

**UNIVERSITY OF GHANA
COLLEGE OF BASIC AND APPLIED SCIENCE**

**STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA) AS A
SUSTAINABILITY TOOL FOR POLICY AND DECISION MAKING: A
CASE OF THE ATIWA FOREST MANAGEMENT IN THE ABUAKWA
SOUTH MUNICIPALITY OF EASTERN REGION OF GHANA**

BY

JIMMY CLIFFORD OPPONG

(10638135)

**A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES,
UNIVERSITY OF GHANA IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF PHILOSOPHY IN
ENVIRONMENTAL SCIENCE**

**INSTITUTE FOR ENVIRONMENT AND SANITATION STUDIES
UNIVERSITY OF GHANA**

JULY, 2019

DECLARATION

I hereby declare that this thesis submitted to the University of Ghana except for the references that have been duly acknowledged is an original work carried out by me under the supervision of Prof. Chris Gordon and Dr. Ted Yemoh Annang. I confirm that the results presented in this study have not been submitted to any other university or institute for the award of any degree.

.....

OPPONG, JIMMY CLIFFORD

(STUDENT)

.....

DATE

.....

PROF. CHRIS GORDON

(Main Supervisor)

.....

DATE

.....

DR. TED YEMOH ANNANG

(Co-Supervisor)

.....

DATE

ACKNOWLEDGEMENT

First to Mrs. Vivian Danquah-Adu and her entire family, my parents and siblings and all friends. Further to my academic supervisors, Dr. Ted Yemoh Annang and Prof. Chris Gordon, and A special thanks to Dr. Christine Okae Asare of the Legal Department of the Environmental Protection Agency (EPA) Ghana, for her immense support, time and advice on the progress of this study.

Further, I wish to appreciate the immense contribution of the people of Abuakwa South Municipal Assembly, the staff of Abuakwa South Municipal Forestry Commission and the entire communities who contributed to the successful completion of this work. I also express the greatest appreciation to Mr. and Mrs. Sylvester Mawusi (Snr.) for their heartfelt kindness and support throughout this entire academic period.

DEDICATION

I dedicate this work foremost to Mrs. Vivian Danquah-Adu and her entire family, most especially Fred Adu Junior, and further to my lovely niece and nephew; Nana Ama Amponsah Nimako and Katakylie Agyemang Tuffuor-Antwi. I further dedicate this work to my parents, siblings, friends, the late Grace Pie Ampratwum and my academic supervisors who have all greatly contributed towards the entire progress of this work.

Contents

DECLARATION	i
ACKNOWLEDGEMENT	ii
DEDICATION	iii
LIST OF FIGURES	vii
LIST OF TABLES	ix
LIST OF ABBREVIATIONS	xi
ABSTRACT	xiii
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background to study	1
1.2 Problem statement	8
1.3 Research questions	11
1.4 Main objective	11
1.5 Specific objectives	11
CHAPTER TWO	13
Literature Review	13
2.1 Forest resource management	13
2.2 Deforestation in Ghana	17
2.3 Causes of deforestation in Ghana	19
2.4 Implications for deforestation	21
2.5 History of forest policies in Ghana	23
2.5.1 Pre-colonial era	23
2.5.2 Colonial Era (1867-1957)	25
2.5.3 Early Colonial Period (1867-1900)	26
2.5.4 Era of Formal Forest Conservation (1900-1939)	27
2.5.4 End Colonial Days 1939-1957	33
2.5.5 Post-Independence Era (1957- Present)	35
2.5.6 Mid Post Independence Era-1994-2012	39
2.5.7 Ecological functions of forests	47
2.5.8 Rainfall and temperature regulation functions of forests	58
2.6 SEA practice in Sub-Saharan Africa	61
2.6.1 Mainstreaming SEA in Ghana	62

2.6.1 Mainstreaming SEA in Atiwa forest reserve management	64
CHAPTER THREE	69
MATERIALS AND METHODS	69
3.1 Description of the study site	69
3.2.1 Location and Size	69
3.3 Geophysical and environmental characteristics	71
3.3.1 Climate	71
3.3.2 Relief and drainage	71
3.3.3 Vegetation and soil characteristics	72
3.4	Economic activities
.....	73
3.4.1 Farming and manufacturing	73
3.4.2 Mining	73
3.4.3 Lumbering	74
3.5 Social facilities	75
3.5.1 Education	75
3.5.2 Water and sanitation	75
3.6 Research design	76
3.6.1 Sources of data	76
3.6.2 Sampling technique	77
3.7 Field data collection	78
3.7.1 Questionnaire survey	78
3.8 Ground truthing	80
3.8.1 Land cover classification and accuracy assessment	80
3.8.2 Field plots estimation for tree inventory	81
3.8.3 Forest trees sampling	82
3.8.4 Cocoa farm sampling	85
3.8.5 Litter and necromass	86
3.8.6 Soil sampling	87
3.8.7 Soil texture analysis	88
3.9 Laboratory Analysis	90
CHAPTER FOUR	94
RESULTS	94

4.1 Impact of SEA on forest sustainability management in Abuakwa South Municipality	94
4.1.1 Questionnaire Results from the Abuakwa South Municipal Assembly	94
4.1.2 Forestry commission	104
4.1.3 Communal perception of forest management	113
4.2 Land cover accuracy classification	128
4.3 Land cover classification and changes	129
4.4 Plant species composition	133
4.5 Soil characteristics	140
4.6 Relationship between forest cover, rainfall, and temperature	140
4.7 Estimation of total carbon stocks	141
4.8 Changes in carbon stock	141
4.8.1 Relationship between soil organic carbon and vegetation parameters in different land cover types	142
4.8.2 Regression model of soil organic carbon stock	143
CHAPTER FIVE	144
DISCUSSIONS	144
5.1 Impact of SEA on forest management	144
5.2 Perception of respondents on forest management	150
5.3 Rainfall and temperature changes	154
5.3. Changes in carbon stock	155
CHAPTER SIX	158
SUMMARY, CONCLUSION, AND RECOMMENDATIONS	158
6.2	Summary 158
6.3 Conclusion	160
6.4 Recommendations	162
REFERENCES	163
APPENDICES	191
Appendix 1	191
Appendix 2	201

LIST OF FIGURES

Figure 1 Area map of Abuakwa South Municipality	70
Figure 2 Macro aggregate separation.....	89
Figure 3 Micro aggregate separation	90
Figure 4 Perception of Management Plan Safeguarding Forest resources	96
Figure 5 Sensitisation Projects frequency in the Abuakwa South Municipality	97
Figure 6 Response on Climate Change Adaptation projects	99
Figure 7 State of Forest Cover in the Abuakwa South municipality	99
Figure 8 Response on the Degree of Forest Encroachment.....	101
Figure 9 Representation of Forest Plan addressing Forest management	107
Figure 10 Drivers to Forest Conservation.....	110
Figure 11 Summary of Illegal Land use activities in the Forestry.....	117
Figure 12 Summary Response on Forest Conservation Regulations Compliance	118
Figure 13 Forest Conservation Effects on Livelihood.....	119
Figure 14 Livelihood Themes Perceived to be affected by Forest Conservation.....	120
Figure 15 Summary Response on Benefit Sharing.....	121
Figure 16 Response on Awareness of Alternative Livelihood Project.....	122
Figure 17 Thematic Representation on the Perception on Forest as a Resource	123
Figure 18 Thematic Representation of the Perceptions Regarding Forest Decline ...	123
Figure 19: Perception on Rainfall and Temperature Variability in the Past two decades	125
Figure 20: Perception on the Benefits from the Forest Conservation.....	126
Figure 21: Thematic Presentation on Benefits derived from Forest Conservation....	127

Figure 22 Classified satellite image of Abuakwa South municipality showing land cover types and land cover changes for 1986	130
Figure 23 Classified satellite image of Abuakwa South municipality showing land cover types and land cover changes for 2003	131
Figure 24 Classified satellite image for Abuakwa South municipality showing land cover types and land cover changes for 2017	132

LIST OF TABLES

Table 1 External efforts in MMDA Plans and Programmes towards Forest Management.....	97
Table 2 Summary of the State Institutional Capacity in the Abuakwa South municipality	103
Table 3 Summary of the Forestry Commission’s Awareness on Forest Management Plan	106
Table 4 Summary on Awareness and Institution of Alternative Livelihood Projects.....	108
Table 5 Summary of Social Inclusion to Forest Conservation in Abuakwa South municipality	109
Table 6 Relationship between institutional parameters and forest cover	113
Table 7 Demography Summary for Respondents.....	115
Table 8 Relationship between the community’s perception and forest cover	128
Table 9 Accuracy assessment of classified images (accuracy in percentage %)	129
Table 10 Area of land cover types (km ²).....	133
Table 11 Land cover changes (km ²)	133
Table 12 List of species composition.....	134
Table 135 Mean values of woody plant dendrometric variables under different land cover types	139
Table 14 Mean Values of Soil Properties in Different Land Cover Types.....	140
Table 15 Estimated carbon stock across land cover types (Mg ha ⁻¹)	141
Table 16 Summary Presentation of Changes in Carbon Stock.....	142

Table 17 Regression model of Soil organic carbon and tree parameters 143

LIST OF ABBREVIATIONS

AFRC	Armed Forces Revolutionary Council Decree
ANOVA	Analysis of Variance
CERSGIS	Center for Remote Sensing & Geographic Information System
DANIDA	Danish International Development Agency
DBH	Diameter at Breast Height
E.A.M.A	East Akyem Municipal Assembly
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
ERP	Economic Recovery Programme
E.U	European Union
FAO	Food and Agriculture Organisation
FMMP	Forest Management Master Plan
GDP	Gross Domestic Product
GSGDA	Ghana Shared Growth Development Agenda
GSS	Ghana Statistical Service
IDA	International Development Agency
IPCC	Intergovernmental Panel on Climate Change
ITTO	International Tropical Timber Organisation
IUCN	International Union for the Conservation of Nature
L.I	Legislative Instrument
MEA	Millennium Ecosystem Assessment
MESTI	Ministry of Environment, Science, Technology & Innovation
iNDCs	Intended Nationally Determined Contributions
NFTP	Non-Timber Forest Products
NREG	Natural Resources and Environment Governance Programme
NRCD	National Redemption Council Decree
ODA	Overseas Development Agency
PPPs	Policy, Plans and Programmes
REDD+	Reducing Emission from Deforestation & Forest Degradation
R-PP	Readiness-Preparation Proposal

SAP	Structural Adjustment Programme
SEA	Strategic Environmental Assessment
UNDP	United Nations Development Programme
UNEP	United Nations Environmental Programme
UNFCCC	United Nations Framework Convention on Climate Change

ABSTRACT

Environmental degradation and the unsustainable exploitation of non-renewable resources continue to increase to satisfy socio-economic demands which call on a National Development Agenda to make use of Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) as sustainability tools imperative. The use of these tools is to balance environmental and economic sustainability with institutional capacity building, and social cohesion to direct the sustainable management of natural resources and development planning. A study to assess the role of Strategic Environmental Assessment (SEA) as a sustainability tool in managing the Atiwa Forest reserve and its resources is reported in this thesis. The Atiwa Forest reserve, located in the Abuakwa South Municipality in the Eastern Region of Ghana, is one of the few primary highland forests in West Africa and the only remaining type in Ghana. It is also a biodiversity hotspot in the IUCN biodiversity conservation list, and serves as the source of 3 major rivers in Ghana; Birim, Ayensu and the Densu Rivers, which together serve the potable water needs of about 20% of Ghana's population. The Atiwa Forest reserve is known to be holding a chunk of the nation's minerals like bauxite, gold, diamond, and kaolin, which is currently being targeted by the Government for massive exploitation, especially bauxite, to drive the nation's developmental agenda. Specifically, the study determined the readiness of the Abuakwa South Municipal Assembly to mainstream SEA in the sustainable management of the natural resources of the Atiwa forest. Further, community perception on this level of sustainability of forest management was assessed, as well as rainfall and temperature variability in relation to forest cover. Finally, carbon stock of

forest trees and soil were assessed in three land cover types as part of Ghana's efforts to meet its intended Nationally Determined Contributions (iNDCs), an obligation in the Paris Agreement (2015). The research employed simple random and purposive sampling methodology for data acquisition, sought the knowledge of local communities and the formal institutions related to managing the resource as well. Landsat imagery was acquired for the years 1986, 2003 and 2017 to analyze the trend in land cover changes in Atiwa forest. Allometric standard methods were used to estimate tree biomass and carbon, necromass biomass and carbon and carbon stocks of soil (Chave *et al.* (2005); Pearson *et al.* (2005); Walkley-Black (2015) and Pearson *et al.* (2005). Expansion factor on per hectare scale and the potential carbon weight that could be lost to the atmosphere were estimated using the Walker *et al.* (2011) equation. A one-way ANOVA was performed to determine the mean differences between various environmental (ecological and social) parameters as well. Results indicate that SEA mainstreaming in the Abuakwa South Municipal Assembly is being fairly implemented, with public participation, institutional capacity building (in operational logistics) as well as economic sustainability (alternative livelihood support projects) lacking. In addition, there is a significant improvement in forest cover (2003 to 2017) after a significant decline from 1986 to 2003. Further, the state of the forest has improved as of 2017 by a significant margin with a consequent improvement in tree carbon stocks between 1986 and 2017 although bare/settlement land continues to increase since 1986. Results from Pearson correlation between soil organic carbon and tree parameters (height, density per hectare and *dbh*) showed no significant correlation to the value of $p < 0.01$. The highest correlation was 0.950 tree density per hectare with

the least value of tree height at 0.007. Similarly, simple and multiple regression analysis between soil carbon and tree parameters showed coefficient determinants to be 0.008 and 0.260. The highest adjusted R^2 for coefficient determination was 0.054 which was recorded for tree height only, tree height and tree density per hectare, tree height and diameter at breast height as well as tree height, diameter at breast height and density per hectare. The least adjusted R^2 for coefficient determination was recorded for tree density per hectare only at -0.015.

Findings from the study, however, did not agree entirely with the progress and success of SEA specifically on the Atiwa Forest reserve management as indicated in the 2014-2017 Medium Term Development Plan report of the Abuakwa South Municipality. The report showed steady efforts in maintaining environmental sustainability which corroborated the findings of the study. Also, results on other pillars like social inclusion and institutional capacity building in conserving the forest reserve showed poorly in the findings of the study which did not corroborate the progress report of Abuakwa South Municipality for the 2014-2017 Medium Term Development Plan. The relationship between soil organic carbon stock, tree density per hectare, tree height and tree diameter at breast height were statistically not significant at 0.950, 0.007 and 0.88 respectively. These were similar to the findings of Zhou *et al.* (2012), Li *et al.* (2013) and Djagbletey (2015). The study concluded there is a fair level of implementation of Strategic Environmental Assessment in the management of natural resources within the Atewa Forest which was evident in the significant increase in forest tree stocks and its subsequent increase in tree and soil carbon stocks. Nonetheless, it is recommended that the Government must strengthen its economic sustainability framework to decrease

extensive exploitation on the forest cover. Finally, benefits accrued from the conservation must be equitably shared with the forest communities to ensure social inclusion and promote participation in the efforts towards conservation of the forest.

CHAPTER ONE

INTRODUCTION

1.1 Background to study

Globally forest resources are generally the source for satisfying most of the economic, social and cultural needs of people. These resources play a vital environmental sustenance role and are critical to sustainable development. They provide major ecosystem benefits and services, which can be quantified in economic terms for economic growth and development with its associated cultural essence for traditional values. Forest reserves provide essential services that ensure the security of water supply, the provision of favorable conditions for the cultivation of agricultural crops and the promotion of public education and research (Ghana Forestry Commission, 2016).

In view of the importance of forest resources in Ghana and the need to employ appropriate measures in their exploitation, various national development policies encompassing forest estate creation and the timber industry's sustainability have been developed and implemented by previous governments to ensure that the citizenry enjoys the optimum benefits from forest resources. These policies have been introduced since 1948, with a focus central to create permanent forests. Further, forests serve as a hub for the abundant earth mineralogy globally and as wildlife habitat. This partially explains why most of the mining companies and other artisanal and small scale mining are situated in the forest belts of the country.

The history of forest resource management policies can be traced back to 1906 when parliamentary legislation created a Forest Department to oversee and manage the felling of commercial tree species (Degrassi, 2003), and this legislation, thus created the then Forest Department which had been the Forestry Commission since 1908. The entire forest area demarcation and reserve creation were largely completed in the year 1939 and a forest resource management policy was adopted in 1948 (Ghana Forestry Commission, 1994). These demarcations and forest reserves were to eventually set the stage in strengthening Ghana's economy to ensure the constant supply of natural capital through the creation of favorable conditions in the growth of agricultural crops, protection of water resources, public education and scientific research (Boon and Ahenkan, 2008). Consequently, the government allotted 3,267,250 hectares of forested lands as a permanent forest estate (Boon and Ahenkan, 2009). These early policies therefore only guaranteed a continued supply for economic tree species for the timber market which rather led to a constant decline in the forest cover of unreserved forest areas. Despite the reduction in forest stock, it has immensely contributed to the national economy through the provision of raw materials for agro-based industries, serving as a source of formal and informal employment avenues, and providing other livelihood necessities among other factors (Forestry Commission, 2016; Quacou, 2017). These reasons among others account for the increase in demand for the nation's forest resources, consequently influencing the decline of forest cover.

In its efforts to restore the nation's vegetation cover, the 1994 Forest and Wildlife policy were enacted to replace the 1948 Forest Policy. This new policy was targeted to

achieve forest conservation and protection of forest reserve estates (Ministry of Land and Natural Resources, 2012). Further, the new Forest and Wildlife policy was also to ensure environmental protection, sustainable production and judicious use of forest and wildlife resources, local/community participation in forest management, primarily concerned with benefit-sharing, institutional restructuring and finally the promotion of research and human resource development (Ministry of Lands and Natural Resources, 2012). The policy was implemented under a Forestry Development Master Plan (FDMP) and its implementation themes sought strategic approaches to integrate good governance, transparency, and equity and poverty reduction. However, these themes were not achieved after almost two decades of policy implementation due to forest resources continual over-exploitation at an alarming rate, contributing to GDP losses of about 10% (World Bank, 2006).

Ghana's forest cover was once estimated to be about 36% (84,000km²) of its total landmass (E.U, 2006). In this expanse of forest cover, reserve spots were created to protect water sources, protect fragile soils and biodiversity species (UNEP, 2002; FAO 2007). The once wide forest cover has been declining at a rate of 2% annually which is principally owed to major deforestation activities through legal and illegal activities (Boon *et al.*, 2009). With the rate of demand for forest resources surging until current times, the forest cover of the nation is gradually dwindling in the off-reserve spots

In addition, a study by Ghana Forestry Commission (1994) and Boon and Ahenkan (2009) estimate the aggregated rate of forest decline is on average of 81,000km² which

accounts for about 40% in the entire forest cover. Further assertions by Ghana Forestry Commission (1994) and Siaw (2001) give an account of reserved forests now host about 11,590km² of productive forest species, 4,323km² of protected forest species and about 1,980km² of game production reserves. Further, the loss of forest cover in Ghana between 1990 and 2005 is estimated to be 1.9 million hectares, this is about 26% of the entire forest cover of the country (Boon *et al*, 2009). This led the government to implement a plan to reforest 20,000 trees per hectare annually since most of the forests in the country have lost their interior pristine characteristics (IUCN 2006; Domson & Vlosky, 2007).

However, the trend in forest loss is of concern to the current global development context and has been enshrined in the African Union Agenda of 2063 and the Sustainable Development Goals Agenda of 2030. The operationalization of the Sustainable Development Goals incorporates the principle of Strategic Environmental Assessment (SEA) in ensuring the effective and efficient institution of active frameworks for national development. In these development frameworks, environmental protection and conservation are primarily integrated into socio-economic development matrice. Currently, the role of SEA in development has transcended the straightforward approach of merely evaluating environmental impacts of policies, plans, and programs (Therivel *et al.*, 1992), to a sophisticated model of providing guidance to development decisions in achieving sustainable development (Noble, 2002).

Generally, the aims of SEA is to direct higher-tier decision making in development by designing policies, plans, and programs (PPPs) which incorporates fundamental guiding principles to achieving sustainability, creating new knowledge and learning avenues and increasing the participation of a wide range of actors in the national development decision making (Noble, 2002; Therivel, 2004).

The proposition for a new Forest and Wildlife Policy was therefore partly due to Ghana's efforts to mainstream SEA in its national development in general and the exploitation of its natural resources in particular. The new 2012 Forest and Wildlife Policy apparently contains similar objectives as that of the pillars of the SEA; social inclusion, institutional capacity building, environmental sustainability and economic sustainability in managing all forests in Ghana (Forest Commission, 2016). The policy document was implemented through an over-arching 20 year Forest Development Master Plan which fitted into the National Poverty Reduction Strategy of the Ghana Shared Growth Development Agenda 2 (GSGDA II) and the current national development policy (Agenda for Jobs-2018-2021).

The new 2012 Forest and Wildlife Policy in conjunction with such legal frameworks like the Forestry Commission Act 1960, Forest Improvement Fund Act 1960, Concessions Act 1962, Forest Ordinance for the Protection of Forests including Reserves of 1972, Trees and Timber (Chainsaw Operation) Regulations of 1983, Administration of Land (Amendment) Decree of 1984, Forest Products Inspection Bureau Law of 1985, Forest Protection (Amendment) Law 1986, Economic Plants

Protection Act, 1979 (AFRCD 79), Control and Prevention of Bushfires Law of 1985 and the Trees and Timber Regulation of 1991 now serve as a composite guiding tool for forest resource management in Ghana. Some of these Acts of Parliaments are vested in separate sector ministries and agencies for implementation, but nevertheless, still, maintain the central focus of environmental sustainability. The management of forest and wildlife resources, in general, has been under the aegis of the Forestry Commission which coordinates the activities of the various institutions of the forestry sector; the Services Division, Wildlife Division, Timber Division, and Timber Industry Development Division. Under these departments, the Commission is mandated to manage and regulate all forest resources utilization as well as coordinate all policies relating to Forestry Commission (Ghana Forestry Commission, 2015).

In addition, the principles of the forest policy chiefly address the promotion of equitable allocation of forest resource benefits, supporting rural livelihoods, realigning forest sector institutions to suit all stakeholder expectations without compromising ecological functions and environmental integrity (Ministry of Lands and Natural Resources, 2012). Efforts to incorporate this strategy in the policy, therefore, rests largely on the bottom-up governance approach style where decentralized administrative institutions are expected to draw up development plans and programs to reflect how best they can achieve economic growth (Ministry of Lands Natural Resources, 2012). In such management style, sustainability planning is guaranteed within the context of SEA since the fundamental pillars to the concept are ensured in the Forest and Wildlife Policy as central themes (Therivel, 2004)

In considering the perspective of forest management and sustainable environmental resources governance, the Abuakwa South Municipality is one of the prime focal areas in Ghana because of its location. Abuakwa South Municipality is most notable for agriculture and mining (E.A.M.A, 2010). Further, the municipality has 15% of its entire landmass to be forested and sheds the source of three major river courses in the country, namely; the Birim River, Ayensu and the Densu River. The forest in the municipality also has within its demarcated zone the Atiwa forest reserve, which is estimated to be approximately 108.8km².

In recent times, the upsurge in mining activities in the municipality is seriously competing with other land uses especially agriculture. As a result, the demand for land for other subsistence needs violates the principle of the Forest Protection Act (N.R.C.D. 243). This creates a challenge for the nation on its efforts to meet its carbon reduction obligation to the Paris Agreement. According to a study by Todaro and Smith (2009), deforestation and vegetation degradation contributes greatly to the phenomenon of global warming by contributing about 25% of all global carbon dioxide emissions. This indicates that forests are key carbon sequesters, and they produce the needed oxygen to keep the optimum air cycle. They also influence temperature and rainfall variability patterns. In an effort to safeguard the forest covers of the country, it is imperative for administrative institutions to include and enforce environmental sustainability principles to compensate for other land use activities that lead to forest degradation and depletion.

In the process of curtailing environmental degradation, specifically forest degradation, management efforts must concentrate on incorporating SEA in the Municipal Medium Term Development Plan and how best its principles are been operationalized. This concept is to maintain environmental integrity and quality as well as providing sustainable economic alternative livelihood methods.

This significance of the study is foremost premised on the fact that it is to inform policymakers on the role of SEA in enhancing forest and environmental sustainability. In addition, it will also inform policymakers on the performance of SEA in the Abuakwa South municipality since its inception. Secondly, the study is necessary with regards to informing the indigenous people's appreciation of SEA principles in local developments and their contribution to the realization of such developments. Thirdly, it will contribute to meteorological information on the relationship between forests and climate variability. Lastly, the study will contribute to carbon accounting for aboveground biomass, providing an adequate basis for Ghana to record its intended Nationally Determined Contributions (iNDCs) towards the Paris Agreement obligation.

1.2 Problem statement

Forest cover decline in tropical regions has created problems associated with the loss of biodiversity, an increase in atmospheric carbon inducing climate change, as well as erratic rainfall and temperature patterns. Among other major implications of a forest, cover decline is the general reduction in economic growth as forests, and the general

environment provides ecosystem goods and services or natural capital to sustain the national economy.

In Ghana, for instance, the contribution of forest resources to economic decisions dwells highly on traditional natural resource governance, which hinges on the fact that collectively forestry, wildlife, and mining contribute about 15% of total GDP, and 60% of foreign exchange earnings to the national economy (UNDP, 2015). Further to this, it has been shown that Foreign Direct Investment (FDI) in these streams of economic inputs has been on the rise from US\$1.3 billion in 2005 to US\$3.2 billion in 2013 (UNDP, 2015).

The economic viability of these resources, however, is linked to its availability which by virtue of constant exploitation is causing the decline in products like timber stocks, wildlife, reduction in carbon sinks contributing to atmospheric carbon accumulation (Chave *et al.*, 2007), and changes in temperature and rainfall patterns regimes. The principle of SEA is, however, necessary to evaluate general national development policies where environmental sustainability is considered paramount.

Focusing on the Atiwa Forest reserve, it is found in the Abuakwa South Municipality which is one of the socio-economic diverse hotspots in Ghana. It is an area well known for its mining, farming, hunting and lumbering activities. Nonetheless, in the recent past, mining activities have been rampant in the Municipality. In a study by Obara and

Heledd (2006), it was revealed that illegal mining activities are causing immense vegetation degradation to the Atiwa forest reserve. Further, studies reveal that illegal mining activities are affronting environmental quality in the municipality, affecting vegetation stock, water quality, soil quality and biodiversity conservation (E.A.M.A, 2015). Schep *et al.* (2016) opine that illegal mining activities or galamsey in Ghanaian parlance in the Municipality has been a major threat to the Atiwa Forest, cash crops major rivers and streams serving as potable water to the inhabitants of Municipality.

Hitherto, studies in the Atiwa Forest reserve have largely focused on small-scale mining and its social and environmental consequences. For instance, such studies as regarding soils and water resources (Aryee *et al.*, 2003), gender roles and child labor issues (Hinton *et al.*, 2003; Hentschel *et al.*, 2003) and technical and legal frameworks (Amankwa & Anim-Sackey, 2003). Despite these efforts, issues of alternative livelihood support for indigenous people within the framework of SEA, and aspects of clean development mechanism in carbon accounting as a climate change mitigation strategy has not been thoroughly investigated in the Abuakwa South Municipality with regards to the Atiwa Forest conservation. This study, therefore, seeks to investigate how the adoption of SEA in the development agenda framework in Ghana is been employed in the Abuakwa South Municipality to ensure sustainable management of the Atiwa Forest. Further, the study seeks to determine the ecological role of the Atiwa Forest as a carbon sink in facilitating Ghana's efforts to cut down greenhouse emissions and conserving biodiversity.

1.3 Research questions

In a bid to achieve the research question objectives the following research questions became prudent.

- a. How does the municipality mainstream the practice of strategic environmental assessment in its development plans?
- b. What is the communities' perception of forest management and resource exploitation?
- c. What is the rainfall variability pattern in the past thirty years?
- d. What is the temperature variability pattern in the past thirty years?
- e. What is the trend of forest cover depletion in the Abuakwa South municipality?

1.4 Main objective

The main objective of the study is to evaluate the extent to which strategic environmental assessment is influencing forest management in the Abuakwa South municipality as a means of answering the research questions.

1.5 Specific objectives

Specifically, these following objectives have been set to help achieve the general objective;

- a. To assess the influence of strategic environmental assessment in the District Medium Term Development Plans in the Municipality.
- b. To determine municipality's perception on forest resource management.

- c. To evaluate rainfall variability patterns against the trend of forest cover changes in the last two decades.
- d. To evaluate temperature variability patterns against the trend of forest cover changes in the last two decades
- e. To estimate the tree and soil carbon stocks.

CHAPTER TWO

Literature Review

2.1 Forest resource management

Forest resource management as explained by the United Nations (2007) refers to a dynamic concept that seeks to improve socio-economic and environmental values through forest conservation to guarantee the perpetual provision of utility services to all generations. Forest resource management in effect deals with the conservation of the forest ecosystem which includes all woodland units consisting of all plants, animals, and microorganisms functioning together with the non-living components of the biosphere and the products of such interactions (Quacou, 2017).

Forest management principles thus, embody the codes and conducts as well as the possible actions that emanate from policy towards the formulation and enforcement of the best practices related with particular focus on its sustainability together with social cohesion, economic value, environmental value and institutional and citizenry capacity building on management (ITTO, 2015).

A study by Attah (2014) observed that forest products provide about US\$450 billion annually to the world economy, indicating how beneficial proper management of forests will impact positively on global socio-economic growth and development. This sets the underlying premise upon which ITTO advocate for the incorporation of best forest management practices to include themes like forest governance and security of tenure, land use planning and permanent forest estate management planning, ecological resilience planning, ecosystem health and climate change adaptation, social values and

community involvement and lastly investment in natural forest management and economic instruments (ITTO, 2015).

The state of forest management practices in Ghana has not been impressive in the past decades due to the increased rate of indiscriminate forest resources exploitation (Boon and Ahenkan, 2009). This reason has been explained to be stemming from the disregard for the environmental benefits of forests, but dwelling entirely on their economic returns (World Bank, 2013). In their study, “Forest and Economic Development”, the World Bank indicated that market forces do not capture the environmental value of forests but rather put much emphasis on their economic values, making the valuation of forest products purely utilitarian. This purported reason, however, influences the rate of vegetation decline in the tropical belts of Africa. Further to this finding on the causes of the decline of forests in Ghana, is the establishment of the fact that there is a dis-coordination between policies from different institutional sectors of the national administrative framework and actual management practices.

However, in assessing forests as part of national development indices, forests are assimilated into socio-economic and cultural life patterns of the people of Ghana (Ministry of Lands and Natural Resources, 2012). This overarching emphasis on forests contributes to their widespread exploitation (Forestry Commission, 2017). It is estimated that the ecosystem benefits and services provision of forests offer sustenance and revenue to about 2.5 million people of Ghana (Boafo, 2013). According to Amisah *et al.* (2009), due to this fact, there has been a drastic decline in forest cover in Ghana

from the period of 1990-2005, where a quarter of all the forests in Ghana have been lost. This fate of poor forest management practices has been related to poor collaboration between stakeholders and policymakers in forest resource management (Boafo, 2013).

In other findings relating to the rate of vegetation degradation, population increase and settlement expansion have been asserted to have a strong correlation factor to forest decline (World Bank, 2014). Further, poverty and the inability to afford clean sources of energy culminates in the demand for wood fuel and charcoal by forest-dwelling communities which advertently contributes to forest loss (Yachori, 2017). Based on this is a matter of reckoning for nations to achieve at least an optimum success of meeting sustainability threshold in managing forests with regards to meeting socio-economic demands. Such optimum achievement induces developmental efforts to at least satisfy on all seventeen Sustainable Development Goals (SDGs). To achieve this, efficient approaches call for a strategic effort to plan, guide and monitor all stated national development policies in a sustainable direction (Abubakari *et al.*, 2018).

Some of the reasons supporting the reduction of the rate of forest resources exploitation mostly concerns timber harvesting because of its carbon sequestration potential. Carbon emission reduction is of great concern to this current generation due to imminent climate change effects. Remediation plans to cutting down climate change precursors have been proposed by the United Nations through the agency of the United Nations Framework Convention on Climate Change (UNFCCC), which some concerns

maintaining forest covers as carbon sinks. The objectives spelled in this convention include reducing carbon dioxide emission from countries with industrialized economies and countries in economies transition (Annex 1 and Annex 2 countries), promoting green and sustainable development in developing countries (Non-Annex countries) and reducing emission from deforestation and aspects of land degradation through the advocacy of conservation programs and carbon stock management (Kashaigili & Majaliwa, 2010).

Initiatives to reduce carbon emission and forest degradation have principally been under different programs like the REDD and in current implementation the REDD+, with a central value to create incentives to motivate forest communities who are the major stakeholders to employ safe approaches to forest resource exploitation and to better manage forests to improve the efforts on climate abatement (Sandker *et al.*, 2010). Ways to ensure the implementation of the REDD+ initiative include among other streams of factors the ability to map the carbon stock potential of the forest ecosystem and the possible stream of factors that could inhibit the longevity of the forest ecosystem as a carbon sink. This among other reasons is the main global concern to protect forest ecosystems and create sub-national development frameworks that incorporate the pillars of SEA as the fundamental arena in pursuance to economic growth and development.

2.2 Deforestation in Ghana

Deforestation refers to the removal of forests for some other spatial uses or the continuous reduction in vegetation cover in a particular spatial region (FAO, 2009). Quacou (2017) defines deforestation as the clearing, destroying or removal of vegetation, either deliberate or by accidental means. This phenomenon has gained global attention in recent decades owing to its adverse ecological and environmental consequences.

