UNIVERSITY OF EDUCATION, WINNEBA

ANALYSIS OF ECOSYSTEM SERVICES OF THE ATEWA RANGE FOREST RESERVE IN THE EASTERN REGION, GHANA

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DECLARATION

I, JOANNA NYOMEDZI FIATI, declare that this thesis, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: …………………………………

DATE: …………………………………………

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with the guidelines for supervision of Thesis as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: …………………………………

SIGNATURE: ……………………………..…………………

DATE: ………………………………………………………

DEDICATION

To my parents; Amos Agbo and Ivy Constance Eghan, my siblings; Nathan, Levina, Favour, Juliet, Nyamekye, Ezekiel and Gyan. And also, to my grandparents Emmanuel Eghan and Rose Kesse.

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ABBREVIATIONS

ARFR	Atewa Range Forest Reserve
ES	Ecosystem Services
FAO	Food and Agriculture Organisation of the United Nations
GIS	Geographic Information System
GSS	Ghana Statistical Service
NTFP	Non Timber Forest Product
NTP	Non Timber Production
OLI	Operational Land Imager
PCA	Principal Component Analysis
SPSS	Statistical Package for Social Science
SES	Socio-Ecological System
TIRS	The International Ecotourism Society
TM	Thematic Mapper
USGS	United States Geological Survey

ABSTRACT

The study sought to analysed ecosystem functioning and services of the Atewa Range Forest Reserve (ARFR). Land cover change analysis was done to assess the change in state of vegetative cover of the reserve. Remotely sensed images for the period of 1990- 2018 were used. A mixed method approach to research was employed, using the descriptive and explanatory case study designs. Stratified random sampling technique was used to select six communities from the three ranges and convenient sampling was also used to select 278 respondents who answered the questionnaires. 23 key informants were interviewed in the communities using purposive sampling technique. The study found that there have been reductions in the provision of ecosystem services by the ARFR over the past thirty years. Provision of ecosystem services is mainly influenced by anthropogenic factors which include illegal mining, logging, hunting, farming and activities of chainsaw operators. It was again revealed that the reserve is endowed with numerous fascinating sites that can be developed into tourist's sites. The forestry commission manages the reserve and has employed methods such as tree planting, weeding of forest line, arresting of offenders to ensure continuous ecosystem functioning of the reserve. Fringe communities have less hand in the management process. The study concluded that, the forestry commission has not succeeded in managing the reserve single handedly. The study recommended that the government together with the local assembly and traditional authorities should collaborate to ensure effective management schemes. Fringe communities should be highly involved in the management processes to ensure effective ecosystem services provisioning.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Forest according to International Union of Forest Research Organisation (IUFRO) (2002), can be define as a land area with minimum 10% tree crown coverage or formerly having such tree and that is being naturally or regenerated. Aerts and Honnay (2011) stated that, forest cover almost one third of the land area globally and comprises of over 80% of terrestrial biodiversity. However, the rate at which forests cover are disappearing over the past years is very alarming (Yaro, Okon, Bisong, & Ukpali, 2016). The high demand for timber and other forest products such as word for fuel and others has resulted in the high level of forest encroachment and high rate of deforestation and forest degradation worldwide (Yaro et al, 2016). According to World Resources Institute (WRI) (2000), forests play a vital role in biogeochemical cycles most especially in the global carbon and hydrological cycles. Forest also provides raw materials for food, fuel and shelter. Krieger, (2001) as cited in Apeanti, (2014), found that beyond the physical benefits derived from forest, the forest also provides intangible benefits to human well-being. Krieger, (2001) explained that ecosystem components interact with each other to provide purified water and air, regulate the climate and recycle nutrients and wastes.

The MA, (2005) simply defines ecosystem services as the benefits that people obtain from ecosystems. Daily, Matson, and Vitousek, (1997), indicated in that, proper functioning of the world's ecosystem is very important for human survival and having knowledge on ecosystem services is very necessary. The characteristics of ecosystems, for example the composition of species, tree growth conditions, species compositions, determine the type and magnitude of ecosystem services that can flow to societies.

Millennium Ecosystem Assessment, (2005), categorized ecosystem services into four types. These are;

i. Provisioning services are products obtained from ecosystems. Examples are wood, firewood, food, water etc.
ii. Regulating services which are the benefits that are derived from ecosystem processes that regulate the conditions in the environment. Examples are; the regulation of floods, climate, soil fertility, etc. These services rarely have market and valued indirectly,
iii. Cultural services and these are intangible benefits that result from the interaction between human and ecosystem. Examples are; employment, sense of identity, spiritual value, aesthetic value and cognitive development. Some of these services, for instance recreation, have markets, while others do not.
iv. Supporting services encompass the fundamental ecosystem processes such as photosynthesis, nutrient cycling and evolution, which underpin the provision of other services and thus find societal benefit through them.

In Tropical Africa, forest ecosystems are important repositories for vital livelihood resources and ecosystem services, and at the same time, constitute major wildlife habitats (Balvanera, Quijas, Karp, Ash, Bennett, Boumans, Brown, Chan, Chaplin-Kramer, Halpern, Honey-Rosés, Choong-Ki Kim,Cramer, Martínez-Harms, Mooney, Mwampamba, Nel, Polasky, Reyers, Roman,Turner, Scholes, Tallis, Thonicke, Villa, Walpole,Walz, 2016). In West Africa, natural forests have been reduced and fragmented to less than 30% of their original land area and the remaining forest patches continue to be degraded or completely lost at an alarming rate (Balvanera et al., 2016) West African forests have been designated as one of 34 Global Biodiversity Hotspots due to species richness found in these forests (biodiversity), high number of unique species found nowhere else on earth, and high rate of loss (Rapid Assessment Program (RAP), 2007).

According to Aerts and Honnay (2011), the size and quality of forest habitat continue to decrease and the associated loss of biodiversity put at risk forest ecosystem functioning and the ability of forests to provide ecosystem services. This according to Ecological Society of America, (2000), is caused by human activities such as population size, per-capita consumption and effects of technology to produce goods and services.

In Ghana, forest degradation and deforestation pose a very dangerous threat to the economy. According to BIRD, (1998) as cited in Edusah, (2011) the high forest zone in Ghana was estimated to cover over 82,000 sq.km in the early 20th century but this has been declining for many years. Particularly, since the 1970s to about 18,726 sq.km presently and at a deforestation rate of 0.9 percent translating into about 5.2 million ha. of forest cleared annually. The forestry commission, (2017) also stated that, the total land area covered by forest in Ghana in the year 2000 was 8.9 million ha. However, 4.7 million ha out of this forest cover was lost in 2001-2015. It was pointed out by the Forestry Commission that, the current rate of deforestation and forest degradation stands at (3.51% annual loss of forest cover in Ghana). This is because Ghana's forest resources face pressures from mining, agricultural encroachment, legal and illegal logging, and wood fuel harvesting, wildfires and infrastructural development. These have made the future of Ghana’s forests of which the Atewa Range Forest Reserve is not an exception an issue of major concern (Forestry Commission, 2017).

This is a threat because forests provide many ecosystem services that support the country’s predominantly agrarian economy. Due to this, continuous loss of Ghana’s forests poses severe challenges to the Ghanaian economy as well as the capacity of forest ecosystems to sustainably supply critical goods and services for the country (Forestry Commission, 2017).

This study sought to investigate and analyzed ecosystem services provided by the Atewa Range Forest Reserve and explored factors that may influence the provision of ecosystem services and tourism potentials of the forest.

1.2 Problem Statement

The Atewa Range Forest Reserve was established in 1926 as a national forest reserve and has since been labelled as a Globally Significant Biodiversity Area (GSBA) and an Important Bird Area (IBA) by BirdLife International in 1999 and 2001 respectively (Abu-Juam, Obiaw, Kwakye, Ninnoni, Owusu, and Asamoah, 2003; RAP, 2007). However, in 2018, Ghana and China signed a 2 billion dollar deal to mine bauxite in the ARFR (A ROCHA Ghana, 2020). This according to A ROCHA Ghana, (2020) is a threat to the reserve as the strip mining of bauxite will lead to a total loss of forest in the mined areas, along with all the biodiversity it contains, hence, affecting ecosystem services provided by the ARFR. There are also many reports of threats to this unique forest by illegal logging, mining, farming activities and others (RAP, 2007; Ruffor foundation, 2016). These may require effective management by the Government and other stake holders such as the local people to ensure that the reserve is continually protected. Despite these alarming reports, there is little information on how these human activities have affected ecosystem services provided ARFR.

In addition, some environmental institutions and civil organisations such as civil organisations such as wildlife division, concern citizens of Atewa led by A ROCHA Ghana are advocating for the ARFR to be turn into a national park (A ROCHA Ghana, 2020). Turning the Reserve into a national park according to these institutions and civil organization will generate income in the long run than the bauxite mining. It is therefore necessary to investigate and identify a number of potential tourism sites in the ARFR to sentitised the general public and contribute to the appeal on government for the Government to protect the reserve

There have been quite a number of studies conducted on forest reserves in Ghana. Edusah, (2011) conducted a study on how the livelihoods of forest fringe communities have been affected by the constitution of four forest reserves in Brong Ahafo and Ashanti Regions of Ghana and it was found in the study that, farming was the main occupation of the people with cocoa and oil palm being the major cash crops grown in the area therefore, constituting forest reserves means claiming their farmlands which affect their livelihoods and also community participation in management of the reserve is very minimal. Apeanti, (2014) assessed the effects of climate change on ecosystem services provided by the Atewa Range Forest Reserve and its effects on livelihood outcomes on fringe communities along the reserved. Kponstu, (2011) also concluded in her study that, disparity in the Atewa Range Forest Reserve is due to frequent human disturbances going on in the forest. This study therefore focused on investigating and analysing ecosystem services provision by the Atewa Range Forest Reserve in Ghana as identified by the Millennium Ecosystem Assessment, (2005) and to explore factors that may influence the provisioning of these services As well as the tourism potentials of the ARFR amidst many challenges faced by forests in Ghana.

1.3 Research Purpose

The main purpose of conducting this research was to investigate ecosystem services provided by the Atewa Range Forest Reserve in Ghana and the factors that influenced the delivery of these services provided by the forest.

1.4 Research Objectives

The following specific objectives guided the study.

1. To investigate ecosystem services provided by the Atewa Range Forest Reserve
2. To examine factors that influenced the provision of ecosystem services.
3. To explore tourism potentials of the Atewa Range Forest Reserve.
4. To investigate the various management practices adapted to ensure protection of the ARFR.

1.5 Research Questions

Based on the specific objectives, the following questions guided the study.

1. How is the Atewa Range forest Reserve performing in terms of providing ecosystem services?
2. What factors influence the provision of the ecosystem services?
3. To what extent can the ARFR function in terms of tourism services delivery?
4. What are the various management practices adapted to ensure continuous protection of the ARFR?

1.6 Significance of the Study

The significance of ecosystem services provided by forests in Ghana can never be underestimated. This is because forest ecosystems provide critical goods and services for the country. Due to this, investigating the various ecosystem services that can be provided by the Atewa Range Forest Reserve and finding out factors that can affect the provision of these services will be very vital for the country. The study will help to know ecosystem services provided by Atewa Range Forest Reserve, find out factors that influence the provision of these services and also explore the tourism potentials of the Reserve. The results of this study will be of great benefit to the forestry commission and Non-governmental organizations and the country at large. The report of the research can be used in recommending appropriate measures that needs to be taken to protect the Forest Reserve in order for it to be able to provide quality ecosystem services.

1.7 Scope of the study

Studying all forests and the ecosystem functions and services they can provide is impossible. This is as a result of the nature of investigation that needs to be conducted and also due to time limitation and financial constraints. Therefore, the Atewa Forest was selected among the various forest reserves in Ghana and was restricted to the Atewa Range Forest Reserve. Although there were many issues concerning the Atewa Range Forest Reserve, the study focused mainly on the ecosystem functioning and services provided by the Forest Reserve and explored factors that influenced the provision of these services and the Forest's tourism potentials.

1.8 Organization of the Study

The study was organized under five chapters. Chapter One included introduction and background to the study, problem statement, purpose of the research, research objectives and questions. The chapter also included significance of the study, scope of the study and how the whole study was organized. Chapter Two also focused on theoretical and empirical review of literature, where the researcher explained the theory chosen, how it was used and how it was applied to the study. Also, relevant literature related to the subject under study was reviewed under various themes. Chapter Three described the study area and provided an outline of the research methodology to be used, that is the research approach and design, data and source, study population, sample and sample techniques, instruments for data collection, data presentation and analysis and ethical consideration. Chapter Four involved presentation of results and findings and also discussed the research findings, and the last chapter five, took into accounts, the summary of the main findings, conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This section reviews relevant related literature to this study. The review is based on themes to reflect the objectives of the study. Ecosystems and ecosystem services were reviewed and also factors influencing the provision of ecosystem services. Management practices to ensure continues provision of ecosystem services and tourism potentials were also considered. The theoretical evidence was observed in detail on what various authors have reviewed on this study.

2.1 Ecosystems

According to Ecological Society of America, (2000), ecosystems include physical and chemical components, such as soils, water, and nutrients that support the organisms living within and that these organisms may range from large animals and plants to microscopic bacteria. It was further explained that human beings are also part of an ecosystem. Therefore, the health and wellbeing of human populations depend upon the services provided by ecosystems and their components that is organisms, soil, water, and nutrients. “Ecosystems provide a multitude of benefits to humanity, from food, clean water and flood protection to cultural heritage and a sense of place, to name but a few” (Science for Environment Policy, 2015 pp.3). Aerts and Honnay, (2011) explained in a study conducted on Forest Restoration, Biodiversity and Ecosystem that, the functioning of an ecosystem incorporates processes such as decomposition of organic matter, fixation of carbon, nutrient and water cycling and degradation of toxic compounds. Defra, (2007) also defined ecosystem at the most basic level as a natural unit of living things, that is animals, plants and micro-organisms and their physical environment. It was further explained that living and non-living elements function together as an interdependent system and that if one part is damaged it can have an impact on the whole system.

The 2005 Millennium Ecosystem Assessment shows that nearly two-thirds of the world‘s ecosystems are now under threat due to incessant depletion of the earth‘s forest (Bond, Grieg-Gran, Wertz-Kanounnikoff, Hazlewood, Wunder &Angelson, 2009). A well-defined ecosystem has strong interactions among its components and weak interactions across its boundaries and also, a useful ecosystem boundary is the place where a number of discontinuities coincide, for instance in the distribution of organisms, soil types, drainage basins, or depth in a water body (Kimmins, 2006).

Shiwnarain, (2018) categorized ecosystem into two main types under which all other ecosystems fall and these are terrestrial ecosystems and aquatic ecosystems. Terrestrial ecosystems sometimes referred to as biomes can be placed into four types and these are Forest, desert, Grasslands and Tundra ecosystems while aquatic ecosystems represent the ecosystems that lives in the world's waters and they can be broken into two main categories and these are marine ecosystems and freshwater ecosystems (Shiwnarain, 2018). In addition, Defra, (2007) also stated that ecosystems can be terrestrial or marine, inland or coastal, rural or urban. They can also vary in scale from the global to the local and at the continental level examples include rainforests, deserts and coral reefs. Closer to home we might think more in terms of different types of habitats (e.g. woodlands, grassland, marshes, heathland, rivers, peat bogs) though this can also extend to the urban environment (e.g. parks and gardens, rivers and streams). In many cases, ecosystems overlap and interact (Defra , 2007). According to Harris, (2018), within any ecosystem, specific features vary widely and an example was given as an oceanic ecosystem in the Caribbean Sea will contain vastly different species than an oceanic ecosystem in the Gulf of Alaska. Chan, Guerry, Balvanera, Klain, Satterfield, Basurto, Bostrom, Chuenpagdee, Gould, Halpern, Hannahs, Levine, Norton, Ruckelshaus, Russell, Tam and Woodside, (2012) indicated that, ecosystems have “unaccountable”’ characteristics that is very important to acknowledge for three reasons. The reasons are first, the complexity of ecosystems is such that applying accounting practices modeled in accordance with traditional economic accounting is often both impossible and inappropriate. In other words, while economic activities can be aggregated to a certain extent, attributes of ecosystems and their functions do not lend themselves well to aggregation. Second, supporting services or support functions underlie all other services (e.g., provisioning and cultural services are made available in part by supporting services). Third, supporting services are often considered to be most important from cultural and spiritual perspectives, which have their own specific value.

2.2 Ecosystem Services

The concept of ecosystem services was brought into widespread use by the Millennium Ecosystem Assessment (MA), a global initiative set up in 1999 to assess how ecosystem change would affect human well-being (MA, 2005) as cited in Science for Environmental Policy, (2015). Ecosystem services are the processes by which the environment produces resources that we often take for granted such as clean water, timber, and habitat for fisheries, and pollination of native and agricultural plants (Ecological Society of America, 2000). Whether we find ourselves in the city or a rural area, the ecosystems in which humans live provide goods and services that are very familiar to us. The services provided by an ecosystem result from the interaction between ecosystem and the societies which together form a social-ecological system (Balvanera, et al., 2016). The benefits derived from ecosystem services cover various dimensions of human well-being, namely basic human needs, economic, environmental, and subjective happiness (Sangeeta, Om Prakash, & Ashish, 2018). The Millennium Ecosystem Assessment, (2005) also defined ecosystem services simply as the many different benefits that ecosystems provide to people. An example of these benefits according to them is a stand of trees that can reduce air pollution, purify the water supply, reduce the likelihood of floods and help regulate the climate by capturing and storing carbon.

According to Ecological Society of America (2000), ecosystem services are so fundamental to life that they are easy to take for granted and so large in scale that it seems impossible for human activities to destroy them. Regardless, ecosystem services are severely threatened through activities such as growth in the scale of human enterprise (population size, per-capita consumption, and effects of technologies to produce goods for consumption) and a mismatch between short-term needs and long-term societal well-being as further explained by the Ecological Society of America. In assessing the flow of ecosystem services, and how they may behave or change in the future, scientists generally assume that any habitat that remains untouched will continue to provide its normal, full range of services (Isbell et al., 2014) as cited in (Science for Environment Policy ,2015). However, habitat fragmentation can lead to an 'extinction debt' that is, a delay between reduction in habitat and extinction of species in the remaining fragments (Kuussaari, Bommarco, Heikkinen, Helm, Krauss, Lindborg, Öckinger, Pärtel, Pino, Rodà, Stefanescu, Teder, Zobel, & Steffan-Dewenter, 2009). For example, an individual of a long-lived tree species may persist in a habitat fragment for a long time, but if there are not enough individuals to enable reproduction the species will become extinct. This could, in turn, lead to an 'ecosystem services debt'. It is usually impossible to place an accurate monetary amount on ecosystem services;

however, we can calculate some of the financial values. Many of these services are performed seemingly for “free”, yet are worth many trillions of dollars (Bargali, 2018).

Irrespective of the importance of ecosystem services to people, many have been taken for granted in the past, being viewed as free and unlimited. However, according to MA, (2005) it is now clear that the worldwide degradation of ecosystems is also reducing the services they can provide. As indicated by Millennium Ecosystem Assessment (2005), (Kuussaari, et al., 2009),Foresight, (2012) and Raworth, (2012), human activity poses multiple environmental challenges on the planet’s ability to support the adoption of high consumption lifestyles by increasing numbers of people, widespread overexploitation and pollution of natural systems is causing degradation and loss of local and global ecosystems and natural resource stocks and hence loss of ecosystem services on which human activities are critically dependent. Human interventions can increase some services, though often at the expense of other ones. Thus human interventions have dramatically increased food provisioning services through the spread of agricultural technologies, although this has resulted in changes to other services such as water regulation (Belt, Granek, Gaill, Halpern, Thorndyke & Bernal, 2016). It was further explained that data on ecosystem services and their valuation for specific case studies are often reused for similar case studies in different locations, because local data collection and analysis are expensive and require specific skills in non-market analysis

2.2.1 Categories of Ecosystem services

Ecosystem services concept provides a starting point towards defining, monitoring and valuing such services (MA, 2005). . Making the fundamental nature of these services explicit not only helps to raise awareness of the importance of protecting ecosystems, it can also provide decision makers such as the government, NGOs and other stake holders with quantitative data, that will help them to consider all aspects of the socio-economic-ecological system in which we live. Millennium Ecosystem Assessment (2005), categorized ecosystem services into four types. These are supporting, provisioning, cultural and regulating services.

Supporting

These are services, such as nutrient cycling and soil formation, which are needed for the production of all other services that is the fundamental ecosystem processes such as photosynthesis, nutrient cycling and evolution, which underpin the provision of other services and thus find societal benefit through them. According to Landers and Nahlik, (2013), supporting services are mostly considered as an 'intermediate' level as it support functions toward "final ecosystem services". The intermediate nature of supporting services makes accounting more challenging, that is, avoiding double counting (Belt, et al., 2016). Supporting services differ from provisioning, regulating, and cultural services in that their impacts on people are either indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people (Chan, et al., 2012).For example, humans do not directly use soil formation services, although changes in this would indirectly affect people through the impact on the provisioning service of food production. The production of oxygen gas (through photosynthesis) is categorized as a supporting service since any impacts on the concentration of oxygen in the atmosphere would only occur over an extremely long time. Other examples of supporting services include primary production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat (Belt, Granek, Gaill, Halpern, Thorndyke & Bernal, 2016).

Provisioning services

Products obtained and consumed from ecosystems, such as food, wood, firewood, timber etc. which are valuable in market (Science for Environment Policy, 2015). Provisioning services such agriculture, timber products, and fish, are widely recognized and may be more highly valued than other service types (Brauman, Daily, Duart, & Mooney, 2007). The flows of provisioning services do not accurately reflect their condition, since a given flow may or may not be sustainable over the long term and this flow is typically measured in terms of biophysical production, such as kilograms of maize per hectare or tons of tuna landings (MA, 2005). The provisioning of ecological goods such as food, fuel wood, or fiber, depends both on the flow and the “stock” of the good, just as is the case with manufactured goods (Belt, et al., 2016).Most provisioning goods are ‘rival and excludable’ and therefore more suitable for valuation through markets, (e.g., fisheries in an Exclusive Economic Zone). However, some provisioning services are ‘rival but non-excludable’ (e.g., fisheries outside of Exclusive Economic Zones) (Belt, et al., 2016).

