduction in say plantain production as a result of severe climatic changes.

5.2.4 Local Climate Knowledge and Meteorological Data

Knowledge and experiences are rife at the local level culminating in the overwhelming majority of respondents in Feyiase, Miaso, Mianya, Akwansrem, and Komferi communities bringing to bear what in their opinion temperature and rainfall variability means. This is an indication that people know about change in temperature and rainfall levels and the threats to forest and aquatic systems. From this study, temperature variation and change data between 20-35 years showed that, livelihoods of the respondents had been affected. Indeed analysis of the time series of temperature records indicate evidence of climate change with increasing trends of both mean minimum and maximum temperature and this is consistent with the period of declining rainfall. The evidence is that, the values of Standard deviation (2.1) and Mean (24.51mm), shows a relatively strong variability in temperature values from year to year as the coefficient of correlation of temperature and time (1980-2006) is 0.690 and statistically significant at 1%. This implies that, temperature changes with time significantly, and underscores the fact that, warming is incontrovertible in the WSFR area. Meanwhile, rainfall has a weak (0.19) positive

relationship with time although there is a large variability in the amount of rainfall from year to year. This supports the work of Adewuyi, *et al* (2014) in Oyo State, Nigeria which revealed that, evidence of climate variability (rainfall and temperature) is the effect on yam yield in the area. Furthermore, communities' perception on climate variability and change was taken into account using the statistical analysis of rainfall and temperature records of between 30 and 35 years for the Worobong South Forest Reserve area. What this revealed was the concerns that farming activities, hunting for game, supply of pestles, mortar and freshwater were not assured if this climatic conditions persisted on this trajectory.

As the peoples' knowledge and perceptions of climate variability is matched against actual recordings of data from the statutory agencies like GMeT validates some of this perception. Such analysis suggested that, there is almost no difference of respondents' opinion in the changes in temperature and rainfall, and the change in the livelihoods of the people. This exercise supports the perception to the extent that, temperature and rainfall have both affected the lives of the people. Further records from GMeT safely suggested that, the area experiences a bimodal rainfall regime, from March to July (Main season) and August to October (minor season), as was also reported by Tachie-Obeng et al (2014). The decline in rainfall is not uniform although its aggregate records are significant to adversely affect the forest ecology and biodiversity, as well as influence local seasonal and annual water balances relevant to the communities for their livelihoods. This goes with a similar study in Ondo-State, Nigeria, by Tunde (2011), which indicated that, cocoa yield fluctuated between 2004 and 2007, with the changes attributed to unusual climatic variability. Boissirie *et al*'s (2013) observed that, inconsistencies exist between local perceptions and climate data which raise concerns about the validity of local knowledge. Therefore, this has to be considered with caution as the seasonality and variability in climate elements (i.e., temperature and rainfall) are normal feature with the likelihood of rendering any value judgement deficient.

5.3 Livelihood Activities and Impact on Ecosystem Services

Local livelihoods are linked to the forest resources, and in this study, farming was the main livelihood activity of the people. In the context of climate change and vulnerability, human involvement cannot be described as remote but an active contributors to a lot of the forest degradation challenges particularly, those who derive direct benefits from the ecosystem. A lot of uncontrolled activities in the use of the forest resources also have serious implications which could be far more alarming than the direct impacts of drought and flooding. Establishing a

relationship between size of respondents household and how regular they access the services from the forest, gives better indication of the threat some of these livelihood activities pose to the existence of the forest ecosystem services when used uncontrolled. Access of the resources comes in the form of visit to farms to plant, tend or harvest crops and hunting of wildlife which can be a daily activity. Changes to the ecosystem services, according to the respondents was believed to have occurred, and this confirms the report of Dale and Polasky (2007), which stated that changes to the environment associated with agriculture affects a wide range of ecosystems services such as water quality and quantity. It was revealed in the responses that bushfires are major threats to the forest. The same can be said about increase in the use of fertilizer which also exacerbates the decline in forest resources.

