Livelihoods Support Programs, Conservation Attitudes, And Tropical Biodiversity: An Evaluation Of Biocomplexity In Southeastern Ghana

Edem Kodzo Ekpe
University of Central Florida

LIVELIHOODS SUPPORT PROGRAMS, CONSERVATION ATTITUDES, AND TROPICAL FOREST BIODIVERSITY: AN EVALUATION OF BIOCOMPLEXITY IN SOUTHEASTERN GHANA

by

EDEM KODZO EKPE
B.S. Kwame Nkrumah University of Science and Technology, Ghana, 1998
M.S. University of Kent, Canterbury, United Kingdom, 2004

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy
in the Department of Biology
in the College of Sciences
at the University of Central Florida
Orlando, Florida

Spring Term
2012

Major Professor: Charles Ross Hinkle

ABSTRACT

Human activities are a major driver of biodiversity degradation and loss, especially in tropical forest areas, where forest-fringe towns and villages depend on the forests for their livelihoods. In order to reduce threats that human activities pose to biodiversity, livelihoods support programs are employed as economic incentives for biodiversity conservation. These programs support the livelihoods activities of local communities, with the aim of triggering favorable attitudes and behaviors towards conservation, and ultimately reduce biodiversity degradation. Their effectiveness as conservation tools has not been evaluated. I investigated the effects of livelihoods programs on conservation attitudes and the consequent effects on biodiversity in the Afadjato-Agumatsa and Atewa forest areas in southeastern Ghana.

The study areas are coupled human and natural systems, which are excellent for research in the theoretical framework of biocomplexity in the environment. Using literature reviews and field visits, I documented the specific livelihoods support activities (LSAs) used for biodiversity conservation, their historical trend and geographical distribution in Ghana. I used ex-post cost-benefit analysis to determine socio-economic estimates of the LSAs in the two forest areas. Since communities were not randomly assigned to the interventions, I employed quasi-experimental design to evaluate the effects of LSAs on environmental attitudes. I evaluated the effect of conservation attitudes on biodiversity at two levels. These levels included 1) functional biodiversity at the landscape level represented by mean Normalized Difference Vegetation Index (NDVI) of forest; and 2) compositional biodiversity at the species level represented by species diversity of fruit bats.

The earliest record of LSAs used for biodiversity conservation in Ghana was in 1993. I identified 71 different activities belonging to eight categories. Some of these activities are beekeeping, animal husbandry, crop farming, and snail rearing. Most LSA programs have been in northern Ghana. There was an increasing tendency to make LSAs part of every conservation program in Ghana and this satisfies the current policy of collaborative conservation.

The socio-economic estimates of LSAs included: 1) capital investment; 2) net socio-economic benefits; and 3) the benefit-cost ratio. The per-community values of the three estimates were not different between the two study areas. The per capita values of capital investment and net economic benefit were not significantly different between the two study areas. However, benefit-cost ratio per capita was higher in Afadjato-Agumatsa than in Atewa. Estimates of economic returns from LSAs were marginal but the perceptions of success were relatively high.

Environmental attitudes in LSA communities and non-LSA communities were not significantly different, and this was confirmed by an estimate of infinitesimal effects of LSAs on forest conservation attitudes. Among LSA communities, benefit-cost ratio of LSAs predicted favorable forest conservation attitudes; and change in pro-conservation attitudes were significantly higher in communities that had active LSAs than in communities which had no active LSA.

Mean NDVI of the forests decreased from 1991 to 2000 and decreased further but at a slower rate to 2010. Higher forest conservation attitudes predicted higher mean NDVI in 2010. Higher change in mean NDVI from 1991 to 2000 predicted higher change in mean NDVI from 2000 to 2010. Eleven of the 13 fruit bat species in Ghana were recorded in the study areas. Longer *distances between a local community and its forest predicted higher species diversity of forest-specialist fruit bats.*

The results indicate that LSAs have become a major contribution to Ghana's current collaborative forest policy. The fact that perceptions of LSA success were moderate even though the economic returns from them were marginal suggest that other factors such as provision of employment, training in new skills and community cohesion played a part in how communities viewed the success as LSAs. Evaluations of conservation attitudes suggest that just participating in LSAs did not improve attitudes; but higher benefit-cost ratio predicted favorable conservation attitudes, and conservation attitudes were higher in communities that sustained their LSAs. Therefore, it may serve biodiversity conservation to invest in LSAs that can be sustained and involve the least costs to local communities. Primary production of the forests, a proxy for a functional habitat, continued to decrease. Preventing communities from locating closer to forests could improve fruit bat diversity, which contributes to natural forest regeneration. Improving conservation attitudes should be an objective of conservation at the landscape scale.

On the basis of the results, I developed a conceptual model for forest biodiversity conservation in a biocomplexity framework. This model could be useful for evaluating conservation in tropical forest areas. Lessons from this study can be applied in other incentive-based conservation programs such as payments for ecosystem services systems and carbon market schemes. I suggest that this study be repeated after a decade and that other socio-political and biogeochemical variables be integrated into future studies.

Dedication

I dedicate this work to my wife Elizabeth, and my children Eyram, Lebene, and Aseye.

ACKNOWLEDGMENTS

I could not have undertaken this study without the support, advice, and assistance of several people and institutions. I would like to thank my Academic Advisor, Dr. Ross Hinkle for his untiring support to my academic work especially towards this dissertation. I am very grateful to Dr. Martin Quigley of the University of Denver for all his support. My thanks to other members of my dissertation committee namely, Dr. John Weishampel, Dr. Betsy Von Holle, Dr. Walter Milon, Dr. Nizam Uddin, of the University of Central Florida, and Dr. Erasmus Owusu of the University of Ghana. To the Chiefs and People of Fodome Ahor, Gbledi, Wli in the Afadjato-Agumatsa area; and Akyem Abuakwa in the Atewa, I say thank you for giving me access to your communities to interact with you and collect data. I am grateful to the following institutions for providing resources for this dissertation: Department of Biology, University of Central Florida; Ghana Wildlife Society; International Tropical Timber Organization; International Foundation for Science; West African Research Association; Okyeman Environment Foundation; Begoro District of the Forest Services Division (Forestry Commission) of Ghana; Ghana Statistical Service; and Ghana Meteorological Agency. I cannot complete these acknowledgments without mentioning the support and assistance of the following in collecting data and writing up this dissertation: the group of field assistants Reuben Ottou, Samuel Adu, Eric Cudjoe, Fauster Akutse, Nana Adu, Frank Kofi Botchway, and Liz Becker. Thanks to my mum Lucy, my siblings Sylvester and Audrey for your encouragement and prayers. Many thanks to my wife Elizabeth and the children: Eyram, Lebene, and Aseye for the months you endured without me during data collection; and for your prayers and encouragement throughout my studies. To many others whom I did not mention, I thank you for your support in various forms.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

CBD:	Convention on Biological Diversity
CHAN:	Coupled Human and Natural Systems
DANIDA:	Danish Development Agency
DFID:	Department for International Development of the United Kingdom
EA:	Environmental Attitudes
FAO:	Food and Agriculture Organization of the United Nations
FCA:	Forest Conservation Attitudes
GIZ (formerly GTZ):	German Development Agency
GWS:	Ghana Wildlife Society
ICDP:	Integrated Conservation and Development Project
IGA:	Income Generating Activity
IUCN:	International Union for Conservation of Nature
JICA:	Japan International Cooperation Agency
LSA:	Livelihoods Support Activity
NDVI:	Normalized Difference Vegetation Index
NEP:	New Ecological Paradigm
NGO:	Non-Governmental Organization
SNV:	Netherlands Development Agency
UNDP:	United Nations Development Programme
USAID:	United States Agency for International Development
WB:	The World Bank

CHAPTER 1: GENERAL INTRODUCTION

1.1 Biodiversity, Biocomplexity and their Importance to Human Welfare

The importance of conserving biological diversity in all its forms for the purpose of sustaining life on the planet earth cannot be over-emphasized. There have been many efforts with varying strategies to conserve biodiversity in all its forms. Biodiversity is defined as the variability among living organisms from all sources including, among other things, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems (Convention on Biological Diversity 1993). By this definition, biodiversity involves the hierarchy of living organisms at genetic, species, ecosystem and landscape levels, and the natural functions that maintain them and their habitats (Noss 1983, Noss 1986). These functions are regularly modified by interactions with social, physical and other non-biological systems. Biocomplexity in the environment, a more inclusive term of these interactions was therefore proposed by Colwell (1999) to encourage interdisciplinary environmental research. The term biocomplexity was coined to characterize, among other phenomena, multiple levels of biological organization, interacting feedbacks and the non-linear behavior of coupled-human-and-natural (CHAN) systems through time (Covich 2000, Dybas 2001, Cottingham 2002, Pickett et al. 2005). The theory behind biocomplexity stems from the fact that there is an intricate interplay between organisms and their environment (Ecological Society of America 2002). Studying biodiversity in this context requires the attention of conservation biologists who integrate biology and other fields of study to protect biodiversity from extinction.

Biodiversity is often valued for its role in supporting different ecosystem services such as assimilation of waste, protection of watershed and mitigation of floods and droughts, purification of air and water, stabilization of microclimate, generation and renewal of soil and its fertility, pollination of crops and other vegetation, control of agricultural pests, dispersal of seeds, and transport of nutrients (Benhin and Barbier 2004) and provision of resources that directly support human livelihoods such as food, shelter and medicine.

1.2 Loss of Forest Biodiversity due to Resource Exploitation

Biodiversity is declining globally due to habitat degradation and loss, habitat fragmentation, species invasion and overexploitation (Groom et al. 2006). This decline is worsened by global climate change, increasing human populations and poverty especially in many forest-fringe communities in tropical regions. Globally, forests have been dwindling at an alarming rate. Between 1990 and 2000, the world's forests decreased by 8.9% (FAO 2005) and Africa lost 8.0% of its forests (Achard et al. 2002). During this period, Ghana, in West Africa lost 120,000 hectares (about 4.4%) of its forests (FAO 2005). Although from 2000 to 2005, net loss of forests globally and in Ghana has decreased, the decline in forest cover still continues. This results in habitat loss that may pose adverse implications for biodiversity in Ghana.

Ghana's forests are part of the Guinea Forests, a global biodiversity hotspot, about 70% of which has been lost due to centuries of human activities (Conservation International 2009). The forests in southeastern Ghana are an important component of this biodiversity hotspot because they are the only remaining "stepping stones" linking the Upper Guinea Forests and the Nigeria-Cameroon Forests, which together make up the Guinea Forests. Forests in the Afadjato-

Agumatsa Range and Atewa Range areas in southeastern Ghana form part of these, and their conservation is important for the biological integrity of the Guinea Forests

In many parts of Ghana, people depend on forests for their livelihoods through activities such as bushmeat hunting, fuelwood and charcoal production, wood-carving and canoe-carving, rattan production, chewstick gathering and timber production. Some forest products are consumed in the local areas and others are transported to market centers in nearby towns or to the cities and much timber is exported. These forests also serve as watersheds for many rivers that serve various communities including major towns and cities. However, very poor forest-fringe communities bear the largest cost of maintaining the forests and/or the opportunity cost of fully utilizing the forest resources for their needs and wants.

Direct threats to Ghana's tropical forests include logging, slash-and-burn agriculture, mining and quarrying, wildfires, conversion for settlements and other infrastructural developments (Richards 1995, Donkor and Vlosky 2003). To reduce the threats to forest conservation which have poverty as an underlying factor, conservation programs use economic incentives for biodiversity conservation.

1.3 Incentivising Biodiversity Conservation through Livelihoods Programs

Globally, economic incentives for biodiversity conservation include user fees, conservation easements, conservation banking, compensation programs, tax incentives (Defenders of Wildlife 2006), ecotourism, payments for ecological services (IUCN 2008) development interventions (Ferraro 2001), and income generating activities that may use local biological resources (Mcneely 1988). In Ghana, timber loggers pay forest fees, including royalties (Richards 1995), as economic incentives for forest-fringe communities to protect economic timber trees. Economic incentives for biodiversity conservation in Ghana include ecotourism, and other income generating activities (Owusu 2001, Owusu 2008), which are referred to as livelihoods support activities (LSAs) in this dissertation.

Ghana has a developing economy. Therefore, in defining the LSA concept, I considered two development approaches. The first development approach involves alleviating poverty and sustainably managing the environment; utilizing local customs, knowledge and natural resources, developing activities that exist outside the traditional or established system (Tropenbos International 2005). The second approach I considered was the Sustainable Livelihood Framework of the United Kingdom's Department for International Development's (DFID). It is a typology of assets which poor individuals, households and communities deploy to maintain well-being under changing conditions (Norton and Forster 2001). On the basis of these development approaches, I defined LSAs for biodiversity conservation as investment activities in resource-fringe villages and towns for individuals, households and communities to increase and diversify their incomes in order to maintain their well-being and ultimately to get their support for biodiversity conservation. The use of LSAs can be explained by the simplified model that increasing and diversifying income of participants will increase favorable conservation attitudes and behavior from them, and consequently reduce biodiversity degradation or loss (Figure 1.1). This model consists of economic, social and bio-physical components whose spatial and temporal dynamics present an excellent situation for investigating biocomplexity in the environment associated with coupled human and natural (CHAN) systems.

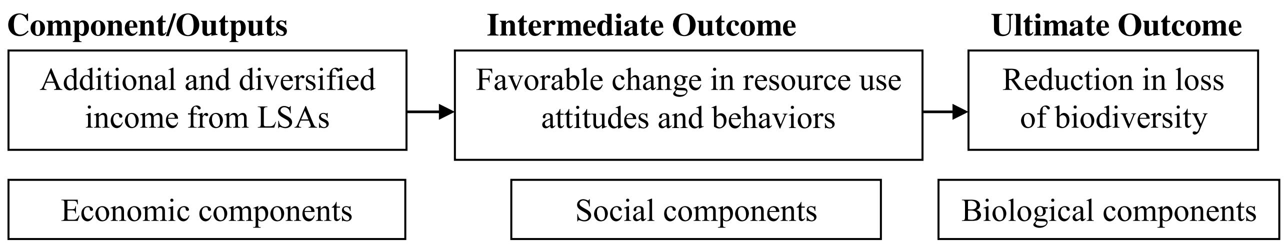


Figure 1.1: A simplified logic model of livelihoods support activities used for biodiversity conservation.

1.4 Problem Statement

The ultimate problem that this study attempted to address was whether the activities of livelihoods support programs are effective forest conservation tools. This requires assessing and evaluating the components of the simplified model (Figure 1.1) in their environmental context, which introduces methodological challenges. These components include the LSAs, conservation attitudes, and forest biodiversity.

1.4.1 The Need to Evaluate Livelihoods Programs used for Forest Biodiversity Conservation

Livelihoods support activities (LSAs) as tools for biodiversity conservation have been implemented on a pilot-basis in parts of Ghana including the Afadjato-Agumatsa and Atewa Ranges in southeastern Ghana since the 1990s. These activities are different from income generating activities which aim solely at reducing poverty, and do not have biodiversity conservation as their focus. Specific examples of the LSAs used for biodiversity conservation are beekeeping, animal husbandry, crop farming, and snail rearing. Although these LSAs are being promoted as economic incentives for biodiversity conservation in many parts of Ghana, evaluations of their effectiveness in reducing biodiversity loss is rare. Assessments of LSAs have been project specific for reporting to government, donors and other stakeholders. Empirical evaluations of effects of economic instruments on forests in Ghana have been focused on the timber values of the forests (Sargent et al. 1994, Richards 1995, Dadebo and Shinohara 1999). Other studies have assessed the potential of ecotourism for biodiversity conservation (e.g. Owusu 2001, Owusu 2008). Documentation of the historical trend, geographical distribution and experiences of LSA use in Ghana as well a rigorous evaluation of their use for biodiversity conservation in specific areas will be of great value to environmental policy in Ghana, and for other areas in West Africa.

1.4.2 The Need to Evaluate Intermediate and Ultimate Outcomes of Conservation Interventions

Evaluations of conservation interventions are often limited to the project and program outputs. These limitations are often due to the short-term nature of conservation interventions, high cost of rigorous evaluations and poor data collection (Ferraro and Pattanayak 2006), output-focus of development agencies and the short contract time given to evaluators. The measures evaluated are often limited to administrative outputs such as the amount of funds used, the number of activities, the number of tree seedlings planted, the number of participants and isolated reports of how beneficiaries expressed their benefits and challenges. Evaluating these measures is adequate for assessing project outputs, but inadequate for evaluating the intermediate outcomes of changes in people's conservation attitudes and behaviors as well as the ultimate outcomes: biodiversity conservation. Evaluating the intermediate and ultimate outcomes of conservation interventions is important for informing conservation policy and action.

1.4.3 Methodological Challenges in Evaluating Biodiversity Conservation Interventions

Conventional conservation project evaluations usually attribute differences between pre-intervention and post-intervention data to the effects of conservation interventions. These methods do not adequately control for plausible rival hypotheses. One reason for the inadequacy is that the conservation or evaluation units are not randomly assigned to interventions, thus not eliminating systemic bias (Ferraro and Pattanayak 2006). Apart from inadequate capacities, project managers are required to focus on activities and output requirements of donors and they are not able to collect relevant data for rigorous evaluations. Other demographic and biophysical factors such as population changes and proximity to markets confound biodiversity conservation systems. These issues present methodological challenges, which could be addressed by employing research designs and analyses used in program evaluation practice and other fields such as education, public health, and pharmacology.

1.5 Aim, Objectives and Hypotheses

I investigated the effects of LSAs on environmental attitudes and subsequently on forest biodiversity in the Afadjato-Agumatsa Range and Atewa Range forest areas in southeastern Ghana. Primary productivity of tropical forest habitat and fruit bat diversity were used as proxies for forest biodiversity. The interventions or treatments were LSAs and the research units were the forests and the human settlements (towns and villages) located on the fringes of the forests. The aim of the study was to answer the counterfactual evaluation question: *what would have happened to the forest biodiversity in the study areas if the LSAs had not been implemented*? The difference between the counterfactual and the observed is the effect of the LSA. The specific objectives of the study and brief explanations are presented as follows.

1. Document the specific LSAs used for biodiversity conservation in Ghana. This objective was important because no consolidated information on the issue in Ghana existed.
2. Evaluate the socio-economic estimates of LSAs (capital investments, net socio-economic benefits or costs, and the benefit-cost ratios) in the Afadjato-Agumatsa and Atewa areas.
3. Evaluate the effects of LSAs on environmental attitudes in the Afadjato-Agumatsa and Atewa areas. I hypothesized that LSAs would increase environmental attitudes.
4. Evaluate the effects of the environmental attitudes on forest biodiversity in the Afadjato-Agumatsa and Atewa forest areas. I hypothesized that positive environmental attitudes would improve forest biodiversity.
5. Develop a conceptual model in a biocomplexity framework for the conservation of forest biodiversity in southeastern Ghana. The conceptual model was developed on the basis of objectives 1 to 4 above.

1.6 Theoretical Framework of Dissertation

The objectives described above were investigated in coupled-human-and-natural (CHAN) systems, which are inherent with complexities. Biocomplexity in the environment is therefore an appropriate theoretical framework. It is a relatively new biodiversity research framework. A few studies of CHAN systems that employ biocomplexity models include Monticino et al. 2005, Moreno et al. 2006, Walsh et al. 2008 and Lassoie and Sherman 2010.

I undertook this study in the framework of biocomplexity in the environment and integrated many factors that are perceived to affect conservation attitudes and tropical forest biodiversity. Conservation of forest biodiversity in Ghana can be perceived from many perspectives such as ecological, economic, social, geological, historical, hydrological and other components, which are equally important from a scientific viewpoint. Among these, the ecological, social and economic components are major forest management policy perspectives for a developing country like Ghana. This study integrates policy and scientific study and so focuses on these three components.

On the basis of the biocomplexity framework proposed by Picket et al. (2005), the theoretical framework of this study is an integration of social, economic and ecological components of forest biodiversity conservation in spatial, temporal and organizational dimensions. Socio-economic values of LSAs represent the economic component; estimates of environmental attitudes represent the social component; and estimates of forest biodiversity represent the ecological component. These provided a theoretical framework that helped to fill knowledge gaps in conservation biology by evaluating effects of social investments on biodiversity conservation, and by testing the application of the concept of biocomplexity for forest biodiversity conservation in Ghana.

1.7 Presentation Outline of Dissertation

This dissertation has eight chapters. In the first chapter (this chapter), I presented a general background information, a general review of the main issues, the scope and objectives of the study. In chapter 2, I discussed an overview of forest management in Ghana. I described the study areas and the research design including a general methodology of the study in chapter 3. In chapter 4, I presented a detailed overview of the use of LSAs for biodiversity conservation in Ghana. It is a documentation of the specific LSAs used in Ghana, their historical trend, and their geographical distribution through a collation and description of relevant details of their implementation. This addressed the first objective of the dissertation. Chapter 5 is a socio-economic evaluation using cost-benefit analysis of the LSAs implemented in communities in the two study areas. It outlined various socio-economic estimates of LSAs. This addressed the second objective of this dissertation. In chapter 6, I evaluated the effects of LSAs on environmental attitudes in communities in the two study areas. This chapter addressed the third objective of this study. In chapter 7, I addressed the fourth objective of this study by investigating and presenting the dynamics of the effects of environmental attitudes on forest biodiversity. In chapter 8, I addressed the fifth objective of this study by developing a conceptual model of biocomplexity in the environment for forest conservation in southeastern Ghana. I concluded this dissertation by discussing the implications of the study, challenges to the study and recommendations for future research that would enhance conservation research in a biocomplexity framework. Chapters 4 to 8 of this dissertation have been presented in the format of research articles submitted for publication in to the journal Conservation Biology, a peer-reviewed journal but all literature citations are combined at the end of the dissertation.

CHAPTER 2: FOREST MANAGEMENT IN GHANA

2.1 An Overview of Ghana

Ghana is located in West Africa (Figure 2.1) and between latitudes 4^o and 11.5^o N and longitudes 3° 15' W and 1° 12' E. It is bordered by Togo on the east, La Côte D'Ivoire on the west, Burkina Faso on the north and the Atlantic Ocean on the south. Ghana's coastline is about 540km long. The total area of the country is about 238,533 km^2 made up of 227,533 km^2 of land and 11,000 km^2 of water (CIA 2009).

Ghana has a tropical climate, with two rainy seasons occurring in the south from April to July and from September to November and one rainy season in the north from April to September. Annual rainfall ranges from about 1,100 mm in the north to about 2,100 mm in the southwest. Mean temperature is between 25-27°C with the highest annual mean maximum of 34°C in the extreme north and least mean maximum of 29-30°C on the coast (Ghana Meteorological Services Department 2009). The natural vegetation cover and distribution over many areas of Ghana is closely related to the distribution of mean annual rainfall (Ntiamoa-Baidu et al. 2001). These ecological zones include a high forest and deciduous forest zones, a transitional zone to their north, a coastal savannah in the southernmost parts and a northern savannah in the north (Figure 2.1). The northern savanna has the largest area and the lowest mean annual rainfall and occurs in the northern part of Ghana. Ghana's economy is largely agrarian, employing about 56% of the working population (Ghana Statistical Service 2008). Land use includes crop farming, forestry, wood fuel, cattle grazing, urbanization, tree plantations of exotic and indigenous species such as cocoa, rubber, timber, and protected areas.

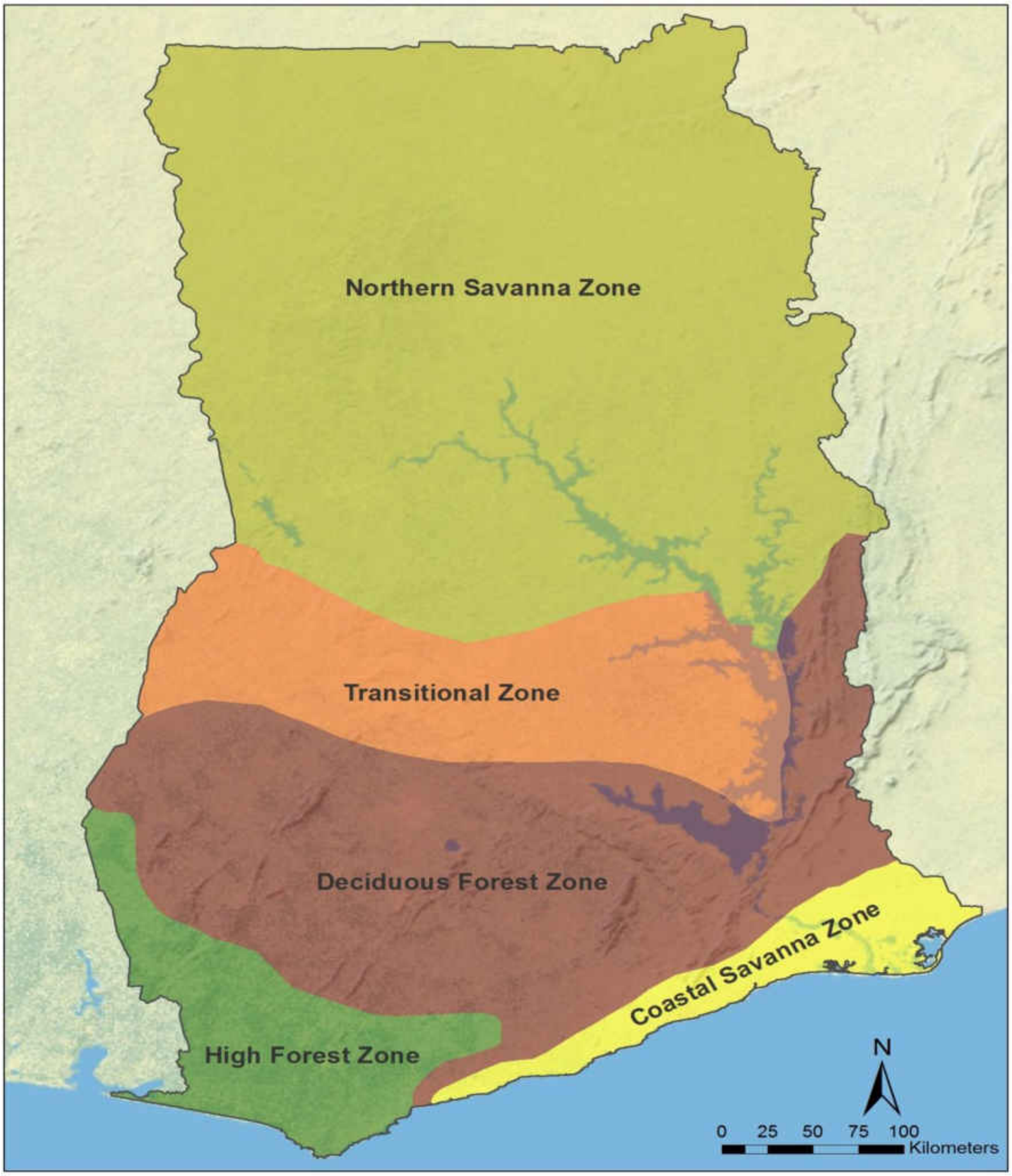


Figure 2.1: Map showing the location of the study areas in Ghana, West Africa.

2.2 The Forests of Ghana

Most of Ghana's forests are located in the southwestern parts of the country and a few in the southeast. The forests of Ghana are classified into wet evergreen, moist evergreen, moist semi-deciduous, dry semi-deciduous, upland evergreen and the southeast outliers (Hall and Swaine 1976). The wet evergreen, moist evergreen and upland evergreen are collectively called the high forest zone. The deciduous forests are largely located in the central, southern and eastern parts of the country, where this study is focused.

Within the high forest zone, 1.76 million hectares (21%) are permanently protected (Hawthorne and Abu-Juam 1995). Human settlements and agriculture are not legally permitted within most reserves but in some reserves, certain lands were designated as admitted farms at the time the reserves were legally established. Agroforestry is practiced within some reserves as part of the *Taungya* system of plantation under the supervision of the government agency (Forestry Commission of Ghana 2009). Some restricted forest areas are currently human settlements and farms of substantial sizes. About 126,600 hectares in forest reserves are under the jurisdiction of the Wildlife Division as wildlife protected areas (Forestry Commission of Ghana 2009). About 21,500 hectares is used for research and education (Ministry of Lands and Forestry of Ghana 2004). Other forests are in sacred groves, other culturally significant areas and community reserves, farmlands and fallow areas. Legal logging takes place within timber contract areas, in both reserves and off-reserve areas (Forestry Commission of Ghana 2009).

The focus of forest management research has been greatly influenced by the evolution of forest management policy in Ghana. Until the late 1980s forest research in Ghana had been very much focused on timber species of economic value. Reducing forest cover, as well as global forestry and biodiversity conservation trends resulted in expansion of forest research into biodiversity, social and economic issues. This is supported by the fact that forest conservation includes the explicit involvement of individuals and groups such as traditional land-holding authorities, forest fringe communities, farmers, the state and its forest sector agencies, the timber industry (Kotey et al. 1998) as well as civil society groups who have rights, interests and impacts on forests. I present a historical perspective of forest management policy in Ghana beginning before colonization of the country by the British Empire.

2.3 A Historical Perspective of Forest Management Policy in Ghana

The history of a people is very much based on their environment. Historical and cultural evidence such as the regalia of chiefs, totems, traditional festivals and other practices in Ghana indicate that the lives of people of the present day Ghana have been intricate with the forests for centuries. According to Kotey et al. (1998), the current forest management policy of collaborative management has evolved through three main phases, namely the consultative phase, the "timberization" phase, the 'diktat' phase, before the current policy of collaboration with communities, which Kotey et al. (1998) term as the collaborative phase (Figure 2.2). Preceding the first three phases was the phase I denoted as the pre-colonial phase.

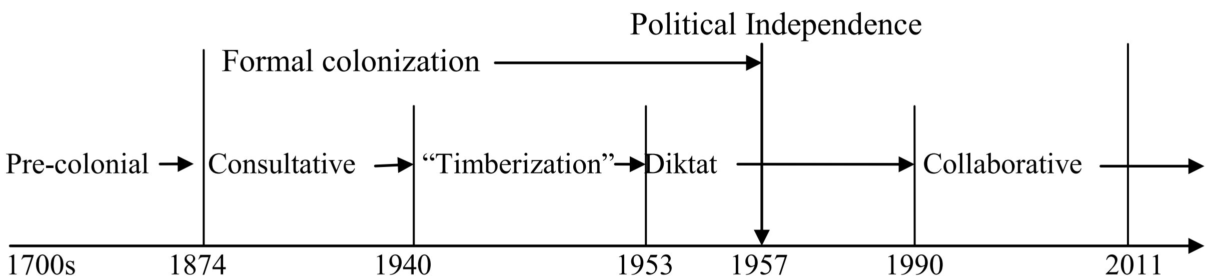


Figure 2.2: Historical summary of forest management policy in Ghana (Not drawn to scale).

The main policy issues involved forest management driven by varied foci such as land protection for agriculture, timber protection and later for biodiversity conservation. Other factors such as changes in political ideologies and paradigms and increasing human populations also affected the changes in forest management policy in Ghana as summarized in (Table 2.1).

Table 2.1: Historical phases of forest management policy in Ghana.

#	Historical phase	Key forest management policy strategies
1	Pre-colonial (before 1874)	Traditional tribes' land tenure systems Very low commercial forest exploitation
2	Consultative (1874 to 1940)	Formal forestry and commercial timber trade started Colonial government managed forest through chiefs
3	"Timberization" (1940 to 1953)	Commercial timber production dominant National interest emphasized
4	Diktat (1953 to 1990)	Statist ideology reduced role of traditional chiefs Timber production for national development
5	Collaborative (from 1990 to date)	Collaboration with communities emphasized Forest management integrates biodiversity

2.3.1 The Pre-colonial Phase

During the pre-colonial phase, forests were largely managed for subsistence use of natural resources such as poles, timber, fuelwood, medicinal plants, game, for sacred ancestral heritage, and for protection of water bodies. Commercial exploitation for timber was at a very low level. Forest management depended on the land tenure system in each traditional area. In many areas the forest lands were administered by the traditional chiefs, who held the land in trust for their people. In some areas, some lands belong to families or clans while others belong to the traditional area. Chiefs and clan heads therefore managed the forest resources separately. Apart from timber and mineral resources, other forest products were treated as common resources and used for subsistence. Forest biodiversity was protected using traditional systems of closed seasons when hunting is not allowed, superstitious beliefs and traditional laws (Owusu 2001) and full protection as sacred groves (Dorm-Adzobu et al. 1991, Ntiamoa-Baidu et al. 1992). In some forest areas, ther are days of the week on which no one is permitted to go into the forest or to farm. Some of the sacred groves were burial grounds of very prominent members of tribes (Owusu 2001), and some were battlegrounds which had important historical and cultural values for certain tribes (Dorm-Adzobu et al. 1991, Ntiamoa-Baidu et al. 1992). Within the forests, certain tree or animal species were protected by taboos (Ntiamoa-Baidu 1991). An example is the protection of mona monkeys (*Cercopithecus mona*) in Boabeng-Fiema area in the Brong-Ahafo Region of Ghana since 1831 (Asamoa 1990).

2.3.2 The Consultative Phase

The consultative phase (1874 to 1939) was the period from the formal introduction of colonial rule to the outbreak of World War II (Kotey et al. 1998). This formal introduction was prompted by reports of destruction of tropical forests in the British colony from the botanist of the colonial government (Owusu 2001). Formal forestry, commercial timber trade, introduction and rapid expansion of cocoa production, establishment of the Forestry Department and of some forest reserves across the high forest zone started during this period. The forest reserves were aimed at protecting watersheds and maintaining climatic and soil quality for production of cocoa because the varieties of cocoa produced then required shade for maximum production. The colonial policy of indirect rule through traditional authorities strengthened the role of the Chief, as the main vehicle of local government. Earlier attempts by the colonial authorities to nationalize forest lands failed due to effective use of the judicial courts by the traditional landowners. Therefore, landholding chiefs and local communities were consulted and involved in the process of forest reservation. The rights of communities in forest reserves, including access to harvest non-timber forest products, were "admitted". In timber trade, chiefs negotiated concession agreements with loggers (Ibid.). During this period, laws regarding game management were initiated by the colonial government in 1901 (Asibey 1971). These stemmed from the 1900 London Convention which obliged all colonial governments to manage game within colonies in Africa (Ntiamoa-Baidu et al., 2001). Even though there was no government department explicitly responsible for wildlife management, these resulted in the establishment of the first game reserves in 1909 and later 1928 (Owusu 2001).

2.3.3 The "Timberization" Phase

During the "timberization" phase (1940 to 1953), timber production was the dominant concern in forestry policy (Kotey et al. 1998). Cocoa production continued to be a major consideration with minimal emphasis on environmental concerns as well as non-timber forest products management. . National interests began to be emphasized at the expense of the local community because of the political issues of that period such as the World War II and Ghana's independence movement. The colonial government and local politicians used an authoritarian approach to forest management. The influence of foresters and timber merchants grew, while the landholding chiefs' influence declined and local communities began to be marginalized in forest management. The first formal forest policy of 1948 established forestry as a technical exercise, to be carried out without dealing with local communities. During this period, elected district councils were created (Kotey et al. 1998) as part of the introduction of western political governance system during the political struggle for the establishment of an independent nation. These changes in political structures reduced the power of traditional chiefs and so divorced landholding chiefs from forestry and land use decisions.

2.3.4 The "Diktat" Phase

During the "diktat" phase (1954 to the early 1990s), the post-independence government, which started in 1957, reduced the role of the chiefs and traditional authorities in development because of its statist ideology. In 1962, the government took formal control of land and trees - "in trust" for the chiefs and people. "Indigenization" policy in the mid 1960s turned the timber industry from being controlled by a small number of foreign "merchant princes" into a large number of local companies. The notion was that the timber industry could be a driving force for national development and kept royalty levels low as a result and timber traders began to log in off-reserve areas. Protected Timber Lands were introduced to prevent conversion of standing forest into farmland, at least before the timber could be removed. This resulted in mutual mistrust between government agencies and local communities. The Wildlife Department was established in this period – in 1965 (Forestry Commission 2009) and Ghana's first wildlife policy was adopted in 1974. Later, macro-economic reforms in the 1980s eroded social services, deepened rural poverty and resulted in large scale settlements in forest areas and the consequent degradation of the forests and its wildlife resources. In this situation, the Forestry Department and Wildlife Department were ill-equipped to cope and the landholding authorities and local communities were marginalized and alienated (Kotey et al. 1998).

2.3.5 The Collaborative Phase

The collaborative phase started in the early 1990s following the perception of a crisis in forest management and a period of studies and reappraisals in the late 1980s (Kotey et al. 1998). Increasing demand for agricultural land, technological advances, growing importance assigned to the forests as genetic resources, increasing value and concerns for biodiversity, institutional changes as well as the international paradigm shifts in forest management (Owusu 2001) contributed to the initiation of this phase. The 1948 Forest Policy and the 1974 Wildlife policy could not address these new challenges. The Government of Ghana then promoted policy strategies towards collaborative forest management. Other policy changes included: reduction in the annual allowable cut of timber; temporary bans on the export of round logs; improved collection of royalties and promotion of tertiary processing of timber. Forest protection began to include non-timber resources such as riparian strips and non-logging areas. After consultations among stakeholders from 1989, a new Forest and Wildlife Policy was promulgated in 1994 (Forestry Commission of Ghana 2009). This policy created a framework for sustainable forest resource management, participatory management and multiple-use values. This policy re-set the balance of forest management rights and responsibilities, to stronger environmental and social commitments; improved landholder and farmer rights over trees; and biodiversity conservation. In 2008, the Government of Ghana initiated a Natural Resource and Environmental Governance (NREG) program (Forestry Commission of Ghana 2009). Among other things, the aims and activities of NREG are focused on financing of the forest and wildlife sectors and effective forest law enforcement, management, and transparency; addressing social issues in forest communities; mainstreaming environment into national development and growth; and developing a climate change strategy (World Bank 2009). Forest certification processes are also being undertaken in Ghana, with the support of government agencies, timber trade organizations, landowners, civil society groups and international organizations. All these policy actions have made biodiversity conservation an integral part of current forest management in Ghana.

CHAPTER 3: STUDY AREAS AND GENERAL RESEARCH DESIGN

3.1 The Study Areas

The study was undertaken in Ghana, and more specifically the forests and the human settlements of Afadjato-Agumatsa Range and Atewa Range areas. A total of 40 communities were selected for the study. Of this, eight are located in the Afadjato-Agumatsa Range area and 32 are in the Atewa Range area. Four communities in the Afadjato-Agumatsa area participated in livelihoods support activities (LSAs) and four did not participate in LSAs. Sixteen communities in Atewa of the participated in LSAs and the other 16 did not participate in LSAs (Figure 3.1).

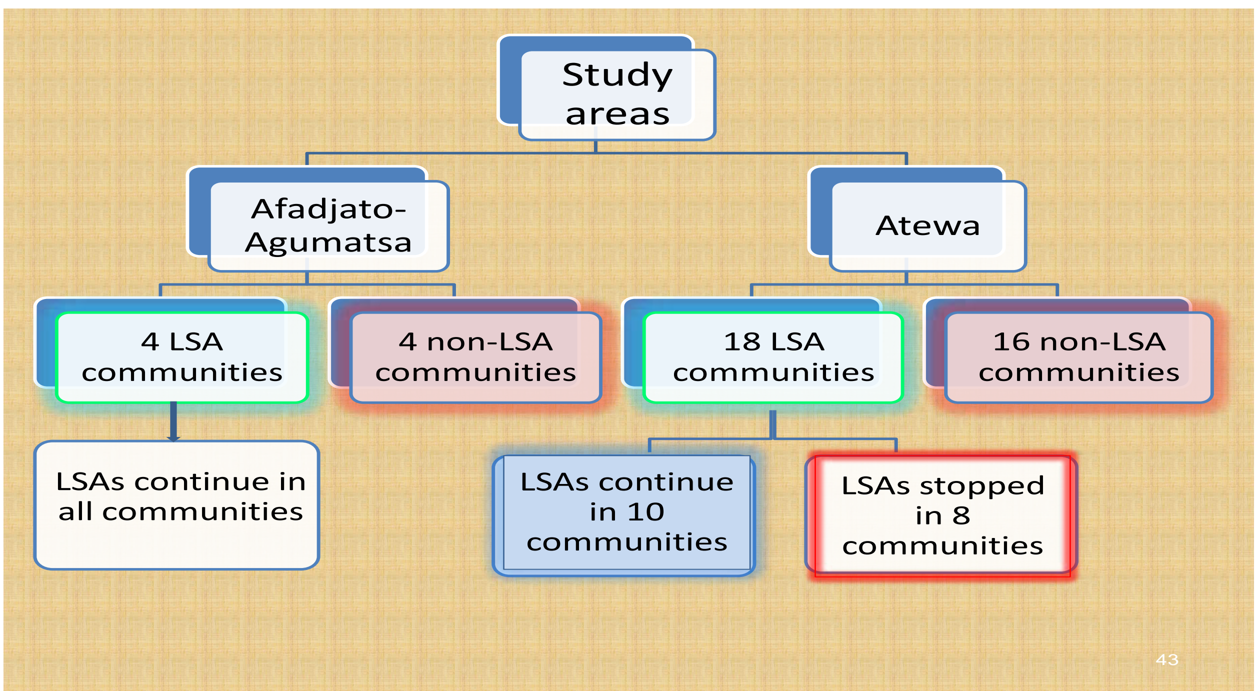


Figure 3.1: A schematic diagram of the communities studied in the study areas, showing the number of participating and non-participating communities in livelihood support activities (LSAs).

3.1.1 A Brief Description of the Afadjato-Agumatsa Range Area

The Afadjato-Agumatsa Range area is located in the Hohoe District, south-east of the town of Hohoe in the Volta Region of Ghana. The central coordinates are 0^{o} 34' East 7^{o} 1' North. It is part of the Akwapim-Togo Range, which is aligned north-east to south-west between the Volta River and Ghana's international border with Togo. Afadjato, at about 885m above sea level, is the highest mountain in Ghana. The forests referred to in this dissertation include parts of the mountain range which falls within Gbledi, Fodome, Liati and Wli Traditional Areas. There are 11 communities surrounding an area of about $20km^2$. Mount Afadjato and the adjoining Agumatsa Ranges lie within the Dry Semi-Deciduous Forest zone, but include some well-developed patches of Guinea Savanna. The western slopes of the hills support semi-deciduous forest, parts of which are disturbed, but the steeper eastern sides are dominated by wooded savanna. Along the upper slopes of Afadjato, closed-canopy forest persists until within 20m of the peak. Forest vegetation then gives way to wooded savanna at the summit at many parts (BirdLife International 2008). Of the 11 communities that live around these forests, eight are included in the study (Table 3.1). In the Afadjato-Agumatsa Range area the LSAs were implemented by Ghana Wildlife Society since 1999 as part of the Afadjato-Agumatsa Community Forest Conservation Project. The project was funded by the Dutch government in the Gbledi Traditional Area and Fodome Ahor Community from 1998, with formal funding ending in 2008 (Ghana Wildlife Society 2009). Other communities near the range are in Liati-Wote and Wli Traditional Area. These communities are largely small rural villages where the main occupation is subsistence crop farming. The specific names and their locations are shown in Figure 3.2.

Table 3.1: Communities surveyed in the Afadjato-Agumatsa area.

#	Community	GPS Position	Elevation (m)	Population in 2000	Population in 2010**	LSA***
1	Fodome Ahor	N7° 05.124′ E0° 33.702′	211	601	727	Yes
2	Fodome Ando 2	N7° 05.900′ E0° 34.494′	217	129	156	No
3	Gbledi-Agumatsa	N7° 04.234′ E0° 36.093′	730	355	430	Yes
4	Gbledi-Chebi	N7° 03.408′ E0° 34.155′	266	857	1,036	Yes
5	Gbledi-Gborgame	N7° 02.059′ E0° 33.790′	276	934	1,129	Yes
6	Gbledi-Torglo	N7° 02.046′ E0° 35.517′	744	284	343	No
7	Wli Afegame & Agorviefe*	N7° 06.943′ E0° 35.160′	235	2,528	3,057	No
8	Wli Todzi	N7° 05.381′ E0° 36.460′	675	916	1,108	No

** Wli Afegame and Agorviefe were combined as one community because they have merged.*

*** Population data for 2010 was a projected population from the 2000 Population Census at a regional growth rate of 1.9% increase per annum (Ghana Statistical Service, 2010).*

****LSA column indicates whether livelihoods support activities were implemented or not.*

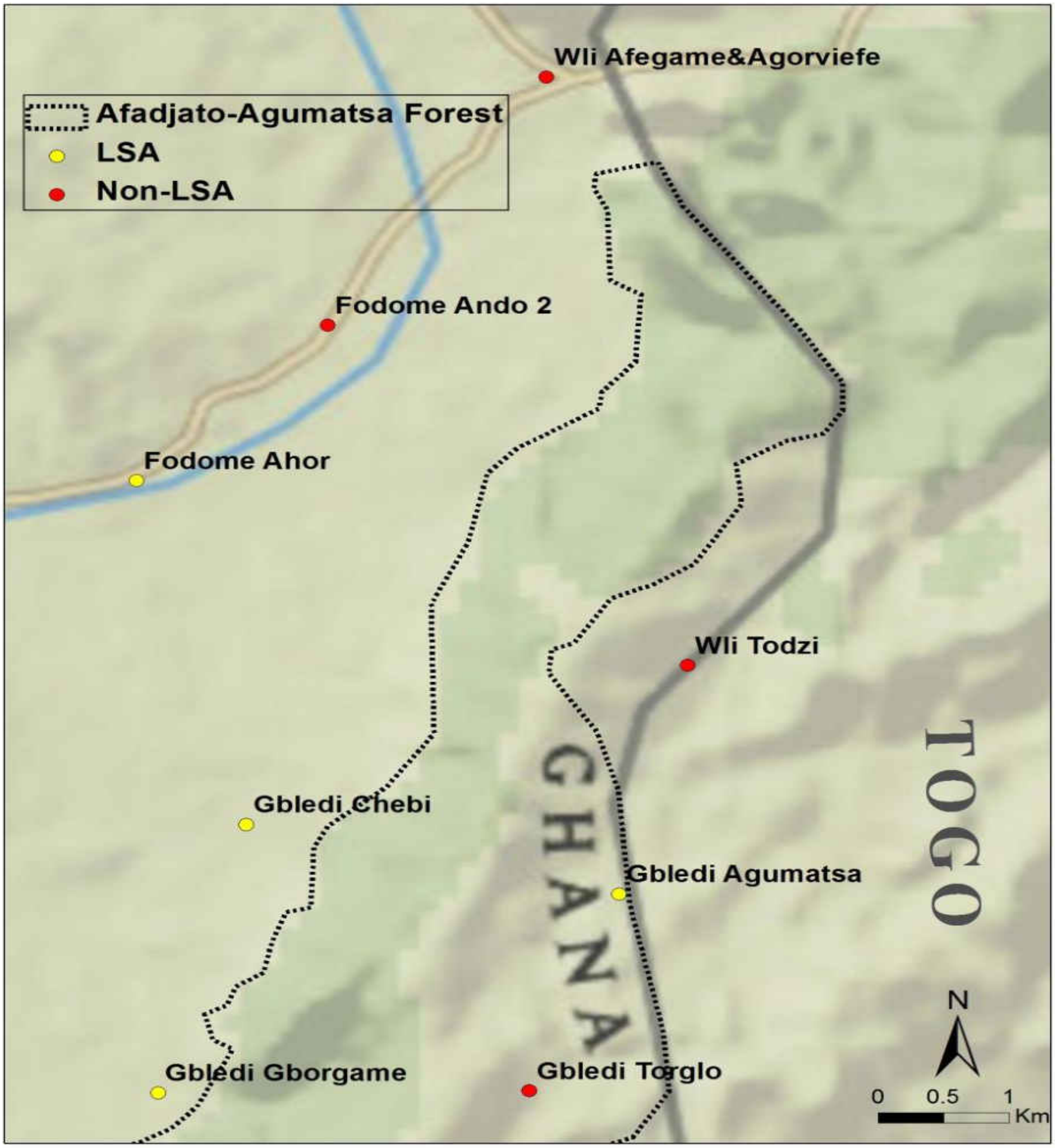


Figure 3.2: Map of Afadjato-Agumatsa area showing the study communities. Communities that participated in livelihoods support activities (LSAs) are marked yellow and non-LSA communities are marked red.

3.1.2 A Brief Description of the Atewa Range Forest Area

The Atewa Range Forest area is located near Kyebi, in the Eastern Region of Ghana. The area studied in this dissertation is actually the Atewa Range and Atewa Extension forest reserves (Forestry Commission 2001). The two reserves form a contiguous forest and referred to as Atewa Range located within the Akyem Abuakwa Traditional Area. The central coordinates are 0^{o} 36' W 6^{o} 10'N and the total area is $236.65km^2$ (McCullough et al. 2007). It is a range of hills, aligned approximately north-south, with steep sides and plateaus and largely characterized by very ancient bauxite soils. It lies within the moist semi-deciduous forest zone of Ghana. Atewa Range is, one of only two forest reserves in Ghana, in which the upland evergreen forest type occurs (Ntiamoa-Baidu et al 2001) and it covers about 75% of upland evergreen forests in Ghana (McCullough et al. 2007). The diverse flora contains submontane elements, with characteristic herbaceous species, and abundant and diverse epiphytic and terrestrial ferns; many plant species found here are not known to occur elsewhere in Ghana. Atewa provides the headwaters of three river systems, the Ayensu River, the Densu River and the Birim River, which are the most important source of domestic and industrial water for many rural communities and major population centers, including parts of Accra, the capital of Ghana. Over 200 communities are located on the fringes of the Atewa Range. In the Atewa Range area, LSAs were implemented as part of the High Forest Biodiversity Conservation Project funded by the World Bank/Global Environment Facility and the Government of Ghana from 2002. This study was undertaken in 16 LSA communities and 16 non-LSA communities (Table 3.2 and Figure 3.3).

Table 3.2: Communities surveyed in the Atewa Range area.