Regulating services

The benefits that are derived from the regulation of ecosystems which we experience, including services such as purification of water, flood control, regulation of the climate via carbon sequestration, soil fertility, etc.(Science for Environment Policy, 2015). These services rarely have market and valued indirectly. Belt, et al., (2016) indicated, that regulating services is generally not relevant when it comes to the level of “production”. Instead the condition of the service depends more on whether the ecosystem’s capability to regulate a particular service has been enhanced or diminished as further explained. Thus if forest clearance in a region has resulted in decreased precipitation and this has had harmful consequences for people, the condition of that regulatory service has been degraded (Belt, et al., 2016). Examples of regulating services include; air quality maintenance, climate regulation, water regulation, erosion control, water purification and waste treatment, regulation of human diseases, biological control, pollination, storm protection(Belt, et al., 2016).

Cultural services

The intangible benefits people obtain from ecosystems from the interaction between human and ecosystem through spiritual enrichment, cognitive development, reflection, recreation, aesthetic experiences, employment, sense of identity etc (Science for Environment Policy, 2015).. Some of these services, for instance recreation, have markets, while others do not (Science for Environment Policy, 2015). The evaluation of the condition of cultural services is more difficult and some cultural services are linked to a provisioning service (such as recreational fishing or hunting) that can serve as a proxy measure of the cultural service. Moreover, unlike provisioning or regulating services, assessing the condition of cultural services depends heavily on either direct or indirect human use of the service (Belt, et al., 2016).For example, the condition of a regulating service such as water quality might be high even if humans are not using the clean water produced, but an ecosystem provides cultural services only if there are people who value the cultural heritage associated with it. Information about the condition of cultural services can be obtained by identifying the specific features of the ecosystem that are of cultural, spiritual, or aesthetic significance and then examining trends in those features. For example, salmon are a totemic or revered species in almost all parts of the world where they are found, and thus the degradation of wild salmon stocks represents degradation of a cultural service provided by the ecosystem (Belt, et al., 2016). Cultural services are tightly bound to human values and behavior, as well as to human institutions and patterns of social, economic, and political organization. Thus perceptions of cultural services are more likely to differ among individuals and communities than, say, perceptions of the importance of food production (Belt, et al., 2016).

The MA opened a wider understanding and use of ecosystem services and offered an excellent heuristic and classification system. Despite its recent publication date, the MA classification of supporting, regulating, provisioning and cultural services is one of the most widely used (Boyd & Banzhaf, 2007; Wallace, 2007; Fisher & Turner, 2008).This classification is understandably not meant to fit all purposes, and this has been pointed out for contexts regarding environmental accounting, landscape management and valuation, for which alternative classifications have been proposed (Boyd & Banzhaf, 2007; Wallace, 2007; Fisher & Turner, 2008).

2.2.2 Forest ecosystem

The world's forests cover thirty per cent of the earth's surface, and serve as a source of diverse values to human society (Jenkins & Schaap, 2018). Forest supports local biota, non-timber forest products (NTFP's) s, medicinal plants, and fuel wood, along with long-lasting services such as groundwater recharge, flood control and fire resistance and thus requires a larger dimension of proper management. Further, the forest provides shelter to a variety of wildlife, have great powers to heal body and spirit, reservoirs of endemic and endangered plant and animal species, carbon sequestration, contain relatives of crop species that can help to improve cultivated varieties, maintains water cycle, and improve soil stability, hence, forests are the lifeline for the rural community (Ray, Chandra, & Ramachandra, 2010) in many ways either socio-cultural, religious or livelihood maintenance. Forests are key element in the regulation of hydrological cycles, climate and the reduction of the atmospheric pollution, and they play an essential role in the global carbon cycle (Rasche, Fahse, & Bugmann, 2013). Forests have been assisting forest-dwelling communities for meeting their day-to-day needs since time immemorial (Edusah, 2011). These forest communities support a large number of threatened species including those that have vanished from the major landscape. According to Ayivor, Gorden, Adomako and Ntiamoa-Baidu, (2011), the decrease in forest cover generally attributed due to the transform in social and religious values mainly due to advancement in technology and infrastructural development the ever-growing market growth of the various natural resources including medicinal, firewood, and other non-timber forest products was among the key drivers for depletion. However, for the general population of villages, it is easier to understand the economics than the ecology

A healthy forest ecosystem provides a wide range of services including reliable clean water, climate regulation, and productive soils and forests underpin many of society's basic needs, economic processes, and cultural or spiritual values. A forest ecosystem is therefore an area of the landscape, varying in size from a local stand (a few hectares or less) to an entire continent, in which the structure, function, complexity, interactions and patterns of change over time are dominated by trees (Kimmins, 2006). It was further stated that forest ecosystems consist of: soil or some geological or organic substrate in which the trees and other plants are rooted; an atmosphere and a regional climate that is modified locally by slope and aspect; a microclimate that results from the shade, the reduced wind speed and the increased humidity created by the trees; and Organisms, including plants. Bargali (2018) also defined forest ecosystem as the community formed by plants and animals of that particular area that interact with the chemical and physical features of the environment in which they live. Ecosystem services derived from forest communities are vital to the welfare of human society and depending on its location and management status; a forest can provide all major ecosystem services from provisioning to cultural amenities which have not been much scientifically explored yet (Ray, Chandra, & Ramachandra, 2010). This ecosystem is a home to a wide variety of plant and animal species, which include producers, consumers and decomposers and these organisms, are interdependent on each other for their survival (Bargali, 2018). Bargali further mentioned that, forest ecosystem performs three main functions and these are protective, productive and social. Also, Nasi, Wunder and Campos, (2002) mentioned that, forest ecosystem services can be grouped under use and non-use, direct and indirect values and examples of direct use values in forests include timber, non-timber products and non-commodity benefits such as forest recreation while Indirect use values also include the services of forests in protecting watersheds, fisheries and carbon storage.

Forest ecosystems in tropical Africa are important repositories for vital livelihood resources and ecosystem services, and, at the same time, constitute major wildlife habitats (Balvanera, et al.,2016). Forest ecosystems provide a wide range of ecosystem services from which people benefit, and upon which most life forms depend. These include provision of food, fuel, building materials, freshwater, climate regulation, flood control, nutrient and waste management, maintenance of biodiversity, and cultural services, and many others. Provisioning service such as timber is produced only in forested ecosystems (Boyd & Banzhaf, 2007). According to Food and Agriculture Organisation (FAO), (2001), forests ecosystems contribute to the protection of watersheds of hydro-electric power generation schemes, as in the case of the Ntaruka station within the Rugezi wetland, and provide water for irrigation and protect soil against erosion, making agriculture more viable. Rwanda Environmental Management Authority (REMA), (2014) indicated that local communities and local governments can be helped to appreciate and be made aware of the opportunities of using forests to earn carbon funds. Most of the plant species found in forests in Rwanda are used in traditional medicine and some plants species can provide important biochemical extracts.

2.3 Factors influencing the provision of Ecosystem services

Forest decline results from many direct causes, some of which are natural but are aggravated by humans, such as climate change (Ayivor, Gorden, Adomako, & Ntiamoa-Baidu, 2011). The most important factors that decline the forest eco system are human-induced causes, these include both factors of deforestation, which is the complete or near-complete removal of tree cover, and forest degradation resulting from significant changes in forest structure that diminish or destroy its ability to deliver certain services as observed by (Nasi, Wunder, & Campos, 2002).The crucial factors are the permanent conversion of forest to cropland and pasture, overgrazing, unmitigated shifting cultivation, unsustainable forest management including poor logging practices, over-extraction of fuel wood and charcoal, or over-exploitation of non-timber forest resources - including bush meat and other living organisms (Nasi et al., 2002). Other sources are the introduction of alien and/or invasive plant and animal species, infrastructure development such as road building, hydro-electrical development, improperly planned recreational activities, and urban sprawl, mining and oil exploitation, forest fires caused by humans, and pollution (SCBD 2001). All these activities cause decline in our forests. Both the extent and quality of forest habitat continue to decrease and the associated loss of biodiversity jeopardizes forest ecosystem functioning and the ability of forests to provide ecosystem services (Aerts & Honnay, 2011).

According to Balvanera et al (2016), societies are embedded within ecosystems of which they depend and influence the services they produce. The biodiversity of tropical forests in Africa is being threatened by a range of human activities such as mining, habitat loss due to conversion to agricultural land and logging, over-exploitation for fuel wood, food, medicinal plants, overgrazing, water catchment and river channel destructions some of which are in response to climate change pressures (Nkem, et al., 2010). Human activities are already impairing the flow of ecosystem services from the forests on a large scale. If current trends continue, human activities will dramatically alter a large share of the Earth's remaining natural forest ecosystems within a few decades, especially in the tropics (Nasi et al., 2002). It was further explained by Nasi et al., (2002) that statements about these direct causes may provide little insight unless we answer why each of the proximate factors comes about. That is, we need to ask why loggers log unsustainably, why agricultural pioneers penetrate the forest, why forest people hunt unsustainably, and many others and that will help know why these activities are rampant. There can be strong economic incentives or disincentives to engage in deforestation or forest degrading activities. Recent research on the causes of deforestation emphasises that these "underlying causes" may be powerful (Nasi et al., 2002). In general, economic policies that favour agricultural land intensification (e.g. subsidies for colonisation, lower agricultural export taxes, and better crop and livestock prices) will all cause higher forest loss. Similarly, measures that induce a higher profitability of logging and other forest-based extraction (exchange rate depreciation, road building into forested areas or national booms in urban construction) will all induce higher forest degradation (Nasi et al., 2002).

Further, other factors that influence the provision of ecosystem services are what we termed as ecosystem tradeoffs and synergies. Trade-offs can be defined as an increase in one ecosystem service resulting in a reduction in another (Rodríguez, et al., 2006). For example, felling a forest to grow corn maximizes food provision but reduces carbon storage, storm buffering, and air quality and flood regulation. One service is therefore 'traded off' against others. Spatial trade-offs occur when maximizing one ecosystem service reduces another in a different location An example of this is the hypoxic or 'dead' zone in the Gulf of Mexico that has been so heavily polluted by fertiliser run-off it can no longer support marine life. In this spatial trade-off, maximising provision of crops has been traded-off against fishing catch, recreation, system resilience, etc. in another location (Rodríguez et al., 2006).Trade-offs can also occur over time. Maximising an ecosystem service in the short term may reduce its supply in the long term (Mouchet et al., 2014) as cited in (Science for Environment Policy 2015). In addition, examples of this include some intensive agricultural practices, which may maximize crop production in the short term but have negative effects on soil structure and fertility, genetic resources and soil erosion, causing yields to decline in the long term (Science for Environment Policy 2015).

Also, synergies occur where increases in one service result in an increase in another. A clear example of a synergy occurs between the regulating service pollination and the provisioning service crop production. In fact, 75% of the world's major crops are dependent on, or benefit from pollination (Carvalheiro et al., 2012) as cited in (Science for Environment Policy 2015).. There is also a synergy between soil erosion control and crop production. Erosion can result in a loss of the more fertile soil, reducing yields. Good erosion control can therefore mean better supply of crops (Bennett, Peterson & Gordon, 2009) as cited in (Science for Environment Policy 2015). If soil erosion prevention measures involve planting or protecting vegetation along river banks this can also boost water purification, creating a further synergy (Gundersen et al., 2010) as cited in (Science for Environment Policy 2015).

2.4 Forest and ecotourism

Héctor, (1996) defined ecotourism as an ‘‘environmentally responsible travel and visitation to relatively undisturbed natural areas, in order to enjoy and appreciate nature (and any cultural features) and promotes conservation, has low negative visitor impact, and provides for beneficially active socio-economic involvement of local populations’’. Ecotourism can be considered as a subset of sustainable tourism and nature tourism because it represents a sustainable way of travelling in natural areas (Nasi, Wunder and Campos, 2002). The International Ecotourism Society (TIES), (2015) also defined ecotourism as “responsible travel to natural areas that conserves the environment, sustains the well-being of the local people, and involves interpretation and education”. The two definitions shows that when it comes to ecotourism the natural environment should be conserved and human well-being should be sustained. However the latter added interpretation and education which is very essential as tourists need to be educated.

In ecotourism the prime motivation is the observation and appreciation of natural features and related cultural assets unlike adventure tourism that involves physical exercise and challenging situations in the natural environment (Wood, 2002). Ecotourism plays double role both in conservation and rural development in Sub-Saharan Africa. Important sources of economic diversification and livelihood opportunity in remote rural areas are ecotourism activities using natural resource attractions (Ashley, Roe, & Godwin, 2001; UNWTO, 2002). This is because it invigorates the social wellbeing of people and at the same time preserves the natural environment and cultural heritage through awareness creation (Manu & Wuleka , 2012

). If every individual in the local community is given the chance to participate in tourism development at an early stage, there will be a sufficient consensus on opinion to permit broad based planning objectives (Murphy, 1985). Impact of ecotourism can only be effective globally when the rights, roles and responsibilities of the communities are highly considered by officials driving the process. Giving every individual in the local community a chance to participate in tourism development at an early, will help reach a sufficient consensus on opinion to permit broad based planning objectives (Murphy, 1985).

Ghana is an eco tourist's delight (Ghana High Commission, 2018). The sunny equatorial climate and fertile well-watered soils bolster an enchanting selection of wildlife, ranging from elephants to monkeys and marine turtles to crocodiles, as well as hundreds of colourful bird and butterfly species. More than 5% of the country's surface area has been accorded official protection across 16 national parks or lower-profile conservation areas, of which the most popular tourist destinations are the vast Mole National Park in the northern savannah and the forested Kakum National Park near the coast (Ghana High Commission, 2018).

According to a report by Jonny-Nuekpe (2019), Ghana has emerged as a pioneer in the field of community-based ecotourism, which aims to create a mutually beneficial three-way relationship between conservationists, tourists and local communities over recent years. It was further reported that Boabeng-Fiem Monkey Sanctuary is home to sacred troops of mona and black-and-white colobus monkeys. The Wechiau Hippo Sanctuary in the Upper West and Amansuri Wetland Sanctuary in the Western Region are other fascinating sites in Ghana that can be visited by eco tourist. The Domana Rock Shrine, set in the forests near Kakum National Park, and the painted houses and pottery of Sirigu in the Upper East are cultural sites that can be visited by Eco tourists (Jonny-

Nuekpe, 2019). He continued to say that the Volta Region is the most topographically varied part of Ghana and hosts the country's largest concentration of community-based ecotourism sites, and offers outdoor enthusiasts' superb opportunities for hiking, rambling and mountain biking. Popular attractions include the sacred monkeys of Tafi Atome, a plethora of magnificent forests and waterfalls around Amedzofe, the country's highest peak on Mount Afadja, and the impressive forest-fringed Wli Falls, the tallest cascade in West Africa.

Ghana is highly alluring to birdwatchers, with 725 species recorded in an area comparable to Great Britain (Ghana High Commission, 2018). For casual visitors, it is colourful savannah birds such as gonoleks, rollers, parrots and weavers that tend to catch the eye, as well as the eagles and other raptors that inhabit the drier north. Serious birdwatchers, however, are likely to want to seek out the more elusive residents of the shadow rainforests interiors of Kakum, Bui and Ankasa, as well as the exceptional variety and volume of marine species that congregate on coastal lagoons such as Keta, Songor and Muni-Pomadze (Jonny-Nuekpe 2019). Many rural communities in Ghana are blessed with various attractive ecotourism.

Forests hold a wide range of fascinating sites, which can be developed into recreational sites. They provide important habitat for game animals and fish sought by hunters and anglers. A major part of non-consumptive recreational activities such as hiking, bird watching, wildlife viewing and other such pursuits occur within forest stands. Ecotourism is a booming business and constitutes a potentially valuable non-extractive use of tropical forests. Forest ecotourism is also unique, though the same service can be provided from many similar, competing sites (Nasi, Wunder and Campos, 2002). Some sites attract large numbers of visitors. In 1996 for instance, recreational activities accounted for a value of $1 billion in five national forests in the southern Rocky Mountains (Krieger, 2001) and Barnhill (1999) estimated the total economic impact of hunting activities and wildlife viewing in the Southern Appalachians region at $594 million and $407 million, respectively. The value of ecotourism in the Wolong Panda Reserve lies between $29-42 million per annum (Swanson, Qiwen, Kontolen, Xuejun, & Tao, 2001). According to Campos et al. (2001), one million tourists visited Costa Rica in 2000 and more than half of them visited the forests in public protected areas or private lands. However, it should be noted that the values generated have many different stakeholders captured, from the tourist's own consumer surplus to travel agents and capital-based operators. Although the percentage of total value that accrues at the local forest level tends to be small or non-existent, even a minor share may constitute an important amount in absolute terms.

The Atewa Range Forest Reserve holds beautiful and fascinating sites that need to be developed into tourist sites. The Reserve possesses about 314 plant species belonging to 71 plant families including 106 Upper Guinea endemics (Siaw & Dabo, 2007). Atewa is also known to be a center for numerous endemic and rare faunal species, due to its unique floristic composition generated by the misty conditions on top of the plateaus (Swaine & Hall, 1977). Hawthorne, (1998) and Larsen, (2006) stated that, the Atewa forest is home to several endemic butterfly species and is on record as having the highest butterfly diversity of any site in Ghana. There is also high diversity of dragonflies, katylids, fishes, amphibians, birds and mammals (Mahama, 2014). Mahama, (2014) further mentioned that, there are 72 species of *Odonata* (dragonflies and damselflies) in Atewa with *Atoconeuraluxata* as the only regionally-threatened dragonfly in western Africa.

In addition, there are 143 butterfly species belonging to 55 genera from five families, which show that the ARFR is a good forest habitat. *Neaveialamborni and*

Bicyclusauricruda are endemic to Atewa since they have not been recorded in any protected area in Ghana (Mahama, 2014). There are 16 species of butterflies endemic to the West Africa sub-region, of which two *(Euphaedramariaechristinae and Ceratrichiamaesseni*) are endemic to Ghana. There are also some rare butterfly species which are known either exclusively from Atewa or from just one other protected area in Ghana. Four of these rare species *(Mimeresiacellularis, Heteropsispeitho, Vanessulamilca and Euphaedrasplendens*) have been recorded exclusively from Atewa (Aduse-Poku & Doku-Marfo, 2007). The Reserve also serve as headwaters for most rivers and streams in the Eastern region the Ayensu, Birim and Densu rivers which serve a large number of Ghana's population hails from the Reserve. All these sites can be developed into tourist sites. If ecotourism is promoted, Eco tourists will appreciate the beautiful nature of the reserve and at the same time conserve and sustain the wellbeing of the local people as it will create employment avenues to the people in the fringe communities.

2.5 Managements practices to ensure continues forest ecosystem protection

The management objectives that people set for ecosystems and the actions that they take are influenced not just by the consequences of ecosystem changes for humans but also by the importance people place on considerations of the intrinsic value of species (Petrosillo, Aretano, & Zurlina, 2015; Zurlini, Petrosillo, & Cataldi, 2008). Intrinsic value is explained as the value of something in and for itself, irrespective of its utility for someone else. For example, villages in India protect "spirit sanctuaries" in relatively natural states, even though a strict cost-benefit calculation might favor their conversion to agriculture (Petrosillo, Aretano, & Zurlina, 2015). Many countries have also passed laws protecting endangered species based on the view that these species have a right to exist, even if their protection results in net economic costs (Millennium

Ecosystem Assessment (MA), 2003). Sound ecosystem management thus involves steps to address the utilitarian links of people to ecosystems as well as processes that allow considerations of the intrinsic value of ecosystems to be factored into decision-making as further explained.

In the light of the increasing population pressure, it is of major importance not only to conserve, but also to restore forest ecosystems (Aerts and Honnay, 2011). It is generally assumed that the incomplete valuation of the forest goods and services is one of the main reasons contributing to deforestation and forest degradation (Gregerson, Arnold, Lundgren, & Contreras-Hermosila, 1995). Therefore the total economic value of forests really needs to be taken into account for people to recognise their importance and better protect and manage forest ecosystems. Forest valuation is therefore a tool that can provide society and decision-makers with information for deciding among alternatives or upon preferred combinations of possible interventions (Kengen, 1997).

Like the benefits of increased education or improved governance, the protection, restoration, and enhancement of ecosystem services tends to have multiple and synergistic benefits. As explained Zurlini et al., (2008) many governments have already begin to recognize the need for more effective management of these basic life-support systems. Examples of significant progress toward sustainable management of biological resources can also be found in civil society, in indigenous and local communities, and in the private sector. It has therefore become necessary to fully engage stakeholders in the management processes of ecosystem services. For instance, according to Smith and Sullivan, (2014), farmers have a high awareness of ecosystem services and that they act as significant contributors to societal well-being and policy optimisation. In addition, several studies have also shown that local communities without conventional scientific training have successfully collected accurate data on a wide range of ecosystem services such as forest carbon storage and sequestration, water quantity and quality, and their links to well-being (Hodgetts, Essilfie, Adu-Gyamfi, Akom, Kumado, & Opoku, 2016; Dinerstein, et al., 2013). Involving communities in data generation enables year-round, low cost generation of local data and wide spatial coverage. It provides information for local-level decision-making for ecosystem service management, and it can also generate employment, enthusiasm, and personal investment in ecosystem service based initiatives as further explained by (Hein et al. 2006; Dinerstein et al. 2013).

2.5.1 Community Based Forestry (CBF).

Community based forestry is synonymous to participatory forestry where the state, local people and sometimes organizations are involved in forest management. According to Teitelbaum, Beckley and Nadeau (2006, p. 417), CBF is defined as: "A public forest area managed by the community as a working forest for the benefit of the community." At the latter part of the 19th century, the practice of tree planting in establishing forest and or agricultural plantation became a key practice especially, in agroforestry which later brought about a positive change in mostly open forest (Nair, 1993).