5.4 Appropriate Ecosystem-based Adaptation (EbA) Strategies

Not all strategies intended to help vulnerable societies to adjust to the impacts of climate change or threats from poorly regulated non-climatic activities are easily accepted. A good majority of respondent gave the indication that their standard of living had declined, yet had done nothing in coping with the situation, in contrast to what Blench (2003), in a study revealed that farmers would rather minimize or spread risk by managing a mix of crops, use of crop varieties and sites, staggering the sowing/planting of crops as a strategy to adapt to adverse environmental challenge, such as declined rainfall and increase in temperatures. Meanwhile, the minority of respondents who saw the need to for a coping strategy, took some extreme options which were non-sustaining and costly such as taking their children out of school to assist in their livelihood activities, particularly farming.

Apart from changing of planting time for their crops, tree planting for payment, use of irrigation and crop diversification which were adopted by some, the remaining strategies (grass cutter rearing, snail farming and reduction in livestock), were not the most preferred strategies in these communities. A similar outcome was reported in Yeboah and Ameyaw, (2004), in which communities chose planting food crops and trees, greenbelt establishment, combating illegal chainsaw and fire for adaptation strategies.

To find out why some of the adaptation strategies intended to improve their livelihoods and enhance the ecosystem services had not received the needed acceptance in the communities, respondents said they lacked knowledge, finance, and did not have trust in the strategy among others, as the pushbacks for not adopting any strategy. These findings reaffirms Apata's (2011) study in Nigeria where respondents listed series of difficulty of adaptation, such as; lack of information on adaptation methods, no access to effective adaptation methods, lack of money

or access to credit facilities (Ojea, 2015), shortage of labour, shortage of land and poor capability for irrigation. Again, Yeboah and Ameyaw (2004), reported that, the motivation of fringe communities to fully embrace selected strategies was built on the future income to be derived from a 40% share of trees planted and supply of farm inputs such as cutlasses. The theoretical underpinning of the EbA concept is that, it is low in adoption because according to CBD, (2009), it is relatively new.

Depending on the choice of strategy, EbA in general terms has a key feature that targets the immediate adaptation needs of the poorest and most vulnerable to be adversely affected by climate change (Chong, 2014). So therefore, in making proposal towards a more achievable and sustainable interventions that will encourage full participation of communities and major stake holders - Forestry Commission, Environmental Protection Agency, Fanteakwa District Assembly, Ghana Meteorological Agency, Ghana Police Service, Ghana National Fire Service, Cocoa Research Institute of Ghana, NGOs, CSOs, and the Academia will have a role to play. This is in recognition that, an EbA approach is a process, and designed as cross-sectorial, community-level participation that is intended to be cost effective (Pramova *et al*, 2012).

Intervention such as agroforestry intensification was also proposed as a tool to restore degraded parts of the forest, although they expect to be incentivised with farming tools, finance and benefit sharing agreements that are not illusionary but will afford them the opportunity to grow enough crops to feed their family and make some extra income to take care of their basic needs. Even though strategies such as, expansion of farmlands, avoiding of the slash and burn methods of farming, education on environmental conservation issues, and food storage were proposed, only a limited number of the respondents thought it is a useful strategy. In communities such as Miaso, Akwansrem, Komferi, and Mianya none of the respondents found the strategy of avoiding slush and burn method of farming as relevant. This underscores the focus of the EbA concept which fundamentally relies on the biodiversity and ecosystems for livelihoods improvement thereby informing the least consideration for slush and burn as a formidable strategy.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Introduction

This chapter underscores the major findings and recommendations also made accordingly.