#	Community	GPS Position	Elevation (m)	Population in 2000	Population in 2010*	LSA**
1	Abesim	N6° 13.357′ W0° 37.422′	225	66	76	No
2	Adadientem	N6° 10.039′ W0° 34.584′	335	598	688	Yes
3	Adukrom	N6° 13.034′ W0° 31.509′	302	1,042	1,199	No
4	Afiesa	N6° 09.442′ W0° 35.495′	345	212	244	No
5	Ahwenease	N6° 09.735′ W0° 35.198′	343	688	791	Yes
6	Akanteng	N6° 00.871′ W0° 41.584′	208	3,595	4,134	No
7	Akropong	N6° 11.748′ W0° 39.401′	199	2,126	2,445	Yes
8	Akwadum	N6° 07.637′ W0° 34.055′	339	858	987	Yes
9	Akyeansa	N6° 01.749′ W0° 33.403′	219	1,243	1,430	No
10	Apampatia	N6° 16.154′ W0° 36.596′	243	656	755	No
11	Apapam	N6° 08.870′ W0° 35.798′	367	2,737	3,148	Yes
12	Asiakwa	N6° 15.538′ W0° 30.324′	257	3,773	4,340	Yes
13	Asikam	N6° 11.517′ W0° 32.264′	287	3,912	4,500	Yes
14	Awenare	N6° 16.154′ W0° 37.452′	216	1,436	1,652	No
15	Banso	N6° 14.671′ W0° 37.631′	207	1,425	1,639	No
16	Bomaa	N6° 17.269′ W0° 35.317′	253	1,895	2,180	No
17	Dokyi	N6° 08.651′ W0° 39.299′	269	826	950	Yes
18	Dompim	N6° 10.425′ W0° 38.213′	233	694	798	Yes
19	Dwafoakwa	N5° 54.430′ W0° 42.059′	170	609	701	No
20	Dwenease	N6° 05.654′ W0° 41.736′	219	323	372	Yes
21	Kobriso	N6° 01.774′ W0° 40.661′	209	1,614	1,857	No
22	Kwakusae	N5° 56.055′ W0° 37.656′	159	1,006	1,157	No
23	Kwesikomfo	N6° 04.006′ W0° 33.013′	259	234	269	Yes
24	Larbikrom	N6° 10.214′ W0° 37.348′	246	518	596	Yes
25	Mpeasem	N6° 07.967′ W0° 40.502′	222	366	421	No
26	Osafo	N6° 07.667′ W0° 39.663′	244	2,268	2,609	Yes
27	Pameng	N6° 12.547′ W0° 37.427′	224	182	209	No
28	Pano	N6° 10.847′ W0° 32.697′	321	1,134	1,304	Yes
29	Pinamang	N6° 04.966′ W0° 41.747′	189	526	605	No
30	Potroase	N6° 06.546′ W0° 33.775′	285	1,529	1,759	Yes
31	Sagyimase	N6° 14.167′ W0° 31.181′	305	1,580	1,817	Yes
32	Takyiman	N6° 09.891′ W0° 40.053′	239	3,291	3,786	No

** Population data for 2010 was a projected population from the 2000 Population Census at a regional growth rate of 1.4% increase per annum (Ghana Statistical Service 2010).*

***LSA means livelihoods support activities. Yes = LSA community. No = non-LSA community*

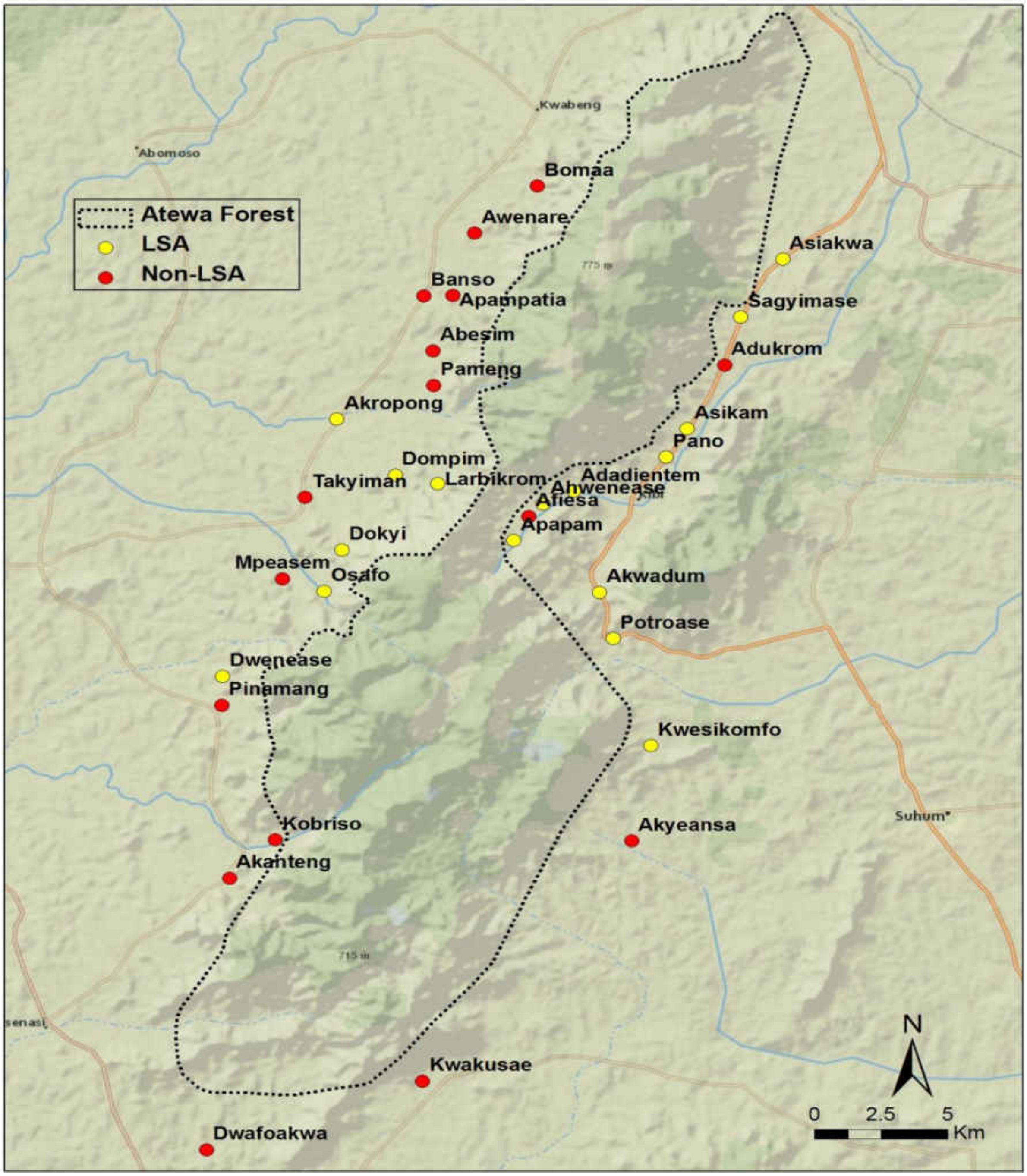


Figure 3.3: Map of Atewa Range Area showing the study communities. Communities that participated in livelihoods support activities (LSAs) are marked yellow and non-LSA communities are marked red.

3.1.3 Criteria for Selection of Study Areas

The Afadjato-Agumatsa Range and Atewa Range Forests were selected for the study for the following specific reasons.

1. They have forests at almost the entire range of elevations in Ghana, thus presenting good sites for including the physical dimensions of biocomplexity into the study. Afadjato-Agumatsa Range has forests at elevations from 200m to 885m above sea level and Atewa Range has forests from 100m to 700m above sea level. This improved the generalization or external validity of the results of this study.
2. Atewa Range is government-managed with support from the traditional authorities while Afadjato-Agumatsa Range is managed by the communities and a non-governmental organization. The different management regimes improved the external validity of the study for forest management strategies used in Ghana and in the tropics at large.
3. Some communities living on the fringes of both forests have been participating in LSAs for biodiversity conservation since the early 2000s. Therefore they provided about a decade's experience in using LSAs as economic instruments for biodiversity conservation. Any lagged effect on the conservation attitudes and the forests would presumably be evident after a decade.
4. In both areas, not all communities had participated in LSAs. This made it possible to compare participating communities to non-participating communities.
5. Logging has been prohibited from both sites since the late 1990s. As a result, any illegal timber logging can be assumed to be due to resource exploitation by the local communities or with their connivance.

6. Comprehensive biodiversity and socio-economic data before the implementation of LSAs were available at both sites.

7. Atewa Range is fairly large ($236km^2$) and Afadjato-Agumatsa is relatively small ($20km^2$). The impacts of LSAs and environmental attitudes on small and large forests could be compared.

8. The two forests are located in the southeastern parts of Ghana, where there is a very high population density. The capital of Ghana, Accra and, the port city of Tema, two regional capitals, other major towns and many other towns and villages are located in this part of the country. These forests are therefore under a lot of resource exploitation pressure.

9. The land tenure systems in the two study areas are different. In the Afadjato-Agumatsa area, land is owned by family or clans, with very little ownership and inheritance rights to the chiefs, although they adjudicate local land disputes. In the Atewa area, some of the lands are owned by families and clans but the chiefs have substantial ownership and consequently inheritance rights.

10. Both forests are of international conservation importance because they are recognized as Important Bird Areas (IBAs) by BirdLife International. IBAs are conservation sites for that are small enough to be conserved in their entirety and often already part of a protected-area network. IBAs are selected based on one or more of the following criteria:
    i. They hold significant numbers of one or more globally threatened bird species.
    ii. They are one of a set of sites that together hold a suite of restricted-range species or biome-restricted species of birds.
    iii. They have exceptionally large numbers of migratory or congregatory bird species.

3.2 General Research Design

In this section, I present details of the research design which involes a logic model, evaluation research as applied in other fields; and how this dissertation complied with research ethics.

3.2.1 The Logic Model of the Research Design

This study was a summative outcome evaluation research (Trochim 2006) because I investigated whether a program caused demonstrable effects on specifically defined target outcomes. In evaluation research, these effects are measured by estimating the difference between the unobserved counterfactual and the observed outcomes (Baker 2000). The counterfactual is what would have happened if the intervention had not been implemented. The logic design of this study (Figure 3.3) shows that LSAs are expected to increase income sources and net incomes, which will reduce dependence on natural resources and improve conservation behaviors and attitudes; and ultimately result in improved conservation of biodiversity. If the LSAs do not increase and diversify incomes, the lessons can be applied in future conservation action. Also, if the dependence on the forests is not reduced and conservation attitudes are not improved, the lessons can be applied in future conservation action. Such re-application of lessons learned could be modification of the specific LSAs or complementing the LSAs with more targeted and directed conservation education. This model is an open system within the context of other conservation activities such as conservation education, community collaborations and forest protection activities. Other external factors include changing human populations, demand for forest resources, different land tenure systems, and changing markets for forest products and services. By following this logic model, the components as well as the intermediate and ultimate outcomes were assessed and evaluated.

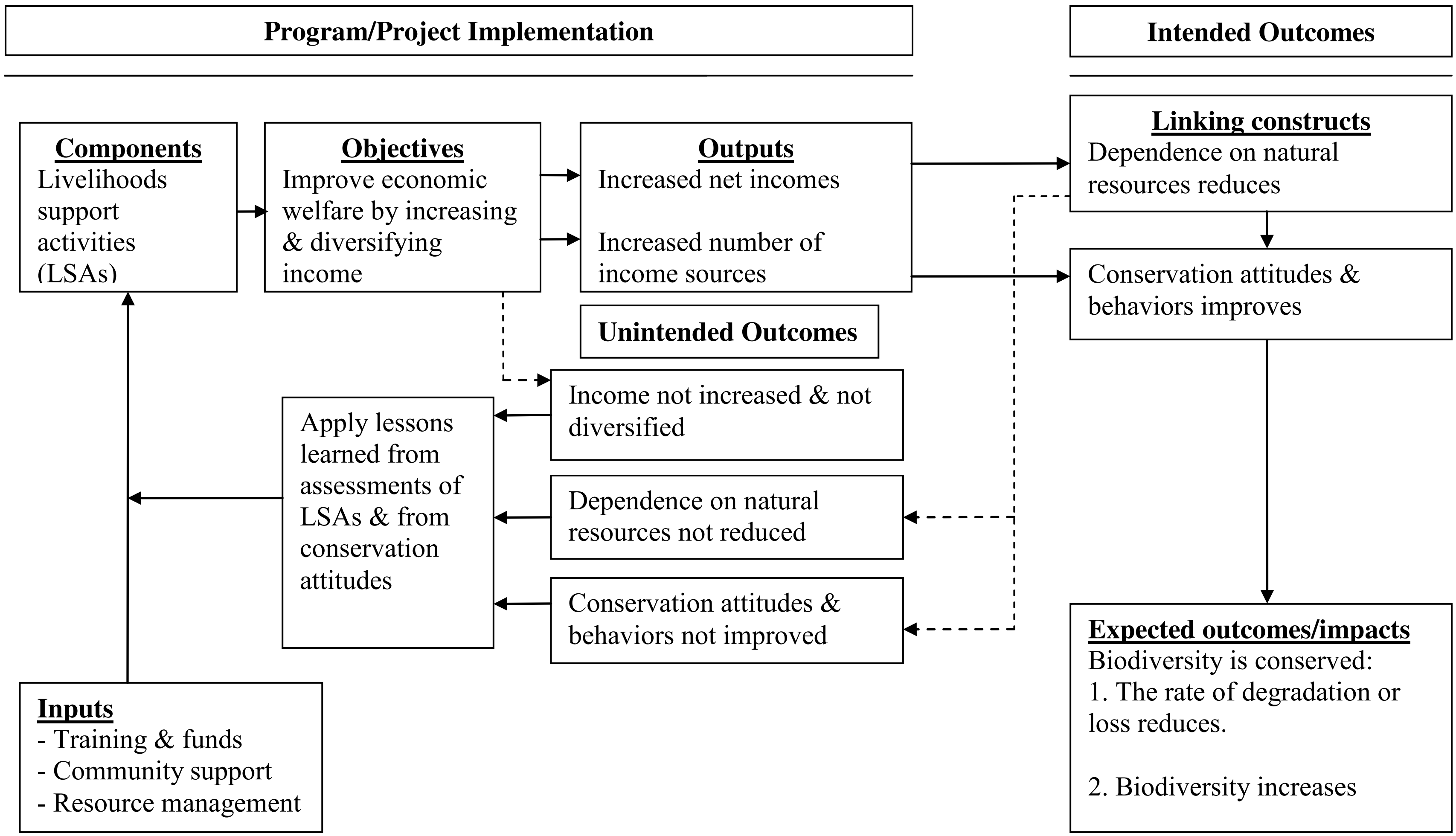


Figure 3.4: Logic model for using livelihoods support activities (LSAs) for biodiversity conservation.

3.2.2 Design of Evaluation Research

I used observational data to evaluate the effectiveness of a conservation intervention. Evaluative research requires a design that satisfies three conditions, which are individually necessary and jointly sufficient for establishing a causal relationship between variables (McDavid and Hawthorn 2006, Shadish at al. 2002) namely: 1) temporal asymmetry, 2) co-variation and 3) no plausible rival hypothesis could explain the co-variation between the two variables.

Various design alternatives for evaluating the effectiveness of conservation interventions exist. These include quantitative designs, which include experimental, quasi-experimental and non-experimental; and qualitative designs (Margoluis et al. 2009). This study is an interdisciplinary research in which both quantitative and qualitative designs were used. Following the logic model, quantitative and qualitative designs were used to collect economic data on net income from LSAs; qualitative design was used to collect social data on conservation attitudes; and quantitative design was used for biophysical data. Counterfactual thinking in a quasi-experimental design was employed to reduce shortfalls of bias and lack of randomized controls.

According to Margoluis et al. (2009), quasi-experimental designs are most appropriate to test the efficacy of a specific conservation tool, when true experimental approach is not possible, but there is the need for a high confidence in the observed effect of the conservation tool. Using counterfactual thinking in a quasi-experimental design reduces the bias due to non-random assignment of research units to treatments or interventions. Though the use of counterfactuals is rare in the environmental literature, it is critical to building evidence about what types of conservation interventions are effective and under what conditions (Ferraro 2009).

I employed a matching method called matched control/comparison group design (Margoluis et al. 2009) to determine the counterfactual. Matching method copies the classical experimental design but for the fact that it lacks randomization. This is the best option for this study because it addresses randomization, which is impossible in the study area by virtue of the treatment being a conservation tool. Matching works on the basis of comparison of pre-intervention and post-intervention conditions of a group that is ''very similar'' to the treatment group with only one key difference: the comparison group did not participate in the program of interest (Rubin 1980, Rosenbaum and Rubin 1983, Imbens 2004 and Margoluis et al. 2009). In this study, the matching was done using propensity score matching. However carefully matching is done, there is always the possibility that some critical difference remains between the intervention group and the selected controls (Rossi et al. 2004). The main independent and dependent variables were therefore measured and statistically controlled for confounding variables which could plausibly explain the co-variation. The specific inferential analysis is a modification of a non-equivalent groups design (Trochim 2006) for pretest-posttest data. For variables that the pretest data were not available, recall or recollection data were used, where appropriate.

3.2.3 Compliance with Research Ethics

This study involved administering questionnaires to human participants. It also involved animal research because fruit bats were trapped and released. Both of these activities require that the study complies with research ethics and policy standards of both the Institutional Review Board (IRB) and the Institutional Animal Care and Use Committee (IACUC) of the University of Central Florida.

With respect to IRB, the initial approval letter was obtained on October 21, 2009 with IRB number SBE-09-06487. Also after a review of an IRB Addendum and Modification Request Form, which revised survey questions, an approval letter was obtained in May 05, 2010. In line with the approved protocol, an introductory and information letter was sent to the leaders of every community in which the studies were conducted. This letter was accompanied by a Summary Explanation for Exempt Research statement, which is available at the IRB website. Copies of the IRB approval letter, the letter of introduction and the Summary Explanation for Exempt Research statement are in Appendix A. The IACUC approval for the use of animals in this study was obtained on November 6, 2009 and renewed on September 21, 2010. Both approval letters are available in Appendix B.

In the next chapter (Chapter 4), I documented the historical trend, geographical distribution and a socio-economic overview of the use of LSAs for biodiversity conservation in Ghana.

CHAPTER 4: LIVELIHOODS SUPPORT ACTIVITIES USED FOR BIODIVERSITY CONSERVATION IN GHANA

Abstract

Investments in livelihoods support activities as economic incentives for biodiversity conservation in renewable resource communities is common in Ghana. Examples include woodlots, beekeeping, snail breeding, mushroom farming, crop farming and animal husbandry. Documentation of such livelihoods support activities is scattered in project reports of government and non-governmental agencies. In this chapter, I documented the historical trends, the specific activities and their geographical distribution, implementation strategies and lessons learned from livelihoods support activities used for biodiversity conservation in Ghana. The methods I used included literature review and thematic and chronological analysis of reports of conservation and other development agencies, interviews with project managers, and focus group discussions with participants of livelihoods support activities. The earliest record of investments in livelihoods support activities was the establishment of woodlots in 1993 in northern Ghana. I identified a total of 71 different livelihoods support activities, which belonged to eight categories. The majority of livelihoods support activities have been based on non-timber forest products. A trend analysis showed an increasing tendency to make livelihoods support activities part of conservation projects in Ghana. These results indicate that investments in these livelihoods activities are a major contribution to the implementation of Ghana's current collaborative forest policy.

4.1 Introduction

Globally, increasing human populations and poverty in renewable resource communities have increased the exploitation and consequent degradation of biodiversity and natural resources. Economic instruments such as social investments in livelihoods support activities (LSAs) are therefore employed in biodiversity conservation. These LSAs are usually funded by governments and also under financial assistance in multi-lateral agreements with international organizations. In developing countries, such funds are usually small targeted grants and transfer payments designed to provide financial support for organizations involved in sustainable livelihoods and environmental conservation activities (UNEP 2004). These funds are used to support local economic activities that have minimal environmental impacts, usually in communities located on the fringes of natural resource areas such as protected areas. These investments aim to bridge the profitability gap between unsustainable activities and sustainable alternatives, and thus induce actors to conserve biodiversity or use its components in a sustainable manner (UNEP 2004). The aim of these LSAs is to reduce poverty and consequently change attitudes towards biodiversity and natural resource exploitation.

For purposes of biodiversity conservation, LSAs are used to complement and not replace other conservation strategies such as existing regulations, conservation education and protection activities. Most LSAs involve using natural resources for generating additional income but in a few cases they do not involve the use of natural resources (Tropenbos International 2005). Participants learn new skills or in some cases, improve their financial management skills for additional and more diversified income. From the perspective of recipient communities, LSAs are a form of compensation for restricting access and exploitative rights to resources. This makes LSAs important for conservation in poor economies such as Ghana's.

In Ghana LSAs have been used in poverty alleviation programs, as alternative livelihoods sources for farmers and landowners who have lost their livelihoods in mining areas and as economic instruments for biodiversity and natural resource conservation. Research on their use as alternative livelihoods projects in mining areas (For example Aryee et al. 2003, Hilson and Banchirigah 2009, and Temeng and Abew 2009) and as part of government's poverty alleviation programs (Botchway 2000) have largely focused on their role in reducing poverty. Studies on their use for conservation are rare and restricted to their potential for forest conservation (Owusu 2001), ecotourism as a conservation tool (Owusu 2008) and their use in microcredit schemes for integrated agriculture (Adu-Anning et al. 2005).

Documentation of LSAs used for biodiversity conservation in Ghana is scattered in workshop reports, technical project reports and media reports. This situation could be because LSAs have been implemented by international and national non-governmental organizations, community-based organizations and a few government agencies and international development agencies, whose primary reporting obligations have been to the immediate requirements of their donors. Donors work independently of each other and so consolidating the impacts of their interventions is rare. In their use as a conservation tool, the investments are given to participants as micro-credits. Therefore, evaluating success has been highly focused on outputs such as the number of people benefitting, the number of activities and loan repayment rates. In addition, academic involvement in the implementation of LSAs for biodiversity conservation has been minimal. In this chapter I addressed the first objective of this dissertation by presenting a consolidated overview of LSA use for biodiversity conservation purposes in Ghana. The specific objectives were to determine the following about the use of LSAs for biodiversity conservation in Ghana.

1. The specific LSAs used.
2. The historical trend of using LSAs since the first record.
3. The geographical distribution of LSA used.
4. LSA implementing strategies and role in biodiversity conservation.

4.2 Materials and Methods

I collected the data in Ghana during November and December 2009; and January, April and May 2010. I collected other data from literature and internet sources in 2008, 2009 and 2010.

4.2.1 Sources of Data

I collected the primary data from 20 towns and villages that participated in LSAs in Afadjato-Agumatsa area in the Volta Region; and the Atewa Range area in the Eastern Region of Ghana during focus group discussions with community leaders, LSA cooperatives and their leaders. I also visited the activity sites and in few cases, I reviewed the accounts books of LSA cooperatives. During these field visits, I collected secondary data were from published project reports, library copies of workshop reports and other relevant documents. I collected more secondary data from literature sources and official websites of local, national and international development agencies working in Ghana (Table 4.1). Brief descriptions of the organizations and the sources of information are presented in Appendix C.

Table 4.1: Sources of data on the use of livelihoods support activities in Ghana.

#	Organizations	Description of Organization	Source of data/Websites
1	Global Environment Facility/Small Grants Programme	A program implemented by the United Nations Development Programme	Project briefings and reports of 170 small projects. http://sgp.undp.org
2	The World Bank	An international development bank	Project reports funded since 1953. www.worldbank.org
3	Tropenbos International	International tropical forest conservation NGO*	Workshop report on alternative livelihoods in Ghana http://www.tropenbos.org
4	Forestry Commission	Government conservation agency	Project fact sheets and reports & website. http://www.fcghana.com/
5	Environmental Protection Agency	Government agency for implementing environmental policy	Website http://www.epa.gov.gh/
6	Ghana Wildlife Society	A national conservation NGO	Project reports and website www.ghanawildlifesociety.org
7	Microsfere	A French microcredit NGO	http://www.microsfere.org/en
8	Ricerca e Cooperazione	An Italian development NGO	http://www.ongrc.org
9	Centre for Biodiversity Utilisation and Development	Research and extension center at Kwame Nkrumah University of Science and Technology	http://www.knust.edu.gh
10	Samartex Timber and Plywood Company Limited	Private wood processing firm	http://www.samartex.com.gh/
11	Okyeman Environment Foundation	Environmental NGO with interest in Akyem Abuakwa Traditional Area	Project reports & www.oefghana.org

*NGO is Non-governmental organization

#	Organizations	Description of Organization	Source of data
12	CARE International	An international NGO	Project outlines (1994 to 2010). http://www.care.org
13	International Union for Conservation of Nature (IUCN).	An international conservation NGO* with country programs in Ghana.	IUCN Dialogue program. Development of *Allanblackia floribunda* for production edible oil from its seeds
14	Nature Conservation Research Centre	A national nature conservation NGO	http://www.ncrc-ghana.org/
15	Development agencies of major bilateral development partners of Ghana	These include Germany (GTZ), USA (USAID), Japan (JICA), The Netherlands (SNV), United Kingdom (DFID) and Denmark (DANIDA).	Their websites

*NGO is Non-governmental organization.

4.2.2 Data Compilation and Analysis

To determine the history of LSAs, I analyzed the time of implementation and chronological trends of the use of LSAs for conservation in Ghana. This involved determining the annual frequency (number of projects or programs initiated each year) of LSA use since the earliest record until 2010. An issue with the data for the trend analysis was the large range of percentage values (from the lowest of 0 to the highest of 100). To address this, the dependent variable (percentage of LSA versus non-LSA projects) was displayed on a logarithmic (base 10) scale, creating semi-logarithm plots. I conducted further literature review to determine and confirm the earliest records and historical trends.

I listed the specific LSAs by reviewing conservation project reports from pre-colonial times to current documents and from field visits. Some of the old forestry and wildlife conservation documents included published documentation of the history of forestry in Ghana such as Kotey et al. (1998) and pre-colonial documents about the Gold Coast (Ghana's colonial name) dating back to 1953, which were available on the website of The World Bank. All the LSAs documented in project reports, websites and during the field visits were listed and categorized based on the type of natural resource product or service. This classification was based on the agro-economic sector that the LSA targeted.

Another criteria for categorization was the rural income classification of Carletto et al. (2007), which includes agricultural production, employment for agricultural wage, non-farm enterprises, transfers and non-labor income sources. A third criteria I employed for categorization was whether the LSAs could be located within the protected area. This classification was relevant because it served as the basis for discussions on whether LSAs would be more effective when they were located within the protected area or not.

To determine the geographical distribution of LSAs used for biodiversity in Ghana, I enumerated individual LSA interventions and tallied their distributions over the vegetation zones: coastal, high forest, deciduous forest, transitional and northern savanna zones, of Ghana. I described the LSA implementation process, and the different agencies involved. I also conducted an analysis of the strengths, weaknesses, opportunities and challenges (SWOC Analysis) of five objectives of conservation incentives at the village level and some relevant issues from the perspectives of biodiversity conservation in the communities.

4.3 Results

4.3.1 History of Using Livelihoods Support Activities for Biodiversity Conservation

I identified 162 biodiversity conservation projects which were located in all the vegetative zones of Ghana. One hundred and twelve (112) of these projects employed LSAs while 50 did not (Table 4.2). The earliest biodiversity conservation project that actively involved resource-fringe communities was the Forest Resources Management Project (FRMP), which was funded by the World Bank from 1988. This project involved capacity building of government agencies in forest management, and did not employ LSAs.

The earliest record of LSA used for biodiversity conservation was in 1993 under the Global Environment Facility/Small Grants Programme (GEF/SGP). This was a small project in northern Ghana, which supported women farmers to grow economic fruit trees and woodlots in order to reduce fuel wood harvesting which was threatening biodiversity. The fact that the GEF/SGP program was the first conservation program to employ LSAs was confirmed in the Implementation Completion and Results Report of the Coastal Wetlands Management Project (CWMP) (World Bank 2000). Explaining delays in implementing the Community Investment Fund (CIF) component (the LSA component) of the CWMP, the report stated that in 1997 the only sources of Implementation Manuals for the CIF were the GEF/SGP and; International Fund for Agricultural Development (IFAD) projects, which were not conservation projects. A trend analysis based on the percentage of projects indicated an increase in the proportion of LSA projects from 1993 to 1997 (Table 4.2).

Table 4.2: Number and percentages of LSA and non-LSA conservation projects in Ghana from 1988 to 2010.*

Year	LSA Projects		Non-LSA Projects		Total number of projects
	Number	Percentage	Number	Percentage	
1988	0	0%	1	100%	1
1993	1	14%	6	86%	7
1994	4	31%	9	69%	13
1995	2	67%	1	33%	3
1997	2	100%	0	0%	2
1998	6	38%	10	63%	16
2000	5	83%	1	17%	6
2001	2	33%	4	67%	6
2002	3	100%	0	0%	3
2004	10	71%	4	29%	14
2005	12	75%	4	25%	16
2006	16	76%	5	24%	21
2007	8	100%	0	0%	8
2008	24	96%	1	4%	25
2009	14	82%	3	18%	17
2010	3	75%	1	25%	4
TOTALS	**112**		**50**		**162**

*LSA means livelihoods support activities.

The best-fit curves ($R^2 = 0.5087$) of the semi-logarithmic (base 10) plot of the percentages were used to show the trend graphically (Figure 4.1). This chronological analysis showed an increasing trend in using LSAs for biodiversity conservation in Ghana since the earliest record and a more sharp corresponding decrease in non-LSA projects.

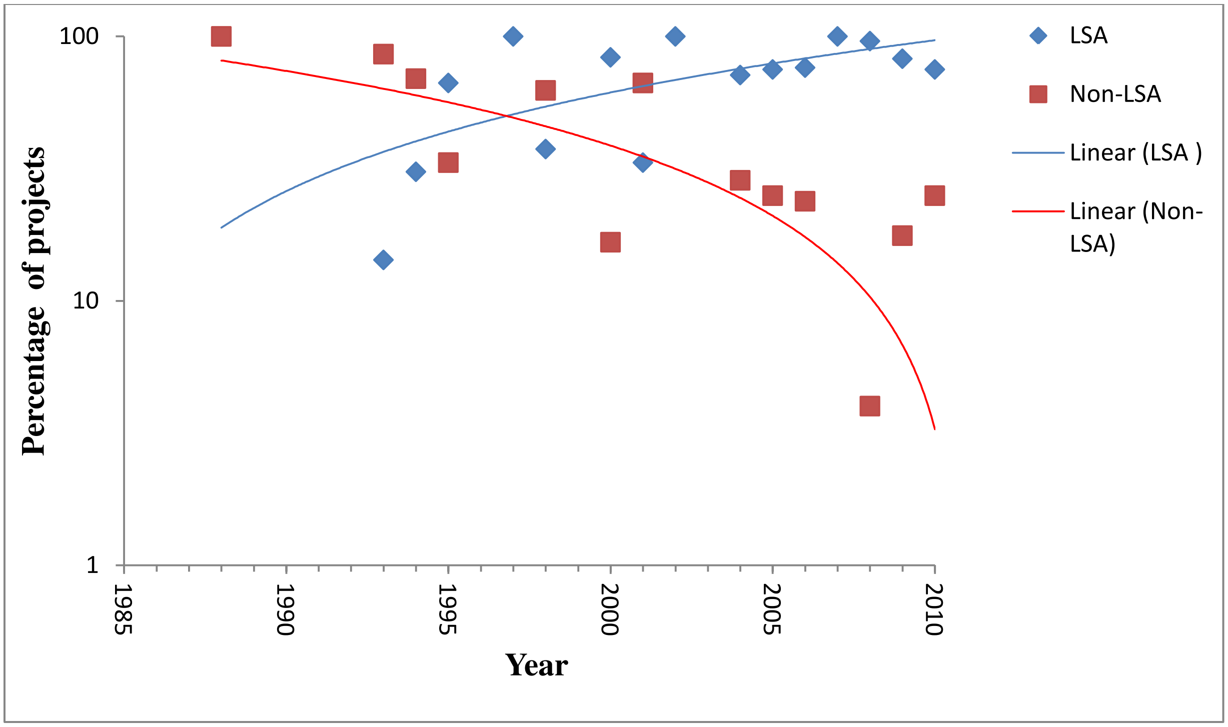


Figure 4.1: Trend of use of livelihoods support activities (LSAs) for biodiversity conservation in Ghana from 1988 to 2010.

4.3.2 The Specific Livelihoods Support Activities used for Biodiversity Conservation in Ghana

A total of 71 different livelihoods support activities (LSAs) belonging to eight categories and 21 sub-categories were identified (Table 4.3). The eight categories included perennial crops, annual crops, livestock, water resources, agro-processing, non-timber forest products, services and rural non-food products. All LSAs were directly or indirectly based on natural resources. Apart from the services category LSAs, the other activities involved consumptive use of natural resources. A rural economy assessment showed that non-farm activities included construction services, traditional medicine, trading, nature tourism, and non-food products. The other LSAs were agricultural production income activities.

Table 4.3: Livelihoods support activities (LSAs) used for conservation in Ghana.

#	LSA Category	LSA Subcategory	Specific LSAs & Descriptions
1	Perennial crop farming	Woody products	Woodlots for pole, timber and fuelwood production.
		Fruit orchards and cash crops	Mango (*Mangifera spp.*), Cashew (*Anacardium occidentale*), Sheanut (*Vitellaria paradoxa*), Moringa (*Moringa oleifera*), Cocoa (*Theobroma cacao*), *Jatropha curcas* for biodiesel production.
2	Annual crop farming	Food crop farming	The crops include corn, rice, millet, sorghum, tomatoes, okra, chili peppers, corn, cassava, yam, plantain, rice, cowpeas, spinach, and soybeans.
		Annual cash crop	Sunflower farming, sugar cane.
3	Livestock	Animal husbandry	Goats, sheep, pigs, rabbits and cattle
		Poultry	Guinea fowl, turkey, chicken and ducks
4	Water resources	Fish farming	Tilapia, Crabs and Lobster farming.
		Fishing in natural waters	Artisanal (canoe) fishing
5	Agro-processing	Primary agro-processing	Processing of Shea butter, Gari (grated and dry-fried cassava), palm oil (cooking oil from *Eleais guineensis*), fruit juice, cooking oil from peanuts, dawadawa (a spice from seeds of *Parkia biglobosa*), fish processing, coconut oil and Akpeteshie (local gin)
		Secondary agro-processing	Kenkey (a corn meal), baking & confectionery

#	LSA Category	LSA Subcategory	Specific LSAs & Descriptions
6	Non-timber forest product (NTFPs)	Animal NTFPs	Beekeeping for honey and honey wax Rearing snails (especially *Achatina spp.*) Grasscutter or Cane rat (*Thryonomys swinderianus*) farming for meat.
		Mushroom farming	Production of oyster mushroom (*Pleurotus ostreatus*) and Shiitake mushrooms(*Lentinula edodes*)
		Plant NTFPs	Growing of Prekese (*Tetrapleura tetraptera*) and blackpepper (*Piper nigrum*) for spices; and *Thaumatococcus danielli* for the natural sweetener thaumatin.
7	Services	Nature and culture tourism	Involves using waterfalls, forests, mountain hiking, animals (especially monkeys) and culture as tourist attractions
		Agricultural services	Donkey and bullock carting of agricultural produce Bullock ploughing/tilling Production of animal feed
		Traditional medicine	Improving packaging of traditional herbal medicine
		Rural construction services	Training in bricklaying/masonry
		Trading	Retail of crops, agro-processed products, non-timber forest products.
8	Non-food rural industries	Production of energy efficient stoves	Cooking stoves that use less wood and charcoal.
		Arts and craft making	Weaving of mats and traditional cloth, tie dye, bead-making and support to seamstresses and tailors, bamboo and rattan products, wood carving.
		Body care products	Soap, body cream & talcum powder.

The frequency is the actual number of LSA cooperatives and/or activities as reported in all biodiversity conservation projects and programs reviewed. Using the natural resource type classification, non-timber forest products (NTFPs) recorded the highest frequency of 102 cooperatives and/or activities, followed by 70 livestock cooperatives and/or activities and 42 cooperatives and/or activities involved in cultivation of annual crops. Those involving water resources recorded the lowest frequency of 20 cooperatives and/or actvitites (Figure 4.2) .

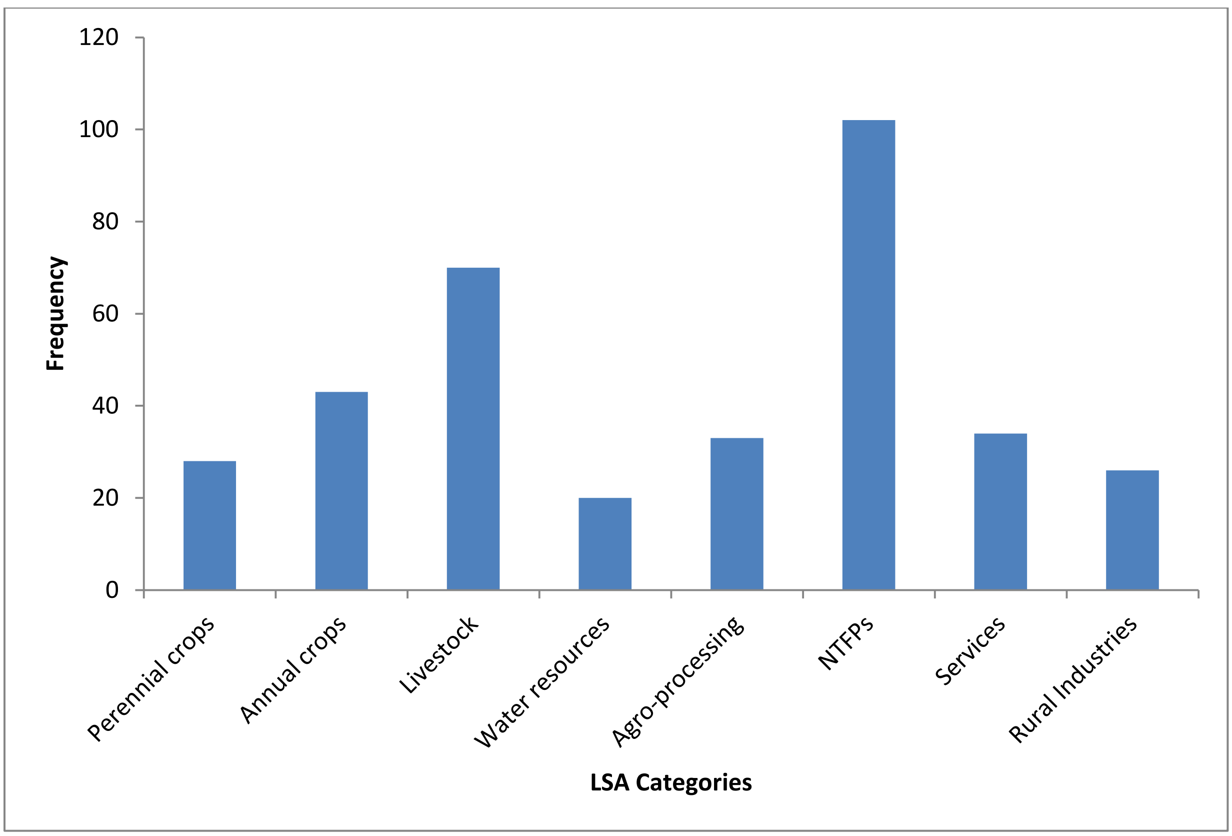


Figure 4.2: Frequency of use of livelihoods support activity (LSA) categories in Ghana from 1993 to 2010. NTFPS are non-timber forest products.

Among the LSA categories, perennial crops such as woodlots for timber and fuelwood, animal NTFPs such as beekeeping, plant non-timber forest products and nature tourism were determined to be those that could be located within a protected area. The sum of the number of NTFP-type LSAs and perennial crops was 119 and these could have been located within protected areas.

4.3.3 The Geographical Distribution of Livelihoods Support Activities in Ghana

Out of a total of 112 LSA projects in Ghana, the northern savanna recorded the highest proportion (33%) followed by the deciduous forest zone (22%) and the transition zone (21%); and the coastal savannah zone recorded the lowest of 9% (Figure 4.3). Most of the projects in the northern savanna were small projects under the UNDP GEF/SGP program.

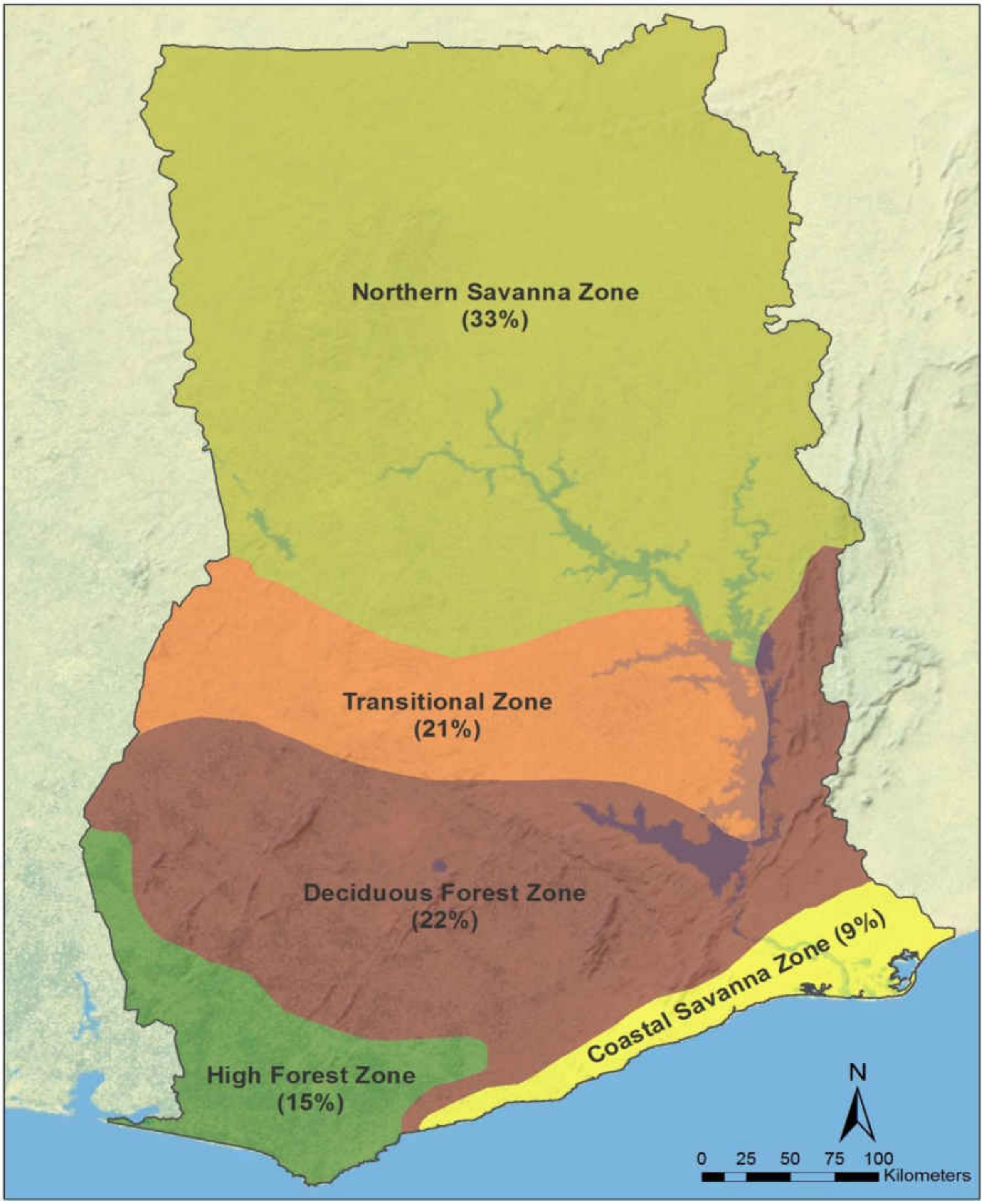


Figure 4.3: Distribution of livelihood support activities (shown in parenthesis) in ecological zones of Ghana.

4.3.4 Implementation Strategies of Livelihoods Support Activities

Of the 112 LSA projects analyzed, 102 of them were implemented by non-governmental organizations (NGOs) and 10 were implemented by governmental agencies. The projects were implemented by environmental organizations, but the LSA component was usually developed in conjunction with microfinance experts who worked as consultants for the conservation projects. Therefore the LSA components of the projects were usually managed and monitored by micro-finance consultants including private consultants, microfinance NGOs and rural banks.

The implementation process included identification and selection of the LSAs, selection of participants, training, release of funds and monitoring. The identification and selection of LSAs were usually undertaken in consultation with community leaders and as part of socio-economic studies on the livelihoods in the areas. The LSAs supported in an area were usually influenced by the location, culture and the resources in the area. For example, beekeeping was more common in forest areas than in savanna areas. Animal husbandry was more common in the northern savanna where it is a very common livelihood practice to keep goats and sheep as part of household income source. Also, in many sites NTFP LSAs were introduced by the project implementers, especially those who developed the grant proposals. Such LSAs were also accepted by communities because of the viabilities documented in other parts of the world.

After the identification and selection of LSAs, selection of participants was overseen by the leaders of the community or group which was the focal target of the LSA. This ensured effective local participation and use of local knowledge because the community leaders knew individuals better than the development agencies, which come from outside the community.

The selected participants went through training programs that were usually of two types, namely, a general program and a specialized program. The general training program consisted of business management and simple book-keeping, leadership skills and team building. The specialized training program involved technical training in LSA activities such as beekeeping, snail breeding, and grasscutter farming. Such LSAs were usually introduced by project developers during proposal development or by project managers who inform community members about the viability of the LSAs in other parts of the country or the West African sub-region.

After the training programs, the materials and funds were disbursed to participants in phases as small loans with relatively low interest rates. Some participants worked as groups while others worked as individuals but coordinated their experiences and loan repayment as members of a cooperative. The most common system involved participants working as individuals belonging cooperatives. The funds were managed as revolving funds by the implementing agency or communities. After the participants start the LSAs, they were monitored by the implementing agency and in some cases with community agents. The factors monitored included the quantity of products or services, the income and repayment of loans. Most focus of the monitoring has been on the repayment of loans because other community members were interested in benefitting from loans after they are paid back; and the monitoring agencies were financial agencies. Some attention is given to challenges of group dynamics within LSA cooperatives but the monitoring agency or officers are not able to do much about such issues. This has been largely due to the inadequate capacity of the agencies.

4.4 Discussion

4.4.1 Historical Trend, Location and Types of Livelihoods Support Activities

The increasing trend in the percentage of LSA projects from 1993 to 1997 (Table 4.2) could be explained by the fact that these were the years during which Ghana's current collaborative forest policy, was completed and promoted. This trend of LSA use over the period helped to explain how important LSAs have become in biodiversity conservation in Ghana. More specifically and importantly, the very sharp decrease in the non-LSA projects after 2000 suggest how conservation projects and managers have not been able to do without including LSAs. This particular issue was identified in two projects, which modified their implementation strategies to increase involvement of communities by increasing the projects' focus on income-generating activities (IGAs) in resource-fringe communities. These were the Northern Savanna Biodiversity Conservation Project (NSBCP) funded by The World Bank and other bilateral developmental partners of Ghana in 2005 and the Participatory Forest Resource Management Project in the Transitional Zone of the Republic of Ghana (PAFORM) funded by the Japan International Cooperation Agency (JICA) in 2006.

The highest frequency of LSA involving NTFPs (Figure 4.2) could be explained by the strategy to increase supply of non-timber forest resources for community members that participate in LSA programs. Also the high number of livestock activities and groups could be explained by the high number of LSA projects in the northen savanna area where animal husbandry for sheep and goats is a very common income generating activity. The level of investments in annual crops as conservation LSAs could be explained by the agrarian economy in most rural areas in Ghana. The low number of water resources groups could also be explained by the small number of LSAs in the coastal areas and the relatively smaller attention given to water resources conservation as compared to forest vegetation and terrestrial wildlife conservation in Ghana. Most LSA activity sites were not located within the protected areas even though that may not be detrimental to biodiversity. This could be because the classical conservation paradigm of excluding anthropogenic factors still lingers in biodiversity conservation and management. With the current forest conservation practices, this may be applicable only within community forests.

The high number of LSAs in the northern savanna could be due to the relatively large area of the zone. In addition, there are few government managed conservation areas in this zone hence the intervention of the GEF/SGP program to support NGO activities that enhance conservation. From an economic perspective, the northern zone of Ghana has high poverty levels and consequently high dependence on natural resources. Using economic tools to encourage biodiversity conservation in the area has been very important for addressing poverty and biodiversity conservation. The lowest record of LSAs in the coastal savannah zone could be explained by the relatively small size of the area. In addition, due to the high number of human settlements in coastal areas (Small and Nicholls 2003), areas available for biodiversity conservation are few. Coastal biodiversity conservation in Ghana has not been attractive to policy makers because the management of coastal resources is focused on marine fishing, thus leading to inadequate protection of wetlands. The low number of LSAs in the high forest zone could also be explained by the high number of government-managed conservation areas in this zone. The GEF/SGP projects, which formed about 83% of the LSA projects, were located in areas that have few conservation areas managed by government agencies. Also, due to favorable climatic conditions, the stress on natural resources in the forest areas is relatively lower.

4.4.2 Livelihoods Support Activities as Incentives for Biodiversity Conservation

McNeely (1988) outlines five objectives that can be addressed by incentives to conserve biological resources at the village level. These objectives include:

1. Capacity building in activities that do not deplete biological resources.
2. Reduce pressure on marginal lands for agriculture.
3. Concentrate agricultural production on the most productive lands
4. Conserve traditional knowledge
5. Compensation of community members for income lost through access limitations and restrictions on the use of protected biological resources

Capacity building was one of the major objectives that investments in LSAs for biodiversity conservation in Ghana achieved very well. Participants' were trained in cultivation of vegetables and rearing domesticated wildlife. In many areas the participants were introduced to livelihoods activities which were new to them such as beekeeping and snail farming. These training programs as well as training in teamwork and simple bookkeeping helps build long-term capacity for sustainable management of natural resources in the community. The LSA training programs also provided the opportunity to increase conservation education, improved financial management, and group dynamics among community members. The strengths of LSAs training programs were that they were done locally and were based on the natural resources in the area. One weakness was the very short times (a maximum of 5 days in many cases) used for the training programs. This was the case of some specialized technical training programs, which led to inadequate training and consequently bad practices. For example, there were some cases in which grasscutter farmers could not effectively identify male animals from females. They ended up putting two of the same sex together for a long time without any reproduction. An opportunity could be that the capacity built could be harnessed for other community development actions. Also, some participants expressed the wish to work at increasing resources in-situ such as producing snail eggs and trans-locating them into the forests, just as it is done with transplanting for enrichment planting in forests. A challenge was that the capacity building budgets were inadequate.

There was very little intentional program to reduce agricultural pressure on marginal lands, which could serve conservation purposes better. LSA programs could work to increase crop production through the improvement of soil fertility or by introducing better yielding crops or animals. This was observed in a few programs where agroforestry was introduced as a way of improving increasing outputs from the same piece of land and improving soil fertility. In some other cases, animals which yield bigger offspring were introduced to animal husbandry groups. A strength of using LSAs was that they were used to reduce agricultural pressure on marginal lands so that it left more marginal lands for biodiversity conservation. A weakness was that reducing agricultural pressure on marginal lands may lead to a change in the focus from conservation to agriculture. An opportunity identified was that it could help community members spend more time on their farms instead of exploiting uncultivated natural resources. A challenge identified was that with increased technology and knowledge about increasing crop production, marginal lands could be easily turned into productive lands for agriculture.

The objective of concentrating agricultural production on the most productive lands was difficult to influence because in Ghana, the land on which an individual villager farms on was determined by his or her family or ability to buy or lease land. To address this effectively, LSA managers would have to go to the extent of assessing the best crops of each area before funding crop farming in an area. This objective has similar strengths and weaknesses, and poses similar opportunities and challenges as the objective of reducing agricultural pressure on marginal lands.

Conserving traditional knowledge by LSAs would involve investing in, maintaining and propagating natural resources which had been used to sustain the local food systems, health and traditions of an area. One such activity was the propagation and improved packaging of herbal medicine. It is important to promote this due to the decreasing forests and inadequate documentation of the medicinal values of plants in Ghana. Such an activity empowers the local communities. One weakness was that, the focus of LSA participants has been to make quick economic returns, and this may not be possible in traditional knowledge activities. Sustaining such activities on revolving funds, may be difficult, if not impossible. This objective would help to sustain cultural practices which have maintained these communities for centuries; and provide local employment. Protecting intellectual rights of such communities would be a challenge.

From the perspective of the communities, the investments in LSAs were compensation for the limited access and restrictions on the use of protected natural resources they have had access to before formal conservation started. Therefore LSAs addressed this objective of economic incentives for conservation well. Some managers observed increased support for conservation activities from community members, especially beneficiaries and their relatives, immediately after disbursement of funds. A weakness was the inadequacy of the funds as compensation for lost income. LSAs presented an opportunity to address the concerns of community members about compensation. It was a challenge to educate the beneficiaries of LSAs about the link between the LSA funds and the natural resources being conserved. In many cases, program managers avoided the use of the word compensation in all discussions about LSA investments.