CBF emerged in the 1970's with the aim of addressing the connection between forestry and the local people (Arnold, 2001) and for restoring landscape, conserving biodiversity and to globally improve rural livelihoods (Paudyal, Baral, Lowell and Keenan, 2017). It also came about after the increasing pressure on lands for the main livelihoods that cut across the globe, crop and livestock farming. Centralized means of forest management didn't help in achieving efficient and effective sustainability of forest resources. For instance, the forestry sector in countries in Sub-Saharan Africa which is being regulated by the state given substantial financial aid to sustain forest resources still operated below expectations (Wilder, 2016). It was therefore essential to decentralize forest management to involve these people in protecting and sustaining forest resources. It was also a means to curtail degradation within the forest areas and to help in reclaiming degraded lands, increasing forest cover and improving on the living condition of the rural folks. Gradually, there has been the introduction of smallholder forest management where household or private individuals have the right to own and manage forest lands aside the well – known centralized one which was in relation to the state - owned forest areas. According to Arnold (2001), these household practiced longer term management as compared to those in the collaborative schemes though on a relatively small area yet associated with effective management. He also stated that, this forestry began in Nepal, India, Indonesia, China, Brazil, Costa Rica, and Ecuador and has shifted to several parts of the world including Ghana. CBF has been given several names in different countries. For instance in West Africa, it is mostly identified as Forest co-management, Mexico as Community management of forests, Ethiopia as Participatory forest management, India as Forest Management or Social forestry and in Nepal as Hill community forestry (Arnold, 2001). Moreover, CBF can be grouped into five models by Singh (1992) as 'Super Management Model', 'Non-Governmental Support Model', 'Partnership Model', 'Support Service Model' and the 'Leasehold Contract Model'. These models were to be practiced in Government forest which was known as Panchayat Forest and Panchayat Protected Forest and Private forest thus individual lands used for tree planting. Among these models, both the state and the local people were involved in the management of the forest but at different degree of participation where in some, that of the state exceeds the local people and vice versa. Also, in other models there was an involvement of Non-Government Organizations (NGOs).

A survey carried out by Teitelbaum et al., (2006) grouped CBF schemes based on common organizational structures, land bases and tenure arrangements which can also be related to the ownership and the stakeholders. Osei-tutu (2018) also classified CBF strategy into three groups of participatory forestry schemes which are ‘passive participation’, ‘partial devolution’ and ‘complete devolution’. Just like Singh’s models, this classification was based on the collaboration between State forestry institutions and local people. A situation was determined as ‘Passive participation’ where the local people were being treated as forest users who have to be predetermined in terms of, their access to the lands and their involvement in management of the forest. It is the State forestry institutions that have control over the decision making and planning activities.

In ‘Complete Devolution participation’, local people were treated as owners and managers in forest management where decision making and protecting forest resources is solely the role of those leaving at the forest fringes (local people). This class happened to be the one which is most satisfactory in ensuring a positive environmental and socio – economic results in the society (Osei-tutu, 2018). Also, the third class (‘Partial Devolution’) recognized local people as partly owning and managing forest areas mostly on contract bases.

Similarly, Ampofo, Gyan and Acheampong (2015) categorized CBF into three forest approaches that is Solely Government, Private Afforestation and Collaborative/ Modified Taungya System (MTS). They also used the degree of ownership and participation as the means of categorization. Solely Government approaches are practiced in forest areas that are owned by the state and therefore they have greater control in terms of planning and managing such areas. The Private Afforestation is also known as PADO (Private Afforestation Developers Organisation) which is the reciprocal of the Solely Government. The former is solely owned and governed by private individuals or local people. Again, Collaborative or MTS forest approach ensures that both the state and the local people have an equal responsibility towards forest sustainability and both parties in play have a share in the ownership where at times it may be on agreement. Nair (1993) also wrote on the origin of taungya as it originated in the 1950's in Burma (Myanmar) from two words that is "Taung" which means hill and "ya" which also means cultivation. That is farming done in a mountainous environment. In 1806, a British empire planted teak using the taungya method. The taungya method was basically used in planting agricultural crops in between trees but its features vary from places or countries. The system is likened to shifting cultivation in the tropical regions but was later associated with afforestation. The ultimate aim of the practice is for tree plantation notwithstanding, it is also accompanied with food production.

It was introduced to Africa (first in South Africa) in 1887 with the aim to establish forest even using farmers who are landless. The taungya system can be seen in two forms that is the partial and the integral systems. The former concentrates on the economic value of the sub aim of the taungya, thus benefits people get from the agricultural crops being planted with the trees but the latter focuses on not just the temporal uses of land but where the practice of both tree planting and crop planting (agroforestry) is sustained for some period. This same system is being referred as Shamba system in Kenya (Mogaka, Simons, Turpie, Emerton and Karanja, 2001). It was adopted in the early 1900 by the forest department in Kenya for the establishment of plantation which began with farmers who were already into any form of taungya system (Nair, 1993).

In Africa, about 60 million people live within the forest zones and solely depend on them for their livelihoods (Asare-kissiedu, 2014). Wilder (2016) also stated in her study that more than 70% of the people in Sub-Saharan African rely on forest and woodlands for a living. Most of these people use fuelwood and the forests in the continent provide about 60% energy to be used as fuel. Community based forest management (CBFM) began in Africa since 1980 with its goals as improving community involvement, lessen rural poverty and enhance forest resource sustainability (Duguma, Atela, Ayana, Alemagi, Mpanda, Nyago, Minang, Nzyoka, Foundjem-Tita and Ntamag - Ndjebet, 2018). These are recently part of the Sustainable Development Goals (SDGs). By 2002 about 35 countries in Africa have been practicing several CBF schemes in both the national forests and that of private lands (Odera, 2004 as cited in Gilmour, 2016).

In Ghana, the Traditional Taungya System (TTS) began in the early 1950's which was a reforestation scheme in replanting trees in poor forest reserves in the high forest zones (Tufuor, 2012). It continued till 1980's where greater portions of the country's forest areas experienced wild fires (Asare-kissiedu, 2014; Heist, 2001). Though most of these degradations were as a result of natural disasters, some were also from human induced activities such as bush fires, illegal logging and farming.

It was after this disaster that several mechanisms were being introduced to restore and conserve such lands just as Heist (2001) confirmed that, several agencies both governmental and non-governmental in Ghana in 1987 went for a workshop to know the appropriate forest schemes and projects to implement in the restoration of degraded lands. They then came up with the Collaborative Community Forestry Initiative (CCFI) which was to focus on environmental problems like desertification, decline in soil fertility, deforestation. It was also to better the leaving conditions of small-scale farmers by the planting of trees as an alternate livelihood activity. There was also the implementation of the 1994 forest and wildlife policy with its aim as a means of protecting and sustainably managing state's forest and wildlife resources to benefit all sections of the society (Asare-kissiedu, 2014).

Furthermore, Osei-mainoo (2012) explained that the policy was to bring to bear the importance of active partnership between agencies and local communities in forest sustainability specially in the off-reserves areas. In 2001, the government lunched the National Forest Plantation Development Programme (NFPDP) which included Modified Taungya System (MTS) and Private timber tree plantations with the former occurring in state owned forest reserves and the latter in the off-reserves or on private lands (Asare-kissiedu, 2014). The modification of the Traditional Taungya System (TTS) is that of the MTS where the partnership between the state and the local people were being improved upon in terms of years. The local people were also allowed to cultivate crops in between the trees for at most three years and were also being accompanied with incentives to increase the participation of the local people in forest management. The NFPDP programmes were revived in 2009 to improve on the local people's participation (Tufuor, 2012). Plantation forests are mostly practiced in the forest zone regions in Ghana since farming is the predominant activity in those communities.

However, in the coastal areas like Winneba, MTS practiced in the degraded portion happens with low participation of the local people because is not intensified. In such areas tree planting are mostly done by institutions such as schools, associations on their environment. Land owners who may willingly give out their lands for tree planting after few years (often less than 3 years) give up and clear the land for other use.

2.6 Theoretical perspective

2.6.1 Socioecological System (SES) theory

Socioecological systems are define as systems the strong link between social, economic, ecological, cultural, political, technological, and other components , emphasizing the integrated concept of the 'humans-in-nature' perspective. Socioecological systems (SESs) are truly interconnected and co-evolving across spatial and temporal scales, where the ecological component provides essential services to society such as supply of food, fiber, energy, and drinking water scales (Zurlini, Petrosillo, & Cataldi, 2008). The socioecological system theory sprang from the recognition of close interaction between society, in terms of social–economic system, and natural system (Petrosillo, Aretano & Zurlini, 2015). Socialecological systems are based in the concept that ''humans are a part of not separate from nature'' (Balee, 2006).

There exist various socioecological system (SES) frameworks employed by researchers in different research fields based on respective research problem under study. Some of these frameworks include the vulnerability framework, the Earth Systems Analysis, the DPSIR (Driver-Pressure-State-Impact-Response) framework, The Human-Environment System (HES) framework and the Ecosystem Services (ES) framework, (Petrosillo, Aretano & Zurlini, 2015). All these theories are based on concepts as adaptive cycles, resilience, adaptability, transformability, and hierarchy (panarchy), and aim to provide knowledge basis to manage complex adaptive systems and to achieve sustainable development in theory and in practice. These SESs recognize that human dimension shapes and is shaped by environment, so that social and ecological systems are interconnected and coevolving across scales (Petrosillo et al., 2015). The complex interactions between development decisions and ecosystems, and how the consequences of these decisions may then influence human values and subsequent decisions is an important area of research interest. Ecosystems, structure and function are determined basically by human interactions, perceptions, and behaviors. It is therefore more appropriate to think of ecosystem services framework which is under the socioecological systems frameworks as an approach combining from both environmental and social sciences (Petrosillo et al., 2015).. This study therefore employed ecosystem services (ES) approach, a framework by the Millennium Ecosystem Assessment as the main concept to address the research questions.

2.6.2 Ecosystem Services (ES) framework

The Millennium Ecosystem Assessment introduced a framework for analysing SESs connecting drivers, ecosystem services and human well-being (Science for Environment Policy, 2015). In addition to ecological processes, also social factors such as skills, management regimes, and technology are involved in ecosystem services production. In particular, the framework makes more visible the links between the spatial and temporal provision of ecosystem services (supply) and the beneficiaries where corresponding well-being is appreciated (demand) (Zurlini et al., 2008). For this reason the ecosystem service approach is very useful for a better understanding of ecological functioning, social structures, trade-offs and synergies between services, benefits on human well-being, and how these aspects feedback to influence governance and policy and, therefore, SESs and their services (Science for Environment Policy, 2015) As a consequence, this framework has considerable influence in policy and scientific communities supporting problem solving and proactive management (Petrosillo et al., 2015).

The framework places human well-being as the central focus for assessment, while recognizing that biodiversity and ecosystems also have intrinsic value and that people take decisions concerning ecosystems based on considerations of well-being as well as intrinsic value (Petrosillo et al., 2015). The framework assumes that a dynamic interaction exists between people and other parts of ecosystems, with the changing human condition serving to both directly and indirectly drive change in ecosystems and with changes in ecosystems causing changes in human well-being At the same time, many other factors independent of the environment change the human condition, and many natural forces are influencing ecosystems (MA, 2003). Particular attention on the linkages between ecosystem services and human well-being was focused. Further, the assessment deals with the full range of ecosystems from those relatively undisturbed, such as natural forests, to landscapes with mixed patterns of human use and ecosystems intensively managed and modified by humans, such as agricultural land and urban areas (Zurlini et al., 2008). The frame work has three components. These are Ecosystems and Their Services, Human Wellbeing and Poverty reduction and Drivers of Change.

2.7 Conceptual framework

The Ecosystem Services (ES) approach is employed as the main concept to address the research questions of this study. The framework postulates that, there is a link between ecosystem and services, human well-being and drivers of change and places human well-being as the central focus for assessment. The framework also assumes that a dynamic interaction exists between people and other parts of ecosystems, with the changing human condition serving to both directly and indirectly drive change in ecosystems and with changes in ecosystems causing changes in human well-being. It also supports problem solving and proactive management. That is, changing needs of humans cause changes in ecosystem and their services they provide and a consequent change in well-being. However, with effective management human well-being will be met (MA, 2003).

Every ecosystem provide services such as food, water, wood, regulating services such as flood and climate regulation, recreation, spiritual value etc. to satisfy human well-being (Science for Environment Policy,2015). However, due to population growth, urbanization and other human activities (Drivers of Change), the extraction of natural products and other human benefits (ecosystem services) from ecosystems has implicit costs of production and other ancillary costs associated with preserving the integrity of the natural production system itself (Schmutz & Sendzimir, 2018). This has led to ecosystem trade-offs and synergies. That is, changes in the production of one ecosystem affecting the production of the other either positively or negatively. The Atewa Range Forest Reserve is a forest ecosystem that provides the fringe communities provisioning, cultural, regulating services and supporting services which aid the production of other services (Supply). However, population increase which has led to increase human needs such as food and medicine and economic activities such as gold mining, timber extraction (Demand) cause changes in the provision of ecosystem services. The ES frame work focuses on well-being and also shows that humans are drivers of change. The ES also helps to identify the various management strategies to adopt to ensure continuous ecosystem service production in other to ensure human wellbeing. The study explains these processes, which are the feedback effect on both humans (fringe communities) and the environment (ARFR) as shown in figure 1.

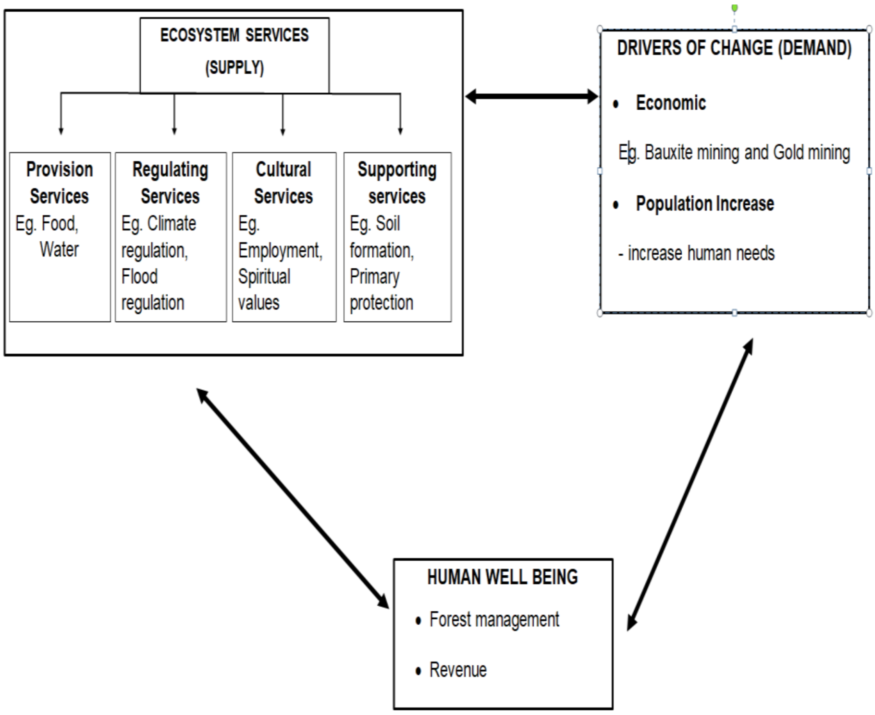

Figure 1: Ecosystem services framework
Source: Author's construct, 2020

2.8 Summary

This chapter was devoted to the review of related literature for the study; specifically the concept of ecosystem functioning and services production was the principal area of concern. The chapter unfilled a number of issues related to ecosystem functioning and services. It reviewed past and present literature to gain different perspectives on the subject by different authors. In addition, the chapter provided an overview of the various factors that influence the provision of ecosystem services. Also it reviewed ecotourism potentials of ecosystems and how they can be developed to satisfy human well-being and at the same time conserve the environment. Finally, the various management practices to be adopted to ensure continuous ecosystem functioning and services delivery were addressed.

Forest and forest reserves in Ghana are under serious threat due to forest degradation and deforestation. There have been quite a number of studies conducted on reserves in Ghana of which the Atewa Range Forest Reserve is not an exception. Although these studies pointed out that human disturbance going on in these forests cause forest degradation, there is still insufficient literature that assesses the performance of forest reserves in terms of providing ecosystem services, factors influencing the provision of these services despite these threats faced by forests in Ghana and the managements practices to be adopted to ensure continuous forest ecosystem functioning. This study therefore examines the gap in literature and provides empirical results addressing stifle that exist in the need to ensure continuous ecosystem functioning of the Atewa Range Forest Reserve in the Eastern region of Ghana. The study therefore made use of the ecosystem frame work to address the hold back.Hence the next chapter delves into issues relating to how the study was conducted (Methodology). It looks at issues on the study area, study design and approach, sampling procedures, data collection, processing and analysis.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This section of the study presents a description of the study area, the research approach and design, sample and sample techniques, target population of the study, data and sources and methods of data presentation and analysis.

3.1 Study Area

Atewa Range Forest Reserve is bordered by the East Akim Municipality and Kwaebibirim district in the Eastern Region and it is one of the only two upland evergreen forest types in Ghana, which is located within the moist semi-deciduous forest zone in the south eastern part of Ghana (Ruffor Foundation, 2016). The Forest was recognized as an important reservoir of biodiversity and was officially classified as a national forest reserve in 1926, as special biological protection area in 1994, a Hill Sanctuary in 1995 and as one of Ghana's 30 Globally Significant Biodiversity Areas (GSBAs) in 1999. It was also listed as an Important Bird Area (IBA) by BirdLife International in 2001 (Rapid Assessment Programme (RAP), 2007). Atewa Range Forest Reserve is one of the largest remaining areas of rainforest in the country, covering 23,665 ha and reaching an altitude of 842 m, the second highest point in Ghana. The Atewa range of hills runs roughly from north to south and is characterised by a series of forested plateaux. It represents about 33.5% of the remaining closed forest in Ghana's Eastern Region, harbouring a high diversity of species, including vascular plants, butterflies, dragonflies, katydids, amphibians and birds (Hodgetts, et al., 2016). There are many endemic and rare species in the Forest Reserve.

It is unique because it contains Upland Evergreen forest. The forest serves as the source of three important rivers in Ghana, that is the Densu, Birim and Ayensu

Rivers and they are the most important source of domestic and industrial water for local communities as well as for many of Ghana’s major population centers, including Accra. Thus, the Atewa forests protect and provide a clean water source for much of Ghana’s human population and for key elements of the country’s biodiversity.

The Atewa Range passes through several political administrative districts in the Eastern Region of Ghana. However, for the purpose of the study, communities selected for the study form part of the larger Atiwa West District Assembly, which has its administrative capital at Kwabeng which is situated at the foot of the Atewa Range Forest Reserve. The Atiwa West District lies between longitudes 0˚ 3‘ West and 0° 50 East and latitudes 6° 10 North and 6° 30, North. The District is bounded in the North by Kwahu West and Kwahu South Districts, on the North-East by the Fanteakwa District, East Akim to the South-East, Kwaebibrim to the South and Birim North to the West. The Atiwa District both East and West covers an estimate area of 2,950 square kilometres, the Fanteakwa district, East Akim and Ayensuano districts in Ghana (Ghana Statistical Service, (GSS), 2016b).

The Atewa RFR is under the authority of the Fanteakwa District (Eastern Region) of the Forest Services Division. The reserve is divided into three Ranges, namely the Suhum Range in the south, the Kibi Range in the centre and the Anyinam Range in the north. Each of the three Ranges is headed by a Range manager who is accountable to the District Manager. At least four forest guards are assigned to each Range Supervisor to help maintain law and order and to clean the reserve boundaries (Forestry Commission, 2020). Figure 2 shows the study area map.

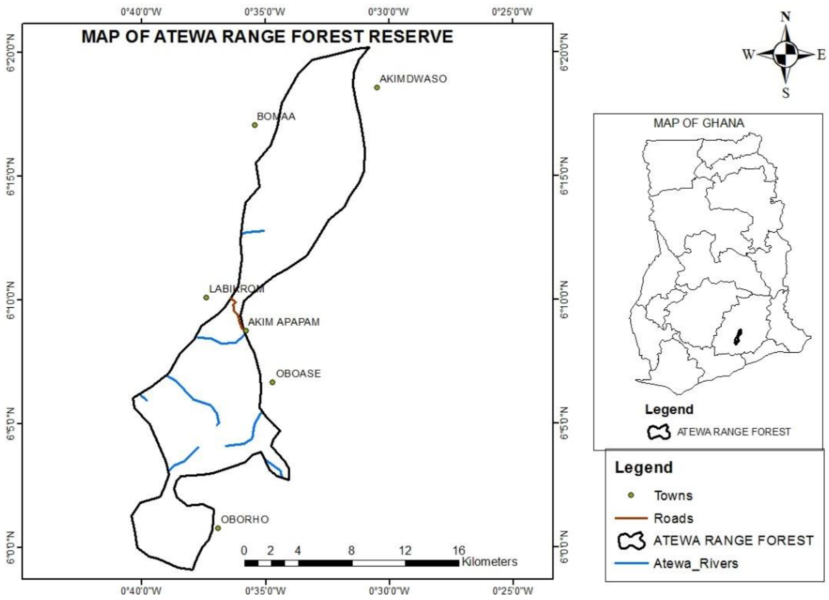

Figure 2: Study Area Map

Source: Authors construct (2020)

3.2 Research Approach

The research made use of both qualitative and quantitative approaches (pragmatic approach). The mix methods approach helps widens the understanding and makes social problem more intelligible than strictly using either quantitative or qualitative approach. In addition, Creswell, (2009) stated that, problems that need to be addressed by social sciences are complex and the use of either of this approach is insufficient to address this complexity. It was further explained that under the mix methods approach, instead of focusing on methods, researchers emphasize on the research problem and use all approaches available to understand the problem. That is attention is focused on the research problem in social science research and then pluralistic approaches are used to derive knowledge about the problem. For the mixed methods researcher, pragmatism allows for the use of multiple methods, different world views, different assumptions as well as different forms of data collection and analysis (Creswell, 2009). This study adopted the mixed method approach because both qualitative and quantitative data was used for the study. Methods for data collection were mixed, as well as instruments for data collection. Both questionnaire and interview guides were used in data collection, data was also analysed both quantitatively and qualitatively. This helped to obtain the best understanding of the research problem.