6.1 Conclusion

Ecosystem-based adaptation approach for livelihood improvement as contextualised by EbA process framework, and adopted for this study, has provided good basis for fringe communities to identify the ecosystem services derived from the WSFR. It is firmly established that, males and females in all five communities appreciates what sustains their livelihoods (mainly farming), and enumerated all the ecosystem services with the major ones including; freshwater (97.6%), bush meat (96.0%), chewing stick (91.6%), pestles, fuel wood, snails, timber and the least rated service was wooden tray for the provisioning services category. For the other categories, the major services respondents derived were; supporting services (pollination: 55.6%, carbon sequestration: 52.8%), regulating services (air quality-93.6%, fertile soil for food production-92.4%), and cultural services (spiritual value-71.6%). Again in accordance with the EbA frame work, society build resilience when ecosystems are sustainably managed. To achieve this is to understand what impacts human activities have on the ecosystem. The EbA frame work suggest that, when immediate pressures on forest are addressed, a longer term perspective and climate change can considered. So therefore, the study revealed that, the quantity and quality of the forest ecosystem services have declined (i.e.,, 95.2%) as a result of the expansion of farmlands in the forest reserve (land/bush clearing-77.6%), over use and abuse of river system (e.g., overdrawing water for irrigation), bush burning, and over exploitation of timber (70.0%), as well as climatic changes or extreme weather events (severe drought, and floods), that impacts the forest ecosystems, with the potential to reduce their resilience (i.e., decline in income-230 (92.0%), reduction in crop yield-207 (82.8%), with food security implications, and eventually increase vulnerability of the people.

A few interventions that came in from donors and the Forestry Commission did not achieve much results because, once projects' life span ended and funding withdrawn, locals reverted to the old unsustainable ways of undertaking their livelihood activities. In pursuit of sustainability

as a foundation for improve livelihoods, the study also found that, adopting certain strategies were impossible. Situations such as; lack of finance and knowledge, trust issues, and lack of permanent lands, were the pushback. It however has not prevented communities from declaring their intensions to adopt any of the EbA strategies with the view to achieve sustainable management of the forest ecosystem, consistent with the EbA conceptual frame work. On that account, they proposed some appropriate EbA strategies such as agroforestry intensification (23.2%), provision of incentives (benefit sharing), law enforcement (13.2%), control bushfires (28.4%), and storage facilities as some of the strategies to adopt in improving their livelihoods and enhance the ecosystem services.

Challenges are part of the concept, however it does not vitiates its object. A process that allows for livelihoods activities to be assessed within the scope of vulnerability to climate change as EbA does, is not only expressed in theory, but provides practical solution to climate risks.

6.2 Recommendations

In Feyiase, Miaso, Mianya, Akwansrem, and Komferi, people have indicated the willingness to adopt EbA strategies to improve their livelihoods while enhancing the forest ecosystem. Based on this, the following recommendations are made;

- Skills training to improve the knowledge base of the people in some of the strategies they are willing to adopt, and technical support from the Forestry Commission and its partners in conservation matters to address the knowledge gap and enhance participation of communities to improve livelihoods of a lot more of the people.
- As way of addressing the financial challenges, some support under target projects, such as cooperatives in agroforestry programmes as well as effective monitoring and control in the utilisation and reforestation of degraded forest reserve lands by the Fanteakwa District Assembly, FC, and NGO or Government of Ghana (GoG), in an effective stakeholder engagement will be required to bridge the financial gap the study revealed.
- Government through its agencies may seek support from donors under a special scheme of making about 15% of the 40% benefit sharing with locals policy available to the farmers (A policy they find remote) ahead of the maturity of planted trees by the people. This way, motivation would grow, knowing that they do not have to wait their whole life to benefit from an enterprise they contributed in nurturing. Money received from

this arrangement would improve standard of living whiles the restoration of degraded portions of the forest reserve could also be sustained.

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APPENDIX A

UNIVERSITY OF GHANA

CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

Introduction

This survey is being undertaken as part of a study on the topic '*Adoption of EbA approach in the face of climate change: Improving livelihoods in fringe communities around the Worobong South Forest Reserve*'. It is entirely for academic purpose therefore you can be assured of anonymity in the use of your responses.

Instruction: A household head or a representative of each household is required to answer the questions. Please circle, tick codes where appropriate or write response in space provided.

A. Background Characteristics of Respondents

1. **Community name:** ……
2. **Age:** ……
3. **Gender:** 1. Male 2. Female
4. **Level of Education:**

   1. No formal education 2. Primary 3.JHS/Middle 4.Seconday 5.Tertiary
5. **How long have you lived in the community?. ……**
6. **What is your main source of livelihood?**
7. **How long have you been engaged in this livelihood activity?**
8. **What is your annual or seasonal income from your livelihood activity?**

   1. Low (<500), 2. Middle (501-800), 3. High (>801)
9. **How many dependants do you have?**

   1. (1 - 3), 2. (4 – 6), 3.(7 – 9) 4. (>10)
10. **List other sources of income:** ……..