In conclusion, the use of LSAs as part of biodiversity conservation programs has not been without challenges. Very few LSAs were directly aimed at increasing natural resources and biodiversity within the resource base or protected areas – in-situ development of biological resources. Only enrichment planting of timber and other useful trees in forests and planting of mangroves served that purpose. Animal populations could be increased by rearing snails and reintroducing juveniles ones into the protected areas. Another key issue was the delay in releasing funds for some activities, which resulted in some materials becoming available during the wrong seasons. Despite these challenges, one outcome of the inclusion of LSAs in small conservation projects in Ghana was their contribution to conservation of lands outside protected areas. For example, the GEF/SGP Programme reported that about 2500 km^2 (250,000 hectares) of land outside protected areas were placed under effective community management (Global Environment Facility 2008). The country's current collaborative conservation policy and the consequent need to provide economic incentives for communities to support conservation efforts make LSAs very important. In order to understand the roles that LSAs play in the lives of poor communities located on the fringes of protected areas, it is necessary to evaluate their socio-economic values from the perspective of the beneficiaries and the villages and towns they live in. That is the goal of the next chapter.

CHAPTER 5: A SOCIO-ECONOMIC EVALUATION OF LIVELIHOODS SUPPORT ACTIVITIES USED FOR BIODIVERSITY CONSERVATION IN SOUTHEASTERN GHANA

Abstract

Understanding the socio-economic effects of livelihoods support activities (LSAs) employed in biodiversity conservation is important for conservation policy and action in Ghana. More importantly, the perspective of the beneficiaries and the communities in which they live gives a more realistic account of how these activities affect socio-economic lives. In this chapter, I conducted a socio-economic evaluation of LSAs used for forest biodiversity conservation in the Afadjato-Agumatsa Range and the Atewa Range in southeastern Ghana in 2009-2010, using ex-post cost-benefit analysis. The economic measures I estimated included: 1) the capital investment in livelihoods support activities; 2) the net socio-economic benefit as a measure of cost effectiveness; and 3) the benefit-cost ratio, as a measure of cost efficiency of LSAs. I also used semi-structured questionnaire survey to assess perceptions of LSA success. The three economic estimates per community were not different between the two study areas. Also, the per capita values of both capital investment and net economic benefit were not significantly different between the two study areas. However, the per capita benefit-cost ratio was higher in Afadjato. There were marginal economic returns from LSAs but the perception of success was relatively high. This suggested that other factors such as provision of employment, training in new skills and community cohesion played a part in how communities viewed the success of social investments such as LSAs.

5.1 Introduction

The use of economic instruments to address the biodiversity crisis is important because economic activities of humans are a major cause of biodiversity degradation and loss. Livelihoods support activities (LSAs) used for biodiversity conservation in the Afadjato-Agumatsa Range and Atewa Range forests are representative of the LSAs used in forest areas in Ghana, as presented in the previous chapter. From the logic framework of this dissertation, LSAs are the first components of the biodiversity conservation strategy investigated in this study. Therefore to understand the effects and impacts of conservation strategies that use LSAs in these areas, their specific values need to be estimated from a socio-economic perspective. This chapter addresses the second objective of this dissertation, which is to evaluate the net socio-economic benefits or costs of LSAs in intervention communities in the Afadjato-Agumatsa and Atewa areas.

Livelihoods support activities are socio-economic investments which are aimed at the economic welfare of humans and so require tools and techniques from welfare economics for their evaluation. A socio-economic evaluation of an investment requires financial and economic research methods that adequately take into account the costs and benefits of the investments to society at large or at least to the immediate social environment of the investment. Different techniques exist for socio-economic evaluation of natural systems. These include cost-benefit analysis, input-output analysis, mathematical programming, and simulation (Hufschmidt et al. 1983). The most commonly used is cost-benefit analysis (CBA). Boardman et al. (2006) define CBA as a policy assessment method that quantifies in monetary terms the value of all consequences of a policy to all members of society. For this study, the members of society of concern are those in the immediate community of the LSA. This study is therefore an evaluation that looks beyond financial analysis or cash flow and includes the non-market costs and benefits of the LSAs in the communities. The study involves systematically listing and cataloging the processes and impacts of an intervention as benefits and costs, valuing in monetary terms, and then determining the net benefits or costs for social decision making. For evaluations that estimate cost efficiency, the benefit-cost ratio is estimated (Harrison and Herbon 2008). When the benefit-cost ratio of a project is greater than one, it implies the benefits are greater than the costs. Also, a high benefit-cost ratio indicates a high cost efficiency of the project.

Boardman et al. (2006) describes three major types of CBA. The first is *ex-ante* cost-benefit analysis, which is conducted when a project is under consideration and before implementation starts. The second type of cost-benefit analysis is *in medias res*, which is undertaken during the implementation course of life of a project. The third type, *ex-post*, is conducted at the end of a project. Cost-benefit analyses are undertaken for different reasons. These include determining whether a project is worthwhile, or to compare alternative project implementation pathways or to compare pay-offs of alternative expenditure allocations for a project (Harrison and Herbon 2008), or ex-post evaluations to determine the social costs or benefits of a project after the project in completed (Rossi et al. 2004, Florio and Sartori 2010) and for making decisions on future projects. This chapter is an ex-post evaluation of LSAs in each participating community in the study areas.

Although decision making is usually contextual (Pomerol and Brezillon 2002), the classical concept of rational decision making model is applied in this study. This model of decision making assumes that humans are rational consumers who have all information available about the problem, generate alternative solutions to the problem before selecting and implementing a solution (March 1994). Therefore as presented in the logic framework of this dissertation, the net benefits or costs are expected to be the main initial drivers of the change in resource use attitudes and behavior. This is in line with the economic assumption of using LSAs for biodiversity conservation that, all other things being equal, when incomes are increased and diversified to compensate for income lost due to conservation restrictions, humans will reduce exploitation of natural resources and protects biodiversity. Therefore, it was important to do these socio-economic evaluations from the perspective of the LSA participants and the communities they live in.

This socio-economic evaluation addressed the following specific objectives in 20 communities that participated in LSAs the Afadjato-Agumatsa and Atewa forest area.

1. Determine and document the LSAs undertaken in each LSA community. The specific LSAs undertaken in each community, the active and inactive LSAs, the number of LSA participants and the proportions of the populations that participated in LSAs were documented. I hypothesized that there would be a difference between the proportions of the populations that participated in LSAs in the two study areas.
2. Estimate capital invested in LSAs, net benefit or cost of LSAs, and the benefit-cost ratio of the LSAs in each intervention community. I hypothesized that each socio-economic estimate would be different for the two study areas.
3. Determine how LSA participants rated the success of LSAs they participated in.

I hypothesized that there would be a difference in the perception of LSA success between communities in the two study areas.

5.2 Materials and Methods

I present the sources of information, data collection and analysis for documenting the specific LSAs, as well as the cost-benefit analysis of the LSAs in the two study areas.

5.2.1 Documenting the Specific Livelihoods Support Activities Undertaken in the Study Areas

I documented the specific LSAs in each community using individual interviews, visits to activity sites and parts of a structured questionnaire. These questions are part of the questionnaire in Appendix D. I also collected data on the number of participants and whether the LSA was active. I used the population data of the LSA communities to determine the proportion of the population in each LSA community that had participated in LSAs since the activities started. I compared the proportions in the Afadjato-Agumatsa and Atewa areas using the two sample z-test.

Though nature tourism is listed as an LSA, it was not included in the socio-economic evaluation of LSAs at the study sites. This was because revenues from nature tourism were so much more than from the other LSAs undertaken by groups and individuals in each community. Including it could have skewed the net benefits of LSAs in favor of communities in which there is nature tourism. Also, the main nature tourism attractions are in only some communities although most of the income is distributed to other communities in the area. Collecting reliable data, which must include total revenues, the amounts shared by communities so far, the number of visitors and the visitor trends is beyond the scope of this study. Nature tourism is the only livelihoods activity that is being practiced based solely on the availability of the actual natural resource being conserved. Therefore the existence or non-existence of an active nature tourism attraction in a community is used as a nominal variable of a factor that affects forest conservation in data analysis in later chapters.

5.2.2 Estimating the Socio-Economic Measures of Livelihoods Support Activities

The socio-economic estimates included the capital investments in LSAs in the conservation projects, the net socio-economic benefit and the benefit-cost ratio. The capital investments were obtained from project reports. The per capita investments were also computed and compared for the two study areas.

The net socio-economic benefit and the benefit-cost ratio were estimated by a cost-benefit analysis of the specific LSAs undertaken in the intervention communities. Data on financial and social benefits obtained and costs incurred by the cooperatives and communities as a result of participating in the LSAs were collected during focal group discussions. The cost-benefit analysis (CBA) questionnaire is in Appendix 3. Also, accounting books of the LSA cooperatives and project reports were reviewed to validate information provided by the groups. The per capita values of the net benefits and the benefit-cost ratio were computed and the estimates for the two study areas compared using the non-parametric Mann-Whitney U-test. The formulae for these estimations and computations are listed as equations 5.1, 5.2 and 5.3.

(i) Net per capita socio-economic benefit of LSAs in each community, PB_C,

$$\mathrm{PBc} = \frac{\mathrm{EBC}}{\mathrm{N}} \quad \ldots \ldots \ldots \ldots (5.1)$$

Where, $\mathrm{EB_C}$ = Net economic benefit of LSAs in a community, and

N = Population of the community

$$EB_C = \sum_{i=1}^{i=n}(B_G - C_G) + IB_C - IC_C \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (5.2)$$

Where, B_G = total direct benefits of LSAs to each LSA group in a community

C_G = total direct costs of LSAs incurred by each LSA group in a community

n = number of LSA groups in a community

IB_C = indirect benefits to the community

IC_C = indirect costs to the community

(ii) Per capita benefit-cost ratio of LSAs in each community, nCB_C

$$nCB_C = (1/N) \text{x} (\text{Total benefits} \div \text{Total cost}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots . (5.3)$$

$$\text{Total benefits} = \sum_{i=1}^{i=n}(B_G) + IB_C \quad \text{and} \quad \text{Total costs} = \sum_{i=1}^{i=n}(C_G) + IC_C$$

The direct benefits from the perspective of the LSA participants included the capital investments from the conservation project, estimates of prices of products sold and consumed at home by participants. Indirect benefits included skills gained from training in basic business management and bookkeeping as well as technical skills in LSAs new to a community, and the transportation costs saved when the LSA provides an agro-processing machine in a community.

The direct costs included the initial co-investments by participants to open bank accounts, operational costs such as labor and energy, interests on loans, and costs of land used for the activities. Indirect costs included the time used by community leaders to resolve LSA related conflicts, and any other costs incurred by participants and community as a whole. Operational costs were factored into business plans during the appraisal of the LSA projects. These operational costs were determined as percentages of total LSA project costs by the project managers before the initial capital investments were disbursed. Although some participants considered the loans repaid as costs, these were not computed into costs because such funds were reinvested into the community. Only the interests paid were considered as part of costs incurred.

The estimates were conducted in the local currency (Cedis before 2007 and Ghana Cedis from 2007). For each benefit or cost estimated, the exchange rate to the US Dollars ($) at the time of the activity was used. For estimates which spanned the whole activity period, the foreign exchange rate at the median year was used. For example, since the Afadjato-Agumatsa LSAs started in 2001 and those of the Atewa area were disbursed in 2005, for the Afadjato-Agumatsa area, exchange rate in June 2005 was used while for the Atewa area exchange rates in June 2007 were used. The exchange rate in the median year was used instead of the average exchange rates because data on the average exchange rates over the period was not available due to the fact that exchange rates changed over different lengths of periods (daily, weekly, or monthly, etc).

The results of the 2010 National Population Census of Ghana were not available during the study for determining per capita values. Therefore, I estimated the 2010 populations of each community by projecting the populations from the 1984 and 2000 National Census results. I employed the exponential growth model, which the Ghana Statistical Service employs for its population projections. Annual population growth rates of the Volta and Eastern Regions of Ghana (1.9% and 1.4% respectively) were used for the Afadjato-Agumatsa and Atewa areas.

5.2.3 Estimating Perceptions of Success of Livelihoods Support Activities

To estimate the perception of LSA success, the LSA participants were asked to rank the success of the LSAs on a scale of 0 (indicating not successful) to 10 (indicating very successful). The mean success rating in each community was then computed and used as the LSA success rating for each community. This was part of the questions in the questionnaire in Appendix 4. I used Mann-Whitney U-test to determine whether there was a significant difference between the perceptions of LSA success ratings in the two study areas.

5.3 Results

5.3.1 The Specific Livelihoods Support Activities in the Study Areas

A total of 51 LSA cooperatives in 20 communities were identified in the two study areas. These were made up of 23 cooperatives in four communities in the Afadjato-Agumatsa area and 28 cooperatives in 16 communities in the Atewa Range forest areas. The total numbers of LSA participants in the Afadjato-Agumatsa and Atewa areas were 539 and 282 respectively, and the mean size of each cooperative was 23 and 10 in the Afadjato-Agumatsa and Atewa areas respectively (Tables 5.1 and 5.2). In the Afadjato-Agumatsa area, Ghana Wildlife Society managed the LSA program when it started in 2001. Later the program was contracted to a micro-finance organization. In the Atewa area, the LSA was managed by the microfinance units of rural banks in the area since the LSA program started in 2004.

Table 5.1: List of livelihoods support activities in the Afadjato-Agumatsa Range Forest area.

Community	LSA* Cooperative	# of Participants	LSA Active?
Fodome-Ahor	Rice farming	12	No
	Vegetable farming	15	No
	Sheep rearing	14	No
	Grasscutter** rearing	5	Yes
	Beekeeping	5	Yes
	Corn & cassava farming	66	No
	Palm oil	10	No
	Trading and Catering	14	Yes
Gbedi Agumatsa	Beekeeping	12	Yes
Gbledi Chebi	Soap	25	No
	Gari*** making	30	No
	Corn Farming	21	No
	Beekeeping	34	No
	Rice farming	35	Yes
	Palm oil	25	No
Gbedi Gborgame	Yam farming	12	No
	Corn farming	21	No
	Palm oil	40	Yes
	Beekeeping	65	Yes
	Gari making	40	Yes
	Sheep & goat rearing	12	No
	Wood carving	10	No
	Rice farming	16	No
Total number of LSA participants		**539**	
Mean number of LSA cooperative members		**23**	

* LSA means livelihoods support activity.

**Grasscutter is *Thryonomys swinderianus*, also called cane rat.

***Gari is granular meal made from cassava, *Manihot utilissima*.

Table 5.2: List of livelihoods support activities in the Atewa Range Forest area.

Community	LSA* Cooperative	# of participants	LSA Active?
Adadientem	Piggery	10	No
	Snail rearing	10	No
Ahwenease	Piggery	10	No
	Snail rearing	10	No
Akropong	Snail rearing	10	No
	Soap making	10	No
Akwadum	Vegetable farming	10	No
	Grasscutter** rearing	10	No
Apapam	Tree Nursery	10	No
	Grasscutter rearing	10	Yes
	Snail rearing	10	No
Asiakwa	Piggery	10	Yes
	Cocoa farms and nursery	10	Yes
	Vegetable farming	10	Yes
Asikam	Grasscutter rearing	10	No
	Palm oil	10	No
Dokyi	Grasscutter rearing	10	Yes
Dompim	Piggery	10	Yes
Dwenease	Trading	10	Yes
Kwesikomfo	Piggery	10	Yes
Larbikrom	Grasscutter rearing	10	No
Osafo	Grasscutter rearing	10	No
Pano	Goats and sheep	10	No
Potroase	Piggery	10	Yes
	Goat rearing	10	Yes
	Gari*** making	10	No
Sagyimase	Palm oil	12	Yes
	Goat rearing	10	Yes
Total number of participants		**282**	
Mean cooperative size		**10**	

* LSA means livelihoods support activity.

**Grasscutter is *Thryonomys swinderianus*, also called cane rat.

***Gari is granular meal made from cassava, *Manihot utilissima*.

5.3.2 Sustainability of Livelihoods Support Activities in the Communities

An important factor that may determine how the LSAs have influenced attitudes is how the LSAs have been sustained in the various communities in the two study areas. Therefore additional information was collected on the number of LSA group activities that were active. In the Afadjato-Agumatsa area, 35% (8 of 23) of LSA cooperatives were still active and in the Atewa area, 43% (12 of 28) of LSA cooperatives were active (Figure 5.1). A two sample z-test indicated that there was no significant difference between the proportions of LSAs that were active in the two study areas ($p = 0.557$).

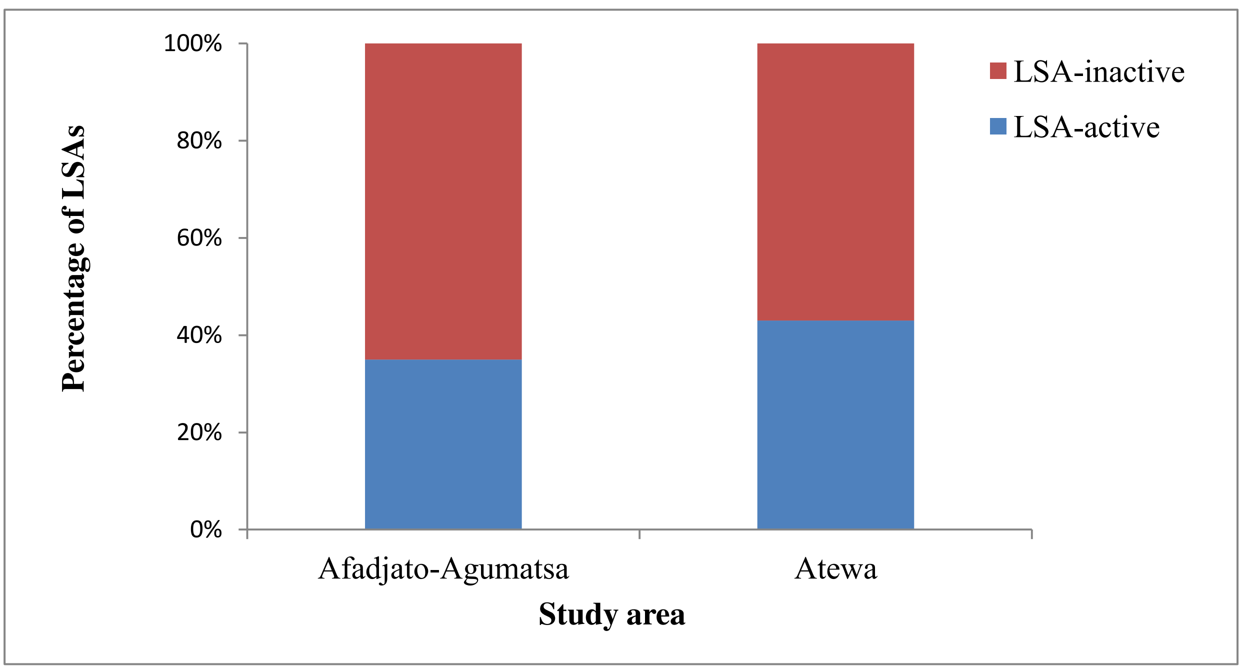


Figure 5.1: Percentage of active and inactive livelihoods support activities (LSAs) in the two study areas.

5.3.3 Proportions of Population that Participated in Livelihoods Support Activities

Another factor that may affect conservation attitudes is the proportion of the population that have participated in the LSAs. Tables 5.3 and 5.4 show the percentages of the populations in each community that participated in the LSAs. Although the activities spanned a period of time, the population estimates of 2010 were employed because they give conservative figures, which are important for such policy-driven studies.

The mean proportion of the population which have participated in LSAs in the Afadjato-Agumatsa area was 16.2% (N = 4) and in the Atewa are it was were 1.23% (N = 16). In the Afadjato-Agumatsa area, Fodome-Ahor recorded the highest proportion (19.4%) of the population being LSA participants and Gbledi-Agumatsa recorded the lowest of 2.8% (Table 5.3). In the Atewa area, the highest proportion of population which participated in LSAs was recorded in Osafo (4.78%) and the least of 0.54% was recorded in Dwenease (Table 5.4). A Mann-Whitney U-test indicated that there was a significant difference between the proportion of populations of the communities that participated in LSAs in the two study areas ($p = 0.005$). Therefore the hypothesis that the proportions of the populations that participated in LSAs in Afadjato-Agumatsa would be different from that in the Atewa could not be rejected.

Table 5.3: Proportions of populations that participated in LSAs in the Afadjato-Agumatsa area.

Community	Number of participants	Population in 2010	Percentage of population participants
Fodome-Ahor	141	727	19.40
Gbledi- Agumatsa	12	430	2.80
Gbedi-Chebi	170	1,036	16.40
Gbledi-Gborgame	216	1,129	19.12
Totals	**539**	**3,322**	**Overall Mean = 16.2**

Table 5.4: Proportions of populations that participated in LSAs in the Atewa area.

Community	Number of participants	Population in 2010	Percentage of population participants
Adadientem	20	688	2.91
Ahwenease	20	791	2.53
Akropong	20	2,445	0.82
Akwadum	20	987	2.03
Apapam	30	3,148	0.95
Asiakwa	30	4,500	0.67
Asikam	20	1,652	1.21
Dokyi	10	798	1.25
Dompim	10	701	1.43
Dwenease	10	1,857	0.54
Kwesikomfo	10	596	1.68
Larbikrom	10	421	2.38
Osafo	10	209	4.78
Pano	10	605	1.65
Potroase	30	1,759	1.71
Sagyimase	22	1,817	1.21
Total	**282**	**22,974**	**Overall Mean = 1.23**

5.3.4 Socio-Economic Estimates of Livelihoods Support Activities in the Communities

The three socio-economic estimates include the per capita capital investments in LSAs, the per capita net benefit or cost of the LSAs, and the per capita benefit cost ratios of the LSAs.

5.3.4.1 Capital Investments in Livelihoods Support Activities

The total capital investments by the projects in the Afadjato-Agumatsa and Atewa areas were \$27,158 and \$106,400 respectively (Tables 5.5 and 5.6). The mean capital investments per community were \$6,790/community (standard deviation = \$5,202); and \$6,522 (standard deviation = \$3,498) in the Afadjato-Agumatsa and Atewa areas respectively. In the Afadjato-Agumatsa area, the highest investment was \$11,973 in Gbedi-Gbogame and the least was \$400 in the Gbledi-Agumatsa village. In the Atewa area, the highest investment was \$13,200 in Asiakwa and the least was \$1,000 in Dwenease. A Mann-Whitney U-test indicated that there was no significant difference between the capital investments per community in the two study areas ($p = 0.925$). Therefore the hypothesis that there would be a difference between the capital investments per community in the two study areas was rejected.

The capital investments per LSA participant were \$45.41/person (SD = 13.32); and \$382.00/person (SD = \$155) in the Afadjato-Agumatsa and Atewa areas respectively (Tables 5.5 and 5.6). In the Afadjato-Agumatsa area, the highest capital investment per LSA participant was recorded in Gbledi-Chebi (\$58.34/person) and the lowest of \$33.33/person in Gbledi-Agumatsa village. In the Atewa area, the highest capital investment per participant was recorded in Dompim (\$750/person) and the lowest of \$100/person in Dwenease. A Mann-Whitney U-test indicated that the mean capital investments per participant was a significantly higher in Atewa than in Afadjato-Agumatsa ($p = 0.002$). Therefore, I could not reject the hypothesis that there would be a difference between the capital investments per participant in the two study areas.

The per capita investments were \$6.95/person (SD = 4.34); and \$7.27/person (SD = \$5.91) in the Afadjato-Agumatsa and Atewa communities respectively (Tables 5.5 and 5.6). In the Afadjato-Agumatsa area, the highest per capita investment was recorded in Gbledi-Gborgame (\$10.60/person) and the lowest of \$0.93/person in Gbledi-Agumatsa village. In the Atewa area, the highest per capita capital investment was recorded in Osafo (\$21.53/person) and the lowest of \$0.54/person in Dwenease. A Mann-Whitney U-test indicated that there was no significant difference between the per capita investments in the communities in the two study areas ($p = 0.850$). Therefore, I rejected the hypothesis that there would be a difference between the mean per capita investments in the two study areas.

Table 5.5: Capital investments in livelihoods support activities in the Afadjato-Agumatsa area.

Community	Capital investment ($)	Investment per LSA participant ($)	Population in 2010	Per capita investment ($)
Fodome-Ahor	4,867	34.52	727	6.69
Gbledi-Agumatsa	400	33.33	430	0.93
Gbledi-Chebi	9,918	58.34	1,036	9.57
Gbledi-Gborgame	11,973	55.43	1,129	10.60
Total	**27,158**	**182**	**3,322**	**27.79**
Mean	**6,790**	**46**	**830**	**6.95**
Standard deviation	**5202**	**13**	**318**	**4.34**

Table 5.6: Capital investments in livelihoods support activities in the Atewa area.

Community	Capital investment ($)	Investment per LSA participant ($)	Population in 2010	Per capita Investment ($)
Adadientem	12,000	600	688	17.44
Ahwenease	10,500	525	791	13.27
Akropong	5,000	250	2,445	2.04
Akwadum	6,500	325	987	6.59
Apapam	7,200	240	3,148	2.29
Asiakwa	13,200	440	4,500	2.93
Asikam	7,500	375	1,652	4.54
Dokyi	3,000	300	798	3.76
Dompim	7,500	750	701	10.70
Dwenease	1,000	100	1,857	0.54
Kwesikomfo	3,000	300	596	5.03
Larbikrom	4,500	450	421	10.69
Osafo	4,500	450	209	21.53
Pano	3,000	300	605	4.96
Potroase	9,500	317	1,759	5.40
Sagyimase	8,500	386	1,817	4.68
Total	**106,400**	**6,108**	**22,974**	**116.39**
Mean	**6,650**	**382**	**1,436**	**7.27**
Standard deviation	**3,498**	**155**	**1,151**	**5.91**

5.3.4.2 Net Socio-economic Benefits of Livelihoods Support Activities

The total net socio-economic benefit estimated in the Afadjato-Agumatsa ($26,418) was lower than $104,441 in the Atewa area (Tables 5.7 and 5.8). However, the overall per capita socio-economic benefit was higher in the Afadjato-Agumatsa area ($7.95/person) than the $4.55/person in the Atewa area. In the Afadjato-Agumatsa area, the highest net socio-economic benefit as well as the per capita benefit of LSAs was recorded in Gbledi-Gborgame. The lowest net socio-economic benefit as well as per capita value of LSAs was recorded in Gbledi-

Agumatsa. In the Atewa area, the highest net socio-economic benefit was recorded in Asiakwa and the lowest net socio-economic benefit was recorded in Dwenease. The highest per capita socio-economic benefit was recorded in Osafo and the lowest per capita socio-economic benefit was recorded in Dwenease. A Mann-Whitney U-test indicated no significant difference between the net socio-economic benefit between the two study areas ($p = 0.777$).

The mean of per capita benefits of communities was lower in Afadjato-Agumatsa area ($6.86/person, SD = 3.90) than in the Atewa area ($6.92/person, SD = 5.27). There was no significant difference between the per capita benefits of LSAs in the two study areas ($p = 0.705$). This insignificant difference is shown graphically in Figure 5.2. Therefore, the hypothesis that net per capita benefits of LSAs in the two study areas were different was rejected. The mean per capita benefits of $7.95/person in the Afadjato-Agumatsa area over a period of 9 years (from 2001 to end of 2009) is an average of $0.88/person/year. The $4.55/person in the Atewa area over a 5-year period (from 2005 to the end of 2009) was a mean of $0.91/person/year.

Table 5.7: Net economic benefits and populations in LSA communities in Afadjato-Agumatsa.*

Community	**Net benefit ($)**	**Population in 2010**	**Per capita net benefit ($)**
Fodome-Ahor	4,958	727	6.82
Gbledi-Agumatsa	599	430	1.40
Gbledi-Chebi	9,413	1,036	9.08
Gbledi-Gborgame	11,448	1,129	10.14
Total	**26,418.00**	**3,322**	**27.44**
Mean	**6,604.50**		**(Overall mean = 7.95) 6.86**
Standard deviation	**4,834.74**		**3.90**

* LSA means livelihoods support activities

Table 5.8: Net economic benefits and populations in LSA communities in Atewa.*

Community	Net benefit ($)	Population in 2010	Per capita net benefit ($)
Adadientem	11,270	688	16.38
Ahwenease	9,570	791	12.19
Akropong	4,375	2,445	1.79
Akwadum	6,525	987	6.61
Apapam	6,580	3,148	2.09
Asiakwa	16,085	4,500	3.60
Asikam	6,670	1,652	4.04
Dokyi	2,680	798	3.36
Dompim	6,670	701	9.52
Dwenease	2,040	1,857	1.11
Kwesikomfo	3,020	596	5.07
Larbikrom	4,054	421	9.63
Osafo	4,072	209	19.45
Pano	3,975	605	6.57
Potroase	8,500	1,759	4.83
Sagyimase	8,355	1,817	4.60
Total	**104,441.00**	**22,974**	**111.00**
Mean	**6,527.56**		**(Overall mean = 4.55) 6.92**
Standard dev.	**3,659.76**		**5.27**

* LSA means livelihoods support activities

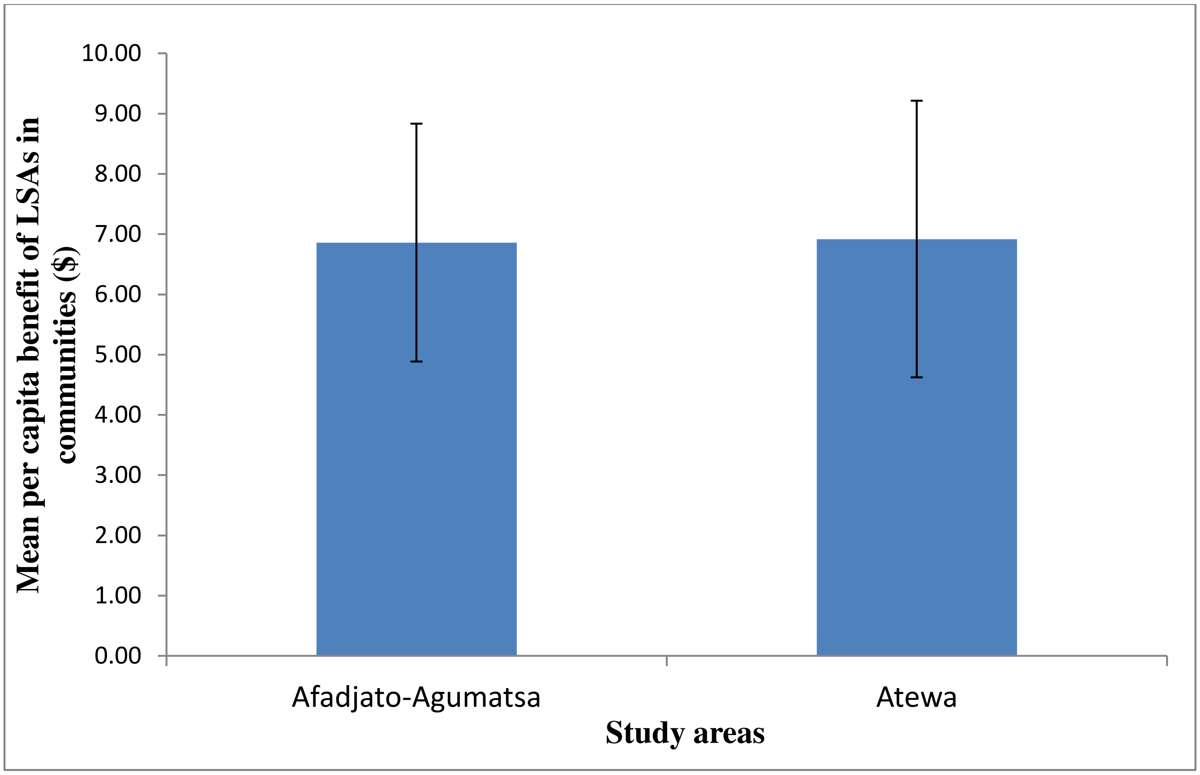


Figure 5.2: Mean net per capita socio-economic benefits of livelihoods support activities in the two study areas (error bars +-SD).

5.3.4.3 Benefit-cost Ratio of Livelihoods Support Activities

In the Afadjato-Agumatsa area, the highest benefit-cost ratio was recorded Gbledi-Gborgame and the lowest benefit cost ratio was recorded in Gbledi-Agumatsa. In the Atewa area, the highest benefit-cost ratio was recorded in Asiakwa and the lowest was recorded in Kwesikomfo. The mean benefit-cost ratios were 39.86 (SD = 23.11) in the Afadjato-Agumatsa area; and 14.71 (SD = 5.98) in the Atewa area (Tables 5.9 and 5.10). A Mann-Whitney U-test indicated that there was significant difference between the benefit-cost ratios in the two study areas (p =

0.047). Therefore, the hypothesis that the benefit-cost ratios in the two study area would be different could not be rejected.

The highest per capita benefit-cost ratio in the Afadjato-Agumatsa area was recorded in Gbledi-Gborgame and the lowest was recorded in Gbledi-Agumatsa. In the Atewa area, the highest benefit-cost ratio was recorded in Osafo and the lowest was recorded in Asiakwa. The mean per capita benefit-cost ratios were 0.044 (SD = 0.016) and 0.015 (SD = 0.009) at the Afadjato-Agumatsa and Atewa areas respectively (Tables 5.9 and 5.10). A Mann-Whitney U-test indicated that there was a significant difference between the per capita benefit-cost ratios in the two study areas (p = 0.005). Therefore, the hypothesis that the per capita benefit-cost ratios in the two study areas would be different could not be rejected.

Table 5.9: Benefit-cost ratios of livelihoods support activities in Afadjato-Agumatsa.

Community	Benefit-cost ratio	Population in 2010	Per capita benefit-cost ratio
Fodome-Ahor	38.07	727	0.052
Gbledi-Agumatsa	8.99	429	0.021
Gbledi-Chebi	48.69	1,036	0.047
Gbledi-Gborgame	63.68	1,129	0.056
Mean	**39.86**		**0.044**
Standard deviation	**23.11**		**0.016**

Table 5.10: Benefit-cost ratios of livelihoods support activities in Atewa.

Community	Benefit-cost ratio	Population in 2010	Per capita benefit-cost ratio
Adadientem	17.39	688	0.025
Ahwenease	15.79	791	0.020
Akropong	14.16	2,445	0.006
Akwadum	15.69	987	0.016
Apapam	21.73	3,148	0.007
Asiakwa	28.48	4,500	0.006
Asikam	16.89	1,652	0.010
Dokyi	8.24	798	0.010
Dompim	8.25	701	0.012
Dwenease	13.00	1,857	0.007
Kwesikomfo	7.43	596	0.012
Larbikrom	8.80	421	0.021
Osafo	8.83	209	0.042
Pano	11.06	605	0.018
Potroase	21.83	1,759	0.012
Sagyimase	17.86	1,817	0.010
Mean	**14.71**		**0.015**
Standard deviation	**5.98**		**0.009**

5.3.5 Perceptions of Livelihoods Support Activities' Success

The perceptions of LSA success was rated on a scale of zero to ten. Success ratings in all communities ranged from 3.67 to 7.50 (Table 5.11). In the Afadjato-Agumatsa area, the highest rating was recorded in Fodome-Ahor (6.42) and the lowest in Gbledi-Chebi (3.67). In the Atewa area, the highest success rating was 7.5 recorded in Apapam and Adadientem and the lowest was 4 recorded at Akwadum, Ahwenease and Dwenease. Average LSA success ratings in the Afadjato-Agumatsa and Atewa areas were 5.02 and 5.60 respectively and standard deviations were 1.12 and 1.25 respectively (Figure 5.3). A Mann-Whitney test indicated no significant difference between perception of LSA success in the two study areas (p = 0.446). Therefore I rejected the hypothesis that perceptions of LSA success in the two study areas were different.

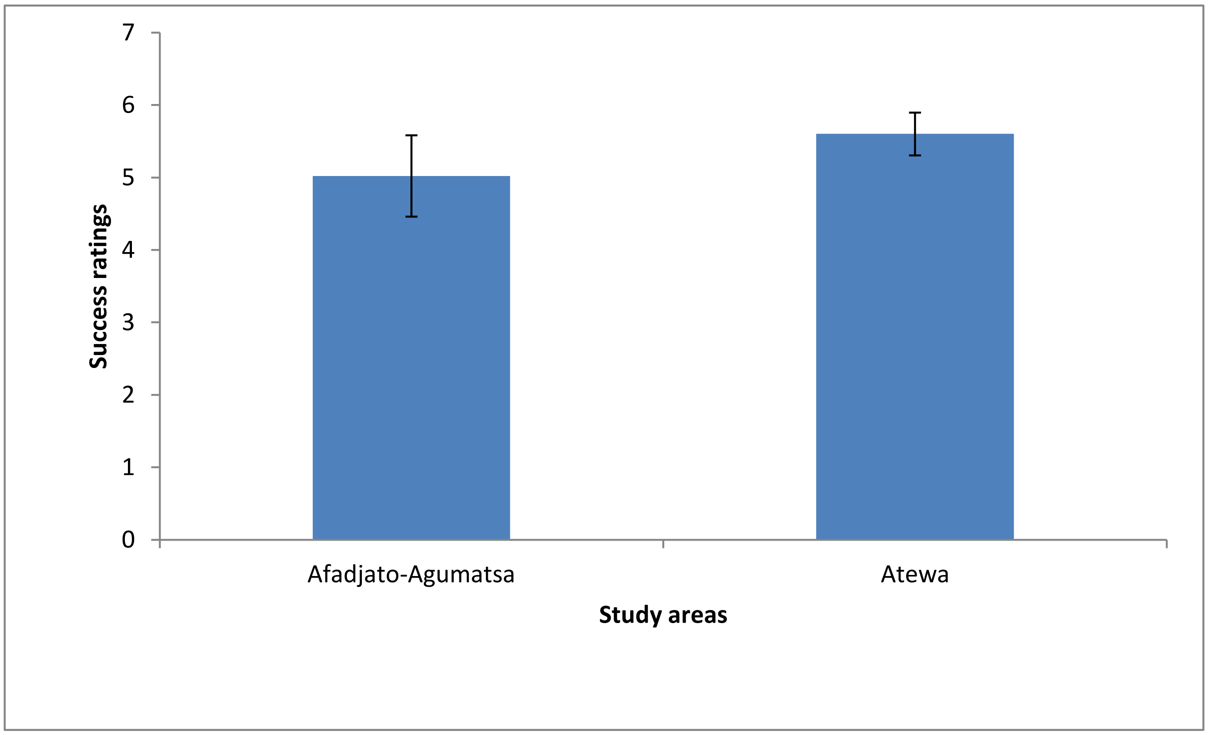


Figure 5.3: Mean success rating of livelihoods support activities in the study areas (Error bars are +/- SD).

Table 5.11: Average success ratings and standard deviations from LSA communities.

Study Area	Community	Mean perception rating	Standard deviations
Afadjato-Agumatsa	Fodome Ahor	6.42	2.35
	Gbledi-Agumatsa	5.00	0.00
	Gbledi-Chebi	3.67	1.73
	Gbledi-Gborgame	5.00	2.38
Atewa	Adadientem	7.50	0.71
	Ahwenease	4.00	1.41
	Akropong	4.50	0.71
	Akwadum	4.00	1.41
	Apapam	7.50	1.00
	Asiakwa	7.00	1.00
	Asikam	6.00	2.83
	Dokyi	5.00	0.00
	Dompim	5.50	0.71
	Dwenease	4.00	0.00
	Kwesikomfo	7.00	0.00
	Larbikrom	4.50	0.71
	Osafo	5.00	0.00
	Pano	7.00	0.00
	Potroase	4.33	1.51
	Sagyimase	6.50	2.12

5.4 Discussion

Generally, there few differences between the socio-economic estimate of LSAs in the two study areas. The fact that there was no significant difference between the proportions of LSAs that were active in the two study areas suggests that there was no difference in the sustainability of LSAs in the two study areas. The significantly higher proportion of the population that participated in LSAs in the Afadjato area was influenced by the low number of communities that were involved in the program. Also, landowning clans in a few communities contributed land for establishing a community nature reserve. In order to maximize benefits from the program, these clans and families listed as many people as possible as cooperative members.

The insignificant difference between the capital investments per community in the two study areas suggests that though there was a huge difference in the total capital investments in the two areas, the investments per community were not statistically different. However, the higher investment per LSA participant in Atewa than Afadjato was because there were fewer LSA participants in Atewa than in the Afadjato-Agumatsa area. In Atewa, participation in the LSA was largely limited to 10 (only one group having 12) members of the Community Biodiversity Advisory Groups (CBAG), who volunteered in forest management. In the Afadjato-Agumatsa area, LSA participation was opened to all community members especially members of landowning families and clans. The insignificant difference between the per capita investments in LSAs in the two study areas indicates that though there was a difference in the total capital investments in the two areas, the per capita investments were not different. This result suggests that the economic analysis and cost estimates done to determine how much to invest for the populations in the two project areas were similar.

Despite the difference in total socio-economic benefits from the LSAs as well as the overall net per capita benefit; the per capita benefits between the communities in the two areas were not different. The differences in the overall estimates (total and overall mean) were due to the differences in populations in the two study areas. The results suggest that the net socio-economic benefits of the LSAs were evenly distributed among the communities in each study area. The annual estimates of per capita socio-economic benefits ($0.88/person/year and

$0.91/person/year in Afadjato-Agumatsa and Atewa respectively) were very insignificant proportions of the livelihoods of people in Ghana, even with a minimum wage of about $2.00 per day. This shows the low economic investments in and returns from social investments for environmental conservation. It also indicates the low investments in conservation programs that go directly go to individuals living near biodiversity hotspots.

The significantly higher per capita benefit cost ratio in Afadjato-Agumatsa than in Atewa suggests that from the perspective of the LSA participants, the cost efficiency of the LSAs for communities as well as for individuals in the two study areas were different. The higher per capita benefit cost ratio in Afadjato-Agumatsa was due to the smaller mean population (830/community) of the study communities in Afadjato than in Atewa (1,435/community). The insignificant difference in perceptions of LSA success supports the larger number of similarities between the socio-economic estimates for the two study areas.

The per capita benefits for the project period as well as the annual estimates suggested that LSAs used for biodiversity conservation have resulted in marginal increases in income. However, the number of activities undertaken with the support of conservation funds, as well as the number of participants and their employees suggested that LSAs have played an important role in creating employment in the project areas. The LSAs provide other social benefits such as community cohesion through the training programs in team building, which could have influenced the relatively high success ratings participants compared to the economic returns, were marginal. These socio-economic evaluations have given an insight about the role LSAs play in local economies. It is important to note that the estimates were largely evaluated from the perspective of the participants and the communities. For example, from the perspective of a business, capital investments will include both capital invested by the projects and the funds invested by the participants. However, from the perspective of the participants their funds invested was viewed as costs to them and not capital. This suggests the importance of policy research and analysis to give increased attention to the perspective of policy beneficiaries. These socio-economic estimates of LSAs provide a good basis for evaluating how and whether they affect attitudes towards conservation of the natural environment, which is the focus of the next chapter.

CHAPTER 6: AN EMPIRICAL EVALUATION OF THE EFFECTS OF LIVELIHOODS SUPPORT ACTIVITIES ON ATTITUDES TOWARDS THE NATURAL ENVIRONMENT IN SOUTHEASTERN GHANA

Abstract

Investments in livelihoods support activities (LSAs) employed for biodiversity conservation are aimed at changing attitudes and behaviors towards natural resource use in order to reduce natural resource exploitation. These activities have been employed in communities in the Afadjato-Agumatsa Range and Atewa Range forest conservation areas in southeastern Ghana since early 2000s. In this chapter, I assessed environmental attitudes and evaluated whether and how they are affected by participation in LSAs in 40 communities in the two study areas. I used a non-equivalent group research design with a recollection proxy pretest-posttest analysis to estimate changes in attitudes towards the natural environment. There was no significant difference in environmental attitudes between communities that participated in livelihoods support activities and those that did not participate. This was confirmed by infinitesimal effects determined using propensity score matching. Among LSA communities, benefit-cost ratio of investments in livelihoods support activities predicted favourable forest conservation attitudes. Pro-conservation attitudes were higher in communities that sustained the livelihoods support activities. On the basis of these results, it may serve biodiversity conservation better to invest in LSAs that involve the least costs to participants and communities; and in LSAs that communities could undertake for a long time. The methodology used in this chapter shows that evaluating the effects of conservation interventions have some challenges, but it can be done using rigorous analysis.

6.1 Introduction

Livelihoods support activities (LSAs) employed for biodiversity conservation aim to induce conservation by changing environmental attitudes and behaviors of communities living near the natural resources. As economic instruments, they are predicated on the assumption that individuals and/or households act as economic agents and so do not decide directly how much biodiversity to preserve, but rather make decisions about how much biological resource is used (van Kooten and Bulte 2000). Livelihoods support activities target the natural resource exploitation behaviors by increasing and diversifying incomes. This brings to the forefront the issue of human attitudes and behaviors towards the natural environment, specifically tropical forests in Ghana, West Africa.

Human attitudes and behaviors can reduce or worsen environmental problems (Mobley et al. 2010), including degradation of biodiversity. For example, recent global studies identify human behavior as a major driver of loss of natural resources (Millennium Ecosystem Assessment 2005) and global climate change (Intergovernmental Panel on Climate Change 2007). Changing environmental attitudes and behaviors is considered a means to achieving biodiversity and natural resource conservation. This makes them intermediate outcomes in such conservation interventions (Margoluis et al 2009) as outlined in the logic model of this dissertation.

Explaining human behavior is very cumbersome because of the many complex behavior dispositions attributable to different humans (Ajzen 1991). However, different theories in psychology have been used to explain them. Early theories such as the classical attitude-behavior consistency theory proposed a very strong link between human attitudes and behaviors.

Later, Wicker (1969) described weak correlations between them and discouraged the classical theory. Further empirical studies in psychology have shown that, the weak correlations between attitudes and behaviors exist only in some contexts and these gave rise to the theory of reasoned action (Fishbein and Ajzen 1975, Ajzen and Fishbein 1980), and the theory of planned behavior (Ajzen 1991), which explained human behavior in terms of the intentioned behavior. Intentioned behavior is very much determined by attitudes (Rauwald and Moore 2002) and so can serve as proxies for behaviors.

Environmental attitudes are psychological tendencies that represent the degree of favor or disfavor for the natural environment after evaluating it (Hawcroft and Milfront 2010). They are a predisposition to behavior expressed in terms of the degree to which one likes or dislikes the natural environment. Environmental attitudes have been used to explain behaviors in various environmental management regimes and these have led to the development and use of a large number of scales for measuring environmental attitudes. Examples of the environment regimes include waste management and recycling (Purcell and Magette 2010, Sidique et al. 2010), stormwater management (Emmerling-DiNovo 1995, Jorgensen and Syme 2000) and biodiversity conservation (Gubbi et al. 2008, Tessema et al. 2009). Dunlap and Jones (2003), and Hawcroft and Milfont (2010) state that three of the most widely used environmental attitudes are the Ecology Scale (Maloney and Ward 1973), The Environmental Concern Scale (Weigel and Weigel 1978) and the most widely used New Environmental Paradigm Scale (Dunlap and Van Liere 1978), which was later revised and renamed New Ecological Paradigm (Dunlap et al 2000).

6.1.1 Context of Livelihoods Support Programs in Study Areas

Livelihoods support activities (LSAs) have been part of forest conservation projects in the Afadjato-Agumatsa and Atewa areas since the early 2000s. In the Afadjato-Agumatsa area, the LSAs were introduced in 2001 as part of a community-based program which started in 1998. Formal forest protection in the Atewa area started 1925 but LSAs were introduced in 2003 as part of a project to establish Globally Significant Biodiversity Areas (GSBAs) in parts of the forests. I undertook this study in 40 towns and villages. These included four LSA communities and four non-LSA communities in the Afadjato-Agumatsa area; and 16 LSA communities and 16 non-LSA communities in the Atewa area (Table 6.1).

Table 6.1: List of LSA communities in the two study areas.

Afadjato-Agumatsa Range Area		**Atewa Range Area**	
LSA-communities	**LSA-active**	**LSA-communities**	**Non-LSA**
1. Fodome-Ahor**	1. Wli Todzi	1. Adadientem	1. Abesim
2. Gbledi-Agumatsa**	2. Gbledi-Torglo	2. Ahwenease	2. Adukrom
3. Gbledi-Chebi**	3. Fodome-Ando2	3. Akropong	3. Afiesa
4. Gbledi-Gborgame**	4. Wli Afegame & Agorviefe	4. Akwadum	4. Akanteng
		5. Apapam**	5. Akyeansa
		6. Asiakwa**	6. Apampatia
		7. Asikam	7. Awenare
		8. Dokyi**	8. Banso
		9. Dompim**	9. Bomaa
		10. Dwenease**	10. Dwafoakwa
		11. Kwesikomfo**	11. Kobriso
		12. Larbikrom	12. Kwekusae
		13. Osafo	13. Mpeasem
		14. Pano	14. Pameng
		15. Potroase**	15. Pinamang
		16. Sagyimase**	16. Takyiman

*LSA means livelihoods support activities. **At least one LSA was active in these communities.

6.1.2 Aim, Objectives and Hypotheses

The aim of this chapter was to determine whether and how participating in LSAs affected environmental attitudes (EAs) and forest use behaviors in towns and villages in the study areas. The objectives involved evaluations of: 1) LSA communities and non-LSA communities; and 2) only intervention (LSA) communities (Table 6.2).

Table 6.2: Specific objectives and hypotheses of chapter six of this dissertation.

#	Objectives	Hypotheses
	A. Analysis involving LSA communities and non-LSA communities	
1	Determine the overall changes in environmental attitudes (EA) since conservation interventions with LSA* components started.	There would be a significant increase in the overall environmental attitudes from 1999 to 2009/2010.
2	Determine whether and how socio-demographic factors predicted change in EA of individuals.	Socio-demographic factors would significantly predict changes in EA.
3	Determine the correlations between self-reported frequency of forest use and their EA.	The stated frequency of resource use would correlate strongly with EA.
4	Compare EA of the two study two study areas.	EA would be higher in Afadjato-Agumatsa than in Atewa.
5	Compare EA of LSA communities with the attitudes of non-LSA communities.	EA would be higher in LSA communities than in non-LSA communities.
6	Estimate the effect that a community's participation in LSAs had on EA	LSAs would have a significant effect on EA.
	B. Analysis involving only LSA communities	
7	Compare EA of LSA communities which had active LSAs with the attitudes of those which had no active LSA.	EA would be higher in LSA-continues communities than in LSA-stopped communities.
8	Determine how the per capita values of capital investment, net benefit, and benefit cost ratio of LSAs predict EA of communities.	Each of the three economic estimates of LSAs would significantly predict EA of LSA communities.

*LSA means livelihoods support activities

6.2 Materials and Methods

The dependent variables of this chapter included attitudes towards the natural environment, and forest-use behavior. I employed two different EA scales, namely 1) Forest Conservation Attitudes (FCA) scale; and 2) The New Environmental Paradigm (NEP) scale of Dunlap et al. (2000). For the forest-use behaviors, I employed a self-reported frequency of forest use. The independent variables included socio-demographic factors; and the socio-economic estimates of LSAs namely, the per capita estimates of capital investments, net socio-economic benefits and benefit-cost ratios of LSAs from Chapter 5 of this dissertation. I estimated attitudes towards the natural environment and the frequency of forest use using questionnaire surveys of individuals, in all the 40 communities in the two study areas.