The issue of rapid forest loss in the general sense is troubling in Africa considering the ecological and environmental reasons that associate with it. Deforestation has been known to be widespread mostly in developing countries, leading to an annual tree loss of about 13 million hectares (Boafo, 2013). Ghana, for instance, records deforestation principally due to agriculture-related land use with a 28.5% loss in GDP per annum (Forestry Commission, 2014).

Mineral exploration in the forest regions of Ghana is also noted to account for significant deforestation of about 6% of the country's GDP per annum (Forestry Commission, 2014). Further, the Forestry Commission (2014) has revealed that other aspects of environmental degradation are said to account for 5-10% of the total cost of GDP while forest degradation alone accounts for about 63% of GDP cost, which is equivalent to US\$ 500 million.

The trend of forest loss in Ghana shows that if current management best practices are not effectively enforced, there could be the total destruction of all forests in the country

in the next 25 years (ITTO, 2005). The FAO in a more popular analysis has opined that forests in Ghana currently cover a spatial area of about 21.7% (which is equivalent to 4,490,000 hectares) out of which 395,000 hectares (8%) stand classified as high carbon-dense and biodiversity-rich zone (FAO, 2010). However, it is estimated that between 2005 and 2010 deforestation in this zone stood at 2.19% per annum, which was the highest in the global deforestation trend.

This situation thus attests to the fact that 2.5 million of the people in forest communities in Ghana rely on forests for timber and Non-Timber Forest Products (NTFP) for livelihood assets (Acheampong & Marfo, 2011; Appiah 2009; Asamoah *et al.* 2007). These sources opine that most people who live in the forested communities have their livelihood predicated on the forests and as such contribute to the rate at which forest cover is on a decline in Ghana. This reiterates the view that deforestation is principally caused by anthropogenic activities (Quacou, 2017). Further to this, deforestation in Ghana is estimated to be the highest in the Sub-Saharan region of Africa (World Bank, 2013). Further to this, forest products dominate the socio-economic development assets in urban areas. A study by Appiah (2009) asserts that household income from forest products is 38% more than other income-generating activities in a survey conducted in three forest district communities in Ghana.

Notwithstanding the socio-economic benefits associated with forestry in Ghana, the over-reliance on it for mass exploitation has shown clear signs that it will be detrimental to the state of environmental development. For instance, it has been recorded that

between the years of 1990 and 1999, an estimate of 6.5 million hectares of forests has been degraded in Ghana out of about 18 million hectares (World Bank, 2013). Similarly, a report by the International Tropical Timber Organisation (ITTO) in 2005 observed that total deforestation of 65,000 hectares occurs annually in Ghana. The FAO in 2010 also pegged the annual deforestation rate in Ghana to be 135,935 hectares. The FAO further reported in 2011 estimating forest loss to be about 125,400 hectares from 1990-2010. Amisah *et al.* (2009) also opined that Ghana has lost about 26% of its forest cover, which estimated to be about 1,931,000 hectares of the entire forest cover in Ghana from 1990-2005. In total, Ghana has lost an average of 33.7% of its forest cover which corresponds to about 2,508,000 hectares (FAO, 2011). (Forest Commission, 2017) estimated the total forest lost to be about 4.7 million hectares between the years of 2001-2005.

These predictions and revelations clearly indicate that policies and best practices have been poorly implemented with associated abysmal enforcement which can be explained by, poor implementation of forest management, with abysmal enforcement strategies integrated into national development goals in both colonial and post-colonial regimes of Ghana.

2.3 Causes of deforestation in Ghana

The motivation behind deforestation is of socio-economic nature that reflects the essence of livelihood issues and general economic growth and development across all sectors of the economy (Guuroh, 2010). In Ghana, deforestation is reported to be predominant due to anthropogenic activities (Forestry Commission, 2016). Factors

underlying deforestation in Ghana has been differentiated between the geographic regions, for instance, the characteristic reasons that contribute to deforestation in certain parts of the Southern regions has been attributed to mining, timber logging, and agriculture as the predominant motivators (Boafo, 2012), whereas the northern sector experiences deforestation based on woodfuel harvesting, forest fires and agriculture expansion (Agyeman *et al.*, 2012).

Without a more rigorous mitigation and law enforcement plan, the state of deforestation is not likely to decrease owing to the percentage of Ghanaians engaged in farming to be 60%, and the population increase coupled with a consequent increased demand for forest products, space for settlement, wood for fuel and food (Amisah *et al.*, 2009). According to a report by Quacou (2017) agriculture land occupied about 31,552km² in 1975, increasing to about 61,998km², an increase of about 96.5% in the late 20th century (Quacou, 2017). Also, in 2014 alone timber exports ranked as the highest foreign exchange earner with earnings from 249,846m³ of felled timber (World Bank, 2006). This indicates tree felling has been motivated entirely by economic gains.

Understanding the concept of reforestation and forest conservation from the perspective of Abuakwa South municipality led to the inception of the local strategic environmental assessment framework to be a guide to the local policies, plans and projects (PPPs) for the period between 2014-2017 (E.A.M.A, 2014). This framework was to evaluate the rate of environmental degradation and ensure indigenous and local capacity building in promoting clean development (E.A.M.A, 2014). In spite of the

terms and objectives of the local SEA objectives, the community still recorded rapid deforestation arising from woodfuel harvesting, agriculture expansion and illegal mining (E.A.M.A, 2015).

As part of national efforts to curtail the rapid incidence of deforestation especially in the forest communities, the REDD+ program offered incentives to drive national efforts to achieve a low-carbon environment economy (Asare & Kwakye, 2013; Forestry Commission, 2016). Part of the aims of the REDD+ project is to focus on the “Business as Usual” scenario in the communities where deforestation and unsustainable land management is on the rise (Asare & Kwakye, 2013). Understanding the continued existence of deforestation and unsustainable land use management in the Abuakwa South municipality can be known by exploring the predominant cultural occupations and the social lifestyle patterns of the indigenous people in the framework of the business as usual scenario.

In the process of exploring the dominant traditional occupations and other land use activities, it is imperative to understand the Abuakwa South Municipality’s role in mainstreaming environmental sustainability and socio-economic sustainability as a means to satisfy on all key tenets of sustainability planning.

2.4 Implications for deforestation

Forests in Ghana are classified into three main ecological areas, namely; Dense Vegetation Zone, Transition and Semi-Deciduous Zone and Savannah and Grass Zone (Forestry Commission 2016), with the delineation based on rainfall and temperature

distribution regimes. Forest in the Abuakwa South municipality falls within the Semi-Deciduous Zone, which dominates the middle and southeastern sectors of the country. It is one of the hotspots for biodiversity in West Africa (Schep *et al.*, 2016; Forestry Commission, 2016).

The current rate of deforestation in Ghana is 3.51% and mainly due to mining, agricultural encroachment, illegal and legal logging, woodfuel harvesting, wildfires and infrastructure development (Forestry Commission, 2017). This phenomenon is taking place at the expense of the nation's forest stock, contributing immensely to the rate of desertification of Sub-Saharan Africa (World Bank, 2014).

Deforestation in forest communities in Ghana has become widespread and it is negatively impacting the provisioning and regulating ecosystem services forest communities enjoy (Acheampong & Marfo, 2011). The reduction of forest cover has also reduced levels of non-timber forest products forcing forest community dwellers to travel long distances into forests to access such services (Bosu *et al.*, 2010). In addition, it affects above-ground biomass stock and influences the net emission of carbon into the atmosphere, thus facilitating the incidence of sudden climate dynamics. For instance, it has been estimated that emissions from land use and land cover dynamics account for 20% of all carbon emitted into the atmosphere (Pearson *et al.*, 2005). Details of the progression of carbon stocks in terrestrial biomass are estimated to have decreased from 564 metric tons in 1990 to 381 metric tons in 2010 (World Bank, 2014). Further, the recent estimation of carbon emissions from terrestrial biomass, deforestation accounts for about 15% of all carbon emissions from terrestrial biomass

(Forestry Commission, 2016). In effect, the result of carbon emissions giving rise to the evidence for climate change patterns is dominantly associated with temperature and rainfall variability (Ghana Forestry commission, 2017).

Consequently, the rate of forest loss and the threat of imminent climate change and its associated negative effects has led to the creation of forest reserves to forestall the environmental, cultural and socio-economic significance of forests. In this respect, there is however the need to assess forest management practices within the matrices of local participation, institutional capacity building on monitoring and evaluation as well as the socio-economic growth and environmental accounting within Abuakwa South municipality.

2.5 History of forest policies in Ghana

This understanding of the historical pathways that have accounted for forest resources exploitation and how management regimes of both the formal and the informal/traditional sectors have been instrumental from the pre-colonial times until now is very important. It further brings to the fore the functions of past foreign policies and legislative instruments that have been useful in forestry governance in Ghana.

2.5.1 Pre-colonial era

Much emphasis has been placed on the role of the colonial regime for giving impetus to the formalization of forest governance in Ghana. Nevertheless, this fact should not disregard the actions of native Ghanaians in safeguarding their territorial lands and forests (Boafo *et al.*, 2016).

Native Ghanaians' effort towards forest protection focused on protecting trees along banks of water bodies and other spatial territories like sacred grooves to protect trees and wildlife species in line with customary preference and essence (Kotey *et al.*, 1998). This adopted traditional practice led to ascribing waterbodies, forests and certain wildlife species as fetishes. Currently, in Ghana, it is still estimated that at least 2000-3200 sacred forest groves exist, where the majority is being hosted in the northern regions (Boadi *et al.*, 2017). Accounting for the contribution of indigenous forest protection strategies, original forest estates forests in Ghana is now estimated to be about only 1% out of which predominantly contains sacred groves. This proves the success and contribution of indigenous strategies in protecting vegetation in pre-colonial times.

From a global perspective, the Millennium Ecosystem Assessment (MEA) stresses the importance of local knowledge and practices that enhance forest, wildlife and environmental sanity (Millennium Assessment, 2005). Anane (2015) asserted that before the industrial revolution and urbanization, traditional societies preserved their forests with their cultural norms and ethics, which proved efficient. Further, Asante (2011) opined that several forest reserves in Ghana are testimonies to show the effectiveness of socio-cultural beliefs in forest conservation.

This, however, strengthens the belief that in the era of pre-colonial Ghana, forest conservation was purely based on traditional norms and practices that reflected the traditional identity and spiritual union with the natural environment. According to Jimoh *et al.* (2012), these socio-cultural practices of forest conservation proved to be cheap on time and energy resources.

However, despite these efforts of the traditional councils to conserve forests in the sacred groves and along banks of water bodies, no evidence precludes the exploitation of forest timber and its other resources in the off-reserve forest zones (DeGeorges and Reilly, 2008). The Forestry Commission (2016) account that the exploitation of cola nut in Ghana to Europe and other sub-Saharan African countries started as far back as the late 15th century. This trade is known to have contributed to the demand for a large expanse of land for cash crop agriculture cultivation. Additionally, the discovery of oil palm in the Eastern region is noted to have influenced the destruction of a large expanse of forest lands by the Krobos and the Akuapems for the cultivation of oil palm trade.

In this vein, Fairhead and Leach (1998) and Teye (2008) reveal that the chiefs and traditional councils of the native territorial areas were mainly responsible for the depletion of Ghana's forest stock because they were the main people to grant the right of access to lands and forests. In conclusion, pre-modern forest conservation did not consider objective scientific imperatives but rather was focused on subjective communal economic interests and maintaining local traditional values and ethics (Fairhead and Leach, 1998). Many scholars, however, have argued that the extent of socialization between western colonial economics and local social lifestyles relegated traditional ethics and customs in forest management (Berkes, 2012).

2.5.2 Colonial Era (1867-1957)

The colonial era in Ghana is grouped into three regimes. The initial administration of the colonial government was not focused on an actual stated policy but was more of the concern of natural resource exploitation. In the subsequent administration phase, a

stated policy of conservation and judicious exploitation and utilization was adopted, whilst the third administration phase operated like the initial regime. It was greatly concerned with resource exploitation before the first formal stated national policy was introduced in 1948.

2.5.3 Early Colonial Period (1867-1900)

During the initial times of colonial administration in Ghana, the forestry sector was governed with no clear stated principles of policy (Teye, 2008). It was basically administered through the exploitative stimulus to meet the economic demands of the colonial masters. The demand for valuable forest resource products led the colonial masters to speculate the forest zones of Ghana in pursuit of rich economic resources (Parren and Graaf, 1995).

In such pursuits, Kortey *et al* (1998) opine that poor road infrastructure leading to the interior regions of the country made the inland forest belts inaccessible resulting in a concentration of attention on the coastal forest zones. The rate of timber exploitation in this era revealed that the colonial masters were purely utilitarian to exploit the forest stock of Ghana.

As part of the strategy to increase control in forest exploitation, the Crown sought to lay claim to all lands in the colony by vesting all mineral lands, forested lands and wastelands in itself leading to the creation of the Crown Lands Ordinance (Degrassi, 2003).

Nevertheless, this initiative by the colonial government was met with strong opposition from the indigenes under the organization of the Aborigines Rights Protection Agency, which protested that lands and resources in the state were ancestral heritage handed to them by their forebears (Degrassi, 2003). Thus, in 1898, the British crown adjudicated in favor of the natives to control their lands and resources through their traditional authority (Kortey *et al*, 1998).

2.5.4 Era of Formal Forest Conservation (1900-1939)

In the mid-20th century, environmental concerns came to dominate the world's development focus and resources governance (Grove, 1997). In the era of early 1900 in Ghana, there were no formal forest conservation policies and initiatives from the colonial government (Degrassi, 2003), and lands and resources were dominantly customarily owned with colonial influences in the form of indirect rule dictating the patterns of forest and natural resources exploitation and utilization.

However, during this era, H.N Thompson, who was the conservator of forests for British colonies of India and Nigeria (Teye, 2008) instigated the wave of growing environmental concerns in Ghana. His influence was to incite the colonial government to regulate forest exploitation through the regulation of concession rights during the period of the early 1900s since no forest lands were under formal reservation. The idea to his advocacy was that the administrative government must attempt to effectively respond and utilize the ecological and social context in which they exist to solve developmental problems and to take cognizance of the finiteness of the ecological and

the environmental thresholds of natural resources with regards to human dependence on it (Juma, 1996).

The institution of restriction on forest resource exploitation established the first timber harvesting regulation (Teye, 2008). Another regulatory framework was also constituted, the Timber Protection Ordinance of 1907, to protect and prevent the logging of immature trees and indiscriminate tree felling in general. In the Timber Protection Ordinance, forest personnel was recruited to accompany licensed lumbermen to inspect trees before they were felled. Advocacy by Thompson also led to the creation of the Forest Department in 1909 to supervise and manage all forestry sector resources.

The impacts of the environmentalist concerns in promoting sustainable forest resources utilization also contributed to the moderation of weather and climate which promoted the cultivation of cocoa, kola and oil palm (Teye, 2008). This has been beneficial since colonial times to date, a reason to sanction decisions towards forest reserve creation. The correlation between forest cover, climate moderation, and tree crop cultivation was affirmed by Degrassi (2003) who stated that forest degradation will contribute to the decline and subsequent disappearance of cash-crops like cocoa, kola and oil palm commerce in Ghana. Also in 1928, during the empire forestry conference, Ghana's forestry statement was articulated as thus, "reservation of areas of permanent forest suitably distributed through the cocoa-growing zone to maintain that zone as a forest climate" (Kortey *et al.*, 1998; Forest Service, 1998).

The history of forest conservation appears to run contrary to other scholars' observation that forestry exploitation was what guided the colonial administration's discourse on forestry governance (Grainger & Konteh, 2007), a popular notion shared among prominent scholars like Amanor (1996) and Degrassi (2003). In all these the natives vehemently resisted strategic environmental framework that was instituted and the efforts by the colonial administration to put in place a comprehensive law that will bind the lands and the resource hotspots in the country under a single administrative figure was seen as a ploy to deny them of their property. For instance, a Forest Ordinance was drafted by the colonial government to constitute as reserve lands, any wasteland which ambiguously translated as any unoccupied or uncultivated land in the year 1910 and later amended in 1911 was forcefully opposed by the natives from being implemented.

In spite of these oppositions, the colonial administration through the strategy of indirect rule managed to influence the traditional authorities through the formal agency of Chief Conservator of Forest to regulate tree felling within concession zones (Teye, 2008). Another side of the efforts to create forest reserves by the colonial administration according to Degrassi (2003) was to persuade the traditional authorities to create within their native by-laws, options geared towards forest reservation. The liaison between the traditional authority and colonial administration proved the justification that certain socio-economic parameters served as inputs in deciding on forest policy and administrative framework. The native traditional council and the colonial masters' relationship fostered the implementation of the first three forest reservation policies, native authority ordinance, forest ordinance, and the concession ordinance. Thus, setting the first precedent towards state formalization of forest conservation.

2.5.3.1 Native Authority Ordinance of 1927 (CAP 111)

The Native Authority Ordinance of 1927, also known as CAP 111 was enacted as a forest governing legislation in the British colony of Ghana through the creation of forest reserves to be governed by traditional authority. The Act empowered the traditional authorities through their own territorial by-laws to create and enforce forest reserves with the colonial administration's backing. Its main aim was to promote sustainable forest resources exploitation and management.

The underlying feature of this Act was the powerful synergy that existed between the colonial authority and the traditional authority. It provided some essence of legitimacy and instilled in the natives some sense of trust in the colonial administration because of the power-sharing regime. It can be said this power synergy contributed to the emergence of indirect rule. The effect was that the traditional authority was clandestinely charged with the mandate of enforcing colonial constitutional provisions on forest management and exploitation at the local level through traditional by-laws (Teye, 2008). The Act also sought to not only strengthen the timber industry and trade but as well ensure suitable atmospheric conditions for the growing of cash crops like cocoa, kola, and rubber. In the evaluation of the new power synergy, the objectives of the Act spelled out a new utility to be derived from forest resources, comparing it with the erstwhile pre-colonial expectations.

Studies by Abu Juam and Hawthorne (1995) and Fairhead and Leach (1998) observed that, in pre-colonial times, natives sought the creation of forest reserves to largely suit their cultural beliefs with ecological and environmental utility as secondary effects.

These situations, however, were great contributors to the cash-crop plantation expansion in the Akyem state in the colonial era.

2.5.3.2 Forest Ordinance of 1927 (CAP 157)

The Forest Ordinance Act 1927 was enacted around the same time as the Native Authority Ordinance in 1927. The purpose of this Act was similar to that of the former but only differed in the operation. While the former operated through the traditional authority in accordance with their by-laws, the CAP 157 rather empowered the colonial administration to lay claim to lands and put them under reserves contrary to the will of the natives and the traditional authority (Teye, 2008).

The Forest Ordinance aim was not to divest and usurp ownership rights of the natives and the traditional authority but to limit the power of traditional authority as to the extent to which they grant access to forest exploitation. Its power was similar to the existing Administration of Lands Act (ACT 123) whose mandate does not seek to divest traditional authority's rights and ownership in the land but rather vest such ownership and usufructuary mandates in the central government in trust for the people of the state.

Forest administration under this ordinance was however controlled by the central government through the Forestry Department (Teye, 2008). Comparing the Native Authority Ordinance and the Forest Ordinance, the former was more accepted to the latter because the natives saw the terms in the Forest Ordinance to be usurping their native ownership rights and affronting their socio-economic imperatives to a sound

living (Smith, 1996). Another reason why the latter ordinance was not accepted by the natives was the fact that it did not fulfill the promise it made to ensure a decentralized mode of forest management through native landowners under the supervision of the Forestry Department (Oppon, 2004). Most of the forest reserves existing in Ghana had their safe operationalization through the impetus of the Native Authority Ordinance. In effect, by the year 1944, Degrassi (2003) reported that 127 of the then 200 forest reserves had been created.

However, despite the benefits forest reserves offer in the current understanding of environmental and ecological functions, the rule that laid the creation for forest reserves in the pre-colonial times to the colonial times was more of traditional and neoclassical economic stimulus to resource exploitation and utilization (Oppon, 2004). According to Hawthorne *et al.* (2012), native people only saw forest governance and management as a legal means to achieve their socio-economic ends and not to check the occurrences of negative environmental imbalances.

2.5.3.3 The Concession Ordinance of 1939

This ordinance came through as the colonial government mandate to empower the traditional authorities to grant access to their subjects to exploits the timber on their lands. The modus operandi of this ordinance was to regulate indiscriminate tree felling and forest speculation by both the local and foreign timber merchants through the issuance of licenses.

The ordinance, aside from the grant of licenses to prospective timber merchants, also permitted the traditional authorities to receive royalties and revenues for timber exploitation.

2.5.4 End Colonial Days 1939-1957

This era marked the period where the focus of forestry management and governance shifted from its previous protectionist goal and orientation towards more exploitation to support the local economy. During this administration period, the Ministry of Lands and Natural Resources (1996) and Degrassi, (2003) opined that forest protection which had dominated previous traditional and formal administrative economics shifted to rapid exploitation of timber in the year 1939. During this period, the forest administration policy was geared to a protectionist objective as its newly stated forest management governance principle.

This period further saw an expansion in the timber supply stock for both local and international timber markets, in effect promoting an actual exploitative timber utilization of the forest stock (Degrassi, 2003). Smith (1996) and Kotey *et al* (1998) reported that the international timber trade fueled this drive towards exploitative economics of timber after the Second World War. The period after Second World War saw a global demand for natural resources with the view of state-building, a phenomenon which contributed immensely to environmental quality decline since almost all development projects did little or no environmental impact analysis of their resource exploitations and projects building (Rajvanshi, 2003; Ajaja, 2013). Efforts to restore the environmental quality led countries to formalize Environmental Impact

Assessment (EIA) practice and to institute Environmental Quality Assurance Departments (E.P.A, 2004; Appiah *et al.*, 2009). Ghana in this era drafted the first comprehensive national forestry policy of 1948 to regulate forest resources and timber exploitation and utilization.

2.5.4.1 The 1948 Forest Policy

The interest in tree planting in Ghana dates back to the 1920s, a period that focused on planting indigenous tree species mainly in the high forest zone (Forestry Commission, 2016). It was in such a pursuit that the first stated forest policy was enacted and implemented. The policy was targeted at creating a permanent and sufficient resource of the country (Forest Service, 1998). The objectives of the policy were oriented principally towards favorable climatic mediation to sustain agriculture, protection, and supply of water and direct benefits like timber and other non-timber forest products (Forest Service, 1998).

Prior to the passing of the policy, the forest in Ghana was in a binary category of protection and productive importance. This binary categorization reflected in the protection of water resources, climate regulation and the stimulation of ecological functions were grouped under the protection side while the productive category was viewed in the sense of economic and social benefits.

According to Todaro and Smith (2009), though the policy had environmental sustainability objectives, the poverty level in Ghana, predominantly among the inhabitants of forest communities still made the policy's operationalization largely

exploitative. For instance, in the 1950s, the entire forest area in Ghana had just about 30% of its total stock marked as protected or reserved zones with the largest remaining 70% earmarked for exploitation (Mayers & Kotey, 1996). The policy was thought to be implicitly encouraging the liquidation of off-reserve forests with the assumption that farmers may destroy the tree stocks when they are faced with situations of farm expansion. Therefore it made economic sense for the government to liberalize logging in the off-reserve zones (Degrassi, 2003).

Consequently, this has affected the area of forest cover in Ghana and Akyem Abuakwa to be precise, a phenomenon principally attributed to the large scale lumbering, agriculture, and mining activities in the municipal area. However, in the current global efforts to conserve terrestrial biomass, it is imperative to measure the efficiency of SEA in national policies and decentralized local plans that do not seek an imbalance to promoting economic development but rather assess development in light of environmental sustainability.

2.5.5 Post-Independence Era (1957- Present)

With respect to the forest management policies and its associated management regimes, the post-independent era is categorized into the regime or zones of the 1994 policy and the 2012 policy.

2.5.5.1 Early Post Independence (1957-1994)

In this era, the management of forestry in Ghana continued to be dominantly exploitative like the pre-independence era. This called for a major afforestation

initiative to be embarked on by the forest commission between 1963 and 1987 in all degraded areas of the country under the Taungya system where crop cultivation was allowed on plantations designated for reforestation (Forestry Commission, 2016).

In the early years of Ghana's independence, the government was motivated to roll out economic policies and plans that will boost the growth of the local economy through rapid natural resource exploitation (Asante and Owusu, 2013). This economic vision fueled the rate of timber exploitation and other forest resources that accounted for forest decline in the country (Mayers and Kotey, 1996; Asante and Owusu, 2013). Though the managing policy at that time had in its core principle the reservation of forests for some ecological functions, nevertheless, in 1967, Mayers and Kotey (1996) revealed that concession had been given on forest reserves and other off-reserve spots to augment Ghana's efforts in the timber and minerals trade.

The coming into force of successive governments immediately after the first republican government all continued to follow the exploitative ventures of the 1948 forest policies (Boon *et al.*, 2009; FAO, 2001). In 1970, rapid forest exploitation was however recorded to have declined due to a recess in the inputs that fueled the timber market (Degrassi, 2003; Teye, 2008). The period also witnessed the government passing the other forest protection-related Acts like Administration of Lands Act (1962), the Concessions Act, Trees, and Timber Amendment Law (1983) and Forest Protection Law (1986), Protected Timber Land Act (1959, Act 34), Forest Protection Decree and Trees and Timber Protection Decree 1974 to limit traditional authorities' power and access to lands and forests (Degrassi, 2003).

Therefore, relating to the study, it is critical to assess contemporary forest governance efficiency in promoting sustainable forest exploitation whilst promoting economic growth and development. Thus, assessing the efficient operationalization of SEA as a sustainable tool in national development and environmental sustainability.

2.5.5.2 Forest Resource Management Plan (1989-1999)

As a part of the world's focus to embark on clean development strategies through sustainable development agenda, international protocols, and conventions that oblige nation-states into a flexible but compulsory obligation to ensure a sustainable constraint on their development plans and programs.

Ghana's effort to implement such principles on climate change, biodiversity conservation among other obligations as part of corrective measures in its past socio-economic pursuits led to the drafting of the Forest Resource Management Plan of 1989. Forest and institutional scoping towards this policy begun in 1986 and was promulgated into action in 1989 when forestry depletion and general environmental degradation was soaring. The International Development Agency (IDA) of the World Bank, the Overseas Development Agency (ODA) of the United Kingdom and the Danish International Development Agency (DANIDA) (Ministry of Lands and Natural Resources, 1996) carried out this plan jointly. This management plan undertook efforts in forest resources inventory, forest sector review and policy and institutional reforms of the erstwhile national economic and natural resource plans with the basic aim of systematizing the development and exploitation of timber, wildlife and mineral exploration in forest lands.

However, in light of these interventions in 1993, it was recorded that the exploitation of timber and forest resources continued to be on the rise (Ministry of Lands and Natural Resource, 1996). To curb these unsustainable exploits, the government set up an *ad hoc* preventive tool to control and manage the environmental stock of resources, which included mobile forest action group, felling control for off-reserve harvesting, control for speculative felling for log exports and other interventions (Ministry of Lands and Natural Resources, 1996). In spite of the major efforts articulated in this plan, the desired results of conserving the forests of the country did not yield which later led to the termination of the forest management plan and led to the ushering in of the new forest and wildlife policy of 1994 and the Forestry Development Master Plan of 1996.

Factors leading to the inadequacies of this forest management plan could be linked to its paternalistic style in administration. It was dominantly technocratic and professional in terms of its decision-making style. Expert advice that went into its formulation was basically hinged to presumed technical idealists in the field of forestry and natural resource governance and also opinions from capitalist entrepreneurs who were dominantly engaged in the timber and forest resource industry.

Another point of contention was whether any alternative source of livelihood was proposed and initiated to the majority of the stakeholders who had their livelihood consolidated on the forest resources. Lastly, the plan did not make any efforts to study the correlation of carbon emissions and vegetation decline to general weather patterns, an idea that had been emphasized in a study in 1987 by the Overseas Development

Agency asserting that trees offer an atmospheric regulatory role by sequestering carbon, which is a major greenhouse gas.

2.5.6 Mid Post Independence Era-1994-2012

This era marked a reviewing of the 1948 forest policy which sought to fill in the technical gaps the policy lapsed in its implementation. The motivation to revise the previous forest policy was in accordance with international environmental protectionist protocols and conventions spearheading sustainable development.

A key characteristic of this era was the ambiguous nature of the national development agenda, which typified the balance of policy pressure model where there is a tension between the exploitative stimulus and protection stimulus in forest management (Cline-Cole & O'Keefe, 2006). The tension between environmental protectionism and rapid natural resource exploitation in the mid-post-independence era was chiefly characterized by the economic crisis of the early 1980s, which necessitated the institution of the Economic Recovery Program and the Structural Adjustment Program. A study by Asante and Owusu (2013) showed that Ghana's GDP in the early 1980s stood at 2.9% in 1981, 6.5% in 1982 and 4.5% in 1985 indicating a rapid decline in economic growth. This decline, however, set the stage for large scale environmental resources exploitation to sustain the economic development of Ghana.

In the efforts to revive the national economy, the terms of the new economic recovery initiatives encouraged a wide utilization and exploitation of the nation's natural resources to boost economic growth. It placed economic emphasis on the expansion and utilization of the mining sector, the timber industry, and the agricultural sector.

However, efforts in these industries helped improve GDP growth to about 8.8% in 1984, it contributed immensely to natural resources overexploitation, subsequently leading to environmental degradation (Ministry of Lands and Natural Resources, 1996). A reason to this phenomenon was the fact that a new economic structural modifications led to an over-investment in the forest and mining sector (Konteh, 2007), depicting the central theme of the Miller policy model which asserts that in a developing economy, forest policies tend to be shaped by other sectors of the economy which affects the forestry sector.

In the period of ERP and the SAP, demand for forest resources rose to a point where the rate of forest decline stood at 1.3% between the years of 1981 and 1985, which continued until the early times of 1989 when it was revealed that the heightened demand for timber export species was far outstripping their annual allowable maturity potential, resulting in a decreased life span of the tree species. This was because the operational plan existing at that time was based on the principle Gibson and Hoffman (2002) referred to as the “resources patronage” based on the fact that the loans secured to pre-finance timber exploitation were given to few businessmen who had ties with government officials.

The period prior to the promulgation of the economic recovery initiatives, export rates had dropped from 40% (worth about US\$130 million) in 1973 to 9% (worth about US\$12 million) in 1982. In the face of this economic decline, the SAP which was augmenting the efforts of the ERP to promote foreign investments led to a soar in foreign exchange earnings from timber receipts recording as high as US\$44 million in

1986 from a previous record of US\$12 million in 1984, this suggested an increase in timber felling to meet the international timber market demand.

However, in spite of the anticipated success in economic growth being realized through the institutionalization of the ERP and the SAP, unanticipated environmental effects resulted in the form of extensive surface mining activities that encroached into forest lands, unsustainable timber exploitation causing rapid deforestation and general biodiversity loss (Asante and Owusu, 2003). Another dimension to the ERP and the SAP's effect has been about the decision-making style which dwelled on the neo-patrimonialism style where the government awarded economic investment opportunities to his favorites (Grainger and Konteh, 2007). It has again been argued that the flaw of the economic policy towards economic development, which led to environmental decay, was because the funding agencies to the economic programs did not put aside funds for environmental conservation and restoration in their budget plans.

The rapid decline in the forest cover in Ghana between 1990 and 2000 attracted the concerns for both local environmental protectionists and international protectionists. Sustainable forest management was however advocated by donor agencies like World Bank and the Official Development Agencies (ODA) on the need for Ghana to change its forest and economic policy strategy to make incorporeal environmental sustainability (Smith, 1996; Kotey *et al.*, 1998). Other donor gestures also came from other international organizations like the Tropical Forestry Action Program, which recommended forestry management and governance in Ghana by reviewing the

structure of the existing forestry sector. They further recommended that the forestry sector should be supported through the Forest Resource Management Project, which was scheduled to be operational from 1989 to 1995. Pressure from ITTO and the United Nations Conference on Environment and Development nudged the government at that time to revise and modify forest management and governance in the country (Ministry Lands and Forestry, 1994).

The World Bank preparatory mission for Forest Resource Management Project (FRMP) on the basis that the 1948 forest was not realizing its stated directives in terms of environmental sustainability (Ministry of Lands and Forestry, 1994) began preparation towards a new forest policy.

A reaction to the agitation for a new forest policy led the Ghana Forestry Commission to be created in 1993 through the Forestry Commission Act, 1993 (Act 453) to serve as an advisory body to the government on forest management. It was mandated further as the sole agency to draft forest management and exploitation policies in the pursuance of environmental sustainability.

2.5.6.1 Forest and wildlife policy 1994

The 1994 Forest and Wildlife Policy had an introductory premise that entailed several improvements to Ghana's forestry sector. It was purposively introduced to make up for the deficiencies of the 1948 forest policies and the subsequent Forest Management Plan that was promulgated.

The 1994 Forest and Wildlife Policy changed the forestry sector of Ghana by establishing it as an institutional forestry sector, which became a corporate Forestry Commission in accordance with the directives of the 1992 constitution of Ghana (Ministry of Lands and Natural Resources, 2012). It aimed to promote equity in the sharing and management of responsibilities in the forests of Ghana, promote an increase in benefit flows to allocation stakeholders, promote public involvement as well as promote transparency and accountability in resource governance (Ministry of Lands and Natural Resources, 2012). Aside from these objectives, other strategic initiatives like alternative livelihood projects as a poverty reduction plan among others were introduced with the introduction of the policy.

A new strategy was introduced to support the 1994 policy under the name of the 1996 forest development master plan with the main aim to promote a sound consolidation for the technical and efficient framework towards meeting the set aims of the policy (Ministry of Lands and Forestry, 1996). During the initial scoping plan on its drafting stage, it sought to study the interventions of past policies and researches conducted by foreign donor agencies like DANIDA/IDA/ODA in sustainable forest resource management in management in Ghana.