B. Ecosystem Services

11. What ecosystem services do you know the forest provides? (Tick as many as applicable)

Ecosystem services	Availability	
1. Provisioning	**Yes**	**No**
1. Bush meat		
2. Freshwater		
3. Fish		
4. Fruits		
5. Honey		
6. Mushroom		
7. Snails		
8. Spices		
9. Cola nuts		
10. Barks		
11. Leaves		
12. Seeds		
13. Roots		
14. Essential oil		
15. Wood fuel		
16. Timber		
17. Mats		
18. Wooden tray		
19. Grinders		
20. Mortars		
21. Pestles		

22. Chewing sticks		
23. Sponges		
2. Regulating		
1. Air quality		
2. Local climate regulation		
3. Prevention of erosion		
4. Water purification		
5. Pest regulation		
6. Improved soil for food production		
3. Cultural		
1. Spiritual and religious values		
2. Recreation		
3. Royal burial grounds		
4. Habitat for gods		
4. Supporting		
1. Pollination		
2. Carbon sequestration		
3. Seed dispersal		

12. Which one (please, select only one) of these services is highly linked to your livelihood activities?……..

C. Impact of climate change on forest ecosystem

13. Do you know about the issue of climate change in your community? 1. Yes 2. No

14. Has the temperature in this area changed over the past 20-30 years? 1. Yes 2. No

15. If yes, has it; 1. Increased 2. Decreased 3. Extreme fluctuations 4. No change 5. Don't know

16. Has the rainfall in this area changed over the past 20 years? 1. Yes 2. No

17. If yes, has it, 1. Increased 2. Decreased 3. Extreme fluctuation 4. No change 5. Don't know

18. What level of evidence of climate change impact have you experienced?

Experienced impact	Very evident	Evident	Not evident	Don't know
1.Fluctuation in rainfall pattern				
2.Erosion and flooding				
3.Changes in planting periods				
4.Decrease in availability of forest resources				
5.Droughts and longer period of dry season				
6.Increase in pest infestation on farms				
7.Increase in soil depletion/nutrition				
8.Increased use of fertilizer				
9.Increased bushfires				
10.Reduction in water values				
11.Changes in Vegetation				

D. Vulnerability of fringe communities

19. Has your source of livelihood changed over the past 10-20 years? 1. Yes 2. No

20. How consistent has the change been?

1. Very consistent 2. Consistent 3. Not consistent 4. Don't know

21. To what extent has your livelihood been exposed to climate change?

Sources livelihood	Level of exposure			
	Very exposed	Exposed	Not exposed	Not sure
1.Decline in income				
2.Reduction in crop yield				
3.Spread of infectious disease				
4.Rural-Urban migration				
5.Increase in soil depletion				
6.Depletion of wildlife				
7.Increase in forest resources				
8.Increase in fertilizer use				
9.Decline in forest resources				
10.Drying up of rivers				
11.Decline in vegetation				

E. Impact of livelihood activities on ecosystem services

22. How dependent is your livelihood activity on the ecosystem services?

1. Very dependent 2. Dependent 3. Fairly dependent 4. Not dependent

23. How regularly do you use the services of the ecosystem?

1. Daily 2. Weekly 3. Monthly 4. Yearly 5. Others specify……..

24. Has your income from the use of the ecosystem changed? 1. Yes 2. No

25. Have the services declined in quantity and quality over the past 10-20 years? 1.Yes 2. No

26. Are there any regulations as to the use of these services? 1. Yes 2. No

27. If yes, from who or what authority? 1. Traditional authority 2. The State 3. NGO 4. Others specify……..

28. Are you aware that the following activities in question 29 being carried out by you contribute to the decline in the ecosystem services? 1. Yes 2. No

29. If yes, how severe?

Activity	Very severe	Severe	Not severe	Not sure
1.Land/bush clearing				
2.Cultivation technique				
3.Croping system				
4.Improper application of fertilizer				
5.Over exploitation of timber				
6.Indiscriminate hunting				
7.Collection and use of fuelwood				
8.Overgrazing				
9.Over use and abuse of river system				
10.Uncontrolled gathering of NTFPs				
11. Bush burning				
12.Mining				

F. Appropriate Adaptation strategies

30. Which adaptation strategy do you know?. ……..

31. How have you adjusted in your livelihood activities which have been impacted by climate change?.....

32. Which of the following adaptation strategies have you or will you adopt to cope with climate change impact on your livelihood? For each of the strategies state whether it has been able to or will reduce the impact.