6.2.1 Survey Design and Sampling

One major goal of this dissertation was to investigate the cause-effect relationship between LSAs and attitudes towards the natural environment, especially forests. Therefore I designed the survey to satisfy three conditions, which are individually necessary and jointly sufficient for establishing a causal relationship between variables (McDavid and Hawthorn 2006, Shadish at al. 2002) namely: temporal asymmetry, co-variation and no plausible rival hypothesis which could explain the co-variation between the two variables. The dependent variables were attitude estimates and stated forest-use frequencies. Specifically, the surveys estimated pretest environmental attitudes (before the LSA interventions in 1999/2000) and posttest environmental attitudes in 2009/2010; as well as the stated resource-use frequencies in 2009/2010.

To determine the sample size of respondents in each community, I considered similar studies, and a sampling formula recommended by Israel (2009a; 2009b). Similar studies such as Gubbi et al. (2009) sampled 1.8% of households; and Tessema et al. (2010) sampled 5% or 50 households whichever was reached first. In line with these reference studies, I sampled all households in small communities (number of households is equal to or less than 50). For larger communities (number of households greater than 50), I sampled 50 households or a derived sample size, whichever is greater. The formula I used for determining the sample size as recommended by Israel (2009a; 2009b) is defined in equation 6.1.

$$n = N \div [1 + N(e)^2] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.1)$$

Where, n is the sample size,

N is the population size, or number of households (for household surveys), and

e is the confidence interval

Confidence intervals of 5% give sample sizes which were beyond the study's financial resources. In such situations, Dean and Voss (2006) suggest a wider confidence interval. Therefore I used 10% confidence interval in determining the sample sizes in each community.

A total of 2,553 individual household interviews were conducted. These were made up of 461 and 2,092 in the Afadjato-Agumatsa and Atewa areas respectively (Tables 6.3 and 6.4). The number of households surveyed in Afadjato-Agumatsa ranged from 36 to 83 (Table 6.3), and in the Atewa area, it ranged from 15 to 91 (Table 6.4). Average number of households sampled was 58 and 62 in the Afadjato-Agumatsa and Atewa areas respectively. The proportions of households surveyed ranged from 16.8% to 100% in Afadjato-Agumatsa area; and ranged from 9.1% to 100% in the Atewa area (Tables 6.3 and 6.4). The percentages of the total populations sampled were 5.8% and 4.8% in the Afadjato-Agumatsa and Atewa areas respectively. These proportions compared well and above 1.8% sampled by Gubbi et al. (2009) and 5% sampled by Tessema et al. (2010) in similar studies.

Table 6.3: Characteristics of household survey samples in Afadjato-Agumatsa.

Community	**2010 population**	**Number of households**	**Sample Size**	**% of households surveyed**
Fodome-Ahor	727	153	60	39.2
Fodome-Ando 2	156	36	36	100.0
Gbledi-Agumatsa	429	51	50	98.0
Gbedi-Chebi	1,036	158	61	38.6
Gbedi-Gborgame	1,129	204	67	32.8
Gbledi-Torglo	343	49	49	100.0
Wli Afegame & Agorviefe	3,057	493	83	16.8
Wli Todzi	1,108	124	55	44.4
Totals	**7,985**	**1,268**	**461**	**Overall = 36.4**
Mean/Median	**998**	**159**	**58**	**Median = 42**

Table 6.4: Characteristics of household survey samples in Atewa.

Community	2010 Population Estimates	Number of Households	Sample Size	% of Households Surveyed
Abesim	76	15	15	100.0
Adadientem	688	145	59	40.7
Adukrom	1,199	295	75	25.4
Afiesa	244	47	47	100.0
Ahwenease	791	198	66	33.3
Akanteng	4,134	780	89	11.4
Akropong	2,445	502	83	16.5
Akwadum	987	211	68	32.2
Akyeansa	1,430	276	73	26.4
Apampatia	755	124	55	44.4
Apapam	3,148	603	86	14.3
Asiakwa	4,500	1,000	91	9.1
Asikam	1,652	376	79	21.0
Awenare	1,639	327	77	23.5
Banso	2,180	450	82	18.2
Bomaa	950	141	59	41.8
Dokyi	798	137	58	42.3
Dompim	701	129	56	43.4
Dwafoakwa	372	58	50	86.2
Dwenease	1,857	400	80	20.0
Kobriso	1,157	210	68	32.4
Kwekusae	269	38	38	100.0
Kwesikomfo	596	107	52	48.6
Larbikrom	421	107	52	48.6
Mpeasem	384	63	50	79.4
Osafo	209	28	28	100.0
Pameng	1,304	224	69	30.8
Pano	605	120	55	45.8
Pinamang	4,340	687	87	12.7
Potroase	1,759	356	78	21.9
Sagyimase	1,817	392	80	20.4
Takyiman	3,786	670	87	13.0
Totals	**43,600**	**9,216**	**2,092**	**Overall = 21.0**
Mean/Median	**1,363**	**288**	**65**	**Median = 32.3**

6.2.2 Design of Questionnaire

The main conservation issues identified and used in designing the questionnaire included illegal timber logging, exploitation of game for meat (bushmeat), encroachment of forests for crop farming, collection of non-timber forest products, and bushfires. These issues were identified during meetings with community leaders and field staff of the conservation agencies working in the two areas, and from my professional experience in the two areas. Other sources of these issues included literature such as project reports of Ghana Wildlife Society, Owusu (2001), and the Biodiversity Management Plan for Atewa and Atewa Extension Forest Reserves (Forestry Commission 2001).

I tested the draft questionnaire by a conducting a pilot survey of 10 respondents in the Afadjato-Agumatsa and 15 respondents in the Atewa area. This helped me to check for clarity of and assess potential challenges in translating the questionnaire. I accordingly modified questions which were not clear, after which I discarded the pilot data. The questionnaire consisted of four sections, which included: 1) An introductory part, which introduced the study as an academic work from the University of Central Florida; 2) A section which estimated forest conservation attitudes (FCAs); and the New Ecological Paradigm (NEP) scale section, which estimated general environmental attitude; 3) A section which estimated stated frequency of forest use; and 4) A section for socio-demographic data. The questionnaire for the FCA scale had 10 statements, modeled after Gubbi et al. (2009). Five of the statements were pro-forest conservation and the other five were anti-forest conservation (Table 6.5).

Table 6.5: A forest conservation scale for measuring conservation attitudes.

Positive attitude statements	**Negative statements**
1. It is important to protect the forest.	1. People should be allowed to hunt for bushmeat freely.
2. The forest is important for my children's future.	2. Wild animals damage our crops, they should all be exterminated.
3. People should not be allowed to fell trees or hunt.	3. The forest should be cleared.
4. Protecting the forest benefits us in this area.	4. The forest should be released for farming.
5. These forests are our heritage, they need to be protected.	5. Trees should be logged for us to get jobs.

The New Ecological Paradigm (NEP) scale was originally developed by Dunlap and Van Liere (1978) as the New Environmental Paradigm and was revised and renamed to the current name in 2000 (Dunlap et al. 2000). It is the most widely used measure of environmental attitudes and measures general beliefs about how human beings perceive their relationships with the environment. The validity and reliability of the NEP scale for measuring environmental attitudes have been well-established (Hawcroft and Milfont 2010). This scale is based on five facets of an ecological worldview namely (1) the reality of limits to growth, (2) anti-anthropocentrism, (3) the fragility of the balance of nature, (4) rejection of exemptionalism, and (5) the possibility of an eco-crisis (Dunlap et al. 2000). The scale consists of 15 items, eight of which are pro-NEP and 7 are anti-NEP. Responses to the 15 items were based on a 5-point Likert-type scale consisting of strongly agree (SA), mildly agree (MA), unsure (U), mildly disagree (MD) and strongly disagree (SD). Agreeing to the pro-NEP items and disagreeing with the anti-NEP items indicate a pro-ecological worldview (Dunlap et al. 2000). For this study I modified the eleventh NEP item, which states that: *The earth is like a spaceship with limited room and resources* to: *The earth is like a car or room with limited room and resources.* This modification was necessary because rooms and/or cars make better practical sense than spaceships for respondents in the study areas.

The NEP scale has been used in a wide range of environmental studies such as environmental sustainability studies (Barr and Gilg 2006), waste management (Chung and Poon 2001), watershed management (Cooper et al. 2004), the use of genetically modified organisms (Hall and Moran 2006), water and energy conservation (Kurtz et al. 2005), biodiversity conservation behaviors and attitudes (Schultz et al. 2005), green buying (Mainieri et al. 1997), fisheries management (Steel et al. 2005), protected area management (Liu et al. 2010), nature tourism (Luo and Deng 2008).

Pretest environmental attitude measures were not available for the study areas. Therefore proxy pretest attitudes were employed. Two types of proxy pretest measures have been described by Trochim (2006). These are archival proxy pretest, which are derived from documented records of the study subjects; and recollection proxy pretest measures which are estimated by asking respondents to estimate what their responses would have been before the LSA intervention started. For this study, archival proxy pretest data were not available; therefore recollection proxy pretest attitude scores were employed. Proxy pretest scores may be inadequate, but they are the best option if there is no pretest data and the issue being investigated is about the respondents' perceptions (Trochim 2006). Aeby et al. (2011) explain that recollection proxy pretest designs reduce the tendency for respondents to adjust the criteria for self-rating (response-shift) as may occur in a pretest-posttest only designs. In pretest-posttest only designs, respondents tend to adjust the criteria for self-rating because of different learning experiences during program implementation. Recollection proxy pretest posttest designs also reduce the probability rejecting a potentially beneficial intervention (Type II error); and they are better than using posttest only designs for evaluating a program that has already began (Aeby et al. 2011). For both environmental attitudes scales, we obtained the recollection proxy pretest scores by asking respondents to tell how they would have responded to the same attitude statements just before the LSA interventions were introduced.

The self-reported frequency of resource use section asked respondents to estimate the number of times they visited the forests each week. Socio-demographic data included the community, age, income level, gender, level of formal education, number of years in the community, and whether the respondent was a conservation actor (i.e. a worker, volunteer or beneficiary of LSA activity).

6.2.3 Data Collection

The data was collected using group discussions and questionnaire interviews. A sample questionnaire is in Appendix E of this dissertation. I tested the questionnaires and organized group discussions with traditional leaders, staff of conservation agencies and local conservation volunteers to confirm the main forest conservation issues. I led a team of 15 interviewers to conduct face to face questionnaire interviews in December 2009 and January 2010. Prior to the interviews, the interviewers were trained in understanding the aim of the study, understanding and translating the questions into the local languages, avoiding biases during interviews, ethical issues in face to face interviews, and traditional norms in the study areas.

We conducted the interviews and group discussions using the English and Ewe languages in the Afadjato-Agumatsa area; and English and Twi languages in the Atewa area. In each community, we selected the households by randomly generating house numbers from the total number of households, without replacement. The first adult (aged over 18 years) householder an interviewer encountered was interviewed after permission has been granted by the head of the household. Before each interview started, the aim of the study, and the rights of the respondent were briefly explained. This was primarily for ethical reasons. It also helped to put respondents at ease and thus helped to reduce biased responses. In order to improve reliability by preventing respondents following a trend and reducing biases in their responses, the FCA and NEP scale attitude questions were asked in a random order.

6.2.4 Data Compilation

The responses to the two attitudes scales were scored based on the Likert-type scale used. For the FCA scale, the responses were scored by assigning a score of +1 to an agreement with a positive question; -1 to a disagreement with a positive question; -1 to an agreement to negative -1 and a disagreement to a negative question, +1. Any other response was scored 0. Therefore the highest score for an individual would be 10 and lowest score would be -10. For the NEP scale, the responses were scored from a range of 1 to 5. Strongly agreeing to pro-NEP statements or strongly disagreeing with anti-NEP statements were scored 5; mildly agreeing to pro-NEP statements or disagreeing with anti-NEP statements were scored 4; being unsure of any of the 15

NEP scale statements were scored 3; mildly agreeing to anti-NEP statements or mildly disagreeing with pro-NEP statements were scored 2; and strongly agreeing to anti-NEP statements and strongly disagreeing with pro-NEP statements were scored 1. The highest score for an individual respondent would be 75 and the lowest score would be 5.

6.2.5. Addressing Methodology Issues

Likert-type scales present reliability challenges. Statistical tests are based on assumptions such as random assignment of subjects to treatments, a normal distribution and homoscedasticity of the data. I present how I addressed these challenges in pretest-posttest analyses.

6.2.5.1 Reliability Analyses of Environmental Attitude Scales

I used Cronbach's alpha to estimate the reliability of the two environmental attitude scales. Cronbach's alpha estimates the internal consistency of the measurement instrument and ranges between 0 and 1 (Trochim 2006). Good measurement instruments and scales have alphas over 0.8 and increasing the number of items on a scale increases the alpha (Norusis 2006). The reliability of the pretest scores of FCA and NEP scale attitudes yielded Cronbach's alphas of 0.777 and 0.271 respectively; and posttest scores yielded alphas of 0.674 and 0.194 respectively. This suggests that the FCA scale was more reliable than the NEP scale for estimating the attitude towards forest conservation.

6.2.5.2 Data Adjustments

A methodological challenge to using the raw mean pretest scores for the statistical analysis in this study is that many statistical models are based on the assumption that the subjects (the communities) are randomly assigned to the treatments (livelihoods support activities) and this accounts for errors in measurement. This is not the situation in many biodiversity conservation projects (Ferraro and Pattanayak 2006). The communities in the study areas were not randomly selected for livelihoods support activities. Trochim (2006) recommended using non-equivalent group design to address this methodological issue. This analysis design requires adjusting the pretest values by a reliability value before calculating the change in attitudes. I adjusted the pretest values using Cronbach's alphas of 0.777 and 0.271 for the FCA scale and the NEP attitude scale respectively. I used equation 6.2 recommended by Trochim (2006).

$$X_{adj.} = X_m + r(X - X_m) \quad \ldots \ldots \ldots (6.2)$$

Where, $X_{adj.} =$ adjusted pretest value,

$X_m =$ mean of original pretest values,

$r =$ the reliabilty value (e.g. alpha),

$X =$ original pretest values,

These adjustments prevented zero divisor errors in calculating proportional changes in attitudes. Before and after the adjustments, the data for pretest on both attitude scales did not have normal distributions. Both Shapiro-Wilk and Kolmogorov-Smirnov tests resulted in $p = 0$ in all cases. The data were negatively skewed, and ranking the attitude scores was more relevant than the actual scores. Therefore I used non-parametric tests for statistical analysis.

6.2.5.3 Non-parametric Analysis of Covariance and Regression Analysis

Homoscedasticity (homogenous variances) of the residuals is an assumption in regression analysis and analysis of covariance. That was not the case with the raw pretest scores, the adjusted pretest scores, posttest scores, the difference scores or the proportional change scores of individual respondents did not show homoscedasticity. Bonate (2000) recommended the use of non-parametric analysis which addresses heterogeneity of the regression coefficients. Three of such tests include Quade's non-parametric ANCOVA (Quade 1967), Puri and Sen's non-parametric ANCOVA (Puri and Sen 1969) and parametric ANCOVA applied to ranked pretest and posttest scores applied by Conover and Iman (1982), Olejnik and Algina (1984), and Seaman et al. (1985). Among these, the most robust was the procedure of Quade (1967), which conducts parametric tests on residual deviation rank scores. Residual deviation rank scores are mean corrected rank transformations (Quade 1967 as cited by Bonate 2000) of posttest scores., and they rank scores account for covariation of pretest scores.

I obtained the residual deviation rank scores of the environmental attitudes of each individual respondent on the two attitude scales by the following steps derived from Bonate (2000):

1. Separately rank adjusted pretest scores and posttest scores.

2. Convert rank scores into deviation scores using equations (6.3) and (6.4).

$$\mathrm{DEV_{obspost}} = \text{Rank score of posttest scores} - \text{mean rank of posttest scores} \ldots\ldots\ldots\ldots\ldots\ldots \quad (6.3)$$

$$\mathrm{DEV_{obspre}} = \text{Rank score of pretest scores} - \text{mean rank of pretest scores} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6.4)$$

Where, $\mathrm{DEV_{obspre}} =$ Deviation score of adjusted pretest scores, and

$\mathrm{DEV_{obspost}} =$ Deviation score of posttest scores

3. Determine the predicted deviation rank of the posttest scores using equation (6.5):

$$\text{DEV}_{\text{predpost}} = \text{DEV}_{\text{obspre}} \text{ X } \rho \ldots\ldots\ldots\ldots\ldots\ldots (6.5)$$

Where, $\text{DEV}_{\text{predpost}} =$ the predicted deviation rank of posttest, and

$\rho =$ Spearman rank correlation coefficient of the raw ranks

4. Determine the residual deviation rank score, E_r using equation (6.6):

$$\text{Residual deviation rank score, } E_r = \text{DEV}_{\text{obspost}} - \text{DEV}_{\text{predpost}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.6)$$

Where, $E_r =$ the residual deviation rank score

5. Conduct parametric tests on the residual deviation rank scores, E_r.

Residual deviation rank scores accounted for the covariation of the adjusted pretest scores with the posttest scores. I conducted inferential statistical tests on the residual deviation rank scores of FCA and NEP scales in most cases.

6.2.5.4 Addressing the Issue of Difference Scores versus Proportional Change Scores

Another methodological issue was whether to use difference scores or proportional change scores as the estimate of change in attitude. Kaiser (1989) as cited by Bonate (2000) suggested using the measure which correlates less with the pretest scores because it corrects for regression towards the mean. Tests for correlations among the FCA scores of individual respondents indicated that the proportional change scores correlated more (Spearman's rho = 0.204) with the adjusted pretest scores than the difference scores (Spearman's rho = 0.114) correlated with the adjusted pretest scores. On the NEP scale, the correlation coefficient between the proportional change scores and the adjusted pretest scores (Spearman's rho = 0.137) was greater than correlation coefficient between the difference scores and the adjusted pretest score (Spearman's rho = 0.130). Therefore I used the difference scores as estimates of change in attitudes of individuals in most cases.

6.2.6 Data Analysis

I used the statistical software IBM SPSS statistics 19 (IBM Inc. 2010) and Microsoft Excel Analysis ToolPak (Microsoft Corporation 2007) for data analysis.

6.2.6.1 Determination of Overall Changes in Environmental Attitudes

I estimated the overall environmental attitudes (EAs) using the mean of FCA and NEP scores of the individual respondents. I tested for a significant increase in EAs using the non-parametric One-Sample Wilcoxon Signed Rank Test on the median posttest environmental attitude scores, using the median adjusted pretest scores as the test values. This was because the posttest scores of individuals on the two EA scales did not exhibit normal distribution.

6.2.6.2 Analysis of How Socio-Demographic Factors Predicted Environmental Attitudes

I employed multiple regression analysis to determine whether and how socio-demographic factors predicted FCA and NEP attitude scores, using Akaike's Information Criteria (AIC) to select the best regression model. The residual deviation rank scores of individual respondents was the dependent variable and the socio-demographic factors of respondents were the predictor variables. The socio-demographic factors included age, gender, highest educational level, tenure (number of years the respondent had lived in the community), income, whether the respondent was conservation actor, whether the respondent lived in an LSA community, whether the respondent lived in an LSA community in which the LSA was active, and the study area of the respondent. A conservation actor was an employee of a conservation agency or a prominent and active conservation volunteer. This group includes LSA beneficiaries.

6.2.6.3 Analysis of Correlations between Environmental Attitudes and Forest Use Frequency

The posttest scores of individuals on the two environmental attitude scales did not show normal distributions (Shapiro-Wilk tests yielded $p = 0$ on both scales). Therefore, I employed the non-parametric Spearman's rank correlation to determine correlations between the stated frequency of forest use and the posttest attitude scores on both the FCA and NEP scales.

6.2.6.4 Comparing Environmental Attitudes in the Study Areas

I compared EAs in the two study areas because the areas have different locations, land tenure systems, forest conservation and management regimes, number of years of formal forest conservation, type of conservation agency and other socio- demographic factors. I employed Wilcoxon-Mann-Whitney tests to test for differences in individuals' pretest scores, posttest scores and the residual deviation rank scores and community attitudes on both EA scales.

6.2.6.5 Comparing Environmental Attitudes in LSA and Non-LSA Communities

To compare the EAs in communities that participated in LSAs (LSA communities) with non-participant communities (non-LSA communities), I conducted the Wilcoxon-Mann-Whitney test on individual pretest scores, posttest scores, residual deviation rank scores, and community attitude scores of both FCA and NEP attitudes.

6.2.6.6 Estimating the Effects of Participation in LSA on Forest Conservation Attitudes

Multiple regression analysis assumes that each subject (community) had equal probability of being an LSA community and this is achieved by randomly assigning the treatment (LSAs) to the communities in a purely experimental design. This was not the case in this study, so I applied propensity score matching (PSM) analysis (Rosenbaum and Rubin 1983) to match the communities. PSM reduces selection bias and creates a counterfactual of the effects of the intervention. Propensity scores in this study represent the probability of a community participating in the LSAs. These scores are typically estimated from a statistical model of participation as a function of ecological, socio-economic, institutional, and geographic factors (Ferraro and Pattanayak 2006). The general procedure for PSM derived from Rosenbaum and Rubin (1983) and Luellen et al. (2005) are as follows:

1. Run logistic regression:
    - Dependent variable: use dummy variable $Y = 1$, if participate; $Y = 0$, otherwise.
    - Choose appropriate instrumental variables. The variables must overlap.
    - Obtain propensity score from: predicted probability (p) or log $[p/(1-p)]$.
2. Match each participant to one or more nonparticipants based on their propensity scores.
    - Group them into strata, based on the propensity scores. Use at least 5 strata.
3. Conduct a multivariate analysis based on new sample.
    - Within each stratum, compare the responses of participants with non-participants.
    - Summarize the measure of treatment effects into a Direct Adjustment Estimator. In case there are different sample sizes in each stratum, use weighted responses.

The instrumental variables are factors which were most likely to determine whether a community participated in the LSA or not. I obtained eight variables (Table 6.6) during group discussions with LSA participants, and past and current managers of the conservation programs. I estimated the Direct Adjustment Estimator (DAE) using mean weighted effect size of FCAs because of the small sample sizes of each stratum. Effect size is valuable as a simple and easily understood way to quantify the effectiveness of an intervention Coe (2002), is mainly used in meta-analysis and quantifies the size of the difference between two groups.

$$\text{Effect size} = \frac{(\text{Mean of Treatment Group} - \text{Mean of Control Group})}{\text{SD}_{\text{pooled}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.7)$$

$$\text{SD}_{\text{pooled}} = \sqrt[2]{\{[(\text{N}_\text{T} - 1)\,\text{SD}_\text{T}^{\,2} + (\text{N}_\text{C} - 1)\text{SD}_\text{C}^{\,2}] \div (\text{N}_\text{T} + \text{N}_\text{C} - 2)\}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.8)$$

Where, SDpooled is the pooled standard deviation

N_T is the sample size of the treatment group

N_C is the sample size of the control group

SD_T is the standard deviation of the treatment group

SD_C is the standard deviation of the control group

Table 6.6: Instrumental variables used for determining propensity scores of communities.

#	Instrumental variables	Descriptions			
		Afadjato-Agumatsa area		Atewa area	
		Attribute	**Code**	**Attribute**	**Code**
1.	Study area	Located in the Afadjato-Agumatsa area	1	Located in the Atewa area	2
2.	Location in administrative area	Located within the Gbledi and Fodome Ahor communities	1	Located within the East Akyem and Atiwa Political Districts	1
		Located outside the Gbledi and Fodome Ahor communities	0	Located outside the East Akyem and Atiwa Political Districts	0
3.	Expert perception of level of resource exploitation (e.g. timber, bushmeat)	High	1	High	1
		Low	0	Low	0
4.	Proximity to boundary of protected forest	Near	1	Near	1
		Far	0	Far	0
5.	Forest management prescription and action	Logging, hunting and new crop farming not allowed	1	Protected Globally Significant Biodiversity Areas (GSBAs)	1
		Logging, hunting, and/or new crop farming goes on	0	Non-GSBAs (Taungya allowed)	0
6.	Status of traditional ruler	Highest level	2	Highest level	2
		Medium level	1	Medium level	1
		Low level	0	Lower level	0
7.	Conservation worker lives in community	Yes	1	Yes	1
		No	0	No	0
8.	Dominant ethnic or tribal group	Natives	1	Natives	1
		Non-natives	0	Non-natives	0

6.2.6.7 Comparing Forest Conservation Attitudes in LSA-active and LSA-inactive Communities

The continuity and sustainability of LSAs in the communities was another factor deemed important for influencing conservation attitudes. This was based on the assumption that the longer the time people spend on conservation project-funded LSAs, the better and longer the opportunities they have to change their attitudes towards the environment. Forest conservation is the focus in the study areas, and preliminary analyses indicated that FCA scores were more reliable than NEP scores. Therefore I compared FCA scores in communities in which LSAs were active (LSA-active) to FCA scores in communities in which the LSA had stopped (LSA-inactive) at the time of the study. I employed Wilcoxon-Mann-Whitney test on individual pretest scores, posttest scores, residual deviation rank scores, and community attitude scores of FCAs. This analysis was restricted to FCAs in the Atewa area because only the Atewa area had both LSA-active and LSA-inactive communities. All LSA communities in Afadjato-Agumatsa had active LSAs at the time of the study in 2009/2010.

6.2.6.8 Determining How Estimates of LSAs Predicted Forest Conservation Attitudes

The socio-economic estimates of LSA attributes in communities, namely the per capita values of the capital investments, net socio-economic benefits and the benefit-cost ratios estimated in Chapter 5 were employed in this analysis. To determine whether and how these LSA attributes predicted FCAs, I used multiple regression analyses in which the dependent variable was the mean residual deviation rank score of each community and the predictor variables were per capita values of each LSA estimate. I selected the best regression model on the basis of Akaike's Information Criteria (AIC).

6.3 Results

6.3.1 Socio-Demographic Characteristics of Respondents

The socio-demographic factors of the respondents in both study areas are outlined in Table 6.7. Overall, more males (52.6%) were interviewed than females (47.4%). A one sample binomial test indicated that these proportions were significantly different (p = 0.010). In the Afadjato-Agumatsa area more males (56.4%) were interviewed than females (43.6%). A one sample binomial test indicated that these proportions were significantly different (p = 0.007). In the Atewa area, more males (51.7%) were interviewed than females (48.3%). However these were not significantly different (p = 0.121). The significantly higher number of males interviewed could be explained by the cultural practice of men more willing to speak to strangers than women. Also this difference was much influenced by the data of the smaller sample size (461) respondents interviewed in the Afadjato-Agumatsa area. The similar sampling of genders in the Atewa area could be because of the larger sample size (2,092) of respondents in the area.

Age categories were based on generational influences since the conservation project funded LSAs started around 2000. The age categories used were those younger than 30 years (representing people who were not adults before LSA use started); those aged from 30 to 40 years old (representing young adults in 2000), those aged 41 to 60 years (representing the rest of the adults who are still actively working) ; and those aged over 60 years (representing currently retired citizens). In both study areas, the most sampled age group was those in the 41-60 years group, and least sampled age group was the retired citizens (Table 6.7). The large number of respondents in the 41-60 years age group could be explained by the group having the widest age range of 20 years, are most likely to be the heads of households and therefore most likely to respond to interviewers. The low number of respondents aged over 60 years is consistent with the age distribution in Ghana, and this conforms to a life expectancy of 57 years in 2009 (UNICEF 2010) in the country. In the Atewa area, the proportion of respondents who were older (aged over 40 years) was greater (51.1%) than the proportion of respondents (48.9%) who were younger (aged 40 years or younger). A one sample binomial test indicated that the proportions were not significantly different (N = 2,092, p = 0.352). In the Afadjato-Agumatsa area, there was a greater proportion (50.6%) of older (aged over 40 years) respondents than younger (aged 40 years or younger) respondents (49.4%) who were, but these were not significantly different (N = 461, p = 0.852). These suggest that in the two study areas and overall, the proportion of those who were not yet and adults did not differ from older ones.

The educational level with the largest sample size in both study areas was those with basic education (overall of 59.7%), and the smallest sample size was an overall 3.5% of respondents having tertiary education (Table 6.7). In the Afadjato-Agumatsa area, 54.7% of respondents had basic education and 7.4% of them had tertiary education. In the Atewa area, 60.9% of respondents had basic education and 2.6% of them had tertiary education (Table 6.7). This is consistent with educational levels in rural areas in Ghana because of the high urban rural-urban drift and the fact that there are few jobs for educated people in rural areas.

With respect to tenure in the community, respondents who had lived in their communities for more than 20 years were the most surveyed (overall of 53.2%). People who had lived in their communities for less than 10 years were the least surveyed (21.2%). In the Afadjato-Agumatsa area, 64.2% and 15.8% of the respondents had lived in their communities for over 20 years and less than 10 years respectively. In the Atewa area, 50.8% and 22.4% had lived in their communities for over 20 years and less than 10 years respectively. This sample composition is consistent with the aim of the research because it is expected that those with long tenures in the communities can provide better comparisons of environmental attitudes before the introduction of LSAs funded by biodiversity conservation projects.

Income level categories were based on multiples of the minimum wage in Ghana ($2.50/day). The largest sample size was recorded for those who earned $2.50 to $5.00 a day and the smallest sample size was obtained from those who earned more than $10.00 a day (Table 6.7). The group whose income was less than $2.50 was the second largest group sampled in the two study areas. This group and those who earned $2.50 to $5.00 formed an overall of 71.4% of respondents. These data reflect the low income levels of people living in Ghana. Also overall 26.7% of the respondents had income less than $2.50. This compares well with the national poverty level of 30% below the international poverty line of $1.25 per day (UNICEF 2010).

In both study areas, more non-conservation actors were surveyed than conservation actors (Table 6.7). Proportion of respondents who were conservation actors in Afadjato-Agumatsa (34.5%) was more than the proportion in Atewa (15.97%). Afadjato-Agumatsa area is most likely to have a higher proportion of conservation actors surveyed because formal forest conservation in the area is a community-based program. In the Atewa area, the forest has been managed by the government agency since the reserve was established in 1925. Community participation in forest conservation was introduced after decades of strict restrictions.

Table 6.7: Socio-demographic characteristics of respondents to attitude surveys.

Socio-demographic Characteristics		Study Area				Totals	
		Afadjato-Agumatsa		Atewa			
		Number	%	Number	%	Number	%
Gender	Female	201	43.6	1,010	48.3	1,211	47.4
	Male	260	56.4	1,082	51.7	1,342	52.6
	Totals	461	100	2,092	100	2,553	100
Age group (years)	<30	110	23.9	562	26.9	672	26.3
	30 – 40	118	25.6	461	22.0	579	22.7
	41- 60	152	33.0	719	34.4	871	34.1
	≥61	81	17.6	350	16.7	431	16.9
	Totals	461	100	2,092	100	2,553	100
Education	None	63	13.7	223	10.7	286	11.2
	Basic	252	54.7	1,273	60.9	1,525	59.7
	High school	112	24.3	541	25.9	653	25.6
	Tertiary	34	7.4	55	2.6	89	3.5
	Totals	461	100	2,092	100	2,553	100
Tenure: No. of years in community	<10	73	15.8	468	22.4	541	21.2
	10-20	92	20.0	561	26.8	653	25.6
	>20	296	64.2	1,063	50.8	1,359	53.2
	Totals	461	100	2,092	100	2,553	100
Income level ($/day)	<2.50	146	31.7	536	25.6	682	26.7
	2.50 - 5.00	187	40.6	955	45.7	1,142	44.7
	5.00 - 7.50	59	12.8	287	13.7	346	13.6
	7.50 - 10.00	45	9.8	206	9.8	251	9.8
	>10.00	24	5.2	108	5.2	132	5.2
	Totals	461	100	2,092	100	2,553	100
Conservation actor	Yes	159	34.5	333	15.9	492	19.3
	No	302	65.5	1,759	84.1	2,061	80.7
	Totals	461	100	2,261	100	2,722	100

6.3.2 Overall Attitudes towards the Natural Environment

The total and mean FCA scores increased, but the NEP scores decreased (Table 6.8). The overall mean FCA score increased by 0.87 from 5.76 (standard error of mean = 0.06) to 6.63 (standard error of mean = 0.07). The overall mean NEP score decreased by 2.85 from 48.80 (standard error of mean = 0.03) to 45.95 (standard error of mean = 0.13). A Wilcoxon Signed Rank Test using the median adjusted pretest scores as the test values indicated that changes in both FCA and NEP scores were significant ($p < 0.001$ in both cases).

Table 6.8: Overall environmental attitude scores.

Estimates	Attitude scale					
	Forest Conservation Attitudes			New Ecological Paradigm Attitudes		
	Adjusted pretest score	Posttest score	Change in attitude	Adjusted pretest score	Posttest Score	Change in attitude
Total	14,699.00	16,930.00	+2231.00	124574.00	117299.00	-7275.00
Mean	5.76	6.63	+0.87	48.80	45.95	-2.85
Median	5.95	8.00		48.85	47.00	
Minimum	-6.49	-8.00		42.89	20.00	
Maximum	9.05	10.00		53.73	63.00	
Standard error	0.063	0.068		0.031	0.132	

6.3.3 Relationships between Forest Conservation Attitudes and New Ecological Paradigm Attitudes

All correlations between the adjusted pretest scores, posttest scores, and difference scores on the FCA and NEP scales were significant ($p = 0$ in all cases). Spearman’s rho values between the FCA and NEP scores were weak and ranged from 0.052 to 0.138 (Table 6.9).

Table 6.9: Correlation matrix of adjusted pretest, posttest and difference scores of attitudes.*

	Posttest FCA**	Adjusted Pretest FCA	Change in FCA	Posttest NEP***	Adjusted Pretest NEP	Change in NEP
Posttest FCA	1.000					
Adjusted Pretest FCA	0.687	1.000				
Change in FCA	0.710	0.114	1.000			
Posttest NEP	0.122	0.073	0.098	1.000		
Adjusted Pretest NEP	0.138	0.126	0.084	0.322	1.000	
Change in NEP	0.102	0.052	0.086	0.974	0.130	1.000

* Spearman's Correlation Coefficient was used, and all correlations were significant
** FCA is Forest Conservation Attitudes score.
*** NEP is New Ecological Paradigm score.

The highest correlation coefficient was 0.974 between change in NEP score and posttest NEP scores, followed by 0.710 between change in FCA score and posttest FCA scores suggesting that respondents who indicated higher attitude changes tended to indicate higher environmentalism. The highest correlation between two scores of the same type was 0.126 between the adjusted pretest scores, followed by 0.122 between the posttest scores, which were real time scores.

FCA scores had a higher reliability estimate (Cronbach's alpha = 0.777) than the NEP scale (Cronbach's alpha = 0.271). This suggests that the FCA scores were more reliable and consistent. Further analysis of the NEP scale responses also indicate that at least over 65% of respondents strongly agreed with five of the seven anti-NEP statements. The statements which generated such high agreements in descending order include:

1. Humans have the right to modify the natural environment to suit their needs.
2. Human ingenuity will insure that we do NOT make the earth unliveable.
3. The earth has plenty of natural resources if we just learn how to develop them
4. Humans were meant to rule over the rest of nature.
5. Humans will eventually learn enough about how nature works to be able to control it.

The first three of these statements involve exploitation of natural resources and so generated high agreement from the respondents. This could be explained by the fact that the communities are renewable resource communities where natural resource exploitation is the main livelihood source. Individuals living in such communities are connected to their biophysical environment through harvest exchange relationships (Marshall et al. 2005) and so will agree with statements that promote resource exploitation.

The fourth and fifth statements promote exemptionalism of humans. The high number of positive responses to these statements could be explained by traditional view in the study areas that humans are different from and superior to non-human living things.

6.3.4 Socio-Demographic Factors and Attitudes towards the Natural Environment

6.3.4.1 How Socio-demographic Factors Predicted Forest Conservation Attitudes

The best multiple regression model (using AIC) which predicted 13.6% of the variance showed that the overall model was significant ($F = 66.802$, $p < 0.001$) (Table 6.10). This suggested that collectively, the socio-demographic factors predict forest conservation attitudes in the communities in both study areas. Therefore the hypothesis that socio-demographic factors would significantly predict forest conservation could not be rejected. However, it is important to note that the regression model predicted only 13.6% of the variance and that suggests that socio-demographic factors were collectively weak predictors of forest conservation attitudes in the study areas, and this was is consistent with the literature (Entem 2007).

Table 6.10: Overall regression model of socio-demographics and forest conservation attitudes.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	94326545.142	6	15721090.857	66.802	0.000
	Residual	5.992E8	2546	235339.230		
	Total	6.935E8	2552			

Predictors: (Constant), Education, Number of years in the community (Tenure), Income, Conservation actor, Gender, Study area
Dependent Variable: Residual deviation rank score of forest conservation attitudes

The best model showed that three independent variables namely, study area and conservation actor and gender, were significant predictors of the change in forest conservation attitudes (Table 6.11). The study area was a higher predictor ($B = -441.963$, $p < 0.001$), where a respondent who lives in the Afadjato-Agumatsa area (coded 1) was more likely to have a higher change in FCA scores than one who lives in the Atewa area (coded 2). Conservation actors (coded 2) were more likely to have higher FCA scores than non-conservation actors (coded 1) (B = 76.514, p = 0.023). Male respondents (coded 2) tended to have higher FCA scores than female respondents (coded 1) (B = 80.133, p < 0.001).

Table 6.11: Parameter estimates of socio-demographic factors and forest conservation attitudes.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	668.730	70.087		9.541	0.000
	Study area	-441.963	25.589	-0.326	-17.272	0.000
	Conservation actor	125.451	24.839	0.095	5.050	0.000
	Gender	80.113	19.444	0.077	4.120	0.000
	Income	-9.432	8.771	-0.020	-1.075	0.282
	Tenure	3.374	12.063	0.005	0.280	0.780
	Education	1.325	11.831	0.002	0.112	0.911

Dependent Variable: Residual deviation rank score of forest conservation attitudes

6.3.4.2 How Socio-demographic Factors Predicted NEP Scale Attitudes

For the NEP scale attitudes, the best multiple regression model which predicted 4.5% of the variance score was significant (F = 120.623, p < 0.001). The only predictor variable was study area (Table 6.13). Respondents in Afadjato-Agumatsa tended to record higher NEP scores. So, I could not reject the hypothesis that socio-demographic factors would predict NEP attitudes.

Table 6.12: Overall regression model of socio-demographics and the NEP scale attitudes

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	700.294	65.172		10.745	.000
	Study Area	-384.898	35.045	-.212	-10.983	.000

Predictors: (Constant), Study area
Dependent Variable: Residual deviation rank score of New Ecological Paradigm (NEP) attitudes.

6.3.5 Frequency of Forest Use

The proportion of respondents who reported that they never went into the forests was highest in both the Afadjato-Agumatsa area (39%) and the Atewa area (58.5%). The least frequency was those who entered six times a week (Table 6.13). These frequencies were not consistent with the fact that the questionnaire was administered during the months of December and January when crop farming was reduced and so there was usually increased use of forest resources.

Table 6.13: Counts and percentages of frequencies of forest entry in the two study areas.

Study area		**Frequency of forest entry per week**								**Total**
		0	**1**	**2**	**3**	**4**	**5**	**6**	**≥7**	
Afadjato-Agumatsa	Count	180	80	79	49	21	11	1	40	461
	%	39.0%	17.4%	17.1%	10.6%	4.6%	2.4%	0.2%	8.7%	100.0%
Atewa	Count	1,223	239	252	171	78	50	44	35	2,092
	%	58.5%	11.4%	12.0%	8.2%	3.7%	2.4%	2.1%	1.7%	100.0%
Total	Count	1,403	319	331	220	99	61	45	75	2,553
	%	55.0%	12.5%	13.0%	8.6%	3.9%	2.4%	1.8%	2.8%	100.0%

There were insignificant correlations between posttest FCA scores and frequency of forest entry (Spearman's rho = 0.009), and between posttest NEP scores and frequency of forest entry (Spearman's rho = -0.023). Therefore, I rejected the hypothesis that there would be a strong relationship between the two EAs and the frequency of forest entry. The number of respondents who reported not entering the forests over the past one month before the surveys was unusually high (55%) even though every respondent agreed using at least one forest resource such as medicinal plants, fruits, timber, and bushmeat during the last month before the surveys. This could be because the respondents feared implicating themselves in illegal activities. The results suggested that the self-reported frequency of forest entry were not reliable proxies for the environmental behaviors of the respondents.

6.3.6 Environmental Attitudes in the Afadjato-Agumatsa Area

The adjusted pretest FCA scores of communities in the Afadjato-Agumatsa area ranged from 3.22 in Gbledi-Torglo to 7.01 in Wli-Afegame and Agorviefe. Posttest FCAs ranged from 7.17 in Fodome-Ando 2, to 9.02 in Wli-Todzi (Table 6.14). The smallest change in FCA score of 1.51 was recorded in Gbledi-Gbogame, and the largest change in FCA score of 5.19 was recorded in Gbledi-Torglo. The adjusted pretest NEP scores of the communities in the Afadjato-Agumatsa areas ranged from 48.47 in Fodome-Ando 2, to 49.23 in Gbledi-Agumatsa. The posttest NEP scores ranged from 47.57 in Wli-Afegame and Agorviefe, to 51.02 in Gbledi-Agumatsa. Only Gbledi-Agumatsa, Gbledi-Gbogame, and Wli-Todzi recorded increases in NEP attitudes (Table 6.14).

Communities in Afadjato-Agumatsa recorded a mean adjusted pretest FCA score of 5.36 (S.E. of mean = 0.42) and a mean posttest FCA score of 8.25 (S.E of mean = 0.20), resulting in a change in mean attitude of 2.89 (Table 6.14). On the NEP scale, change in mean attitude of 0.06 was recorded from a mean adjusted pretest of 48.78 (S.E. of mean = 0.11) and a mean posttest attitude score of 48.84 (S.E. of mean = 0.46). In Afadjato-Agumatsa area, FCA scores of communities increased by 53.9% and NEP scores of communities increased by 0.12%. The increase on the FCA scale was significant but it was insignificant on the NEP scale (Figure 6.1). This however suggests that from 2000 to 2010, environmental attitudes improved in the Afadjato-Agumatsa area.

Table 6.14: Environmental attitudes in the Afadjato-Agumatsa area.

Community	**Forest Conservation Attitudes**			**New Ecological Paradigm Attitudes**		
	Adjusted Pretest	**Mean Posttest**	**Attitude change**	**Adjusted Pretest**	**Mean Posttest**	**Attitude change**
Fodome-Ahor	5.87	7.90	2.03	48.56	48.23	-0.33
Fodome-Ando 2	4.65	7.17	2.52	48.47	47.81	-0.66
Gbedi-Agumatsa	5.11	8.70	3.59	49.23	51.02	1.79
Gbledi-Chebi	5.74	8.16	2.42	48.48	47.89	-0.59
Gbledi-Gbogame	6.53	8.04	1.51	48.78	48.81	0.03
Gbledi-Torglo	3.22	8.41	5.19	49.05	48.84	-0.21
Wli-Afegame & Agorviefe	7.01	8.63	1.62	48.54	47.57	-0.97
Wli-Todzi	4.75	9.02	4.27	49.15	50.56	1.41
Total	**42.88**	**66.03**	**23.15**	**390.26**	**390.73**	**0.47**
Mean	**5.36**	**8.25**	**2.89**	**48.78**	**48.84**	**0.06**
Standard error	**0.42**	**0.20**	**0.47**	**0.11**	**0.46**	**0.35**

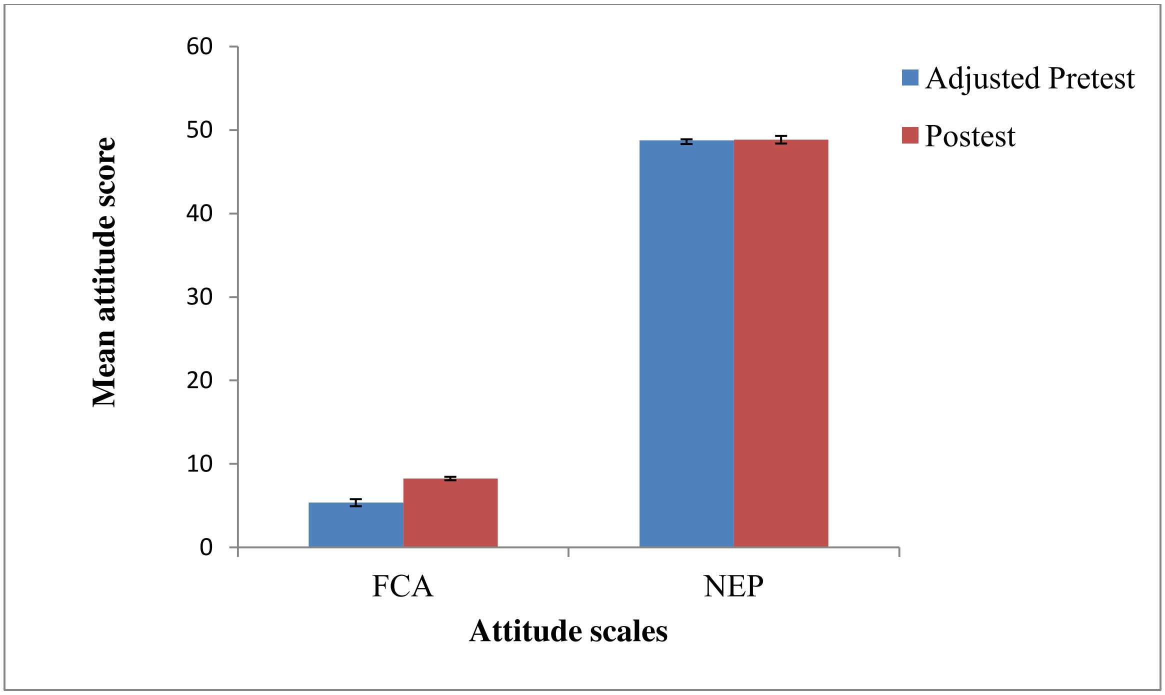


Figure 6.1: Changes in mean Forest Conservation Attitude (FCA) and New Ecological Paradigm (NEP) scores in the Afadjato-Agumatsa area. (Error bars are +/- SE).

6.3.7 Environmental Attitudes in the Atewa Area

In the Atewa area, the adjusted pretest FCA scores of communities ranged from 2.60 in Apapam to 7.17 in Kwesikomfo. Posttest FCA scores ranged from 4.26 in Apapam to 7.60 in Asiakwa (Table 6.16). The largest increase in mean FCA score of 1.66 was recorded in Apapam. One community, Dokyi did not record any change in FCA score. Four communities namely Apampatia, Kobriso, Mpeasem and Potroase recorded decreases in FCA scores (Table 6.16). The adjusted pretest NEP scale attitudes in the Atewa area communities ranged from 48.00 at Abesim to 49.87 at Takyiman. The posttest NEP scale attitudes ranged from 40.60 at Apampatia to 47.80 at Abesim. All the communities recorded decreases in NEP attitude scores (Table 6.15).

In the Atewa area, the communities recorded a change in mean FCA score of 0.45, resulting from a mean adjusted pretest FCA score of 5.78 (standard error of mean = 0.16) and a mean posttest FCA score of 6.23 (standard error of mean = 0.16) (Table 6.16). The mean NEP scores of the Atewa communities decreased by 3.48 from a mean adjusted pretest of 48.76 (standard error of mean = 0.07) to a mean posttest attitude score of 45.28 (standard error of mean = 0.31) (Figure 6.2). Among the communities in the Atewa area, the increase in FCA score was significant and the decrease in NEP score was significant. These results suggest that in the Atewa area, while the increase in attitudes towards forest conservation was minimal, general environmental awareness and attitudes towards nature decreased at a greater magnitude.

Table 6.15: Environmental attitudes in the Atewa area.

Community	Forest Conservation Attitudes			New Ecological Paradigm Scale		
	Adjusted pretest	**Mean posttest**	**Attitude Change**	**Adjusted pretest**	**Mean posttest**	**Attitude change**
Abesim	4.18	5.20	1.02	48.00	47.80	-0.20
Adadientem	5.55	5.63	0.08	48.57	46.31	-2.26
Adukrom	6.82	7.55	0.73	49.26	45.95	-3.31
Afiesa	5.85	6.68	0.83	48.70	44.00	-4.70
Ahwenease	5.26	5.36	0.10	48.72	45.66	-3.06
Akanteng	6.30	6.61	0.31	48.65	44.01	-4.64
Akropong	6.47	7.20	0.73	49.24	44.95	-4.29
Akwadum	6.22	6.97	0.75	48.47	45.56	-2.91
Akyeansa	6.56	6.93	0.37	49.09	45.01	-4.08
Apampatia	5.35	4.80	-0.55	48.38	40.60	-7.78
Apapam	2.60	4.26	1.66	48.75	46.94	-1.81
Asiakwa	6.99	7.60	0.61	49.18	46.86	-2.32
Asikam	4.88	5.27	0.39	48.85	46.46	-2.39
Awenare	6.79	6.83	0.04	49.80	46.32	-3.48
Banso	5.23	6.05	0.82	48.98	46.51	-2.47
Bomaa	5.81	6.10	0.29	48.89	46.47	-2.42
Dokyi	6.72	6.72	0.00	48.58	44.35	-4.23
Dompim	4.42	5.21	0.79	49.64	46.73	-2.91
Dwafoakwa	5.36	6.36	1.00	48.48	43.62	-4.86
Dwenease	5.91	6.98	1.07	48.27	41.93	-6.34
Kobriso	5.21	4.91	-0.30	49.00	44.73	-4.27
Kwakusae	5.50	5.95	0.45	48.78	42.32	-6.46
Kwesikomfo	7.17	7.46	0.29	48.73	47.08	-1.65
Larbikrom	6.69	7.27	0.58	48.41	45.06	-3.35
Mpeasem	6.54	6.36	-0.18	48.21	42.90	-5.31
Osafo	5.67	5.93	0.26	48.57	45.43	-3.14
Pameng	5.97	6.17	0.20	48.53	46.96	-1.57
Pano	6.34	6.91	0.57	49.06	45.89	-3.17
Pinamang	6.11	6.69	0.58	49.02	47.70	-1.32
Potroase	5.21	4.82	-0.39	48.43	42.67	-5.76
Sagyimase	5.58	6.38	0.80	48.20	45.99	-2.21
Takyiman	5.59	6.09	0.50	48.87	46.05	-2.82
Total	**184.85**	**199.25**	**14.40**	**1560.31**	**1448.82**	**-111.49**
Mean	**5.78**	**6.23**	**0.45**	**48.76**	**45.28**	**-3.48**
St. Error	**0.16**	**0.16**	**0.08**	**0.07**	**0.31**	**0.29**

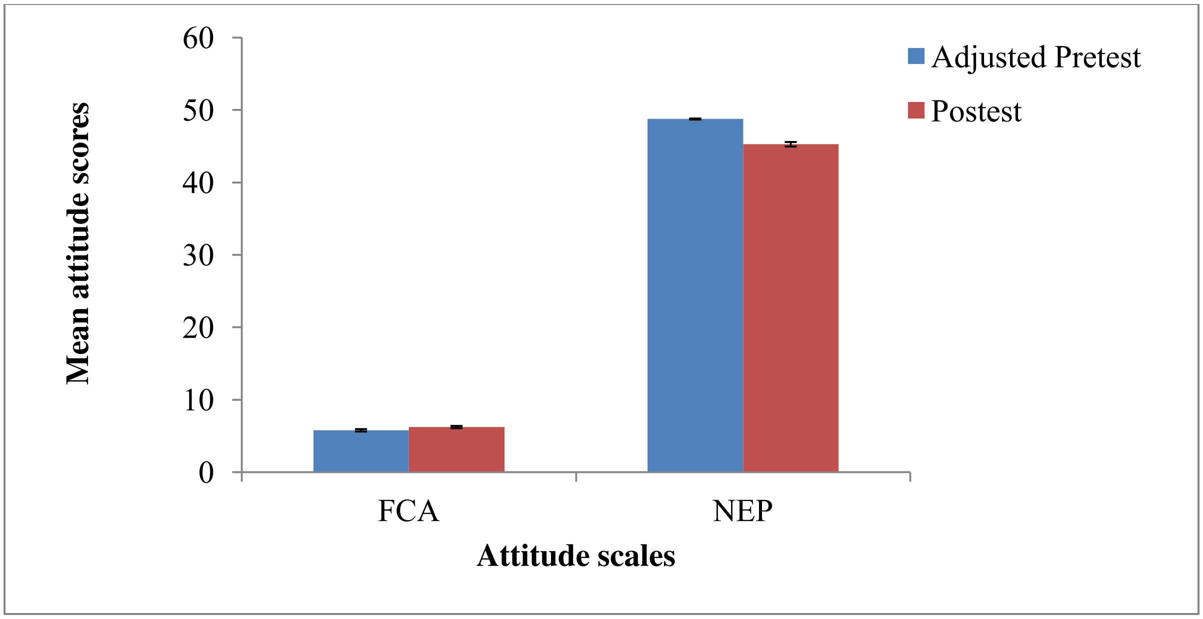


Figure 6.2: Changes in mean forest conservation attitude (FCA) and New Ecological Paradigm (NEP) scores in the Atewa area. (Error bars are +/- SE).