3.3 Research Design

This study employed the descriptive, explanatory case study design. The purpose of this research design was to describe the phenomena as it was without any influence. According to (Zainal, 2007) a descriptive research design involves observing and describing the natural phenomena that occur in the data in question without influencing it in any way. Due to this, a descriptive design was used to describe the state of the forest reserve. Explanatory case study design on the other hand is intended to give explanation to the phenomena under study rather than describing it (Maxwell & Mittapalli, 2010). This design gave vivid explanations to ecosystem services provided by the forest and factors that affects its functioning. Also, case study design as stated by Zainal (2007) examines the data within a specific context. In this case data was specifically collected and examined from the Atewa Ranges Forest Reserve.

3.4 Data and Source

The study made use of both primary and secondary sources of data. Primary data was obtained through field observation, questionnaire, and interviews. Secondary data was obtained from existing literature on the subject under study and also satellite data from United State Geological Survey (USGS) website. Finally, other relevant data from the forestry and wildlife commission were also used for the study.

3.5 Target Population

The target population includes communities that border the Atewa Range Forest Reserve, opinion leaders, chiefs and experts from forestry and wildlife commission were contacted for information.

3.6 Sample and Sampling Techniques

For the sample size and technique, the study employed both the probability and non-probability sampling techniques using stratified random sampling and purposive sampling. The stratified sampling technique was employed to select six communities from the three ranges which were Suhum Range, Kibi Range and Anyinam Range. Three communities were selected from Anyinam Range, Two from Suhum Range and one from Kibi Range based on level of interaction. This was to ensure total coverage of the Forest Reserve. These communities were Larbikrom, Akyem Bomaa, Kyebi Apapam, Akyem Saamang- Juaso, Oborho and Akyem Oboase. The total population of these communities according to the traditional council and the 2010 population census were, 6624 with each community having a population of 550, 898, 3127, 959, 1010 and 80 respectively (GSS, 2016a; GSS, 2016b; GSS, 2016c; GSS, 2016d). Purposive sampling technique was used to specifically select chiefs from each of the six communities except Apapam, opinion leaders and expert from the forestry and wildlife commission were interviewed. Three (3) experts (Range managers), five (5) chiefs and fifteen (15) opinion leaders from the six selected communities making a total of 23 participants interviewed. This was to access specific and the right information necessary for the research. Using the Research Advisors table 2006, with a study population of 6624, a sample size of 360 was chosen for the study. The number of respondents selected from each community was based on size of population, exhaustion of respondents and level of interaction with the forest reserve. Level of interaction of these communities with the ARFR was obtained from the forestry officials in charge of the reserve. This is shown in Table 1 and 2.

Table 1: Summary of sample and sampling techniques

Population	Sample	Sampling technique	Justification
Communities	6	Stratified random sampling	Equal representation and total coverage
Experts from forestry and Wildlife commission	3	Purposive	Access to right information.
Chiefs	6	Purposive	Access to right information.
Opinion leaders	15	Purposive	Access to right information.
People who live in the selected communities	360	Convenient	Timely and easy access to information

Source: Author's construct, 2020

Table 2: Sample size

Categories of Respondents	Larbikrom	Bomaa	Saaman-Juaso	Kyebi-Apapam	Oborho	Potrase-Oboase	Total
Number of respondents	60	70	70	60	70	30	360
Key Informants Interviews							
Chiefs	1	1	1	1	1	1	5
Opinion leaders	3	2	3	2	3	2	15
Forestry commissioners	-	-	-	-	-	-	3
Total							**383**

Source: Field data, 2020.

3.7 Instruments for data collection

The study made use of a questionnaire and two different sets of semi-structured interview guide, one for experts from the forestry and wildlife commission, one for chiefs and opinion leaders in each of the six communities selected and a questionnaire for residents of the six communities selected that borders the forest reserve. The interview guide was used to get specific information that was relevant for the study from specific people. The questionnaire, which was both closed and open ended gave a greater opportunity to respondents to contribute and express their knowledge on the Forest Reserve. Google Earth and USGS Earth Explorer were used to obtained satellite images of the study area to analyze patch density change.

3.8 Data Presentation and Analysis

Data was presented and analyzed both quantitatively and qualitatively. Data generated from Google Earth and Earth Explorer was analyzed spatially using Erdas Imagine 2013 software and ArcGIS versions 10.1 and presented using tables, graphs, maps and diagrams. The qualitative data was analyzed in narrations based on common themes that run through the responses. The Statistical Package for Social Science (SPSS) version 20 was used to analysed data generated from the questionnaire and the results was presented in mean and percentages. Some of the variables were also correlated to establish the relationships that exist between the variables. Principal component analysis was also used to determine the factors that mostly influence the provision of ecosystem services of the Atewa Range Forest Reserve (ARFR).

3.8.1 Land cover Change Analysis

Remote sensing and GIS were used in the classification and analysis of land use land cover change of the Atewa Range of Forest Reserve using three Landsat satellite images for the years 1990, 2003 and 2018. 1990 image was used as the base year because it was the image or map available. These images were downloaded from United States Geological Survey (USGS). The images were obtained from Landsat 4 Thematic Mapper (TM), Landsat 7 ETM and the Landsat 8 Operational Land Imager (OLI). These images for the study were obtained between November and early February which corresponds to the dry season in Ghana with clear and cloud free images. The analytical software used was ERDAS Imagine 2013 and ESRI ArcGIS versions 10.1.

3.8.2 Image Processing

This section provided the various processes satellite data went through to enable analysis and interpretation of the data. Monochromatic bands of downloaded images were composited using the layer stacking tool in ERDAS Imagine.

Before image classification, the three Landsat images for the various years 1990, 2003 and 2018 underwent radiometric correction to minimize the effects of atmospheric factors. Haze and noise corrections were run on the images to correct disturbance factors. After these corrections, the images were ready for land use, land cover classification.

3.8.4 Image classification

The study performed an unsupervised classification of 100 classes per each image for the Atewa Range Forest Reserve for the years 1990, 2003 and 2018 at a maximum iteration set at 100. The unsupervised classes obtained were downsized through ground trothing using Google Earth Pro to arrive at 3 major classes that represented the whole area. The unsupervised classification approach was adopted because it allowed spectral clusters to be identified with a high degree of objectivity (Yang & Lo, 2002). This method involved unsupervised clustering and cluster labeling.

The ISODATA (Iterative Self-Organizing Data Analysis), algorithms in ERDAS Imagine was used to identify spectral clusters. ISODATA method uses a minimum spectral distance to assign a pixel to a cluster. To avoid the impacts of sampling characteristics, the ISODATA algorithm was run without assigning predefined signature sets as starting clusters. The images of the three dates (1990, 2008 and 2018) were also reclassified according to the LAND COVER classes in Table 3 using the Maximum Likelihood Supervised classification method in ERDAS Imagine 2013 by the help of the signature classes that was obtained through the unsupervised classification. The Maximum Likelihood Supervised classification method assumed that the spectral values of the training pixels are normally distributed and calculated the probability that the given pixel belongs to a specific class (Islam, Borgqvist, & Kumar, 2018).

Table 3: Land Cover Classification

Land cover classes	**Description**
Bare land	Areas with exposed soil surface either from human activities or natural occurrences. In general, it is an area of thin soil, sand, or rocks. Vegetation, if present, is more widely spaced and scrubby than that in the Shrub and Brush category of Rangeland.
Forest	Areas where the vegetative cover is in balance with the biotic and abiotic forces of its biotype.
Secondary vegetation	Is defined as vegetation not planted but influenced by human actions. These may result from grazing, possibly overgrazing the natural phytocenoses or else from practices such as selective logging in a natural forest where by the floristic composition has been changed. Human activities may be deliberate or inadvertent

Source: Adapted from FAO Land Cover Classification

The land cover classification is adapted from the Food and Agriculture Organisation classification of land cover. This helped streamline the land cover of the Atewa Range Forest Reserve in 5 land classes for easy differentiation and general acceptance.

3.9 Ethical Considerations

Ethical consideration particularly informed consent was crucial in the study. This enabled me booked interview with experts from the forestry and wildlife commission, chiefs and opinion leaders, and also sought permission from chiefs and residents of the bordering communities before the questionnaire was administered. I also explained the purpose of the interview to the participants in a language that was well understood. Making the voluntariness of the exercise known to the participants enabled them made informed decision on being part of or to withdraw from the study. Confidentiality, anonymity and other ethical issues were all ensured on the interview guide and questionnaire by not requesting for names and other personal information of the participants and the respondent.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the results and discussion on ecosystem functioning and services of the Atewa Range Forest Reserve in the Eastern Region of Ghana. The analysis begins with the demographic characteristics of the respondents. It is then followed by the Ecosystem Services provided by the Reserve, the factors that influence the provision of these services, tourism potentials of the reserve and the management practices adapted to ensure continues functioning.

4.1 Demographic characteristics of respondents

A total sample of 360 was chosen for the study. However, 278 responded to the questionnaire. Therefore, a total of 278 respondents were sampled from 6 communities (Larbikrom, Bomaa, Saaman-Juaso, Kyebi- Apapam, Oborho and Potrase-Oboase). Out of these, 48 (17.3%) were from Larbikrom, 56 (20.1%) from Bomaa, 52 (18.7%) from Saaman-Juaso, 42 (15.1%) from Kyebi-Apapam, 60 (21.6%) from Oborho and 20 (7.2%) from Oboase. 23 participants were also interviewed. These included 5 chiefs, 15 opinion leaders and 3 officials from forestry commission. In all, a total of 301 were sampled for the study.

Table 4: Demographic characteristics of respondents

Variables	Frequency	Percentage (%)
Gender		
Male	181	65.1
Female	97	34.9
Age group		
18-24	1	0.4
25-29	36	12.9
30-34	9	3.2
35-39	70	25.2
40+	162	58.3
Academic qualification		
Basic	227	81.7
Secondary	25	9.0
Tertiary	13	4.7
Others	13	4.7
Occupation		
Farming	196	70.5
Trading	42	15.1
Teaching	6	2.2
Others	34	12.2
Total	**278**	**100**

Source: Field data, 2020

According to the study, out of the 278 respondents, 181 representing (65.1%) were males while 97 (34.9%) were females as shown in table 4. This result is attributed to the fact that most of the female respondents do not have enough knowledge about the forest reserve. Also, they preferred their male spouse to answer, since they are the heads of the family. The study found that out of the total of 279 respondents, majority of the respondents were above 40 years and the least respondents (0.4%) were within 18-24 age group.

Information on respondents' educational levels was obtained with respect to the educational system currently running. Most of the respondents who answered the questionnaire had low level of education. Out of the 278 people sampled, 227 (81.7%) have had up to basic education, 13 (4.7%) have had tertiary education while 13 (4.7%) had other forms of education or did not attain any formal education at all. This result proves the occupational characteristics of the respondents as majority of the respondents are engaged in the informal sector.

The respondents constituted 196 (70.5%) farmers, 42 (15.1%) traders, 6 (2.2%) teachers and 34 (12.2%) engaged in other activities such as hunting, carpentry, pastoring, hairdressing and others. This indicates that most of the respondents engaged in farming activities which is the most important source of livelihood in these communities. These farmers exhibited much knowledge of ecosystem services because they interact more with the reserve. This confirms a study conducted by Smith and Sullivan who found out that farmers are aware of the existence of ecosystem services and that they act as significant contributors to societal well-being and policy optimization (Smith & Sullivan, 2014).

4.2 Respondents' knowledge on the Atewa Range Forest Reserve

This section presents the knowledge respondents have on the Atewa range forest reserve. This was done to measure respondents' level of knowledge on the reserve in order to know the right people to get the right information from. Table 5 below shows respondents' knowledge on the ARFR.

Table 5: Respondents' knowledge on the Atewa Range Forest Reserve

Knowledge on the Reserve	**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
I know much about the forest reserve	278	1	5	4.52	.749
I know when it was considered as a National Reserve	278	1	5	2.31	1.714
The Reserve is accessible to the community	278	1	5	2.00	1.520
The community benefit a lot from the Reserve	278	1	5	4.31	.961
I know the various activities that goes on in the Forest Reserve	278	1	5	4.44	.920
There have been some destructions in the Reserve recently	278	1	5	4.59	.840
These destructions have affected the Forest Reserve greatly	278	1	5	4.63	.844
Valid N (listwise)	**278**				

The study found that the mean level of how well respondents know the Atewa Range Forest Reserve is 4.52. This implies that averagely, the respondents indicated that, they strongly agree that they have knowledge on the ARFR which is further established by the standard deviation of 0 .749 which shows that most of the responses are basically around the mean. For communities' accessibility to the reserve, respondents' Knowledge on activities that goes on in the reserve and respondents' knowledge on destructions in the reserve, the study found means of 2.00, 4.44, and 4.59 with standard deviations of 1.520, 0.920, and 0.840 respectively. These imply that, according to the respondents, with respect to communities' accessibility to the reserve, they disagree that they have access to the reserve. Respondents also agreed that they have knowledge on the activities that goes on in the reserve and that there has been some form of destructions in the reserve recently. These results show that, respondents exhibited great knowledge on the Atewa Range Forest Reserve and provided the right information needed for the study. The result confirms a study conducted by Gouwakinnou, Biaou, Vodouhe, Tovihessi, Awesso and Biaou, (2019) on Local perceptions and factors determining ecosystem services identification around two forest reserves in Northern Benin. It was found that communities leaving close to forests and forest reserves exhibits great knowledge about the reserve.

4.3 Ecosystem services provided by the Atewa Range Forest Reserve

According to Millennium Ecosystem Assessment (MA) (2005), ecosystem services are the many different benefits that ecosystems provide to people and these may include; a stand of trees that can reduce air pollution, purify the water supply, reduce the likelihood of floods and help regulate the climate by capturing and storing carbon. It might also provide timber for buildings, a space for recreation, some bare fruits for food, habitat for animals and improve the aesthetic qualities of the landscape. According to Zurlini, Petrosillo, and Cataldi, (2008) supporting services underpin the provision of the other 'service' categories and that, their impacts on people are either indirect or occur over a very long time. The study therefore focused on provisioning, regulating and cultural services. Respondents showed in-depth knowledge of the usefulness of the ARFR. That is the various services the reserve provides, especially the provision services which they are most familiar with as they use and encounter most often. The study found that provision services are mostly and easily identified by respondents. This is in line with a study conducted by Gouwakinnou, Biaou, Vodouhe, Tovihessi, Awessou and Biaou (2019) on local perceptions and factors determining ecosystem services identification around two forest reserves in Northern Benin. It was found in their research findings that provisioning services was easily identified by people living close to the two forest reserves. The respondents mentioned snails, mushrooms, honey, mortar, pestle, bush meat, water from the rivers that take their source from the reserve, firewood, wood, medicine and many others as some of the provisioning services the forest provides them. Flood, climate and soil fertility regulation, air quality, employment, traditional ecological knowledge, recreation, sense of identity and many others were identified by the respondents as regulating and cultural services they derived from the reserve (MA, 2005). This result confirms the research findings of Muhamad, Okubo, Harashina, Parikesit, and Gunawan, (2014) who found that people living close to forested areas tend to have a good appreciation and knowledge of ecosystem services in West Java. Plate 1, 2, 3, 4, 5, 6, 7 and 8 show pictures of some of these services the ARFR provides to the fringe communities.

Plate 1: Firewood
Source: Field data, 2020

Plate 2: Rattans for art and craftwork
Source: Ruffor, 2016

Plate 3: Grains of paradise, used for medicines
Source: Ruffor, 2016

Plate 4: Snails from the Atewa forest reserve
Source: Field data, 2020

Plate 5: Mortar, made from wood from the Atewa forest reserve
Source: Field data, 2020

Plate 6, 7, and 8 show some rivers that take it source from the Atewa forest and drain through the fringe communities. These communities make use of the rivers and streams for potable and non-potable uses.

Plate 6: River Dafua
Source: field data, 2020

Plate 7: River Subim at Samang-Juaso
Source: field data, 2020

Plate 8: River Densu at Obuasi
Source: field data, 2020

Respondents were further asked on how the ARFR has been performing in terms of providing these services over the years. Responses were given below;

Tables 6, 7 and 8 show the various ecosystem services adopted from MA, (2005) categorization of ecosystem services; that is provisioning services, cultural services, regulating services and supporting services and their performance over the past 30 years by the respondents. MA, (2005) continued to explained that supporting services underpin the provision of the other services. The study therefore concentrated on the other three ecosystem services and analysed how the Atewa Range Forest Reserve is performing in terms of providing these services. Core ecosystem services under each service type were selected and analysed based on the researcher's discretion.

4.3.1 The state of ecosystem services provision by the ARFR

This section presents respondents perception on state of ecosystem services provision by the Atewa Range Forest Reserve

4.3. 2 Provisioning Services

The table below shows the core services under provisioning services that were analysed on a five points likert scale to see how they have been performing over 30 years using drastic reduction to drastic increment. These were food, water, wood, firewood, timber and medicinal plant as shown in table 6.

Table 6: Provisioning Services

Changes in provisioning services						
Towns	**Drastic reduction**	**Reduction**	**Remain the same**	**Increment**	**Drastic increment**	**Total**
			Timber			
Larbikrom	33	14	1	0	0	48
Bomaa	28	18	8	2	0	56
Saaman – Juaso	28	17	7	0	0	52
Kyebi Apapam	28	12	2	0	0	42
Oborho	33	14	13	0	0	60
Oboase	9	10	1	0	0	20
Total	**159**	**85**	**32**	**2**	**0**	**278**
			Water			
Larbikrom	33	15	0	0	0	48
Bomaa	22	22	9	2	1	56
Saaman – Juaso	26	19	6	1	0	52
Kyebi Apapam	26	15	1	0	0	42
Oborho	31	18	10	1	0	60
Oboase	7	11	2	0	0	20
Total	**145**	**100**	**28**	**4**	**1**	**278**
			Firewood			
Larbikrom	33	14	1	0	0	48
Bomaa	20	25	9	2	0	56
Saaman – Juaso	25	20	7	0	0	52

Kyebi Apapam	25	13	4	0	0	42
Oborho	33	13	14	0	0	60
Oboase	6	14	0	0	0	20
Total	**142**	**99**	**35**	**2**	**0**	**278**
			Wood			
Larbikrom	34	13	1	0	0	48
Bomaa	20	26	8	2	0	56
Saaman – Juaso	24	21	7	0	0	52
Kyebi Apapam	26	12	4	0	0	42
Oborho	32	14	14	0	0	60
Oboase	6	14	0	0	0	20
Total	**142**	**100**	**34**	**2**	**0**	**278**
			Medicinal plant			
Larbikrom	30	17	0	0	1	48
Bomaa	25	20	10	1	0	56
Saaman – Juaso	24	19	9	0	0	52
Kyebi Apapam	23	14	5	0	0	42
Oborho	28	14	18	0	0	60
Oboase	9	10	1	0	0	20
Total	**139**	**94**	**43**	**1**	**1**	**278**
			Food			
Larbikrom	34	13	1	0	0	48
Bomaa	22	24	8	2	0	56
Saaman – Juaso	24	20	6	1	1	52
Kyebi Apapam	24	13	3	1	1	42
Oborho	27	17	12	2	2	60
Oboase	**7**	13	0	0	0	20
Total	**138**	**100**	**30**	**6**	**4**	**278**

Source: Field data, 2020

The results from the study conducted showed that the Atewa Range Forest Reserve has been providing the provisioning service. However there have been great reductions in some of these services over the past 30 years.

According to the respondents, Timber has experienced the greatest reduction over the years. 159 (57.2%) out of the total respondent 278 indicated that there has been a drastic reduction in timber production, 85 (30.6%) also said there has been a reduction in timber over the past 30 years. This was followed by water with 145 (52.2%) out of the total indicating that there has been a drastic reduction in the provision of water. 100 (36.0%) also confirmed a reduction in water supply, with 1 (0.4%) saying that there has been a drastic increment in water production. This was followed by wood and firewood. Both had 142 (51.1%) out of the total respondents indicating that there has been a drastic reduction in their production. 2 (0.7%) also indicated that both wood and firewood has seen a drastic increment over the years. It can be inferred from table 6 that, there has been a drastic reduction in food production as well. Out of the 278 respondent**s,** 138 (49.6%) said there has been drastic reduction in food production. Followed by 100 (36.0%) who also said there has been a reduction in food over the years. However, 4 (1.4%) also indicated that there has been a drastic increment in terms of the reserve providing food. Foods such as bush meat, snails, mushrooms that were obtained from the reserve according to the local people have reduced immensely.

Among all the communities, timber and water production recorded the highest decline (drastic reduction and reduction combined) among all the provisioning services, with 47 (97.9%), 46 (82.1%), 45 (86.5%), 40 (95.2%), 47 (78.3%) and 19 (95%) for timber. 48 (100%), 44 (91.7%), 45 (86.5%), 41 (97.6%), 49 (81.7%) and 18 (90%) for water and for Larbikrom, Bomaa, Saaman-Juaso, Kyebi Apapam, Oborho and Oboase respectively out of the total respondents based on the community level, with the highest respondents coming from Larbikrom.

4.3.3 Cultural Services

Table 7 below shows core services under cultural services that were analysed on a five points likert scale to see how they have been performing over the past 30years. These were employment, spiritual value, recreation, ecotourism, scientific research, sense of identity and traditional ecological knowledge as shown in table 7.