However, despite the efforts of the policy and the master plan, forest degradation continued to increase at a rate that threatened the forest area and timber resource stock of the country. This situation was associated with the ineffectiveness of the policy and its associated development master plan of 1996. Experts in the policy sciences explained the policy in line with Miller's policy model where other sectors of national

economy serve as the basic economic inputs to drive growth and progress of nations. In this case, the forestry sector served that purpose (Forestry commission, 2014). The net effect was, however, a decline in forest cover chiefly in areas where timber trade, mining, and agriculture were principal socio-economic determinants.

This corroborates the assertion of Boon and Ahenkan (2009) that as population increases, so human demand for space and other forest ecosystem services demand increases, this conundrum inevitably accounts for general forest decline.

In addition, little has been done in evaluating the district and municipal medium-term plans to ascertain their goal orientation in pursuing development and socio-economic growth about checking forest space and ecological resilience. Ideally, forest conservation principles are to be enshrined in decentralized medium-term plans to foster the capacity building of institutions and indigenes.

2.5.6.2 The 2012 Forest and wildlife policy

The 2012 Forest and Wildlife Policy is the current policy on forestry governance in Ghana. It opens up as a new amendment to forest resource management in Ghana, which tries to satisfice on the demand of forest as a socio-economic and cultural asset and forest as an environmental sustainability asset (Ministry of Lands and Natural Resources, 2012). The policy seeks to remedy the effects of the 1994 policy which had a disconnection between its stated and actual policy terms resulting in an exponential decline in general forest cover in Ghana (Forestry Commission, 2017).

The terms of the policy emphasize the non-consumptive values of forests by establishing a balance between timber production and marketing, and the ecological services the forest provides (Ministry of Lands and Natural Resources, 2012). As part of the objectives, the policy also guarantees community involvement in forest management schemes, ensure accountability and good governance of forests, develop small and medium-term forest and wildlife enterprises to improve local employment avenues in rural in communities, ensure conservation of biodiversity, help restore degraded landscapes through plantation schemes, sustainable management of woodlands in the savannah regions, ensuring climate change adaptation and mitigation measures, and lastly the provision of security for sustainable financing in forest and wildlife industry (Ministry of Lands Natural Resources, 2012). These aims are to be realized through a decentralized approach where local governments in the forest zones of Ghana are to embark on a local sustainable socio-economic development pursuit in the District/Municipal Medium Term Development Policies.

Further to the terms of the policy, attempts have been made to restructure the methodological plan of the 1996 forest management development plan which is set to design the new 2012 forest management plan expected to span from 2012 to 2032 (Ministry of Lands and Natural Resources, 2012). In addition, the institution of the Natural Resources and Environmental Governance Programme (NREG) is to segue with the forest policy in both its stated and actual policy terms to oversee forest conservation development. The aim of the NREG is to influence the government's policy on governance reforms toward both mining and forest management to combat environmental degradation and climate change (Forestry Commission, 2015).

However, in spite of the remaking of the 1994 forest policy and its associated forest management plan of 1996 to the current 2012 forest and wildlife policy, the terms of objectives and stated program have not actually made any reference to keeping a catalog of the soil and tree carbon stocks. Another shortfall of the policy after its inception is how it has not successfully operationalized into actual policy outcomes of the local decentralized development policies, plans, and programs. This implies that the stated objectives of the policy must carefully be assessed in the districts and municipalities to ascertain how well indigenous capacity has been built to create awareness for forest protection and general environmental protection. In addition to this, institutional regulatory systems must also be evaluated as indicators to show how effective forest management is being carried out.

Further, the policy is concerned with promoting the sustenance of the AICHI targets in conserving flora and fauna in the forest ecosystems of Ghana (Forestry Commission, 2015). This idea is in line with Article 6 of the Convention on Biological Biodiversity which Ghana is a signatory. According to the Ministry of Environment, Science, Technology, and Innovation (MESTI) (2016), reduction grassland cover contributes significantly to losses in general biological biodiversity. It is estimated that grassland has reduced by 34,000km², with croplands, forest lands, and settlement lands gaining about 22,000km², 6000km² and 2,400km² respectively (Forestry Commission, 2016).

In addition, it is reported that the rate of deforestation in Ghana is about four times the sustainable allowable rate (MESTI, 2016). This is reported to have contributed to the loss of a major primate species like the Red Colobus Monkey. However, a recent

assessment of the biodiversity conservation in Ghana revealed that the 2000 National Biodiversity Strategy did not adequately consider the goals of the AICHI targets. Efforts to redesign a new National Biodiversity Strategy has therefore been drawn in conjunction with other national development strategies like the Forest Development Master Plan and the National Climate Change Action Plan for the conservation of all biological biodiversity.

This is, therefore, a justification for the assessment of SEA as required for the purpose of this study, with much consideration on the land use activities prevalent in the Abuakwa South municipality. It is then necessary to assess the municipal's governance structures with regards to the local economy and development planning to promote a holistic national sustainable development.

2.5.7 Ecological functions of forests

Ecologically forests play critical roles as they provide suitable habitat and conditions for other flora and fauna to interact with the physical and chemical factors to provide ecosystem goods and services. In this section, the ecosystem regulatory functions of forests, specifically the trees and soil carbon sequestration abilities are reviewed. The section begins with the role of forest trees in carbon sequestration, soils as carbon sinks and finally concludes with the general forest ecosystem as a climate stabilizer, precisely regulating rainfall and temperature patterns.

2.5.7.1 Role of trees in carbon sequestration

Forest trees are one of the major terrestrial carbon sinks that sequester atmospheric carbon (Prentice *et al.*, 2001). Globally, they have been noted by FAO (2005) to cover about 30% of the terrestrial landmass, accounting for about 4.0×10^6 hectares. A study by Aerts and Honnay (2011) it was asserted that tropical forests are major carbon sinks and sources and as a result, they function as natural climate change mitigation systems. Chave *et al.* (2005) further reiterate that tropical forests sequester more carbon from the atmosphere than any other terrestrial carbon sink system. The main pools of carbon in tropical forests are tree biomass, shrubs, deadwood debris, and necromass and below ground stock of vegetation roots and soil fauna (Hairiah *et al.*, 2011).

In measuring total carbon contained in tropical tree biomass, 50% of the entire tree biomass is estimated to be dominated by carbon which accounts for the quantum of sequestered carbon from the atmosphere (Hairiah *et al.*, 2011). Most tropical forests that form the largest aboveground biomass pools for carbon storage are however faced with human disturbances due to socio-economic growth expansion leading to forest destruction leaving a consequent effect of carbon emission into the atmosphere (Adu-Bredu *et al.*, 2010; Ngo, 2013). In recent reports and studies concerning the state of the forest and environmental management in the Abuakwa South municipality, evidence shows that the Atiwa forest and its buffer vegetation have been under the threat of decline in past and recent times (E.A.M.A, 2014; Schep *et al.*, 2016). Due to this, it is important to determine its carbon retention capabilities and accounts for its carbon losses in the past decade.

The consideration for carbon retention function of forests have been opined by many authors including Grace (2004), Beer *et al.* (2010) and Pan *et al.* (2011) that tropical forests store about 40% of all tropical terrestrial carbon, this reason has led Smith and Long (2001) and Beedlow *et al.* (2004) to opine that forests should be managed based on their function to maximize carbon sequestration in both above grounds and below ground pools. Therefore, in the carbon sequestration significance of forests, priority determination is given to live tree biomass, deadwood and forest floor litter, and the soils in the forest ecosystem (Sierra *et al.*, 2007; Malhi *et al.*, 2009).

In spite of the sequestering abilities, there are variations in how forest ecosystem parameters store carbon. For instance, a study by Djomo *et al.* (2011) revealed that there were three times carbon in the aboveground biomass as compared to the soil composition. Conversely, Gibbon *et al.* (2010) revealed in their study in the Peruvian montane ranges that the aboveground biomass contained about two times carbon as compared to the soil's composition. Lastly, in a study by Lü *et al.* (2010) and Saner *et al.* (2012), a double of carbon's composition in soils was found in comparison with the aboveground biomass like dead wood, litter and necromass, and a live tree.

The phenomenon of carbon retention variations in the various forest parameters has been attributed to the composition of the tree species, history of forest ecosystem disturbance and regenerative sequences, climatic factors and the fertility of the soil (Wright, 2005). Thus, in this regard, the determination of the potential carbon retention and carbon losses of the Atiwa forest is based on the variations of its tree species, the history of disturbances and the regenerative capacity of the forest ecosystem due to

mining, agriculture and lumbering activities which are principally the indigenous economic activities impacting on the vegetation cover of the Abuakwa South municipality.

However, in assessing deforestation in Ghana, the alarming effect has mostly dwelt on direct economic loss to the GDP neglecting the ecological net effects of the forest decline (Forestry Commission, 2017). Forests aside its socio-economic benefits are a reservoir for terrestrial carbon preventing superfluous carbon emissions into the atmosphere which could result in possible climatic consequences like climate change.

The recent efforts to curb climate change have however been operational through afforestation programs, which have proven to be a less cost-effective method to reduce carbon release into the atmosphere. Hairiah *et al.* (2011) espouse that tropical forests contain more aboveground biomass than other land uses and land covers. Lu *et al.* (2014) also opine that the total carbon content of forest ecosystems is based on all its total aboveground biomass, which comprises all tree stems and branches, leaves and other forest shrubs and vines together with all soiled litter, deadwood biomass and roots of vegetation.

Forest ecosystems are however recorded to hold about 80% of carbon in its aboveground stock of biomass with 20% stock in its belowground stock (IPCC, 2001). This sequestering potential explains the ability of forests to hold about 100 gigatonnes of carbon dioxide from the atmosphere with only a half release back into the atmosphere when compared to the oceans which rather takes in about 104 gigatonnes

of carbon dioxide and releases 100 gigatonnes back into the atmosphere (Africak, 2015). This reflects the possible potential of large carbon fluxes into the atmosphere when large forest lands are converted to different land uses (Hairiah *et al.*, 2011).

Ghana's application to be part of the REDD+ initiative which is primarily concerned with the reducing emissions from deforestation and forest degradation has been focused on structuring the needed training to implement reforestation and afforestation programs and projects geared towards increasing aboveground biomass to serve as carbon sinks (Forestry Commission, 2017). This idea comes as a follow up to the estimation that the global forest stock store up to 289 gigatonnes of carbon, which has been on a decline by 0.5 gigatonnes annually during the period of 2005-2010 (FAO, 2010). Since carbon is a potent greenhouse gas, it has been asserted that the conversion of forest lands into other spatial uses accounts for a 10% surge in atmospheric carbon quantity (IPCC, 2013). Thus, it is pertinent to determine the land use, land cover change and forestry dynamics in the Abuakwa State municipality regarding past and recent times in assessing carbon stocks in the Atiwa forest.

Following the implementation course of the REDD+ initiative, Ghana embarked on a phase strategy implementation approach in accordance with standardized methodologies for monitoring and evaluating afforestation, assessing carbon sequestration and carbon emission (Forestry Commission, 2015). Technically, this activity was a ground-truthing method to know the drivers of deforestation. In effect, the initial stage of the implementation was based on preventing deforestation and ensuring a sustainable forest resource management principle. As part of the efforts to

ensure the success of the REDD+ initiative in the country, it is incumbent on the national government to decentralize the programs and projects of the REDD+ action into local development plans within the framework of strategic environmental assessment.

An assessment of the forest cover bordering the Abuakwa South municipality has been noted to have decreased in its closed-canopy stock by about 10% and the buffer regions of its forest reserve also decreasing about 35% in the last 20 years (CERSGIS, 1990, 2000, 2010). The change in land cover is primarily attributed to farm expansion, logging, woodfuel harvesting and small scale gold mining (Schep *et al.*, 2016). This is affirmed by the Resource Management Support Centre (2016) of the Forestry Commission, with the assertion that gold mining now occupies 28% of the entire spatial region of the buffer zone bordering the Atiwa forest. Further, Hairiah *et al.* (2011), assert that when a tropical forest with an estimated carbon stock of 250 Mg.C ha⁻¹ is converted to agriculture activities, the subsequent agriculture land determines the potential amount of carbon restocking that will happen in a later time. Further estimates assert that forests converted to agricultural lands have their average annual crop systems estimated to contain only 3 Mg.C ha⁻¹ while an intensive tree plantation will only constitute about 30-60 Mg.C ha⁻¹, thus, representing 1% and 10-25% of the forest tree biomass with its associated carbon stock respectively (Palm *et al.*, 2005). This quantification determines the potential of terrestrial carbon restocking in tropical forest systems.

However, in assessing forest ecosystem carbon stocks, the focus is predominant on aboveground biomass since that account for the total accumulated biomass of trees and other aboveground parameters (De Gier *et al.*, 2012; Riegel *et al.*, 2013). In such measurement thereof, allometric model equations are used to allow for simplicity in estimating biomass over large sample plots (Brown, 2002). Therefore in the assessment of tree carbon stocks in the Atiwa forest, an appropriate allometric equation function for the vegetation and climatic zone of the Abuakwa South municipality must be used to give an accurate estimation of carbon stocks. This will give adequate baseline information on carbon accounting in terms of environmental and forest sustainability planning.

Further, terrestrial carbon inventories are highly prioritized by the United Nations Framework Convention on Climate Change, which stipulates as one of its obligations for all member countries in article 4 paragraph 1(a); that there should be a publication and regular update on carbon accounting and such information should be made available to the conference of parties in accordance with article 12 of UNFCCC's regulations. Again in article 4 paragraph 1(d) the regulation requires as thus; to promote sustainable management, promote and cooperate in the conservation and enhancement, as appropriate of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass, forests, and oceans as well as other terrestrial, coastal and marine ecosystems. An extensive follow up to these obligations however set the premise for REDD+ initiative which led to Ghana's effort in the Readiness-Preparation Proposal (R-PP) survey in 2010 which revealed that the major contributors to deforestation are farmland expansion; which accounts for 50% in deforestation,

wood fuel harvesting 35%, increase in population and social development expansion 10% and the mining industry is 5% (Forestry Commission, 2015). This is because most forest communities base the sustenance of their livelihood on the forest's ecosystem. This situation cumulatively places impacts from land use and land cover change to being responsible for 20% carbon emitted into the atmosphere (Pearson *et al.*, 2005). Safe methods of putting forests under conservation advertently also impede the flow of resources needed for livelihood and optimum sustenance making forest management in Ghana a challenge (Ministry of Lands and Natural Resources, 2012; Forestry Commission, 2017).

Looking at the recent political challenges which affront efforts of national inputs toward climate change mitigation activities in the global scale, it has been advocated by Fearnside (2011) and Tulyasuwan *et al.* (2012) that proper implementation strategy should depend primarily on monitoring ground-based activities, recording and cross-checking the relevance local protocols in connection with the wellbeing of carbon sources and sinks. This calls for a re-inventory and estimation of the vegetation carbon pool potential of forest ecosystems by taking into consideration other land cover types and land-use changes.

2.5.7.2 Role of soil in carbon sequestration

Soil carbon stock is generally composed of the organic carbon class and the inorganic carbon class. With the organic component, it is a heterogeneous composition of materials like roots and soil fauna, decayed microbial biomass and such simple compounds like polysaccharides (Johansen *et al.*, 2010). The inorganic carbon class,

however, is composed of pedogenic bicarbonates and carbonates mostly found in basic and alkaline soils (FAO, 2018). For the estimation of carbon in soils, organic carbon class is given much priority due to its influence on soil quality for agriculture purposes.

Soil organic carbon according to Davidson and Janssens (2006), Zhou *et al.* (2012) play a vital role in terrestrial carbon sequestration as it forms a larger part of the terrestrial carbon reservoir. Thus, phenomenal dynamics in land use and land cover can affect significantly the carbon stock of aboveground biomass and the below-ground ecosystem, as well as the practiced soil management strategies with regards to agriculture, also affect the content of soil organic matter (Khanna *et al.*, 2007). Hüttl *et al.* (2008) and Schlesinger and Bernhardt (2013) similarly opine that soil carbon is lost through the conversion of natural and semi-natural ecosystems to human managed agroecosystems.

For the purpose of accounting for carbon in all the carbon pools, it has been asserted that accurate soil carbon quantification will provide a basis for assessing soil quality and the modeling carbon cycle in the global or local context (Zhi *et al.*, 2014). Khanna *et al.* (2007) and Djagbletey (2015) opine that organic matter reduction in soils stands as a precursor to soil quality decline with a consequent effect on agriculture production. It has been revealed that, in terrestrial ecosystems, soil organic carbon makes up almost three times the terrestrial vegetation ecosystem (Sheikh *et al.*, 2009; Zhi *et al.*, 2014), and is approximately two times as dominant as the atmospheric carbon stock. Further, the stock of carbon in soils has been linked to the vegetation with a strong correlation

to vegetation height only, vegetation diameter at breast height (*dbh*), height and diameter at breast height (*dbh*) and vegetation height and density per hectare (Negasi *et al.*, 2018).

However, because of its large scale sequestration of terrestrial carbon, any disturbance in the condition of soil can cause a significant release of the carbon stored affecting the general climate (Li MM *et al.*, 2013). Nonetheless, the livelihood support systems that typify the Abuakwa South municipality dominantly rests on agriculture, logging, woodfuel harvesting, and mining, with the former engaging the majority population in the area (E.A.M.A, 2015). These activities, however, disrupts the terrestrial carbon sink abilities in sequestering carbon from the atmosphere (Miller *et al.*, 2004).

In addition, agriculture is noted to be one of the key land use activities that influence the loss of carbon in soils (Tilman *et al.*, 2002; Yao *et al.*, 2010). This proves necessary due to the REDD+ initiative, which is of the view that land-use conversion, particularly into farming systems, is one of the major themes to consider in terms of carbon reduction (Nketia *et al.*, 2009; Forestry Commission, 2017). Nevertheless, soil carbon assessment has been determined to be responsive to land-use change and management, which mostly reflects the previous land use or management employed, which is what has been identified as the legacy effect (Foster *et al.*, 2003). Therefore, estimating the carbon stocks in soils has the potential to unravel the dominant land use management methods in a particular region (Foster *et al.*, 2003).

Despite the attention given to the potential abilities of soil as a carbon sink, knowledge on its baseline, its hotspots, the vulnerable spots for carbon losses and gains under the land use managements are still limited (FAO, 2018). This translates into different countries who despite having signed unto the UNFCCC, still have limited baseline data in their soil carbon accounting which makes global carbon cycle estimation uncertain (Whitehead *et al.*, 2012). For instance, in a study by Henry *et al.* (2009), it was observed that the information on the global carbon cycle is not certain due to the differences in information sources and methodologies used by authors.

The obligation of Ghana to the World Bank through the REDD+ program, therefore, makes it important to conduct a detailed data on soil carbon stocks in soils in Ghana (Batjes, 2001; Smith, 2005; Takimoto *et al.*, 2008). This activity though is imperative to terrestrial carbon accounting; it has nevertheless been asserted to be a complex and difficult activity to undertake (Wang and Hsieh, 2002). This explains the underlying reason why little studies have been done in Ghana relating to soil organic carbon stocks with respect to different land cover and land use systems (Atsivor *et al.*, 2001; Bellassen *et al.*, 2010; Yao *et al.*, 2010). With respect to this study, the emphasis is focused on the international definition of soil carbon which states as the organic component of fine soil that passes through two millimeters (2 mm) sieve (Whitehead *et al.*, 2012).

2.5.8 Rainfall and temperature regulation functions of forests

The rate of deforestation in Ghana has not only been worrisome to wildlife preservation and the preservation of some essential ecosystem benefits and services needed for forest community sustenance.

Tropical forests are noted to function as natural ecological systems that regulate the earth's thermo-system. This function is achieved through the absorption of gases that regulates temperature, which causes rainfall. The amazon forest in Southern America, for instance, is noted to be responsible for the creation of about 50%-80% of its own rainfall (Mongabay.com). Forest decline account in Ghana as reported by the Ghana Meteorological Agency (GMA) shows a rise in temperature and a fall in rainfall values as well as its erratic nature in the forest ecological zones of the country from the year 1960 to present (EPA, 2016). The economy of Ghana is however built on climate-sensitive sectors like agriculture, fisheries, tourism among others (EPA, 2016), and thus any change in the general climate may induce an effect on these socio-economic sectors and invariably take a heavy toll on the nation's socio-economic development.

For instance, the recent erratic patterns of rainfall and the rise in temperature has led to a prediction that maize production will reduce by 70% by 2050 based on 20-year baseline study (EPA, 2011). This revelation comes as a support of the Intergovernmental Panel's (IPCC) 4th assessment on Climate Change, which presents evidence for climate change and global warming.

Furthermore, the ecological functions of forests specifically with regards to climatic moderation are its relation to effect reduction on ground surface albedo thereby reducing ground temperature and influencing evapotranspiration. In addition, studies account for the ability of forests to create low-pressure zones, which draws in atmospheric moisture from the oceans inducing rainfall inland (Makarieva & Gorshkov, 2010). This pressure creation ability according to Makarieva and Gorshkov (2007) is what maintains the terrestrial hydrological cycle in balance. This function follows a process where an upward-directed force causes moist air to rise adiabatically in the vertical column of the atmosphere through an evaporative-condensation mechanism (Sheil & Murdiyarso, 2009).

During such a process, the surface area index of trees accounts for the process of transpiration, which facilitates high evaporation fluxes, compared to the evaporation flux capacity of oceans (Makarieva & Gorshkov, 2010). The process creates a condensation effect above the forest trees canopy area. What has been reasoned to account for a low-pressure column is the condensation of air rising adiabatically through the atmospheric column above the forest canopy, which pulls in air masses from the oceans to sustain low air pressure region in the base of the forest column (Makarieva & Gorshkov, 2007).

Another revelation on climatic indices is the fact of its association with forest growth as indicated in a study by Amissah *et al.* (2014), where rainfall seasonality was shown to have greatly affected the growth of some tree species in their spatial distribution in

Ghana with temperature contributing less. This revelation is however similar to the biotic pump theory afore explained, which predicts an association between atmospheric air pressure, temperature, and precipitation necessary for creating convectional air currents to stabilize the hydrological cycle. Again, it has been espoused that the tropical climate of Ghana typically correlates to the vegetation cover in the country, which hinges to the fact of evapotranspiration and its correlation to mean annual temperatures and rainfall (Ntiamoah-Baidu *et al.*, 2001). Therefore, it is imperative to assess rainfall and temperature variability patterns in relation to land use, land cover, and forestry dynamics.

In addition, studies reveal a correlation between climate change and livelihood systems, where an unfavorable climate with high temperatures and low and erratic rainfalls affect agricultural communities (EPA, 2011). For instance, in a report by the UNDP in conjunction with the environmental protection agency revealed that agriculture's contribution to the GDP of the country has dropped from 51% to 36% in the last decade due to climate change effects in Ghana, specifically on the microclimate of major agricultural communities. This again has affected about 60% of the active working force in a country where the majority are engaged in agriculture and other climate-dependent vocations.

The urgency of the situation concerning forest ecosystems and their role in mitigating climate change effects is therefore imperative considering the rate of growth of our national population as well as the rate at which forest ecosystems are exploited for their benefits and resources. It is therefore justified to conduct an empirical study to make a

correlation between the Atiwa forest in Abuakwa South and how it influences micro-climate as well as supporting the livelihood of the indigenous people in the municipal area.

2.6 SEA practice in Sub-Saharan Africa

The concept of Strategic Environmental Assessment in the recent past is widely mainstreamed in the development framework of Sub-Saharan Africa. This employs the tools to assess the performance of environmental sustainability, economic sustainability, institutional capacity building and social inclusion to national development. In assessing the objective of SEA with current development capabilities and thresholds, the aims of the sustainable development goals in general and the 2063 agenda goals, in particular, serve as a limiting threshold for the development scope of Africa (Gutiérrez, 2015). In 2006, Namibia applied SEA in developing its agriculture, poverty reduction strategies, and improving its tourism industry under the Millennium Challenge Corporation Program (OECD, 2012).

According to the Organization of Economic Corporation and Development (OECD) (2012), the principal aim of SEA is to consolidate a list of assessment topics and evaluate existing baseline data and potential environmental impacts relevant to the planned activities. Further, it stipulates that SEA through professional judgment and public consultation should identify gaps in baseline data collection. In conclusion, the OECD opines that the SEA framework identifies risk and propose mitigation and adaptation strategies thereof.

According to a study by Palermo *et al.* (2012), Mauritius in 2007 employed the SEA framework in its Multi-Annual Adaptation Strategy for the sugar cane industry in ensuring environmental sustainability. The results of the evaluation hinged on the imperative of making a positive environmental safety contribution by identifying possible risks. This advised policymakers on the need to re-evaluate their proposed project strategies to ensure environmental sustenance.

Similarly, in Benin, SEA was used to mainstream environmental concerns into their Poverty Reduction Strategy Plan (Dagba *et al.*, 2012). This emphasized the need to promote sectoral cross-cutting to ensure that sustainability is adequately maintained.

In 2006-2007, Sierra Leone employed Strategic Environmental and Social Assessment to mainstream environmental quality assurance in the mining sector (World Bank, 2008). This approach adopted a dialogue scenario that solicited stakeholder concerns from all sectors. From the results, the government of Sierra Leone was advised to strengthen its institutional capacity and social inclusion pillars to address mining sector issues.

2.6.1 Mainstreaming SEA in Ghana

In the history of Ghana's national development, Environmental Assessment (EA) has fundamentally been based on the principle of prevention. This principle employs Environmental Assessment methods as proactive tools to evaluate program projects. The main themes that guide EA in Ghana are enshrined in the Ghana National

Environmental Action Plan (NEAP). According to the provisions of the NEAP, all project proposals are to be evaluated and endorsed by the erstwhile Environmental Protection Council (EPC) in pursuance of a government directive published in 1989. However, with the promulgation of an official Environmental Protection Agency Act (EPA), Act 490, Environmental Impact Assessment received formal recognition as a tool for evaluating projects in Ghana. This was subsequently enhanced with the promulgation of the Environmental Assessment Regulations, 1999 (LI 1652), spelling out keynotes and prerequisites for the effective performance of Environmental Impact Assessment in Ghana.

Currently, SEA and EIA remain the dominant practiced EA in Ghana. Nevertheless, environmental sustainability in Ghana has been given impetus by foreign organizations like the World Bank, European Union, and the United Nations Development Program among others. However, in the SEA framework of EA, the Natural Resource and Environmental Governance (NREG) program has been greatly contributed towards its practice in Ghana since 2009.

This is evident in the fact Ghana has been a model for the operationalization of SEA in sub-Saharan Africa after the implementation of the Ghana Poverty Reduction Strategy 1 development policy (GPRS 1) which was in line with the Millennium Development Goals. The success of the GPRS 1 was owed to the influence of SEA which enhanced the environmental sustainability of its projects. This consequently led to the

implementation of the Growth and Poverty Reduction II (GPRS II) propelling Ghana in the West African sub-region as a forerunner in environmental management (OECD, 2012).

Mainstreaming SEA for environmental sustainability, therefore, attracted donor supporters for Ghana's development (OECD, 2012). However, in all, about 21 SEA interventions were carried out from 2004 to 2012 on several development sectors in Ghana, excluding forestry (OECD, 2012).

2.6.1 Mainstreaming SEA in Atiwa forest reserve management

The Abuakwa South municipality is endowed with abundant natural resources from earth mineralogy to a vast forest cover. Forests and earth minerals are been exploited in a manner that is environmentally not sustainable contributing to general environmental degradation (E.A.M.A, 2014; Schlep *et al.*, 2016).

The continuous state of forest resources exploitation, which includes small-scale mining, agriculture, and the felling of timber in the municipality continues to worsen the environmental safety of the area (E.A.M.A, 2014). These conditions have largely been associated with the lack of formal recognition and operationalization of strategic environmental assessment in the previous Medium-Term development plans of the municipality. Hence, in light of Therivel (1992), where SEA is conceptualized as a framework of formalized, systematic and comprehensive process of evaluating environmental impacts of policies, plans and programs must be duly acknowledged.

This is in line with the introductory statement of the 2014 Medium Term Development Plan of the Abuakwa South municipality, asserting the non-cognizance of environmental sustainability in previous Medium Term Development Plans in the municipality.

However, in the mission statement of the immediate past 2014-2017 Medium Term Development Plan of the municipality, environmental and socio-economic considerations were made paramount as a new development plan framework paradigm. This was in consonance with the findings of Ekpe *et al.* (2014) stating that the historical assessment of formal forest conservation is fundamental pillars to guide the institution of livelihood support activities in support of forest conservation. This, therefore, makes institutionalization of sustainable livelihood support activities and community and institutional capacity building a necessary tool to gain community trust and cooperation in knowledge sharing toward safe environmental resource exploitation and utilization (E.A.M.A, 2014).

Further to buttressing this assertion is an earlier recommendation by Sadler and Verheem (1996), who proposed the incorporation of economic and social sustainability in ex-ante environmental management and evaluations for proposed development plans and programs. However, contrary to the expectations of 2014 Medium Term Development Policy Framework promoting sustainability in all sectors of the local economy of the Abuakwa South municipality, the 2015 local budget of the municipality revealed socio-economic, haphazard spatial development, inadequate capacity building

and a rise in environmental degradation to be persisting (E.A.M.A, 2015). These challenges, therefore, explains the state of SEA implementation and the enforcement of sustainability tenets in development plans. It also reveals the stakeholders' sensitivity socio-economic pursuits in relation to environmental protection.

This prevailing situation as mentioned afore in the local 2015 budget of the Abuakwa South municipality can be attributed to the rate of population increase which could be accounting for an acceleration in the demand for space and resources as well hampering conservation plans and projects (Boon and Ahenkan, 2007; Boon *et al.*, 2009; E.A.M.A, 2015). In addition to population increase, an assessment of forest conservation policies, plans and projects in Ghana by Tropenbos International-Ghana (2007) and Boon *et al.* (2009) have revealed that the factors affecting the success of forest conservation legislation in Ghana are primarily linked to over-exploitation of timber, the nature of the land tenure system, lack of community involvement in the conservation process, weak institutional capacity building and lack of political will.

Furthermore, the 2017 internal budget of the Abuakwa South municipality implemented to span from 2017-2019 also indicates challenges affecting the municipality to be environmental degradation resulting from illegal mining activities, deforestation resulting from illegal logging, farm expansion and woodfuel harvesting (E.A.M.A, 2017). This indicates a defect by the municipal assembly to institute a clearly defined sustainable livelihood support activities to guide the style of natural resource exploitation mechanisms in the municipality (Schep *et al.*, 2016)

Regarding alternative livelihood support activities, Ekpe *et al.* (2014) assert that most of the livelihood support activities operationalized in Ghana were instituted under private organizations with their primary obligations owed to themselves, with little or no obligation directly owed to the government. Nonetheless, interventions by the central government to use livelihood support activities (LSA) in decentralized administration have come to rest solely on poverty reduction in the past two decades (Botchway *et al.*, 2001; Boon *et al.*, 2009). This corroborates the fact that past projects on alternative livelihood support activities (LSA) in other socio-economic homogenous communities like the Abuakwa South municipality including Aryee *et al.* (2003); Hilson and Banchirigah. (2009); Temeng and Abew (2009) on LSA. The findings revealed by these searches focused on the government's efforts of alleviating poverty but with no stated principle to conserve environmental resources and prevent environmental degradation.

Based on this, Owusu (2001) asserts that livelihood support activities study on strategic environmental assessment is rare on forest conservation in Ghana. This, however, offers an explanation of the state of forest area encroachment in the Abuakwa South municipality.

Efforts by the REDD+ project, therefore, has been one of the outstanding initiatives to conduct the "business as usual" activity as part of its objectives in forest communities where deforestation is alarming to carefully synthesize local livelihood needs into

forest management plans and propose an environmentally sound livelihood options for the indigenous people (Forestry Commission, 2015).

Despite the efforts mentioned, the state of SEA practice in the Abuakwa South municipality, specifically on socio-economic, social inclusion and environmental sustainability are still lacking. The study, however, is geared towards the empirical approach of finding assessing the state of forestry management and what has been accounting for forest decline in the municipal area.

In conclusion, the focus of the research is concerned with SEA implementation status and general perception of the indigenous people to forest management in the Abuakwa South Municipal area. Further, the research is based on the land cover types and land cover changes and its association with rainfall and temperature patterns, as well as a further assessment of carbon accounting for trees and soil.

CHAPTER THREE

MATERIALS AND METHODS

This chapter provides a description of the study area on the general climatic conditions, location and size of the area, vegetation characteristics, drainage, and relief features. Socio-economic issues including demographic parameters such as education, economics, and health-related issues are added.

Further, the research design and relevant methodology for the generation of the relevant results and other information. Data sources and collection techniques and instruments used in sampling methodology are also presented.

3.1 Description of the study site

3.2.1 Location and Size

The Abuakwa South Municipal Assembly was established by an Act of Parliament under the Legislative Instrument (L.I) under a Legislative Instrument (L.I) 1878 in 2008. The municipality is located in the central part of the Eastern Region with an approximate land area of 725km² (E.A.M.A, 2015). Its capital is Kyebi which incidentally is also the seat of the Traditional council of the Akyem Traditional Area.