6.3.8 Comparisons of Environmental Attitudes in Afadjato-Agumatsa and Atewa

Mean adjusted pretest FCA score was higher in Atewa (5.78) than in Afadjato-Agumatsa (5.36), but the mean posttest FCA score was lower (6.23) in Atewa than in Afadjato-Agumatsa (8.25) (Figure 6.3). Therefore, the change in mean FCA was higher in Afadjato-Agumatsa than in the Atewa area. A Wilcoxon-Mann-Whitney test indicated that the adjusted pretest FCA scores of individuals were not significantly different between the two study areas ($p = 0.710$) but the posttest FCA scores and the residual deviation rank scores of FCAs of individuals were significantly higher in Afadjato-Agumatsa than in Atewa ($p = 0.000$ in both cases). These results are illustrated in Figure 6.3.

Therefore, the hypothesis that forest conservation attitudes in Afadjato-Agumatsa will be more favorable than in Atewa could not be rejected. These results suggested that pretest attitudes in the two study areas were similar but change in attitudes were more favorable towards forest conservation in the Afadjato-Agumatsa area communities than in the Atewa area communities. The lower increase in FCA score in Atewa than in Afadjato-Agumatsa could be explained by the fact that the Atewa Range has been a forest reserve for decades before LSA and collaboration with communities were introduced in the late 1990s and early 2000s. Therefore changing perceptions about and attitudes towards the forest conservation would be more difficult. In Afadjato-Agumatsa, LSAs were introduced with the beginning of active forest conservation in the area in 1999.

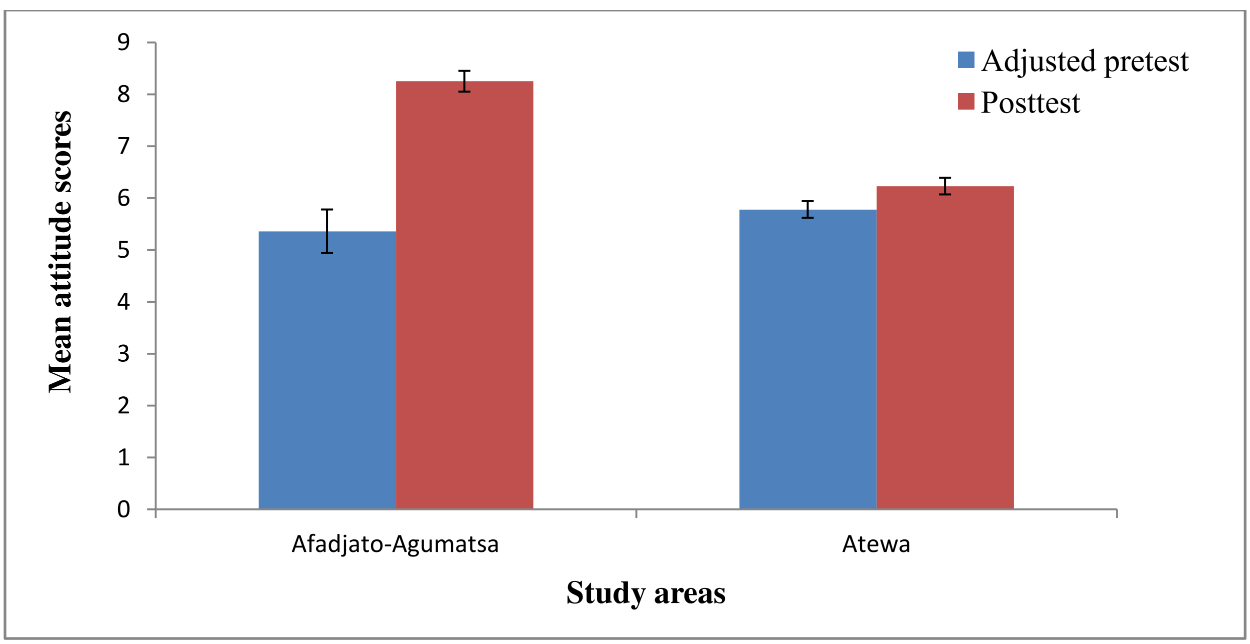


Figure 6.3: Forest Conservation Attitudes in the two study areas. (Error bars are +/- SE).

On the NEP attitude scale, mean adjusted pretest score was marginally higher in Afadjato-Agumatsa (48.78) than in the Atewa area (48.76) (Figure 6.4). However, mean posttest attitudes score was much higher in Afadjato-Agumatsa (48.76) than in the Atewa area (45.28). Therefore, while mean NEP score increased by 0.06 in Afadjato-Agumatsa, it decreased by 3.48 in Atewa. The increase in NEP score in Afadjato-Agumatsa was not statistically different, but the decrease in NEP score at Atewa was significant. These changes in the NEP score were significantly different between the two study areas. Therefore, the hypothesis that changes in NEP scores in Afadjato-Agumatsa will be more favorable than in Atewa was rejected. These results suggest that general environmental attitudes had not changed in Afadjato-Agumatsa but had decreased in Atewa.

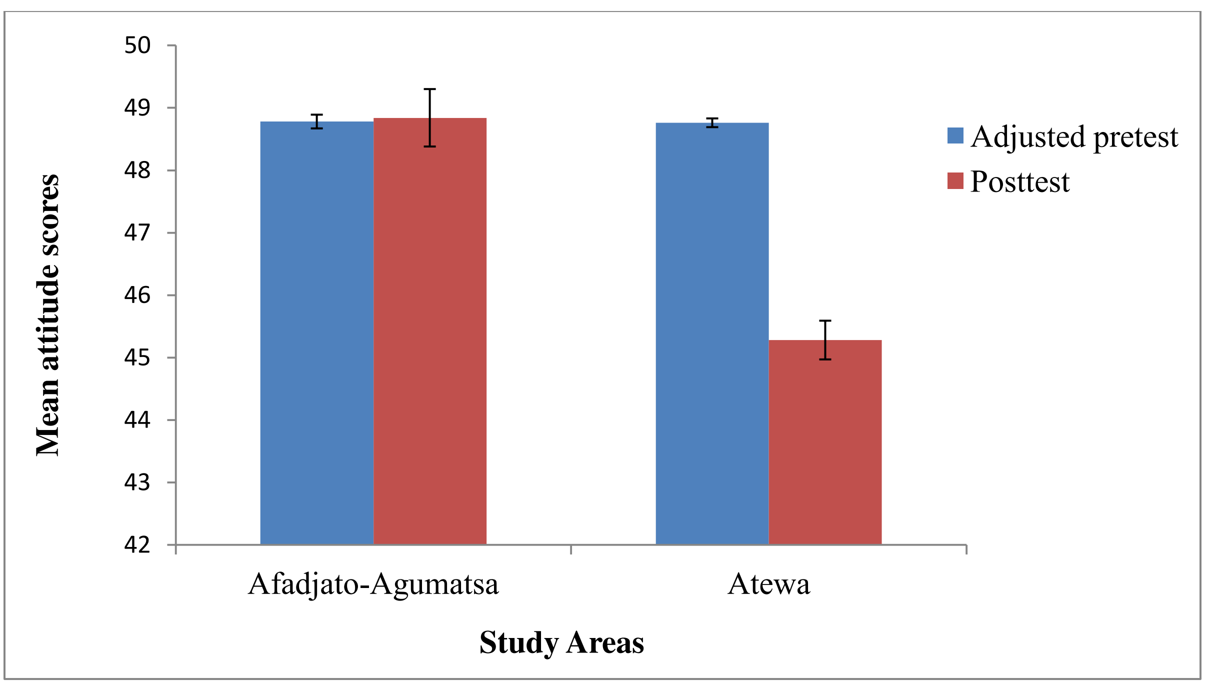


Figure 6.4: New Ecological Paradigm attitudes in the two study areas. (Error bars are +/-SE).

Table 6.16 is a summary of the significance and insignificance of the differences in environmental attitudes scores between the two study areas.

Table 6.16: Summary of differences in FCA and NEP scores between the two study areas.

Attitude Scale	**Type of attitude score**		
	Adjusted pretest score	Posttest score	Change in attitude score**
FCA* score	Not significant	Significant	Significant
NEP* score	Not Significant	Significant	Significant

* FCA means Forest Conservation Attitudes and NEP means New Ecological Paradigm

** This was tested using the residual deviation rank scores.

Attitudes towards forest conservation and general attitudes towards the environment were higher in the Afadjato-Agumatsa area than in the Atewa area. The higher attitudes in Afadjato-Agumatsa than in Atewa could be explained from the fact that a greater proportion of the respondents were conservation actors in Afadjato-Agumatsa (34.5%) than in Atewa (15.9%).

6.3.9 Environmental Attitudes in LSA Communities and Non-LSA Communities

I compared environmental attitudes in communities that participated in LSAs (LSA communities) with those in communities that did not participate in LSAs (non-LSA communities). A total of 1,309 respondents lived in LSA communities; and these were made up of 238 and 1,071 in the Afadjato-Agumatsa and Atewa areas respectively. The number of respondents who lived in non-LSA communities was a total of 1,244; and these included 223 and 1,021 in the Afadjato-Agumatsa and Atewa areas respectively.

6.3.9.1 Overall Environmental Attitudes in LSA Communities and Non-LSA Communities

In LSA communities, mean FCA scores increased by 0.88 (Table 6.18). In non-LSA communities, mean FCA scores increased by 0.87. The mean NEP score increased by 13.29 in LSA communities, and increased by 13.60 in non-LSA communities (Table 6.18).

Table 6.17: Mean attitudes scores in LSA communities and non-LSA communities.*

Attitude scales	Attitude score type	Attitude scores			
		LSA communities		Non-LSA communities	
		Mean	S.E.**	Mean	S.E.
Forest conservation attitudes	Adjusted pretest scores	5.70	0.09	5.81	0.09
	Posttest scores	6.58	0.10	6.68	0.10
	Change in mean scores	0.88		0.87	
NEP*** scale attitudes	Adjusted pretest scores	48.74	0.05	48.86	0.04
	Posttest scores	46.08	0.19	45.80	0.19
	Change in mean scores	-2.66		-3.06	

* LSA means livelihoods support activities. ** S.E. is standard error of mean.
*** NEP means New Ecological Paradigm

Wilcoxon-Mann-Whitney tests indicated no significant difference in pretest FCA scores ($p = 0.451$), no significant difference in posttest FCA scores ($p = 0.699$) and no significant difference in change in FCA scores ($p = 0.929$) between LSA and non-LSA communities. The tests also indicated no significant differences in pretest NEP scores ($p = 0.071$), no significant difference in posttest NEP scores ($p = 0.680$), and no significant difference in change in NEP scores ($p = 0.252$) of individuals between LSA and non-LSA communities. Thus, there was no significant difference between EAs of LSA and non-LSA communities on both scales (Figures 6.5 and 6.6).

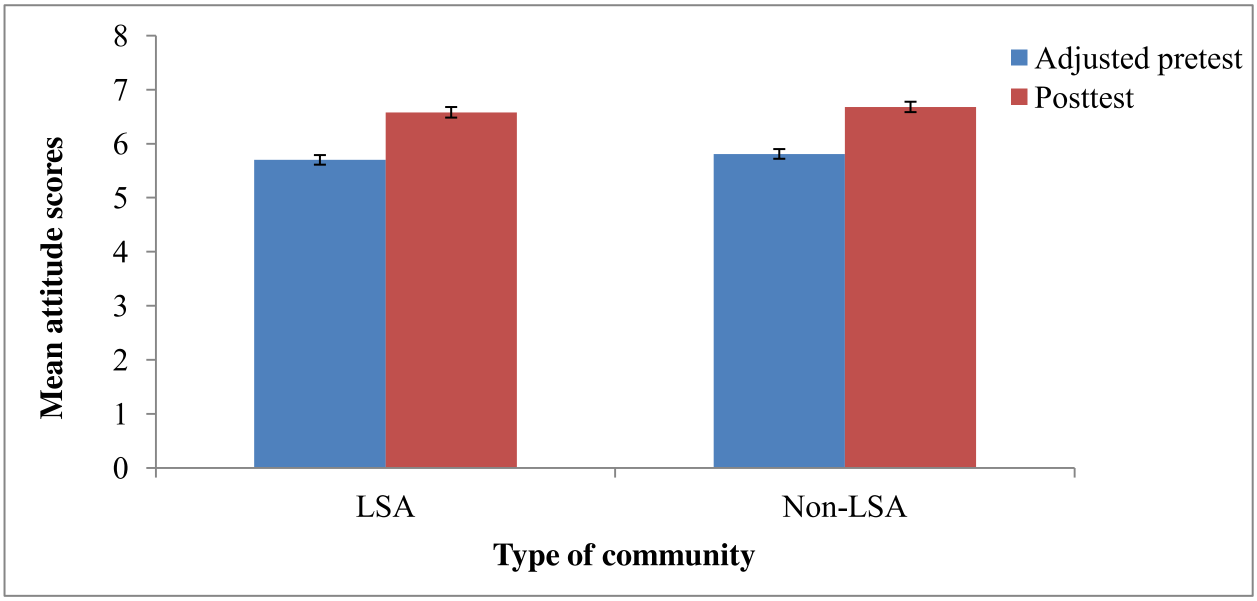


Figure 6.5: Forest conservation attitude scores in LSA and non-LSA communities. (Error bars are +/- SE).

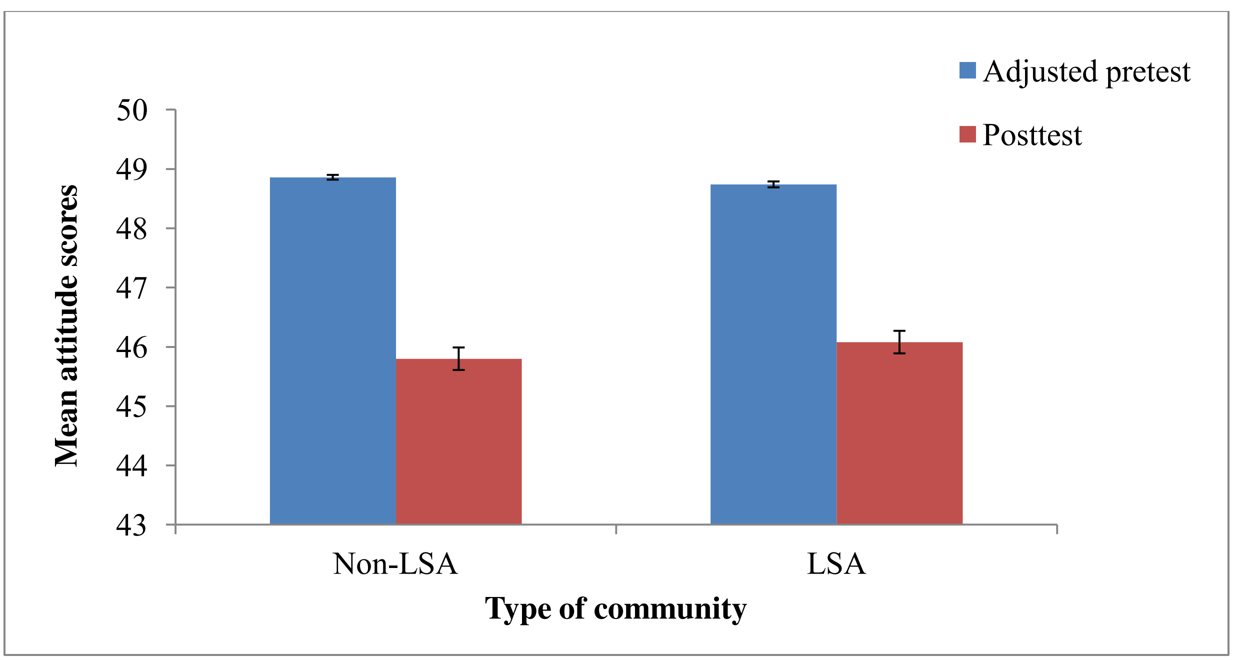


Figure 6.6: New Ecological paradigm (NEP) scale attitude scores in LSA and Non-LSA communities. (Error bars are +/- SE).

6.3.9.2 Environmental Attitudes in LSA and Non-LSA Communities in Afadjato-Agumatsa

The non-parametric Wilcoxon-Mann-Whitney test was used to test for differences in posttest scores and residual deviation scores of individuals on both FCA and NEP scales between LSA communities and non-LSA communities in the Afadjato-Agumatsa area. The results indicate that there were no significant differences in the distribution of posttest FCA scores ($p = 0.198$); of posttest NEP scores ($p = 0.437$); and of residual deviation rank scores of NEP attitudes ($p = 0.467$) between LSA communities and non-LSA communities. However, the distribution of the residual deviation rank scores of FCAs were significantly different between LSA communities and non-LSA communities ($p = 0.030$). These suggest that generally, there was no significance difference between the environmental attitudes of individuals but the change in FCA was different in LSA communities and non-LSA communities in the Afadjato-Agumatsa area.

6.3.9.3 Environmental Attitudes in LSA and Non-LSA Communities in Atewa

In the Atewa area, differences in posttest scores and residual deviation scores of both FCAs and NEP attitudes between LSA communities and non-LSA communities were tested using the non-parametric Wilcoxon-Mann-Whitney test. The results indicate that there were no significant differences in the distributions of all four scores between LSA communities and non-LSA communities in the study area. The results yielded $p = 0.891$ for the distribution of posttest FCA scores; $p = 0.510$ for the residual deviation rank scores of FCAs; $p = 0.865$ for the posttest NEP scores; and $p = 0.438$ for the residual deviation rank scores of NEP scale attitudes. These suggest that in the Atewa area, there was no significant difference between the environmental attitudes between LSA communities and non-LSA communities. Therefore, I rejected the hypothesis that changes in both environmental attitude scales as well as posttest environmental attitudes would be more favorable in LSA communities than in non-LSA communities.

6.3.10 Effects of Communities Participating In LSAs on Forest Conservation Attitudes

The results of the propensity score matching (PSM) analysis that I employed to evaluate the quantitative cause-effect relationship between LSAs and FCA scores are presented. The PSM analysis involved running a logistic regression, using the resulting regression model to determine propensity scores, which were then used as the basis for matching LSA communities to non-LSA communities. Each stratum was then analyzed using the weighted mean effect size of the LSA versus non-LSA communities. From the logistic regression model (Table 6.18), only two instrumental variables were significant predictors of a community being selected to participate in an LSA program or not. These factors were the status of traditional ruler or chief, and the dominant ethnic or tribal group. Communities that had higher level chiefs and had more natives than settlers were more likely to be selected to participate in LSA programs.

The resulting logistic model was:

$$\log(p/(1-p)) = -457 + 1.870 \text{ x ChSt} + 3.5 \text{ x EtDm} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6.9)$$

Where $\text{ChSt} = \text{status of traditional ruler or chief}$

$\text{EtDm} = \text{dominant ethnic group (natives or settlers)}$

Table 6.18: Parameter estimates of logistic regression model for determining propensity scores.

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
DsAr	-1.392	1.123	1.537	1	.215	.248
RsEx	.333	.856	.152	1	.697	1.396
PrFr	1.077	1.212	.791	1	.374	2.937
MgAx	-1.086	1.144	.902	1	.342	.338
ChSt	1.846	.897	4.236	1	.040	6.337
CnAg	-1.302	1.135	1.317	1	.251	.272
EtDm	3.300	1.329	6.162	1	.013	27.115
Constant	-1.715	2.009	.728	1	.394	.180

Key:
DsAr = Location in administrative area
RsEx = Level of resource (e.g. timber, bushmeat) exploitation
PrFr = Proximity to boundary of protected forest
MgAx = Forest management action
ChSt = Status of traditional ruler
CnAg = Whether conservation worker lives in community.
EtDm = Dominant ethnic or tribal group in population (Natives or settlers)

The propensity scores derived for each community for the matching are shown in Table 6.20. Communities in the two study areas were analyzed separately because of the significantly different FCAs between the two study areas. Initially, I derived two strata in Afadjato-Agumatsa (Table 6.19) but combined them into one stratum because one stratum had only one community in the treatment group (gives no standard deviation). In the Atewa area, Abesim was added to the nearest strata using nearest neighbor matching, resulting in four strata. This made a total of five strata (Table 6.20), the minimum recommended by Rosenbaum and Rubin (1983).

Table 6.19: Propensity scores of participation in livelihoods support activities (LSAs).

Study area	**Propensity score**	**Propensity score rank**	**LSA* Communities**	**Non-LSA* Communities**
Afadjato-Agumatsa	-457	3.5	Gbledi-Agumatsa	Fodome-Ando 2 Gbledi-Torglo
	-449.76	35.0	Gbledi-Chebi Fodome-Ahor Gbledi-Gbogame	Wli-Afegame Wli-Todzi
Atewa	-457	3.5	Dokyi Dompim	Akyeansa Kwekusae
	-455.13	10.5	Kwesikomfo Larbikrom Osafo	Dwafoakwa Mpeasem
	-453.50	15.0	**None**	Abesim
	-451.63	21.5	Adadientem Ahwenease Akropong Akwadum Pano Potroase	Afiesa Akanteng Apampatia Awenare Bomaa, Adukrom Kobriso, Pameng,
	-449.76	35.0	Apapam Asiakwa Asikam Dwenease Sagyimase	Banso Pinamang Takyiman

A key assumption of using effect sizes is a normal distribution of the data. Communities' posttest FCA scores had a normal distribution (Shapiro-Wilk test yielded $p = 0.877$). Therefore, I estimated the Direct Adjustment Estimator (DAE) by computing the mean of weighted effect sizes of the posttest FCA scores. The DAE was 0.0118 (Table 6.21).

Table 6.20: Direct Adjustment Estimator of effect Size of LSAs on forest conservation attitudes.*

Study area	Stratum number	LSA community	Non-LSA community	Effect size	Weighted effect Size
Afadjato-Agumatsa	1	Gbledi-Agumatsa	Fodome-Ando1 Gbledi-Torglo		
	2	Gbledi-Chebi Fodome-Ahor Gbledi-Gbogame	Wli Afegame Wli Todzi	-0.1743	-1.3944
Atewa	1	Dokyi Dompim	Akyeansa Kwekusae	-0.5277	--2.1108
	2	Kwesikomfo Larbikrom Osafo	Dwafoakwa Mpeasem Abesim	1.0164	6.0984
	3	Adadientem Ahwenease Akropong Akwadum Pano Potroase	Afiesa Akanteng Apampatia Awenare Bomaa Kobriso Pameng Adukrom	-0.0598	-0.8372
	4	Apapam Asiakwa Asikam Dwenease Sagyimase	Banso Pinamang Takyiman	-0.1605	-1.284
			Total	1.13197	0.472
			Mean	0.02695	0.0118

*LSA = Livelihoods support activities

Although effect sizes were analyzed separately for each study area, they were combined in determining the DAE because of the need for a larger sample size, since sample size correlates negatively with effect size (Slavin and Smith 2009). The negative effect size in the Afadjato-Agumatsa area was because of the large increase in FCA scores in Wli-Todzi, a non-LSA community. Cohen (1988) interprets effect sizes of 0.2 as low, 0.5 as medium and 0.8 as high.

On the basis of this, the DAE of 0.0118 is considered infinitesimal. Therefore I rejected the hypothesis that LSAs would have a significant effect on forest conservation attitudes.

6.3.11 Forest Conservation Attitudes in LSA-Active and LSA-inactive Communities

Mean FCA score increased from 5.54 to 6.61 in LSA-active communities and increased from 6.06 to 6.53 in LSA-inactive communities (Table 6.22).

Table 6.21: Attitudes in LSA-active and LSA-inactive communities in the Atewa area.

Descriptive statistics	**LSA Continuity**			
	LSA-Active		**LSA-Inactive**	
	Adjusted pretest	**Posttest**	**Adjusted pretest**	**Posttest**
N	898	898	411	411
Mean	5.54	6.61	6.06	6.53
Standard dev.	3.43	3.66	2.70	3.28
Standard error	0.11	0.12	0.13	0.16

Wilcoxon-Mann-Whitney test indicated significant difference in pretest FCA scores ($p = 0.050$), but no significant difference in the distribution of individuals' posttest FCA scores ($p = 0.141$) as well as residual deviation rank scores of FCAs ($p = 0.745$) across LSA-active and LSA-inactive communities. A two proportions z-test indicated that the proportional change in mean FCA scores was higher in LSA-active communities than in LSA-inactive communities ($p = 0.025$). This is confirmed in the Figure 6.7. Thus, pretest FCAs of individuals were not different between respondents who lived in the two types of communities, but overall mean change in FCAs was greater in LSA-active communities than in LSA-inactive communities.

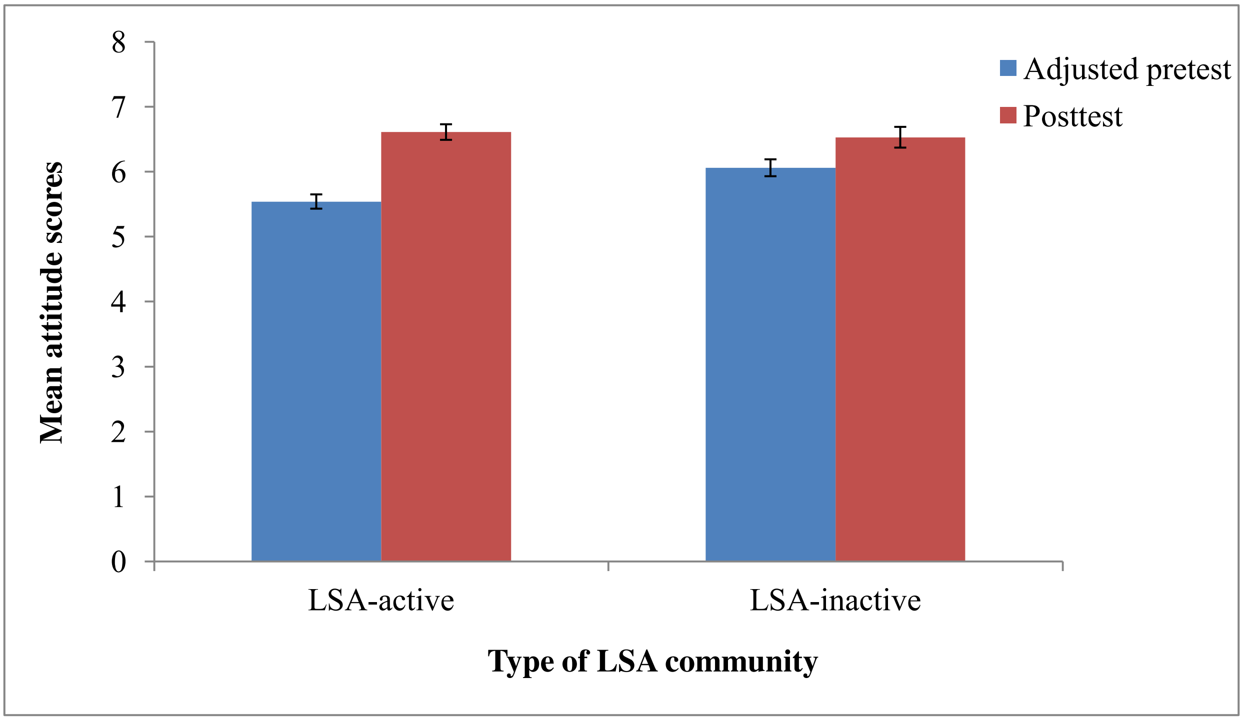


Figure 6.7: Forest conservation attitudes and LSA continuity in Atewa area communities. (Error bars are +/- SE).

6.3.12 Effects of Socio-Economic Estimates of LSAs on Forest Conservation Attitudes

The economic attributes of LSAs that were computed for each LSA community in Chapter 5 of this dissertation included the per capita investment, the per capita net benefit and the per capita benefit-cost ratio. The best regression model (based on AIC) which predicted 45.5% of the variance was significant ($F = 7.095$, $p = 0.006$). From the multiple regression model only the per capita benefit-cost ratio was a significant predictor ($B = 58.968$, $p = 0.002$) of favorable forest conservation attitudes (Table 6.23). Therefore I rejected the hypothesis that per capita values of capital investment and net economic benefit would significantly predict favorable forest conservation attitudes in LSA communities. I accepted the hypothesis that per capita benefit-cost ratio significantly predicted favorable forest conservation attitudes.

Table 6.22: Coefficients table of multiple regression of forest conservation attitudes (FCAs) by economic estimates of livelihoods support activities.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-130.120	64.412		-2.020	.059
	Per capita benefit ratio	6457.478	2425.895	.531	2.662	.016

Dependent Variable: Residual deviation rank score of FCA

6.4 Discussion

6.4.1 Changes in Attitudes towards the Natural Environment

There was a significant increase in the overall FCAs but a decrease in the overall NEP scores from the pretest scores to posttest scores. These suggest that the biodiversity conservation projects in the two study areas have had an impact on the attitudes and intentioned behaviors of people in these communities. From the analysis, the NEP attitude scale was less reliable and less consistent than the FCA scale. Therefore the increase in forest conservation attitudes was more reliable and a substantial increase worth noting by conservation practitioners.

The significant socio-demographic predictors included the study area, whether the respondent was a conservation actor, gender, and the number of years the respondent had lived in the community (tenure). With respect to the study area, respondents in Afadjato-Agumatsa tended to have higher FCA scores and NEP scores. Conservation actors tended to have higher FCA scores than respondents who were not conservation actors. Men tended to have higher FCA scores than women. Among these factors, the gender difference and conservation actors could be addressed through management prescriptions. For example, improving gender mainstreaming may help to improve the forest conservation attitudes in the two study areas. The number of conservation actors could be increased by establishing more volunteer groups or increasing the number of direct beneficiaries from conservation programs.

The higher reliability and consistency of the FCA scores than NEP scores; as well as the fact that they were higher in Afadjato suggest that community-based forest conservation in communities that largely utilize renewable natural resources for their livelihoods (renewable resource communities) may be important for conserving tropical forest biodiversity. This suggests that although NEP scale is the most widely used environmental attitude scale, it may not be adequate for all cultural situations. Modifications to suite the resource use regime as well as different cultural situations may be appropriate.

6.4.2 Livelihoods Support Activities and Attitudes towards the Environment

Four aspects of the relationships livelihoods support activities (LSAs) and environmental attitudes were analyzed. The first aspect analyzed if there was any difference between environmental attitudes of individuals in LSA communities and those in non-LSA communities. There was no difference between the environmental attitudes of individuals and the communities, whether they participated in LSAs or not. The factors which could have contributed to this included the low proportions of LSA participants in the communities as well as the very low net per capita benefit of LSAs (ranging from $0.82 to $0.88 per person per year) as computed in Chapter 5 of this dissertation.

The second aspect was an empirical estimation of the effect of LSAs on forest conservation attitudes. This analysis employed propensity score matching (PSM), which is commonly applied in fields such as evaluation, education, psychology and public health studies, bur rare in the biodiversity conservation literature. The results indicate a very infinitesimal effect (Direct Adjustment Estimator = 0.012) of LSAs on forest conservation attitudes. This infinitesimal effect is supported by other aspects of the analysis in which there was no significant difference between attitudes in LSA communities and non-LSA communities, the very low net socio-economic benefits from LSAs ranging from $0.82 to $0.88 per person per year. It is important to note that the results of the PSM analysis confirmed the non-significant difference in forest conservation between LSA communities and non-LSA communities.

The third aspect was a comparison of changes in forest conservation attitudes in LSA communities in which the LSAs were ongoing (LSA-active communities) to environmental attitudes in LSA communities in which the LSAs had stopped (LSA-inactive communities). The proportional changes in forest conservation attitudes were significantly greater in LSA-active communities than those in LSA-inactive communities. These higher attitudes scores suggest that it may be more effective to invest in LSAs that can be sustained in the communities. Therefore conservationists would want to employ LSAs that renewable resource communities are more familiar with and can undertake for a long time. An analysis of the specific sustained LSA suggests that piggeries, as well as goat and sheep rearing were most sustained in the Atewa area while beekeeping and trading were most sustainable in the Afadjato-Agumatsa area. In the case of beekeeping in the Afadjato-Agumatsa area, there was sustained technical support to the beekeepers, and this shows the importance of continuous technical support to LSA participants.

The fourth aspect was a determination of how economic attributes of LSAs namely per capita capital investment, per capita net socio-economic benefit and per capita benefit-cost ratio could predict forest conservation attitudes in the communities. The results indicate that per capita benefit-cost ratios were very important predictors of favorable forest conservation attitudes. Therefore it would be prudent for LSAs which present low costs to the participants and communities to be employed. Higher per capita investment in LSAs predicted lower posttest forest conservation attitudes. One would expect that if higher benefit cost ratio positively predicted forest conservation attitudes, higher investments should also predict same. However, while the per-capita investment is a one-time event at the beginning of the LSA process, benefit-cost ratio is as a result of the whole LSA process. High investments at the beginning of the project could not result in higher attitudes at the end. Therefore conservation managers would want to give attention to the process of monitoring and supporting the LSA participants and communities.

However, the infinitesimal effects of LSAs on forest conservation attitudes do not suggest that LSAs cannot be effective in changing attitudes and by extension, behaviors towards the natural environment. Specifically, for LSAs to be effective in favorably affecting attitudes towards the environment, LSAs with low costs to participants as well those that have the potential to be sustained in communities should be given the needed attention by conservation policy makers.

6.4.3 Methodology Issues and Suggestions for Future Research

In this chapter, I employed rigorous research design and statistical methods to investigate social investments for biodiversity conservation. The use of PSM analysis indicates that even though conservation interventions cannot be evaluated with conventional experimental statistics because of the non-random assignment of subjects to treatments, other rigorous methodologies from other fields of study can be successfully employed.

However, the methodology was not without limitations. One limitation which affected the statistical power of the analysis was the small number of LSA communities (Four in Afadjato-Agumatsa and 16 in Atewa). The intensity of sampling individual respondents helped reduce the effect of the low sample size of communities. Another limitation was that communities could not be randomly assigned to the treatments. Though the use of PSM analysis helped to reduce that, PSM requires large sample sizes, which was not available and not very practicable in many observational studies in environmental conservation. The fact is that many conservation programs do not cover large numbers of communities because of the limitations of funding, scope and adequate expertise in project management. Therefore for research to influence policy makers, conservation research will have to make do with the current situation and employ the best research design and statistical analysis available in other fields to practically show and quantify effects of interventions.

For future research, I recommend that anthropological assessments of forest conservation behaviors be studied and compared with estimates of environmental attitude scores, especially in West Africa where such research is rare. A repeat of this study after a decade may be useful to evaluate changes as well as the validity of these assessments. I recommend that PSM be promoted in conservation research and used more widely for evaluating large scale conservation projects which involve a large number of subjects (either individuals or communities) effective for policy decisions.

Further, it may be necessary to employ deterministic models such as latent class analysis to determine the effect of forest conservation attitudes on land use patterns, since they are the main causes of habitat destruction in high biodiversity areas.

Environmental attitudes evaluated in this chapter are intermediate conservation outcomes. It is important to assess their relationships with the ultimate outcome: biodiversity. These relationships were investigated and are presented in the next chapter (Chapter 7). It addresses the ecological aspect of biocomplexity in the environment.

CHAPTER 7: THE EFFECTS OF FOREST CONSERVATION ATTITUDES ON FOREST VEGETATION BIOMASS AND FRUIT BAT DIVERSITY IN SOUTHEASTERN GHANA

Abstract

I investigated whether and how conservation attitudes and other specified factors in 40 communities affected forest biodiversity in the Afadjato-Agumatsa Range and Atewa Range areas in Ghana. The dependent factors of biodiversity included: 1)mean Normalized Difference Vegetation Index (NDVI) of the forests in 2010; 2) change in mean NDVI from 2000 to 2010; and 3) species diversity (using Shannon-Weaver Index) of fruit bats (Megachiroptera). The main independent factors included: 1) forest conservation attitude scores of late 2009/early 2010; 2) change in forest conservation scores from 2000 to 2010; and 3) the per capita benefit-cost ratio of livelihoods support activities used as conservation incentives. Other independent factors included change in mean NDVI from 1999 to 2000, forest management prescription, annual rainfall, distance and elevation from the villages to forest, income levels, gender ratio, population, and population density. The results indicated that mean NDVI decreased from 1991 to 2000 and decreased further (but at a slower rate) to 2010. Eleven of the 13 fruit bat species in Ghana were recorded. Longer distances between a local community and its forest affected higher fruit bat diversity. Higher forest conservation attitudes affected higher mean NDVI in 2010. Greater change in mean NDVI from 1991 to 2000 affected greater change in mean NDVI from 2000 to 2010. These suggest that primary production of green forest continues to decrease in the study areas. Preventing communities from locating closer to forests could improve fruit bat diversity, which may be helpful for natural regeneration of tropical forests. Improving attitudes towards forest conservation could help biodiversity at landscape scales.

7.1 Introduction

When social interventions are used as tools for biodiversity conservation, they are aimed at changing human behavior towards conservation, and consequently reduce the degradation of biodiversity or improve the status of biodiversity. Practically, the use of livelihoods support for biodiversity conservation has been promoted because of the opposing and sometimes complementary demands of human welfare and biodiversity conservation (Salafsky and Wollenberg 2000). Therefore, in assessing the effects of livelihoods support activities (LSAs) as conservation tools it is important to investigate the relationships between environmental attitudes and biodiversity, which are the intermediate and ultimate outcomes, respectively. This was illustrated in the logic model for this dissertation which linked LSAs to environmental attitudes behaviors and further to conserved biodiversity. In this chapter, I address the fourth objective of this dissertation by evaluating whether and how the environmental attitudes (intermediate outcome) affect biodiversity (the ultimate outcome) in the Afadjato-Agumatsa and Atewa areas in Ghana.

Biodiversity can be measured in terms of the compositional, structural and functional diversity (Franklin 1988, Noss 1990) and at different levels of organization including landscape, community, population and genetic levels (Noss 1990, Noss 1992). These different levels of organization and diversity, the scarcity of resources for conservation research, as well as the need for urgent information for conservation policy decisions have posed challenges to estimating biodiversity. The application of functional groups and indicator taxa to estimate biodiversity (Moles and Hayes 2001) reduces these challenges. I employed a functional group (forest vegetation biomass) and functional indicator taxon (fruit bats) as proxies for biodiversity.

7.1.1 Biomass of Forest Vegetation

The biomass of forest vegetation affects the ability of forests to maintain biodiversity (Gustafson et al. 2010). This is especially relevant in tropical forests where a large diversity of terrestrial fauna depend on the green forest biomass. The primary productivity of the above-ground green forest biomass could be estimated as a functional indicator of biodiversity at the ecosystem level (Noss 1990). Remote sensing applications are useful for estimating biodiversity at the ecosystem level, specifically for assessing and monitoring deforestation, analysis of fragmentation, neighborhood and functional impairment assessments such as assessment of change in primary productivity (Joseph et al. 2011). For these reasons, remote sensing is a cost-effective tool for vegetation analysis. The most widely used vegetation index in remote sensing is Normalized Difference Vegetation Index (NDVI) (Ray 1994, Pettorelli et al 2011). NDVI is the ratio of the difference in reflectance to the sum of reflectance of the red and near-infrared bands of remotely-sensed images (Curran 1983). NDVI indicates the level of photosynthetic activity (Sellers 1985), and correlates with green biomass (Tucker et al. 1981, Running and Nemani 1988). The value of NDVI ranges from -1.0 to +1.0. Water bodies, snow and ice usually have negative values; dry bare soil has values close to 0; and dense green vegetation has values from about 0.5 up to 0.7 (Holben 1986). In ecology, NDVI has been used to predict the spatial and temporal abundance, distribution and life history traits of herbivores and non-herbivores (Pettorelli et al. 2011). NDVI has been used for vegetation analysis at different scales ranging from fragments of a forest (e.g. Freitas et al. 2005), an island (e.g. Julien et al. 2011), a biome (e.g. Anyamba 2005) and at the global scale (e.g. Justice et al. 1985). The sums and differences, instead of absolute values in NDVI makes it appropriate for comparing derived statistics between remotely-sensed images of the same region of interest obtained on two different times (Mather and Koch 2011). Factors that affect NDVI include precipitation and temperature (Wang et al. 2003) because they modulate the phenology of vegetation (Tourre et al. 2008). Temperature is fairly uniform over the study areas and so has minimum influence differences in NDVI of different parts of the forests I studied. In the case of precipitation, the influence was reduced in the study areas because the last major drought in southern Ghana was in 1983. This was at least seven years before early 1991, at which time any effects of the drastic droughts would have been minimal. Moreover, rainfall patterns (indicated by the normalized rainfall values) have shown relative consistency over the years since the mid 1980s (Oduro-Afriyie and Adukpo 2006). The use of NDVI estimates during the dry season could further reduce the expression of the influence of precipitation on the primary productivity. Therefore, in order to determine the effects of human attitudes on biodiversity, NDVI in 2000 and change in NDVI from 2000 to 2010 were important dependent factors of biodiversity since the effects of temperature and precipitation were assumed to be reduced as discussed above.

7.1.2 Fruit Bats in Tropical Forests

Fruit bats are mammals that belong to the order Chiroptera and suborder Megachiroptera. This suborder includes both frugivorous bats and nectarivorous bats. These bats depend on a year-round supply of flowers and fruits for food (Kingdon 2003). They usually forage away from their roosts at night and return to their roosts at dawn or early morning. The temporal and spatial distribution of their roosting sites and foraging sites as well as competition and predation are known to be important to their ecology (Patterson et al. 2003). The frugivorous species spit out fibers and seeds after eating, and the nectarivorous species facilitate pollination by transferring pollen from flower to flower. By their feeding ecology, fruit bats play very important ecological roles in pollination, seed dispersal, germination and the establishment of woody vegetation (Medellin and Gaona 1999, Taylor and Kankam 1999, Henryi and Jouard 2007). Many of the Megachiroptera live in large social groups but may also forage as individuals (Kingdon 2003). Some species such as the Straw-colored fruit bat, *Eidolon helvum* are migratory and may migrate over 2000 km (Richter and Cumming 2008). *Eidolon helvum* has a foraging distance of about 60km (Richter and Cumming 2008), while the nectar-bat *Megaloglossus woermanni* has a foraging distance of about 15km (Weber et al. 2009). These social, migratory and foraging behaviors make fruit bats an important functional group for natural regeneration of tropical forests. Their species diversity can be used as a compositional indicator of biodiversity at the species level.

7.1.3 Aim, Objectives and Hypotheses

The logic model for this dissertation links LSAs to forest conservation attitudes (FCAs) and FCAs to biodiversity, and this chapter addresses the second part of the logic model. Proxies for biodiversity in this chapter included NDVI in 2010, change in NDVI from 2000 to 2010, and fruit bat diversity. Results of Chapter 6 of this dissertation indicated that among LSA communities, higher FCAs were significantly predicted by higher per capita benefit-cost ratios of LSAs; and proportional changes in FCAs were significantly higher for LSA communities which had active LSAs than for the LSA communities, which had no active LSA at the time of the study. This made FCA scores, change in FCA scores from 2000 to 2010, and per capita benefit-cost ratio of LSAs the main predictor variables. On the basis of these, my hypotheses for this chapter were as follows:

1. Higher FCA scores would significantly affect higher levels of the biodiversity proxies.
2. Greater increase in FCA scores would affect higher levels of each of the biodiversity proxies.
3. Higher benefit-cost ratios of LSAs would significantly affect higher biodiversity proxies.
4. LSA communities which had active LSAs at the time of the study would significantly have greater change in NDVIs and greater fruit bat diversity than LSA communities which had no active LSA.

7.2 Materials and Methods

7.2.1 Study Areas

This study was undertaken in all 40 communities in the two study areas. These were made up of 8 communities (4 LSA and 4 non-LSA communities) in the Afadjato-Agumatsa Range area and 32 communities (16 LSA and 16 non-LSA communities) in the Atewa Range area.

7.2.2 Data Collection

7.2.2.1 Estimating Mean Normalized Difference Vegetation Index (NDVI) of Forests

I estimated buffer distances between each community and the protected forest during ground-truthing. The buffer distances ranged from 500 m to 5 km, and are presented in Appendix F. The buffers reduced the influence of small homes, gardens and other human disturbances on NDVI estimates. Beyond the buffer and within the protected forest, I determined regions of interest that each community had control over with community leaders. The basis for these regions of interest was the assumption that any encroachment on these forests could not be done without the connivance or permission of the community leaders, family heads, or individuals within the corresponding community.

I obtained relatively cloud-free Landsat 4/5 Thematic Mapper (TM) images for 1991 and 2000; and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) images for 2010 from the Global Visualization Viewer (GLOVIS) managed by the Earth Resources Observation and Science Center (EROS) of the United States Geological Survey (USGS) (USGS 2011a). In order to reduce the effects of differences in precipitation, and the primary production of non-woody annual food crops in encroached areas, I obtained the images of January and February, during the mid harmattan season. The harmattan season is usually dry (no rains), has low humidity, and consequently annual crops are already harvested. The images of the Afadjato-Agumatsa area are on Path 193 Row 55; and the images of Atewa area are on Path 193 Row 56 of the Landsat satellites. The specific details of the images are presented in Table 7.1.

Table 7.1: Details of satellite images obtained and used for the multi-spectral analysis.

Study area	Year	Date of Image	Percent Cloud Cover (%)
Afadjato-Agumatsa	1991	January 10, 1991	0
	2000	February 4, 2000	0
	2010	January 30, 2010	0
Atewa	1991	January 1, 1991	0
	2000	February 4, 2000	0
	2010	January 30, 2010	5

I used the remote sensing software Environment for Visualizing Images 4.8 (ENVI 4.8) (Exelis Visual Information Solutions 2011) to undertake multi-spectral image analysis to estimate the mean NDVI of the forest region of interest of each local community. A summary of the procedure I used for vegetation analysis for mean NDVIs included the following as derived from ITT Visual information Solutions (2007) and other remote sensing sources such as the Landsat Science documents of USGS (USGS 2011b), and the Yale Center for Earth Observation (Yale University 2011).

1. Change Digital Numbers (DNs) of pixels to Top of Atmosphere (TOA) reflectance units.
2. Conduct atmospheric correction of image. I used Dark Object Subtraction (DOS) method for the atmospheric correction.
3. Create region of interests (ROIs) within the forests for each of the 40 communities.
4. Fill gaps for Landsat 7 image (the 2010 image). I performed single file triangulation method to fill the scan line gaps (corrections) of Landsat 7 (SLC-off) images using ENVI's gap filling extension LANDSAT_GAPFILL.SAV**.**
5. Remove cloud cover if it occurs in the regions of interest. There was cloud cover in the 2010 image for Atewa. I removed the cloud cover by masking clouds, classifying the masked areas and employing ENVI's gap filling extension, LANDSAT_GAPFILL.SAV.
6. Estimate the mean NDVI for each ROI for 1991, 2000 and 2010.

7.2.2.2 Trapping of Fruits Bats

I trapped fruit bats in forests located near each of the 40 communities using mist-nets placed in foraging and travel corridors, on the banks of rivers, streams and ponds which served as drinking points for bats. The occurrence and abundance of fruit bats varies with the season (Thomas

1983, Yeboah 2007). Therefore, the surveys were undertaken during the dry harmattan season in December 2009 to January 2010, and during the rainy season in May and June 2010.

At each sampling point, three 12-meter mist nets were set up each night. The nets were braided nylon mist nets with 11/16 inch mesh strung on light-weight aluminium poles 10 feet high held strong and tight by guy cords. The nets were opened about 30 minutes after sunset (usually about 6:30pm), inspected every hour and during any opportunistic captures between the hours, from the time they were opened to about midnight; opened again at dawn (4:30am) and finally closed 30 minutes before sunrise (about 6:00am). A net night was 12 meters of mist nets opened for 7 hours. Surveys of three nights with three mist nets at each site, equals a sampling effort of nine net nights at each site during each season. Therefore for the two seasons of surveys in the 40 forest regions of interest, the total sampling effort was 720 net nights.

Captured bats were removed from the nets, the species identified, marked, weighed, the length of their forearm as well as their head and body measured, and then released in the field. Species names were based on Rosevear (1965), Grubb et al. (1998) and Kingdon (2003). Generally the capture methods were based on Kunz and Kurta (1988). The animals were marked (maximum about 1 inch in length) on their abdomen and under their wing membranes using non-washable paint from felt-tipped permanent markers. Combinations of the paint color, position of mark on abdomen (center, left side, right side, anterior side, posterior side) and patagium of the wing membrane (left or right wing as well as the membranes between the different forearm digits) marked were used to identify captured individuals. This helped identify recaptured individuals. This marking method was more appropriate than tags or bands for a short-term study. The animals were weighed using a spring scale (precise to 1 gram). I measured the biometrics using a rule and/or vernier callipers (to the nearest millimeter). I collected data on weather conditions, habitat surveyed, date of capture and release, species, sex, age (adult or juvenile), and reproductive condition (lactating or non-lactating; scrotal or non-scrotal). Assessment of reproductive status of females, and age determination were based on Racey (1988) and Anthony (1988). The data sheet used for the bat surveys is Appendix H of this dissertation.

7.2.3 Data Analysis

7.2.3.1 The Independent Variables and the Dependent Variables

On the basis of the analysis and results of the previous chapters, the main independent variables in this chapter included the per capita benefit-cost ratios of LSAs in each LSA community, whether an LSA community had any active LSAs or no active LSA, the change in forest conservation attitudes (FCAs) of each community, and the posttest FCA scores of each community. The dependent variables were the mean NDVI of forests of 2010 (**NDVI_2010**), change in mean NDVI from 2000 to 2010 (**NDVI_2000_2010**), and the species diversity of forest-specialist fruit bats in the forests near each community.

I used the remote sensing software, ENVI Version 4.8 (Excellis 2011) to estimate the mean NDVI for the forests near each community as well as the overall mean NDVIs for each study area. I employed Shannon-Weaver index, H' (Shannon and Weaver 1949 as described by Magurran 2004) as a measure of fruit bat diversity.

$H' = -\Sigma p_i \ln p_i$ …………………………………………………………………………….. (7.1)

Where, p_i is the proportion of individuals of the *i*th species.

Shannon-Weaver index, H' is the most common species diversity index (Gotelli 2008), and using it helps to maintain consistency and comparability with similar studies in the past and future. I computed fruit bat diversity for all species (H'_all) and for only forest–specialist species (H'_forest). The habitat preference of the species was based on the literature (For example Grubb et al. 1998, Medellin and Gaona 1999, Taylor and Kankam 1999, Kingdon 2003, Henryi and Jouard 2007) and from my professional experience. Using H'_forest reduced the influence of edge effects and matrix effects (Noss et al. 2006) of higher diversity indices in mosaics of forests and degraded areas than in forests. In addition, it was important to investigate forest-specialist species because the focus of this study was conservation of forest biodiversity. I used the non-parametric Spearman's correlation coefficient to test the correlation between the three dependent variables (the biodiversity estimates) for all the 40 communities.