Table 7: Cultural Services

Changes in cultural services						
Towns	**Drastic reduction**	**Reduction**	**Remain the same**	**Increment**	**Drastic increment**	**Total**
			Employment			
Larbikrom	38	9	0	1	0	48
Bomaa	26	22	8	0	0	56
Saaman – Juaso	26	16	9	1	0	52
Kyebi Apapam	26	13	1	2	0	42
Oborho	25	17	16	2	0	60
Oboase	9	9	2	0	0	20
Total	**150**	**86**	**36**	**6**	**0**	**278**
			Spiritual value			
Larbikrom	23	24	1	0	0	48
Bomaa	20	23	12	1	0	56
Saaman – Juaso	22	20	10	0	0	52
Kyebi Apapam	19	20	3	0	0	42
Oborho	24	19	17	0	0	60
Oboase	7	10	3	0	0	20
Total	**115**	**116**	**46**	**1**	**0**	**278**
			Sense of identity			
Larbikrom	20	18	8	1	0	48
Bomaa	12	21	11	9	3	56
Saaman – Juaso	21	11	15	5	0	52
Kyebi Apapam	17	13	11	1	0	42
Oborho	26	14	18	2	0	60
Oboase	5	7	1	5	2	20

Total	**101**	**84**	**65**	**23**	**5**	**278**
			Traditional ecological knowledge			
Larbikrom	19	17	11	1	0	48
Bomaa	14	21	15	3	3	56
Saaman – Juaso	21	13	15	3	0	52
Kyebi Apapam	12	13	13	1	0	42
Oborho	27	15	18	0	0	60
Oboase	5	9	2	2	2	20
Total	**101**	**88**	**74**	**10**	**5**	**278**
			Scientific research			
Larbikrom	2	10	26	8	2	48
Bomaa	3	7	42	3	1	56
Saaman – Juaso	5	7	32	7	1	52
Kyebi Apapam	3	4	23	10	2	42
Oborho	7	8	43	2	0	60
Oboase	1	4	12	2	2	20
Total	**21**	**40**	**178**	**32**	**7**	**278**
			Recreation			
Larbikrom	2	0	46	0	0	48
Bomaa	1	4	49	1	1	56
Saaman – Juaso	6	6	39	1	0	52
Kyebi Apapam	4	2	36	0	0	42
Oborho	7	7	46	0	0	60
Oboase	1	2	16	0	1	20
Total	**21**	**21**	**232**	**2**	**2**	**278**
			Ecotourism			
Larbikrom	2	0	46	0	0	48
Bomaa	1	4	49	1	1	56
Saaman-Juuaso	6	5	41	0	0	52
Kyebi Apapam	4	2	36	0	0	42
Oborho	7	7	46	0	0	60
Oborho	1	2	16	0	1	20
Total	**21**	**20**	**234**	**1**	**2**	**278**

Source: field data, 2020

The result from table 7 shows that, employment as a cultural service has experienced the greatest reduction over the years. 150 (54.0%) out of the total respondents of 278 indicated that there has been a drastic reduction in employment, 86 (30.9%) also said there has been a reduction in employment. However, 36 (12.9%) and 6 (2.2%) also indicated that employment has remain the same and increase respectively over the past 30 years. This was followed by spiritual value with 115 (41.4%) out of the total respondents indicated that there has been a drastic reduction in the reserves spiritual value. 116 (41.7%) also confirmed a reduction in spiritual value. 1 (0.4%) respondent also said that there has been an increment in spiritual value. This was followed by sense of identity and traditional ecological knowledge. Both had 101 (36.3%) out of the total respondents indicating that there had been a drastic reduction in their production. Also, 84 (30.2%) indicated that sense of identity has decreased and 88 (31.7%) indicated that tradition ecological knowledge has seen a reduction over the years. 5 (1.7%) however, indicated a drastic increment in both sense of identity and traditional ecological knowledge. Nonetheless, recreation, ecotourism and scientific research according to the result has remained the same over the years with 232 (83.5%), 234 (84.2%) and 178 (64.0%) respectively out of the total 278 respondents confirming these.

Among the six communities, employment and spritrual value recorded the highest decline (drastic reduction and reduction combined), among cultural services with 47 (97.9%), 48 (85.7%), 42 (80.2%), 39 (92.9%), 42 (70%) and 18 (90%) for empolyment. 47 (97.9%), 43 (76.8%), 42 (80.8%), 39 (92.9%), 43 (71.7%) and 17 (85%) for spirirtual value and for Larbikrom, Bomaa, Saaman-Juaso, Kyebi Apapam, Oborho and Oboase respectively out of the total respondents based on the community level, with the highest respondents coming from Larbikrom.

4.3.4 Regulating Services

The table 8 below shows core services under regulating services that were analyzed on a five points likert scale to see how they have been performing over the past 30years. These were flood regulation, climate regulation, soil fertility regulation, hydrological regulation, habitat maintenance and pollination of useful plants as shown in table 8.

Table 8: Regulating Services

	Changes in regulating services					
Towns	**Drastic reduction**	**Reduction**	**Remain the same**	**Increment**	**Drastic increment**	**Total**
			Climate Regulation			
Larbikrom	35	11	2	0	0	48
Bomaa	28	19	9	0	0	56
Saaman – Juaso	36	10	6	0	0	52
Kyebi Apapam	30	9	3	0	0	42
Oborho	34	12	14	0	0	60
Oboase	12	8	0	0	0	20
Total	**175**	**69**	**34**	**0**	**0**	**278**
			Hydrological Regulation			
Larbikrom	31	15	2	0	0	48
Bomaa	31	16	8	1	0	56
Saaman - Juaso	35	10	7	0	0	52
Kyebi Apapam	29	9	4	0	0	42
Oborho	34	10	16	0	0	60
Oboase	12	8	0	0	0	20
Total	**172**	**68**	**37**	**1**	**0**	**278**
			Habitat Maintenance			
Larbikrom	29	19	0	0	0	48
Bomaa	31	17	7	1	0	56

Saaman - Juaso	33	12	7	0	0	52
Kyebi Apapam	25	15	2	0	0	42
Oborho	35	9	16	0	0	60
Oboase	11	9	0	0	0	20
Total	**164**	**81**	**32**	**1**	**0**	**278**
			Pollination for Useful Plant			
Larbikrom	25	17	6	0	0	48
Bomaa	23	17	15	1	0	56
Saaman - Juaso	32	7	13	0	0	52
Kyebi Apapam	23	11	8	0	0	42
Oborho	35	9	16	0	0	60
Oboase	9	8	3	0	0	20
Total	**147**	**69**	**61**	**1**	**0**	**278**
			Regulate Soil Fertility			
Larbikrom	25	18	5	0	0	48
Bomaa	22	18	16	0	0	56
Saaman - Juaso	30	11	11	0	0	52
Kyebi Apapam	22	13	7	0	0	42
Oborho	34	10	16	0	0	60
Oboase	9	9	2	0	0	20
Total	**142**	**79**	**57**	**0**	**0**	**278**
			Flood Regulation			
Larbikrom	5	7	36	0	0	48
Bomaa	10	13	33	0		56
Saaman - Juaso	7	10	35	0	0	52
Kyebi Apapam	8	6	28	0	0	42
Oborho	10	6	44	0	0	60
Oboase	6	6	8	0	0	20
Total	**46**	**48**	**184**	**0**	**0**	**278**

Source: field data, 2020

With regard to regulating services provided by the reserve, according to the respondents, climate regulation experienced the highest reduction over the years with 175 (62.9%) out of the total respondent 278 indicating that there has been a drastic reduction in terms of the reserve regulating the climate of the area, 69 (24.8%) also said there has been a reduction in climate regulation. However, 34 (12.2%) also indicated that climate regulation has remained the same over the past 20 to 30 years. This was followed by hydrological regulation with 172 (61.9%) out of the total indicating that there has been a drastic reduction in hydrological regulation of the reserve. 68 (24.5%) also confirmed a reduction in hydrological regulation, with 37 (13.3%) saying that hydrological regulation has remained the same. Habitat maintenance followed. 164 (59.0%) out of the total respondents indicated that there has been a drastic reduction in habitat maintenance. 87 (24.5%) also indicated a reduction in habitat maintenance over the years. It can be inferred from table three (11) that, there has been a drastic reduction in pollination for useful plants well. Out of the 278 responden**ts,** 147 (52.9%) stated that, there has been drastic reduction in pollination for useful plants. Also 81 (24.8%) and 1 (0.4%) indicated that there have been a reduction and remain the same respectively over the years. In terms of regulating soil fertility, 142 (51.1%) of the respondents indicated that there has been a drastic reduction, 79 (28.4%) indicated a reduction while 57 (20.5%) also indicated that it has remained the same over the years. Followed by 100 (36.0%) who also said there has been a reduction in food over the years. However, for flood regulation, most of the respondents (65.8%) indicated that it has remained the same. But 16.9% and 16.5 stated that there has been a reduction and drastic reduction respectively over the past 30 years in terms of flood regulation as indicated in Table 8.

Among all the six communities, climate regulation and hydrological regulation recorded the highest decline (drastic reduction and reduction combined) among regulating services with 46 (95.8%), 47 (83.9%), 46 (88.5%), 39 (92.9%), 46 (76.6%) and 20 (100%) for climate regulation. 46 (95.8%), 47 (83.9%), 45 (86.5%), 38 (88.3%), 44 (73.3%) and 20 (100%) for hydrological regulation and for Larbikrom, Bomaa, Saaman-Juaso, Kyebi Apapam, Oborho and Oboase respectively out of the total respondents based on the community level. With the highest respondents coming from Larbikrom.

With regards to all the services, on a five points likert scale study found that the mean levels of change in the provision of ecosystem services that is provisioning (food, water, wood firewood etc), cultural (spiritual value, sense of identity, cultural heritage, scientific research etc) and regulatory (climate regulation, air quality, regulation of soil fertility, flood regulation, etc) services by the Atewa Range Forest Reserve is 1.8728. This implies that averagely, the respondents indicated that, there is a drastic reduction to reduction in the provision of all ecosystem services by the Atewa forest reserve which is further established by the standard of 0.57376 which shows most responses are basically around the mean. For respective services, the study found means of 1.6337, 1.7338, and 2.2509 with standard deviations of 0.66803, 0.62375 and 0.57376 for the provision of provisioning, regulating, and cultural services respectively as shown in Table 9. These imply that, according to the respondents, there is a reduction in either of the delivery of provision services, regulation services and cultural services. However, the reduction in the delivery of cultural services which has a mean of 2.2509 is not as drastic as in the cases of provisioning and regulating services.

Table 9: State of ecosystem service provision by the ARFR

Services	N	Minimum	Maximum	Mean	Std. Deviation
Provision service	278	1.00	4.00	1.6337	.66803
Regulation service	278	1.00	3.57	1.7338	.62375
Cultural service	278	1.00	4.13	2.2509	.57376
Ecosystem service	278	1.00	3.77	1.8728	.52397
Valid N (listwise)	**278**				

Source: Field data, 2020

4.3.5 Land cover classes

With the help of remote sensing, the vegetative cover of the Atewa Range Forest Reserve was monitored over a twenty-eight-year range. That is 1990, 2003 and 2018. This was done to ascertain the rate at which the Reserve is changing or deteriorating and to give scientific evidence of the state of the ARFR and associated ecosystem services and functioning. The analysis was done using remotely sensed images for 1990, 2003 and 2018. Three (3) land use classes were generated form the analysis. These were areas with thick vegetative cover (Forest), areas that have light vegetative cover (Secondary vegetation) this area includes farms and areas with less tree cover and bare areas.

4.3.5.1 Land cover distribution in 1990

The land use land cover distribution, according to the study in 1990 which form the base year for the study revealed that forest (thick vegetative cover) was the domineering feature type with 18538.2 hectares (87%), followed by secondary vegetation and bare areas which recorded 2565.45 hectares (12.1%) and 169.40 hectares (0.8%) respectively as shown in Table 10. The land use land cover classes in 1990 showed a vast land covered by forest (thick vegetative cover) with bare areas being the least feature type. This can be attributed to the reason that the area was a reserve and was being protected against degradation as confirmed by the forestry officials in charge of the reserve. However, 12% of the total land area was covered by secondary vegetation, this may be as a result of the fact that the reserve was formerly under production in the early years and due to this, some of the thick vegetative cover was cleared for farms by the fringe communities. There were also few bare lands in the area as anthropogenic activities such as illegal mining (galamsey) was very minimal in the early years. The land cover distribution of the Atewa Range Forest Reserve (ARFR) is shown in figure 3 for the year 1990.

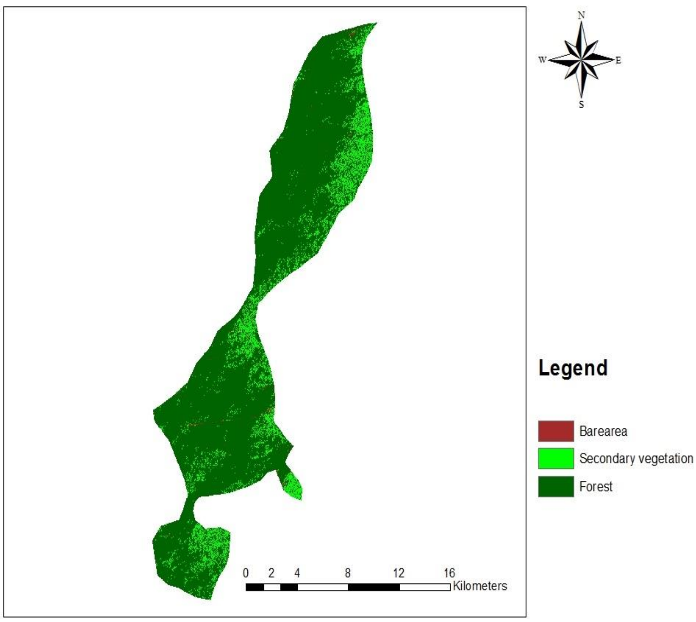

Figure 3: Land cover distribution map of Atewa Range Forest Reserve for, 1990
Source: Author's Construct from Landsat 4 Images of 1990

Table 10 below also shows the surface area covered by each land of the ARFR for 1990 and their percentages

Table 10: land use unit coverage for 1990

Land use unit	Surface area (hectares)	Percentage (%)
Bare land	169.40	0.8
Secondary vegetation	2565.45	12.1
Forest	18538.2	87.1
Total	**21273.05**	**100**

Source: field work, 2020

4.3.5.2 Land cover distribution in 2003

Also, in the year 2003 which was 13 years from the base year, the land use land cover distribution saw forest (thick vegetation) still remaining the domineering feature type even though there was a decrease from 18538.2 hec (87.1) to 17215.8 hec (80.9%) within the 13-year period of 1990 to 2003. This means that thick vegetation cover decreased by 6.2% of the total study area. Bare areas increased and covered 279.99 hectares (1.3%) of the entire area. That is, between 1990 and 2003, bare areas increased by 65% of the existing size or space. Secondary vegetation within the same period of 1990 to 2003 also increased by 5.7%, covering an area of 3777.66 hectares (17.8%) as Table 11 depicts. These changes in land cover between 1990 to 2003 could be ascribed to the illegal chainsaw and farming activities that became rampant in the late 90s and early 2000s as explained by most of the respondents. This explains the decrease in forest in the area. This also signifies destruction of the forest ecosystem thereby affecting the services it provides. As indicated by Balvanera, (2016), excessive cutting down of trees in the forest destroys animal habitat, plant species, animal species, and rivers, reduces carbon sequestration, pollination of useful plant and others, which destroys the ecosystem and affects the services they provide to human wellbeing. This clearly shows that as more areas of the forest are being cleared for other land use, we should expect a future destruction of the ecosystem and resulting decrease in provision of ecosystem services with time. Figure 4 shows the decrease in forest (thick vegetation) within the Atewa Range Forest reserve.

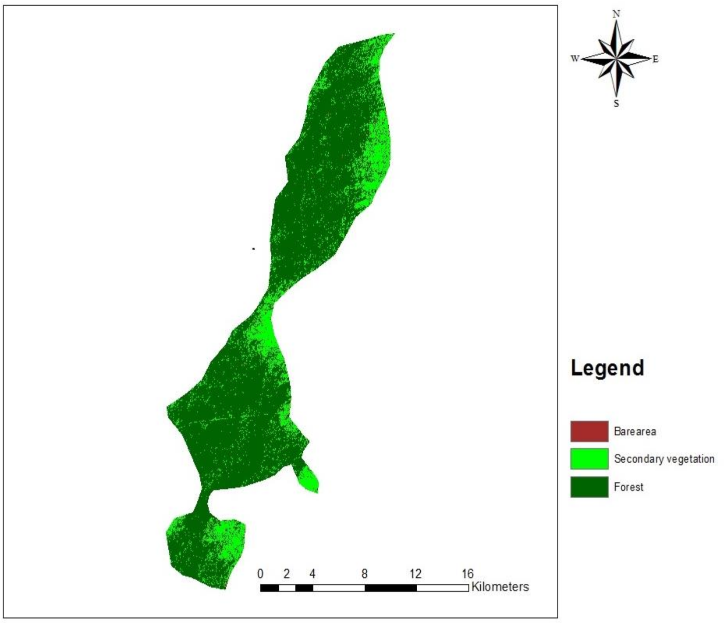

Figure 4: Land cover distribution map of Atewa Range Forest Reserve for, 2003

Source: Author's Construct from Landsat 7 Images of 2003

Table 11 below shows the surface area covered by each land of the ARFR for 2003 and their percentages

Table 11: Land use unit coverage for 2003

Land use unit	**Surface area (hectares)**	**Percentage (%)**
Bare land	279.99	1.3
Secondary vegetation	3777.66	17.8
Forest	17215.4	80.9
Total	**21273.05**	**100**

Source: Field data, 2020

4.3.5.3 Land cover distribution in 2018

In 2018, the land use land cover feature type of forested areas continued to be the domineering feature type but this time increased from 17215.4 hec to 18356.47 hec (86.3%) within the 15-year period of 2003 to 2018. Bare areas covered a land area of 450.04 hectares (2.1%) in 2018 which is an increase in land area. This is shown in Table 12

In all, within the 28-year period (1990 to 2018), bare areas increased by 1.3%. Secondary vegetation however, decreased within the 15- year period by 6.2% as shown in figure 4 covering an area of 2466.54 hectares (11.6%) in the year 2018. See table 9. Altogether, forested areas (thick vegetative cover) and secondary vegetation suffered losses to their coverage between the years 1990 to 2018, a 28-year period. Forested areas and secondary vegetation decreased by 0.9% and 0.5% respectively as shown in figure 5. The land cover distribution of the Atewa Range Forest Reserve (ARFR) for the year 2018 is shown figure 5

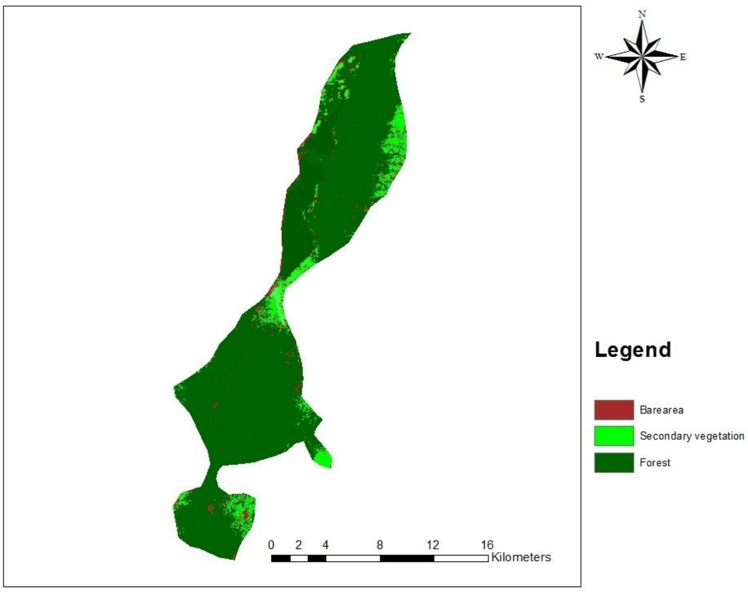

Figure 5: Land cover distribution of Atewa Range Forest Reserve for, 2018

Source: Author's Construct from Landsat Images of 2018

Table 12 below also shows the surface area covered by each land of the ARFR for 2018 and their percentages

Table 12: Land use unit coverage for 2018

Land use unit	Surface area (hectares)	Percentage (%)
Bare land	450.04	2.1
Secondary vegetation	2466.54	11.6
Forest	18365.47	86.3
Total	**21273.05**	**100**

Source: field data, 2020

Figure 6 illustrates the net change in the various land use land cover feature types between the years 1991 to 2020

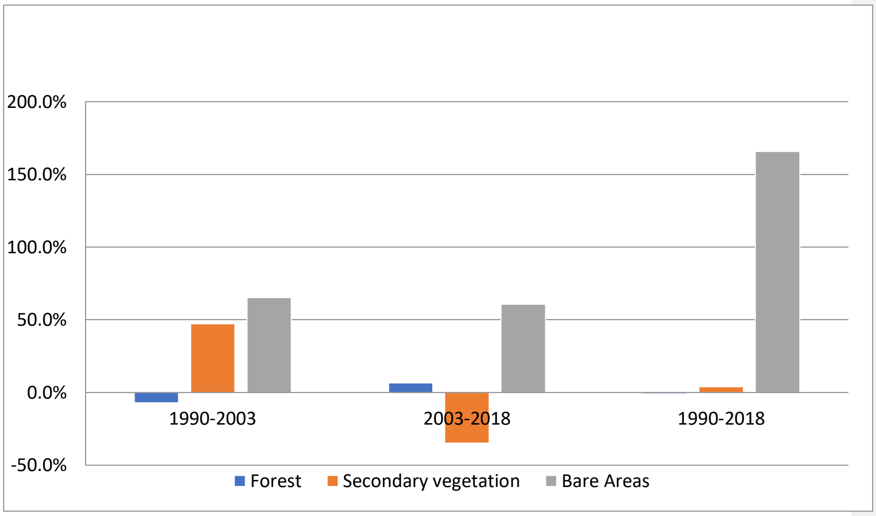

Figure 6: Net change in land use land cover distribution

Source: Author's Construct from Landsat Images 1990, 2003 and 2018

The study revealed a general decrease in both forested areas and secondary vegetation over the 28-year period between the years 1990 and 2018 as shown in figure 4 above and a concurrent increase in bare areas in the opposite direction to forested areas and secondary vegetation with an overall increase of 165.7%. The various changes to the land use land cover types in terms of land coverage are also addressed. In general, the land use land cover type of bare areas expanded in term of land area by 0.52% from 1990 to 2003 and a further gain of 0.8% between the years 2003 to 2018, a 15-year period and between the 28-year periods it gained 1.32% land area. With reference to secondary vegetated areas, the feature type experienced an increase in land area with a net change of 47.3% between 1990 to 2003 but decreased from 2003 to 2018 with a net change of 34.7% and in the 28-year period there was a loss with a net change of -3.9% in land area covered. Finally, forested areas (thick vegetative cover) covering 87.1% of the total land area of the Atewa Range Forest Reserve in 1990 experienced a decline in its area losing potential resources to bare areas and secondary vegetation from 1990 to 2003 with a net change of -7.1%. Forested areas lost a substantial land area of 6.2% of its original 87.1% to bare areas and secondary vegetation in 2003 and however gained an extra 5.4% in 2020. But for the 28-year period forested areas lost 0.9% of its total land area. This is shown in figure 5 and table 12. This result can be attributed to increase illegal chainsaw activities, galamsey activities in the study area which led to an increase in bare areas. The result confirms the research findings of (Matano, et al., 2015). The result obtained in their research showed that, land cover changes are mainly associated with human activities such as illegal mining, deforeststion and commercial farming and natural factors that affect our ecosystem systems. Planting of trees by the forestry commission as Table 17 depicts and other measures put in place by the forestry and wildlife commission which led to an increase in land areas of the forested areas. However, the 28-year period showed a decrease in total land area of forested areas. This shows that human induced activities are degrading the reserve which is quite alarming since this can affects the forest ecosystem and the services it provides. A study conducted by Musa and Odera (2015), on the effects of land use land cover changes on agricultural land in Kiambu County, Kenya (1984 – 2013) and to determine the main drivers of land use land cover change, over the period of study, saw gricultural land decreased from 39.7% to 15.8% with grassland, forest, waterbody and bare areas also decreasing in contrast to an increase in built-areas due to human activies. This study on the other hand, observed a decrease in forest land to bare areas. According to a study by Tendaupenyu, Magadza, and Murwira, (2017), changes in land covers all over the world are regarded as the single most important variable of global change affecting ecosystems. Table 13 gives a representation of the percentage change in land cover area of the various land cover feature types.