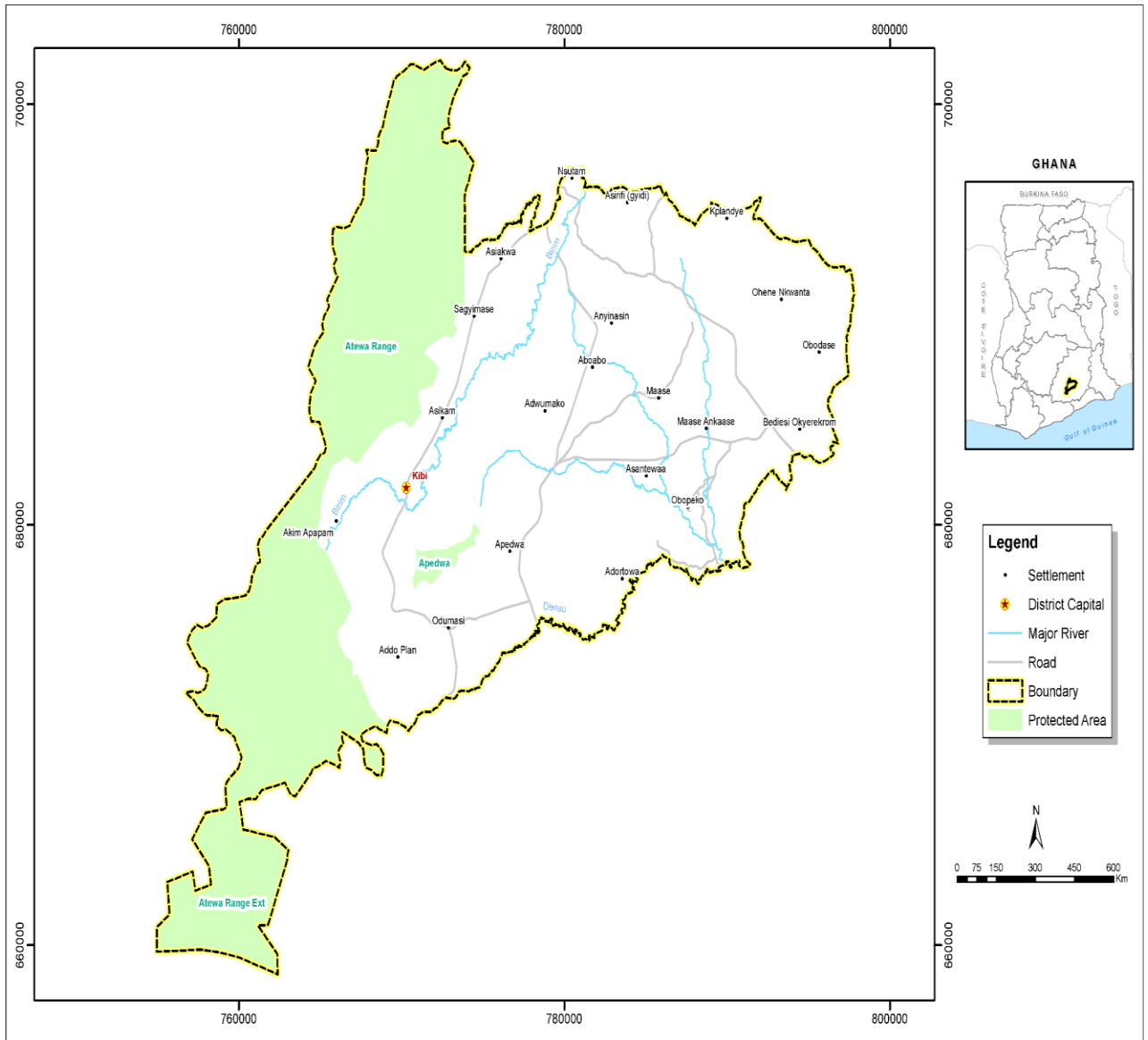


Figure 1 Map of the study area

The municipality is bordered by six districts as follows; the Atiwa to the north, West Akyem to the north-west, Fantekwa to the east, in the south by New Juaben which shares its southeastern border with Yilo Krobo and Suhum Kraboa-Coaltar to the west (E.A.M.A, 2015).

The population of the area was estimated as 181,153 according to an interim population census by the Abuakwa South municipality in their local budget (G.S.S, 2010). The population of the Abuakwa South municipality is made up of 52% females and 48% males. The general occupation structure of the municipality is centered on agriculture which accounts for about 65% of the population. The main crops cultivated are cocoa and coffee and other staple food crops like plantain, cassava, oil palm, maize, banana among others. Other occupational sectors include mining, manufacturing, and commerce.

3.3 Geophysical and environmental characteristics

3.3.1 Climate

Abuakwa South municipality lies in the wet semi-equatorial climate zone with two rainfall regimes beginning from May to October. The first rainfall regime begins from May and ends in June while the second starts from September to October. The mean maximum annual rainfall and temperature are 125mm and 26°C in July and August respectively. (E.A.M.A, 2015). Average relative humidity ranges between 70%-80%, with the dry season normally peaking at 75% on average and the wet season at 80% on average.

3.3.2 Relief and drainage

The area has a general undulating topography, which rises at a height of about 240m, with the Atiwa highland rising at a height of 350m above sea level (GSS, 2010). The geology of the area is predominantly of the Birimian formation underlying about three-

fourth of the municipal's forest spatial cover, and it abounds in minerals like diamond, gold, bauxite, and kaolin. Other rock formation types like the Tarkwaian formation, which are embedded with gold deposits, also typifies the geology of the area in communities like Kyebi and Appam. The geology gives rise to distinct relief characteristics that range from flat bottom valleys to steep-sided highlands which are also rich in iron pan and kaolin (E.A.M.A, 2010).

The drainage pattern of the area is dendritic and is composed of three major river courses; Birim, Ayensu, and Densu that have their catchment within the Atiwa and Apedwa forest ranges. However, when the land is left bare without vegetation, it is susceptible to soil erosion (E.A.M.A, 2006).

3.3.3 Vegetation and soil characteristics

The Abuakwa South municipality lies in the moist-semi deciduous vegetation. The dominant economic viable tree species found in the Abuakwa South municipality are *Milicia excelsa*, *Triplochiton scleroxylon*, *Terminalia superba*, *Khaya ivorensis*, *Albizia zygia* and *Antiaris toxicaria*. The vegetation stock of Abuakwa South municipality comprises of few forest reserve spots covering approximately 108.8km². Nevertheless, the Atiwa forest covers an area of 158km².

In addition, the Abuakwa South municipality predominantly has the soil classes of Asikuma-Atiwa-Ansum/Oda compound association whilst the Peki class exists as a minor class (E.A.M.A, 2010). Out of the class, the Atiwa series is the dominant type

with a characteristic reddish color, well-drained, deep gravel-free silty loam and silty clay loam. There is also the Peki soil class type which has a characteristic brown to reddish yellow, is relatively well-drained and is very shallow and rocky, and the valley areas of the municipality are composed of the Oda series which are mainly alluvial silt-clays and are poorly drained. The available soil types in the area, however, plays a role in the dense vegetation food crops that are grown in the area.

3.4 Economic activities

3.4.1 Farming and manufacturing

The soil and climate nature of the Abuakwa South municipal area is favorable for crop production. Farming is practiced on a subsistence level with some crops produced for sale outside the municipality. The major food crops grown are plantain, cassava, cocoyam, oil palm, pepper and garden eggs (E.A.M.A, 2015). Cocoa is also one of the main cash crops cultivated in the municipality.

Manufacturing firms found in the municipality are mostly small-scaled and include the industries involved in palm oil extraction, Gari making, Soap Making, Blacksmithing, local gin distilleries, and wood and furniture making (E.A.M.A, 2015).

3.4.2 Mining

The Abuakwa South municipality is abundant in mineral deposits like gold, diamond, and kaolin, mostly found in the Birim and Pra basins. Gold exploitation and prospecting

are on the large scale in the municipality, though it is largely small-scale exploitation. It is estimated that gold prospecting and gold exploitation covers a land area of about 343 acres and 159 acres respectively (Ron *et al.*, 2010). Several large-scale mining companies have explored mining potentials in the municipality. For instance, in 2004, RUSAL a Russian mining company applied for bauxite prospecting in Kyebi (E.A.M.A, 2012). In addition, currently, the Atiwa forest has been leveraged for large scale bauxite mining by the current government (Schep *et al.*, 2016).

The municipality has been under intense illegal mining activities in recent times, with a heavy toll on the environmental safety and sustainability of the area. This called for the intervention of the current government in a bid to reduce environmental damage. Thus, leading to the institution of the operation vanguard to limit and regulate all mining activities in the country.

3.4.3 Lumbering

The area is well endowed with dense forest vegetation containing several tree species like *Khaya ivorensis*, *Antiaris toxicaria*, *Triplochiton scleroxylon*, *Milicia excelsa*, and others. The availability of economic tree species in the Atiwa forest influences activities like illegal chainsaw operations. Again, some of the indigenous folks also rely on trees, herbs, and shrubs for household fuel and medicine respectively (E.A.M.A, 2012).

3.5 Social facilities

3.5.1 Education

The municipality has fairly resourced educational facilities in terms of both infrastructure and staff. There are approximately 125 nursery schools and the kindergarten, 135 primary schools and 97 Junior High School, 11 Senior High Schools, 3 Technical and Vocational Schools and 1 Teacher Training College of Education (E.A.M.A, 2012). There is also a School for the Deaf in Kyebi.

3.5.2 Water and sanitation

The Abuakwa South municipality provides 65% of its population with potable water in comparison with a national figure of 38.4% (E.A.M.A, 2015). This contributes to a considerable delivery of water in the municipality. This improvement is due to supply from bore-holes and pipe-borne water in the municipality.

However, with the improvement in water supply in the municipality, some communities have limited access of less than 40% of the total population to centralized pipe-borne water supply (E.A.M.A, 2014). Others in the municipality depend on wells, the Birim River and other streams for water.

Also the state of sanitation according to E.A.M.A (2015), has not been impressive in recent times owing to the spate of environmental resources exploitation and general

waste management in the area. The population of the people with access to and using hygienic sanitation facilities is estimated at 35% (E.A.M.A, 2012).

3.6 Research design

The research design for the study is mixed methods. The quantitative design employed is to give a systematic and accurate mathematical representation of data gathered. The qualitative design employed is to give a peculiar representation of the phenomena occurring in the Abuakwa South municipality. These research designs are selected based on how the research objectives are connected to the available data and the research design instruments for data collection and analysis (Punch, 2005).

3.6.1 Sources of data

Data for the study were gathered from primary and secondary sources. Primary data were gathered from empirical information through intensive fieldwork in the selected communities in the Abuakwa South municipality. Instruments for the data collection were questionnaires, personal observations and field vegetation biomass and soil sampling. Communities selected for the study were Kyebi, Asikam, Sagyimase, and Apapam. These communities were selected based on their proximity to the Atiwa forest, the homogeneity in their socio-economic lifestyles, the fact that the formal entrance to the Atiwa forest was in one of the selected communities and the fact one of the selected communities was the administrative capital of the municipality.

Selected Sources for the primary data collection were from the indigenous people in the four selected communities, the Municipal Assembly and the Forestry Commission office in the Abuakwa South municipality. Secondary data was obtained from peer-reviewed articles and journals, past and current Medium Term Development Plan documents for the Abuakwa South municipality.

3.6.2 Sampling technique

Simple random sampling and purposive sampling were employed in the questionnaire distribution. Among the indigenous people in the four selected communities, simple random sampling was employed to give each person an equal opportunity to contribute to the study. Further, soliciting for data from the Municipal Assembly and the Forestry Commission employed purposive sampling techniques to determine the distribution of questionnaires.

Slovin's formulae were employed in determining the sample size for data collection. From each selected community, a sample size of 39 was estimated, in a total of 156 sample size for four communities. This was estimated from a population size of 15,113, 3,127, 3,027 and 2,785 for Kyebi, Apapam, Sagyimase, and Asikam respectively. The formulae for sample size determination is expressed as thus,

$$n = \frac{N}{1 + Ne^2}$$

Where,

n = sample size

N = population size

e = margin of error (5%)

3.7 Field data collection

3.7.1 Questionnaire survey

For the purpose of objective quantification of perception on forest management and the extent of the role of Strategic Environmental Assessment respectively in this study, the questionnaire was the best instrument for soliciting such information. The justification for using questionnaires for this study is the fact that questionnaires are cheap and easy to administer, they do not require many efforts like interviews and open survey discussions which have the possibility of yielding the same results.

Questionnaires also come with preset questions and a predetermined range of answers to guide the respondent to limit his range of imagination of answers in relation to the scope of the needed information.

3.7.1.1 Questionnaire survey for selected communities

Questionnaire pre-testing was done for both formal institutions and the selected communities to ascertain the relevant and sensitive scopes for the final questionnaire design. A simple random sampling was used to distribute the questionnaires for the selected communities. Out of a total of 156 questionnaires, 150 were distributed successfully in the four selected communities for the data collection.

The questions explored areas of forest management frameworks, climate variability and general perception about forest resources. The questions were both open-ended and closed-ended questions. The open-ended questions were intended to explore other perspectives the research did not target, whilst the close-ended questions were to stimulate the respondents to select any of the options provided to make for easy analysis. Other questions were frame as Lickert-scale style questions grade the level of agreement and shared perception and certain phenomenal experiences.

3.7.1.2 Questionnaire survey for Abuakwa South Municipal Assembly and the Forestry Commission

Purposive sampling was employed to obtain data from the Abuakwa South Municipal assembly and Forestry Commission. This sampling technique was employed because its application works on the principle of judgmental sampling, which predetermines the respondents and agencies with the necessary information for the study.

Based on purposive sampling, 9 sets of questionnaires were distributed to selected departments of the Abuakwa South Municipality based on their functional role for environmental sustainability, municipal budgetary and financial allocation for development and overall administrative functional duties. The selected departments were the Environmental department, Planning department, Budget office, Municipal Coordinating Director's office. In addition, a total of 8 questionnaires were distributed to the officials of the Forestry Commission.

3.7.1.3 Questionnaire Analysis

Questionnaires data were processed with SPSS and excel worksheets and tables to generate a graphical representation of the information given by respondents.

Content analysis was done by reviewing the current development policy (Agenda for Jobs: Creating Prosperity and Equal Opportunity for All), the immediate past development policy (Ghana Shared Growth and Development Agenda), the immediate past and current development plans of the Abuakwa South Municipality and the 2012 forest policy and other international documents on climate change and forest management like the Marrakech accord.

3.8 Ground truthing

Global Positioning System (GPS) was used to confirm ground coordinates corresponding to exact control points where samples were taken as was done by Hailemariam *et al.* (2016). Based on the Maclean and Congalton protocol (2012) in determining accuracy assessment, thirty control points per land cover were purposively assigned. These points were validated through supervise classification on an ArcGIS software to ensure the legitimacy of the final ground coordinates for field samples.

3.8.1 Land cover classification and accuracy assessment

Three Landsat satellite images dated 9/03/1986, 12/02/2003 and 25/01/2017 were obtained from the United States Geographical Surveys (USGS). The surface reflectance toolbox in ArcGIS was used to convert the top of the atmosphere (TOA)

into visible spectral features. Thirty training samples for each land class name; the dense forest area, open vegetation area, and the bare land area, were selected and supervised classification was performed using the Random Forest Classifier in Sentinels Application Platform (SNAP). The vegetation classes identified comprised of dense forest, open-canopy forest, shrublands, grasslands, farmlands, and bare lands. The formulae below were used to estimate the pixel accuracy for each land cover type.

$$\frac{30\text{ m} \times 30\text{ m}}{1,000,000\text{ km}^2}$$

3.8.2 Field plots estimation for tree inventory

This section employed the carbon sampling technique to estimate the aboveground biomass parameters of the carbon stocks. Selected parameters were forest tree biomass, cocoa tree biomass and litter and necromass in all selected land cover types which included dense forest regions, open canopy forest regions, shrublands, grasslands, and farmlands. These parameters were selected based on the fact that the above-ground biomass of vegetation stock holds a greater stock of carbon than other carbon pools. In addition, the carbon content of the cocoa tree was estimated based on the dominant cash crop cultivation in the municipality and its biomass contribution to carbon stocking. Again, due to the increase in illegal mining activities in the municipality, it is imperative to assess soil carbon. A total area of 50 hectares was sampled in each land cover type for carbon assessment in each aboveground biomass parameter.

With the help of local personnel and personnel from the Forestry Commission, plant species were identified and recorded. Supporting data on vegetation species were taken from recent research journals from the Forestry Commission.

3.8.3 Forest trees sampling

To determine the main plots for estimating the aboveground tree biomass, the Pearson *et al.*, (2005) equation was used to calculate the total plot numbers in a sample field of 50 hectares for both dense forest area and open forest areas. A preliminary number of plots of 6 and 7 (25 m x 25 m) were randomly sampled for dense and open vegetation zones respectively, with each plot at a 50 m distance from the other. In the sampling process, tree heights were determined with a clinometer. Trees with a height of less than 10 m were marked as unsuitable for sampling. Further, tree diameter at breast height (*dbh*) was measured with a diameter tape. Trees with a diameter less than 5 cm (*dbh* measured as 1.3 m vertically above ground from the base of the tree) were not included in the biomass and carbon assessment. However, trees with $dbh \geq 5$ marked for biomass and carbon assessment. These parameters are indicators of greater biomass stock of trees (Walker *et al.*, 2011). A total of 95 and 57 plots were determined for dense forest zone and open vegetation zone respectively. The sampling was done in the wet and dry seasons to justify seasonal climatic effects on biomass and subsequent carbon sequestration. During vegetation sampling, shrubs, grasslands, and farmlands were sampled. The Pearson *et al.* (2005) formula is expressed as:

$$n = \frac{(\sum_{i=1}^n Ni \times Si)^2}{\frac{N^2 \times E^2}{t^2} + (\sum_{i=1}^n Ni \times Si^2)}$$

Where:

N = represents the number of sampling units for the stratum (area of the stratum in hectares).

S = standard deviation of the carbon means in the stratum.

E = represents the allowable error of the confidence level. It is calculated by multiplying the mean carbon stock by the desired precision level (in this case the desired precision level was 10%).

t = sample statistic from a selected preliminary distribution for means the carbon estimation having a confidence level of ninety-five percent (95%). This is usually set at two since the sample size is undetermined at the preliminary sampling moment.

Aboveground biomass (AGB) for tree carbon stock was assessed using the Chave *et al.*, (2005) equation for humid moist semi-deciduous forest region;

$$AGB = 0.0509 * \rho DBH^2 H$$

Where;

AGB= aboveground biomass.

ρ = tree density for tropical Africa which is approximately estimated as 0.58g/cm³ (Negasi *et al.*, 2018)

DBH = tree diameter at breast height taken at 1.3 m from the ground.

H = tree height.

The conversion of total biomass to carbon stocks was done with Pearson *et al.* (2005) equation. According to this equation, carbon estimation is half of the total biomass.

$$\text{Carbon} = 0.5 * \text{biomass}$$

An assessment of the true horizontal radii of plots was corrected on slopes using the Pearson *et al.* (2005) formula;

$$L=L_s \times \text{Cos } S$$

Where,

L= true horizontal radius

L_s= along slope measured radius on the field.

S= slope (degrees).

Cos= the angle's cosine.

In addition, the expansion factor for assessing aboveground biomass per hectare was estimated using the Walker *et al.* (2011) equation;

$$\frac{A\beta}{A\rho} \times AGB$$

Where,

A β = area of one hectare in square kilometers

A ρ = area of the sampled subplot in square kilometers

AGB= Aboveground biomass sampled subplots

Further assessment of the potential carbon weight that can be emitted into the atmosphere was estimated using the equation by Walker *et al.* (2011);

$$CO_2 = AGB \times \frac{MW_{CO_2}}{MW_C}$$

Where,

CO₂= Carbon dioxide

AGB= Aboveground biomass

MW_{CO₂}= Molecular weight of carbon dioxide

MW_C= Molecular weight of carbon

3.8.4 Cocoa farm sampling

Carbon stocks in farmlands were estimated based on the dominant cultivated crop. *Theobroma cacao* farms, however, were selected for carbon estimation analysis. The average size of the cocoa farms selected was 20 hectares which confirms the assertion of Wessel and Quist-Wessel (2015). Five cocoa farms were selected at random, out of which three (3) farms were selected for preliminary sampling to determine the required plot number in the cocoa tree biomass assessment. Each plot measured 25 m x 25 m, and 4 plots were determined for each of the five cocoa farms selected using the Pearson

et al. (2005) equation. Aboveground cocoa tree biomass was estimated using the allometric equation of Yuliasmara (2009);

$$AGB = 0.1208 * D^{1.98}$$

Where;

AGB= Aboveground biomass

D= Diameter at breast height (*dbh* at 1.3 m vertically above ground from the base of the tree).

3.8.5 Litter and necromass

Litter and necromass samples were taken from 1 m x 1 m nested plots within the 25 m x 25 m subplots in the 95, 57 and 4 subplots in the 50 hectares and 20-hectare plots for dense and open vegetation strata as well as the cocoa farm. In each subplot (25 m x 25 m), a composite sample of 100 g was fetched. This protocol was followed in each stratum. A total of 95, 57 and 4 samples were bagged separately into plastic bags and labeled according to each stratum. It was sent to the laboratory to be oven-dried at a temperature of 75°C to keep a constant weight before analyzing for carbon content (Gyabaah, 2012; Djagbletey, 2015).

100 g of litter and necromass biomass were estimated using the Pearson *et al.* (2005) equation below;

$$Dry\ mass = \left[\frac{dry\ mass\ of\ composite\ sample}{fresh\ mass\ of\ composite\ sample} \right] * X$$

Where:

X= Total mass of fresh sample collected.

Litter and necromass carbon were estimated using the formulae,

Dry mass * % of carbon (Mg ha^{-1}), (Pearson *et al.*, 2005).

Where the percentage of carbon is represented as the fraction of the IPCC value which is marked at a default value of 0.37.

3.8.6 Soil sampling

A sampling of soil quality in vegetated areas began with nested plots (1 m x 1 m) creation in the main plots for aboveground tree biomass. Using a core sampler of 30 cm depth, three samples were fetched from each of the three nested plots created in each main plot. Composite samples were however taken after pooling together all samples taken. In total, 95, 57 and 4 soil samples were taken from the dense forest area, open vegetation area, and the cocoa farms. In a bid to assess the soil carbon for the open vegetated land cover, 20 soil samples from the dense forest cover were taken as control samples.

Samples taken from the bare land site were purposively sampled from 5-hectare illegal mining sites marked out with pegs. Thirty plots were created at a 30 m distance from each other. Subplots of 5 m x 5 m were created within which three nested plots of 1 m x 1 m were further created for soil sampling. With the aid of a 30 m depth core sampler, the soil was fetched from the three nested plots. The composite sample was bagged from all subplots into a plastic bag and taken to the laboratory to be air-dried and oven-

dried at a temperature of 75°C before the commencement of carbon analysis (Gyabaah, 2012; Djagbletey, 2015).

3.8.7 Soil texture analysis

The protocol of Six *et al.* (2000a) was followed to fractionate all soil sampled into the various soil fractions to enable carbon estimation in each fraction. All Composite samples taken from the four land cover types were gently sieved through an 8 mm mesh sieve. Aggregates size greater than 8 mm were hand broken until all samples passed through the 8 mm mesh sieve. Samples were then air-dried, from which 80 g sub-samples were fetched from each sample and spread evenly on a 2 mm sieve-mesh placed in a white basin (30 cm diameter and 8 cm deep) with watermarking at a level approximately 1 cm over the 2 mm sieve-mesh. The sub-samples were allowed to be on the sieve for 5 minutes to flocculate the samples through a separation of aggregates. The soil was however sieved again for 3 minutes by moving the sieve 50 times up and down at an appropriate positioned angle to drain all soil particles and water smoothly. The sieve was taken out of the water and rinsed thoroughly on all sides to have all soil particles in suspension.

Particles retained on the 2 mm sieve were washed back into a pre-weighed dry pan with clean distilled water. Floating litter and debris were removed and put in the dry pan with large macro-aggregates which was placed in a forced-air oven at a 60°C temperature overnight. The soil aggregates and water that flowed through the 2 mm sieve-mesh were later poured onto a 250-µm sieve-mesh held over a second white basin

and sieved for 2 minutes. The sieve was taken out of the water and rinsed to clean out all particles in suspension. The aggregates of 250-2000 μm (i.e. small aggregates) were back-washed into a pre-weighed drying pan and put inside a forced air oven to evaporate all moisture. In addition, the particles and water that passed through the 250- μm sieve-mesh were emptied onto a 53- μm sieve-mesh basin to repeat the sieving procedure again. The sieve was then rinsed on all its sides and to have all soil particles washed into suspension in the basin.

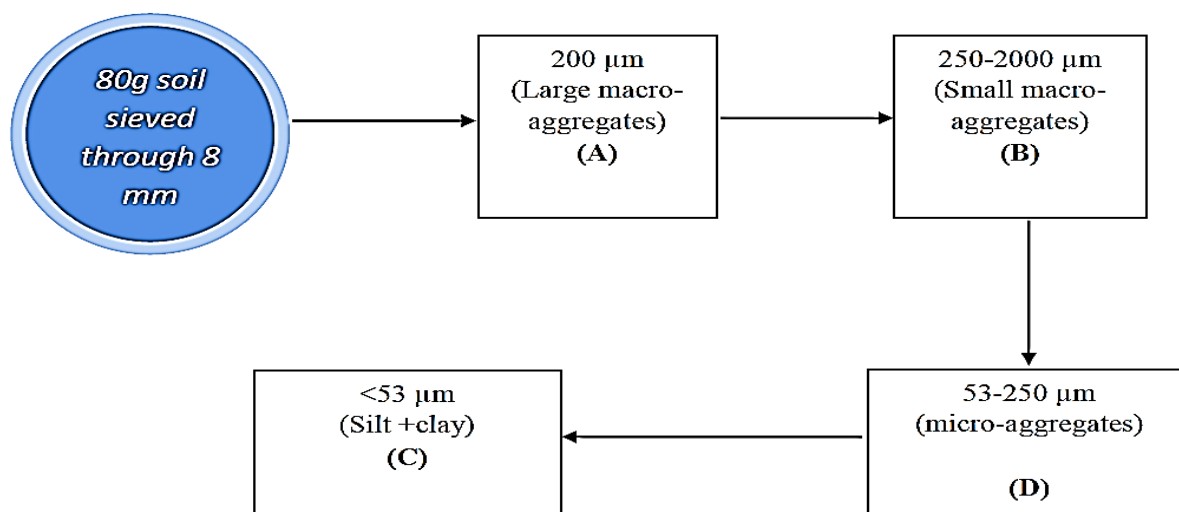


Figure 1 Macro aggregate separation

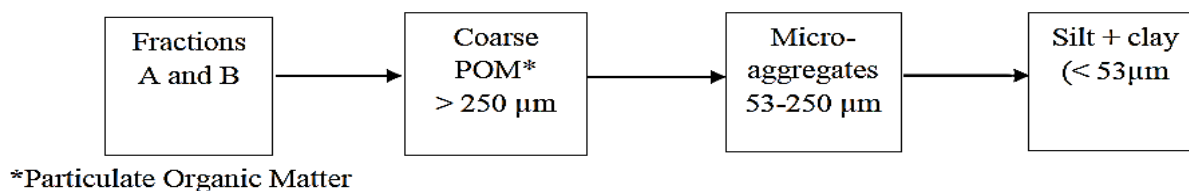


Figure 2 Micro aggregate separation

Fractionation model illustrating soil aggregate isolation and organic matter (Six *et al.*, 2000a)

3.9 Laboratory Analysis

3.9.1 Soil carbon analysis

The soil organic carbon was determined using the Walkley-Black wet oxidation procedure (Djagbletey, 2015; Negasi *et al.*, 2018). A gram of soil sample was weighed and sample into a 500 ml Erlenmeyer flask. A ten milliliters solution containing 1.0 *N* $K_2Cr_2O_7$ was added to the sample with the further addition of 20 ml of concentrated sulphuric acid. The solution was gently mixed by swirling until all soil particles were fully in contact with the solution. The flask with all its content was then allowed to cool on asbestos sheet for about an hour. 200 ml of deionized water and 10 ml of concentrated orthophosphoric acid were added to the solution. A diphenylamine indicator of 1 ml was added to the solution. A titration was then done against 1.0 *M* $FeSO_4$ solution.

The organic carbon content of the soil was calculated as follows:

$$\%OC = \frac{M \times 0.39 \times mcf \times (V_1 - V_2)}{w}$$

Where:

M = Concentration of FeSO₄ solution

V₁ = Volume of FeSO₄ required for blank (ml)

V₂ = Volume of FeSO₄ required for soil sample (ml)

w = Weight of air-dry sample (g)

$$mcf = \text{Moisture correction factor} = \frac{100 + \% \text{moisture}}{100}$$

0.39 = 3 x 0.001 x 100 % x 1.3 (3 = equivalent mass of carbon)

1.3 = a compensation factor for the incomplete combustion of the organic carbon

Bulk density (g/cm⁻³) was determined by the formulae = $\frac{\text{Oven dry mass (g)}}{\text{Volume (cm}^3\text{)}}$

Soil texture analysis was determined by the hydrometer method.

3.9.2 Total carbon stock calculation

The total carbon stock of the separate land cover types was estimated by adding all carbon pool samples estimated in each land cover type.

$$C_t (\text{Mg ha}^{-1}) = \text{TC} + \text{LC} + \text{SOC}$$

Carbon mapping was done using the spatial distribution of carbon stock values for the different land cover types with the aid of the exponential semivariogram model (Du *et al.*, 2010).

3.9.3 Rainfall and temperature assessment

The assessment of rainfall pattern variability was based on annual data values obtained from the Ghana Meteorological Agency. The assessment was based on three data sets representing the respective years selected for the study; 1986, 2003 and 2017. The images were selected based on their surface visibility for analysis. A simple regression analysis was used to establish the correlation between the rate of deforestation and rainfall patterns in the study area.

Annual temperature data similarly were obtained from the Ghana Meteorological Agency (GMA) for the years 1986, 2003 and 2017. The relationship of temperature changes with forest cover was assessed using simple regression analysis.

3.9.4 Statistical analysis

One way analysis of variance (ANOVA) was done with SPSS to check the mean difference between vegetation parameters and carbon stock across land covers. Mean separation was however done with the Tukey HSD model.

Regression analysis was done to ascertain the relationship between soil organic carbon and tree parameters, as well as rainfall and temperature patterns with forest cover. Similarly, Pearson correlation was used to assess the relationship between carbon values and tree parameters and selected Strategic Environmental Assessment parameters; social inclusion, periodic institutional capacity building, environmental

sustainability and economic sustainability with forest cover. The latter assessment will show if there is a significant relationship between SEA and forest sustainable forest management.

CHAPTER FOUR

RESULTS

This section presents results for the study and is divided into 2 main sections, namely; results on questionnaires from the municipal assembly, the Forestry Commission and community perception on forestry management. The final section of the results is on land cover changes, rainfall and temperature variability trends over the past three decades and lastly on carbon content assessment in trees and soil.

4.1 Impact of SEA on forest sustainability management in Abuakwa South

Municipality

Results on the operationalization of the Strategic Environmental Assessment (SEA) in the Abuakwa South Municipality regarding the natural environment are presented in this section. It was observed that deforestation has been predominantly by anthropogenic activities.

4.1.1 Questionnaire Results from the Abuakwa South Municipal Assembly

Table 1 presents results on the availability of a plan document expected to guide administrative institutions concerning forest conservation in the municipality. From the total questionnaires distributed, two responded “Yes” whilst another 2 responded “No” and “Not sure” respectively. Twenty-five of the total respondents responded the management plan has been operational in a period less than 1 year, whilst 75% responded “Do not know” on long the plan has been operational.

Further to this, the response on the level of familiarity with the plan on forest management revealed that only one 25.0% response indicated “Very familiar”, whereas another 25.0% response indicated “Slightly familiar” and 50% responded, “Not familiar”. Additionally, the results showed only one department participated in the drawing up of the forest management plan whilst the remaining three departments indicated their non-participation. Again, on the state of awareness of the current 2012 National Forest Policy and its objectives, the results indicated that all four (100%) departments indicated they were not aware of it.

From Figure 4, results revealed equal responses to the perception of the respondents on the efforts of the existing forest management plan in addressing forest and environmental protection. From responses given, 25% responded as “Strongly agree” and “Slightly agree” respectively, whereas another 25% responded “Not agree” and “Not sure” respectively.

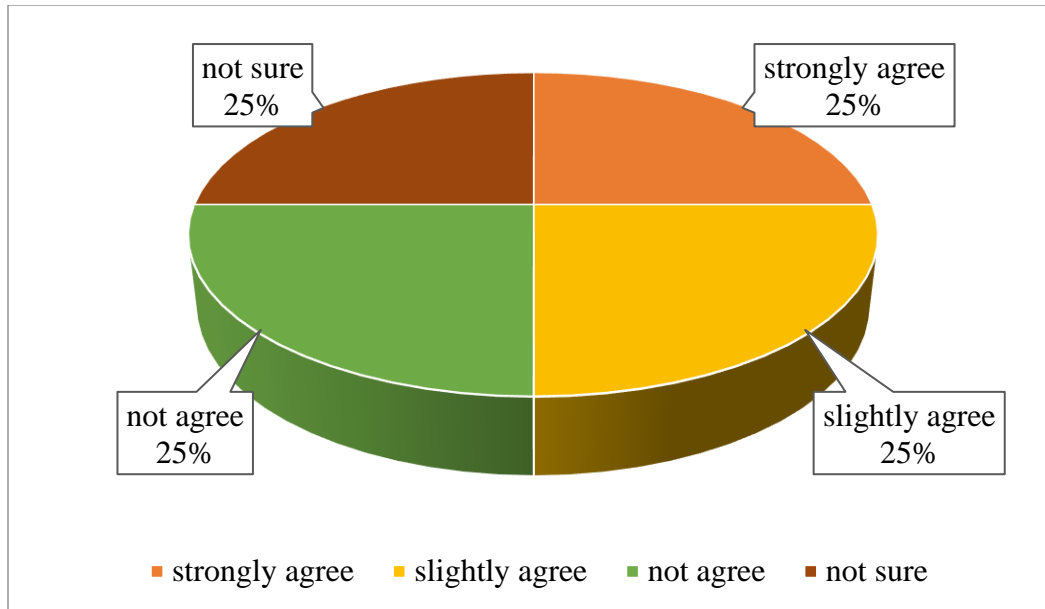


Figure 3: A Pie Chart Showing Results on the Perception of Management Plan in Safeguarding Forest resources.