Adaptation strategy	Strategy adopted-Yes/No	Did strategy help to reduce the impact? Yes/No	Give reasons why strategy was not adopted or able to reduce impact (use codes-1. Lack of knowledge 2.lack of finance 3. Did not believe in strategy 4. Did not have

			permanent land 5. Other specify…..
1.Irrigation use			
2.Crop diversification			
3.Change of planting date			
4.Tree planting			
5.Adoption of fertilizer usage			
6.Reduce livestock			
7.Reduce exploitation of timber			
8.Engage in handicraft activities			
9.Snail farming			
10.Grasscutter rearing			

33. How well has the adaptation strategy improved your standard of living as well as enhance the ecosystem services?

1. Very high 2. High 3. Low 4. Very low

34. What other intervention will help you improve your livelihood as well as enhance the ecosystem services in the face of climate change?.....

APPENDIX B

UNIVERSITY OF GHANA

CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

TOPIC: Adoption of EbA approach in the face of climate change: Improving livelihoods in fringe communities around the Worobong South Forest Reserve

FOCUS GROUP DISCUSSION

ISSUES FOR DISCUSSION

A. Ecosystem services provided by the WSFR and whether climate change or variability has affected the ecosystem services

1. What are the ecosystems services the forest offer?

2. What do you know about climate change?

3. What can you say about temperature and rainfall patterns in the area over the past 20-30 years?

5. How are temperature and rainfall affecting the availability of the ecosystem service derived from the WSFR?

B. Vulnerability assessment of fringe communities of WSFR to impact of climate change or variability

1. How dependent are your livelihood activities to the forest?

2. What do say are the threats to your livelihood activities in the face of temperature change and rainfall pattern?

C. Human activities that affects the ecosystem services of the WSFR

1. What activities in your view are affecting the forest and its services?

D. Propose the appropriate ecosystem-based adaptation (EbA) strategies

1. What interventions do you suggest should be adopted and implemented to improve your livelihood and enhance the ecosystem services?
2. How do we sustain these strategies?
3. Recommendations

APPENDIX C

UNIVERSITY OF GHANA

CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

TOPIC: Adoption of EbA approach in the face of climate change: Improving livelihoods in fringe communities around the Worobong South Forest Reserve

INTERVIEW GUIDE (FC OFFICIAL)

1. What forest management regime is being implemented in this ecological zone?
2. What challenges do you face in protecting the forest?
3. What threats are faced by the forest?
4. What measures or interventions have been implemented previously to restore the ecosystem?
5. How do you manage the livelihood activities of people from the fringe communities and your mandate to protect the forest?
6. What do you suggest can be done to improve the health of the ecosystem without denying the communities the benefits they derive from the forest?

APPENDIX D

UNIVERSITY OF GHANA

CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

***TOPIC*: Adoption of EbA approach in the face of climate change: Improving livelihoods in fringe communities around the Worobong South Forest Reserve**

INTERVIEW GUIDE (CHIEF)

1. What environmental challenge is your community confronted with?
2. What is the extent of the problem to peoples' livelihoods?
3. What intervention has the traditional authority taken to address the situation?
4. What can be done to address the situation?
5. Any recommendations?

APPENDIX E

UNIVERSITY OF GHANA

CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

TOPIC: Adoption of EbA approach in the face of climate change: Improving livelihoods in fringe communities around the Worobong South Forest Reserve

INTERVIEW GUIDE (District MOFA Officer)

1. What is the state of agriculture in this agro-ecological zone?
2. What are the statistics for key crop production in the area for the past 10-20 years?
3. What are the reasons for this type of output?
4. Is climate a factor?
5. If yes, how is it affected?
6. What intervention has been implemented?
7. What can be done to sustain agriculture in the area?
8. Any recommendations?