Further data analysis was at two levels: 1) analyses involving only communities that participated in livelihoods support activities (LSAs); and 2) analyses involving all communities. At both levels, I used the Mann-Whitney Test to test for differences between NDVI in 2010, change in NDVI between 2000 and 2010, and H'_forest between the two study areas. Any biodiversity estimate which differed between the two areas was further analyzed separately for each study area. The exception to this was the LSA communities in the Afadjato-Agumatsa area because the sample size was small (N = 4 communities), and that did not satisfy the requirements for a regression analysis.

7.2.3.2 Analysis of Variability of Biodiversity in LSA Communities

I employed Mann-Whitney test to evaluate differences between the biodiversity estimates in LSA communities that had active LSAs (LSA-active communities) and those that had no active LSA (LSA-inactive communities). I conducted a multiple regression analysis to determine whether and how change in FCA, posttest FCA score, and the per capita benefit-cost ratio predicted each biodiversity estimate (after data transformation) of the communities. I used Akaike's Information Criteria (AIC) to select the best regression model in each analysis.

7.2.3.3 Analysis of Variability of Biodiversity in All Communities

I conducted a multiple regression analysis (using AIC for model selection) to determine whether and how change in FCA score, the posttest FCA scores and other covariates predicted each biodiversity estimate, after data transformations. The covariates (Table 7.2 and described below) included factors that affect deforestation according to the literature (for example Hall and Swain 1976, Hawthorne and Abu-Juam 1995, Kotey et al. 1998, Dadebo and Shinohara 1999, Donkor and Vlosky 2003 and Andam et al. 2008) and from my professional experience.

Table 7.2: Covariate factors tested for their effect on deforestation.

#	**Covariate**
1	Change in Normalized Difference Vegetation Index (NDVI) from 1991 to 2000
2	Population of each community in 2010
3	Population change from 2000 to 2010
4	Population density (household size)
5	Gender ratio (male : female ratio)
6	Elevation from community to forest region of interest
7	Mean annual rainfall in 2009
8	Distance from center of community to forest region of interest
9	Mean income
10	A community agent lives in the community
11	Forest management prescription
12	Proximity and/or access to major road (paved road connecting cities or large towns)

The *change in NDVI between 1991 and 2000* was used based on the assumption that it was a measure of how green above-ground forest resources were being used in the period before the LSA interventions in the early 2000s. The basis for this was that NDVI correlates with biomass. I obtained this using multispectral analysis of satellite images as described earlier in the data collection section.

Demographic factors affect the amount of natural resources used. The *population in 2010, change in population from 2000 to 2010, community-level population density and gender ratios* are some of such important socio-demographic factors. FAO (2004) cited strong correlations in Ghana between the population density and the level of deforestation. This correlation was confirmed in a study of smaller land areas in Costa Rica (Andam et al. 2008). I used data of communities' populations from the 2000 population census of Ghana for the pre-intervention effect and the projections for 2010 obtained from the Ghana Statistical Service. I used the mean household size as a proxy for population density. For gender ratio I used the ratio of males to females based on the assumption that the men will usually degrade more forest by logging and encroaching for larger crop farms than women.

The amount of effort individuals have to make to obtain natural resources affects the amount of resources they can obtain and consequently how they may degrade the natural resources and biodiversity. Therefore the *distances and elevation from the community to the forest region of interest* were also covariates. I obtained these estimates from GPS positions of the communities during the field work in 2009 and 2010 and from Google Earth Images (Google Inc. 2011).

Precipitation, estimated by the *mean annual rainfall* affects on the green forest biomass which is measured by the NDVI. I obtained precipitation data from the Ghana Meteorological Agency. For each community, I assigned rainfall data from the weather station that is located nearest to the community.

The presence or absence of a conservation agent (a staff of the Forestry Commission, Ghana Wildlife Society or an active community conservation group) could affect how much encroachment and illegal logging could be occurring in the forests near a community. That is why the presence of a conservation agent was also a covariate.

The income of individuals and communities influences their dependence on natural resources. Individuals who have low income may depend more on natural resources, but reduce their dependence as their incomes increase. Beyond a threshold level, income of individuals could increase the quantity of natural resources exploited in commercial quantities. Therefore *income* was one of the factors. The data for this was obtained from the socio-economic surveys..

Since the two study areas are conservation areas and the forests being assessed are within the protected areas, the *forest management prescriptions* affect the biodiversity of the area. In the Afadjato-Agumatsa area, farming is restricted in some areas while other areas do not have such restrictions. In the Atewa area, the areas designated as Globally Significant Biodiversity Areas (GSBAs) have restricted farming while other areas do not practice such restrictions.

The *proximity and/or access to a major road (i.e. a tarred road connecting cities or large towns)* were another factor I considered to affect forest degradation. The cities and large towns are the markets for commercial quantities of the major forest products such as lumber, and non-timber forest products; as well as food products from encroached farms within the forests.

7.3 Results

7.3.1 Normalized Difference Vegetation Index (NDVI) of Forests

Normalized Difference Vegetation Index (NDVI) images of the two study areas for the years 1991, 2000, and 2010 are presented in Appendix G.

In the Afadjato-Agumatsa area, the overall mean NDVI decreased from 0.72 (standard deviation = 0.055) in 1991 to 0.63 (standard deviation = 0.075) in 2000, and further decreased to 0.44 (standard deviation = 0.033) in 2010. In 1991, the mean NDVIs in the Afadjato-Agumatsa area ranged from 0.64 in Wli Afegame and Agorviefe to 0.79 in Gbledi Chebi (Table 7.3). In 2000 Wli Afegame and Agorviefe recorded the lowest mean NDVI of 0.52, while Gbledi Chebi recorded the highest of 0.74. In 2010, Wli-Todzi recorded the lowest mean NDVI of 0.39 and Gbledi Chebi recorded the highest of 0.49 (Table 7.3).

Table 7.3: Mean NDVIs of forests near communities in the Afadjato-Agumatsa area.

Community	**Radius of buffer (km)**	**# of pixels**	**Mean NDVIs**		
			1991	**2000**	**2010**
Fodome Ahor	2.0	1,970	0.717017	0.625442	0.454594
Fodome Ando 1	1.0	1,744	0.704927	0.580406	0.432271
Gbledi Agumatsa	0.0	1,548	0.721009	0.680425	0.434662
Gbledi Chebi	0.5	1,620	0.791802	0.744171	0.493651
Gbledi Gborgame	0.3	1,548	0.761669	0.653715	0.462893
Gbledi Torglo	0.0	1,606	0.783335	0.709843	0.471988
Wli Afegame & Agorviefe	0.3	2,062	0.638322	0.517168	0.414016
Wli Todzi	0.0	1,682	0.663121	0.585167	0.392338
Mean		**1,723**	**0.722650**	**0.637042**	**0.444552**
Standard deviation		**194.05**	**0.054760**	**0.074966**	**0.032750**
Standard error of mean		**68.61**	**0.019361**	**0.026505**	**0.011579**

In the Atewa area, the overall mean NDVI decreased from 0.72 (standard deviation = 0.035) in 1991 to 0.48 (standard deviation = 0.089) in 2000, and further decreased to 0.47 (standard deviation = 0.051) in 2010. In 1991, the mean NDVIs in the Atewa area ranged from 0.63 in Akropong to 0.79 in Asiakwa (Table 7.4). In 2000 Akanteng recorded the lowest mean NDVI of 0.35 and Sagyimase recorded the highest of 0.70. In 2010, Dwenease recorded the lowest mean NDVI of 0.33 and Asikam recorded the highest of 0.53.

Table 7.4: Mean NDVIs of forests near communities in the Atewa area.

Community	Radius of buffer (km)	# of pixels	NDVIs 1991	NDVIs 2000	NDVIs 2010
Abesim	1.5	5,034	0.69282	0.3972	0.42892
Adadientem	0.5	3,512	0.74375	0.51071	0.48561
Adukrom	2.0	7,304	0.73143	0.58794	0.52735
Afiesa	1.0	4,350	0.72502	0.46145	0.47614
Ahwenease	0.5	4,340	0.72829	0.46777	0.48748
Akanteng	2.0	10,232	0.69011	0.35325	0.41933
Akropong	3.0	4,674	0.62721	0.3723	0.46729
Akwadum	2.0	5,618	0.73971	0.50011	0.51229
Akyeansa	4.0	10,580	0.69643	0.51636	0.48049
Apampatia	1.0	6,788	0.71711	0.44162	0.45427
Apapam	0.5	5,618	0.75268	0.50936	0.51144
Asiakwa	2.5	10,760	0.78863	0.67569	0.52753
Asikam	2.0	6,706	0.75759	0.53639	0.53263
Awenare	2.5	6,772	0.76028	0.56316	0.47705
Banso	2.5	7,718	0.70898	0.5205	0.48159
Bomaa	2.0	8,008	0.72561	0.64345	0.4988
Dokyi	1.0	3,762	0.69299	0.41087	0.47792
Dompim	2.5	3,272	0.67761	0.41776	0.48325
Dwafoakwa	4.0	7,552	0.66849	0.42134	0.46855
Dwenease	2.5	8,584	0.71752	0.39701	0.32522
Kobriso	2.0	12,104	0.75252	0.39117	0.41609
Kwakusae	3.0	9,860	0.71241	0.44436	0.48984
Kwesikomfo	2.0	12,348	0.70553	0.51231	0.49762
Larbikrom	1.0	3,516	0.70534	0.40378	0.42475
Mpeasem	1.0	3,756	0.70695	0.4263	0.43951
Osafo	1.0	6,706	0.73102	0.4172	0.47343
Pameng	1.5	5,396	0.68318	0.41898	0.42631
Pano	2.0	4,596	0.75946	0.5118	0.52527
Pinamang	2.0	10,228	0.69467	0.35373	0.33041
Potroase	1.0	8,992	0.72017	0.51741	0.49899
Sagyimase	2.0	7,708	0.78334	0.69955	0.52539
Takyiman	4.0	6,226	0.66986	0.42198	0.41528
Mean		**6956.88**	**0.717710**	**0.47571**	**0.46831**
Standard deviation		**2634.29**	**0.034955**	**0.08859**	**0.05072**
Standard error of mean		**465.68**	**0.006179**	**0.01566**	**0.00897**

Comparing the mean NDVIs of the two study areas, they were similar in 1991 (Figure 7.3), though that of Afadjato-Agumatsa was slightly higher (0.722) that that of Atewa (0.717). From 1991 to 2000, the mean NDVI of the Atewa decreased more than that of the Afadjato-Agumatsa area. This resulted in Atewa recording mean NDVI of 0.476 and Afadjato-Agumatsa recording a mean NDVI of 0.637. From 2000 to 2010, the mean NDVIs of both study areas continued decreasing. However, the rate of decrease in mean NDVI in Atewa had been less than in Afadjato. As a result, the mean NDVI in Afadjato-Agumatsa in 2010 was lower than in Atewa.

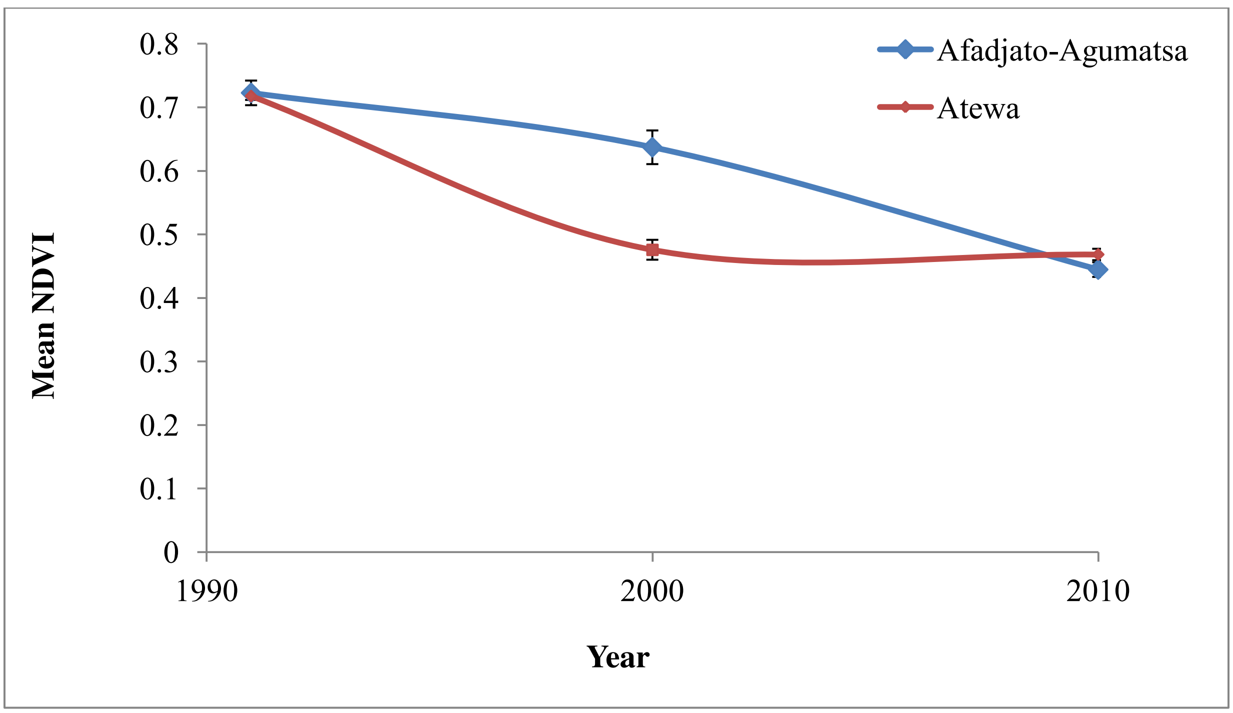


Figure 7.1: Comparison of the mean NDVIs of forests in Afadjato-Agumatsa and Atewa.

7.3.2 Species Diversity of Fruit Bats

A total of 681 individual fruit bats belonging to 11 species were captured and recorded in the two study areas. Of these, 137 individuals of 10 species were recorded in the Afadjato-Agumatsa area; and 544 individuals of eight species were recorded in the Atewa area (Table 7.5). Nine of the 11 species were forest specialists. The other two species, *Epomops buettikoferi, and Micropteropus pusillus* are specialists of mosaics of wooded savanna and forest edges. One species, *Eidolon helvum* is listed on the IUCN Red data list (IUCN 2011) as Near Threatened, and nine are listed as species of Least Concern. One species, *Myonicteris torquata* was not listed on the IUCN Red Data List. Species diversity indices of all fruit bats, H'_all were 1.81 and 1.51 in Afadjato-Agumatsa and Atewa, respectively. Species diversity indices of forest specialist fruit bats H'_forest were 1.50 and 1.12 in Afadjato-Agumatsa and Atewa areas, respectively.

Table 7.5: Fruit bat species recorded in the two study areas.

Species			**Number of individuals**		
#	**Scientific name**	**English name**	**Afadjato-Agumatsa**	**Atewa**	**Total**
1	*Eidolon helvum*	Straw-colored fruit bat	2	0	2
2	*Epomophorus gambianus*	Epauletted fruit bat	50	200	250
3	*Epomops buettikoferi*	Singing fruit bat	4	0	4
4	*Epomops franqueti*	Franquet's singing bat	27	111	138
5	*Hypsignathus monstrosus*	Hammer bat	1	0	1
6	*Lissonycteris angolensis*	Angola fruit bat	15	2	17
7	*Megaloglossus woermanni*	Nectar bat	1	69	70
8	*Micropteropus pusillus*	Dwarf epauletted fruit bat	16	137	153
9	*Myonicteris torquata*	Collared fruit bat	12	9	21
10	*Nanonycteris veldkampi*	Flying calf	9	3	12
11	*Scotonycteris zenkeri*	Tear-drop fruit bat	0	13	13
		Total	**137**	**544**	**681**

For both the Shannon-Weaver index based on all fruit bat species (H'_all) and the same index based on only forest specialist species (H'_forest), the highest species diversity was estimated in Gbledi Gborgame and the least diversity was estimated in Fodome Ando1, in the Afadjato-Agumatsa area (Table 7.6). The diversity indices on the two scales had a high and significant correlation (Spearman's rho = 1.000) in the Afadjato-Agumatsa area.

Table 7.6: Species richness and diversity indices of fruit bats recorded in Afadjato-Agumatsa.

Community	**Number of species**	**H_all***	**H_forest****
Fodome Ahor	3	1.04	0.69
Fodome Ando 1	2	0.38	0.38
Gbledi Agumatsa	4	1.32	1.32
Gbledi Chebi	4	1.22	1.22
Gbledi Gborgame	7	1.63	1.39
Gbledi Torglo	3	1.08	1.08
Wli Afegame & Agorviefe	8	1.71	1.41
Wli Todzi	5	1.48	1.37

* Shannon-Weaver index based on all fruit bat species

** Shannon-Weaver index based on only forest specialist species.

In the Atewa area, the highest fruit bat diversity based on all fruit bat species was estimated in the forests of Adadientem and the least estimate in the Dompim forests. With respect to the diversity indices based on only the forest specialist fruit bats, the highest was recorded in Mpeasem and the least was recorded in Dompim. In the Atewa area, the diversity indices based on the two scales correlated highly (Spearman's rho = 0.778) (Table 7.7).

Table 7.7: Species richness and diversity indices of fruit bats recorded in the Atewa area.

Community	Number of species	H_all*	H_forest**
Abesim	5	1.27	1.27
Adadientem	5	1.53	1.29
Adukrom	5	1.37	1.09
Afiesa	3	0.96	0.96
Ahwenease	4	1.32	1.08
Akanteng	3	1.04	0.61
Akropong	3	1.03	1.03
Akwadum	3	0.96	0.96
Akyeansa	4	1.12	0.82
Apampatia	4	1.21	0.90
Apapam	5	1.36	1.15
Asiakwa	5	1.45	1.18
Asikam	4	1.29	0.97
Awenare	3	0.72	0.72
Banso	2	0.41	0.41
Bomaa	3	0.90	0.90
Dokyi	4	1.19	0.90
Dompim	2	0.69	0.00
Dwafoakwa	4	1.23	0.89
Dwenease	3	0.99	0.99
Kobriso	5	1.39	1.17
Kwakusae	5	1.24	1.06
Kwesikomfo	4	1.11	0.71
Larbikrom	3	1.08	0.67
Mpeasem	6	1.49	1.36
Osafo	5	1.47	1.21
Pameng	4	1.07	0.80
Pano	4	1.16	1.16
Pinamang	5	1.19	1.04
Potroase	4	1.16	0.90
Sagyimase	5	1.40	1.24
Takyiman	4	1.05	0.87

* Shannon-Weaver index based on all fruit bat species

** Shannon-Weaver index based on only forest specialist species.

7.3.3 Correlations between the Mean NDVI and Fruit Bat Diversity Indices

Analyzing the correlations between the biodiversity estimates (H'_all, H'_forest, NDVI_2010, and NDVI_2000_2010), the highest correlation (Spearman's rho = 0.831) was recorded between H'_all and H'_forest (Table 7.8). In addition, H'_forest recorded a lower correlation coefficient (Spearman's rho = 0.024) than the correlation of H'_all (Spearman's rho = 0.065) with the mean NDVI in 2010 (NDVI_2000). It was noteworthy that there was no significant correlation between the two NDVI estimates and the two species diversity indices of fruit bats. Given the fact that the focus of this study was forest biodiversity conservation, I employed the H'_forest as the main measure of fruit bat diversity in the rest of the analyses. The least correlation coefficient (Spearman's rho = 0.024) was recorded between H'_forest and NDVI_2000. Change in NDVI from 2000 to 2010 (NDVI_2000_2010) correlated negatively with the other three estimates of biodiversity.

Table 7.8: Correlation matrix of mean NDVI estimates and species diversity of fruit bats.

Biodiversity estimates	**Biodiversity estimates**			
	H'_all	H'_forest	NDVI_2010	NDVI_2000_2010
H'_all*	1.000			
H'_forest**	0.831	1.000		
NDVI_2010	0.065	0.024	1.000	
NDVI_2000_2010	-0.126	-0.276	-0.047	1.000

NDVI_2010 = Normalized difference vegetation index in 2010
NDVI_2000_2010 = Change in normalized difference vegetation index from 2000 to 2010
* Shannon-Weaver index based on all fruit bat species
** Shannon-Weaver index based on only forest specialist species.

7.3.4 Differences in the Biodiversity Estimates between the Study Areas

Mann-Whitney tests involving all communities, only LSA communities, and only non-LSA communities, indicated that the mean NDVI of the communities in 2010 (NDVI_2010) and the Shannon-Weaver Index of forest specialist fruit bats (H'_forest) were not significantly different between the two study areas. Change in NDVI from 2000 to 2010 (NDVI_2000_2010) was significantly different between the two study areas (Table 7.9).

Table 7.9: Differences in biodiversity estimates between the Afadjato-Agumatsa and Atewa areas.

Biodiversity estimate	**p-value**			**Significance**
	All communities	**LSA* communities**	**Non-LSA communities**	
H'_forest**	0.070	0.131	0.257	Not significant
NDVI_2010	0.068	0.108	0.131	Not significant
NDVI_2000_2010	0.000	0.003	0.003	Significant

NDVI_2010 = Normalized difference vegetation index in 2010
NDVI_2000_2010 = Change in normalized difference vegetation index from 2000 to 2010
* LSA means livelihoods support activities
** Shannon-Weaver index based on only forest-specialist species.

7.3.5 Variability of Fruit Bat Diversity and NDVI in LSA Communities Only

The results of the multiple regression analysis indicated that among the communities that participated in livelihoods support activities (LSA communities), H'_forest was not significantly predicted by the per capita benefit-cost ratio of LSAs (p = 0.629), the posttest FCA scores (p = 0.751), and the change in FCA scores (p = 0.688). NDVI_2010 was also not significantly predicted by the per capita benefit-cost ratio of LSAs (p = 0.808), the posttest FCA scores (p = 0.418), and the change in FCA scores (p = 0.627).

Change in NDVI from 2000 to 2010 (NDVI_2000_2010) was significantly different between the two study areas, but the data were not analyzed separately for Afadjato-Agumatsa because of the small sample size (N = 4). In the Atewa area, NDVI_2000_2010 was not predicted by the per capita benefit-cost ratio of LSAs ($p = 0.399$), the posttest FCA scores ($p = 0.618$), and the change in FCA scores ($p = 0.841$). A Mann-Whitney test indicated that there was no significant difference in the biodiversity estimates between the LSA communities that had active LSAs (LSA-active communities) and communities that did not have active LSAs (LSA-inactive). The p-values were respectively 0.401, 0.753, and 0.141 for H'_forest, NDVI_2010, and NDVI_2000_2010.

7.3.6 Variability of NDVI and Fruit Bat Diversity in All Communities

7.3.6.1 Factors that Affected Fruit Bat Diversity in All Communities

The overall model of the best multiple regression (selected using Akaike's Information Criteria), which predicted 27% of the variance in the diversity of forest fruit bat species (H'_forest) was significant ($F = 4.443$, $p = 0.009$) (Table 7.10). The distance to the forest was the only significant predictor variable ($p = 0.028$), where increasing distance predicted higher fruit bat diversity (Table 7.11).

Table 7.10: Overall multiple regression model of the fruit bat diversity of forest specialists.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.421	3	0.140	4.443	0.009
	Residual	1.137	36	0.032		
	Total	1.557	39			

Predictors: (Constant), Household size, Population change, Distance to forest
Dependent Variable: Natural log transformed H'_forest

Table 7.11: Parameter estimates of the regression model of fruit bat diversity of forest specialists.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	0.503	0.160		3.138	0.003
	Distance to forest	0.070	0.031	0.364	2.287	0.028
	Population change	0.000	0.000	-0.197	-1.327	0.193
	Household size	-0.046	0.026	-0.276	-1.797	0.081

Dependent Variable: Natural log transformed H'_forest

7.3.6.2 Factors that Affected Mean NDVI in 2010 in All Communities

The overall model of the best multiple regression (selected using Akaike's Information Criteria), which predicted 69.2% of the variance in the mean NDVI of 2010 (NDVI_2010) was significant ($F = 12.382$, $p = 0.000$) (Table 7.12).

Table 7.12: Overall multiple regression model of mean NDVI in 2010.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	0.045	6	0.007	12.382	0.000
	Residual	0.020	33	0.001		
	Total	0.065	39			

Predictors: (Constant), Elevation to forest, Management prescription, Population change, NDVI_1991_2000, Distance to forest, Posttest FCA score
Dependent Variable: Reciprocal transformed NDVI_2010

All the selected predictor variables namely the elevation from the village to forest, management prescription, population change (from 2000 to 2010), change in mean NDVI from 1991 to 2000 (NDVI_1991_2000), distance to forest, and posttest FCA score, significantly predicted the mean NDVI in 2010 (Table 7.13). The NDVI_2010 was positively predicted by the posttest FCA score ($p = 0.001$) and change in population from 2000 to 2010 ($p = 0.006$) predicted (Standardized B = 0.479 and 0.307 respectively for the two positive significant predictors). However, the NDVI in 2010 was negatively affected by NDVI_1991_2000, management prescription, distance to forest, and the elevation to the forest (Standardized B = -0.560, -0.544, -0.289 and -0.224 respectively for the four negative significant predictors).

Table 7.13: Parameter estimates of the regression model of the mean NDVI in 2010.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	0.464	0.040		11.465	0.000
	NDVI_1991_2000	-0.256	0.058	-0.560	-4.428	0.000
	Management prescription	-0.044	0.008	-0.544	-5.270	0.000
	Posttest FCA score	0.017	0.005	0.479	3.694	0.001
	Distance to forest	-0.011	0.004	-0.289	-2.692	0.011
	Population change	7.826E-5	0.000	0.307	2.941	0.006
	Elevation to forest	-5.766E-5	0.000	-0.224	-2.124	0.041

Dependent Variable: Reciprocal transformed NDVI_2010

7.3.6.3 Factors that Affected Mean NDVI Change from 2000 to 2010 in Afadjato-Agumatsa

The best regression model (selected based on Akaike's Information Criterion) for the change in NDVI from 2000 to 2010 in the Afadjato-Agumatsa area predicted 78.4% of the variance in the dependent variable. The only significant predictor was the NDVI change from 1991 to 2000 (NDVI_1991_2000) (Table 7.14). Increasing NDVI_1991_2000 predicted increasing NDVI_2000_2010 (B = 0.897).

Table 7.14: Parameter estimates of the regression model of the mean NDVI change from 2000 to 2010 in the Afadjato-Agumatsa area.

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	0.386	0.017		22.189	0.000
	NDVI change from 1991 to 2000	0.897	0.192	0.886	4.673	0.003

Study area = Afadjato-Agumatsa
Dependent Variable: Reciprocal transformed NDVI change from 2000 to 2010

7.3.6.4 Factors that Affected Mean NDVI Change from 2000 to 2010 in the Atewa Area

The best regression model (selected based on Akaike's Information Criterion) for the change in NDVI from 2000 to 2010 in the Atewa area, which predicted 58.7% of the variance in the dependent variable was significant (p = 0.000) (Table 7.15). Of the two selected predictor variables, the only significant predictor was NDVI_1991_2000 (Table 7.16). Increasing NDVI_1991_2000 predicted increasing NDVI_2000_2010 (B = 0.526).

Table 7.15: Overall multiple regression model of the change in mean NDVI from 2000 to 2010 in the Atewa area.

Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	0.046	2	0.023	20.585	0.000
	Residual	0.033	29	0.001		
	Total	0.079	31			

Predictors: (Constant), Population in 2010, NDVI change from 1991 to 2000
Study area = Atewa
Dependent Variable: Reciprocal transformed NDVI change from 2000 to 2010

Table 7.16: Parameter estimates of the regression model of the mean NDVI change from 2000 to 2010 in the Atewa area.

Model		**Unstandardized Coefficients**		**Standardized Coefficients**		
		B	**Std. Error**	**Beta**	**t**	**Sig.**
1	(Constant)	0.291	0.024		12.321	0.000
	NDVI from 1991 to 2000	0.526	0.088	0.719	6.008	0.000
	Population in 2010	8.568E-6	0.000	0.214	1.790	0.084

Study area = Atewa
Dependent Variable: Reciprocal transformed NDVI change from 2000 to 2010

7.4 Discussion

7.4.1 Mean Normalized Difference Vegetation Index and Species Diversity of Fruit Bats

In both study areas, mean Normalized Difference Vegetation Index (NDVI) of forests decreased from 1991 to 2000 and further decreased up to 2010. This continuous decrease in NDVI indicates the continuing degradation of forest habitat at the landscape level in the two study areas. This is the trend of biodiversity in many parts of the world. However, there was a reduction in the rate of degradation based on the mean NDVI in Atewa, while that of Afadjato-Agumatsa increased from 2000 to 2010.

Of the 13 species of fruit bats recorded in Ghana (Yeboah 2007), 11 were recorded in the two study areas. In addition to this, the fact that 10 of the 11 species were listed on the IUCN Red data list indicates the importance of the two forests for fruit bat conservation in Ghana. The higher number of individuals captured in Atewa than in Afadjato-Agumatsa was due to the higher effort in the Atewa area. The number of species was higher in Afadjato-Agumatsa than in Atewa. Two species, namely *Eidolon helvum* and *Hypsignathus monstrosus* were recorded during the systematic trapping in Afadjato-Agumatsa but not in Atewa; while one species *Scotonycteris zenkeri* was recorded in Atewa but not in Afadjato. Opportunistic observations undertaken during the surveys indicated that calls of *Hypsignathus monstrosus* were heard during three nights in Atewa. Therefore this species is found in Atewa but was not captured with my sampling scheme.

Comparing the three estimates of biodiversity namely, species diversity of forest-specialist fruit bats (H'_forest), change in NDVI from 2000 to 2010 (NDVI_2000_2010), and NDVI in 2010

(NDVI_2000), only NDVI_2000_2010 was significantly different between the two study areas. In 1991, the mean NDVI in the forests of Atewa was less than that of the Afadjato-Agumatsa forests. This estimate in addition to the similar NDVIs in 2010, suggest that at the landscape level, the rate of functional forest biodiversity loss or habitat degradation decreased in Atewa. There was a significant correlation between H'_all and NDVI in 2010. However, the correlation between H'_forest and NDVI_2010 was insignificant. This indicated how biodiversity estimates at different levels of scale could be different (Noss 1992, Groom et al. 2006).

7.4.2 Factors that Affected Fruit Bat Diversity and Mean NDVI

Unlike mean NDVI estimates, there were no comparable pretest estimates for fruit bat diversity in the study areas because earlier studies were either not documented in detail enough (especially with respect to the sampling effort) for comparison with this study. Some studies on fruit bats such as in McCullough et al. (2007) was not early enough to be used as a pretest for the Atewa area. Early studies in the Afadjato-Agumatsa area such as Owusu (2001) did not include fruit bat studies.

Among only the LSA communities, none of the three biodiversity estimates in the forests was significantly predicted by the benefit cost ratios of livelihoods support activities (LSAs), forest conservation attitude (FCA) scores in 2010, change in FCA score from 2000 to 2010. This suggests that among communities that participated in LSAs, there was no significant causative link between the forest conservation attitudes and biodiversity at the landscape level as well as fruit bat diversity, even though there was a causative link between LSAs and forest conservation attitudes among them as presented in Chapter 6 of this dissertation. This was not the case in the analyses involving all the communities as presented below. However, it may take time for impacts on forest conservation attitudes to affect biodiversity, so another study undertaken at a later date could potentially capture these human effects on biodiversity.

Among all the 40 communities, the per capita benefit-cost ratio of LSAs, FCA scores and change in FCA scores from 2000 to 2010 did not predict the species diversity of forest-specialist fruit bats. Longer distances between a community and its forest region of interest significantly predicted higher species diversity of forest-specialist fruit bats. This did not suggest that the above-ground green forest was necessarily high because there was a very low and insignificant correlation between the species diversity indices of forest-specialist fruit bats and NDVI in 2010. The prediction of higher species diversity of fruit bats by longer distances between the communities and the forests could be explained by the fact that most of the sampling points were located near water bodies (streams, rivers and ponds) where the bats were most likely to drink water. These water bodies are also the points of water collection in many villages. Therefore the water bodies located far from the towns and villages would have less human interference, and this favored their use as drinking points by the bats. Since many fruit bats tend to be opportunistic feeders (Kingdon 1997), it may be necessary to protect trees that produce their food within areas that are far from human settlements. This may encourage the bats to use and consequently contribute to the dispersal of seeds for natural regeneration of forests as well as for plants with potential direct benefits to humans.

Six factors significantly predicted the NDVI in 2010 among all communities. These included elevation from the village to the forest, the forest management prescription, population change (from 2000 to 2010), change in mean NDVI from 1991 to 2000 (NDVI_1991_2000), distance to forest, and posttest FCA score. Among these predictor factors, it was important to note that higher FCA scores predicted higher NVDI in 2010. This suggests that influencing communities attitudes towards forests could affect how much forest in conserved. Communities which lost more of their above-ground green forest from 1991 to 2000 tended to have lower NDVI in 2010. Areas with strict forest management prescriptions also tended to have lower NDVIs in 2010. These results confirmed the explanations by the forest managers that one of the main criteria for prescribing stricter forest management practices in some areas was the high level of resource exploitation. The low mean NDVI in such areas after more than six years of management restrictions could be because of the lag time for natural regeneration of forests.

Increase in population from 2000 to 2010 was a positive predictor of higher NDVI in 2010. This could be explained by the fact that due to the increase in populations, there may be more conservation volunteers and other informants in such communities. Forest encroachers and illegal loggers tend to move away from such areas.

Estimates of elevation and distance to the forest, which are proxies of efforts made in forest resource exploitation, were significant negative predictors of mean NDVI in 2010. It would be expected that these factors would be positive predictors (higher amounts of effort resulting in reduced disturbance and consequently higher biodiversity estimates). However, the greater effort required to access such forests from the villages also implies that the forest managers and other concerned community members would not be able to monitor such areas regularly.

Consequently such areas are prone to illegal logging and encroachment for farming: factors which would reduce the above ground forest estimated by NDVI estimates.

With respect to the change in mean NDVI from 2000 to 2010, the only significant predictor in the two study areas was change in mean NDVI from 1991 to 2000. Communities which lost more forest biomass from 1991 to 2000 continued to lose more forest from 2000 to 2010. This suggests that the trend of forest vegetation loss between 1991 and 2000 continued from 2000 to 2010.

On the basis of these results, I rejected the hypotheses that greater increase in FCA scores would predict greater biodiversity (mean NDVI, change in mean NDVI, and fruit bat diversity); that greater per capita benefit-cost ratios of LSAs would predict greater biodiversity; that higher FCA scores would predict greater change in mean NDVI and higher fruit bat diversity; that LSA communities which had active LSAs would have higher change in NDVIs and higher fruit bat diversity than LSA communities which had no active LSA. However, I could not reject the hypothesis that higher FCA scores would predict higher mean NDVI.

These results suggest that forest conservation attitudes predicted forest biodiversity at the landscape level but not at the species level (with respect to forest-specialist fruit bats). This was not observed for the analyses involving only LSA communities. The implications for conservation policy suggest that addressing tropical forest biodiversity conservation is a socio-ecological activity, which requires interdisciplinary research and action. The fact that the prediction of mean NDVI by environmental attitudes could not be determined in the analysis of only LSA communities suggest that evaluations of conservation interventions that are restricted to the intervention (treatment) group may not be conclusive. The use of 'control' intervention units will enhance the understanding of conservation outcomes better. The fact that the forests with the strictest management prescriptions predicted lower mean NDVIs could be because the forests had been managed by natural regeneration and not active restoration by enrichment planting. It is important to repeat this study in after a decade to determine if the low change in mean NDVIs was due to the lag time needed for natural regeneration, the lag between improved forest conservation attitudes, or other factors.

On the basis of the socio-demographic factors, other predictors of FCAs (in Chapter 6) and the results of this chapter, I present a biocomplexity framework and a conceptual model for forest biodiversity conservation in southeastern Ghana in the next chapter, which concludes this dissertation.

CHAPTER 8: A BIOCOMPLEXITY FRAMEWORK AND A CONCEPTUAL MODEL FOR FOREST BIODIVERSITY CONSERVATION IN SOUTHEASTERN GHANA

Abstract

The coupled human and natural systems in the Afadjato-Agumatsa and Atewa areas present an excellent system for investigating biocomplexity in the environment. In this chapter, I developed two biocomplexity frameworks and a conceptual model for forest biodiversity conservation in the study areas. The biocomplexity frameworks were developed on the basis of the framework proposed by Pickett et al. (2005). These frameworks consisted of the spatial, organizational and temporal dimensions of the economic, social, and ecological components of the system. The scope of the first framework was for forest conservation in Ghana. The scope of the second framework was southeastern Ghana, specifically the forests in the Afadjato-Agumatsa and Atewa areas. The scope of the conceptual model was restricted to the targets of conserving a functional green forest cover and forest-specialist fruit bats in the Afadjato-Agumatsa and Atewa areas because those were the biodiversity proxies used in this dissertation. This conceptual model is a useful example of how conservation projects in an area such as study areas could be monitored and evaluated. Apart from other variables, the relationships within and between the economic, social and ecological components of the system were the basis of the conservation strategies of the conceptual model. In addition to the biocomplexity frameworks and the conceptual model, I concluded this dissertation with an outline of the general conservation implications of this dissertation, the limitations of the study and suggestions for future research.

8.1 Introduction

8.1.1 The Complexities of Coupled Human and Natural Systems

The use of livelihoods support activities (LSAs) for biodiversity conservation purposes is only a component of conservation projects. These projects are actually implemented within coupled human and natural systems (CHAN) and the framework of many other factors, which affect the biodiversity. These factors could be social, economic, behavioral, cultural, political, chemical or biophysical, and are themselves dynamic. The dynamics of these and other factors are linear and non-linear, thus introducing different complexities into environmental systems. Margoluis et al (2009b) identified two types of complexity that need to be understood and addressed by conservation managers: dynamic complexity and detail complexity. Dynamic complexities refer to the unpredictable interactions of environmental factors; detail complexities mean the many internal and external variables that affect environmental systems. It is important for the biodiversity conservation community to give increased attention to these complexities by continuing to collect and analyze relevant data, and share information through networks in order to better understand and model these complexities. On the basis of these, the use of biocomplexity in the environment as a framework for this dissertation was very appropriate.

Though biocomplexity in the environment was first proposed in 1999 to encourage interdisciplinary research in environmental conservation, its practical applications are rare. Pickett et al. (2005) defined biocomplexity as the degree to which the interactions in ecological systems comprising biological, social, and physical components incorporate spatially explicit structure, organizational connectivity, and historical contingency. To encourage the use of the concept in understanding coupled human and natural systems, Pickett et al. (2005) proposed a multi-dimensional theoretical framework consisting of spatial, organizational and temporal complexities. The components of the system are analyzed in each of these dimensions.

According to the Ecological Society of America (ESA 2002), biocomplexity in the environment is an effort to seek an integrative and quantitative approach to science in order to better understand the complex interactions in CHAN systems. This requires that environmental research is done using more interdisciplinary approaches than currently. ESA (2002) lists some characteristics of biocomplexity to include non-linear behavior, interactions over multiple levels of scale and time, must be studied in whole or piece by piece, relevant for all organisms ranging from unicellular organisms to humans, and relevant for all environments ranging from the coldest to the warmest to anthropologically-modified such as agricultural lands. Deconstructing the contextual complexities of an environmental system is necessary for measuring the success of conservation projects (Margoluis et al 2009b). These characteristics, as well as the linear and non-linear dynamics of CHAN systems make feedbacks and thresholds important in developing appropriate models for environmental systems. Often, these models of the natural environment are simulated using cellular automata and observations/actions of humans are defined as agents (Torii et al. 2005, Walsh and McGinnis 2009). These models work well because of the non-linear interactions between system components (Callicott et al. 2007).

8.1.2 A Conceptual Model for Tropical Forest Biodiversity Conservation

Models are best developed and implemented within a framework. Many forest areas in Ghana, including Afadjato-Agumatsa Range and Atewa Range forests are largely surrounded and exploited by humans and therefore affected by human settlements and their activities. Their current status is a result of centuries of interactions between the natural areas and other factors such as geological and anthropogenic interactions. The use of models in the framework of biocomplexity will enhance scientific understanding of such systems. Pickett et al (2005) proposed that in using the framework, the environmental issue or system could be divided into components, analyzed individually and then integrated into a biocomplexity system.

In this dissertation, I divided forest biodiversity conservation into economic, social and ecological components. The evaluation of the livelihoods support activities to estimate the capital investment, net benefit and benefit-cost ratios was the economic component. The assessment of environmental attitudes made up the social system. The evaluation of the effects of attitudes on the primary productivity of the green forest and the species diversity of fruit bats made up the ecological component. On the basis of the results of the previous chapters of this dissertation, I integrated the three components and used them to develop a conceptual model. A conceptual model is a tool for visually expressing the context within which a system operates (Margoluis et al. 2009). A conceptual model expresses how the components and processes which are deemed important in a system are related (Gross 2003). Therefore a conceptual model can be used to identify gaps in knowledge and for planning, monitoring and evaluation of programs, thus making it an important model of this dissertation.

8.1.3 Aim and Objectives

This chapter addresses the fifth objective of this dissertation. The aim was to develop a practical model within the framework of biocomplexity in the environment for forest biodiversity conservation in southeastern Ghana. The specific objectives were as follows.

1. Outline a biocomplexity framework for forest biodiversity conservation in Ghana.
2. Develop a specific biocomplexity framework for the study areas.
3. Develop a conceptual model for biodiversity conservation in the study areas.

8.2 Methods

To outline the biocomplexity framework for the conservation of forest biodiversity in Ghana, I reviewed the framework of Pickett et al. (2005) and modified it into a general framework for forest biodiversity conservation in Ghana. In line with the components of this dissertation, I divided forest conservation in Ghana into economic, social and ecological components and considered the spatial, temporal and organizational dimensions of each component. To develop a specific biocomplexity framework for the Afadjato-Agumatsa and Atewa areas, I simplified the framework for Ghana and specified components of the system from the variables I considered in the analysis of earlier chapters. These variables include socio-demographics, and factors that are deemed to affect conservation attitudes, and those affect the degradation of forests.

In order to develop a conceptual model for biodiversity conservation in the Afadjato-Agumatsa and Atewa areas, I used the frameworks above, the statistical relationships generated in earlier chapters of this dissertation, as well as the logic model of the dissertation. I derived the general process for developing the conceptual model from Margoluis et al. (2009) and this included:

i) Define the conservation targets.
ii) Determine and add the direct threats affecting each conservation targets.
iii) Determine and add the contributing factors to the direct threats.
iv) Add strategies to address the contributing factors, direct threats or conservation targets.

Due to the specific issues addressed in this dissertation, the conservation targets I used in this model included: 1) to increase forest cover, and 2) to increase fruit bat diversity. The model also showed how the LSAs could be used as a strategy for tropical biodiversity conservation.

8.3 Results and Discussion

8.3.1 A Biocomplexity Framework for Forest Conservation in Ghana

Forest biodiversity conservation in Ghana can be perceived from many perspectives but in this study, the components are restricted to ecological, social and economic because these are the major drivers of conservation policy in Ghana. The assumption here is that there are negligible differences in the effects of all other factors. On the basis of these assumptions, a framework of biocomplexity in the environment which details the dimensions of each of the three components of forest conservation in Ghana is outlined (Table 8.2) and described.

8.3.1.1 Biocomplexity of Forest Conservation in the Ecological Realm

In the ecological realm the spatial units are the forested protected areas. These include wildlife conservation areas, forest reserves and the recently established community reserves. The spatial dimension of biodiversity conservation increases in complexity from the number of conservation areas, to the shifting network of conservation areas in Ghana changes through time (Table 8.1). The organizational complexity in the ecological realm involves the identifiable ecological groups, including animals, plants and microorganism groups or communities. Following Pickett et al (2005), the organizational dimension of biocomplexity will involve the following sequence: within-community process - communities' interaction to conservation area's boundary regulation - cross-community regulation - functional communities' dynamics. Temporal complexity in the ecological realm increases from current or contemporary direct interactions to contemporary indirect interactions to legacies to lagged interactions to slowly emerging indirect effects. These include interactions such as predator-prey interactions, herbivore-plant interactions, wildfire-tree interactions, pathogen-prey interactions and wildlife-human interactions.

8.3.1.2 Biocomplexity of Forest Conservation in the Social Realm

The units of the social component of biocomplexity in Ghana are the decision-making structures. These include the social groups, institutions and individuals in governmental and non-governmental agencies, research, academia, local government and local communities. Spatial dimensions involve the locations of the decision-making structures with respect to the conservation areas that their actions affect (Table 8.1). This dimension increases from the locations of the number of groups, to group location frequency and to group location constitution or configuration and finally to the highest complexity of shifting groups location dynamics. The organizational dimension increases as decision making increases from an individual to households, neighborhoods, community structures, and through to the national level. Temporal contingency in this realm increases from current or contemporary direct interactions between the decision making structures to contemporary indirect interactions between such groups. Next in complexity are the legacies to lagged interactions to slowly emerging indirect effects. These involved social interactions of individuals, within and between groups.

Table 8.1: Summary of a biocomplexity framework for forest conservation in Ghana.

COMPONENTS	Trend of complexity	COMPLEXITY DIMENSIONS		
		Spatial	**Organizational**	**Temporal**
Ecological	Increasing complexity ↓	Number of conservation areas	Within-community process	Current interactions
		Conservation area frequency	Community's interaction	Indirect interactions
		Conservation area configuration	Boundary regulation	Legacies (of fires, precipitation)
		Internal changes	Cross-community regulation	Lagged interactions
		Shifting network of conservation areas	Functional community dynamics	Slowly emerging effects
Social	Increasing complexity ↓	Location of groups and their numbers	Individual decisions	Current direct interactions
		Group location frequency	Households decisions	Current indirect interactions
		Configuration of groups' locations	Neighborhood decisions	Legacies of past collaborations
		Internal group location changes	Town/village decisions	Lagged interactions
		Shifting group location dynamics	District level & higher level decisions	Slowly emerging indirect effects
Economic	Increasing complexity ↓	Locations of the resources	Individual resource uses	Current direct uses
		Resource location frequency	Households uses	Current indirect uses
		Configuration of resource locations	Neighborhood uses	Legacies of past uses
		Internal resource location changes	Local area uses	Lagged effects of past uses
		Shifting resource location dynamics	National uses International uses	Slowly emerging effects of use

8.3.1.3 Biocomplexity of Forest Conservation in the Economic Realm

The economic component of biodiversity conservation in Ghana is one that largely has natural resources of direct economic importance as its units. These include timber, medicinal plants, water, bushmeat, fuel wood and other resources. The economic values as perceived by different interest groups are important. The spatial dimension involves their different locations with respect to the conservation areas. This complexity increases from the simplest form of the location of the resources, through resource frequency, resource configuration, internal resource availability changes and finally to shifting resources availability dynamics (Table 8.1). The organizational complexity of the economic component of biodiversity conservation in Ghana increases as economic use of the resources increases from an individual use to households use to neighborhoods use to local area use to district level use to regional levels use, national level use finally to the international uses of forest resources. Temporal contingency in the economic realm increases from current direct uses to indirect uses of the resources, with highest complexity in slowly emerging indirect effects of past uses.

8.3.2 A Biocomplexity Framework for the Afadjato-Agumatsa and Atewa Forest Areas

The framework for the study areas is a modified version of that for Ghana. The spatial dimension of the ecological component increases in complexity as the consideration of the size and shape of the conservation area changes to the home range of fruit bats that travel far beyond the protected forests to forage (Table 8.2). The organizational complexity increases as the demographics of fruit bats changes to their contribution to seed dispersal within the protected forests. The temporal complexity increases from current species diversity to legacies of precipitation. The social component increases in spatial complexity when the considerations change from the location of the communities to the direction of sprawl (Table 8.2). The organizational complexity increases from gender ratios to attributes such as the status of the chief. The temporal complexity increases from considerations of past population changes to past collaborations with conservation agencies or agents. The spatial complexity of the economic component increases from the location of forest resources from community to the location of livelihoods support activities. The organizational complexity increases from the specific forest resources used by individuals to how the cooperatives are organized. The temporal complexity changes from considering the frequency use of the forest resources to legacies of past uses such as past logging or mining (Table 8.2).

Table 8.2: A biodiversity framework derived from this dissertation for forest conservation in southeastern Ghana.

COMPONENTS	Increasing complexity	COMPLEXITY DIMENSIONS Spatial	Organizational	Temporal
Ecological	↓	Size and shape of the conservation area	Sex ratio and age demographics of fruit bats	Current and future species diversity indices
		Relative sizes of the forests of the two areas	Boundary regulation from forest management prescription	Current and changes in primary productivity of forest
		Distance from communities to forests used by fruit bats	Seed dispersal of fruit bats within the forest	Legacies of precipitation
Social	↓	Location and number of communities	Gender ratio (male:female)	Past population changes
		Household size (population density)	Conservation agent in the community or not	Future population changes
		Direction of sprawl of new homes	Status of local chief and/or ownership rights	Any past collaborations with conservation organizations
Economic	↓	Location of forest resources from community (distance and elevation)	Specific forest resources used by individuals	Frequency of forest resource use
		Distance from community to major roads	Household use of forest resources	Current indirect use of forest (some ecosystem services)
		Location of livelihoods support activities (LSAs)	Organization of LSA cooperatives	Legacies of past uses (past logging or mining)

8.3.3 The Conceptual Model of Forest Biodiversity Conservation in the Study Areas

The proposed conceptual model (Figure 8.1) is for forest biodiversity conservation in southeastern Ghana. It was based on the conditions and analysis of the links between livelihoods support programs and attitudes towards forest conservation and biodiversity at the landscape and species level. Therefore, the scope of the model, which is defined as the broad parameters that show where and what the project is aimed at (Margoluis et al. 2009), is the conservation of tropical forest biodiversity in southeastern Ghana. The biodiversity conservation targets, which are measurable element(s) of biodiversity which the project seeks to affect or change, are specified within the scope. For this model, the targets are functional green forest, measured by NDVI, and the species diversity of forest-specialist fruit bats. The direct threats are actions, processes or events that degrade the biodiversity targets. Examples are encroachment of the forests for crop farming. The contributing factors are indirect threats, opportunities, and other variables that influence the direct threats. For example, an increased demand for food crops could result in encroachment for crop farming. The strategies are project actions that would influence the indirect threats, or in a few cases, direct threats. For example, livelihoods support programs that promote crop varieties of higher yields could reduce the demand for food crops. In a conservation project, other stakeholders, especially the project team are actively involved in developing the conceptual model. The model is dynamic and changes as new issues come up or as evaluators or project managers discover and learn new variables as well as new relationships between variables. Other details, which could be added to the model as presented in Figure 8.3 include, stating how to address biodiversity targets as goal statements; stating how to address direct threats and contributing factors as objectives; and scheduling of the strategies.