Table 13: Land cover change percentage distribution

Land cover type	**1990**	**2003**	**2018**	**Percentage change (%)**		
	Hectares	Hectares	hectares	1990-2003	2003-2018	1990-2018
Bare areas	169.40 (0.8%)	279.99 (1.3%)	450.04 (2.1%)	0.52	0.80	1.32
Secondary vegetation	2565.45 (12.1%)	3777.66 (17.8%)	2466.54(11.6%)	5.6	-6.2	-0.5
Forest	18538.2 (87.1%)	17215.4 (80.9%)	18356.47 (86.3%)	-6.2	5.4	-0.9
Total	**21273.05 (100%)**	**21273.05 (100%)**	**21273.05 (100%)**			

Source: Author's Construct from Landsat 4, 7 and 8 Images 1990, 2003 and 2018 respectively.

4.3.5.4 Respondents perception on land cover change

Data was gathered from the field through interviews and questionnaire to support what was acquired from the image analysis. Respondents were asked to indicate change in state of the forest reserve for the past 30 years. That is from 1988-2018.Table 14 shows the response of the respondents.

Table 14: Change in vegetative cover of the reserve

	Change in State of the Forest Reserve					
	Strong Deterioration	**Deterioration**	**No Significant Change**	**Improvement**	**Major Improvement**	**Total**
1988-1998	45	160	70	3	-	278
1998-2008	118	123	34	3	-	278
2008-2018	191	54	30	3	-	278

Source: field data, 2020

From table 16, out of the 278 respondents, from 1988 to 1998, 160 (57.6%) which is the highest indicated that the reserve has experienced deterioration (change in vegetative cover), 45 (16.2%) also indicated that the deterioration is strong. However, 70 (25.3%) said there is no significant change while 3 (1.1%) also indicated that it has improved rather. From 1998 to 2008 also, 118 (42.4%) indicated that, there have been a strong deterioration over the ten-year period, 123 (44.3%) indicated that there is deterioration and 34 (12.2%) and 3 (1.1%) also indicated that there is no significant change and there is improvement respectively. For the period between 2008 and 2018, 191 representing 68.7% out of the total indicated that there has been strong deterioration, 54 (19.4%) also indicated that there have been deterioration and 30 (10.7%) indicated there is no significant change in vegetative cover and 3 (1.1%) also indicated that there has been improvement in vegetative cover. The result proves what the satellite images provided. This means that the reserve has been degrading over the past 30 years and as these happened the forest ecosystem is degrading as well.

Almost all the chiefs in the fringe communities selected for the study who were interviewed agreed to this. One of them had this to say;

> *"The reserve is full of farms, when you look from here it appears to be thick vegetation. But am telling you those big trees that use to be in the reserve are no more there. All of them have been cut down and used as timber. Because of this we don't even see some animals that use to be in the reserve because their habitats have been destroyed. We don't even know where they are again. Formerly some of the animals even use to come home but it is not so off late. Even nowadays we experience wind storm which we were not experiencing formerly because all the big trees have been cut down. It has even affected our rivers. Even though we have never experience total dry up of any of our rivers, we have noticed a gradual decrease in volume over the years. This can seriously affect us if the situation if not put under control. But I know the forestry commission is trying their best to help curb the situation".*

Results from the classification analysis indicated that there has been a reduction in the size of vegetative cover in the Atewa Range Forest Reserve and that; there has been an increase in non-vegetated patch of lands in the forest. This decrease in the provision of ecosystem services by the ARFR can be inferred to have resulted from the decrease in vegetation. However, since the decrease in the delivery of ecosystem services cannot be quantified in absolute numeric terms (Bond, Grieg-Gran, Wertz-Kanounnikoff, Hazlewood, Wunder & Angelsen, 2009) a straight relationship is unscientific to be drawn between land cover change and ecosystem services' provision change in the Atewa Range Forest Reserve. Therefore, the study is of the view that although the change in land cover has a bearing on the decrease in ecosystem service provision by the Atewa Range Forest Reserve, the influence of other factors should not be underestimated.

Results from the satellite images and responses from the questionnaire administered and interviews conducted show that the ARFR ecosystem is degrading and as a result affected most of the services it provides. They may be as a result of both natural (Gouwakinnou, et al., 2019) and anthropogenic factors such deforestation, illegal mining, and illegal chainsaw activities among others as indicated in Table 17. A report by Science for Environment Policy (2015) on Ecosystem Services and the Environment confirms this. It was indicated in the report that, ecosystem services are under severe threat from man-made pressures as deforestation, overgrazing illegal mining and others and also degradation of ecosystem worldwide reduces the services they produce. Gouwakinnou et al, (2019) further explained that, despite the important role forests play in sustaining livelihoods, deforestation is progressing at an alarming rate around the world and these disturbances induced by numerous human activities are resulting in gradual biodiversity loss from forests with the subsequent impact on their structure, ecological functions, and services provision. A study conducted by Bargali, (2018) on Forest Ecosystem: Structure and Functioning in India also confirms this. It was concluded in the study that human activities have really caused a change in the structure and functioning of forest ecosystems in most part of the world. Deforestation and conversion to agricultural land for example are the most visible threats to forests worldwide. It can therefore be clearly concluded that these activities are degrading the ARFR there by affecting its ecosystem and subsequently degrading the performance of ecosystem services provided by the reserve to supports human wellbeing (MA, 2005). It is therefore important to put the necessary measures in place to help curb the situation and ensure continues ecosystem functioning of the reserve. Some more results of other related works follow the same trend (Ecological Society of America, 2000 and Science for Environmental Policy, 2015) as in this study. One of the chiefs in the fringe communities had this to say;

> *''The reserve is under great threat especially from illegal mining, illegal chainsaw activities, and illegal farming. The galamsey activities are affecting our rivers, the cutting down of trees is also affecting wildlife. Nowadays we don't even get snails and mushrooms as it used to be when we go for snail hunting. Unless you walk deep into the reserve, even for that, you will have to walk for hours before you get some of these mushrooms and snails. All the antelopes and dears have all run away because their habitats have been destroyed. Those who sneak into the forest for bush meat are even saying that you can walk for hours in the forest without getting anything. We must take the needed measures to help curb the situation if not our future generation will suffer a lot.''*

Interestingly, as revealed in the study, some of the respondents attributed the decline in the provision of ecosystem services especially the provisioning service such as food, firewood, wood, etc by the ARFR due to their inability to access the reserve. According to them, because it's a reserve they are not allowed to enter to pick or take anything from there as they use to do when it was under production and they were allowed to enter. This goes to support earlier research of Edusah (2011) who found that Forest Commission denies the local people access to the forest reserves in some reserves in Ashanti and Brong Ahafo region. So to them, ecosystem services provision by the ARFR has declined because the reserve no longer provides them with specific services especially the provision services as it involves direct extraction of non-timber product from the reserve by the residents. Irrespective of the other services like regulating and cultural services that the reserve provides, as far as they are not getting the provision services, they don't seem to get any benefits from the reserve. This goes on to support the research finding of Gouwakinnou et all, (2019) where it was found that fringe communities around the two reserves were able to identify provisioning services more easily than the other services especially regulating services. This could be as a result of their dependence on these services for their livelihoods. It is therefore important to educate the fringe communities on the importance of the other services. These will help them see the need to manage and conserve (Gouwakinnou et. all, 2019) the reserve in other to ensure continues functioning of the ecosystem and provision of ecosystem services.

Correlation analysis was therefore done to assess the relationship between respondents' accessibility of the Atewa Range Forest Reserve and ecosystem services provision by the ARFR. This was to ascertain the relationship between them. Table 15 shows relationship between respondent's accessibility of the ARFR and ecosystem services delivery.

Table 15: Correlation between accessibility of the ARFR to the community and ecosystem services provision

		Accessibility of ARFR to the Community	Provision service	Cultural service	Regulation service	Ecosystem service
Accessibility of ARFR to the Community	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	278				
Provision service	Pearson Correlation	.149*	1			
	Sig. (2-tailed)	.013				
	N	278	278			
Cultural service	Pearson Correlation	-.001	.390**	1		
	Sig. (2-tailed)	.986	.000			
	N	278	278	278		
Regulation service	Pearson Correlation	-.007	.636**	.667**	1	
	Sig. (2-tailed)	.914	.000	.000		
	N	278	278	278	278	
Ecosystem service	Pearson Correlation	.060	.820**	.795**	.911**	1
	Sig. (2-tailed)	.317	.000	.000	.000	
	N	278	278	278	278	278

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

Source: Field data, 2020

The study sought to identify the correlation between how accessible the Atewa Range Forest Reserve is to the communities around the Range and general ecosystem service delivery. It was identified that there is a very weak but positive correlation of 0.06 between the accessibility of communities to the Range and the ecosystem service delivery as far as the Atewa Range Forest Reserve is concerned. This is backed by a not significant p-value of 0.317. The correlation coefficient and p-value implies that as the Reserve is made more accessible to the community, the more ecosystem services are provided by the Reserve; this association is very weak such that the Range would have to lose its reserve status to be made very open to the communities before a significant increase in ecosystem service provision will be witnessed. This as well implies that the restrictions put forth by the forestry commission to limit accessibility to the Atewa Range Forest Reserve although have but little influence in the decline of ecosystem services provision by the ARFR. Other factors effectively have their roles to play in the decline as indicated in Table 17

The study however found a different case when the analysis focused on specific levels of ecosystem service delivery. The study found that there is a correlation of 0.149 with a p – value of 0.013 which indicate that there is a positive but weak correlation between accessibility to the Range and delivery of provision services which is significant at p-value of 0.05. For cultural and regulatory services, the result on table 16 shows that there are as well very weak correlation coefficients of -0.001 and -0.007 with p-values of 0.986 and 0.914 respectively, however, negative correlations between them and accessibility to the Range. These correlation coefficients imply that as the restrictions on accessibility limit and accessibility becomes higher, the delivery of provision services will increase whilst for the cases of cultural and regulatory services, an increase in accessibility will induce a decrease in cultural and regulatory services delivery. The reason for this result is that provision services involve direct extraction from the reserve (Gouwakinnou et all, 2019 ; Ouko, Mulwa, Kibugi, Owuor, & Oguge, 2018) by the respondents and hence requires that the Atewa Range Forest Reserve is open up and made accessible to the people in the communities around as discussed earlier. For cultural and regulatory services, they do not necessarily require the physical extraction of resources (Gouwakinnou et. all, 2019) from the Reserve and hence, the Reserve does not have to be accessible to the people around it before the delivery of cultural and regulatory services can be observed. Also, direct accessibility to the Reserve has the potential of causing the regulatory and cultural services to deteriorate since activities such timber extraction pose threats to regulatory service. This implies why the forestry commission has limited accessibility to the ARFR in order to sustain it.

Also, with respect to relationship between the various ecosystem services provided by the ARFR, the results revealed a correlation coefficient of 0.390 and a p-value of 0.000, 0.667 and a p-value of 0.000 and 0.636 and a p- value of 0.000 between provision and cultural services, cultural and regulation services and regulation and provision services respectively. These indicate that there is a positive and high correlation between each of the services the reserve provides. This implies that a reduction in the provision of one service may lead to a reduction in the provision of other services this according to Rodríguez, Beard, Bennett, Cumming, Cork, Agard, Dobson, and Peterson, (2006) is termed as ecosystem tradeoffs. In tradeoffs an increase in one ecosystem service results in the reduction of another (Rodríguez, et al., 2006). Also an increase in the provision of one service may also lead to an increase in the provision of the other services. This according to Science for Environment Policy (2015) is also termed as synergies. Synergies occur when an increases in one service causes increase in another service (Science for Environment Policy, 2015). The result confirms the Annual Review of Environment and Resources on The Nature and Value of Ecosystem Services: An Overview Highlighting Hydrologic Services, by Brauman et al (2007). It was stated in the review that, production of one ecosystem service depend on the other and that exploiting or damaging one service influences the functioning of others. It also asserts ‘Systems thinking’ which state that “everything affects everything else in the natural world” (Raffaelli & White, 2013).

Correlation was run also between respondents’ academic qualification and their knowledge on the Atewa Range Forest Reserve. The result is shown in Table 16.

Table 16: Correlation between residents’ academic qualification and their knowledge on the ARFR

		Academic qualification	**Knowledge on ARFR**
Academic qualification	Correlation coefficient	1.000	-.044
	Sig. (2-tailed)	.	.464
	N	278	278
Knowledge on ARFR	Correlation coefficient	-.044	1.000
	Sig. (2-tailed)	.464	.
	N	278	278

Source: Author’s construct, 2020

The study established a relationship between academic background of respondents and their knowledge on the Atewa Range Forest Reserve. It was revealed that there is a very weak and negative correlation of -0.044 and a p-value of 0.0464 which is not significant at p-value of 0.05 between respondents’ knowledge on the forest and their academic qualification. The negative correlation implies that as academic qualification increases, the knowledge about the Atewa Range Forest Reserve decreases and hence, respondents with higher academic backgrounds tend to possess less knowledge on the forest reserve. However, the not significant p-value of 0.0464 connotes that there is no certainty that, the level of education of respondents can be used to determine the level of knowledge the respondents have on the Atewa Range Forest Reserve. This result confirms the research findings of Gouwakinnou et al (2019) who found that respondent's academic qualification cannot be used to determine their perception of ecosystem services existence in the Alibori-Supérieur and Ouénou-Bénou forest reserves in Benin. It was therefore concluded that the level of education of the respondents cannot be used to determine their level of knowledge on the ARFR.

4.4 Factors influencing the provision of ecosystem services of the Atewa Range Forest Reserve

The section presents the various factors that influence the provision of ecosystem services of the ARFR.

4.4.1 Major direct drivers of change

The overall delievery of ecosystem services by the Atewa Range Forest Reserve in the Eastern region of Ghana according to results from the study,were found to be decreasing. It was therefore important to identify the primary factors influencing the provision of these services and sources accounting for it. This will help determine appropriate measures or management practices to be carried out by the various stakeholders. Principal components analysis (PCA) was performed on the factors influencing the provision of ecosystem services with the view of identifying the major variables that influence the delivery of these services in the study area and associate their possible sources. The analysis was done in oder to understand the underlying cause of decrease in ecosystem services delivery and to be able to suggest measures to be put in place to help curb the problem. The factor loading matrix of the principal component analysis are presented in table 17.

Table 17: Factor loadings matrix obtained from Atewa Range Forest Resrve (ARFR)

Variables	Factor 1	Factor 2
Deforestation	.940*	.063
Forest conversion to agricultural land	.934*	.034
Activities of chainsaw operators	.934*	.135
Hunting	.892*	-.066
Illegal mining	.615*	-.071
Vegetation management	.052	.904*
Vegetation restoration	.168	.855*
Land reclamation	-.057	.858*
Forest conversion to urban areas	-.300	.411
Total variance	44.2%	26.7%
Probable origin	Anthropogenic(Economic activities)	Management practices

Source: field data, 2020 *Factors >0.5 are considered significant*

Significant components were picked on the basis of an eigenvalue > 1. The PCA showed the most vital factors that influence the provision of ecosystem services of the study area. PCA yielded in total two significant factors, explaining about 70.8% of the total data variance. Loadings of the Direct Oblimin rotated factors are presented in Table 18.

Factor 1 explained about 44.2% of the total variance, with strong positive loadings for Deforestation, Forest conversion to agricultural land, Activities of chainsaw operators, Hunting, Illegal mining, Vegetation management, and Vegetation restoration, and Land reclamation, showing a high level of anthropogenic activities (economic activities) being carried out in the study area which is negatively affecting and degrading the forest and consequently affecting the delivery of ecosystem services. These activities are carried out by human. That is, human beings are the contributing factor.

Factor 2, which explained 26.7% of the total variance, showed strong positive loading for vegetation management, vegetation restoration and land reclamation. This factor is a positive factor and is a loading of management practices to ensure continuous ecosystem functioning and it is carried out by the stakeholders such as the forestry commission.

Therefore, anthropogenic activities (economic activities) especially deforestation negatively affect the delivery of ecosystem services in the study area. This is followed by management practices which positively influence the provision of ecosystem services in the study area. The management practices factor improves the delivery of ecosystem services in the study area and therefore needs to be encouraged. However the anthropogenic factor which are mainly economic activities carried out by the fringe communities in the reserve is the main concern as it carries the various factors which is negatively affecting the provision or delivery of these services in the study area and with the highest percentage variance of 44.2%.

The anthropogenic factor increases the impacts of human activities such as deforestation and forest conversion to agricultural land, hunting and illegal mining in the reserve. This poses threat to the reserve as it causes the ARFR to lose it vegetative cover, particularly some specific plant and animal species in the reserve (RAP, 2007; Ruffor foundation, 2016). Allotey (2007) stated in his study that about 14% of the total permanent forest reserves in Ghana are now without adequate forest cover due to certain human activities such as logging. The findings is also consistent with Nkem et al., (2008) who found out that the biodiversity of tropical forests in Africa is being threatened by a range of human activities such as mining, habitat loss due to conversion to agricultural land and logging, over-exploitation for fuel wood, food, medicinal plants, overgrazing, water catchment and river channel destructions . Excessive extraction of both timber and non-timber forest product from the forest by the fringe communities possess threat to the study area as it negatively affect the supply of ecosystem service (Gouwakinnou et all, 2019; Ayivor, Gorden, Adomako & Ntiamoa-Baidu, 2011) supplied by the ARFR especially regulatory and cultural services and some essential provisioning services like water supply.

The management practices factor presents control measures such as tree planting, weeding forest line and others being put in place by forestry commission to ensure continuous ecosystem service supply by the ARFR. It was however noticed that these practices are minimal as the anthropogenic activities outweighs the management practices factor. This is because the forestry commission faces a lot of challenges (forestry commission, 2016) in carrying out these practices to protect the reserve.

In general, it can be inferred from the result that, human activities in the ARFR are negatively influencing the supply of ecosystem services. According to a study conducted by Aerts and Honnay, (2011) on Forest restoration, biodiversity and ecosystem functioning, human activities have cause a reduction in both the extent and quality of forest habitat and the associated loss of biodiversity has jeopardizes forest ecosystem functioning and the ability of forests to provide ecosystem services. A related conclusion was drawn in a study by Balvanera et al (2016), who stated that societies are implanted within ecosystems of which they depend and influence the ecosystem services they produce. However, this influence can either be positive or negative. But in the case of the Atewa Range Forest Reserve, the negative influence outweighs the positive influence which is very alarming as it is greatly affecting the supply of ecosystem services by the Atewa Range Forest Reserve in the eastern region of Ghana. The Range manager in charge of the Suhum Range had this to say;

> *''People from the fringe communities enter the reserve illegally to extract both timber and non-timber resources for commercial purposes which is a very big challenge for us. Galamsey activities are carried out in the reserve which we are mostly alerted by some concerned members in the communities. River Pusupusu which take it source from the reserve, have almost the whole stretch of its river bed full of gold and people go there to mine Because of collaborative effort which is currently being initiated by the forestry and the fringe communities, even though the Forest is a reserve, members in the fringe communities are allowed to enter to pick both timber and non-timber product for consumption. However due to human behavior, most of them abuse this opportunity and extract them for commercial purposes which are degrading the reserve.''*

However, with a collaborative effort by the various stakeholders involved such as the government, forestry commission, NGO's and the local community members, the ARFR can be managed properly and ensure continuous supply of ecosystem services

4.5 Tourism potentials of Atewa Range Forest Reserve

This section provides an overview of potential tourist site in the ARFR and the measures to ensure effective tourist inflow.