4.1.1.1 Social integration

Results on the inclusion of local opinion leaders in projects geared towards sustainably conserving the Atiwa showed results of 25% responding in the affirmative, and 75% responded: “not sure”.

On the frequency of soliciting for external inputs in the preparation of forest management plans and programs, 75% responded “Seldom”, whilst 25% responded “Never”. In addition, results on inputs from private organizational entities in the forest and environmental management recorded 75% of “Not sure” and 25% indicating “No”

Table 1: External efforts in MMDA Plans and Programmes towards Forest Management

Variable	Frequency	Percentage
<i>Frequency of soliciting external inputs</i>		
Seldom	3	75%
Never	1	25%
<i>Local opinion leaders input</i>		
Yes	1	25%
Not sure	3	75%
<i>Private entities (NGO's) input</i>		
Seldom	3	75%
Never	1	25%

From Figure 5, results on the frequency of public sensitization programs in the municipality revealed 25% each the total respondents responding “Yes” and “No” respectively, whilst 50% of the respondents responded, “Do not know”.

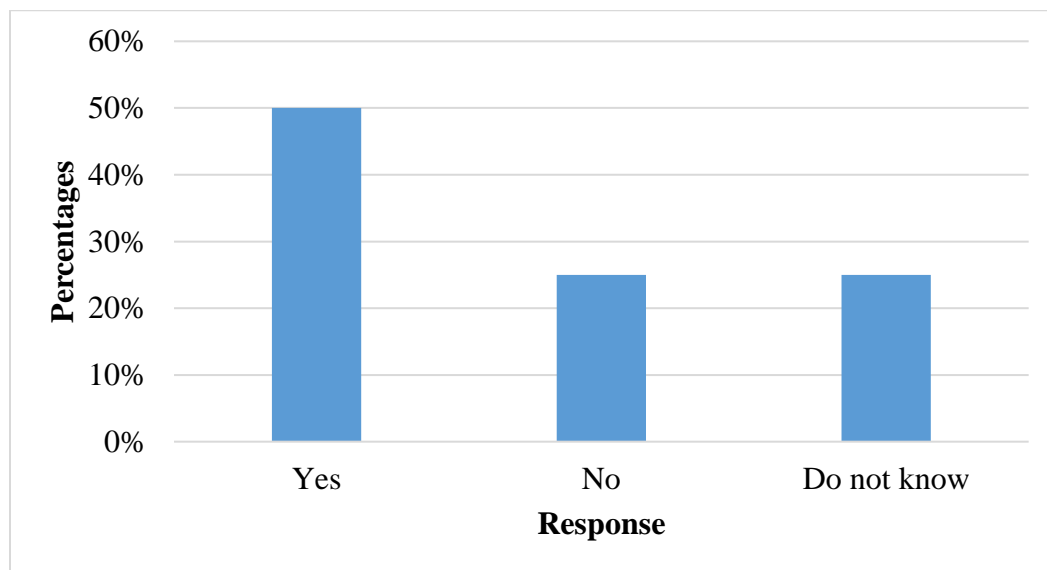


Figure 4: A Bar Graph Showing Frequency of Sensitisation Projects in the Abuakwa South Municipality

4.1.1.2 Environmental awareness

Environmental awareness is central to Strategic Environmental Assessment since it secures ecological balance for biotic and abiotic functions and promotes sustainable national development. From responses to key drivers that promote environmental management, 50% of the respondents indicated increased agricultural yield, 25% each indicated wildlife protection and ecosystem regulatory functions. Additionally, issues on actors contributing to improved environmental management attributed 75% response to the municipal assembly and 25% response by the traditional council.

Concerning environmental management, the study revealed that climate change awareness showed 100% awareness from all four selected departments in the municipal assembly for the study. Based on these results, concerns on climate change were focused on agriculture productivity, the security of potable water, wildlife conservation and forest regenerative capacity. Response on whether climate change adaptation projects existed in the municipality indicated 25% responding “Yes” and 75% response otherwise. This is shown in Figure 5.

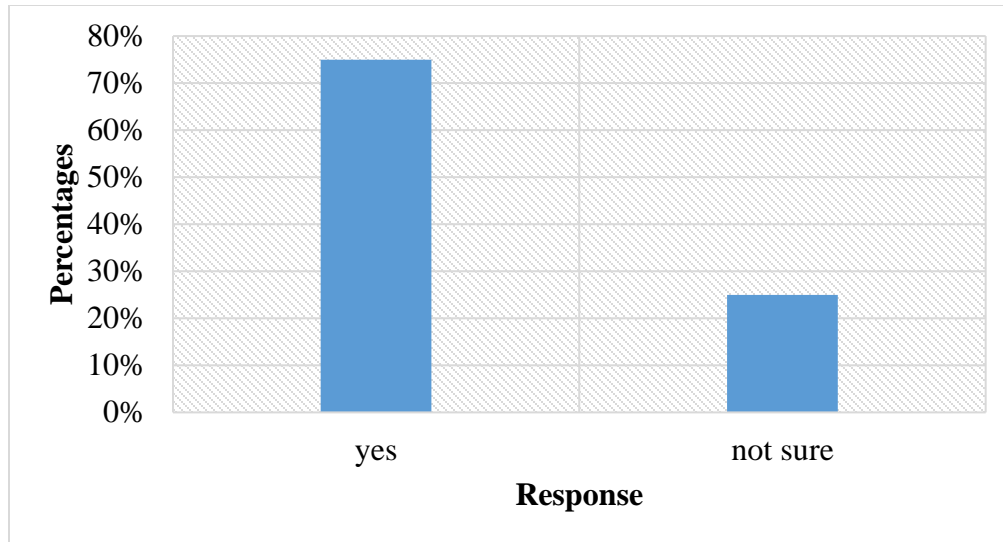


Figure 5: A Bar Graph Showing the Response on Climate Change Adaptation projects in the Abuakwa South Municipal Assembly.

Figure 7 presents results on the state of forest cover in the municipality where 75% response indicates “Slightly declining” and 25% response indicated “Highly declining”.

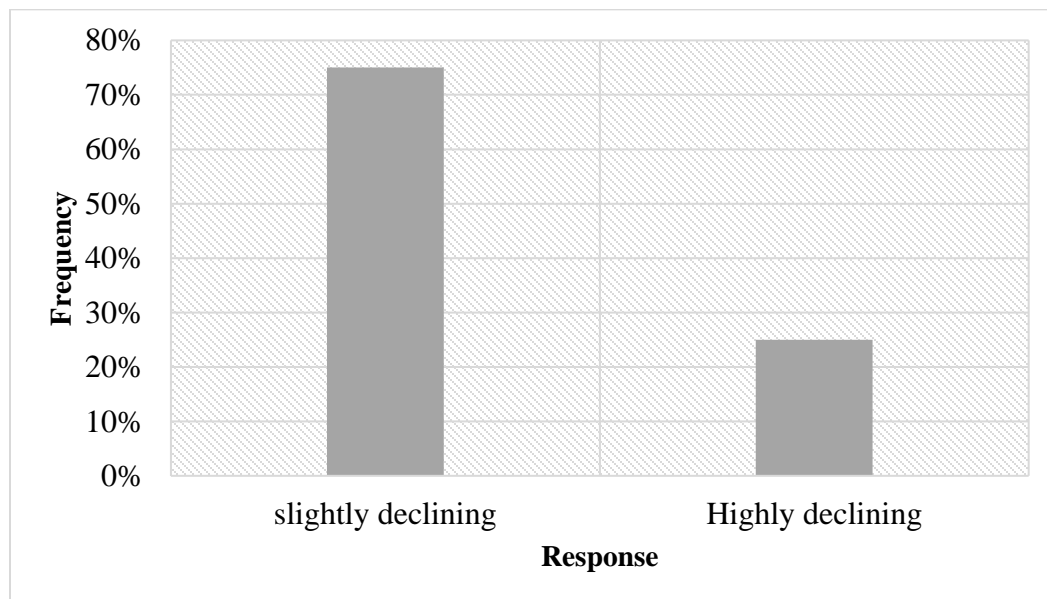


Figure 6: A Bar Graph Showing Response on the State of Forest Cover in the Abuakwa South Municipality

The results further revealed adopted forest management practices in the Abuakwa South Municipality to be agroforestry, woodlot afforestation, effective sanctioning of existing forest protection regulations as responses from three out of the four selected departments, whilst the fourth department had no idea on any recently adopted forest management practice.

However, on the state of the municipality's effort towards environmental and forest protection, responses from the four selected departments in the Abuakwa South Municipal assembly indicated it as minimal.

The disparity between the prescribed forest conservation projects and its effectiveness revealed a 75% response indicating "Low" whereas 25% response indicated it as "Moderate". Further, the response on reasons accounting for such disparity produced a 25% response as lack of political will to enforce regulations, 50% response as lack of trans-sectorial coordination between institutions whilst 25% responded as "Do not know". In figure 8, the results on the frequency of forest encroachment were given as 75% "Seldom" and 25% responding as "Never".

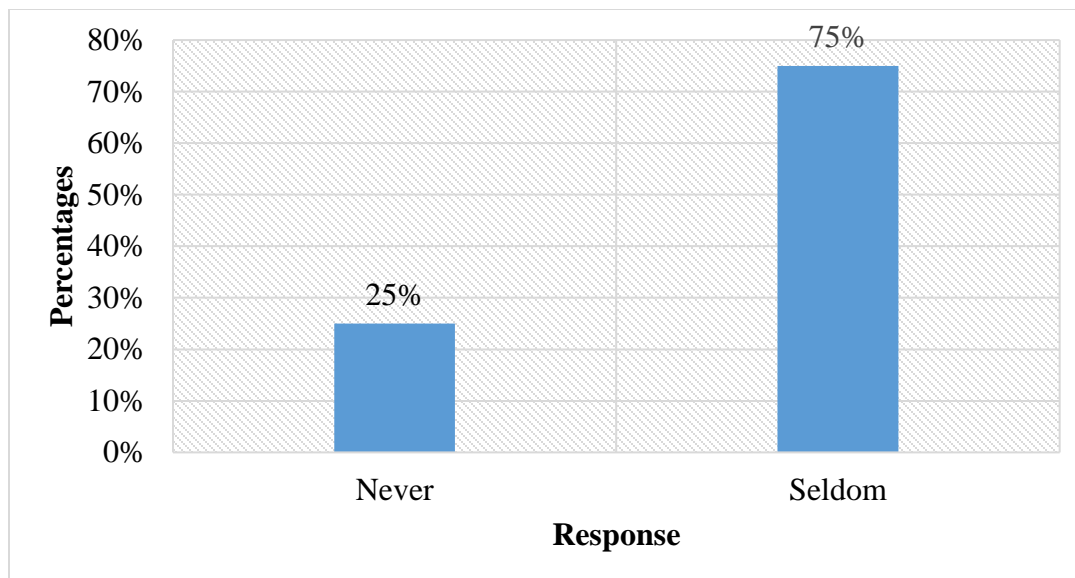


Figure 7: A Bar Graph Showing the Response on the state of forest encroachment

4.1.1.3 Institutional capacity building

Institutional capacity building is pivotal to Strategic Environmental Assessment since it ensures that all stakeholders are adequately resourced with the required instruments for sustainable development. Results showed the state of independence of the municipality as 50% responding as “Slightly independent” in matters of local administration, 25% responding as “Fully independent” and another 25% also responding as “Not independent”.

Further, on the capacity of institutional arrangements in the municipality, 25% of the respondents affirmed allowing there is an unimpeded implementation of projects concerned with environmental and forestry protection, whilst 75% responded: “Not sure”.

Response to the issues of level of resources available in the municipal assembly to augment operations had 75% indicating it as “Moderate” and 25% responded as low. Details of resources lacking in the municipal assembly are listed as follows; human resources only 25%, human resource and logistics 25%, finance only 25% and finance and logistics 25% from the four separate departments who participated in the study.

Results on institutional training and capacity building on methods and approaches on environmental protection also showed 75% indicating no training attended in the last decade, with 25% indicating to have attended an environmental protection training in the last decade.

The result on the frequency of capacity building training in the municipality for environmental protection and assessment also showed 25% responding “Seldom” whilst 75% responded, “Not often”. Table 2 illustrates the results of the institutional capacity status of forest and environment management.

Table 2 A Table Showing the State of Institutional Capacity in the Abuakwa South Municipality

Variable	Frequency	Percentage
<i>Municipal autonomy</i>		
Fully independent	1	25%
Slightly independent	2	50%
Not independent	1	25%
<i>Level of resource availability</i>		
Moderate	3	75%
Low	1	25%
<i>Type of unavailable resource</i>		
Finance and human resource	1	25%
Human resource only	1	25%
Finance and logistics	1	25%
Finance only	1	25%
<i>Training in the last decade</i>		
Yes	1	25%
No	3	75%
<i>Frequency of training in the last decade</i>		
Seldom	1	25%
Not often	3	75%

On any recommendation to enable the effective administration of the duties of the municipal assembly, response indications were regular inspection and environmental accounting, trans-sectorial coordination between all environment and forest stakeholders and regular training seminars. However, there was a response that the existing instruments are satisfactory.

4.1.1.4 Economic sustainability

Economic sustainability serves as a means by which proper and environmentally safe methods are employed towards economic growth and development. Information from the four departments in the study consented to the necessity of alternative livelihood projects' presence in the municipality. However, the results on the implementation of any livelihood project by the municipality to compensate for existing unsustainable activities were 25% responding "No" with 75% responding "Do not know".

Additionally, results on conflict of interest in carrying out administrative duties showed 75% indicating "No" and 25% responding "Yes". Further, results also indicated that in the instance of conflict of interest in carrying out administrative duties, 50% of the respondents were working to achieve management principles whilst another 50% responded as "Pleasing community interests and plight".

4.1.2 Forestry commission

The Forestry Commission's role in this study is owed to the fact they are formally concerned with forest resources protection and timber marketing regulation in the country. Therefore, it is imperative to include consult their opinion on forest management in Ghana. The Forestry Commission's range office in the Abuakwa South Municipality was involved in the study.

Five respondents from the range office comprising of the municipal's range manager, his secretary, and three other forest guard personnel participated in the study. Sixty-

seven percent of the respondents answered “Yes” to an implemented forest management plan in the municipality with 33% responding as “No”.

Further, the results also showed 83% of the respondents indicating they are slightly familiar with the entire plan document whereas 17% responded they are not familiar with the plan document. Additionally, it was revealed that a 17% response indicated the plan has been operational in the municipality for less than a year with about 83% saying they do not know the duration at which the plan had been in operation. On the objective of the plan, 17% each responded as socio-economic and environmental protection oriented and about 67% responded they do not know the objective of the plan. However, none of the respondents indicated ever participating in the drafting of the plan.

On the awareness of the current 2012 Forest Policy, about 17% of the respondents were aware of it, whereas 83% were not aware of it. Further, 83% of respondents were not aware of the objectives of the policy, whereas about 17% responded as slightly familiar with the objectives.

Table 3 Summary of Forestry Commission’s Awareness on Forest Management Plan

Variable	Frequency	Percentage
<i>Implementation plan</i>		
Yes	4	67%
No	2	33%
<i>Familiarity level</i>		
Slightly familiar	5	83%
Not familiar	1	17%
<i>Implementation duration</i>		
Less than a year	1	17%
Don’t know	5	83%
<i>Plan’s objective</i>		
Socio-economic development	1	17%
Environmental protection	1	17%
Don’t know	4	67%
<i>Participation in plan development</i>		
No	6	100%
<i>Awareness on 2012 Forest Policy</i>		
Yes	1	17%
No	5	83%
<i>Awareness on the 2012 forest policy objectives</i>		
Slightly familiar	1	17%
Not familiar	5	83%

Further, all the respondents from Forestry Commission cited environmental degradation as the direct perception attributed to forest exploitation, in addition, half of the respondents strongly agreed to the management plan safeguarding the forest in the Abuakwa South Municipality, with about 17% slightly agreeing and 33% responding, “Do not know”. This is illustrated in figure 9.

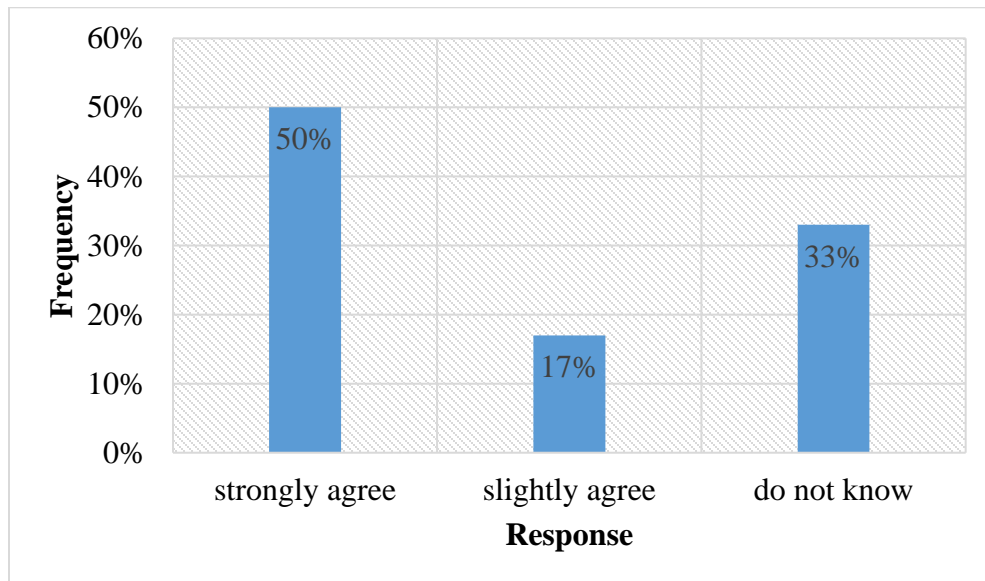


Figure 8 Representation of Forest Plan addressing the Atiwa Forest management

4.1.2.0 Economic sustainability

Economic sustainability is relevant as a means of promoting environmentally friendly methods of exploiting environmental resources. Results on economic sustainability revealed a 67% response indicating an awareness of the necessity of alternative livelihood projects, whilst 33% responded not aware of such an initiative. Response on the implementation of alternative livelihood projects in the municipality, however, showed 17% of the total respondents saying “No” whilst 83% responded, “Not sure”.

Table 4 Summary on Awareness and Institution of Alternative Livelihood Projects

Variable	Frequency	Percentage
<i>Awareness of alternative livelihood support projects</i>		
Yes	4	67%
No	2	33%
<i>Existence of alternative livelihood project in the municipality</i>		
No	1	17%
Not sure	5	83%

4.1.2.1 Social integration

Table 5 presents responses from the Forestry Commission where 33% affirmed that local opinion leaders were included in forest management plans and programs, with 67% responding they do not know whether local opinion leaders were included in forest conservation plans and programs.

Additionally, the study revealed that 33% of the respondents indicated the inclusion of private personnel and organizations on forest conservation management framework, and about 17% responded “No” and 50% responded, “Do not know”.

Table 5 Summary of Social Inclusion to Forest Conservation in Abuakwa South Municipality

Variable	Frequency	Percentage
<i>Inclusion of opinion leaders</i>		
Yes	2	33%
Don't know	4	67%
<i>Inclusion of private organizations</i>		
Yes	2	33%
No	1	17%
Don't know	3	50%

Results on the frequency of seeking external inputs by the Commission in its administrative obligations, 50% each of the respondents answered as “Seldom” and “Always”. In addition, results on public sensitization revealed 67% indicating in affirmation periodic sensitization projects, with 33% responded they do not know if sensitization projects are being organized.

4.1.2.2 Environmental sustainability

Environmental sustainability is appropriate for maintaining an ecologically balanced environment. For the purpose of this study, the environmental sustainable parameters assessed included state of forest cover, drivers promoting forest conservation, perception attached to forest resources exploitation, climate change awareness, adopted improved land management methods and main actors involved in environmental management. Further, the response on the state of forest cover was 50% indicating

slightly declining, with 33% indicating bot declining whereas 17% could not say whether it is declining or not.

On the drivers promoting an improvement in environmental and forestry management in the municipality, 67% opted for increment in agricultural yield, 17% each responded to ecosystem regulatory services and forest regenerative capacity respectively. This is illustrated in figure 10.

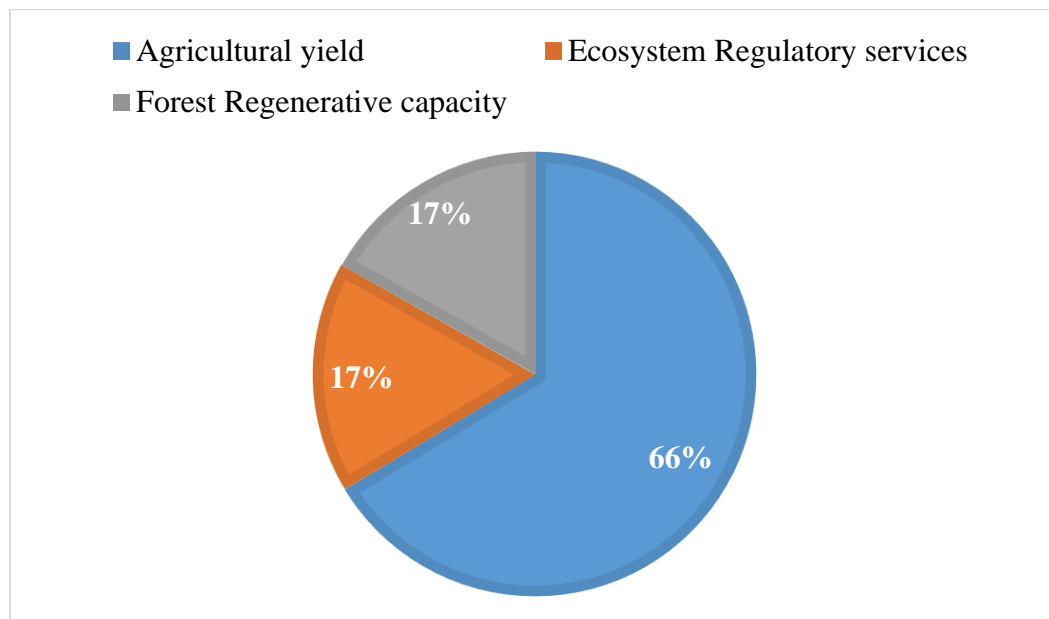


Figure 9: A Pie Chart Showing the Drivers Contributing to Forest Conservation

On the perception of forest resource exploitation, the Forestry Commission perceived forest resource exploitation as leading to environmental degradation.

On climate change awareness, 67% of respondents answered “Yes” to climate change being of concern in the municipality, with the rest responding “not sure”. About climate change concerns in the Abuakwa South Municipality, 50% cited the availability of potable water, with 17% each indicating wildlife habitat, ecosystem regulatory services, and increased agricultural yield. Further, the issue of improved land management projects in the municipality gave a 50% indication each for woodlot afforestation projects and a converse response of not aware of any improved land management projects.

The main actors involved in improved land management strategies implementation and monitoring indicated 50% to local government, with 17% each for Non-Governmental Organisation (NGO) and forest industrialist and stakeholders.

4.1.2.3 Institutional capacity

The autonomy of the Forestry Commission in its administrative functions was indicated as follows by respondents. Thirty-three percent indicated slightly independent, 50% highly independent and 17% responding not independent. Again, 67% of respondents gave a positive response to the institutional structure of the municipality allowing free implementation of administrative obligations, 17% respondent, however, responded as “No” whereas another 17% respondent also responded, “Do not know”.

On the level of resource availability to the commission, 83% of the respondents responded “Moderate” and 17% responded, “High”. Thirty-three percent of the

respondents responded, “Human resource only as of the scarce resource to the commission, 17% responded, “Finance only”, 17% again responded “Finance and human resource” and another 33% responded, “Don’t know”.

Further, 33% responded “Yes” to receiving periodic capacity training and 67% responding, “No” to receiving periodic capacity training, with 33% of the respondents responded the periodic capacity training is rarely organized. On results about committed efforts towards forest management, 67% response indicated it as “Minimal” whilst about 17% each responded as “Very efficient” and “Efficient”.

Further, a percentage of 50% indicated a moderate disparity between the stated management principles and the actual implementation strategies, whereas another 50% indicated the disparity level as low. On the reason behind such disparities, 50% of the respondents attributed it to lack of trans-sectorial coordination, with 17% each attributing it to lack of political will and low level of public censorship. Another 17% responded, “Do not know”. Further, on illegal forest encroachment, 83% response indicated it as a rare occurrence, whilst 17% responded it to be frequent.

Half of the respondents suggested regular monitoring and evaluation of the progress of efforts as a suggestion to safeguard the forest cover in the municipality. On the other hand, another 50% of the respondents said the existing framework and progress of strategy are satisfactory.

Table 6 Relationship between institutional parameters and forest cover

Dependent variable	Predictor variable	P-value
Forest cover	Forest management plan	0.248
Forest cover	Availability of operational resources	0.04
Forest cover	Social inclusion	0.03
Forest cover	Livelihood support projects	0.03

**p<0.05

4.1.3 Communal perception of forest management

4.1.3.1 Demographic data of respondents

Table 7 provides a summary of the demographic parameters assessed by the respondents. Out of the 150 sampled for the study, 82 respondents representing 55% were males and 68 representing 45% were females. The study also indicated the residence status of the respondents, with about 63% as natives and about 35% as migrants.

A total of 101 representing 67% of respondents were employed whereas 48 representing 32% were unemployed, from the employed sample, with 115 representing 77% engaged in the informal sector whilst 23% of people were in the formal sector. Majority of the respondents 24% each belonged to the brackets of GhC 100 and below, GhC 100-300 and GhC 700 and above, with 10 respondents representing 7%, however, belonging to the income bracket of GhC 500-700.

The results indicated that 116 respondents representing 77% were married and 34 respondents representing 23% were single. Widows, widowers, and divorcees were all put under the category of single people. With respect to formal education in the Abuakwa South Municipality, the majority of the respondents representing 44% had formal education from the basic level up to the junior high school level, with 13% having tertiary education, with at least a first degree. A summary of the demographic data of all respondents sampled for the study is represented in table 7.

Table 7 A Table Showing the Demographical Information of Respondents

Variables	Frequency	Percentage
<i>Gender</i>		
Male	82	55%
Female	68	45%
<i>Age</i>		
18-below	14	9%
18-25	44	29%
25-35	57	38%
35 and above	35	23%
<i>Residence Status</i>		
Native	90	63%
Migrant	52	35%
<i>Employment status</i>		
Employed	101	67%
Unemployed	48	32%
<i>Type of occupation</i>		
Formal sector	115	77%
Informal sector	35	23%
<i>Monthly Income levels</i>		
GhC 100 and below	24	16%
GhC100-300	24	16%
GhC 300-500	23	15%
GhC 500-700	10	7%
GhC 700 and above	24	16%
<i>Marital Statistics</i>		
Married	116	77%
Single	34	23%
<i>Education level</i>		
Up to JHS level	66	44%
JHS-diploma	43	27%
Diploma-First degree	21	14%
First degree and above	19	13%

4.1.3.1 Reliance on forest resources for sustenance

An assessment of reliance level on the forest for sustenance resources was done among the respondents. Fifty-seven respondents representing 39% indicated in the affirmative

to be relying on the forest for sustenance products, with 93 representing 61% responding otherwise.

4.1.3.2 Awareness of forest regulation instrument in the municipality

About 79 respondents representing about 53% were positively aware “Yes” to be aware of forest management regulations. On the contrary, 49 respondents representing 33% indicated they are not aware of any existing forest management regulation in the municipality. Twenty-two respondents representing 15% indicated, “Not sure” if there exist any management regulations or not.

Additionally, 42 out of the 79 responses indicating a positive awareness of a forest management framework answered in affirmative on being aware of the objectives of the forest management regulation, with 37 responses indicating, they were slightly familiar with the objectives.

In spite of the awareness level on the existing forest conservation regime, the results of the study indicated a level of forest encroachment. About 44% of the respondents indicated occasionally seeing people encroach the forest borders, with 24% respondents indicating frequently seeing people who encroach the forest, and 32% never seeing anyone encroach the forest. In addition, seven respondents representing 5% indicated hunting and agriculture as some of the illegal activities, with 28 respondents representing 19% indicating mining only. About 7% responded lumbering

and agriculture, whereas 1% responded to agriculture only. Twenty (20) respondents representing 13% responded lumbering and hunting, with 31 respondents representing 21% responding as lumbering and mining. Six respondents making a representation of 4% cited lumbering only, with 2% indicating agriculture and mining.

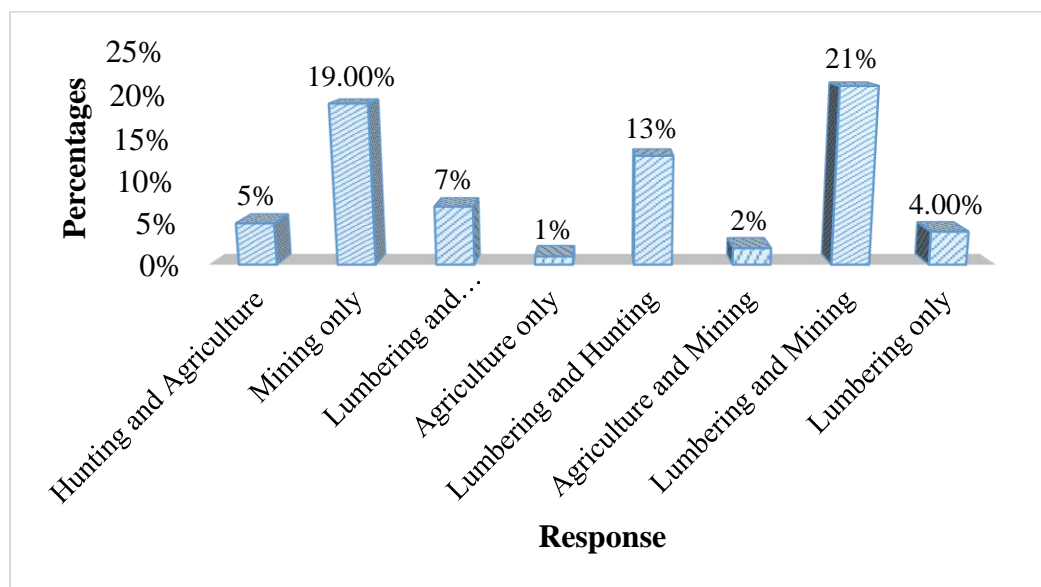


Figure 10: A Bar Graph Showing the List of Illegal Land use activities in the Atiwa Forest

4.1.3.3 Forest regulation compliance

About 45% of the respondents gave a positive indication concerning the possible compliance to all forest conservation regulations. However, 27% responded it is impossible complying with the forest conservation regulations, with 29% also responding “not sure” if compliance will be successful or not.

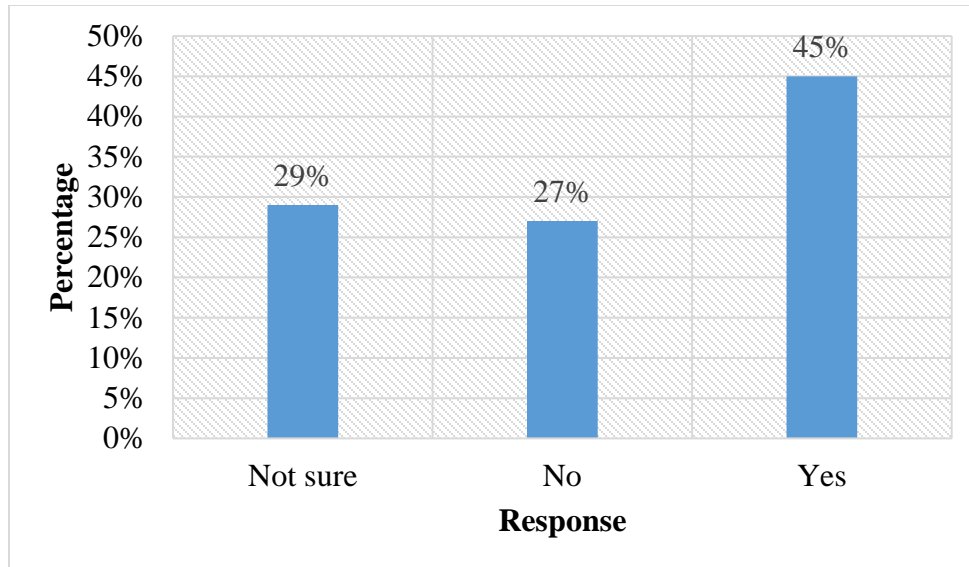


Figure 11: A Bar Graph Showing Responses on Forest Conservation Compliance in Abuakwa South Municipality

Further, the study revealed that 78 respondents accounting for 52% responded affirmatively to forest conservation regulations affecting their livelihood. Twenty-six respondents representing 17% also indicated no effect on their livelihood. Forty-six respondents representing about 31% responded “Not sure” to whether the operation of a forest conservation regulation would either affect their livelihood in the future or not. This is illustrated in figure 13.