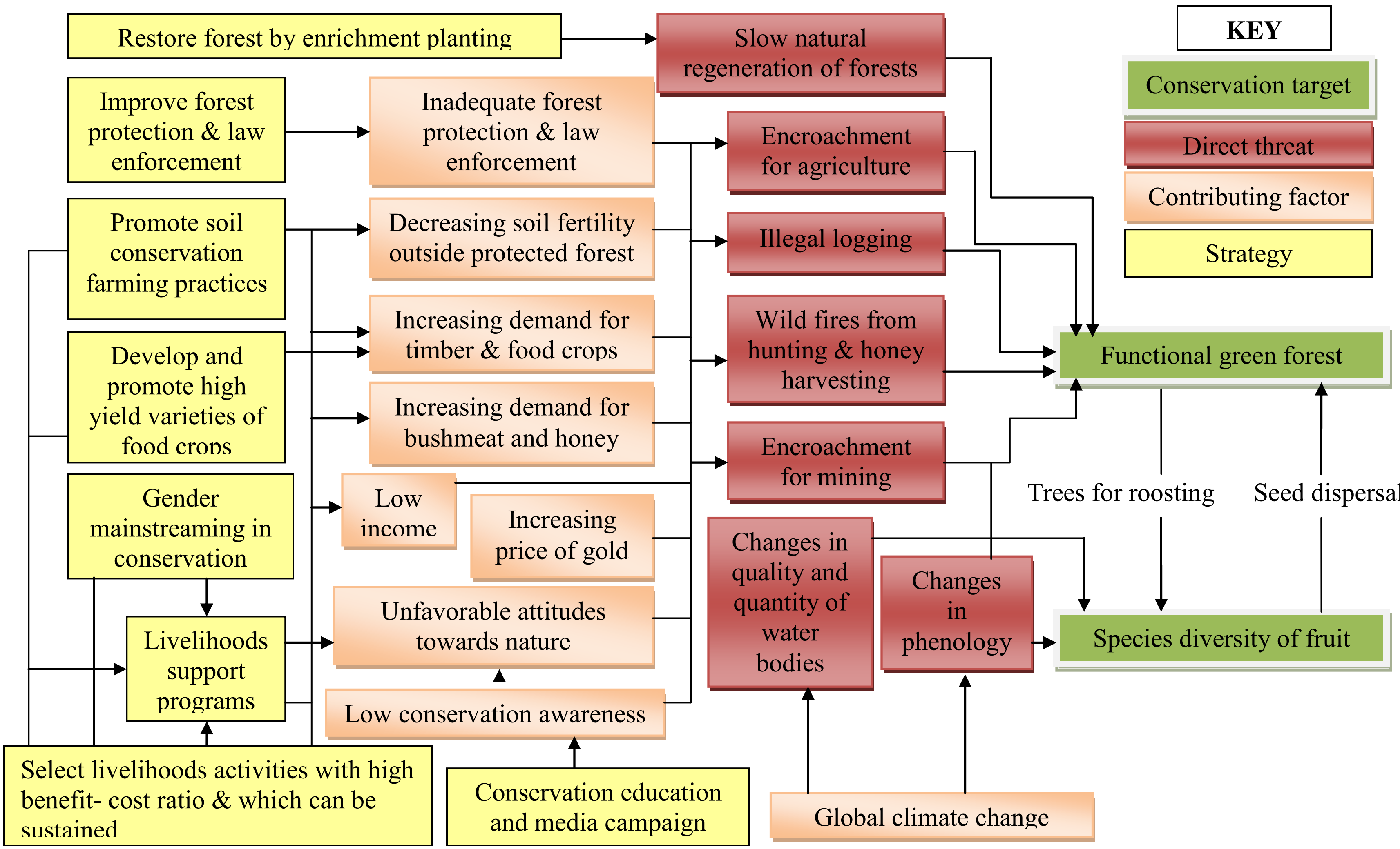


Figure 8.1: A proposed conceptual model of forest biodiversity conservation in Afadjato-Agumatsa and Atewa areas in Ghana.

8.4 General Conclusion

The science of conservation biology is concerned about and works to address the issue of environmental degradation and loss of biodiversity. Humans continue to directly and indirectly modify these systems. Tropical forests are a very good example of natural systems that have become and continue to be stressed by human globally. This study has helped to answer the counterfactual question asked at the beginning of this dissertation, addressed the links between conservation attitudes and forest biodiversity, and addressed methodology issues that come up in evaluating conservation projects and programs.

8.4.1 Answering the Counterfactual Question about LSAs and Conservation Attitudes

The counterfactual question asked at the beginning of this study was: *what would have happened to the forest biodiversity in the study areas if the LSAs had not been implemented*? The difference between the answer to this question and what happened to intervention communities gives an estimate of a causal effect of the intervention. LSAs influence biodiversity indirectly. Therefore the counterfactual question answered initially was: *what would have happened to attitudes towards forest conservation in the study areas if the LSAs had not been implemented*? The results indicated that LSAs had infinitesimal effects on forest conservation attitudes. Among LSA communities only, factors that predicted favorable forest conservation attitudes were the per capita benefit-cost ratio of LSAs, and the sustainability of LSAs in a community. These suggest that just participating in LSAs did not have significant effects on forest conservation attitudes, but some attributes of the LSAs (benefit-cost ratio, and the sustainability of LSAs), and some socio-demographic factors could help improve conservation attitudes.

8.4.2 Conservation Attitudes and Biodiversity

The results of the relationships between forest conservation attitudes and biodiversity indicated that the trend of biodiversity degradation and/or loss at the landscape level has continued, though at a slower rate in the Atewa area. Forest conservation attitudes and other socio-demographic and biophysical factors predicted biodiversity at the landscape level. The distance between a community and the forests of concern was the only predictor of higher fruit bat diversity. The different predictors of biodiversity at the different scales indicate that the estimates of biodiversity vary with the scale (Noss 1990). These results also support the view that apart from economic challenges, and political and biophysical factors, attitudes towards forest conservation activities also influenced how much biodiversity is degraded or lost.

8.4.3 General Conservation Implications of this Study

The overall conservation implications of the findings of this study show that forest conservation attitudes are important for biodiversity conservation. Also, LSAs could be useful conservation tools. Benefit-cost ratio of LSAs and the sustainability of LSAs predicted favorable attitudes towards forest conservation, which in turn predicted reduction in the degradation and/or loss of biodiversity (Figure 8.2).

The two attributes of LSAs which have been identified to favor conservation by predicting favorable forest conservation attitudes; as well as the conservation attitudes in themselves are factors of process. This means processes need urgent and sustained attention in order to reduce degradation or loss of biodiversity: the ultimate target of the science of conservation biology.

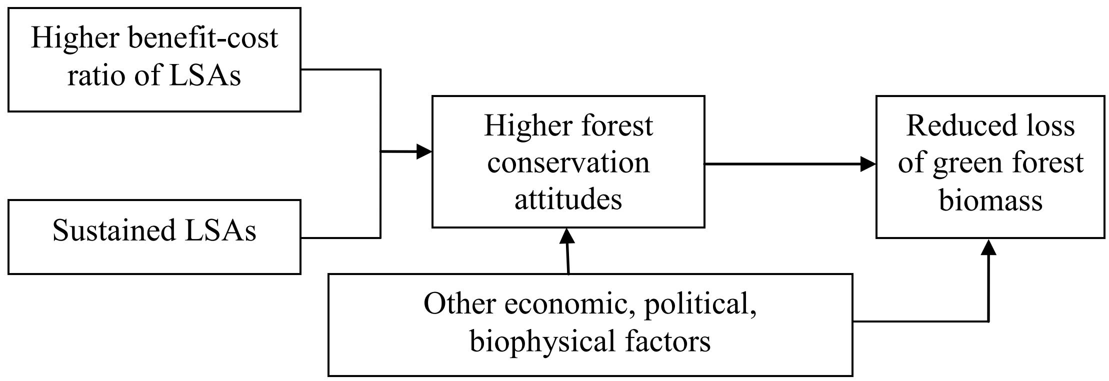


Figure 8.2: An overall summary of the favorable conservation implications of the study.

8.4.4 Limitations of this Study

Much of the methodologies, especially the quasi-experimental design employed in this study were largely from other fields of study such as program evaluation, pharmacology, education, sociology, and public health. Though I have successfully applied it to evaluate biocomplexity in the environment, the implications are not without limitations. Some limitations are as follows.

In the fields of study mentioned above, most of the research/experimental units are individual humans or other organisms. The application of these units to communities which are not as homogenous as individuals is a limitation of this study. However, these are the best options available. I hypothesize that it is better to use the best imperfect options available than the use of inadequate methodologies, or not to do the study.

The sample of size (number of communities) was relatively small when compared to the examples of evaluation research in other fields of study that these methodologies are applied. However, having 40 communities to conduct research in is substantial in biodiversity conservation. Therefore in this case too, this was an excellent opportunity to employ the quasi-experimental design and non-parametric analysis.

Though many factors were considered in this study, I acknowledge that there must have been many other influential factors such as biogeochemical factors that I ignored because I did not discover them before starting the research or I could not measure them within the resources for the research.

Non-parametric analysis and data transformations reduce the statistical power. Non-parametric statistics ranks the data and transformed data is also different from the original data, but were the best options with the structure of the data. In addition, there was much subjectivity inherent in estimates of many of the variables and indices, and so I was interested in the ranks of the indices instead of the real figures. For the results of this study to be used to conduct simulation models, requires information on thresholds and feedbacks within a system. Non-parametric and transformed analyses reduced the ability to measure thresholds and assess feedbacks.

The subjectivity in the variables was also a limitation of this study. NDVI was objectively estimated from satellite images, which are based on the light energy received by the satellites. These which are not necessarily fool-proof, but have been shown to provide reasonable Attitudes were estimated using relatively objective methods, but the answers were not free of subjectivity. Estimating socio-economic attributes of LSAs was limited to information that the cooperatives could give out. Other benefits or costs may have been left out for respondents' personal reasons; because they thought they were irrelevant or forgot at the time of data collection. Some variables were based on expert judgment, which may not be accurate because they are actually the opinions of the experts and not objective measurements. However, they were the best options available, and experts are the ones who make conservation policy and action decisions.

8.4.5 Suggestions for Future Research

On the basis of these limitations I outline the following suggestions for future research.

1. Use anthropological methods and some deterministic models to estimate land use behavior towards the environment and compare these behaviors to attitude estimates.
2. Include other socio-political factors such as the presence of a local government representative in a village, and the number of chainsaws owned in a community. Biophysical factors such as water in forest soils could be added to the analysis.
3. In estimating the conservation attitudes, increase the number of Likert-type response options from three to at least five. This may increase the reliability of attitude estimates.
4. Repeat the study after 5 years and/or ten years. This will help to reduce any lag effects or legacies of some past actions in the forest.
5. Future research should aim at detecting thresholds and feedback. These would be needed to develop simulation models for biocomplexity, which may be useful in predicting effects of conservation policies actions before taking them and that would reduce risk.
6. Repeat in other areas in tropical forests and compare to this. In these other studies, I suggest that larger number of communities be used. This will contribute to establishing quasi-experimental research design for evaluating conservation outcomes.

The contribution of this study to academic and professional knowledge on understanding the impacts of livelihoods programs, which is relevant for policy decisions regarding using them as economic tools for conservation in tropical forests. It is an example for evaluators of conservation programs to begin using more appropriate methodologies. As more research is conducted into the response of biodiversity components to human activities, methodologies that estimate the causal effects of policies on biodiversity have to be promoted.

APPENDIX A:
INSTITUTIONAL REVIEW BOARD APPROVAL LETTERS FOR HUMAN RESEARCH

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: UCF Institutional Review Board #1
FWA00000351, IRB00001138

To: **Edem K. Ekpe**

Date: **May 05, 2010**

Dear Researcher:

On 5/5/2010, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review: Addendum/Modification Request Form
Modification Type: Revised survey to include the questions that measure the endorsement of the New Ecological Paradigm.

Project Title: Livelihoods support programs for conservation, conservation attitudes and behaviors, and tropical forest biodiversity: an evaluative investigation of biocomplexity in southeastern Ghana
Investigator: Edem K Ekpe
IRB Number: SBE-09-06487
Funding Agency: None

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate. In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.
On behalf of Joseph Bielitzki, DVM, UCF IRB Chair, this letter is signed by:
Signature applied by Janice Turchin on 05/05/2010 09:46:57 AM EDT

IRB Coordinator

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Exempt Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Edem K. Ekpe**

Date: **May 05, 2010**

Dear Researcher:

On 5/5/2010, the IRB approved the following activity as human participant research that is exempt from regulation:

Type of Review:	Addendum/Modification Request Form
Modification Type:	Revised survey to include the questions that measure the endorsement of the New Ecological Paradigm.
Project Title:	Livelihoods support programs for conservation, conservation attitudes and behaviors, and tropical forest biodiversity: an evaluative investigation of biocomplexity in southeastern Ghana
Investigator:	Edem K Ekpe
IRB Number:	SBE-09-06487
Funding Agency:	None

This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these changes affect the exempt status of the human research, please contact the IRB. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Joseph Bielitzki, DVM, UCF IRB Chair, this letter is signed by:

Signature applied by Janice Turchin on 05/05/2010 09:46:57 AM EDT

Janice M Turchin

IRB Coordinator

APPENDIX B:
INSTITUTIONAL ANIMAL CARE AND USE COMMITTEE PROTOCOL APPROVAL LETTERS

University of Central Florida

Office of Research & Commercialization

11/9/2009

Dr C. Ross Hinkle
Biology
Biology Department, Rm 302
4000 Cental Florida Blvd
Orlando, Fl 32826

Subject: Institutional Animal Care and Use Committee (IACUC) Protocol Submission

Dear: Dr C. Ross Hinkle:

This letter is to inform you that your following animal protocol was approved by the IACUC. The IACUC Use Approval Form is attached for your records.

Animal Project #:	09-44W
Title:	Livelihoods support programs for conservation, conservation attitudes and behaviors, and tropical forest biodiversity: an evaluative investigation of biocomplexity in southeastern Ghana.
First Approval Date:	11/6/2009

Please be advised that IACUC approvals are limited to one year maximum. Should there be any technical or administrative changes to the approved protocol, they must be submitted in writing to the IACUC for approval. Changes should not be initiated until written IACUC approval is received. Adverse events should be reported to the IACUC as they occur. Furthermore, should there be a need to extend this protocol, a renewal must be submitted for approval at least three months prior to the anniversary date of the most recent approval. If the protocol is over three years old, it must be rewritten and submitted for IACUC review.

Should you have any questions, please do not hesitate to call me at (407) 882-1164.

Please accept our best wishes for the success of your endeavors.

Best Regards,

Cristina Caamaño

Cristina Caamaño
IACUC Coordinator,
Office of Research and Commercialization

Copies: Appropriate Facilty Manager (when applicable).

12201 Research Parkway • Suite 501 • Orlando, FL 32826-3246 • 407-823-3778 • Fax 407-823-3299

University of Central Florida

Office of Research & Commercialization

9/21/2010

Dr C. Ross Hinkle
Biology
Biology Department, Rm 302
4000 Cental Florida Blvd
Orlando, Fl 32826

Subject: Institutional Animal Care and Use Committee (IACUC) Protocol Submission

Dear Dr C. Ross Hinkle:

This letter is to inform you that your following animal protocol was re-approved by the IACUC. The IACUC Animal Use Renewal Form is attached for your records.

Animal Project #:	09-44W
Title:	Livelihoods support programs for conservation, conservation attitudes and behaviors, and tropical forest biodiversity: an evaluative investigation of biocomplexity in southeastern Ghana.
First Approval Date:	11/6/2009

Please be advised that IACUC approvals are limited to one year maximum. Should there be any technical or administrative changes to the approved protocol, they must be submitted in writing to the IACUC for approval. Changes should not be initiated until written IACUC approval is received. Adverse events should be reported to the IACUC as they occur. Furthermore, should there be a need to extend this protocol, a renewal must be submitted for approval at least three months prior to the anniversary date of the most recent approval. If the protocol is over three years old, it must be rewritten and submitted for IACUC review.

Should you have any questions, please do not hesitate to call me at (407) 882-1164.

Please accept our best wishes for the success of your endeavors.

Best Regards,

Cristina Caamaño

Cristina Caamaño
IACUC Coordinator

Copies: Facility Manager (when applicable.)

12201 Research Parkway • Suite 501 • Orlando, FL 32826-3246 • 407-823-3778 • Fax 407-823-3299

THE UNIVERSITY OF CENTRAL FLORIDA
INSTITUTIONAL ANIMAL CARE and USE COMMITTEE (IACUC)
Re-Approval to Use Animals

Dear Dr C. Ross Hinkle,

Your application for IACUC Re-Approval has been reviewed and appproved by the UCF IACUC Committee Reviewers.

Approval Date: 9/21/2010

Title: Livelihoods support programs for conservation, conservation attitudes and behaviors, and tropical forest biodiversity: an evaluative investigation of biocomplexity in southeastern Ghana.

Department: Biology

Animal Project #: 09-44W

Expiration: 11/6/2011

You may purchase and use animals according to the provisions outlined in the above referenced animal project. This project will expire as indicated above. You will be notified 2-3 months prior to your expriation date regarding your need to file another renewal.

Christopher Parkinson, Ph.D.
IACUC Chair

Approved ✓ Renewed ✓

University of Central Florida Institutional Animal Care and Use Committee (IACUC)
IACUC Coordinator: Cristina Caamaño, Email ccaamano@mail.ucf.edu Phone: (407) 882-1164 Fax: (407) 823-3299

University of Central Florida

Office of Research & Commercialization

11/9/2009

Dr C. Ross Hinkle
Biology
Biology Department, Rm 302
4000 Cental Florida Blvd
Orlando, Fl 32826

Subject: Institutional Animal Care and Use Committee (IACUC) Protocol Submission

Dear: Dr C. Ross Hinkle:

This letter is to inform you that your following animal protocol was approved by the IACUC. The IACUC Use Approval Form is attached for your records.

Animal Project #:	09-44W
Title:	Livelihoods support programs for conservation, conservation attitudes and behaviors, and tropical forest biodiversity: an evaluative investigation of biocomplexity in southeastern Ghana.
First Approval Date:	11/6/2009

Please be advised that IACUC approvals are limited to one year maximum. Should there be any technical or administrative changes to the approved protocol, they must be submitted in writing to the IACUC for approval. Changes should not be initiated until written IACUC approval is received. Adverse events should be reported to the IACUC as they occur. Furthermore, should there be a need to extend this protocol, a renewal must be submitted for approval at least three months prior to the anniversary date of the most recent approval. If the protocol is over three years old, it must be rewritten and submitted for IACUC review.

Should you have any questions, please do not hesitate to call me at (407) 882-1164.

Please accept our best wishes for the success of your endeavors.

Best Regards,

Cristina Caamaño

Cristina Caamaño
IACUC Coordinator,
Office of Research and Commercialization

Copies: Appropriate Facilty Manager (when applicable).

12201 Research Parkway • Suite 501 • Orlando, FL 32826-3246 • 407-823-3778 • Fax 407-823-3299

THE UNIVERSITY OF CENTRAL FLORIDA
INSTITUTIONAL ANIMAL CARE and USE COMMITTEE (IACUC)
Approval to Use Animals

Dear Dr C. Ross Hinkle,

Your application for IACUC Approval has been reviewed and appproved by the UCF IACUC Committee Reviewers.

Approval Date:	11/6/2009
Title:	Livelihoods support programs for conservation, conservation attitudes and behaviors, and tropical forest biodiversity: an evaluative investigation of biocomplexity in southeastern Ghana.
Department:	Biology
Animal Project #:	09-44W
Expiration:	11/6/2010

You may purchase and use animals according to the provisions outlined in the above referenced animal project.

Farol N. Tomson, DVM
IACUC Chair

Contact: Cristina Caamaño, IACUC Coordinator Email:ccaamano@mail.ucf.edu Phone: (407)823-1164 Fax: (407)823-3299

APPENDIX C:
BRIEF DESCRIPTIONS OF DATA SOURCES FOR LIVELIHOODS SUPPORT PROJECTS IMPLEMENTED IN GHANA

1. Global Environment Facility/Small Grants Programme (GEF/SGP): Project briefings and reports list of the GEF/SGP. The GEF/SGP is a corporate program that the United Nations Development Programme (UNDP) implements on behalf of the GEF partnership and executed by the United Nations Office for Project Services (GEF/SGP 2010). The program has funded small short-term environmental projects (budgets of up to $50,000 with durations of up to 3 years) since 1993. The briefings and reports of a total of 170 small projects were accessed and reviewed to determine those which involved site-based biodiversity conservation. This review was done in September 2010 at their website http://sgp.undp.org/index.cfm?module=Projects&page=AdvancedSearch.
2. The World Bank: Reports and documents of projects funded and implemented by The World Bank in Ghana since 1953, before Ghana's independence in 1957. The database for these reports was accessed on the official website of The World Bank, www.worldbank.org in September and October 2010. The major projects with biodiversity conservation as the target include Ghana Environmental Action Plan Project of 1988, Natural Resources Management Project, Environmental Resources Management Project, Coastal Wetlands Management Project, High Forest Biodiversity Conservation Project, Northern Savanna Biodiversity Conservation Project, Community-based Natural Resources Management Project in Okyeman and Community-based Rural Development Project.
3. Tropenbos International, Ghana: It is a non-governmental organization (NGO) that supports tropical forest conservation in Ghana. Tropenbos International, Ghana is the local program of Tropenbos International, a Dutch NGO that works in tropical forestry.

The programs of the organization in Ghana aim at bridging the gap between policy, management and science. A key document of Tropenbos reviewed was a workshop report on alternative livelihoods and sustainable resource management (Tropenbos 2005). This document is also available at http://www.tropenbos.org/tbi_publications/documents/Ghana_Proceedings_4.pdf.

4. Forestry Commission of Ghana: It is the government agency responsible for regulation of utilization of forest and wildlife resources, the conservation and management of those resources and the coordination of policies related to them. Documents reviewed included project fact sheets and reports of the High Forest Biodiversity Conservation Project and other conservation projects which were funded by The World Bank. Information on the Forestry Commission is available at http://www.fcghana.com/.

5. Environmental Protection Agency of Ghana (EPA): It is the government agency responsible for carrying out government's environmental policy, inspecting and regulating environmental management in Ghana. Ghana's EPA has a Natural Resources Division. At the time of this study in 2009-2010, the EPA implements the Ghana Sustainable Land and Water Management Project, which is funded by The World Bank. Information on the EPA of Ghana is available at http://www.epa.gov.gh/

6. Ghana Wildlife Society is a national NGO which aims at conserving wildlife in all its forms. It implements two major community-based natural resource management projects, namely Afadjato-Agumatsa Community Forest Conservation Project and Amansuri Community Integrated Development Project. Ghana Wildlife Society also has a junior

wing called the Wildlife Clubs of Ghana. The website of the organization is www.ghanawildlifesociety.org.

7. Microsfere is an NGO that uses microcredit to combine biodiversity conservation and rural development in areas protected for their ecological value. Currently, the organization works in the Amansuri Wetland and Kakum National Park in Ghana. Information on their activities is available at http://www.microsfere.org/en.

8. Ricerca e Cooperazione, Ghana is an Italian NGO registered in Ghana. It implements projects mainly targeted at safeguarding biodiversity of indigenous cultures and human rights. Specifically the organization is involved in environment, health and education and human rights programs. Workshop reports of their activities were reviewed. Information on their work is available at http://www.ongrc.org/lang/eng/cgi-bin/gk.pl?pg=africa_sub.

9. Centre for Biodiversity Utilisaton and Development (CBUD). CBUD is a research and extension center at the Kwame Nkrumah University of Science and Technology (KNUST). The centre undertakes research, consultancy and extension in the sustainable development and use of renewable natural resources in Ghana.

10. Samartex Timber and Plywood Company Limited: It is a wood processing firm in that is also highly involved in natural resource regeneration through the establishment of plantations and agroforestry schemes and processing of some non-timber forest products (NTFPs) as alternative livelihoods.

11. Okyeman Environment Foundation (OEF): It is an environmental NGO established to lead and promote the conservation of natural resources in the Akyem Abuakwa Traditional Area in the Eastern Region of Ghana. OEF is managed by the Akyem

Abuakwa Traditional Council and is one of the major environmental NGOs established and managed by a traditional area in Ghana. OEF was the lead organization that implemented the Community-based Natural Resource Management Project funded by The World Bank.

12. CARE International: It is an international NGO, which has a country office in Ghana. The organization has worked in Ghana since 1994 in works health, education, agriculture and natural resources sectors. Outlines of the projects undertaken from 1994 to 2010 are listed at http://www.care.org/careswork/countryprofiles/58.asp.

13. The International Union for Conservation of Nature (IUCN) has a dialogue program in Ghana, which aims bring the government, civil society, the private sector and the forest communities together to reduce illegal forest logging. The program runs a program that promotes the development edible oil production from the seeds of *Allanblackia floribunda*.

14. Nature Conservation Research Centre (NCRC): It is an NGO that is actively engaged in nature conservation research and management in Ghana. NCRC is well known for developing rural ecotourism and community protected areas in Ghana.

15. Development agencies of major bilateral development partners: Germany (GTZ, now GIZ), USA (USAID), Japan (JICA), The Netherlands (SNV), United Kingdom (DFID) and Denmark (DANIDA). These agencies act as advisors and donors for small projects as well as supporting various components of environmental projects funded through The World Bank and GEF.

APPENDIX D:
QUESTIONNAIRE FOR DATA ON SPECIFIC LIVELIHOODS SUPPORT ACTIVTIES IN COMMUNITIES.

Dear Participant:

The University of Central Florida (UCF) is undertaking a research study on the impacts of livelihoods support activities for conservation on conservation attitudes and behaviors; and forest biodiversity. The study is being undertaken in the Afadjato-Agumatsa and Atewa Range areas in Ghana. This questionnaire is intended to collect information about such livelihoods support activities. You are invited to answer the following questions for this purpose.

Community: Date:

Contact person: Livelihoods support activity:

1. Is the livelihoods support activity still ongoing? Yes/No

2. How many were/are you in your group?

3. Are you still working as a group? Yes [ ] No [ ]

4. If Yes how many are you now

5. Since you started this activity with CIF/GWS project funds did you sell any product? Yes/No

6. If yes, please estimate how much product you sold?

   Quantity: Amount (GHC):

7. Do you think the incentive scheme has been beneficial to you? Yes [ ] No [ ]

8. If Yes what benefits did you get from the livelihoods support activities supported by the project funds?

   ………

   ………

9. State some challenges you faced as a group and as individuals during this livelihoods support activities.

   ………

   ………

10. On a scale of 0 to 10, please indicate how successful your livelihoods support activity was. (Zero means not successful at all and 10 means very successful.

    0 1 2 3 4 5 6 7 8 9 10

APPENDIX E:
QUESTIONNAIRE FOR EVALUATING ATTITUDES TOWARDS THE NATURAL ENVIRONMENT

<u>ATTITUDES QUESTIONNAIRE</u>

Dear Participant

The University of Central Florida (UCF) is undertaking a research study on the impacts of livelihoods support activities for conservation on conservation attitudes and behaviors; and forest biodiversity. The study is being undertaken in the Afadjato-Agumatsa Range and Atewa Range areas. As part of this study, this questionnaire is intended to collect information from community members about their perceptions about forest conservation. You are invited to answer the following questions for this purpose.

<u>Measuring attitudes to forest conservation</u>

Current attitudes: Please state whether you **agree** or you **do not agree** to the following statements (*Administrator: Please present these statements randomly without following the presented order).*

	Agree	Not sure	Disagree
1. It is important to protect the forest			
2. The forest is important for my children's future			
3. People should not be allowed to fell trees or hunt hapharzadly			
4. Conserving the forest benefits us in this area			
5. These forests should be conserved because they are our heritage.			
6. Hunting and/or logging should be allowed everywhere freely			
7. Wild animals damage our crops, they should be exterminated			
8. The forest should be cleared			
9. The forest should be released for farming			
10. Trees should be felled as timber for us to get jobs			

Proxy-pretest attitudes: Ten years ago would you **agree** or would you **not agree** to the following statements. (*Administrator: Please make the statements randomly without following the presented order)*

	Agree	**Not sure**	**Disagree**
1. It is important to protect the forest			
2. The forest is important for my children's future			
3. People should not be allowed to fell trees or hunt hapharzadly			
4. Conserving the forest benefits us in this area			
5. These forests should be conserved because they are our heritage.			
6. Hunting and/or logging should be allowed everywhere freely			
7. Wild animals damage our crops, they should all be exterminated			
8. The forest should be cleared			
9. The forest should be released for farming			
10. Trees should be felled as timber for us to get jobs			

Forest Use

1. How many times have you entered the forest in your area each week over the past week?...

2.What resources do you obtain from the forest? ....

3. Please indicate whether you use the resources for subsistence or for commercial purposes.

Forest resource	Subsistence use	Commercial use

4. In your opinion, what activities destroy the forests in your area most? Please show these in descending order or severity ....

New Ecological Paradigm (Current status)

For each of the following statements, please state your opinion in terms of the following:

Strongly Agree (SA) or Mildly Agree (MA), or Unsure (U), or Mildly Disagree (MD), or Strongly Disgaree (SD)

1. We are approaching the limit of the number of people the earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will insure that we do NOT make the earth unlivable.
5. Humans are severely abusing the environment.
6. The earth has plenty of natural resources if we just learn how to develop them
7. Plants and animas have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities humans are still subject to the laws of nature.
10. The so-called "ecological crisis" facing humankind has been greatly exagerated.
11. The earth is like a aspaceship (or a room) with limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course we will soon experience a major ecological catastrophe.

<u>New Ecological Paradigm (Proxy pretest status):</u>
*Pls give answers you would give **10 years ago.***

For each of the following statements, please state your opinion in terms of the following:

Strongly Agree (SA) or Mildly Agree (MA), or Unsure (U), or Mildly Disagree (MD), or Strongly Disgaree (SD)

1. We are approaching the limit of the number of people the earth can support.

2. Humans have the right to modify the natural environment to suit their needs.

3. When humans interfere with nature it often produces disastrous consequences.

4. Human ingenuity will insure that we do NOT make the earth unlivable.

5. Humans are severely abusing the environment.

6. The earth has plenty of natural resources if we just learn how to develop them

7. Plants and animas have as much right as humans to exist.

8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.

9. Despite our special abilities humans are still subject to the laws of nature.

10. The so-called “ecological crisis” facing humankind has been greatly exagerated.

11. The earth is like a aspaceship (or a room) with limited room and resources.

12. Humans were meant to rule over the rest of nature.

13. The balance of nature is very delicate and easily upset.

14. Humans will eventually learn enough about how nature works to be able to control it.

15. If things continue on their present course we will soon experience a major ecological catastrophe.

Personal information

Date: Community:

Age: Gender: Male/ Female

Education: Basic/High School/Tertiary Occupation:

How long have you lived in this community? ……………………………………………...

What is your monthly income? ……………………………………………………………….

Have you ever participated in any livelihoods support activities targeted at forest conservation?

Yes/No

If yes, which one(s)? ....

APPENDIX F:
BUFFER DISTANCES BETWEEN COMMUNITIES AND THEIR FOREST AREAS OF INTEREST

Appendix F1: Buffer Distances in the Afadjato-Agumatsa Area

#	Community	Buffer distance (km)
1	Fodome Ahor	2.0
2	Fodome Ando 2	1.0
3	Gbledi Agumatsa	0.5
4	Gbledi Chebi	0.6
5	Gbledi Gborgame	0.5
6	Gbledi Torglo	0.5
7	Wli Afegame & Agorviefe	0.5
8	Wli Todzi	1.0

Appendix F2: Buffer Distances in the Atewa Area

#	Community	Buffer distance (km)
1	Abesim	1.5
2	Adadientem	0.5
3	Adukrom	2.0
4	Afiesa	1.0
5	Ahwenease	0.5
6	Akanteng	2.0
7	Akropong	3.0
8	Akwadum	2.0
9	Akyeansa	4.0
10	Apampatia	1.0
11	Apapam	0.5
12	Asiakwa	3.0
13	Asikam	2.0
14	Awenare	2.5
15	Banso	2.5
16	Bomaa	2.0
17	Dokyi	1.0
18	Dompim	2.5
19	Dwafoakwa	5.0
20	Dwenease	2.5
21	Kobriso	2.0
22	Kwakusae	2.0
23	Kwesikomfo	2.0
24	Larbikrom	0.5
25	Mpeasem	1.0
26	Osafo	1.0
27	Pameng	1.5
28	Pano	2.0
29	Pinamang	2.0
30	Potroase	1.0
31	Sagyimase	2.0
32	Takyiman	4.0

APPENDIX G:
NORMALIZED DIFFERENCE VEGETATION INDICES (NDVI)

Appendix G1: Normalized Difference Vegetation Indices in the Afadjato-Agumatsa Area

Appendix G1.1: 1991 NDVIs in Afadjato-Agumatsa

Community	**# of points**	**NDVIs**			
		Min	Max	Mean	Stdev
Fodome Ahor	1,970	0.240077	0.896246	0.717017	0.085862
Fodome Ando 2	1,744	0.538766	0.879992	0.704927	0.063796
Gbledi Agumatsa	1,548	0.425352	0.905814	0.721009	0.101054
Gbledi Chebi	1,620	0.446130	0.999999	0.791802	0.060374
Gbledi Gborgame	1,548	0.132508	0.999999	0.761669	0.119402
Gbledi Torglo	1,606	0.397741	0.999998	0.783335	0.082388
Wli Afegame & Agorviefe	2,062	0.207310	0.864014	0.638322	0.118069
Wli Todzi	1,682	-0.010553	0.999998	0.663121	0.137181

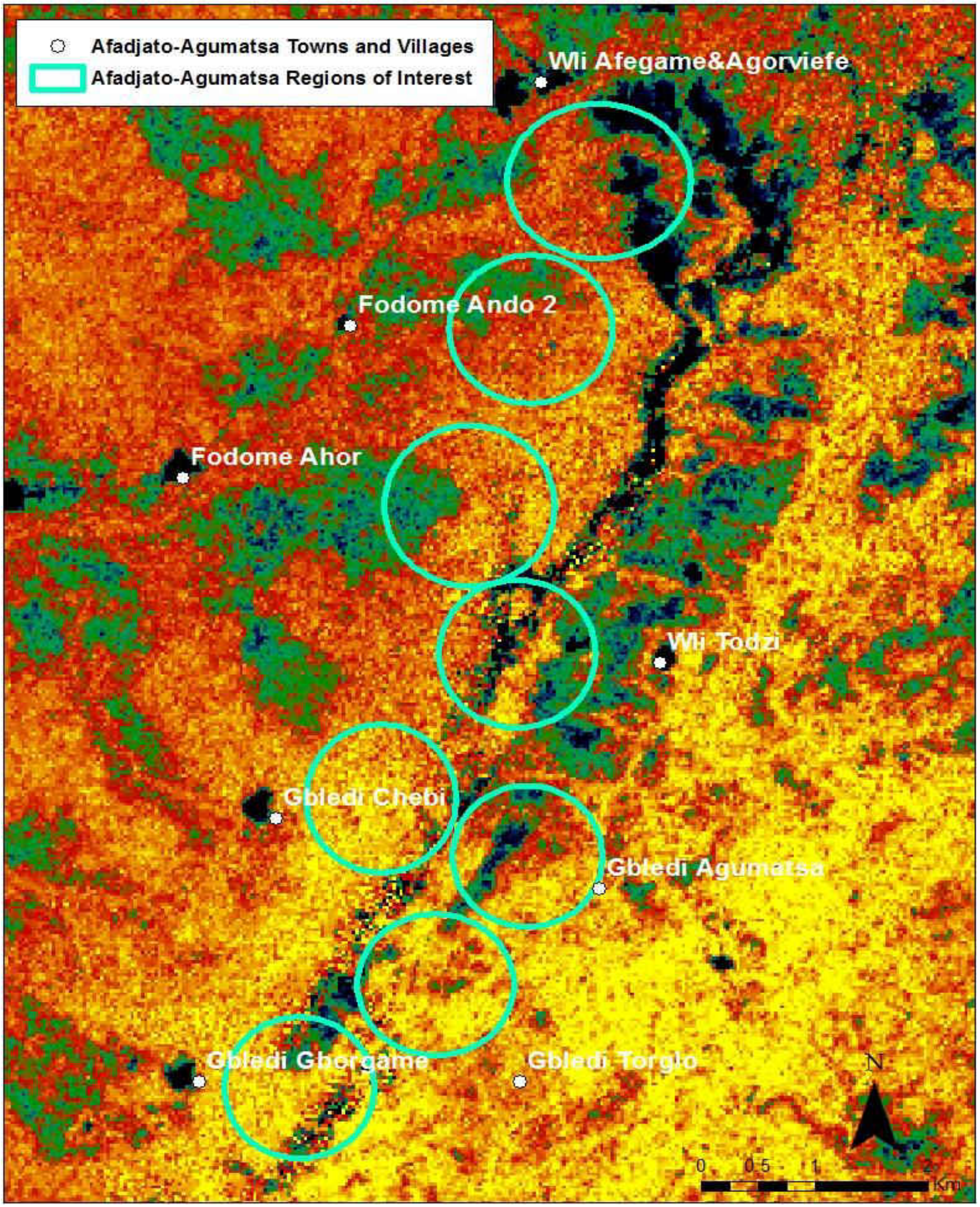
Appendix G1.2: 2000 NDVIs in Afadjato-Agumatsa

Community	**# of points**	**NDVIs**			
		Min	Max	Mean	Stdev
Fodome Ahor	1,970	0.314399	0.845720	0.625442	0.125880
Fodome Ando 2	1,744	0.375921	0.760822	0.580406	0.078785
Gbledi Agumatsa	1,548	0.327035	0.894432	0.680425	0.111670
Gbledi Chebi	1,620	0.537366	0.883081	0.744171	0.049119
Gbledi Gborgame	1,548	0.311813	0.833931	0.653715	0.096379
Gbledi Torglo	1,606	0.331960	0.920505	0.709843	0.083186
Wli Afegame & Agorviefe	2,062	-0.065864	0.794710	0.517168	0.204129
Wli Todzi	1,682	0.135938	0.847079	0.585167	0.119871

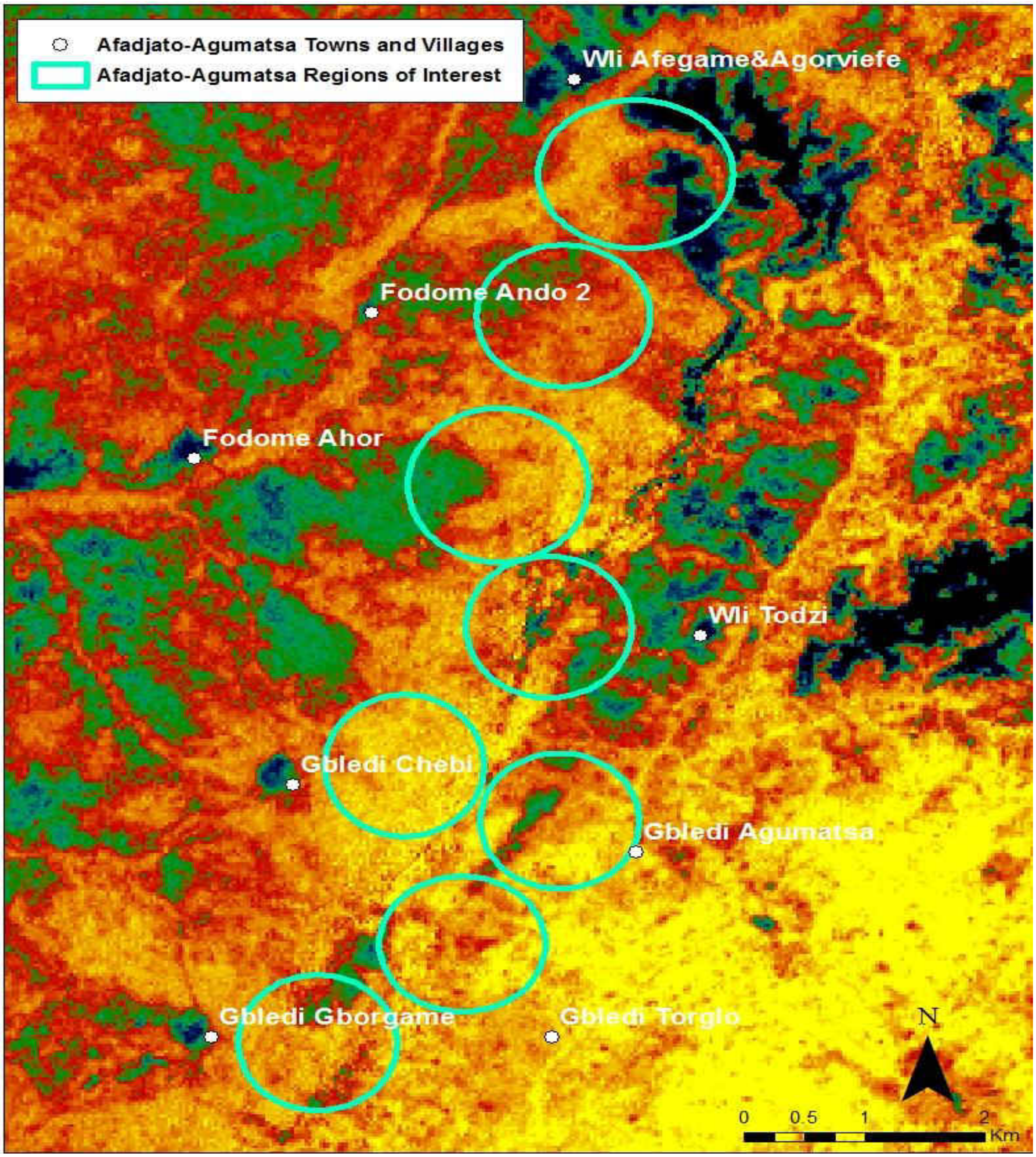
Appendix G1.3: 2010 NDVIs in Afadjato-Agumatsa

Community	**# of points**	**NDVIs**			
		Min	Max	Mean	Stdev
Fodome Ahor	1,970	0.307435	0.561756	0.454594	0.054270
Fodome Ando 2	1,744	0.161964	0.544514	0.432271	0.078436
Gbledi Agumatsa	1,548	0.261706	0.572766	0.434662	0.070827
Gbledi Chebi	1,620	0.321562	0.580626	0.493651	0.046484
Gbledi Gborgame	1,548	0.289576	0.592797	0.462893	0.054604
Gbledi Torglo	1,606	0.279502	0.590053	0.471988	0.052460
Wli Afegame & Agorviefe	2,062	0.175970	0.570173	0.414016	0.092537
Wli Todzi	1,682	0.243991	0.538729	0.392338	0.058003

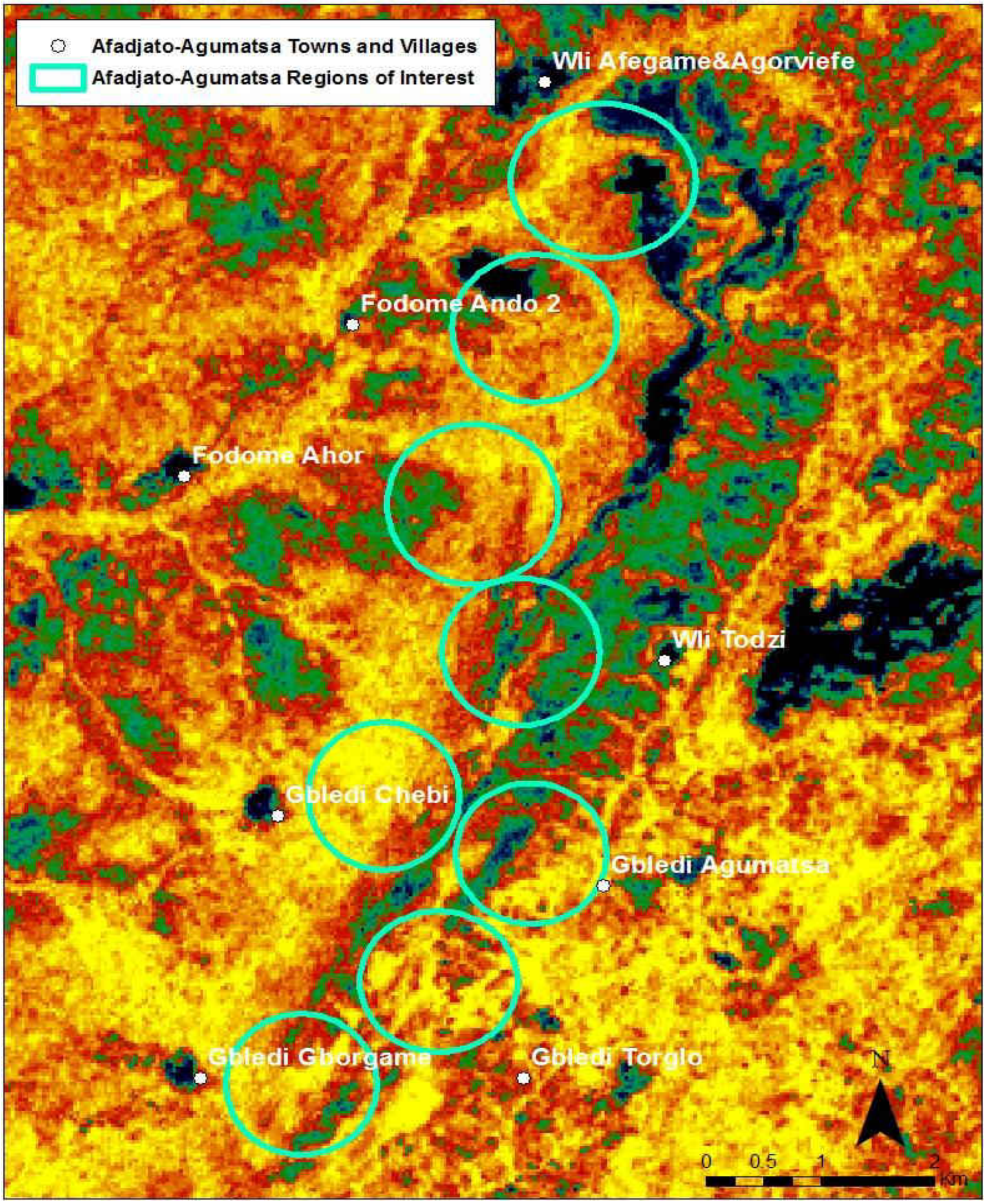
Appendix G1.4: 1991 NDVI Image of Afadjato-Agumatsa Area (Based on Blue/Green/Red/Yellow color table)



Appendix G1.5: 2000 NDVI Image of Afadjato-Agumatsa Area (Based on Blue/Green/Red/Yellow color table)



Appendix G1.6: 2010 NDVI Image of Afadjato-Agumatsa Area (Based on Blue/Green/Red/Yellow color table)



Appendix G2: Normalized Difference Vegetation Indices in the Atewa Area

Appendix G2.1: 1991 NDVIs in Atewa

Community	# of points	NDVIs			
		Min	Max	Mean	Stdev
Abesim	5,034	0.292704	0.869793	0.692816	0.065605
Adadientem	3,512	0.446129	0.908623	0.743750	0.061787
Adukrom	7,304	0.483477	0.913766	0.731428	0.054511
Afiesa	4,350	0.301909	0.879992	0.725023	0.059645
Ahwenease	4,340	0.446129	0.865996	0.728292	0.057986
Akanteng	10,232	0.132514	0.902827	0.690113	0.074047
Akropong	4,674	0.388450	0.786210	0.627213	0.054648
Akwadum	5,618	0.425352	0.885948	0.739713	0.042554
Akyeansa	10,580	0.376803	0.857698	0.696433	0.048030
Apampatia	6,788	0.132508	0.999997	0.717114	0.077241
Apapam	5,618	0.323918	0.929614	0.752675	0.055527
Asiakwa	10,760	0.446129	0.999999	0.788632	0.051606
Asikam	6,706	0.505697	0.942762	0.757594	0.060434
Awenare	6,772	0.370239	0.999999	0.760278	0.068119
Banso	7,718	0.132508	0.929614	0.708975	0.081934
Bomaa	8,008	0.270247	0.999999	0.725614	0.085989
Dokyi	3,762	0.292704	0.892610	0.692988	0.063255
Dompim	3,272	0.525331	0.796166	0.677610	0.038889
Dwafoakwa	7,552	0.315023	0.839006	0.668494	0.068535
Dwenease	8,584	0.132502	0.999999	0.717518	0.080081
Kobriso	12,104	0.132514	0.999999	0.752515	0.076333
Kwakusae	9,860	0.323916	0.865996	0.712406	0.058849
Kwesikomfo	12,348	0.323916	0.879992	0.705534	0.053714
Larbikrom	3,516	0.477605	0.857698	0.705339	0.041175
Mpeasem	3,756	0.414368	0.888710	0.706951	0.057057
Osafo	6,706	0.370239	0.929614	0.731020	0.066381
Pameng	5,396	0.323916	0.892610	0.683183	0.071799
Pano	4,596	0.530921	0.902828	0.759462	0.046912
Pinamang	10,228	-0.393545	0.999999	0.694670	0.087978
Potroase	8,992	0.323918	0.892610	0.720169	0.057243
Sagyimase	7,708	0.505697	0.999999	0.783340	0.060013
Takyiman	6,226	0.313820	0.830078	0.669864	0.057170