4.5.1 Tourism inflow of the Atewa Range Forest Reserve

Typical of tropical rain forest, all the three Ranges of the Atewa Range Forest Reserve headed by three forestry commissioners (Range managers) hold fascinating features and sites that could be developed into ecotourism. Balvanera et al. (2016) attested to this. They stated in their study conducted on the ARFR that, the reserve is aesthetically beautiful with interesting sites. These include different plant species, waterfalls, caves, butterfly with unique species, rocks, mountains, head waters of some rivers in Ghana such as Birim, Ayensu, Densu, Subin, Akusu and many others as confirmed by (RAP, 2007). Table 18 shows community people's knowledge on the existence of interesting site that can be developed into tourist sites.

Table 18: Tourism inflow of Atewa Range Forest Reserve

Tourism Potentials	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**	**Total**
The Reserve has been developed into a tourist site	256	2	13	1	6	278
Tourist are mostly seen visiting the Reserve	250	6	13	5	4	278
The Reserve has potential tourist site	25	-	17	203	33	278

Source: Field data, 2020

The study revealed that, out of the 278 respondents, 203 representing 73% agreed and 33 (11.9%) also strongly agreed that, the Atewa Range Forest Reserve has many fascinating attraction sites. 17 (6.1%) out of these 278 respondents being the least also neither agree nor disagree. However, despite these numerous intriguing sites that the Reserve possesses, 256 which are 92% out of the total respondents confirmed that these sites have not yet been developed into tourist site, where people can go and explore nature. Also, 1 (0.3%) participant out of the 278 participants agreed and 6 (2.2%) strongly agreed that the Atewa Range Forest Reserve has been developed into a tourist site. The results clearly show that the reserve has not been developed into tourist site where tourists are mostly seen visiting the places. 250 representing 90% of the total respondents of 278 confirmed that tourists are not seen visiting these fascinating sites even though they do exist in the reserve. This confirms what Edusah (2011) found in his study. It was found in the study that, tourism potentials of some reserves in Ghana are not properly package to attract tourist from different part of the world to visit.

As the study revealed, this may be as a result of the long distances to these fascinating sites. Most of the respondents confirmed this. One of the forestry commissioners (Range manager) had this to say.

> *‘‘Most of these sites are very far away with long distances from the fringe communities. One can walk for hours before reaching these places. This in one way or the other makes it difficult and unattractive developing these sites into tourist site.’’*

One opinion leader in one of the communities also confirmed this saying that

> *‘‘There are indeed beautiful sites in the reserve that can be developed into tourist site but unfortunately, they are very far from us. Old people like me cannot go there but the young ones can go. It is two to three hours from here (Saamang-Juaso). But that does not mean it cannot be developed because these young energetic men and women and even sometimes children have been going there despite the long distance*.’’

It was also confirmed from the study that, the reserve belongs to the government. Therefore, according to the participants, if there are interesting site in the reserve that need to be developed, then it is the sole responsibility of the government to take that initiative to develop these sites into tourist sites or in other words to promote ecotourism. Also, the government has the sole power and ability in terms of providing financial support that will be needed to develop these sites. One of the forestry commissioners (Range manager) had this to say.

> *‘‘The reserve belongs to the government and stool land owners (Nananom) most especially the government. They have the power to develop those sites into interesting tourist sites that can benefit the fringe communities and the country at large. They have the power to give the go ahead on whatever*

happens in the reserve. They (the government) are capable of carrying out these functions in terms of providing financial support. If they don't give the go ahead and provide financial support what can we do?''

The study further confirmed that some of these fascinating sites in the reserve that can be developed into profitable tourist sites have not yet been identified or discovered. There are indeed numerous intriguing sites in the reserve but some of these sites are known based on what some individuals in the fringe communities are saying. This means that these sites have not been discovered by the higher authority that is the forestry commission, stool land owners (Nanaom) and the Government. Some individuals in the fringe communities who are aware of the existence of these attraction sites fear to prompt the higher authorities. This they say is as a result of them being arrested in case they voice it out because they are forbidden to enter the reserve. One of the forestry commissioners (Range manager) said:

''The reserve is very vast and undulating that, there are some part of the forest under my jurisdiction which I have not reach yet. So, if these parts have interesting sites that need to be developed, I may not know. I have once heard from someone that there used to be settlement in the reserve which was occupied by some people who are no more but the remains of the settlement are still there but I am yet to find out since I haven't been able to cover the whole range yet.''

One respondent from Larbikrom also commented on the fact that some members of the fringe communities know some interesting sites in the reserve but fear to voice it out since they are not permitted to enter the reserve. This was what he said:

''We have lived here for many years, so we know every part of the reserve than any other person. We have discovered some interesting places that can be develop into tourist sites but we have been warned not to enter the reserve so we have also kept these to ourselves. What if you speak out and you are asked how you got to know? What are we going to say? But if they come to us, we will take them there.''

4.5.2 Attraction sites that need to be developed

It can be seen from Table 19 that, out of the 278 respondents, 90% agreed that the Atewa Range Forest Reserve has many interesting and fascinating sites that can be develop into tourist sites which can attract tourist from across the country and even outside the country. The results confirmed a report by (Jonny-Nuekpe 2019). It was reported that Ghana is endowed with beautiful and interesting sites that attract eco-tourists across and outside the country. The remaining 10% also said that the reserve has no interesting site that can be develop into tourist site. These 10% could be those who are afraid to voice it out that the reserve possesses interesting site that need to be develop for fear of being sanction since it is forbidden to enter the reserve. This result shows that most of the communities' members in these fringe communities are aware that the reserve is endowed with beautiful sites that can be develop and benefit these communities bordering the reserve. One chief from one of these communities had this to say;

> *''We have so many interesting places in the reserve that needs to be developed. We have the "shower" (water fall), cave, the Ayensu river taking it source from our part of the forest reserve and many other interesting places. We want the government to develop these sites for us so that we can also benefit as a community rather than mining the bauxite from the reserve which can destroy our waters and even lead to a total evacuation of this entire community. If these places were developed it would have created employment for our people. Our women and youth can sell food and other handicrafts to the tourists who will be visiting these places which will generate income for them. This can even reduce unauthorized entering into the reserve. Please we beg the government to come to our aid.''*

The study revealed that the reserve has a number of waterfalls, cave, and different species of butterfly, plants and animals. Mountains for hiking, head waters of some major rivers and streams in Ghana, a very unique soil type that can be used as paint, rocks and many other interesting sites that can be develop as buttressed by RAP

(2007), and Hodggetts, Essilfie, Adu-Gyamfi, Akom, Kumadoh and Opoku (2016) who mentioned most of these sites as interesting sites in the reserve that can be developed into tourist sites. Apart from these interesting sites in the reserve, there are other side attractions on the way to the reserve in the fringe communities that can also be develop. For instance, there is a cobra palm tree in Oborho that can be made more attractive to attract tourist to the community. The Atewa Range Forest Reserve is blessed with many fascinating sites that when properly package can increase the standard of living in the fringe communities by providing other source of livelihood to the people there by increasing their source of income and also boosting the tourism industry in the country. RAP (2007) further explained in their study that Ecotourism is likely the best option for bringing income to the region, by transforming the Atewa forest into a world-class ecotourism center, which will focus on the rare and beautiful species that was identified during their survey and other studies.

Furthermore, due to inadequate job opportunities in these communities, most of the people in these communities resort to extracting both timber and non-timber products for commercial purposes from the Reserve (Ayivor, Gorden, Adomako & Ntiamoa-Baidu, 2011). Some of the youth especially the men engage themselves in Illegal mining in the forest reserve which in turn destroys the ecosystem of the reserve. Nonetheless, the development of tourist site in the forest reserve can help reduce these excessive extraction and illegal activities in the forest and prevent biodiversity loss. This is because people in these communities can be employed as builders, managers, maintenance and housekeepers, tour guides, researchers, and research assistants. Also, there will be improvements in the hospitality industry and many others which will provide sustainable job opportunities for the local people as confirmed by Ruffor foundation (2016). Simillar studies also asserted to this (Ashley, Roe, & Godwin, 2001; UNWTO, 2002).

4.5.3 Measures to ensure effective tourist inflow

Respondents were asked whether or not there have been some measures being put in place to ensure effective tourist inflow by the government, the local people or any other organization. The result shows that there are little or no such measures being carried out. Out of the 278 respondents, 274 representing 98.6% responded 'No' that there are no such measures being put in place to ensure effective tourist flow neither by the government nor the local people. 4 (1.4%) out of the 278 also responded 'Yes' that there are measures put in place to ensure tourist inflow. This is as a result of inadequate cooperation between the government and the local authorities. The local people think that the reserve is for the government and that there is nothing they can do as local people to promote its eco-tourism. However, if the government comes to them for support when developing these sites, they are ever ready to lend a hand since this will benefit them greatly. This is what one opinion leader in one of the communities said with regard to this;

> ''*There is nothing we can do as local people because the forest is for the government. Even if we start something and the government is not in support with it, we cannot succeed. There is nothing like the government collaborating with us to develop these sites but if they come for our support, we are ready to help. This is because we want the reserve to be turned into a national park than its bauxite being mined which will destroy our rivers.''*

In addition, the study further revealed that, there are no measures being put in place by the government to promote or develop the reserve into a national park. Rather the government is planning to open up the reserve for bauxite mining which the reserve is highly endowed with. However, some organizations like A Rocha Ghana has been collaborating with the local people as some of the participants confirmed and campaigning to keep the reserve in good shape and making a great effort to make the reserve an interesting tourist site. A study by Hodgetts et al. (2016) and FAO, (2001) confirmed that some organizations and conservationist such as A Rocha Ghana, Premaian Global and IUCN (Ghana and Netherlands) are campaigning and making great strides in promoting the forest as a potential national park and to keep the forest more or less intact for its biodiversity, ecosystem services and eco-tourism. Almost all the participants who are the chiefs, opinion leaders and the range officers confirmed this.

It became clear from the study conducted that if the tourism potentials of forest reserves in Ghana especially the Atewa Range Forest Reserve are properly packaged with the fringe communities in mind (Edusah, 2011) that is collaborating with the local people is a very essential tool in achieving this, it would bring tremendous improvement in the livelihoods of the people in the fringe communities as it will reduce their unemployment level and increase their income level and the country at large by boosting the tourism sector as found by (Mieczkowski, 1995).

4.6 Management practices adapted to ensure continues functioning

It was found in the study that, ever since the Reserve was declared by Conservation International as a Globally Significant Biodiversity Area (GSBA), any activity that goes on in the reserve is funded and come directly from the government through the Forestry Commission. Also it was revealed that, because it is a GSBA, The Atewa Range Forest Reserve is supposed to enjoy total protection free from any human activity apart from education and research as confirmed by the forestry commission which also matched the research findings of Ayivor, Gorden, Adomako and Ntiamoa-Baidu (2011). However, the reality is that the Reserve belongs to the Traditional Authorities since they are the stool land owners and without the Reserve the land belongs to them. This was observed in the research findings of Edusah, (2011) in his study conducted to find the impact of forest reserves on livelihoods of fringe communities in Ghana. He found out that Traditional Authorities are part owners of forest reserves in Ghana. The forestry commission (Range manager) had this to say:

> *''Every Reserve belongs to "Nananom" they are the traditional stool land owners. Hence there is no way they can be exempted from managing and protecting the Forest Reserve. Therefore, they need to benefit from the reserve.''*

In addition to this, the study revealed that apart from the Traditional Authorities, the Atewa Range Forest Reserve is being managed by Governmental and public agencies that are responsible for the management of all forest reserves in Ghana which perform different roles. The Ministry of Lands and Forestry for example is responsible for maintaining links with other ministries and agencies that have interest in the forest sector. The Forestry Commission then follows with the responsibility for the management and regulation of the utilization of forest and wildlife resources. At the Local Level the District Assemblies have a statutory responsibility to harness the human and natural resources for the development of the districts. They therefore have stake in the forest reserves situated in their areas of jurisdiction (Edusah, 2011). The results revealed that Forest and Wildlife policy recognizes the rights of people to have access to natural resources and to benefit from ecosystem services provided to improve their standard of living and at the same time to live up to their responsibility to ensure the sustainable use of forest resources. Studies conducted by RAP, (2007); Ayivor, Gorden, Adomako, and Ntiamoa-Baidu, (2011) complement this.

According to the forestry and wildlife commission in charge of the reserve, the Government of Ghana sees fringe communities of the forest as key to pursuing sustainable forest management principles. For that reason, the Government places emphasis on the concept of participatory forest management and protection of forest and wildlife resources and calls for the development of right strategies and programmes, in consultation with relevant agencies, rural communities and some individuals. Nonetheless, the study found out that Forest fringe communities do not see this as effective. The reasons are that the fringe communities even though are seen as partners in protection of the forest they do not benefit directly from revenues generated from the reserve as little or no revenue generated from the reserve comes to the communities.

4.6.1 Measures by the local people to ensure functioning

This section explores the various measures adopted by the fringe communities to ensure effective ecosystem functioning of the ARFR

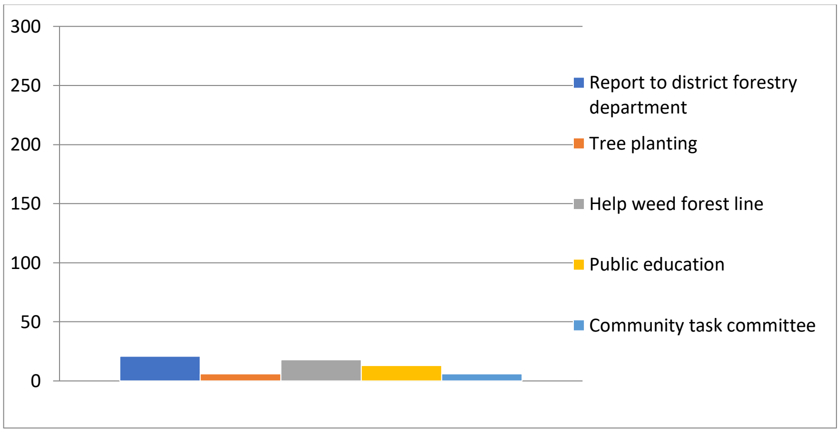

Figure 7: Measures by local people to ensure continues functioning

Results from the study conducted show that there is low community involvement in management of the reserve. Out of the 278 respondents 214 representing 77% which is the majority of people who answered the questionnaire indicated that they do nothing in managing and protecting the reserve. However few of them mentioned 21 (7.6%) tree planting, 6 (2.2%) reporting to district forestry department, 18 (6.5%) helping to weed forest line, 13 (4.7%) public education and 6 (2.2%) community task force communities as some of the measures they put in place in managing and protecting the reserve. This is shown in figure 7. The range commander in Anyinam also confirmed this. He confirmed that some committee members in the fringe communities help the forest guards in weeding the forest line. This was what he said;

> *‘‘In some fringe communities where the community members are good, they help the guards to weed the forest line. Some also draw our attention and report to us some illegal activities going on in the reserve. Some even volunteer to take us to places where these activities are taking place. We also disguise such people for them not to be noticed. We even have specific individuals in the communities who voluntarily work for us by consistently reporting to us every illegal activity that take place in the reserve.’’*

However, result from figure 7 clearly shows that local participation in the management of the reserve is very minimal. This was observed in the research findings of Ayivor, Gorden, Adomako and Ntiamoa-Baidu (2011) where it was observed that, community participation in forest conservation was very poor in their study area.

Furthermore, the ARFR is seen as valuable resources because it provide people especially people in the fringe communities with ecosystem services which are seen as the necessities of life such as timber and Non-Timber Forest Products (NTFPs). Related conclusions were drawn from studies conducted by Science for Environment Policy, (2015), Xun, Hu, Lv, and Tong, (2017) and Brauman, Daily, Duarte and Mooney, (2017). Even though people in the study area depend on the reserve as their alternate source of livelihood, as they get income from NTFPs, they have no role in the management of the forest reserve. Despite the need and call for sustainable management of forest reserves that requires the close involvement of all stakeholders, the study showed that as confirmed by most of the participants who were interviewed, the Forest Commission denies the local people access to the forest reserves and that the communities are not involved in forest management regimes. As a result of these, the local people do not see the need to get involved in the management of the reserve because according to them they do not derive anything from the reserve (provisioning services). This is as a result of the fact that, they are denied access to the reserve and as established earlier they see the reserve as government property and so it is the responsibility of the government to protect and manage it. One opinion leader had this to say.

> *''The forestry commission is being paid to protect the reserve, so there is no need for us to take measures to protect it. How do we help when we don't have any authority over it? What benefit will I gain from it?''*

This clearly shows that there is little collaboration between the fringe communities and the forestry commission in terms of managing and protecting the reserve to ensure continuous functioning. The result suggests very poor community involvement in the management of Atewa Range Forest Reserve. It was very surprising to know that almost all the respondents and even some of the participants were unaware of who represents their communities on the management of the ARFR. The non-involvement of fringe communities in the management of the reserve is a very serious problem that needs to be addressed by the government. This is because the communities are closer to the reserves and have better knowledge about the areas than anybody as observed during the research. A similar conclusion was drawn in a study conducted by Edusah, (2011). It was found in the study that, there is a very poor community involvement in the management of forest reserves in the study areas where the research was conducted. It was explained that, the situation is pronounced in forest reserves in Brong Ahafo Region where respondents were unaware of who represents their communities on the management of the reserves.

4.6.2 Management practices by the forestry and wildlife commission to protect the Forest Reserve

This part presents the various measures being put in place by the forestry and wildlife commission to protect and ensure continuous ecosystem functioning of the Atewa Range Forest Reserve.

Table 19: Management practices by the forestry and wildlife commission

	Frequency	Percentage (%)	Total
Tree planting	252	90.6	278
Arrest culprit	248	89.2	278
Weed forest line	241	86.6	278
Forest guards protecting the reserve	238	85.6	278
None	44	15.8	278
Destroy farms in the reserve	198	71.2	278

Source: Field data, 2020

Result from table 20 shows that the forestry commission undertakes various measures in other to manage and protect the reserve. Most of the respondents agreed to this. 82% out of the total number of respondents responded “yes”, indicating that they are aware of the measures being put in place by the forestry commission to ensure continues ecosystem functioning. Some of these measures as indicated by the respondents are tree planting 252 (90.6%), arresting of culprit 248 (89.2%), weeding of forest line 241 (86.6%), forest guards protecting the reserve 238 (85.6%) and destroying farms in the reserve 198 (71.2%) out of 278 respondents who answered the questionnaire stated that these are some of the measures the forestry commission takes. However, 44 (15.8%) out of the 278 respondents also stated that the forestry commission does nothing. In all almost all the respondents mentioned at least one of the above as measures being taken by the forestry commission. This was also confirmed by the forestry commission (Range managers). One chief had this say;

‘‘We always see the forestry people with tree seedlings in their cars going to plant in the reserve and we have been seeing them plant as well. When they also see farms in the reserve, they destroy them. They will cut everything down sometimes they don’t even allow you to take anything, they will just destroy everything. Whether it maize, plantain, cassava and even cocoa they will cut everything down living you with nothing. Also, when you are caught engaging in galamsey activities in the reserve, they send you to jail right away. We even have four of our boys in jail as we speak for engaging in galamsey activities in the reserve. The forest guards are also sometimes seen patrolling the forest line. They also weed the forest line to show clear demarcation between the reserve and the adjacent forest.’’

However, 44(15.2%) out of the respondents also indicated that the forestry and wildlife commission is doing nothing to manage and protect the reserve. Reasons given were that, in some portions of the reserve, the forest guards do not weed the forest line to show clear boundary. Forest guards also take bribe especially from the chainsaw operators and sometimes even share logs or timbers that have been brought by the chainsaw operators with them instead of punishing them. Most of these comments were made in communities within the Suhum Range. A participant from one of the communities within the Range had this to say;

‘‘We always see the forest guards with the chainsaw operators. Sometimes we see them arresting and ceasing their machines in front of us and taking them away but the next day or three days later, you will see this same person who was arrested or whose machine was ceased entering the reserve again. What do you think can lead to their immediate release if not payment of bribe?’’

4.6.3 Challenges faced by the Forestry and Wildlife commission in Managing the Reserve

High demand of forest resources that is both TFP and NTFPs as a result of continuous growing of the population has raised a great concerned for forest management issues globally. As a result of this, the Forest Services Division (FSD) of the Forestry Commission in Ghana is facing challenges in managing forest resources nationwide (Forestry commission, 2016).

Based on the data gathered through the use of questionnaire and interview guide, the research findings revealed that the ARFR is faced with a lot of pressures coupled with varying degrees of threats. As table 12 depicts, illegal mining (galamsey activities), activities of chainsaw operators, agricultural activities or encroachment, deforestation and hunting constituted the highest scoring pressure and the biggest threat to conservation of the forest ecosystem there by affecting the services they provide. Comparing the result to other related works, the Forestry Commission, (2016) and Edusah, (2011) documented some of these activities as threat to forest reserves in Ghana in a study conducted in TinteBepo Forest Reserve in the Mankranso Forest District and Bobiri, Bonkoni, Ayum and Subin in Ashanti and BrongAhafo regions respectively. Some more results of other related works follow the same trend (Burgin & Zama, 2014; Ministry of Lands and Natural Resources, 2012) as in this study. The study further discovered other pressures and threats which included, illegal entry including poaching, high human population density and poverty in nearby communities (Ofori-Kumah, Appiah, & Benpong, 2013)Responses from the interviews conducted with the forestry officials managing the ARFR that is the three Range Managers confirmed the results illustrated in table 18. According to these interviews, illegal chainsaw operations, illegal farming, and mining (galamsey activities), deforestation and hunting were the most serious management problems. Chainsaw operators without licenses often walk deep into the forest and carry out their activities mostly at night. One of the chiefs had this to say;

> *‘‘If I tell you that the chain saw operators do not operate in this reserve, then I will be lying to you. The fact is they always work deep in the night and go deep in the forest as well where the forest guards cannot reach them. We most often hear the sounds of their machines deep in the night.’’*

The forest guards on duty with the help of some community members who are not happy with these activities help to arrest these operators who can be very dangerous because they are most often armed and ready to attack who ever come after them most especially the galamsey operators. The field survey however revealed that, in some years about 20- 40 years ago, the reserve use to be under production which means that fringe community members were allowed to farm in the reserve and as a result some of the community members have their farms (Edusah, 2011) in the reserve. Due to this, there are still some admitted farms, see plate 9 within the reserve especially Kyebi areas where the community have no lands to farm on. The survey revealed this is as very serious challenge to the forestry commission because owners of these farms most often extend their boundaries which have been demarcated for them and farm in other parts of the reserve with the notion that those parts of the reserve support good crop yield. Burgin and Zama, (2014) confirmed this in a study conducted in Cameroon on Community-Based Tourism- Option for Forest-Dependent communities in 1A IUCN Protected Areas: Cameroon Case Study. A report by the Forestry Commission, (2016) on Tinte Bepo forest reserve management plan in the Mankranso forest District also confirmed the result of this study. This is what the Range commander in Anyinam said concerning this challenge;

''There are some admitted farms in the reserve which are owned by the community members and the government has allowed these farms to be remained in the reserve. However, some owners of these farms extend their boundaries to other part of the reserve which always make our work difficult but when we see these, we have no other option than to destroy those farms. Another big challenge is that some of the illegal chainsaw operators and galamsey operators we find operating in the reserve are most at times fully armed. Recently, we arrested some of these operators operating in the reserve and we found on them pump action loaded with seven rounds and disguised in such a way that you wouldn't see. it was in a sack and placed at where they are working. But my team and I have been doing our best to protect the reserve despite these challenges.''