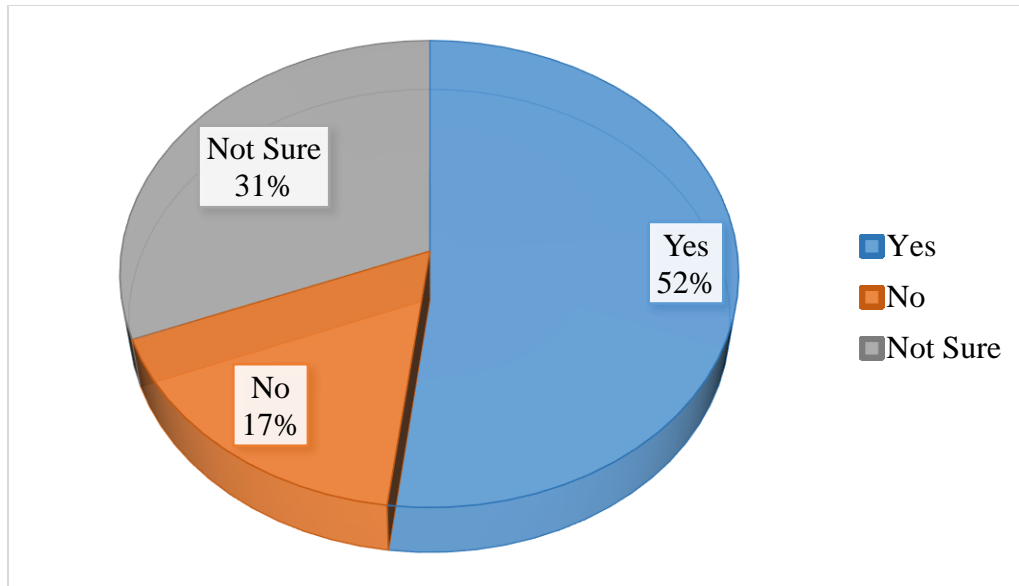


Figure 12: A Pie Chart Showing the Effects of Forest Conservation on Livelihood in the Abuakwa South Municipality

Figure 14 further presents responses on the significant effect of forest conservation, where it revealed twenty-two respondents representing about 15% indicating the effect would be on job availability and commerce. Eleven respondents representing 7% responded an effect could be on access to some basic household products from the forest. Nineteen respondents representing 13% indicated there could be on job losses and basic household products. Three respondents representing 2% indicated a possible lack of access to farmland, with 22 respondents accounting for 15% indicating there could be an effect on job losses only.

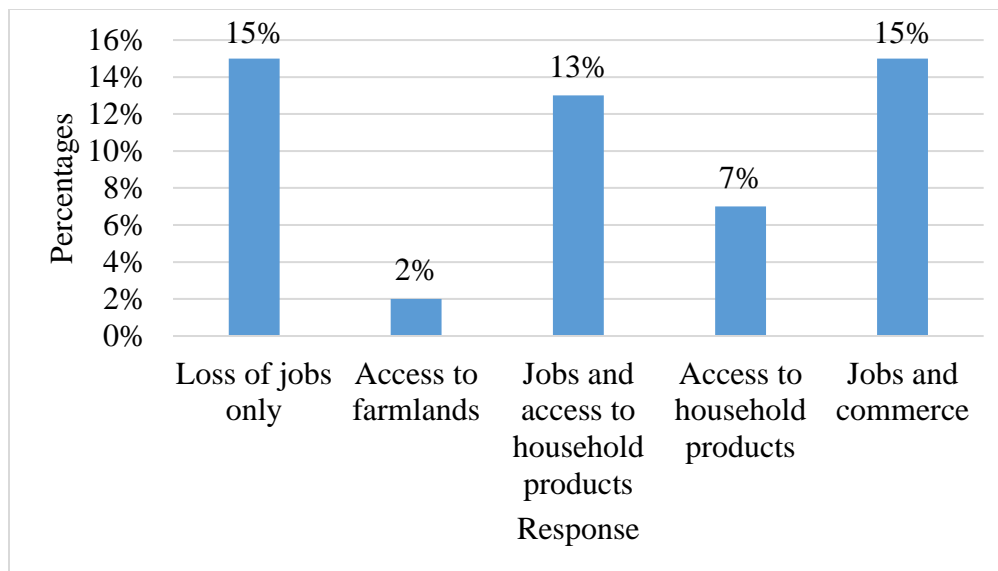


Figure 13: A Bar Graph Showing Livelihood Themes affected by the Forest Conservation in the Abuakwa South Municipality

On the current state of socio-economic wellbeing in the Abuakwa South Municipality since the inception of forest conservation regulation, 67 respondents representing 45% of the total respondent answered “Yes” to a massive decline in socio-economic activities in the municipality. Sixty-two respondents representing about 41% also indicated that socio-economic activities have been on a moderate decline, with 21 respondents representing 14% indicating no significant changes in the socio-economic life in the municipality.

4.1.3.4 Benefit-sharing

Twelve respondents making 8% of total respondents answered “Yes” to the municipality enjoying benefit-sharing from the forest management structure. Fifty-seven respondents representing 38% indicated “No” to any benefit-sharing entitlement,

with 81 respondents representing 54% responding as “Do not know” to the possibility of any benefit-sharing entitlement. This is illustrated in figure 15.

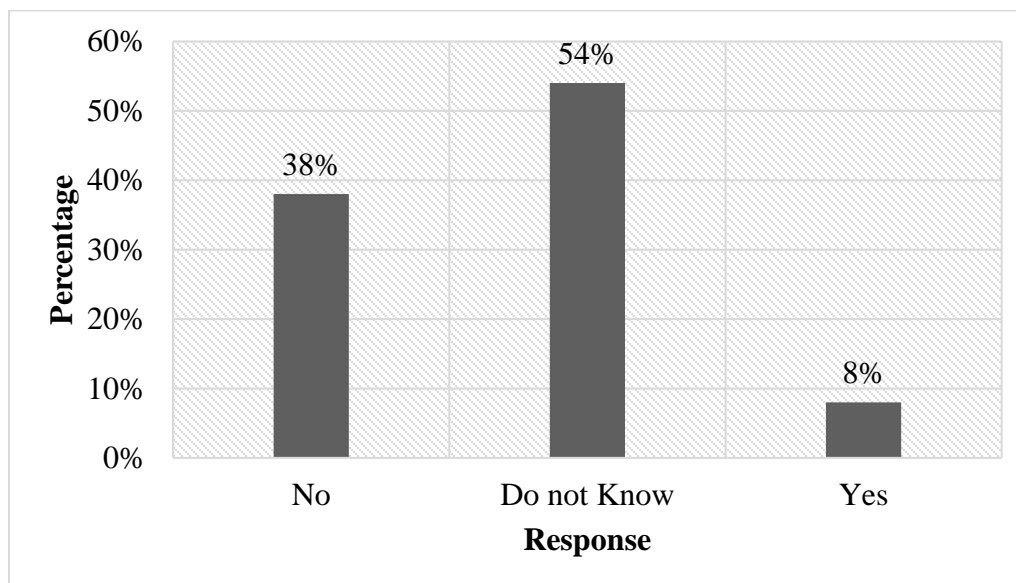


Figure 14: A Bar Graph Showing Response on Benefit Sharing from the Conservation of the Atiwa forest in the Abuakwa South Municipality.

From the response that indicated “Yes” to benefit-sharing existence, 1 person out of the 12 responded “Do not know” when asked about the exact benefit being provided to the municipality, with 4 respondents citing the payment to the traditional council.

4.1.3.5 Alternative livelihood support projects

On alternative livelihood support projects, 2% of the 150 respondents who participated in the study answered “yes” to the institution of an alternative livelihood project in the municipality by the assembly. Eighty-four respondents representing 56% responded “No” to the institution of any livelihood support activity by the municipal assembly.

Sixty-three respondents accounting for 42% responded, “Do not know” to the institution of any livelihood support project by the municipal assembly. This is illustrated in figure 16.

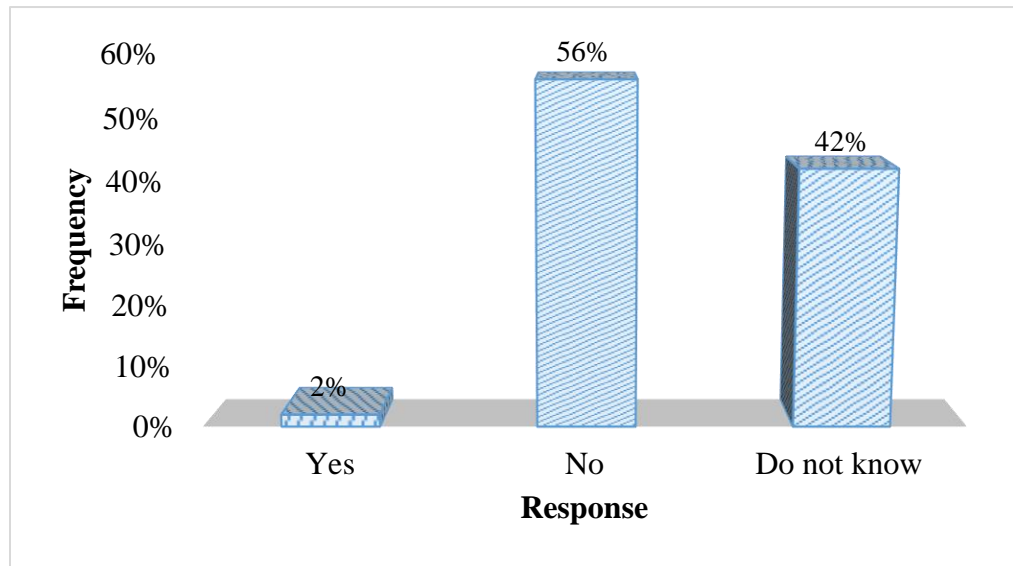


Figure 15: A Bar Graph Showing Response on Awareness of Alternative Livelihood Project in the Abuakwa South Municipality

4.1.3.6 Communal perception on forest

Communal perception about forest resources provides an understanding of the motivation leading to forest exploitation. Figure 17 presents the perception of the indigenous people in the forest as a resource. Five respondents representing about 3% responded perceived the Atiwa forest as a cultural resource. Sixty respondents representing 40% perceived it as of socio-economic importance or as a depleting resource, whereas 85 respondents representing 57% perceived it as an environmental asset.

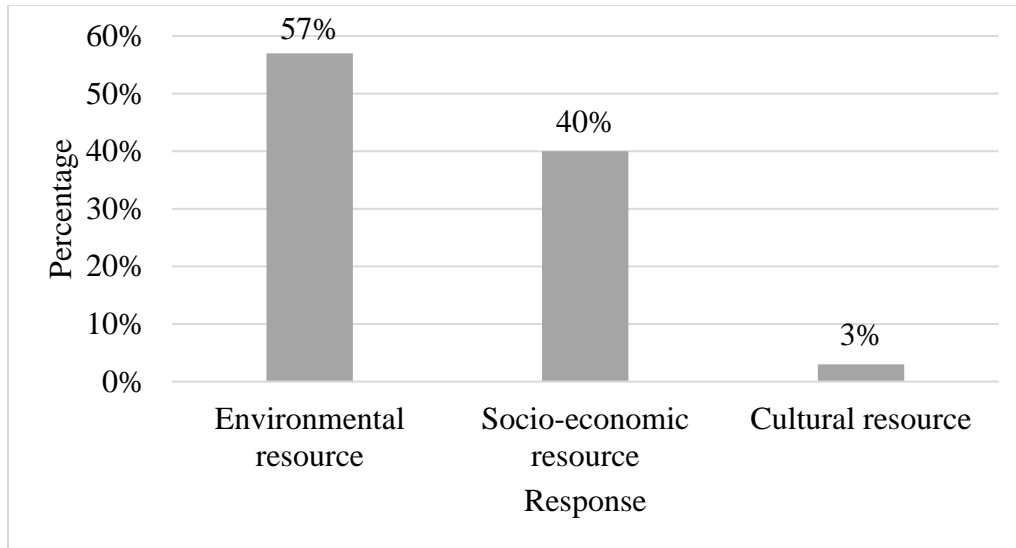


Figure 16: A Bar Chart Showing the Thematic Representation on the Perception of Forest as a Resource in the Abuakwa South Municipality

Regarding deforestation in the municipality, 46% of the respondents' related environmental degradation to forest decline, and 33% associated it with socio-economic development, with 21% relating deforestation to decline in wildlife stock.

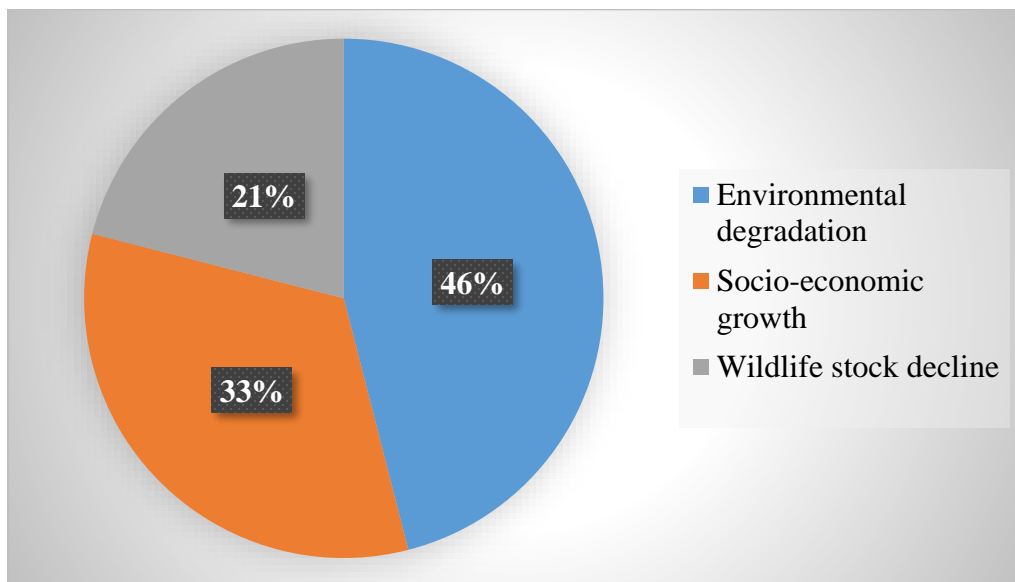


Figure 17: A Pie Chart Showing the Perception Attached to Forest Exploitation in the Abuakwa South Municipality

4.1.3.7 General changes in forest cover in the past two decades

The state of awareness concerning the trend in deforestation in the past two were assessed. Ninety-nine respondents representing 66% of respondents responded “Yes” to the significant decline in the forest cover and 17 respondents representing about 11% responded “No” to any significant decline in the forest cover. Thirty-four respondents accounting for 23% responded “Not sure” whether the forest cover has either declined significantly or not.

Further, information on specific land use activities that contribute to significant forest decline in the municipality was mainly attributed to Mining representing about 41%, Lumbering representing about 35%, Agriculture representing 20%, with Settlement representing 5%.

4.1.3.8 Perception of temperature and rainfall

Temperature and rainfall are key abiotic factors that promote the development of biological survival. Results on temperature and rainfall variability revealed 73 representing 49% responses answered “Yes” to changes in rainfall and temperature. Forty-six respondents representing 31% answered “No” to any significant changes in rainfall and temperature in the patterns, whereas 31 people representing about 21% responded “Not sure” to any significant changes in the rainfall and temperature in the municipality.

4.1.3.9 Forest conservation sensitization projects

Forest sensitization programs and projects are the means of creating awareness and instilling the necessary capacity in the forest and environmental stakeholders on the need for environmental protection.

Figure 19 shows the frequency of sensitization projects on forest management benefits in the municipality. Sixty-six respondents representing 44% answered “Yes” to past and recent sensitization projects on the need for forest conservation. Thirty-one respondents representing 21% responded “No” to the organization of any past and recent sensitization events concerning forest conservation, whilst 53 respondents representing 35% answered “Do not know” if there have been either past or recent sensitization projects.

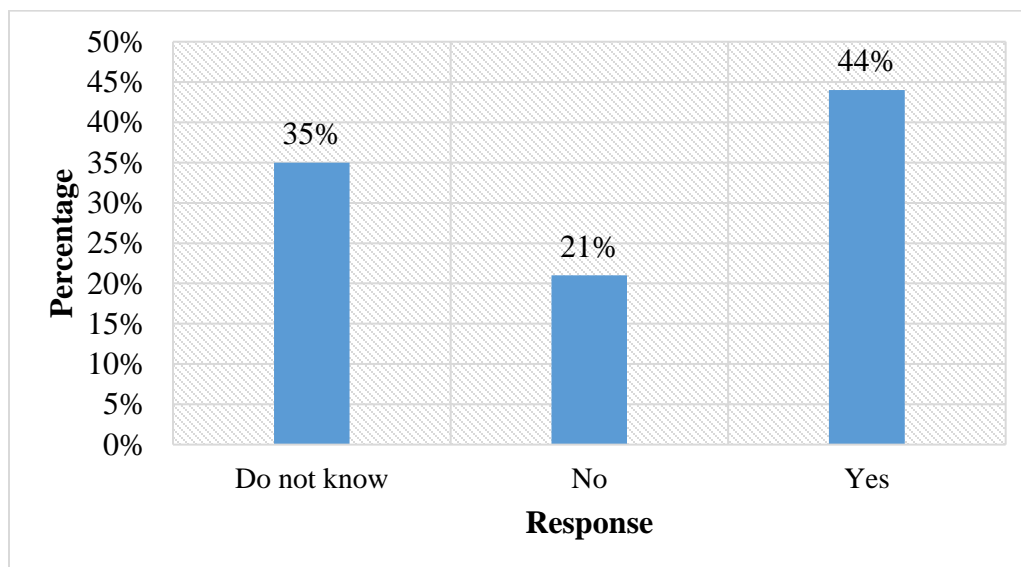


Figure 18: Bar Chart Showing the Perception on Rainfall and Temperature Variability in the Past two decades in the Abuakwa South Municipality

4.1.4.0 Intervention to restore degraded vegetation

On the municipal effort to restore degraded vegetation, results from the respondents on these efforts indicated a greater percentage of about 53% affirming the presence of such projects to restore degraded landscapes. About 27% said “No” to any project in operation to restore degraded vegetation. In addition, about 21% answered, “Do not know” concerning any intervention to restore degraded vegetation in the municipality.

4.1.4.1 Perception of beneficial impacts from forest conservation

Figure 2.4 presents different perspectives regarding the implementation and regulation of the forest resource exploitation in the Abuakwa South Municipality. Fifty-nine respondents representing 39% ranked the efforts of the conservation as “Fairly good”. Forty-five respondents representing 30% indicated it as “Very good”, whereas 21 respondents representing 14% indicated it as “Excellent”, with 25 respondents representing 17% answered the regulation’s efforts to be “Poor”.

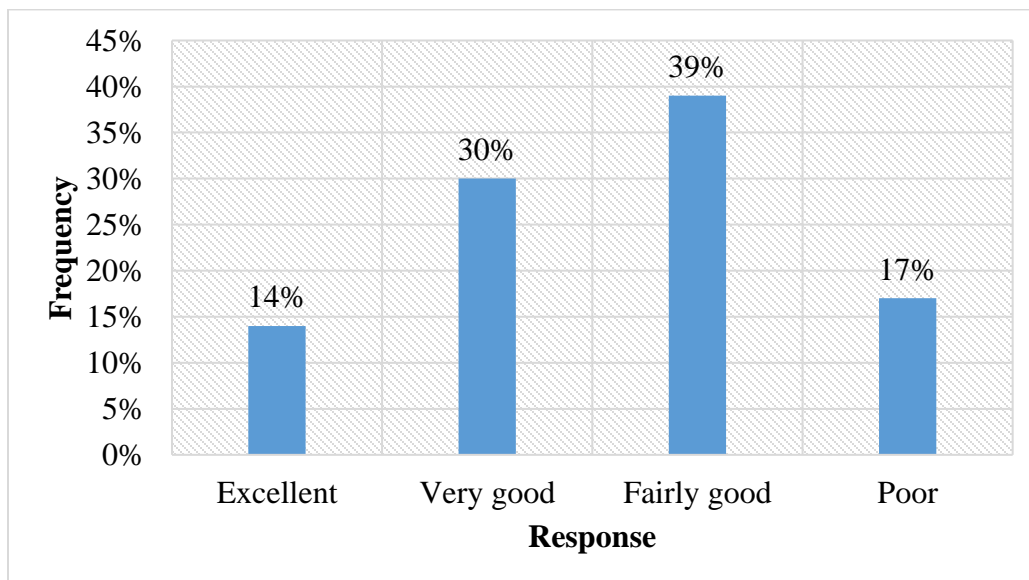


Figure 19: Perception of the Benefits from the Forest Conservation

4.1.4.2 Benefits from conservation

Benefits from conservation are concerned with all the sustainable impacts the forest conservation provides. Figure 21 presents a summary of the benefits made available from the forest conservation in the Abuakwa South Municipality. Thirty percent of the respondents cited water security only as of the benefit derived, 17% cited water security and tree preservation, and 9% of respondents indicated water security and climate stability. In addition, 11% cited wildlife protection and water security, with 7% citing trees preservation only. Further, 2% each of the respondents answered “prevention of accidental deaths in illegal mining pits”, and wildlife protection and climate stability. Finally, 23% responded deriving no benefit from the forest conservation regulation.

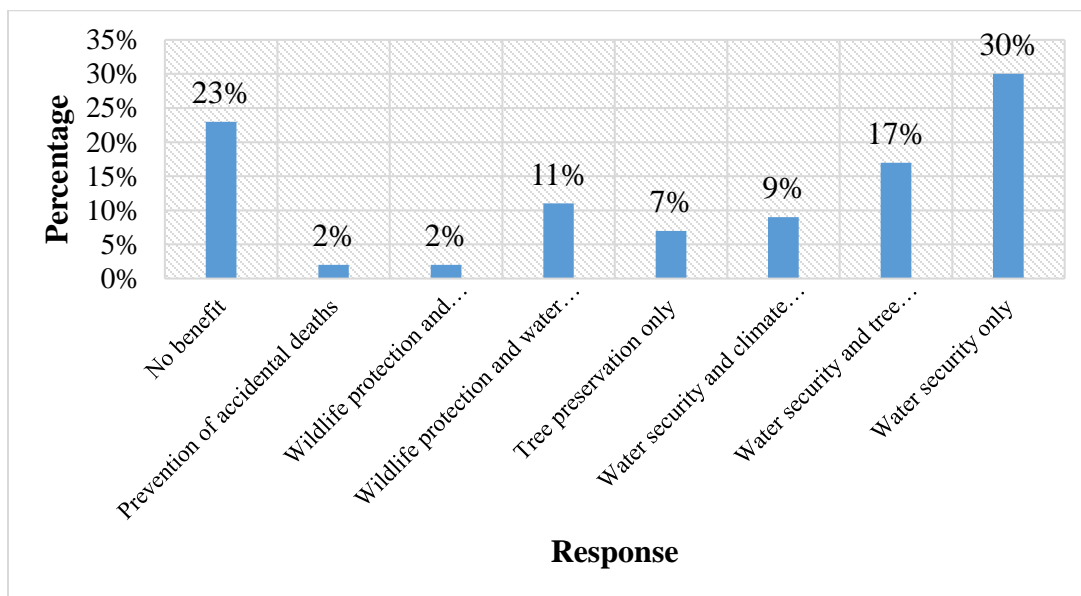


Figure 20: Bar Chart Showing the Response on Benefits Derived from Forest Conservation

4.1.4.3 Communal effort to forest protection

Information from the study on the efforts of the indigenes towards forest protection revealed the following; 16 respondents representing 11% cited being engaged in some

incentive bound communal role on forest protection. The majority of 134 respondents representing 89% responded not engaged in any activity on forest conservation.

However, when respondents were asked to score themselves on their efforts towards forest protection, 6 respondents representing 4% scored “Efficient”, 23 respondents making 15% scored “Moderate”. Further, 27 respondents representing 18% scored “Minimal”. The majority of 94 respondents representing 63% scored on the contrary responded as “Weak” on the efforts towards forest protection.

Table 8 Relationship between the community’s perception and forest cover

Dependent variable	Predictor variable	P-value
Forest cover	Sensitisation programmes	0.465
Forest cover	Forest conservation effects on livelihood	0.03
Forest cover	Livelihood support projects	0.02
Forest cover	Perception of forest	0.501
Forest cover	Benefit-sharing	0.10
Forest cover	Compliance attitude on conservation	0.19
Forest cover	Awareness of forest conservation regulations	0.868

**p<0.05

4.2 Land cover accuracy classification

The results for accuracy assessment are shown in Table 9. Overall accuracy ranged between 88% and 94% with Kappa coefficients between 0.83 and 0.92. The highest producer accuracy was recorded in 2003 for bare and settlement land, which is 100% and the lowest, recorded in 1986 for bare and settlement land at 80%. The highest user

accuracy is 100% recorded in 2003 for open forest vegetation and the lowest is 77% recorded in 1986 for open forest vegetation.

Table 9 Accuracy assessment of classified images (accuracy in percentage %)

Land cover type	1986		2003		2017	
	Prod.	User	Prod.	User	Prod.	User
Dense Forest	92	93	100	94	92	95
Other vegetation	94	77	81	100	94	90
Bare/settlement	80	100	100	84	98	98
Overall accuracy	0.88		0.92		0.94	
Kappa coefficient	0.83		0.89		0.9	

4.3 Land cover classification and changes

Figures 22, 23, 24 and Table 10 show details of land cover types and land changes in the Abuakwa South Municipality for the years 1986, 2003 and 2017.

Open vegetation class has been the dominant land cover type in all three years selected, followed by the dense forest region. However, the state of bare land area has seen gradual increases since 1986, causing a reduction in the area of the open vegetation. Similarly, the dense forest zone shows a gradual reduction in size since 1986.

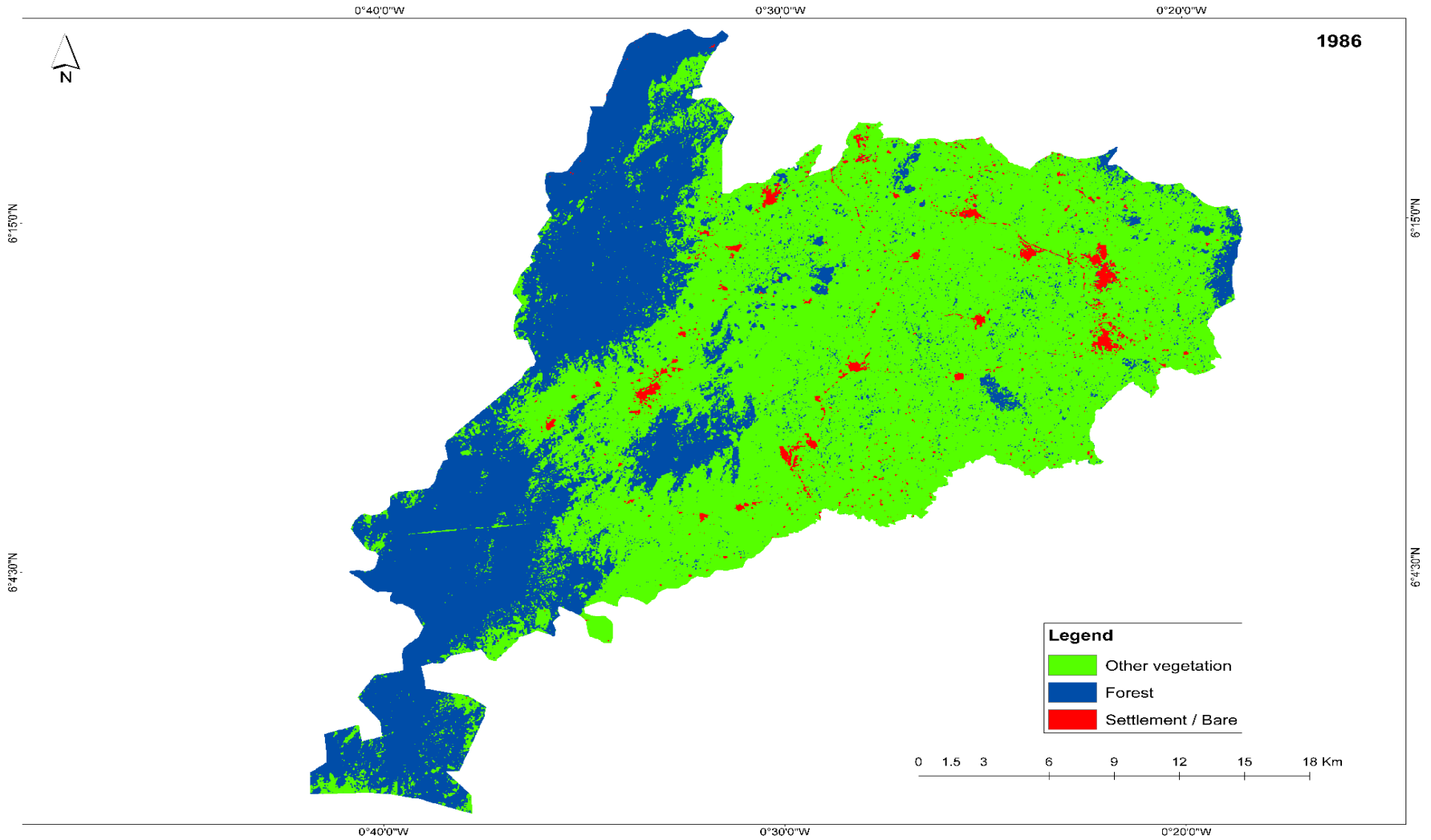


Figure 21 Classified satellite image of Abuakwa South Municipality showing land cover types and land cover changes for 1986

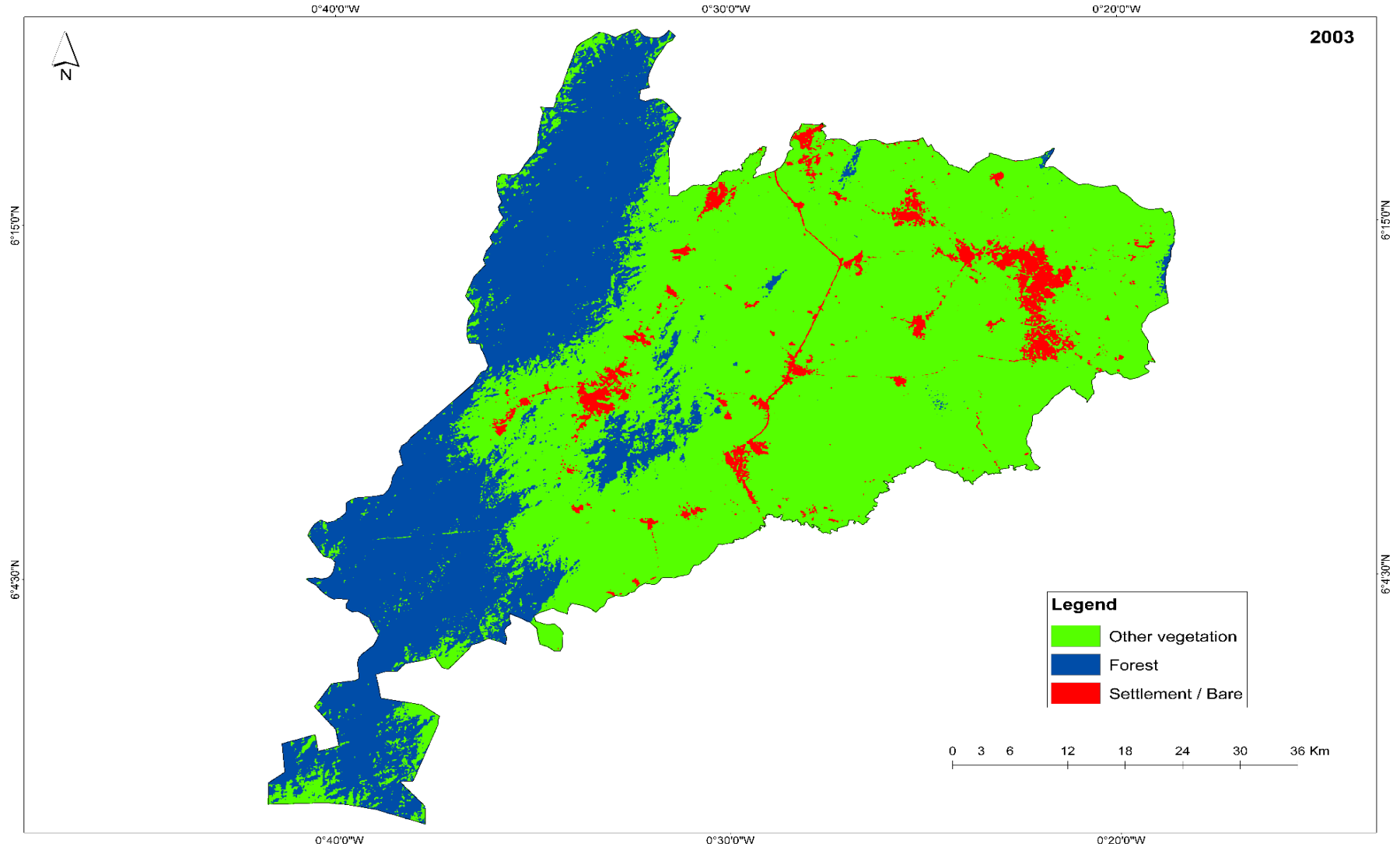


Figure 22 Classified satellite image of Abuakwa South Municipality showing land cover types and land cover changes for 2003

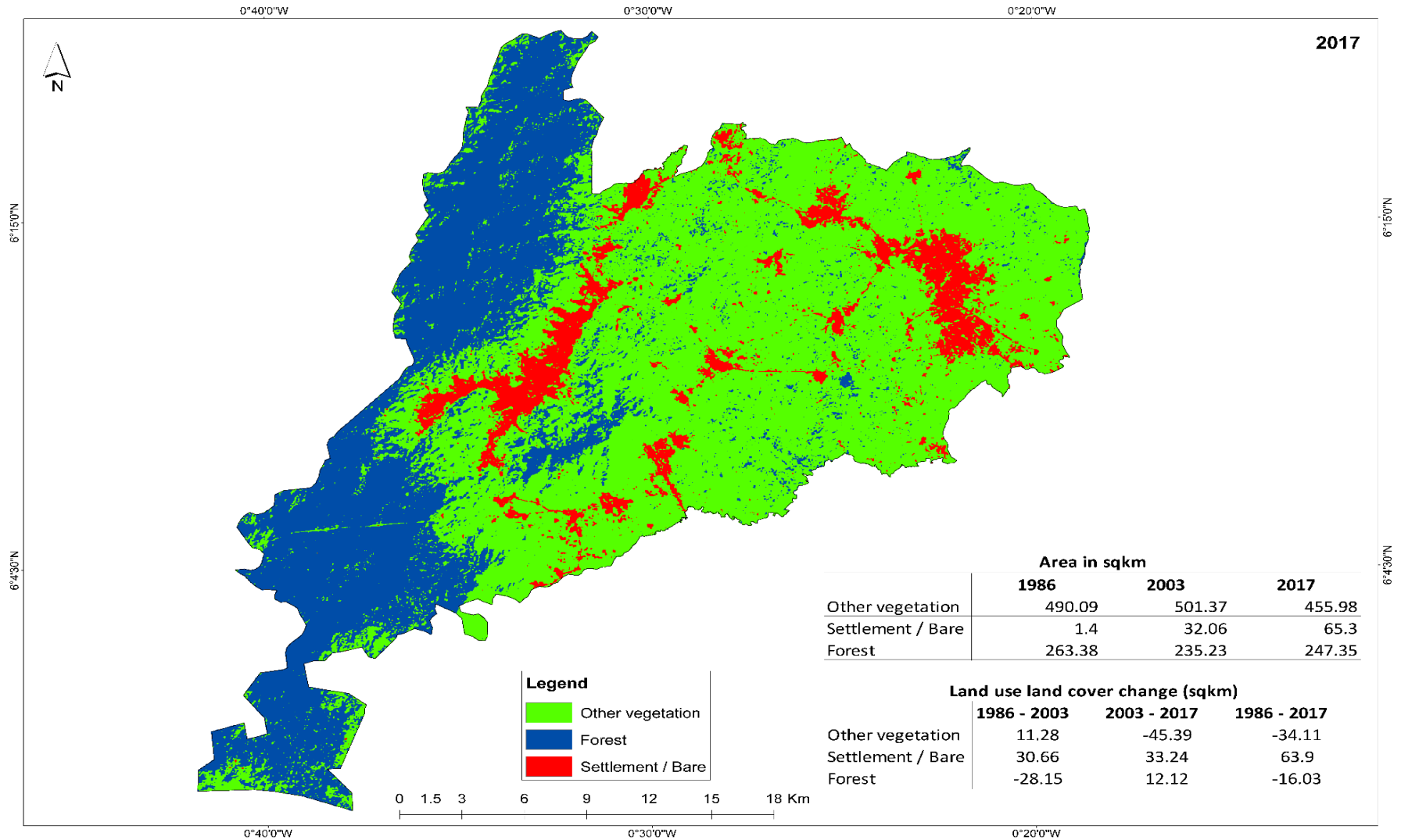


Figure 23 Classified satellite image for Abuakwa South Municipality showing land cover types and land cover changes for 2017

Table 10 Area and Proportion of Land cover in the Atiwa Forest (km²) for 1986, 2003 and 2017

Land cover type	Year	Year	Year
	1986	2003	2017
Dense forest	263.38	235.23	247.35
Other vegetation	490.09	501.37	455.98
Bare land and settlement	1.4	32.06	65.3

Table 11 Land cover changes (km²)

Land cover type	Years		
	1986-2003	2003-2017	1986-2017
Dense Forest	-28.15	12.12	-16.03
Open vegetation	11.28	-45.39	-34.11
Bare land and settlement	30.66	33.24	63.9

4.4 Plant species composition

The dominant plant species identified were woody species, with a total of 1033 woody species identified. The dominant life forms of species identified were woody tree species, lianas, and shrubs. The dominant family of all tree species identified belonged to *Apocynaceae* and *Euphorbiaceae*. The dominant liane and shrub species belonged to the families of *Fabaceae* and *Euphorbiaceae* respectively. In addition, the dominant species identified was the *Terminalia ivorensis* and the *Entandrophragma angolense* for tree life forms. Dominant species identified for the liane and shrubs were *Alfalfa sp.* and *Psychotria sp.* respectively.