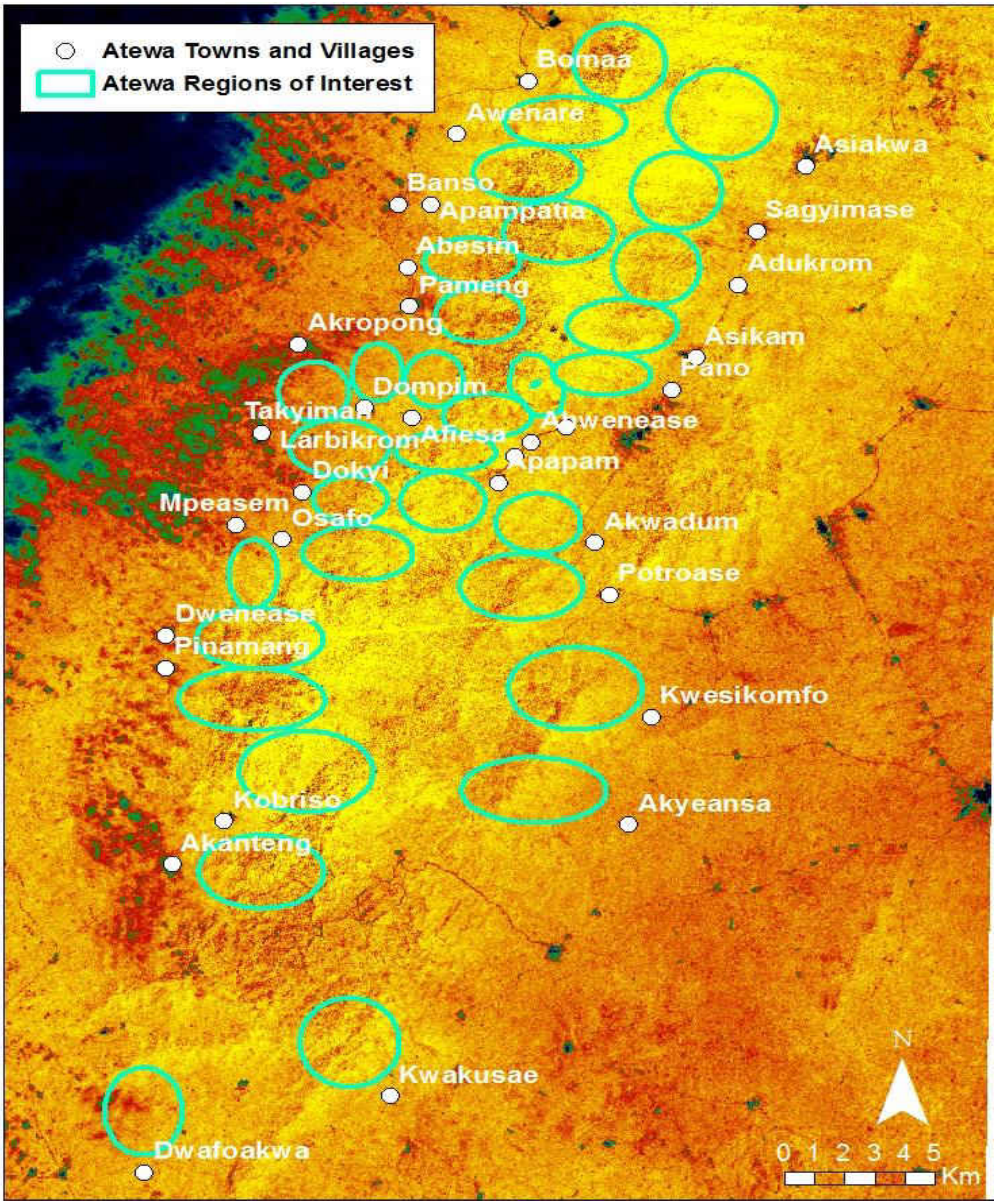
Appendix G2.2: 2000 NDVIs in Atewa

Community	**# of points**	**NDVIs**			
		Min	Max	Mean	Stdev
Abesim	5,034	-0.007084	0.608465	0.397201	0.077337
Adadientem	3,512	0.106639	0.709265	0.510714	0.088631
Adukrom	7,304	0.237777	0.827324	0.587937	0.080888
Afiesa	4,350	0.142324	0.652443	0.461446	0.076116
Ahwenease	4,340	0.139619	0.642925	0.467767	0.076881
Akanteng	10,232	-0.027078	0.591270	0.353251	0.082198
Akropong	4,674	0.148426	0.538722	0.372301	0.053538
Akwadum	5,618	0.266163	0.691638	0.500110	0.050713
Akyeansa	10,580	0.249786	0.710802	0.516361	0.058461
Apampatia	6,788	0.069877	0.709265	0.441620	0.093167
Apapam	5,618	0.128177	0.715864	0.509359	0.069770
Asiakwa	10,760	0.394032	0.999995	0.675688	0.071395
Asikam	6,706	0.228593	0.782990	0.536392	0.076315
Awenare	6,772	0.172083	0.907853	0.563159	0.104829
Banso	7,718	0.069880	0.833921	0.520499	0.149005
Bomaa	8,008	0.295877	0.930084	0.643449	0.112226
Dokyi	3,762	0.069881	0.616685	0.410868	0.063322
Dompim	3,272	0.260383	0.545045	0.417761	0.041751
Dwafoakwa	7,552	0.104115	0.561964	0.421337	0.043347
Dwenease	8,584	-0.097931	0.685924	0.397011	0.096752
Kobriso	12,104	-0.082510	0.634085	0.391166	0.110124
Kwakusae	9,860	0.142324	0.642926	0.444364	0.074358
Kwesikomfo	12,348	0.069880	0.760814	0.512313	0.082989
Larbikrom	3,516	0.176250	0.590345	0.403782	0.046178
Mpeasem	3,756	0.174965	0.607061	0.426303	0.051502
Osafo	6,706	-0.061116	0.690582	0.417201	0.088464
Pameng	5,396	0.098256	0.632133	0.418980	0.073473
Pano	4,596	0.200111	0.764059	0.511804	0.077903
Potroase	8,992	0.159771	0.769278	0.517409	0.071821
Pinamang	10,228	-0.131968	0.623601	0.353726	0.089873
Sagyimase	7,708	0.314390	0.943671	0.699553	0.087662
Takyiman	6,226	0.159778	0.602064	0.421983	0.051190

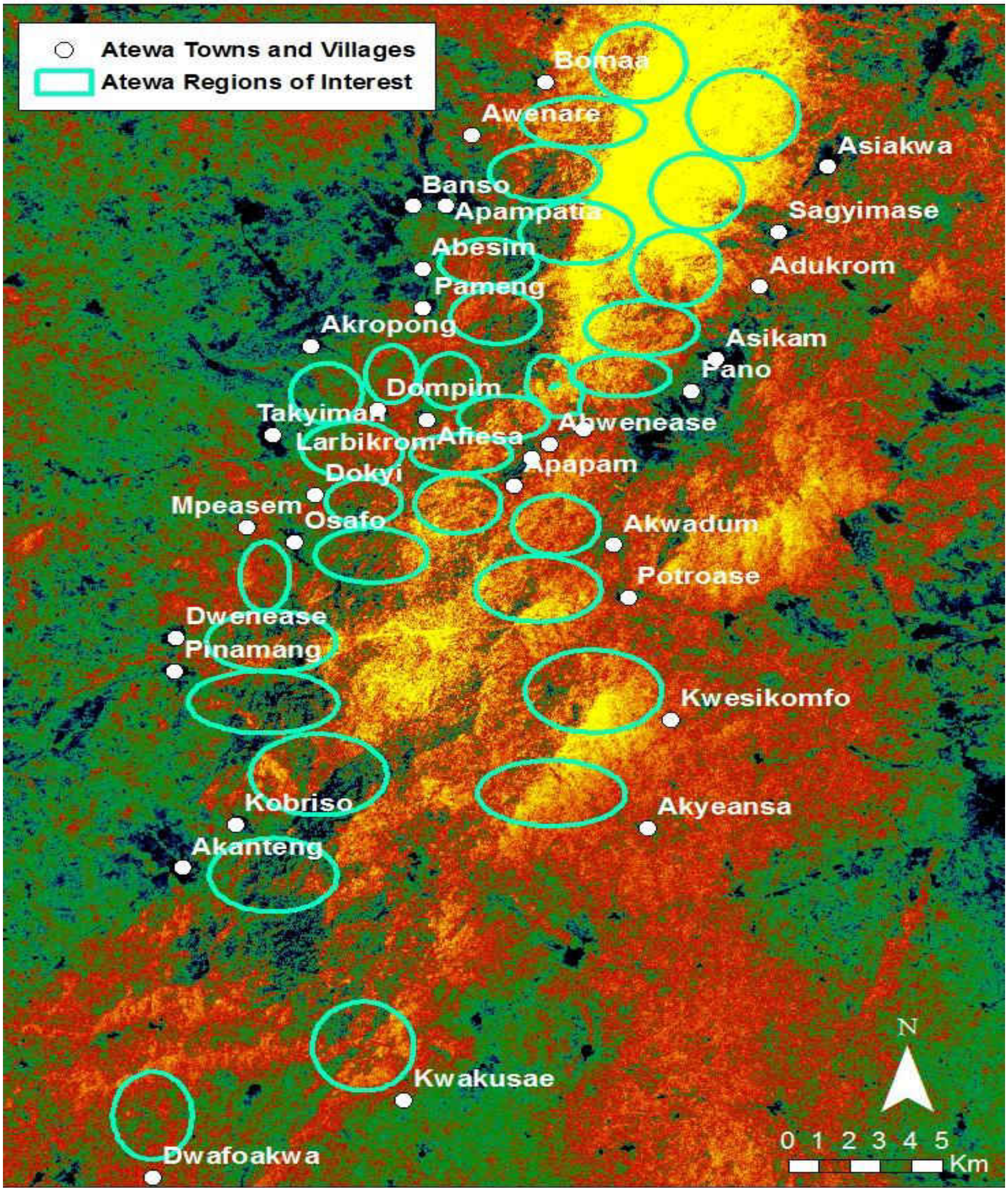
Appendix G2.3: 2010 NDVIs in Atewa

Community	# of points	NDVIs			
		Min	Max	Mean	Stdev
Abesim	5,034	0.295705	0.537910	0.428920	0.045022
Adadientem	3,512	0.417671	0.590574	0.485610	0.029240
Adukrom	7,304	0.307832	0.625611	0.527347	0.032739
Afiesa	4,350	0.269696	0.580545	0.476144	0.049456
Ahwenease	4,340	0.195881	0.593164	0.487478	0.036099
Akanteng	10,232	0.271255	0.551923	0.419326	0.050249
Akropong	4,674	0.302083	0.549796	0.467288	0.035352
Akwadum	5,618	0.349238	0.592787	0.512288	0.022902
Akyeansa	10,580	0.301932	0.584437	0.480491	0.044207
Apampatia	6,788	0.336977	0.595294	0.454274	0.041144
Apapam	5,618	0.308657	0.597249	0.511440	0.027301
Asiakwa	10,760	0.217632	0.626720	0.527533	0.033602
Asikam	6,706	0.335643	0.625611	0.532630	0.034934
Awenare	6,772	0.346347	0.602304	0.477053	0.043907
Banso	7,718	0.241906	0.582584	0.481588	0.041823
Bomaa	8,008	0.355201	0.594064	0.498797	0.034843
Dokyi	3,762	0.333186	0.556289	0.477915	0.027532
Dompim	3,272	0.392895	0.549764	0.483250	0.022467
Dwafoakwa	7,552	0.326282	0.549855	0.468546	0.026197
Dwenease	8,584	0.128105	0.540985	0.325220	0.097326
Kobriso	12,104	0.250289	0.507232	0.416094	0.041457
Kwakusae	9,860	0.392824	0.587957	0.489838	0.032010
Kwesikomfo	12,348	0.345262	0.603123	0.497619	0.033928
Larbikrom	3,516	0.287581	0.516093	0.424753	0.040428
Mpeasem	3,756	0.314888	0.548140	0.439508	0.035081
Osafo	6,706	0.227907	0.571138	0.473427	0.029815
Pameng	5,396	0.363760	0.468567	0.426309	0.028176
Pano	4,596	0.432663	0.608839	0.525270	0.028399
Potroase	8,992	0.350239	0.581637	0.498993	0.032759
Pinamang	10,228	0.115187	0.544495	0.330412	0.107023
Sagyimase	7,708	0.432663	0.616633	0.525394	0.024624
Takyiman	6,226	0.128473	0.572760	0.415283	0.120826

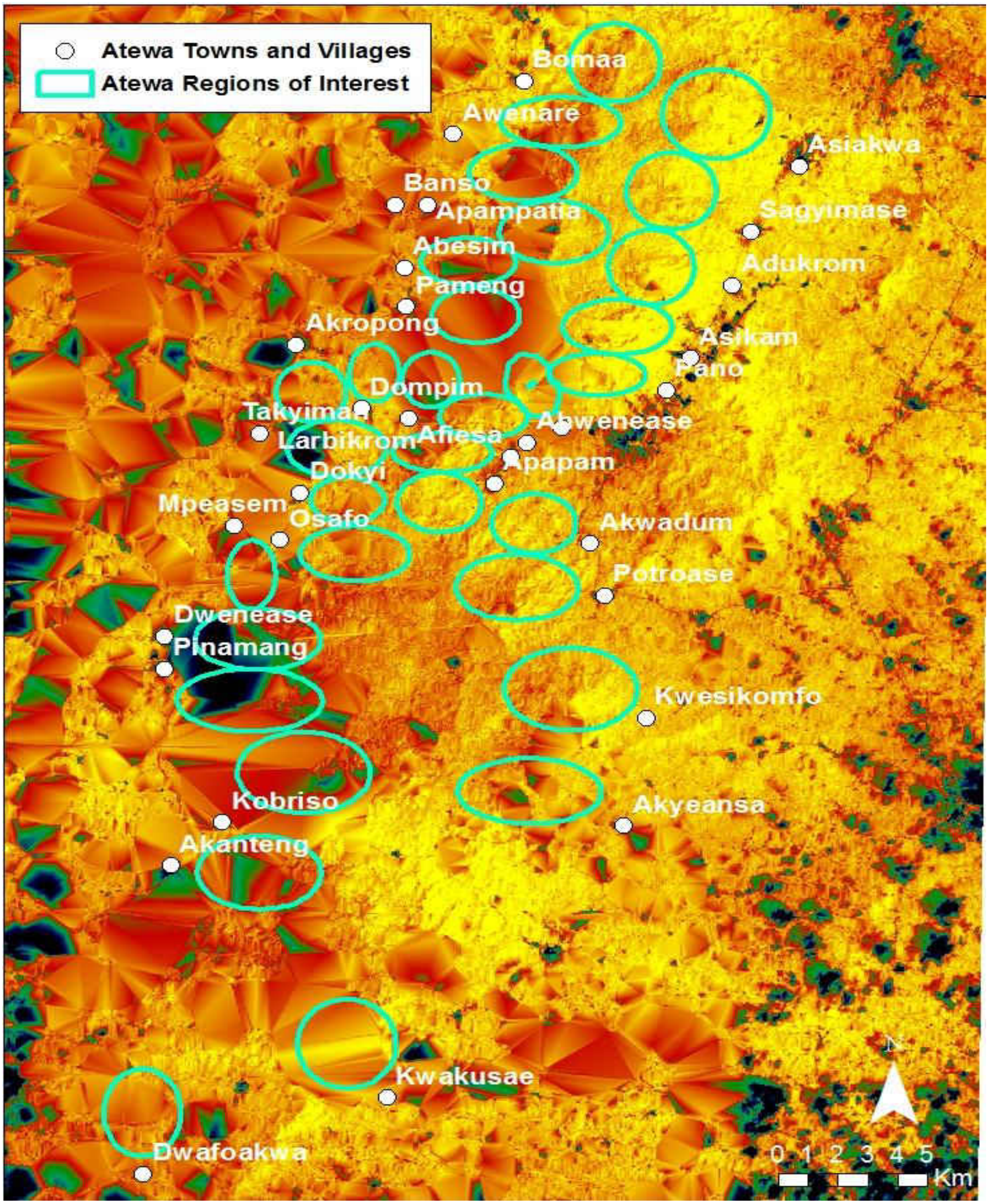
Appendix G2.4: 1991 NDVI Image of Atewa Area (Based on Blue/Green/Red/Yellow color table)



Appendix G2.5: 2000 NDVI Image of Atewa Area (Based on Blue/Green/Red/Yellow color table)



Appendix G2.6: 2010 NDVI Image of Atewa Area (Based on Blue/Green/Red/Yellow color table)



APPENDIX H: A SAMPLE DATA SHEET FOR BAT SURVEYS

Bat Catch Record sheet

<table>
<tr><td colspan="3">Surveyor:</td><td colspan="7">Field sheet Ref:</td><td>Date:</td></tr>
<tr><td colspan="3">Site:</td><td colspan="7">Altitude:</td><td>Aspect:</td></tr>
<tr><td colspan="2">Latitude:</td><td colspan="5">Longitude:</td><td colspan="4">UTM (if available):</td></tr>
<tr><td colspan="3">Vegetation:</td><td colspan="8">Human disturbance:</td></tr>
<tr><td colspan="2">Season:</td><td colspan="8">Weather:</td><td>Temperature:</td></tr>
<tr><td colspan="11">Other:</td></tr>
<tr><td rowspan="2">Net line & no.</td><td rowspan="2">Net Shelf</td><td rowspan="2">Micro-habitat</td><td rowspan="2">Water association</td><td colspan="3">Morphological measurements*</td><td rowspan="2">Species</td><td rowspan="2">Age</td><td rowspan="2">Sex</td><td rowspan="2">Other Remarks</td></tr>
<tr><td>HB</td><td>FA</td><td>W</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

* **HB**: Head and Body **FA**: Forearm **W**: Weight

APPENDIX I:
NUMBER OF INDIVIDUAL BATS CAPTURED IN EACH COMMUNITY'S FOREST REGION OF INTEREST

Community	*Eido.*	*Epomph.*	*Epo. B*	*Epo. f.*	*Hyp.*	*Lis.*	*Meg.*	*Mic.*	*Myo.*	*Nan.*	*Sco.*	**Total**
Afadjato-Agumatsa Area												
Fodome Ahor		1		1				2				**4**
Fodome Ando 1		7		1								**8**
Gbledi Agumatsa		5		5		3				2		**15**
Gbledi Chebi		3		1		1				4		**9**
Gbledi Gborgame		16	3	8	1	7		1	6			**42**
Gbledi Torglo		3		2					2			**7**
Wli Afegame & Agorviefe	2	13	1	7		1	1	6	4			**35**
Wli Todzi		2		2		3		7		3		**17**
Atewa Area												
Abesim		3		2			12		2		2	**21**
Adadientem		5		2			2	4	2			**15**
Adukrom		7		4			1	3	1			**16**
Afiesa		2		4			1					**7**
Ahwenease		2		3				1			2	**8**
Akanteng		5		12				11				**28**
Akropong		5		3			2					**10**
Akwadum		4					2		1			**7**
Akyeansa		1		3			8	2				**14**
Apampatia		6		1			7	3				**17**
Apapam		5		2			1	1	1			**10**
Asiakwa		6		6		2	1	4				**19**
Asikam		4		4			1	3				**12**
Awenare		9		1			2					**12**

Community	*Eido.*	*Epomph.*	*Epo. b*	*Epo. f.*	*Hyp.*	*Lis.*	*Meg.*	*Mic.*	*Myo.*	*Nan.*	*Sco.*	**Total**
Banso		6		1								**7**
Bomaa		5		2			1					**8**
Dokyi		7		1			5	10				**23**
Dompim		7						9				**16**
Dwafoakwa		7		7			1	7				**22**
Dwenease		7		2			5					**14**
Kobriso		5		3			1	6			1	**16**
Kwakusae		8		5				14	1		1	**29**
Kwesikomfo		14		4			1	9				**28**
Larbikrom		8		5				8				**21**
Mpeasem		7		3			3	10		1	1	**25**
Osafo		10		2			5	5			3	**25**
Pameng		5		1			1	1				**8**
Pano		9		5			3		1			**18**
Pinamang		9		7			1	1		1		**19**
Potroase		7		6				2		1		**16**
Sagyimase		6		4			1	1			3	**15**
Takyiman		9		6			1	22				**38**
Overall Total	**2**	**250**	**4**	**138**	**1**	**17**	**70**	**153**	**21**	**12**	**13**	**681**

Key to species names in Appendix I:

Abbreviation	Scientific name	Abbreviation	Scientific name
Eido.	*Eidolon helvum*	*Meg.*	*Megaloglossus woermanni*
Epomph.	*Epomophorus gambianus*	*Mic.*	*Micropteropus pusillus*
Epo. B	*Epomops buettikoferi*	*Myo.*	*Myonicteris torquata*
Epo. f.	*Epomops franqueti*	*Nan.*	*Nanonycteris veldkampi*
Hyp.	*Hypsignathus monstrosus*	*Sco.*	*Scotonycteris zenkeri*
Lis.	*Lissonycteris angolensis*		

REFERENCES

Achard, F., H.D. Eva, H.J. Stibig, P. Mayaux, J. Gallego, T. Richard, and J.P. Malingreau. 2002. Determination of deforestation rates of the world's humid tropical forests. Science 297:999-1002.

Adu-Anning, C., L. Atuah, S. Duku, S.E. Edusah, S.C. Fialor, and S. Sey. 2005. Micro-credit as an instrument to promote indigenous food resources in Ghana. International Centre for Development-oriented Research in Agriculture (ICRA) Working Document Series 123.

Aeby, T.C., V.G. Aeby, and M. Mozingo. 2011. A practice evaluation of professional learning communities among school social workers using a recollection proxy pretest design. Journal of Human Behavior in the Social Environment 21:766-783.

Ajzen, I., and M. Fishbein. 1980. Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall.

Ajzen, I. 1991. The theory of planned behavior. Organizational Behavior and Human Decision Processes 50:179-211.

Andam, K.S., P.J. Ferraro, A. Pfaff, G. A. Sanchez-Azofefia, and J.A. Robalino. 2008. Measuring the effectiveness of protected area networks in reducing deforestation. PNAS 105: 16089-16094.

Anthony, E.L.P. 1988. Capture methods and holding devices. *In* Ecological ad behavioural methods for the study of bats. Kunz T.H. (editor). Smithsonian Institution Press, Washington D.C. Pages 1-30.

Anyamba, A., and C.J. Tucker. 2005. Analysis of Sahelian vegetation dynamics using NOAA-AVHRR NDVI data from 1981 to 2003. Journal of Arid Environments 63: 596 – 614.

Asamoa, A.S. 1990. Villagers' perspective towards monkeys and conservation at Boabeng-Fiema Monkey Sanctuary. Thesis submitted to the Institute of Renewable Natural Resources for the Degree of Bachelor of Science in Natural Resources Management, University of Science and Technology (UST), Kumasi. Unpublished Thesis.

Aryee, B.N.A., B.K. Ntibrey, and E. Atorkui. 2003. Trends in the small-scale mining of precious minerals in Ghana: a perspective on its environmental impact. Journal of Cleaner Production 11:131-140.

Ayoo, C. 2008. Economic instruments and the conservation of biodiversity. Management of Environmental Quality: An International Journal 19: 550-564.

Baker, J. 2000. Evaluating the impact of development projects on poverty. The World Bank.

Barbier, E.B., J.C. Burgess, and C. Folke. 1995. Paradise lost? The ecological economics of biodiversity. Earthscan, London.

Barr, S., and A. Gilg. 2006. Sustainable lifestyles: framing environmental action in and around the home. Geoforum 37: 906-992.

Benhin, J.K.A., and E.B. Barbier. 2004. Structural Adjustment Programme, deforestation and biodiversity loss in Ghana. Environmental and Resource Economics 27:337-366.

BirdLife International. 2008. BirdLife's online World Bird Database: the site for bird conservation. Version 2.1. Cambridge, UK: BirdLife International. Available: http://www.birdlife.org (accessed 23/2/2009).

Boardman, A.E., D.H. Greenberg, A.R. Vining, and D.L. Weimer. 2006. Cost-benefit analysis: concepts and practice. Third Edition. Pearson Prentice Hall, New Jersey, USA. 560 pages

Bonate, P.L. 2000. Analysis of pretest-posttest designs. Chapman and Hall/CRC Boca Raton, FL. 205 pages. Pages 80, 94-100

Botchway, K. 2000. Paradox of empowerment: reflections on a case study from northern Ghana. World Development 29:135-153.

Callicott, B.J., R. Rozzi, L. Delgado, M. Monticino, M. Acevedo, and P. Harcombe. 2007. Biocomplexity and conservation of biodiversity hotspots: three case studies from the Americas. Philosophical Transactions of the Royal Society B 362: 321-333.

Carletto, G., K. Covarrubias, B. Davis, M. Krausova, K. Stamoulis, P. Winters, and A. Zezza. 2007. Rural income generating activities in developing countries: re-assessing the evidence. *electronic* Journal of Agricultural and Development Economics 4:146-193.

Central Intelligence Agency of United States of America. 2009. The World Factbook. Available at https://www.cia.gov/library/publications/the-world-factbook/geos/gh.html. Accessed on February 10, 2009.

Centre de cooperation internationale en recherche agronomique pour le développement (CIRAD). 2009. Natural resources and multi-agent simulations. Available at http://cormas.cirad.fr/indexeng.htm. Accessed on March 10, 2009.

Chen, X., M.N. Peterson, V. Hull, C. Lu, G.D. Lee, D. Hong, and J. Liu. 2011. Effects of attitudinal and Sociodemographic factors on pro-environmental behavior in urban China. Environmental Conservation 38:45-52.

Chung, S. S., and C. S. Poon. 2001. A comparison of waste-reduction practices and new environmental paradigm of rural and urban Chinese citizens. Journal of Environmental Management 62: 3-19.

Coe, R. 2002. It's the effect Size, stupid. What effect size is and why important. Paper presented at the Annual Conference of the British Educational Research Association, University of Exeter, England. September 2002.

Cohen, J. 1988. Statistical power analysis for the behavioral sciences (2nd edition). Lawrence Erlbaum Associates, New Jersey, USA. 569 pages.

Colwell, R.R. 1999. Balancing the biocomplexity of the planet's living systems: a 21st century task for science. International Microbiology 2:47–48.

Conover, W.J., and R.L. Iman. 1982. Analysis of covariance using the rank transformation. Biometrics 38: 715-724.

Conservation International. 2008. Biodiversity Hotspots. Available at http://www.biodiversityhotspots.org/xp/Hotspots/west_africa/Pages/default.aspx. Accessed on December 31, 2008.

Conservation International. 2009. Biodiversity Hotspots. Available at http://www.biodiversityscience.org/priority_outcomes/west_africa/upper.html. Accessed on March 1, 2009.

Convention on Biological Diversity. 1993. Text of the Convention on Biological Diversity. Available at http://www.cbd.int/convention/articles/?a=cbd-02. Accessed on December 30, 2008.

Cooper, P., G.L. Poe, and I.J. Bateman. 2004. The structure of motivation for contingent values: a case study of lake water quality improvement. Ecological Economics 50: 69-82.

Cottingham, K. L. 2002. Tackling biocomplexity: the role of people, tools, and scale. BioScience 52: 793–799.

Covich, A. 2000. Biocomplexity and the future: the need to unite disciplines. BioScience 51: 908–914.

Curran, P. J. 1983. Multispectral remote sensing for estimation of green leaf area index. Philosophical Transactions of the Royal Society, Series A, 309: 257- 270.

Dadebo, M.A., and T. Shinohara. 1999. Forest resources and timber production of Ghana: current instruments for sustainable development. Journal of Forest Research 4:1-12.

Dean, A., and D. Voss. 2006. Design and analysis of experiments. Springer Science & Business Media. Page 93.

Defenders of Wildlife. 2006. Incentives for biodiversity conservation: an ecological and economic assessment. Defenders of Wildlife, Washington D.C. 94pp.

Donkor, B.N., and R.P Vlosky. 2003. A review of the forestry sector in Ghana. Louisiana Forest Products Development Center. Working Paper #61.

Dorm-Adzobu, C., Ampadu-Agyei, O., and Viet, P. G. 1991. Religious beliefs and environmental protection: The Malshegu Sacred Grove in Northern Ghana. World Resources Institute, Nairobi, Kenya: Acts Press, Washington, D. C.

Dunlap, R.E., and R.E. Jones. 2002. Environmental concern: conceptual and measurement issues. In R.E. Dunlap and W. Michelson (Editors), Handbook of environmental sociology (pages 482-524). Greenwood Press, Westport, CT, USA.

Dunlap, R.E., and R.E. Jones. 2003. Environmental attitudes and values. In R. Fernandez-Ballesteros (Editor), Encyclopedia of psychological assessment, Volume 1 (pages 364-369). Sage Publications, London, UK.

Dunlap, R.E., and K.D. Van Lierre. 1978. The new environmental paradigm. The Journal of Environmental Education 9:10-19.

Dunlap, R.E., K.D. Van Lierre, A. Mertig, and R.E. Jones. 2000. Measuring endorsement of the new environmental paradigm: a revised NEP scale. Journal of Social Issues 56:425-442.

Dybas, C. L. 2001. From biodiversity to biocomplexity: a multidisciplinary step toward understanding our environment. BioScience 51:426–430.

Ecological Society of America. 2002. Biocomplexity. A fact sheet prepared by the Ecological Society of America, Washington, DC, USA. Available at http://www.esa.org/education_diversity/pdfDocs/Biocomplexity.pdf. Accessed June 2009.

Emerton, L. 2000. Using economic incentives for biodiversity conservation. IUCN - The World Conservation Union.

Emmerling-DiNovo, C. 1995. Stormwater detention basins and residential locational decisions. Journal of the American Water Resources Association 31:515-521.

Entem, A. 2007. Do environmental attitudes predict organic purchasing and environmental organization involvement? SS-AAE Journal of Agricultural Economics. 1-23. Available at http://ageconsearch.umn.edu/bitstream/113244/2/Paper8.pdf. Accessed June 15, 2010.

Ferraro, P.J., and S.K. Pattanayak. 2006. Money for nothing? A call for empirical evaluation for biodiversity conservation investments. PLoSBiology 4:482-488.

Ferraro, P.J. 2009. Counterfactual thinking and impact evaluation in environmental policy. In BirnBaum, M., and P. Mickwitz (Editors) Environmental program and policy evaluation: addressing methodological challenges. New Directions for Evaluation 122:75-84.

Fishbein, M., and I. Ajzen. 1975. Belief, attitude, intention, and behavior: An introduction to theory and research. Reading, MA: Addison-Wesley.

Florio, M., and D. Sartori. 2010. Getting incentives right: Do we need ex-post CBA? Centre for Industrial Studies, Milan. Working Paper N. 01/2010.

Food and Agriculture Organization of the United Nations (FAO). 2005. Global forest resources assessment 2005: Progress towards sustainable forest management. Rome.

Forestry Commission of Ghana. 2001. Biodiversity management plan for Atewa Forest Reserve, including Atewa Range and Extension Forest Reserves for the period 2001-2005.

Forestry Commission of Ghana. 2008. Inventory of high forest zone. Available at www.fcghana.com/publications/forestry_issues. Accessed November 15, 2008.

Franklin, J. F. 1988. Structural and functional diversity in temperate forests. Pages 166-175 in E.O. Wilson, (editor). Biodiversity. National Academy Press, Washington, D.C.

Freitas, S.R., M.C.S. Mello, and C.B.M. Cruz. 2005. Relationships between forest structure and vegetation indices in Atlantic Rainforest. Forest Ecology and Management 218: 353-362.

Ghana Meteorological Services Department. 2009. Climatology. Available at http://www.meteo.gov.gh/climatology.html. Accessed on January 2, 2009.

Ghana Statistical Service. 2000. Ghana – population and housing census. Available at http://www.statsghana.gov.gh/nada/index.php/catalog. Accessed December 5, 2010.

Ghana Statistical Service. 2008. Ghana living standards survey. Report of the fifth round (GLSS 5). September 2008. Available at http://www.statsghana.gov.gh/docfiles/glss5_report.pdf. Accessed December, 10, 2010.

Ghana Wildlife Society. 2009. http://www.ghanawildlifesociety.org/projects/afadjato.html.

Global Environment Facility. 2008. Joint evaluation of the GEF Small Grants Programme. GEF Evaluation Office, Washington DC. 89 pages.

Global Environment Facility / Small Grants Programme (GEF/SGP). 2010. Project reports and results list of the Global Environment Facility/Small Grants Programme of the United Nations Development Programme, Ghana Projects. Available at http://sgp.undp.org/index.cfm?module=SGP&page=ContactCountry&CountryID=GHA. Accessed in September 2010.

Gotelli, N.J. 2008. A primer of ecology (4th Edition). Sinauer Associates. Massachusetts, USA. 291 pages.

Gotelli, N.J., and A.M. Ellison. 2004. A Primer of ecological statistics. Sinauer Associates Inc. 479 pages.

Groom, M.J., Meffe G.K., and C.R. Carroll. 2006. Principles of conservation biology. Third Edition. Sinuaer Associates. 699 pages.

Gross, J.E. 2003. Developing conceptual models for monitoring programs. Available at http://science.nature.nps.gov/im/monitor/docs/Conceptual_modelling.pdf. Accessed on December 5, 2011.

Grubb, P., Jones, T.S., Davies, A.G., Edberg, E. Starin E.D., and J.E. Hill. 1998. Mammals of Ghana, Sierra Leone and The Gambia. The Trendine Press, Cornwall, UK. 263 pages.

Gubbi, S., M. Linkie, and N. Leader-Williams. 2008. Evaluating the legacy of an integrated conservation and development project around a tiger reserve in India. Environmental Conservation 35: 331-339.

Gustafson, E. J., A.Z Shvidenko, B.R. Sturtevant, and R.M. Scheller. 2010. Predicting global change effects on forest biomass and composition in south-central Siberia. Ecological Applications 20:700-715.

Julien, Y., J.A. Sobrino, C. Mattar, A.B. Ruescas, J.C. Jimenez-Munoz, G. Soria, V. Hidalgo, M. Attitar, B. Franch, and J. Cuenca. 2011. Temporal analysis of normalized difference vegetation index (NDVI) and land surface temperature (LST) parameters to detect changes in the Iberian land cover between 1981 and 2001. International Journal of Remote Sensing 32: 2057–2068.

Justice, C.O., J.R.G. Townshend, B.N. Holben, and C.J. Tucker. 1985. Analysis of the phenology of global vegetation using meteorological satellite data. International Journal of Remote Sensing 6: 1271 – 1318.

Hall, C., and D. Moran. 2006. Investigating GM risk perceptions: a survey of anti-GM and environmental campaign group members. Journal of Rural Studies 22:29-37.

Hall, J.B., and M.D. Swaine. 1976. Classification and ecology of closed-canopy forest in Ghana. The Journal of Ecology 64:913-951.

Harrison, S., and J. Herbon. 2008. Financial and economic research methods. Australian Centre for International Agricultural Research (ACIAR) Training Manual 1. 86 pages.

Hawcroft L.J., and T.L. Milfont. 2010. The use (and abuse) of the new environmental paradigm scale over the last 30 years: A meta-analysis. Journal of Environmental Psychology 30:143-158.

Hawthorne, W.D., and M. Abu-Juam. 1995. Forest protection in Ghana. A paper prepared under an assignment from the Ghana Government, the IUCN and the ODA (now DFID). Forestry Commission of Ghana.

Henryi, M., and S. Jouard. 2007. Effect of bat exclusion on patterns of seed rain in tropical rain forest in French Guiana. Biotropica 39:510–518.

Hilson, G., and S.M. Banchirigah. 2009. Are alternative livelihood projects alleviating poverty in mining communities? Experiences from Ghana. Journal of Development Studies 45:172-196.

Holben, B.N. 1986. Characteristics of maximum-value composite images from temporal AVHRR data. International Journal of Remote Sensing 7:1417-1434.

Hufschmidt, M.M., D.E. James, A.D. Meister, B.T. Bower, and J.A. Dixon. 1983. Environment, natural systems and development: an economic valuation guide. The Johns Hopkins University Press, Baltimore, Maryland, USA. 338 pages.

Imbens, G.W. 2004. Nonparametric estimation of average treatment effects under exogeneity: A review. Review of Economic Statistics 86:4–29.

International Tropical Timber Organization. 2005. Status of tropical forest management. Available at http://www.itto.or.jp/live/Live_Server/1233/Ghana.e.pdf. Accessed on March 1, 2009.

Intergovernmental Panel on Climate Change. 2007. Climate change 2007: impacts, adaptation and vulnerability. World Meteorological Organization, Geneva.

International Union of the Conservation of Nature (IUCN). 2008. Economic instruments for financing conservation and poverty reduction. Available at http://www.iucn.org/about/work/initiatives/sp_cprihome/index.cfm. Accessed November 2, 2008.

Israel, G.D. 2009. Sampling the evidence of extension program impact (http://edis.ifas.ufl.edu/pd005). University of Florida Cooperative Extension Service – Document PEOD5.

Israel, G.D. 2009. Determining sample size (http://edis.ifas.ufl.edu/pd006). University of Florida Cooperative Extension Service – Document PEOD6.

International Union for Conservation of Nature (IUCN). 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>. Downloaded on November 18, 2011.

Jorgensen, B.S., and G.J. Syme. 2000. Protest responses and willingness to pay: attitude toward paying for stormwater pollution abatement. Ecological Economics 33:251-265.

Joseph, S., M.S.R. Murthy, and A.P. Thomas. 2011. The progress on remote sensing technology in identifying tropical forest degradation: a synthesis of the present knowledge and future perspectives. Environmental Earth Science 64:731-741.

Kaiser, L. 1989. Adjusting for baseline: change or percentage change? Statistics in Medicine 8: 1183.

Kingdon J. 2003. The Kingdon field guide to African mammals. A&C Black Publishers Ltd. London. 476 pages.

Kotey, E.N.A., J. Francois, J.G.K. Owusu, R. Yeboah, K.S. Amanor, and L. Antwi. 1998. Falling into place. Policy that works for forests and people series number 4. International Institute for Environment and Development, London.

Kurtz, T., N. Donaghue and I. Walker. 2005. Utilizing a social-ecological framework to promote water and energy conservation: a field experiment. Journal of Applied Social Psychology 35:1281– 300.

Kunz, T.H., and A. Kurta. 1988. Capture methods and holding devices. *In* Ecological ad behavioural methods for the study of bats. Kunz T.H. (editor). Smithsonian Institution Press, Washington D.C. Pages 1-30.

Liu, J., Z.Y. Ouyang, and H. Miao. 2010. Environmental attitudes of stakeholders and their perceptions regarding protected area – community conflicts: a case study in China. Journal of Environmental Management 91:2254-2262.

Luellen, J.K., W.R. Shadish, and M. H. Clark. 2005. Propensity scores: an introduction and experimental test. Evaluation Review 29:530.

Luo, Y.J., and J.Y. Deng. 2008. The new environmental paradigm and nature-based tourism motivation. Journal of Travel Research 46:392-402.

MacDodald, D.H., M.D. Morrison, and M.B. Barnes. 2010. Willingness to pay and willingness to accept compensation for changes in urban water customer service standards. Water Resource Management 24:3145-3158.

Magurran, A.E. 2004. Measuring biological diversity. Blackwell Publishing USA. 256 pages.

Mainieri, T., E.G. Barnett, T. Valdero, J.B. Unipan and S. Oskamp. 1997. Green buying: the influence of environmental concern on consumer behavior. Journal of Social Psychology 137: 189-204.

Maloney, M.P. and M.P. Ward. 1973. Ecology: let's hear it from the people. An objective scale for measurement of ecological attitudes and knowledge. American Psychologist 28: 583-586.

March, J.G. 1994. Decision making: how decisions happen. The Free Press, New York, USA. 289 pages.

Margoluis, R., C. Stem, N. Salafsky, and M. Brown. 2009a. Design alternatives for evaluating the impact of conservation projects. In BirnBaum, M., and P. Mickwitz (Editors) Environmental program and policy evaluation: addressing methodological challenges. New Directions for Evaluation 122:85-96.

Margoluis, R., C. Stem, N. Salafsky, and M. Brown. 2009b. Using conceptual models as a planning and evaluation tool in conservation. Evaluation and Program Planning 32:138-147.

Marshall, B.K., J.S. Picou, and C.E. Bevc. 2005. Ecological disaster as contextual transformation: environmental values in a renewable resource community. Environment and Behavior 37:706-728.

Mather, P., and M. Koch. 2011. Computer processing of remotely-sensed images: an introduction. John Wiley and Sons. 460 pages.

McCullough, J., L.E. Alonso, P. Naskrecki, H.E. Wright, and Y. Osei-Owusu (editors). 2007. A rapid biological assessment of the Atewa Range Forest Reserve, Eastern Ghana. RAP Bulletin of Biological Assessment 47. Conservation International, Arlington, VA.

McDavid, J.C. and L.R.L. Hawthorn. 2006. Program evaluation and performance measurement: an introduction to practice. Sage Publications, USA.

McNeely, J.A. 1988. Economics and biological diversity: developing and using economic incentives to conserve biological resources. IUCN, Gland.

Medellin, R.A. and Gaona, O. 1999. Seed dispersal by bats and birds in forest and disturbed habitats of Chiapas, Mexico. Biotropica 31, 478–485.

Michener, W.K., T.J. Baerwald, P. Firth, M.A. Palmer, J.L. Rosenberger, E.A. Sandlin, and H. Zimmerman. 2001. Defining and unraveling biocomplexity. Bioscience 51: 1018-1023.

Millennium Ecosystem Assessment. 2005. Ecosystem and well-being: synthesis report. Island Press, Washington, DC

Ministry of Lands and Forestry of Ghana. 1994. Forest and Wildlife Policy. Available at http://www.fcghana.com/publications/laws/foresty_wildlife_policy/index.html. Accessed September 15, 2009.

Ministry of Lands and Forestry of Ghana. 2004. Criteria and indicators for sustainable management of natural tropical forests. Reporting questionnaire for indicators at the national level – Report for Ghana. Submitted to ITTO, March 2004. Ghana Forestry Commission, Ministry of Lands and Forestry, Accra, Ghana.

Mobley C., W.M. Vagias, and S.L. Deward. 2010. Exploring additional determinants of environmentally responsible behavior: the influence of environmental literature and environmental attitudes.

Moles R. and K. Hayes. 2002. Evaluating biodiversity through functional groups: a comparison of functional groups and biodiversity measures. Biology and Environment: Proceedings of the Royal Irish Academy 102B: 113-117.

Norton, A., and M. Foster. 2001. The potential of using sustainable livelihoods approaches in poverty reduction strategy papers. Working Paper 148, Overseas Development Institute, London.

Norusis, M.J. 2006. SPSS 15.0: Statistical procedures companion. Prentice Hall Inc. Upper Saddle River, New Jersey, USA. Pages 428-429.

Noss, R.F. 1983. A regional landscape approach to maintain diversity. BioScience 33:700-706.

Noss, R.F. 1986. Nodes, networks, and MUMs: preserving diversity at all scales. Environmental Management 10:299-309.

Noss R.F. 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation Biology 4: 355-364.

Noss R.F. 1992. Issues of scale in conservation biology. In P.L. Fiedler and S.K. Jain (eds.), Conservation biology: the theory and practice of nature conservation, preservation and management, 239–50. New York. Chapman and Hall.

Noss R.F., Csusti B., and M.J. Groom. 2006. Habitat fragmentation. *In* Groom, M.J., Meffe G.K. and C.R. Carroll (Editors). Principles of Conservation Biology. Third Edition. Sinuaer Associates. 699 pages

Ntiamoa-Baidu, Y. 1991. Conservation of coastal lagoons in Ghana: the traditional approach. Landscape Urban Planning 20: 41-46.

Ntiamoa-Baidu Y., Gyamfi-Fenteng, L.J., and D. Abbiw. 1992. Management strategy for sacred groves in Ghana. A report prepared for the World Bank and the Environmental Protection Council.

Ntiamoa-Baidu Y., Owusu E.H., Daramani D.T., and A.A.Nouh. 2001. Ghana. In L.D.C. Fishpool and M.I. Evans (Editors), Important Bird Areas in Africa and associated islands: Priority sites for conservation. Newbury and Cambridge, UK: Pisces Publications and BirdLife International (BirdLife Conservation Series No.11). Pages 367-389.

Oduro-Afriyie, K., and D.C. Adukpo. 2006. Spectral characteristics of annual mean rainfall series in Ghana. West African Journal of Applied Ecology. 9:15-23.

Olson, C. L. 1976. On choosing a test statistic in multivariate analysis of variance. Psychological Bulletin 83: 579-586.

Olejnik, S.F. and J. Algina. 1984. ANCOVA and the rank transform ANCOVA when the data are conditionally non-normal and heteroscedastic. Journal of Educational Statistics 9: 129.

Owusu, E.H. 2001. The potential of Afadjato-Agumatsa Conservation Area for ecotourism development. (Unpublished PhD Thesis). DICE, University of Kent, Canterbury, UK.

Owusu, E.H. 2008. Ecotourism as a conservation tool - a case of Afadjato–Agumatsa Conservation Area, Ghana. Journal of Science and Technology. 28:166-177.

Pettorelli, N., S. Ryan, T. Mueller, N. Bunnefeld, B. Jedrzejewski, M. Lima, and K. Kausrud. 2011. The Normalized Difference Vegetation Index (NDVI): unforeseen success in animal ecology. Climate Research 46: 15-27.

Patterson, B. D., M. R. Willig, and R. D. Stevens. 2003. Trophic strategies, niche partitioning, and patterns of ecological organization. In Bat ecology: 536-579. Kunz, T. H. and Fenton, M. B. (Eds.). Chicago: University of Chicago Press.

Pickett, S. T. A., M. L. Cadenasso, and J. M. Grove. 2005. Biocomplexity in coupled natural-human systems: A multidimensional framework. Ecosystems 8:225-232.

Pomerol, J. and P. Brezillon. 2002. Proceduralization of the contextual knowledge for decision making. In R. Bisdorf (Editor). Proceedings of the HCP 2003, the 14th Mini-Euro Conference on Human Centered Processes. Fonds National de la Recherce, France.

Purcell, M. and W.L. Magette. 2010. Attitudes and behaviour towards waste management in the Dublin, Ireland region. Waste Management 30: 1997-2006

Puri, M.L., and P.K. Sen. 1969. Analysis of covariance based on general rank scores. Annals of Mathematics and Statistics 40:610

Quade, D. 1967. Rank analysis of covariance. Journal of American Statistical Association 62:1187.

Rauwald, K.S., and C.F. Moore. 2002. Environmental attitudes as predictors of policy support across three countries. Environment and Behavior 34:709-739.

Ray T.W. 1994. A FAQ on vegetation in remote sensing. Center for Earth Observation. Yale University. Available at http://www.yale.edu/ceo/Documentation/rsvegfaq.html. Accessed October 15, 2011.

Racey, P.A. 1988. Reproductive assessment in bats. *In* Ecological ad behavioural methods for the study of bats. Kunz T.H. (Editor). Smithsonian Institution Press, Washington D.C. Pages 31-46.

Reid, W.V. 1992. How many species will there be? In Whitmore, T.C. and J.A. Sayer (Editors). Tropical Deforestation and Species Extinction. Chapman and Hall, London.

Richards, M. 1995. Role of demand side incentives in fine grained protection: A case study of Ghana's tropical high forest. Forest Ecology and Management 78: 225-241.

Richter H.V., and G.S. Cumming. 2006. Food availability and annual migration of the straw-colored fruit bat, *Eidolon helvum*. Journal of Zoology 268: 35-44.

Richter H.V., and G.S. Cumming. 2008. First application of satellite telemetry to track African straw-colored fruit bat migration. Journal of Zoology 275:172-176.

Rosenbaum, P.R., and D.B. Rubin. 1983. The central role of the propensity score in observational studies for causal effects. Biometrika 70:41–55.

Rosevear, D.R. 1969. The bats of West Africa. British Museum (Natural History). London, United Kingdom.

Rossi, P.H., Lipsey M.W. and H.E. Freeman. 2004. Evaluation: a systematic approach. Sage Publications, Inc, USA.

Rubin, D.B. 1980. Bias reduction using Mahalanobis-metric matching. Biometrics 36:293–298.

Running, S. W., and R. R Nemani. 1988. Relating seasonal patterns of the AVHRR vegetation index to simulated photosynthesis and transpiration of forests in different climates. Remote Sensing of Environment 24:347-367.

Salafsky, N., and E. Wollenberg. 2000. Framework and scale for assessing the integration of human needs and biodiversity. World Development 28: 1421-1438.

Sargent, C.; Husain, T.; Kotey, N. A.; Mayers, J.; Prah, E.; Richards, M.; and T. Treue. 1994. Incentives for the sustainable management of the tropical high forest in Ghana. Commonwealth Forestry Review 73:155-163.

Schultz, P.W., V.V. Gouveia, L.D. Cameron, G. Tankha, P. Schmuck, and M. Franek. 2005. Values and their relationship to environmental concern and conservation behavior. Journal of Cross-cultural Psychology 36:457-475

Seaman, S.L., J. Algina, and S.F. Olejnik. 1985. Type I error probabilities and the power of the rank and parametric ANCOVA procedures. Journal of Educational Statistics 10: 345.

Sellers, P. 1985. Canopy reflectance, photosynthesis and transpiration. International Journal of Remote Sensing 6:1335-1372.

Shadish, W.R, T.D. Cook, and D.T. Campbell. 2002. Experimental and quasi-experimental designs for generalized causal inference. Houghton Mifflin, Boston. USA.

Shannon, C.E., and W. Weaver. 1949. The mathematical theory of communication. Urbana, IL: university of Illinois Press.

Sidique, S.F., F. Lupi, and S.V. Joshi. 2011. The effects of behaviour and attitudes on drop-off recycling activities. Resources Conservation and Recycling 54:163-170.

Slavin, R., and D. Smith. 2009. The relationship between sample sizes and effect sizes in systematic reviews in education. Educational Evaluation and Policy Analysis 31: 500-506.

Small, C., and R.J. Nicholls. 2003. A global analysis of human settlement in coastal zones. Journal of Coastal Research 19:584-599.

Soto M.A. 1983. The accuracy of population projections. Journal of the American Statistical Association 78:13-20.

Steel, B.S., N.P. Lovrich, D. Lach, and V. Formenko. 2005. Correlates and consequences of public knowledge concerning ocean fisheries management. Coastal Management 33:37-51.

Taylor, D.A.R., and B.O. Kankam. 1999. The role of the straw-colored fruit bat, *Eidolon helvum*, in seed dispersal, survival and germination in *Milicia excelsa*, a threatened West African hardwood. Flagstaff, AZ; Kumasi, Ghana: Northern Arizona University; The Forestry Research Institute of Ghana.

Temeng, V.A., and J.K. Abbew. 2009. A review of alternative livelihoods projects in some mining communities in Ghana. European Journal of Scientific Research 35:217-228.

Tessema M.E. R.J. Lilieholm, Z.T. Ashenafi and N. Leader-Williams. 2010. Community attitudes toward wildlife and protected areas in Ethiopia. Society and Natural Resources 23:489-506.

The Yale Center for Earth Observation. 2011. Converting digital numbers to Top of Atmosphere Reflectance. Yale University. Available at http://www.yale.edu/ceo. Accessed October 9, 2011.

Thomas D.W. 1983. The annual migrations of three species of West African fruit bats (Chiroptera: Pteropodidae). Canadian Journal of Zoology 61: 2266-2272.

Torii, D., Ishida T., Bonneaud S. and A. Drogoul. 2005. Layering social interaction scenarios on environmental simulation *in* Mutli-agent and multi-agent-based simulation. Springer, Berlin/Heidelberg. Pages 78-88.

Tourre, Y.M., L. Jarlan, J-P. Lacaux, C.H. Rotela, and M. Lafaye. 2008. Spatio-temporal variability of NDVI-precipitation over southernmost South America: possible linkages between climate signals and epidemics. Environmental Research Letters 3:044008.

Trochim, W.M. 2006. Research Methods Knowledge Base, 2nd Edition. Available at http://www.socialresearchmethods.net/kb/. Accessed March 10, 2009.

Tropenbos International. 2005. Alternative livelihoods and sustainable resource management. Proceedings of a workshop held in Akyawkrom, Ghana, on the 1st of April 2005. Tropenbos International Ghana Workshop Proceedings 4, edited by D. K. B. Inkoom, K. Okae Kissiedu and B. Owusu Jnr. Wageningen, the Netherlands. Available at http://www.tropenbos.org/tbi_publications/documents/Ghana_Proceedings_4.pdf.

Tucker, C. J., B. N. Holben, J. H. Elgin, and J. E. McMurty. 1981. Remote sensing of total dry matter accumulation in winter wheat. Remote Sensing of Environment 11:171-189.

Tucker, C. J., C. L.Vanpraet, M.J. Sharman, and G. van Ittersum. 1985. Satellite remote sensing of total herbaceous biomass production in Senegalese Sahel: 1980- 1984. Remote Sensing of Environment 17:233-249.

United Nations Environmental Programme. 2002. Plan of implementation of the World Summit on Sustainable Development. In Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August-4 September 2002, pp. 6-72. A/CONF. 199/20. United Nations, New York.

United Nations Environmental Programme. 2004. Economic instruments in biodiversity-related multi-lateral environmental agreements. United Nations Publications, New York.

United State Geological Survey (USGS). 2011a. USGS Global Visualization Viewer. Available at http://glovis.usgs.gov/. Accessed September to December 2011.

United State Geological Survey (USGS). 2011b. USGS Landsat documents. Available at http://landsat.usgs.gov/documents/Cloud_removal_techniques_for_landsat_science_team_workshop.pdf. Accessed October 10, 2011.

Van Kooten, C.G., and E.H. Bulte. 2000. The economics of nature: managing biological assets. Blackwell Publishers, Massachusetts. 512 pages.

Walsh, S.J., and D. McGinnis. 2009. Biocomplexity of coupled human-natural systems: the study of population and environmental interactions. Geoforum 39: 773-775.

Wang J., P.M. Rich, and K.P. Price. 2003. Temporal responses of NDVI to precipitation and temperature in the central Great Plains, USA. International Journal of Remote Sensing 24: 2345 – 2364.

Weber N., E.K.V. Kalko and J. Fahr. 2009. A first assessment of home range and foraging behavior of African long-tongued bat, *Megaloglossus woermanni* (Chiroptera: Pteropodidae) in a heterogenous landscape within the Lama Forest Reserve, Benin. Acta Chiropterologica 11:317-329.

Wiegel, R. and J. Wiegel. 1978. Environmental concern: the development of a measure. Environment and Behavior 10:3-15.

Yeboah S. 2007. Reproductive pattern of some Megachiropteran bats in Ghana. Ghana Journal of Science 47:117-122.