A picture of admitted farms is shown in plate 9;

Plate 9: Admitted farms in the ARFR
Source: Range manager's archives, 2020

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In addition, the study further revealed that, in some areas of the forest reserve, illegal chainsaw operation and mining seems to have reduced tremendously especially the Anyinam Range as confirmed by most people in Larbikrom and Bomaa which are communities within the Anyinam Range. The reason for this was the hard work of the Range Manager on certain hard decisions he takes. He at all times hand over culprits to the police and make sure they are jailed and this has put some kind of fear in the people and helped reduce the practice. Also, some members in the fringe communities drink from rivers that takes their source from the reserve and as a result report any activity that destroy the river to the forestry commission. Larbikrom for instance is one community owned by the Krobos that is they bought the land from the Akyems, and are now traditional owners of the land as the study revealed. As a result of this, this land that was bought by their forefathers are highly cherished and therefore any activity that will destroy their land is highly prohibited in the community especially galamsey activities. The greater majority of the youth however remain unemployed in these fringe communities, which remains a great source of worry. Another challenge was that, areas outside the reserve have been given out by government as mining concessions to small scale mining companies and some of these companies have exhausted their concessions and are encroaching upon the reserve to prospect for gold. The operators cut down trees, clear the forest, divert stream courses and completely remove the top soil that might support re-growth. These activities have also led to the opening up of numerous access routes into the reserve, through which encroachers enter. The reserve currently is even under threat of being given out by the government for bauxite mining (Ayivor, Gorden, Adomako & Ntiamoa-Baidu 2011).

Further, another challenge faced by the forestry commission as the study revealed is ‘politics”. Political parties in power tend to interfere with the activities of the forestry commission. Some measures being put in place by the commission in charge of the reserve to punish culprit are most often interrupted by senior members of the ruling parties. Whenever some people are caught in engaging in illegal activities in the Reserve and are being reprimanded, high officials from ruling parties plead on their behalf. This clearly undermines the activities of the forestry commission being taken to ensure proper management of the ARFR. It will also not deter people from engaging in such activities which in the long run will affect the continuous functioning and provision of ecosystem services of the Reserve. When the Range Managers were asked how they deal with this particular challenge, this is what one of them said;

> *‘‘When I am called by any high official, I always tell them that the case is not in our hands. Because I cannot be a player, a coach, a referee and a lines man at the same time, whenever I arrest people of that sort, I always make sure that I send them to court on the very day they are arrested, even if it on weekends or midnight and hand over everything to them so that in the future when I receive a call from any high official, I will not have a hand in it. This strategy that I have been using has really helped me attain peace of mind. But honestly speaking, it is not easy at all*.’’

4.6.4 Multi-stakeholder approaches available in conserving the Reserve

The researcher wanted to know whether there are other multi-stake holder approaches in conserving the reserve. Multi-stakeholder approaches here means collaborative effort, schemes or programmes either between the forestry commission and the local communities around the reserve, the fringe communities and other NGOs or between the forestry commission, fringe communities and other NGOs in an attempt to ensure effective management and conservation of the reserve thereby ensuring efficient ecosystem functioning of the ARFR. Figure 8 shows the result of this objective.

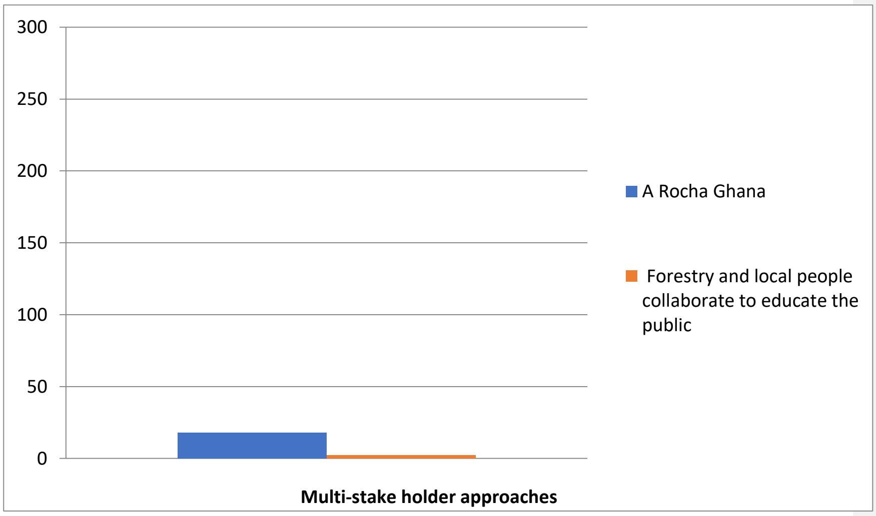

Figure 8: Multi-stakeholder approaches in conserving the reserve.

Source: Field data, 2020

The result revealed that, out of the 278 respondents, 252 representing 90.6% of the people that answered the questionnaire indicated that there are no such programmes or schemes being held. 18(6.5%) out of the 278 also said that A ROCHA Ghana which is an NGO aimed at contributing to the sustainable management of important ecological habitats and initiating programmes aimed at facilitating target community's ability to adapt to current trends in climate and the impacts of a changing natural environmental (A ROCHA Ghana, 2020) have been collaborating with the local people in managing and conserving the reserve. Some of the chiefs in the fringe communities and the range officers confirmed this. Also 8(2.9%) said that the Forestry commission sometimes collaborate with the local authorities and organize programmes to educate members of the fringe communities.

It can therefore be concluded from the study that; the Forestry commission has not been able to successfully stop any form of degradation in the ARFR. It has therefore become obvious that the commission cannot implement the management programmes of the Forest Reserve single-handedly and without the involvement of the fringe communities within and adjacent to the ARFR, especially those whose livelihoods are forest-based. It is then very essential to fully involve the local people in the management programmes (Muam, 2011) of the ARFR in other to ensure continues ecosystem functioning of the Reserve. It is also an indisputable fact that because of user groups' dependence on the forest reserve, estranging the communities from the natural resource base that is totally denying them access to the Reserve is certainly not the way to guarantee the future of the ARFR. With the increasing pressure on the forest reserve, a better management system has to be established to reduce degradation even further and guarantee the future of the Atewa Range Forest reserve and ensure the continues provision of ecosystem services. This result of the study is supported by related studies (RAP, 2007; Edusah, 2011; A Rocha Ghana, 2020; Forestry Commission, 2016). All these studies suggest that it is important to involve the local people in the management regimes of forest reserves in Ghana.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter summarizes the study and key findings derived from the analysis and discussions of the results. Conclusions are drawn and recommendations are made for the study.

5.2 Summary of Research

The purpose of the study was to analysed ecosystem services and functions of the Atewa Range Forest Reserve. Six communities in the three ranges of the ARFR were selected using stratified sampling technique. Purposive sampling technique was also used to select 278 respondents in these communities to express their views on ecosystem services provision of the ARFR. Remotely sensed images were used to determine land cover change for the period of 1990- 2018. Purposive sampling technique was employed to select 23 (5 chiefs, 15 opinion leaders and 3 officials from the forestry and wildlife commission) respondents to participate in interviews for, ecosystem service provision of the ARFR, multi- stakeholder approaches to ensure continuous functioning and tourism potential of ARFR.

5.3 Key findings

This section presents a summary of the major findings from the analysis and discussions of the study. The following are the major findings from the study.

- The Atewa Range Forest Reserve provides ecosystem services that is provisioning (food, wood, water, wood medicinal plant, timber, etc.), cultural (spiritual value, sense of identity, cultural heritage, recreation scientific research, etc.) and regulating (air quality, flood regulation, climate regulation, habitat maintenance etc.) services to the fringe communities. However, the provision of these service by the reserve to the fringe communities for the past thirty years have seen a reduction with a mean level of change of 1.9 and a standard deviation of 0.6 indicating a drastic reduction to reduction in its provision of ecosystem services by the reserve. The provision of these service were found to have a positive relationship as the provision of one affect the other and hence a reduction in the provision of one service leads to a reduction in the other and vice versa.

- Anthropogenic and management practices were the factors affecting the provision of ecosystem services by the ARFR. The anthropogenic factors include; illegal mining (galamsey), deforestation, logging, illegal mining, hunting and activities of chain saw operators. These factors tend to cause a reduction in the provision of ecosystem services as most of these factors cause the reserve to lose its forest cover. The management practices also include vegetative management, land reclamation and vegetation restoration. These factors also tend to increase the provision of ecosystem services and ensures continuous ecosystem functioning of the reserve. However, the management practices are minimal as the anthropogenic factors outweigh the management practices and as a result, the ARFR has seen a reduction in the provision of ecosystem services to the fringe communities.
- The Reserve is endowed with many fascinating site that can be developed into tourist this sites. Some of these sites include; caves, waterfalls, headwaters of some major rivers like Birim, Ayensu, Densu and many others, different plant and animal species and many others. However it was discovered that most of

these interesting sites have not yet been developed into tourist sites and there are no measures being put in place to develop these fascinating sites into tourist site. This is as a result of lack of collaboration between the various stakeholders in managing the reserve especially, between the government and the local people as the study discovered. However, the local people wish these sites to be developed as it will create employment and bring development into their communities.

- It was found that the reserve is being managed by the forestry and wildlife commission under the directives of the government of Ghana. It has been divided into three jurisdictions that is the Anyinam Range, the Kibi Range and the Suhum Range and these ranges are managed by three forestry commissioners known as Range managers. The forestry commission play major role in the management of the Reserve. The fringe communities have less hand in the management of the reserve as they see it as the forestry commission's responsibility. Also, Forest Commission denies the local people access to the forest reserves and that the communities are not involved in forest management. Tree planting, weeding of forest line, destruction of illegal farms in the reserve, arresting offenders and others are the various measures taken by the forestry commission to protect the reserve. The fringe communities do virtually nothing in the protection of the reserve. However, some few concern people in the communities assist the forestry commission by helping them to weed the forest line, and report the hideout of offenders to the forestry commission.

5.4 Conclusion

The study focused on analyzing performance of ecosystem services of the ARFR and the factors affecting the provision of these services. Based on the research findings, the following conclusions have been drawn.

It was found that provision of ecosystem services (provisioning, cultural and regulating) by the ARFR have reduced over the past thirty years and the decline in the provision of one service leads to the reduction of the other and vice versa . However effective measures can be put in place to ensure continuous functioning and provision of ecosystem services.

Further, it can be concluded that a reduction in the provisioning of these services has been influenced by human activities such as illegal mining, deforestation, logging, illegal farming activities, hunting and activities of chainsaw operators. It was also revealed that, the positive influences such as vegetation restoration and vegetation management which are the measures put in place to ensure continuous functioning are minimal.

In addition the ARFR has been blessed with interesting site that can be developed into tourist site. However, it was found that most of these intriguing sites have not been developed into tourist site and there are no laid plans to develop these sites into tourist attraction by the various stakeholders.

Finally, it was revealed from the study that the forestry commission has not succeeded in stopping forest degradation. It has therefore become obvious that the commission cannot implement the management practices of the forest reserves single-handedly and without the involvement of the communities within and adjacent to the Reserve, especially those who depend on the Reserve for NTFP.

5.5 Recommendations

The following recommendations are suggested based on the major findings and conclusions of the study;

- It is recommended from the study that, the forestry commission, traditional authorities together with the local assembly should collaborate and enforce the laws that protect the reserved or protected zones of the area by applying the needed sanctions such as payment of fine and imprisonment to offenders which should be free from political interference. Forest lines should be constantly weeded to ensure clear demarcation between the Reserve and the adjacent forest.
- In order to promote ecotourism in and around the Atewa Range Forest Reserve by the government and the local people, the reserve needs to be transformed into a world-class ecotourism center, which will focus on the rare and beautiful species of both plant and animals. Also tourist or visitor center should be established in some of the communities with tour guides to provide information about the Reserve's biodiversity to visitors or tourists and residents. This will go a long way to create employment for the local communities as members will be used as builders, manager, tour guides and many others to these facilities. Also, the selling of handicrafts such as baskets and wood carvings, food and Kente cloth to tourist also can provide alternative livelihood to the local people and reduce illegal activities such as illegal mining (galamsey) and extraction of NTFPin the Reserve.

- Also, the non-involvement of fringe communities in the management of the ARFR is a very serious problem that needs to be addressed by the forestry commission. The forestry commission therefore can involve the community members in the tree planting scheme regularly, some dedicated members in the communities can be appointed as community based guards and be given some stipends to help protect the reserve. Chiefs and elders in fringe communities should be part of decision makers on the Reserve. This is because the communities are closer to the Reserve and have better knowledge about the areas than anybody else.

- It is recommended from the study that, the Government of Ghana together with traditional authorities and the local assembly should demarcate and establish an integrally protected area, such as a National Park with high protection status. As this will help boost the tourism industry.

5.6 Areas for Further Studies

For further studies, the impact of Atewa Range Forest Reserve on the livelihoods of Fringe communities can be investigated by students, researchers and institutions.

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APPENDICES

APPENDIX A

UNIVERSITY OF EDUCATION, WINNEBA

DEPARTMENT OF GEOGRAPHY EDUCATION

Questionnaire for individuals in the selected communities

Thank you for agreeing to complete this questionnaire. This questionnaire may take few minutes of your time to complete. Please tick as appropriate as you perceive and your candid responses would be highly appreciated. You are not required to provide your name or any personal identification number on this questionnaire. All information provided will be treated with high confidentiality and will be used solely for academic purpose. Participating in this study is voluntary and you may withdraw at any point. The study is on ***Analysis of Ecosystem Functioning and Services of the Atewa Range Forest Reserve in the Eastern Region, Ghana.***

Section A: Demographic characteristics

1. Gender: a. Male [ ] b. Female [ ]
2. Age group: a. 18-24 [ ] b. 25-29 [ ] c. 30-34 [ ] d. 35-39 [ ] e. 40+ [ ]
3. Your Academic qualification: a. Basic [ ] b. Secondary [ ] c. Tertiary [ ] d. Others (specify) ____________
4. Occupation; a. Farming [ ] b. Hunting [ ] c. Herbal Practitioner [ ] d. Trading [ ] e. Teaching [ ] f. Nursing [ ] Others (specify) ____________

Section B: Ecosystem Functioning and Services of the Atewa Range Forest Reserve

5. This section explores your understanding of ecosystem functioning and services of the Atewa Range Forest Reserve. In this study, ecosystem services refer to both tangible and intangible benefits people derived from the forest. ***Please read the statements carefully and tick the option [√] that best describes your experience and knowledge on the subject***

		Strongly disagree	Disagree	Neither agree Nor disagree	Agree	Strongly agree
Knowledge on the Forest Reserve (KFR)						
KFR1	I know much about the forest reserve					
KFR2	I know when it was considered as a National Reserve					
KFR3	The Reserve is accessible to the community					
KFR4	The community benefit a lot from the Reserve					
KFR5	I know the various activities that goes on in the Forest Reserve					
KFR6	There have been some destructions in the Reserve recently					
KFR7	These destructions have affected the Forest Reserve greatly					

6. **In your opinion, how has the forest been performing in terms of providing the major ecosystem services over the years? Please tick [√] the option that best describes your opinion.**

		Drastic reduction	Reduction	Remain the same	Increment	Drastic increment
Service type	**Services**					
Provisioning						
1.	Food					
2.	Wood					
3.	Firewood					
4.	Water					
5.	Timber					
6.	Medicinal plant					
Regulating						
1.	Flood regulation					
2.	Climate regulation					
3.	Regulate soil fertility					
4.	Air quality					
5.	Hydrological regulation					
6.	Habitat maintenance					
7.	Pollination for useful plant					
Cultural						
1.	Employment					
2.	Spiritual value					
3.	Recreation					

4.	Ecotourism					
5.	Scientific research					
6.	Cultural heritage					
7.	Sense of identity					
8.	Traditional ecological knowledge					

7. **In your opinion; what has been the overall change in the state/ vegetative cover of the Atewa Range Forest Reserve? (Please tick [√] one box only that describes your knowledge)**

Dates	**Strong deterioration**	**Deterioration**	**No significant change**	**Improvement**	**Major improvement**
1988-1998					
1998-2008					
2008-2018					

8. What are the major direct drivers of the changes you have described in previous question? Please read carefully and tick [√] the appropriate option(s) that best describes your opinion.

		Strongly Disagree	**Disagree**	**Neither agree Nor disagree**	**Agree**	**Strongly agree**
	Major Drivers (MD)					
MD1	Illegal mining					
MD2	Deforestation					
MD3	Forest conversion to agricultural land (encroachment)					
MD4	Hunting					
MD5	Activities of Chainsaw operators					
MD6	Forest conversion to urban areas					
MD7	Vegetation management					
MD8	Land reclamation					
MD9	Vegetation restoration					

Section C: Tourism potential

This section explores your knowledge of tourism inflow of the Atewa Range Forest Reserve.

Tourism potentials (TP)		**Strongly Disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
TP1	The Reserve has been developed into a tourist site.					
TP2	Tourist are mostly seen visiting the Reserve					
TP3	The Reserve has enough tourist attractions					

9. ***Please read the statements carefully and tick the option [√] that best describes your***

10. ***knowledge on the subject and provide the needed explanations where necessary***

11. Does the Reserve have specific recreational or attraction sites that need to be developed? a. Yes [ ] b. No [ ]If Yes, specify
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12. Are there measures being put in place to ensure effective tourist inflow? a. Yes [   ]

b. No [   ]If

Yes,specify…………………………………………………………………………………

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Section D: Management practices

This section explores your knowledge on management practices being put in place to ensure continues functioning of ecosystem of the reserve of the Atewa Range Forest Reserve. ***Please read the statements carefully and tick the option [√] that best describes your knowledge on the subject and provide the needed explanations where necessary.***

13. What measures have been put in place by the local people to ensure continues functioning?

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14. Are there management practices by the forestry and wildlife commission to protect the Forest Reserve? a. Yes [ ] b. No [ ]If Yes, specify

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15. What other multi-stakeholder approaches are available in conserving the Reserve? Please specify

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Thank you for your participation, your responses are highly appreciated.

APPENDIX B

INTERVIEW GUIDE FOR CHIEFS AND OPINION LEADERS

1. Can you please give a brief history on the Atewa Range Forest Reserve?
2. What benefit do you derive from the Forest Reserve as a local authority and community?
3. How has the reserve been performing in terms of provision of ecosystem services?
4. What do you think is influencing the provision of these services? Both negative and positive.
5. Is the Reserve accessible to the community? If no, why? And if yes, why?
6. How important is the forest reserve to this particular community?
7. What was the state of the forest in about ten to twenty years ago?
8. What is the state of the forest now?
9. Have there been any changes? If yes how?
10. Do you please have an idea on how these changes have affected composition of species and tree growth? If yes, how?
11. Is the Forest Reserve a tourist site?
12. If yes, can these changes have effect on its tourism inflow?
13. Are there effective programmes aimed at protecting the reserve?
14. If yes, when did it start and how effective is it?
15. What is the local authority doing in protecting the Forest Reserve?
16. Please any other additional contribution or information?

   Thank you.

APPENDIX C

INTERVIEW GUIDE FOR WILDLIFE AND FORESTRY COMMISION

1. How is the Atewa Range Forest Reserve important, both locally and globally?
2. In your opinion; what has been the overall change in the state of the Atewa Range Forest Reserve? Improvement or Deterioration? If deteriorated,
3. What has been the rate of destruction of the Forest Reserve recently?
4. What are the major direct drivers of the changes in the Forest Reserve?
5. What measures has been put in place by the wildlife and forestry commission to help curb this problem?
6. What are the major ecosystem services provided by the forest for the past thirty years?
7. How has this affected Ecosystem functioning and services provided by the Forest Reserve in terms of species composition and tree growth?
8. What are the factors that influence the provision of Ecosystem services both positively and negatively?
9. Is the reserve accessible to the community? If yes, why and if no, why?
10. Is the Forest Reserve a tourist site?
11. If yes, can these changes have effect on its tourism inflow?
12. If no, are there measures being put in place to turn it into a tourist site?
13. Who initiated it and how is it going to be funded?
14. What other measures are being put in place to ensure effective tourist inflow?
15. Are there effective programmes aimed at protecting the Atewa Range Forest Reserve?

16. If yes mention some of these programmes and how effective are they?
17. What other multi-stakeholder approaches are available in conserving the Reserve?
18. How do they work with the local people in an attempt to conserve the Reserve?
19. Do the local people participate fully?
20. Please is there any other contribution or information relevant to the study?

Thank you.