Fifty identical trees species were identified on all plots in the open and closed canopy forest zones. *Funtumia elastic*, *Funtumia Africana*, *Landolphia dulci-barteri*, *Alstonia boonei*, *Tabernaemontana crassa*, *Tabernaemontana Africana*, *Terminalia superba*, *Terminalia ivorensis*, *Baphia pubescens*, *Chrysophyllum subnudum*, *Elaeis guineensis*, *Erythroxylum mannii*, *Hannoa klaineana*, *Margaritaria discoredes*, *Maranthes robusta*, *Marratis fraxinea*, *Panda oleosa*, *Petersianthus macrocarpus*, *Scottelia klaineana*, *Strombosia glaucescens* and *Trema orientalis* were the dominant trees that made about 60% of the total trees sampled. The overall density for all sampled trees were 456 ± 45 stems per hectare (mean \pm standard error). The stem density for the closed canopy region was 521 ± 94.3 , which was significantly higher than the open forest region (345 ± 64.9). The average stem diameter differed across land cover types, with 8.45 ± 0.51 cm for the dense forest region and 6.56 ± 0.15 cm at the open forest region. Average tree height was significantly higher at the dense forest region, with 21.95 ± 0.37 m and 19.68 ± 0.21

Table 12 List of species composition

Species	Family	Life form
<i>Funtumia elastic</i>	<i>Apocynaceae</i>	Tree
<i>Funtumia Africana</i>	<i>Apocynaceae</i>	Tree
<i>Landolphia dulci-barteri</i>	<i>Apocynaceae</i>	Tree
<i>Alstonia boonei</i>	<i>Apocynaceae</i>	Tree
<i>Tabernaemontana crassa</i>	<i>Apocynaceae</i>	Tree
<i>Tabernaemontana Africana</i>	<i>Apocynaceae</i>	Tree

<i>Rauvolfia vomitoria</i>	<i>Apocynaceae</i>	Tree
<i>Holarrhena floribunda</i>	<i>Apocynaceae</i>	Tree
<i>Macaranga heterophylla</i>	<i>Euphorbiaceae</i>	Tree
<i>Macaranga huricifolla</i>	<i>Euphorbiaceae</i>	Tree
<i>Macaranga spinose</i>	<i>Euphorbiaceae</i>	Tree
<i>Macaranga barteri</i>	<i>Euphorbiaceae</i>	Tree
<i>Dryptus pellegrinii</i>	<i>Euphorbiaceae</i>	Tree
<i>Ricinodendron heudelotti</i>	<i>Euphorbiaceae</i>	Tree
<i>Bridelia grandis</i>	<i>Euphorbiaceae</i>	Tree
<i>Discoglyprena caloneura</i>	<i>Euphorbiaceae</i>	Tree
<i>Distemonanthus benthamianus</i>	<i>Caesalpiniceae</i>	Tree
<i>Bussea occidentalis</i>	<i>Caesalpiniceae</i>	Tree
<i>Berlinia confuse</i>	<i>Caesalpiniceae</i>	Tree
<i>Hymenostegia aubrevillie</i>	<i>Caesalpiniceae</i>	Tree
<i>Hymenostegia afzelia</i>	<i>Caesalpiniceae</i>	Tree
<i>Fiscus capensis</i>	<i>Moraceae</i>	Tree
<i>Fiscus exasperate</i>	<i>Moraceae</i>	Tree
<i>Milicia excels</i>	<i>Moraceae</i>	Tree
<i>Milicia regia</i>	<i>Moraceae</i>	Tree
<i>Musanga cecropioides</i>	<i>Moraceae</i>	Tree
<i>Anitarius toxicaria</i>	<i>Moraceae</i>	Tree

<i>Cedrela odorata</i>	<i>Meliaceae</i>	Tree
<i>Guarea cedrata</i>	<i>Meliaceae</i>	Tree
<i>Entandropharma angolense</i>	<i>Meliaceae</i>	Tree
<i>Lovoa trichilioides</i>	<i>Meliaceae</i>	Tree
<i>Trichilia prieuriana</i>	<i>Meliaceae</i>	Tree
<i>Albizia adianthifolia</i>	<i>Fabaceae</i>	Tree
<i>Albizia glaberrima</i>	<i>Fabaceae</i>	Tree
<i>Albizia zygogia</i>	<i>Fabaceae</i>	Tree
<i>Afzelia Africana</i>	<i>Fabaceae</i>	Tree
<i>Talbotiella gentii</i>	<i>Fabaceae</i>	Tree
<i>Corynanthe pachyceras</i>	<i>Rubiaceae</i>	Tree
<i>Tricalysia discolor</i>	<i>Rubiaceae</i>	Tree
<i>Psydas subcordata</i>	<i>Rubiaceae</i>	Tree
<i>Morinda Lucinda</i>	<i>Rubiaceae</i>	Tree
<i>Celtis adolfi-fideria</i>	<i>Ulmaceae</i>	Tree
<i>Celtis mildbraedi</i>	<i>Ulmaceae</i>	Tree
<i>Celtis zenkeri</i>	<i>Ulmaceae</i>	Tree
<i>Tetracera sp.</i>	<i>Ulmaceae</i>	Tree
<i>Sterculia rhinopetala</i>	<i>Sterculiaceae</i>	Tree
<i>Sterculia tragacantha</i>	<i>Sterculiaceae</i>	Tree
<i>Cola nitida</i>	<i>Sterculiaceae</i>	Tree
<i>Cola caricifolia</i>	<i>Sterculiaceae</i>	Tree

<i>Blighia welwitschii</i>	<i>Sapindaceae</i>	Tree
<i>Blighia unijugata</i>	<i>Sapindaceae</i>	Tree
<i>Blighia sapida</i>	<i>Sapindaceae</i>	Tree
<i>Parkia bicolor</i>	<i>Mimosaceae</i>	Tree
<i>Pentaclethra macrophylla</i>	<i>Mimosaceae</i>	Tree
<i>Piptadeniastrum africanum</i>	<i>Mimosaceae</i>	Tree
<i>Allanblackia floribunda</i>	<i>Guttiferae</i>	Tree
<i>Harungana madagascariensis</i>	<i>Guttiferae</i>	Tree
<i>Diospyros kamerunensis</i>	<i>Ebenaceae</i>	Tree
<i>Diospyros sanza-minika</i>	<i>Ebenaceae</i>	Tree
<i>Ceiba petandra</i>	<i>Malvaceae</i>	Tree
<i>Bombax buonopozense</i>	<i>Malvaceae</i>	Tree
<i>Irvingia gabonesis</i>	<i>Irvingiaceae</i>	Tree
<i>Klainedoxa gabonesis</i>	<i>Irvingiaceae</i>	Tree
<i>Pachypodanthum staudii</i>	<i>Annonaceae</i>	Tree
<i>Cleistopholis patens</i>	<i>Annonaceae</i>	Tree
<i>Canarium schweinfurthii</i>	<i>Burseraceae</i>	Tree
<i>Dacryodeo klaineana</i>	<i>Burseraceae</i>	Tree
<i>Antrocaryon micraster</i>	<i>Anacardiaceae</i>	Tree
<i>Lannea welwitschii</i>	<i>Anacardiaceae</i>	Tree
<i>Terminalia superba</i>	<i>Combretaceae</i>	Tree

<i>Terminalia ivorensis</i>	<i>Combretaceae</i>	Tree
<i>Baphia pubescens</i>	<i>Papilionaceae</i>	Tree
<i>Chrysophyllum subnudum</i>	<i>Sapotaceae</i>	Tree
<i>Elaeis guineensis</i>	<i>Palmaceae</i>	Tree
<i>Erythroxylum mannii</i>	<i>Erythroxylaceae</i>	Tree
<i>Hannoa klaineana</i>	<i>Simaroubaceae</i>	Tree
<i>Margaritaria discorides</i>	<i>Phyllanthaceae</i>	Tree
<i>Maranthes robusta</i>	<i>Chrysobalanaceae</i>	Tree
<i>Marratis fraxinea</i>	<i>Marattiaceae</i>	Tree
<i>Panda oleosa</i>	<i>Pandaceae</i>	Tree
<i>Petersianthus macrocarpus</i>	<i>Lecythidaceae</i>	Tree
<i>Scottelia klaineana</i>	<i>Flacourtiaceae</i>	Tree
<i>Strombosia glaucescens</i>	<i>Olacaceae</i>	Tree
<i>Trema orientalis</i>	<i>Cannabaceae</i>	Tree
<i>Acacia kamerunensis</i>	<i>Fabaceae</i>	Liana
<i>Acacia pentagyna</i>	<i>Fabaceae</i>	Liana
<i>Griffonia simplicifolia</i>	<i>Fabaceae</i>	Liana
<i>Dalbergia saxatilis</i>	<i>Fabaceae</i>	Liana
<i>Dalbergia hostiles</i>	<i>Fabaceae</i>	Liana
<i>Combretum smeathmannii</i>	<i>Combretaceae</i>	Liana
<i>Combretum sp.</i>	<i>Combretaceae</i>	Liana
<i>Calycobus Africana</i>	<i>Convolvulaceae</i>	Liana

<i>Calycobus heudelotti</i>	<i>Convolvulaceae</i>	Liana
<i>Alfalfa whytei</i>	<i>Apocynaceae</i>	Liana
<i>Alfalfa barteri</i>	<i>Apocynaceae</i>	Liana
<i>Adenia rumicifolia</i>	<i>Passifloraceae</i>	Liana
<i>Agelaea nitida</i>	<i>Connaraceae</i>	Liana
<i>Cissus debilis</i>	<i>Vitaceae</i>	Liana
<i>Dichapetalum sp.</i>	<i>Dicharpitalaceae</i>	Liana
<i>Gongronema latifolium</i>	<i>Asclepiadaceae</i>	Liana
<i>Hugonia sp.</i>	<i>Linaceae</i>	Liana
<i>Alchornea cordifolia</i>	<i>Euphorbiaceae</i>	Shrub
<i>Alchornea floribunda</i>	<i>Euphorbiaceae</i>	Shrub
<i>Placodiscus boya</i>	<i>Sapindaceae</i>	Shrub
<i>Psychotria sp.</i>	<i>Apocynaceae</i>	Shrub

Table 13 Mean values of woody plant dendrometric variables under different land cover types

Land cover type	<i>Dbh</i> (m)	H (m)	Number of stems per hectare
Dense forest	8.45±0.51 ^a	21.95±0.37 ^a	521±94.3 ^a
Other vegetation	6.56±0.47 ^a	19.68±0.21 ^b	345±64.9 ^a
Cocoa farm	0.099±0.002 ^b	-	5.15±0.25 ^b
<i>p</i> - value	0.008	0.001	0.004

Tukey's HSD test ($p > 0.05$) shows values within each column with the same letters are not significantly different.

4.5 Soil characteristics

Table 14 presents results on soil physical parameters and organic carbon. Soil organic carbon content was between 3.30% and 1.3%, with the highest occurring in samples from the cocoa farm and the lowest from bare land. Clay content was highest in the dense forest and lowest in the bare land. Mean value for bulk density ranged between 1.50g/cm³ and 1.28 g/cm⁻³, the highest occurring in the cocoa farm and the lowest occurring in the bare land.

Table 14 Mean Values of Soil Properties in Different Land Cover Types

Land cover types	Sand	Silt	Clay	OC	Bulk density
Dense forest	32.1±3.3 ^a	19.6±2.9 ^a	45.4±2.3 ^a	2.0±0.21 ^a	1.28±0.05 ^a
Cocoa farm	22.7±3.6 ^a	14.4±4.4 ^b	28.5±3.2 ^b	3.3±0.15 ^a	1.50±0.12 ^b
Open canopy forest	29.1±2.4 ^b	20.6±2.2 ^a	23.4±2.6 ^a	1.7±0.19 ^a	1.30±0.04 ^a
Bare/Settlement	53.5±12.1 ^c	23.26±8.0 ^c	22.4±5.1 ^c	1.3±0.39 ^b	1.38±0.25 ^c
<i>p</i> -value	0.22	0.04	0.23	0.05	0.025

OC = Soil Organic carbon. Tukey's HSD test ($p > 0.05$) shows physical parameter values with the same letters within columns to be not significantly different.

4.6 Relationship between forest cover, rainfall, and temperature

Rainfall variability and its correlation with forest cover for the period of 1986, 2003 and 2017 were not significant at a *p*-value of 0.483, 0.966 and 0.501 respectively (*p*-value significant at $p < 0.05$). In addition, minimum and maximum temperature variability for the period ranging 1986, 2003 and 2017 was significant at a *p*-value of 0.000 (significant at $p < 0.05$).

4.7 Estimation of total carbon stocks

The mean estimated carbon stock value in trees and necromass stock across land uses are illustrated in table 15. The mean highest tree carbon stock was recorded in the dense forest to be $66.81 \pm 18.50 \text{Mg ha}^{-1}$, and the open forest was $12.34 \pm 2.20 \text{Mg ha}^{-1}$ with bare land been $1.3 \pm 0.39 \text{Mg ha}^{-1}$. Litter and necromass under dense forest showed the highest carbon content, with open vegetation recording the lowest carbon content in litter and necromass. The potential total carbon weight per hectare that can potentially be emitted into the atmosphere if the Atiwa Forest reserve degrades was estimated as 5263.6 metric tons of carbon.

Table 15 Estimated carbon stock across land cover types (Mg ha⁻¹)

AGB parameters			
	Dense forest	Open forest	Cocoa farm
Tree carbon stock	66.81 ± 18.50^a	12.34 ± 0.20^a	5.02 ± 0.04^a
Litter and necromass	14.02 ± 0.17^b	5.11 ± 0.20^b	4.23 ± 0.22^b
Total	80.63 ± 1.30^c	17.45 ± 0.41^c	9.25 ± 1.62^c

4.8 Changes in carbon stock

Table 16 below presents the total carbon stock and changes in carbon stock for the years 1986, 2003 and 2017 in the different land cover types. Carbon stock was 194394 Gt carbon, 197945 Gt carbon and 197937 Gt carbon in 1986, 2003 and 2017 respectively. In 1986, 2003 and 2017, the highest carbon stock was recorded in the open forest zone, followed by the dense forest zone. The dense forest zone recorded its highest carbon stock in 1986 (67825.6 Gt). Open forest recorded its highest carbon

stock in 2003 (129112.8 Gt), and the least carbon stock was recorded in the bare land zone, with its highest carbon stock recorded in 2017 (16816.1 Gt).

Table 16 Summary Presentation of Changes in Carbon Stock

Periods	1986	2003	2017	1986- 2003	2003- 2017	1986- 2017
Dense forest	67825.6	60576.43	636976	-7249	3121.5	-4128
Open canopy forest	126207.9	129112.8	117423.9	29049	-11688	-8784
Bare/settlement	360.53	8256.1	16816.1	-7896	-8560	-16455
Total	194394	197945.3	197938	35513	-7.73	3543.6

Furthermore, an assessment of total carbon weight that can potentially be emitted into the atmosphere if the total sampled areas of dense and open forest zones are deforested is estimated as 118.03 metric tons and 92.91 metric tons of carbon respectively using the equation of Walker *et al.* (2011).

4.8.1 Relationship between soil organic carbon and vegetation parameters in different land cover types

Pearson Correlation test was performed to assess the relationship between soil organic carbon and vegetation parameters. The highest statistically significant correlation was found between tree density per hectare and soil organic carbon (significant correlation of 0.950, $p < 0.01$), followed by organic soil carbon and diameter at breast height (significant correlation of 0.88, $p < 0.01$). Soil organic carbon and tree height showed the least correlation (significant correlation of 0.007, $p < 0.01$).

4.8.2 Regression model of soil organic carbon stock

Table 17 presents the results for simple and multiple regression models of soil organic carbon. The coefficient of determination ranged between 0.008 and 0.260. Tree height, the combination of tree height and diameter at breast height, the combination of tree height and tree density and the combination of diameter at breast height, height, and density recorded the highest determination co-efficiency with an adjusted R^2 value of 0.054. The lowest determination co-efficiency value was recorded by density at an adjusted R^2 value of -0.015.

Table 17 Regression model of Soil organic carbon and tree parameters

Dependent variable	Predictor variables	Adj.R²	P-value
SOC	Density per hectare	-0.015	0.950
SOC	DBH	0.28	0.088
SOC	Height	0.054	0.029
SOC	Height and density per hectare	0.054	0.029
SOC	Height and DBH	0.054	0.029
SOC	DBH*Height*Density per hectare	0.054	0.029

CHAPTER FIVE

DISCUSSIONS

Recent development approaches employ the principle of Strategic Environmental Assessment as the preferred tool to examine projects and activities in the socio-economic development context of nations. It functions as a proactive tool to compare *ex-ante* and *ex-post* effects of project strategies to enhance its environmental sustainability whilst promoting social inclusion, economic development and capacity building in indigenous people. It is on these pillars that this study sought to explore the role of SEA in forest management in the Abuakwa South Municipality.

5.1 Impact of SEA on forest management

From a general perspective, the findings of the study confirm some of the assertions alluded to in literature. However, in curtailing indiscriminate deforestation and safeguarding land cover, the views of Partidário (2003), Gachechiladze (2010) and EPA (2015) did not corroborate the findings of the study on the significant relationship between a forest management plan and forest cover. This was affirmed by a Pearson correlation test at a *p*-value of 0.248, indicating a non-significant relationship.

On the contrary, results on stakeholder participation and the institution of alternative livelihood projects indicated a significant relationship with forest in the Abuakwa South Municipality. This was indicated by *p*-values 0.03 each. Thus, corroborating the assertion that efficient Strategic Environmental Assessment's effort towards forest

conservation is most dependent on the socio-economic matrix as asserted by Asamoah (2007), Appiah (2009), Guuroh (2010) and Yachori (2017).

In addition, results from the study indicated environmental conservation as the underlying reason for conserving the Atiwa forest. Nevertheless, results on land cover changes indicated open vegetation to be declining whilst forest cover was significantly improving. This does not confirm the assertion of Schep *et al.* (2016) on the state of the Atiwa forest.

Further, assessment of the progress of administration in all sectors of the local economy of the Abuakwa South Municipal assembly showed a consistent alignment with all policy and plan guidelines under the Ghana Shared Growth Development Agenda (GSGDA II) (Abuakwa South Municipality, 2018). In the progress report, themes of sustainable development were;

- Ensuring and Sustaining Macroeconomic Stability
- Accelerated Agriculture Modernisation and Sustainable Natural Resource Management
- Human Development, Productivity, and Employment

On sustaining macroeconomic stability, a progress report from the 2014-2017 Medium Term Development Plan of the Abuakwa South Municipality indicated the macro-economic sector to be satisfactory. This was as a result of a proposed an annual 10% increment from 2014 to 2015 and a later increment of 13.8% in the Internally Generated

Fund. This improvement in the local financial sector according to the Abuakwa South Municipal Medium Term Development Plan (2018), was due to progress made in the efficient tax collection strategies, training on revenue mobilization, stakeholder consultation on fee fixing resolutions and the need for the people to honor their tax obligation.

Further, on improving the macro-economic sector, efforts to enhance the private sector's contributions to the state of economic development were enhanced. These efforts were ranked as satisfactory according to the progress report of the 2014-2017 Medium Term Development Plan of the Abuakwa South Municipal area. The local government's contributions to this initiative were in the industries of agriculture, business counseling, technical and managerial skills training and local soap and Gari making. However, results from the study did not affirm these revelations by the Medium Term Development Plan, knowledge on the institution of livelihood projects were revealed by both the Forestry Commission and Abuakwa South Municipal assembly to be not instituted. The success in maintaining a good fiscal management and livelihood project is therefore necessary for sustaining an efficient and effective operationalization of Strategic Environmental Assessment in governance.

On promoting accelerated agriculture modernization and sustainable natural resource management, the Medium Term Development Plan 2018-2021 of the Abuakwa South Municipal area indicates contributions towards sustainable agriculture through training seminars to local farmers on food security and climate-smart farming methods.

According to the progress report on the 2014-2017 Medium Term Development Plan, food security has generally improved on a satisfactory level as well as sustainable farming methods. However, on natural resources exploitation, the report from the municipal assembly of Abuakwa South indicate threats to forest cover principally due to agriculture and mining (E.A.M.A, 2015). This view does not affirm the results of the study where it was revealed that the major threats to the forest cover of the Abuakwa South Municipal area are mining and lumbering, with agriculture representing the least threat to the forest cover. Further, sustainable natural resource exploitation in the Abuakwa South Municipality asserts environmental quality to be principally declining due to illegal mining (E.A.M.A, 2014). However, the assembly acknowledges the implementation of SEA to be significant to improving the state of environmental quality as asserted by Sadler and Verheem (1996) and Partidário (2003).

In addition, the efforts of checking unsustainable resources exploitation in the Abuakwa South Municipality is revealed by municipal assembly's budget report (2015) monitoring and evaluation logistics to check on illegal felling of trees and illegal mining are lacking. This was further affirmed by the results of the finding where bare land is revealed to be significantly increased at the expense of open vegetation, with forest cover rather increasing since 2003. However, this partially corroborated the findings of the study, where it was revealed that the major resources lacking for checking on sustainable resource exploitation were human resources, finance, and logistics. Nevertheless, the unavailability of these resources from the findings of the study was not significant to the forest at a p -value of 0.248. This was contrary to the

assertions of Ekpe *et al.* (2014) and the Abuakwa South municipal assembly Medium Term Development Plan (2014-2017).

Additionally, information on sustainable natural resource exploitation methods in the municipality's progress report from 2014-2017 confirmed the findings of the study. According to the findings of the study, bare/settlement areas have been increasing rapidly, while open vegetation is reducing significantly. The rate of vegetation depletion is however attributed to the socio-economic venture of agriculture and small-scale mining activities prominent in the municipal area (E.A.M.A, 2014; Schep *et al.*, 2016).

Nevertheless, this is contrary to the assertion of Ametepey (2015), who opine that the efficient implementation of SEA is significant to the prevention pollution and land degradation, corroborating the findings in the study where respondents from the municipal assembly and the Forestry Commission assert the environmental protection as the guiding rationale behind SEA mainstreaming and forest conservation. This ranks environmental quality evaluation as satisfactory in the progress report of the municipal areas according to the implementation of the 2014-2017 Medium Term Development Plan. The progress reports give an indication of reforestation programs beginning from 2014 to the current time (E.A.M.A, 2015; Abuakwa South Municipality, 2018). For instance, in 2014 alone, a project to plant 1000 trees were more than 50% done, which was reported as satisfactory. An assessment of sustainable natural resource exploitation is generally associated with good environmental quality. Based on the results of this,

the gradual increase in bare land cover at the expense of open vegetation is imperative for determining changes in trees and soil carbon stock as a means towards environmental sustainability planning.

Human development, productivity, and employment are key sustainability criteria for evaluating the success of SEA in development planning. It is necessary as a guiding tool for socio-economic planning. Based on this, the Medium Term Development Plans of 2014-2017 and 2018-2021 ranks the socio-economic development of the Abuakwa South Municipality as satisfactory. This is however not consistent with the assertion of Schep *et al.* (2016), who opines that the state of socio-economic development in the Abuakwa South Municipal Assembly is not very well developed. Further, this state of socio-economic development is associated with the decline of the Atiwa forest. This comes in line with the revelations of Partidário (2003) and the Medium Term Development Plan Progress Report (2015) by the National Development Planning Commission (NDPC) as well as the Living Standards Survey Report by the Ghana Statistical service (2014), which states that efficient forest management ensures a strong socio-economic structure. This revelation is further consistent with the notion of Partidário (2003) that the positive net effect of SEA on economic sustainability is related to its inherent sustainability concept. These views were consistent with the results of the study where the availability of sustainable economic enterprises was significant to the state of forest cover at a p -value of 0.03. However, findings from the study did not affirm economic sustainability as satisfactory in the Abuakwa South

Municipality. Results from the findings revealed the institution of alternative livelihood projects to be lacking.

5.2 Perception of respondents on forest management

Knowledge of respondents concerning the implication of SEA and the general plan document for development is considered as a key instrument to the efficient implementation of sustainability matrices. This is because it informs the indigenous people of the core principles that guide all socio-economic and socio-cultural ventures ongoing in the municipality.

Generally, perception of the forest as a resource is diverse in opinions with respect to individuals, but for the purpose and success of mainstreaming SEA, it is imperative to gauge a comprehensive perception to facilitate a sustainable implementation of projects in the Abuakwa South Municipality. In light of this, the general perception of the communities indicated the highest inclination towards the forest as an environmental resource, represented by 85% of the respondents. Statistically, the perception of people as forest as a socio-economic resource was shown to be not significant in the study ($p=0.501, p>0.05$). This view is however contrary to the assertions of FAO (2010), Asare and Kwakye (2013) and Boafo (2013), who opine that the dominant perception attached to forest resources in Ghana and West Africa, in general, is mostly hinged on socio-economic exploitation. This is contrary to the assertions of Appiah (2009) and Acheampong and Marfo (2011), who assert that the socio-economic significance attached forests contribute to the decline of forests in Ghana. They revealed that about

2.5 million people in Ghana directly depend on forest resources for livelihood, which consequently affects a significant decline in forest cover. The World Bank (2013) stipulates that deforestation is highest in the West African sub-Saharan region. In addition, a study by Quacoe (2017) shows that deforestation in the West African sub-region is largely attributable to anthropogenic activities.

Furthermore, on the view that environmental degradation is linked with forest resources exploitation, 46% of the respondents answered in the affirmative to the notion. This was consistent with the revelation Boafo (2013) who opined that the rate of deforestation in West Africa stands as 13 million hectares annually. Other revelations by the Forest Commission (2014) revealed that forest losses attributable to agriculture activities account for about 28.5% of GDP losses, mineral exploitation accounts for 6% GDP losses whilst other forms of environmental degradation attributable to deforestation is responsible for about 5-10% GDP losses. Nonetheless, they assert that deforestation in Ghana contributes to about 63% GDP losses, which is equivalent to US\$500 million.

In addition, results from the study revealed that restraining forest access affronts the livelihood capacities of the forest communities. Further, the results revealed that alternative livelihood support projects were not instituted with the advent of conserving the Atiwa Forest. This was indicated by 56% of the total respondents. The effects of the lack of alternative livelihood support projects in the Abuakwa South Municipality was shown to be statistically significant ($p = 0.02$; $p < 0.05$). The lack of alternative

livelihood support activities and lack of access to the Atiwa Forest in its entirety was not consistent with the objectives of the 2012 Forest and Wildlife Policy. The policy advocates for the institution of sustainable economic activities that will compensate for the previous unsustainable socio-economic lifestyle of forest community indigenes. Further, it was not consistent with the assertions of Boon and Ahenkan (2009) who opine that as forest communities grow, the demand for socio-economic resource options also grows, therefore becoming imperative for them to have the right of access to forests or other sustainable socio-economic ventures to sustain their livelihood. Further revelation by Ekpe *et al.* (2014), also asserts that the historical assessment of forest conservation as fundamental pillars in sustainable development is to guide the institution of livelihood support projects in forest communities.

Results from the study revealed about 45% of the respondents who indicated possible compliance with forest conservation. From the study, it was further revealed that compliance with the regulatory laws governing Atiwa Forest was not significant to the forest cover ($p= 0.19$; $p<0.05$). This finding did not corroborate the findings of Tropenbos-International Ghana (2007), Boon *et al.* (2009), Ministry of Lands and Natural Resources (2012), Ekpe *et al.* (2014) and Forestry Commission (2017), who assert the sustainable forest management is greatly dependent on effective implementation, enforcement and compliance of the regulatory framework that governs forest resources. Ekpe *et al.* (2014) further reiterate that due to the widespread dependence of the local and national economy on forest resources, it is prudent to

institute the necessary regulatory framework that will guide the frequency resource exploitation.

Further, on the results on benefit-sharing accruing from conserving the Atiwa Forest, it was shown that 38% of the respondents indicated “No” and 54% indicated “Do not know”. This finding was not statistically significant to the state of the Atiwa Forest cover in the Abuakwa South Municipality ($p= 0.010$; $p>0.05$). This did not corroborate the objectives of the 2012 Forest and Wildlife Policy and the Medium Term Development Plan of the Abuakwa South Municipality for 2018-2012 on their assertion that shared conservation benefits from the Atiwa Forest will help improve the vegetative cover of the forest due to shared collective efforts in sustaining management principles. Further, it was not consistent with the findings of Boon and Ahenkan (2007) and Boon *et al.* (2009) who are of the opinion that the lack of benefit sharing in forest conservation accounts for significant mismanagement of forest resources due to non-compliance of regulatory laws by the indigenes.

Findings on the relevance of stakeholder participation at the Abuakwa South Municipality in managing the Atiwa Forest showed negative results. This was indicated by the respondents who gave negative responses to the frequency of sensitization programs geared towards sustainable forest management. However, this was not significant to the state of the Atiwa Forest ($p=0.465$; $p<0.05$). This result nonetheless did not affirm assertions made by the 2012 Forest and Wildlife Policy, Tropenbos

International (2007), Boon and Ahenkan (2007) and Forestry Commission (2017) that social inclusion is a significant factor in protecting resources which have both socio-cultural and socio-economic relevance.

5.3 Rainfall and temperature changes

Climate change has been one of the main environmental issues the municipality has been concerned within recent times according to the previous 2015 municipal budget statement and the current Medium Term Development Plan of the municipality. This confirms results from the study where respondents acknowledged the dread of negative impacts of climate change.

However, from the results on data analyzed on rainfall and temperatures in the past two decades, rainfall changes with regards to land cover changes were not significant whilst temperature changes showed significance to land cover changes. This was partially corroborated by data on questionnaires from the respondents regarding changing patterns in temperature and rainfall in the municipality. This corroborates the findings of Schep *et al.* (2016) on the findings that, though the forest cover of the municipality has been declining in past decades, it remains one of the rainforests in Ghana. Similarly, it is contrary to the findings of Makarieva and Gorshkov (2010) and Sheil and Murdivarso (2009) in literature. In a popular assertion, the buoyancy of agricultural activities in the municipality has been linked to the reliability of annual rainfall in the municipality (E.A.M.A, 2010; Abuakwa South Municipality, 2018).

Further, the significance of temperature changes found in the study with a non-variability in rainfall patterns affirms the findings of Ntiamoa-Baidu *et al.* (2001) and Amissah *et al.* (2014) with respect to the regenerative capacity of the forest cover and rainfall patterns from 2003 to present.

5.4. Changes in carbon stock

From the results of the study, bare land is shown to be increasing faster compared to the other land cover types. From the study, bare land has significantly increased by 63.9 hectares since 1986-2017 from a baseline of 1.4 hectares in 1986. This increase according to the study is due to socio-economic activities, principally mining and lumbering. From the study, 24% and 44% of the respondents indicated seeing people illegally encroaching into the borders of the Atiwa forest. This finding, however, affirms the findings of Schep *et al.* (2016) who assert that the indigenes of the forest communities of the Abuakwa South Municipality are principally engaged in unsustainable economic activities in the Atiwa Forest. They assert illegal mining and lumbering as the principal activities carried out in the forest. In addition, Yachori (2017) also assert that the encroaching on reserved forest lands are key factors accounting for the rapid vegetation loss in Ghana.

In addition, results from the study indicated a decline in other vegetation stock owed principally to the significant increase in bare land cover. This was indicated by the results of the satellite imagery. From the study, the loss of vegetation indicated a

decline of 34.11 hectares in 1986-2017 at a baseline area of 490.09 hectares. Further, vegetation decline as indicated by carbon stock values. From the results of the study, carbon stock values for the open vegetation cover indicated a decline to 11688 Gt in 2003-2017 at a baseline of 129112.8 Gt in 2003. Further, there was a decline to about 8784 Gt between 1986-2017, from a baseline stock value of 126207.9 Gt in 1986. This finding is consistent with the assertions made by the Abuakwa South Municipality in their 2014-2017 Medium Term Development Plan and the findings of Schep *et al.* (2016). On the contrary, forest cover indicated a significant gradual increase to 12.2 hectares from 2003-2017 from a baseline vegetation stock of 235.23 hectares in 2003. Nonetheless, forest cover decreased from 1986 to 2003 at a baseline cover of 263.38 hectares in 1986. It is from this reduction that a significant increase in cover was recorded in 2017. This increase in forest cover do not corroborate the assertions of Adu-Bredu *et al.* (2010), Hairiah *et al.* (2011), Ngo (2013), International Tropical Timber Organisation (2015), Schep *et al.* (2016), Forestry Commission (2017) and World Bank (2019) who opine the socio-economic stresses on forest ecosystems in developing countries, mainly in West Africa is affecting the general loss of the world's forest. Nonetheless, with the overall increase, carbon stock values decreased from a baseline figure of 67825.6Gt in 1986 to 60576.43Gt in 2003. Further, the carbon stock values increased from 60576.43Gt in 2003 to 63697.6 Gt in 2017. This indicates a general reduction in tree carbon stock values from 7249.2Gt (1986-2003), 3121.47Gt (2003-2017) to 4128Gt (1986-2017). However, with the recent significant increase in the tree carbon stocks, the findings of the study do not corroborate the earlier findings of Adu-Bredu *et al.* (2010) and Ngo (2013) who assert that the general losses in tropical forests

are causing a significant decrease in carbon stock values. In addition, it did not corroborate the findings of Asare *et al.* (2012) and Schep *et al.* (2016) on the gradual decline.

In addition, results on soil carbon content showed a significant decrease from 1986 to 2017. According to the study, this reduction was due to the loss of vegetation which corroborates the assertions Khanna *et al.* (2007), Hüttnl *et al.* (2008), Schlesinger and Bernhardt (2013) in literature. This is affirmed by the carbon content result which indicated a carbon reduction from the baseline value of 360.53 Gt in 1986 to about 7895.6 Gt from 1986-2003, the baseline of 8256.1 Gt in 2003 to about 8560 Gt reduction from 2003-2017 and finally a reduction in 16455 Gt from 1986-2017.

Further, Pearson correlation results from the study indicated the least significant values to tree height and diameter at breast height, corroborating the findings of Negasi *et al.* (2018). In addition, regression results for soil carbon and tree parameters indicated least adjusted R^2 values for tree height, tree height and density and tree height, tree density per hectare and diameter at breast height which further corroborated the findings of Negasi *et al.* (2018).

CHAPTER SIX

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

This section presents a summary of the study from its introduction, literature review, methodology, results, and discussions. It subsequently ends with a conclusion and recommendations.

6.2 Summary

- a. Environmental awareness and protection have seen much progress and development since its formative era in the 20th century.
- b. In the current environmental management framework, two tools of sustainability assessment are mostly employed, namely the Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) tools.
- c. The former is usually employed for *ex-post* projects assessment whereas the latter is employed for *ex-ante* projects assessment.
- d. Regarding this study on environmental management specifically on SEA, there have been little studies with which focuses on conserving forests whilst exploiting forest resources.
- e. In addition, studies have not focused much on how forest conservation impacts on livelihood projects in the Abuakwa South Municipal Area and the general indigenous perception on forest management in the area.

- f. The focus of this study was however concerned with how SEA is employed in Abuakwa South Municipality's Medium Term Development Plan to conserve the Atiwa forest.
- g. The main of the study was however on assessing how SEA is mainstreamed in the Abuakwa South Municipal Medium Term Development Plan (MTDP).
- h. In achieving this objective, the following specific objectives were determined; assessing SEA influence in the Medium Term Development Plan of Abuakwa South Municipal area, assessing community perception on forest management, assessing rainfall and temperature variability patterns for a period of thirty years and assessing tree and soil carbon stocks.
- i. The study found a fair appreciation of SEA principles in the Municipality, specifically on its environmental pillar. However, economic sustainability, social participation, and institutional capacity building were lacking.
- j. Results from the study revealed a significant increase in forest cover and bare land cover. However, open vegetation stock was revealed to be declining since 1986 to 2017. Tree carbon was shown to be higher in the dense forest area, whereas soil carbon was highest in cocoa farms, with the least values occurring open vegetation.
- k. Lastly, results on rainfall and temperature revealed rainfall to have not changed significantly whilst maximum and minimum temperatures have changed significantly.
- l. Based on the results of the study, SEA mainstreaming in the Abuakwa South Municipal area is fairly below average, with only the environmental pillar

achieving significant progress. Further, results from the study did not confirm the findings of Makarieva and Gorshkov (2010) on the biotic pump theory. Whilst forest cover showed a significant correlation to temperature patterns, it did not show any significant correlation to rainfall.

- m. A 2003 carbon baseline of 60576.43 Gt to 63697.6 Gt in 2017 did not confirm the assertions of Adu-Bredu *et al.* (2010) and Schep *et al.* (2016) that the Atiwa forest is declining.
- n. Finally, the findings from the study revealed 12 plant species listed as endangered on the International Union of Conservation of Nature's endangered list, this did not corroborate the findings of Abu-Juam *et al.* (2003) and Schep *et al.* (2016).

6.3 Conclusion

The economy of the municipality greatly relies on its abundant natural resources amidst the global call on sustainable planning and development. The concept of SEA as a sustainability tool, however, exists as a proactive tool to evaluate and monitor all development plans and projects to achieve a balance in all facets of sustainability planning.

Nonetheless, after more than a decade since the inception of the SEA in Ghana, the municipality still records significant increases in natural environment decay, specifically in its forest sector and general landscape, this leaves a consequent effect on other sectors of the economy. The study, however, sought to investigate the mainstreaming progress of SEA in the Abuakwa South Municipality, one of the forest

regions in Ghana. The findings of the study did not corroborate the assertions of the progress report of the previous 2014-2017 and the development statement of the current Medium Term Development Plan (2018-2021) on the advancement of socio-economic opportunities. Whilst the municipal area reports on efforts towards socio-economic growth in terms of career counseling, technical and managerial skills training, Soap and Gari making, business counseling and environmentally safe agricultural methods, it was nonetheless revealed by the study to be not adequate to promote the efficient implementation of sustainability planning in terms of stakeholder inclusion and capacity building and economic sustainability planning.

In addition to investigating the progress of SEA and carbon accounting as part of its environmental management pillar, stocks of carbon in dense forests show a significant progressive increase due to the reforestation projects initiated by the municipality since 2014. However, the open vegetation stocks of carbon show a significant progressive decline, with an increase in bare land cover. From the study, vegetation degradation is linked to land use activities like mining and lumbering. This in effect contributes to the general in soil carbon content and soil fertility.

The study concludes with a significant appreciation of SEA principles and values in the municipality. Indigenous people have an appreciative perception of the forest as environmental resources, so as the officials. The officials in the municipal area consider SEA tools as a guide to development in the municipality by mainstreaming environmental ethics into socio-economic demands.

6.4 Recommendations

Based on the findings of the study, the following recommendations are proposed:

- a. Inasmuch as the institutional capacity pillar did not show a significant correlation to forest cover, it must be duly strengthened to promote communal commitment towards enforcing state directives on natural resource management.
- b. As part of ensuring communal integration in conserving the Atiwa Forest, there must be transparent with regards to how indigenes benefit from the conservation plans of the forest, although, from the study, there was no significant correlation of it to the state of the Atiwa Forest cover. Nonetheless, benefit-sharing creates a sense of communal inclusion.
- c. In ensuring effective conservation of the Atiwa Forest reserve, there should be an adequate and diverse livelihood support projects to compensate indigenes who dwell on the forest for their livelihood.
- d. Due to the rapid loss of vegetation in the open canopy forest engendering bare/settlement areas, it is imperatives to assess below-ground carbon loss of the Atiwa Forest Reserve.

REFERENCES

- Abu-Juam, M., Obiaw, E., Kwakye, Y., Ninnoni, R., Owusu, E.H. and Asamoah, A. (eds). (2003). Biodiversity Management Plan for the Atewa Range Forest Reserves. Forestry Commission. Accra.
- Abubakari, Z., Richter, C., Zevenbergen, J. (2018). Exploring the “implementation gap” in Land Registration: How it happens that Ghana’s Official Registry contains Mainly Leaseholds. *Elsevier, Land Use Policy*.
<https://doi.org/10.1016/j.landusepol.2018.07.011>
- Acheampong, E. and E. Marfo. (2011). “The impact of tree tenure and access on chainsaw milling in Ghana.” *Ghana Journal of Forestry, Vol. 27: 68-86*.
- Adu-Bredu, S., Abekoe, M.K., Tachie-Obeng, E. and Tschakert, P. (2010). Carbon stock under four land-use systems in three varied ecological zones in Ghana. *In: Bombelli, A. and Valentini, R. (eds). Africa and the carbon cycle: proceedings of the Open Science Conference on Africa and the Carbon Cycle: the CarboAfrica*.
- Aerts, R., and Honnay, O. (2011). Forest restoration, biodiversity and ecosystem functioning. *BMC Ecology, 11: 29*

- Ahenkan, A., Boon, E. (2008). Enhancing Food Security, Poverty Reduction and Sustainable Forest Management in Ghana through Non-timber Forest Products Farming: Case Study of Sefwi Wiawso District, *published online by GRIN Publishing at www.grin.com/de/preview/.html* (Retrieved 15 May, 2010)
- Ajaja, S. (2013). Public participation in environmental impact assessment (EIA) reports: The Nigerian experience. IAIA 13 Conference Proceedings, Impact Assessment: The Next Generation, 33rd Annual Meeting of the International Association for Impact Assessment, 13–16 May 2013, *Calgary Stampede BMO Centre Calgary, Alberta, Canada.*
- Agyeman, K. O., Amponsah, O., Braimah, I. and Lurumuah, S. (2012). “Commercial Charcoal Production and Sustainable Community Development of the Upper West Region, Ghana.” *Journal of Sustainable Development, Vol. 5 (4).*
- Amanor, K. S. (1996). Managing Trees in the Farming System: The Perspective of Farmers (Kumasi: Forest Department).
- Amankwa, R.K., Anim-Sackey, C. (2003). Strategies for Sustainable Development of Small-Scale Gold and Diamond Mining Industry in Ghana. *Elsevier, Resource Policy. <https://doi.org/10.1016/j.resourpol.2004.07.002>*

- Amissah, L., Godefridus M. J., Mohren., Bongers, F., Hawthorne, W., D., and Poorter, L. (2014). Rainfall and temperature affect tree species distribution in Ghana. *Journal of Tropical Ecology* (2014) 30:435–446. *Cambridge University Press* 2014 doi: 10.1017/S026646741400025X.
- Amisah, S., Gyampoh, A. B., Sarfo-Mensah, P. and Quagrainie, K. K. (2009). “Livelihood trends in Response to Climate Change in Forest Fringe Communities of the Offin Basin in Ghana.” *Applied Science and Environmental Management, Vol. 13: 5-15.*
- Anane, M. (2015). Religion and conservation in Ghana. Retrieved from <https://www.unngls.org/index.php/23-publications/policy-booklets/236-religion-and-conservation-in-ghana-by-mike-anane>
- Appiah, O. D. (2009). “Personifying sustainable rural livelihoods in forest fringe communities in Ghana: A historic rhetoric?” *Journal of Food, Agriculture & Environment, Vol. 7.*
- Appiah, M., Blay, D., Damnyag, L., Dwomoh, F. K., Pappinen, A. and Luukkanen, O. (2009). “Dependence on Forest Resources and Tropical Deforestation in Ghana.” *Environment, Development and Sustainability, Vol. 11: 471-487.*

- Asamoah, A.K., Pinard A.M., Cobbinah, R.J., Damnyag,L., Nutakor, E., Nketiah, S.K., Kyere, B., Nyarko, C. (2007). *Chainsaw milling and trade in West Africa. Socio-economic impact of chainsaw milling and the lumber trade in Ghana*. DFID, Renewable Natural Resource Research Strategy (RNRRS) (FRP) PMP 05-08. Natural Resource International, UK.
- Asante, A.F., Owusu, K. (2013). Policies and Options for Ghana's Economic Development. Published by the Institute of Statistical, Social & Economic Research (ISSER) University of Ghana, Legon, Ghana. ISBN: 978-9964-75-097 8
- Asare, R.A., Asante, W., Tutu, D.B., Malhi, Y., Saatchi, S. & Jengre, N. (2012). The Biomass Map of Ghana: Using Carbon Maps for REDD+. Ghana Carbon Map Project. Nature Conservation Research Centre, Accra, Ghana; *Forest Trends, Washington, D.C.*
- Asare, R., A., and Kwakye, Y. (2013). A Guide to Implementing REDD+ in Ghana: Criteria and Modalities for Developing a REDD+ Project. Ghana Forestry Commission.
- Aryee, B.N.A., Ntibrey, B.K and Atorkui, E. (2003). Trends in the small scale mining of precious minerals in Ghana: a perspective on its environmental impact. *J Clean Prod. 11:131–140.*

Attah, A. N. (2014). The contribution of forests to the economy of Ghana. Retrieved from https://www.fornis.net/system/files/users/Contribution_of_forests.pdf

Atsivor, L., Dowuona, G. N., & Adiku, S. G. K. (2001). Farming System-Induced Variability of some Soil Properties in a Sub-Humid Zone of Ghana. *Plant and Soil*, 236(1), 83-90.

Batjes, N. H. (2001). Options for increasing carbon sequestration in West African soils: an exploratory study with special focus on Senegal. *Land Degradation & Development*, 12(2), 131-142.

Beer, C., Reichstein, M., Tomelleri, E., Ciais, P., Jung, M., Carvalhais, N., Rodenbeck, C., Altaf Arain, M., Baldocchi, D., Bonan, G.B., Bondeau, A., Cescatti, A., Lasslop, G., Lindroth, A., Lomas, M., Luysaert, S., Margolis, H., Oleson, K.W., Rouspard, O., Veenendaal, E., Viovy, N., Williams, C., Woodward, F.I. and Papale, D. (2010). Terrestrial gross carbon dioxide uptake: global distribution and covariation with climate. *Science*, 329: 834-838.

Beedlow, P.A., Tingey, D.T., Phillips, D.L., Hogsett, W.E. and Olszyk, D.M. (2004). Rising atmospheric CO₂ and carbon sequestration in forests. *Frontiers in Ecology and the Environment*, 2: 315-322.

- Bellassen, V., Manlay, R. J., Chéry, J.-P., Gitz, V., Touré, A., Bernoux, M., & Chotte, J.-L. (2010). Multi-Criteria Spatialization of Soil Organic Carbon Sequestration Potential from Agricultural Intensification in Senegal. *Climatic Change*, *98*(1), 213-243.
- Berkes, F. (2012). *Sacred ecology. 3rd ed. London: Routledge.*
- Boafo, J. (2013). The Impact of Deforestation on Forest Livelihoods in Ghana. Africa Portal. Center for International Governance Innovation.
- Boafo, Y. A., Saito, O., Kato, S., Kamiyama, C., Takeuchi, K., and Nakahara, M. (2016). The role of traditional ecological knowledge in ecosystem services management: the case of four rural communities in Northern Ghana, *International Journal of Biodiversity Science, Ecosystem Services & Management*, *12*:1-2, 24-38, DOI: [10.1080/21513732.2015.1124454](https://doi.org/10.1080/21513732.2015.1124454)
- Boadi, S., Nsor, A.C., Yakubu, D.H., Acquah, E. & Antobre, O.O. (2017). Conventional and Indigenous Biodiversity Conservation Approach: A Comparative Study of Jachie Sacred Grove and Nkrabea Forest Reserve. *Hindawi International Journal of Forestry Research Volume 2017, Article ID 1721024, 8 pages* <https://doi.org/10.1155/2017/1721024>

- Boon, E. and Ahenkan., A. (2007). Conservation and Management of Biodiversity in West Africa- Case Study of Ghana, in Encyclopedia of Life Support Systems, UNESCO, Paris, France.
- Boon, E., Ahenkan, A. and Badoun, B, B. (2009). An Assessment of Forest Resources Policy and Management. IAIA09 Conference Proceeding', Impact Assessment and Wellbeing 29th Annual Conference for International Association Impact Assessment, 16-22 May 2009, Accra International Conference Center, Accra, Ghana.
- Bosu, P.P., Foli, E.G., Djagbletey, G., Ametsitsi, G., Addo-Danso, S. D., Cobbinah, J.R., Nkrumah, E.E. and Bandoh, P.K. (2010). Assessment of coping and adaptation strategies to the effects of climate change in the Offinso North and South districts, Ashanti Region.
- Botchway, K. (2001). Paradox of empowerment: reflections on a case study from northern Ghana. *World Dev.* 29:135–153.
- Brown, S. (2002). Measuring carbon in forests: current status and future challenges. *Environmental Pollution*, 116(3), pp. 363–372.
- Carlson, L., and Sandstrom, A. (2008). "Network governance of the commons" *International Journal of the Commons* 1(2): 33-5.

CERSGIS (1990, 2000, 2010). Land-Cover Raster Data for Ghana

Cline-Cole, R. and O'keefe, P. (2006). "Mainstreaming the African environment in development?" *Review of African Political Economy* 33(109): 377 - 389.

Chave, J., Andalo, C., Brown, S., Cairns, M.A., Chambers, J.Q., Eamus, D., Folster, H., Fromard, F., Higuchi, N., Kira, T., Lescure, J.P., Nelson, B.W., Ogawa, H., Puig, H., Rie´ra, B. and Yamakura, T. (2005). Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, 145(1): 87-99.

Dagba C-A, Olearius A, Nikov K, van Tilborg H, van Boven G. (2012). *Benin: Strategic Environmental Assessment of the Poverty Reduction Strategy*. In: OECD. *Strategic Environmental Assessment in Development Practice: A Review of Recent Experience*. Paris: Organization for Economic Cooperation and Development; p. 61–68.

Davidson, E. A., Janssens, I. A. (2006). Temperature sensitivity of soil carbon decomposition and feedbacks to climate change. *Nature* 440: 165–173.

DeGeorges P. A. and Reilly B. K. (2008). A critical evaluation of conservation and development in sub-Saharan Africa. Lewiston, New York, NY, USA: *The Edwin Mellen Press*.

De Gier, I. K. S. A. and Hussin, Y. A. (2012). Estimation of Tropical Forest Biomass for the Assessment of Carbon Sequestration Using Regression Models and Remote Sensing In Berau East Kalimantan, Indonesia, Department of Natural Resources, The International Institute for Geoinformation Science and Earth Observation (ITC), Hengelosstraat, 99, 7500.

Degrassi, A. (2003). “Constructing subsidiarity, consolidating hegemony: political economy and agro-ecological processes in Ghanaian forestry” Environmental Governance in Africa, World Resources Working Paper No.13 (Washington DC: World Resources).

Djomo, A.N., Knohl, A., Gravenhorst, G. (2011). Estimations of total ecosystem carbon pools distribution and carbon biomass current annual increment of a moist tropical forest. *Forest Ecology and Management*, 261: 1448-1459.

Doomson, O. & Vlosky, P., R. (2007). A Strategic Overview of the Forest Sector in Ghana. Louisiana Forest Products Development Center Working Paper #81. Louisiana Forest Products Development Center School of Renewable Natural Resources Louisiana State University Agricultural Center Baton Rouge , LA70808

East Akyem Municipal Assembly (2015). Composite Budget for the 2015 Fiscal year.

Republic of Ghana.

Environmental Protection Agency (EPA) (2004). Ghana State of the Environment

Report, EPA Ghana, Accra. Pp 11-51.

Environmental Protection Agency (2016). Preparation of an Implementation

Framework for Operationalizing Strategic Environmental Assessment (SEA)

Practice in Ghana. Accra, Ghana

Fair, J. and Leach, M. (1998). Reframing Deforestation: Global Analysis and Local

Realities: *Studies in West Africa (London: Routledge)*.

FAO. (2005). Global forest resource assessment: progress towards sustainable forest

management. In: *Food and Agriculture Organization Forestry Paper, 147,*

FAO, Rome

FAO. (2018). Measuring and modelling soil carbon stocks and stock changes in

livestock production systems – Guidelines for assessment (Draft for public

review). Livestock Environmental Assessment and Performance (LEAP)

Partnership. *FAO, Rome, Italy.*

Fearnside, P.M. (2011). Gases de Efeito Estufa no EIA-RIMA da Hidrelétrica de Belo Monte Novos Cadernos NAEA, 14 (1) (2011), pp. 5-19

Food and Agriculture Organization (2009). The State of Food and Agriculture 2009. Food and Agriculture Organization of the United Nations Viale delle Terme di Caracalla, 00153 Rome, Italy

Food and Agriculture Organization (FAO) (2010). Global forest resources assessment 2010. *Food and Agriculture Organization of the United Nations, Rome, 2010.*

Foster, D., Swanson, F., Aber, J., Burke, I., Brokaw, N., Tilman, D. & Knapp, A. (2003). The importance of land-use legacies to ecology and conservation. *Bioscience* 53, 77-88.

Food and Agriculture Organization of the United Nations (FAO) (2007). Forest and Water Forests and water, FAO, *Unasylva No. 229 Vol. 58, 2007/4, Rome, 2007*

Food and Agriculture Organization (2011). State of Food and Agriculture Food and Agriculture Organization of the United Nations Rome, 2011. Women in Agriculture: Closing the Gender Gap in Development

Forestry Commission. (1994). *Forestry and Wildlife Policy. Accra, Ghana.*

Ghana Forestry Commission. (2005). *www.fcghana.com/publications*.

Forestry Commission (2014). *National Forest Plantation Development Programme Annual report 2014*.

Forestry Commission. (2015). Development of Reference Emissions Levels and Measurement, Reporting and Verification System in Ghana. FC/FCPF/MRV/REL/RFP/01/2013. Indufor Oy Töölönkatu 11 A FI-00100 Helsinki FINLAND.

Forestry Commission (2016). Inventory and Mapping of Planned and On-Going Mining Activities in Atewa Forest and its Immediate Environment.

Ghana MDG Report. (2015). Ghana Millennium Development Goals Report, United Nations Development Programme. Accra, Ghana.

Ghana Statistical Service (2014). Population and Housing Census 2010, District Analytical Report, East Akyem.

Ghana Statistical Service (2014). Ghana Living Standards Survey Report (GLSS6). *Accra, Ghana*

- Gibbon, A., Silman, M.R., Malhi, Y., Fisher, J.B., Meir, P., Zimmermann, M., Dargie, G.C., Farfan, W.R. and Garcia, K.C. (2010). Ecosystem carbon storage across the grassland–forest transition in the high Andes of Manu National Park, Peru. *Ecosystems*, 13: 1097-1111.
- Gibson, C. C. and Hoffman, B. (2002) Dictators with Empty Pockets: A Political Concessions Model of Africa's Democratization. Paper prepared for the 2002 Annual Meetings of the American Political Science Association, Boston MA.
- Grace, J. (2004). Understanding and managing the global carbon cycle. *Journal of Ecology*, 92: 189-202.
- Grainger, A. and Konteh, W. (2007). "Autonomy, ambiguity and symbolism in African politics: the development of forest policy in Sierra Leone" *Land Use Policy* 24: 42-62.
- Gutiérrez, L. (2015a). The Environmental Effects of Tourism Architecture on Island Ecosystem in Cayo Guillermo, Cuba. *Journal of Environmental Protection*, 6, 1057-1065. Available at: <http://dx.doi.org/10.4236/jep.2015.69093>.
- Guuroh, R. (2010). Forest degradation and deforestation in Ghana.
- Hairiah, K., Dewi, S., Agus, F., Velarde, S., Ekadinata, A., Rahayu, S and Van, N.

- M. (2011). *Measuring Carbon Stocks across Land Use Systems: A Manual*. Bogor, Indonesia. *World Agroforestry Centre (ICRAF), SEA Regional Office, 154 pages*.
- Henry, M., Valentini, R., Bernoux, M. (2009). Soil carbon stocks in Eco-regions of Africa, *4279 Biogeosciences Discussions 6, 797-2009*
- Hilson, G. and Banchirigah S.M. (2009). Are alternative livelihood projects alleviating poverty in mining communities? Experiences from Ghana. *J Dev Stud. 45:172–196*.
- Hüttl, R., Prechtel, A. and Bens, O. (2008). *Humusversorgung von Böden in Deutschland* Berlin .4301 203 pp. Retrieved from <http://www.umweltbundesamt.de/publikationen/humusversorgung-von4302-boeden-in-Deutschland>.
- IPCC, Climate Change (2001). Working Group I: The Scientific Basis. *Cambridge University Press, New York*.
- IPCC. (2013). The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC).

ITTO (2015). Annual report 2015 International Tropical Timber Organization, Yokohama, Japan.

ITTO (2015). Voluntary guidelines for the sustainable management of natural tropical forests. ITTO Policy Development Series No. 20. International Tropical Timber Organization, Yokohama, Japan.

IUCN (1992). Protected Areas of the World: A Review of National Systems. Volume 3: Afrotropical. Prepared by the UNEP World Conservation Monitoring Centre (UNEP-WCMC). IUCN, Gland, Switzerland and Cambridge, UK.

Johansen, K., Bartolo, R., & Phinn, S. (2010). SpecialFeature-Geographic Object-Based Image Analysis. *Journal of Spatial Science*, 55(1),3-7.

Jimoh, S. O., Ikyagba, E. T., Alarape, A. A., Obioha, E. E., Adeyemi, A. A. (2012). The Role of Traditional Laws and Taboos in Wildlife Conservation in the Oban Hill Sector of Cross River National Park (CRNP), Nigeria.

Juma, A., F. (1996). Governance and Sustainable Development, In Land We Trust: Environment, Private Property and Constitutional Change. Nairobi, Kenya: Initiative Publishers: London UK: Zed Books, 1996.

- Kashaigili, J.J., Majaliwa, AM. (2010). Integrated Assessment of Land Use and cover changes in the Malagasy river catchment in Tanzania. *Phys Chem Earth*. 2010;35(13):730–41.
- Khanna, M., Onal, H., Dhungana, B. and Wander, M. (2007). Economics of Soil Carbon Sequestration through Biomass Crops. Univ. Illinois, Dep. Agric. Consumer Econ.
- Kotey, E. N. A., Francois, J., Owusu, J. G. K., Yeboah, R., Amanor, K. S. and Antwi, L. (1998). Falling Into Place: Policy that works for forests and people (London: International Institute for Environment and Development).
- Li, M. M., Zhang, X. C., Pang, G. W. and Han, F. F. (2013). The estimation of soil organic carbon distribution and storage in a small catchment area of the Loess Plateau. *Catena* 101: 11–16.
- Lü, X.-T., Yin, J.-X., Jepsen, M.R. and Tang, J.-W. (2010). Ecosystem carbon storage and partitioning in a tropical seasonal forest in Southwestern China. *Forest Ecology and Management*, 260: 1798-1803
- Lu, D., Chen, Q., Wang, G., Liu, L., Li, G. and Moran, E., (2014). A survey of remote sensing-based aboveground biomass estimation methods in forest ecosystems. *International Journal of Digital Earth*, (ahead-of-print), 1–43.

- Malhi, Y., Aragão, L.E.O.C., Metcalfe, D.B., Paiva, R., Quesada, C.A., Almeida, S., Anderson, L., Brando, P., Chambers, J.Q., Da Costa, A.C.L., Hutrya, L.R., Oliveira, P., Patiño, S., Pyle, E. H., Robertson, A. L. and Teixeira, L. M. (2009). Comprehensive assessment of carbon productivity, allocation and storage in three Amazonian forests. *Global Change Biology*, 15: 1255-1274.
- Makarieva, A. M. and Gorshkov, V. G. (2007). 'Biotic pump of atmospheric moisture as driver of the hydrological cycle on land', *Hydrology and Earth System Sciences*, Vol. 11, No. 2, pp. 1013-1033.
- Makarieva, A. M. and Gorshkov, V. G. (2010). The Biotic pump: Condensation, atmospheric dynamics and climate. *International Journal of water-2010*, DOI: 10.1504/IJW.2010.038729
- Mayers, J. and Kotey, E.N.A. (1996). Local institutions and adaptive forest management in Ghana. IIED Forestry and Land Use Series No.7. *International Institute for Environment and Development, London*.
- Miller, P., Engel, R., and Brickleyer, R. (2004). Carbon sequestration in agriculture farm management practices can affect greenhouse gas emissions. *Montana state university ext. service, MT (4)*.

Ministry of Lands and Natural Resources (2012). Ghana Forest and Wildlife Policy, Republic of Ghana.

Ministry of Lands and Forestry (1996). Forestry Development Master Plan (Accra: Ministry of Lands and Forestry).

Ministry of Lands and Forestry (1994). Forest and Wildlife Policy, Republic of Ghana, 24 November 1994, (Accra: Ministry of Lands and Forestry).

<https://news.mongabay.com/2012/02/new-meteorological-theory-argues-that-the-worlds-forests-are-rainmakers/>.

Negasi, S., Opoku, P., Annang, T., Asante, K, I and, Birhane, E. (2018). The effects of Land Cover Change on Carbon Stock dynamics in a dry Afromontane forest in northern Ethiopia. *13:14* <http://doi.org/10.1186/s13021-018-0103-7>

Ngo, K. M., Turner, B. L., Muller-Landau, H. C., Davies, S. J., Larjavaara, M., bin Nik Hassan, N. F. and Lum, S. (2013). Carbon stocks in primary and secondary tropical forests in Singapore. *Forest Ecology and Management*, 296: 81-89.

Nketia, K. S., Tutu Osei , P., & Asare, A. (2009). The Forest Dialogue-TFD, Implementing REDD+ in Ghana: Contextualization and Some Challenges. A background Paper for REDD+ReadinessField Dialogue in Ghana, November, 2009.

Noble, B. F. (2002). The Canadian experience with SEA and sustainability. *Environmental Impact Assessment Review*, 22(1), 3-16.

Ntiamoa-Baidu, Y., Owusu E. H., Daramani D. T. and Nuoh A. A. (2001). Ghana. In: Fishpool LDC, Evans MI, editors. Important Bird Areas in Africa and associated islands: priority sites for conservation. Newbury: Pisces Publications and BirdLife International– BirdLife Conservation Series No. 11; p. 367–389.

OECD (2012a). *Strategic Environmental Assessment in Development Practice: A Review of Recent Experience*. OECD Publishing. Available at: <http://dx.doi.org/10.1787/9789264166745-en>.

Oppon, S. (2004). Decentralisation of Federal Systems in Forests and National Forestry Programme: The case of Ghana. Paper presented at the Interlaken Workshop on Decentralisation in Forestry, Interlaken, Switzerland, 27-30th April, 2004.

Owusu E. H. (2001). The Potential of Afadjato-Agumatsa Conservation for Ecotourism Development [Unpublished PhD Thesis]. *Canterbury: DICE, University of Kent*.

- Palermo, J., J. Dusik & K. Deepchand (2012), "Mauritius: Strategic Environmental Assessment on the sugar cane sector", in Strategic Environmental Assessment in Development Practice: A Review of Recent Experience, OECD Publishing, Paris, <http://dx.doi.org/10.1787/9789264166745-10-en>.
- Pan, Y., Birdsey, R.A., Fang, J., Houghton, R., Kauppi, P.E., Kurz, W.A., Phillips, O.L., Shvidenko, A., Lewis, S.L., Canadell, J.G., Ciais, P., Jackson, R.B., Pacala, S.W., McGuire, A.D., Piao, S., Rautiainen, A., Sitch, S. and Hayes, D. (2011). A large and persistent carbon sink in the world's forests. *Science*, 333: 988-993.
- Palm, C. A., van Noordwijk, M., Woomer, P., Alegre, J. C., Arévalo, L., Castilla, C. E., Cordeiro, D. G., Hairiah, K., Kotto-Same, J., Moukam, A., Parton, W. J., Ricse, A., Rodrigues, V., and Sitompul, S. M. (2005). Carbon losses and sequestration after land use changes on the humid tropics. In Palm, C. A., Vosti, S. A., Sanchez, P. A., and Ericksen, P. J. (eds.), *Slash-and-Burn Agriculture—The Search for Alternatives*. Columbia University Press, New York, pp. 41–63.
- Parren, M. P. E. and De Graaf, N. R. (1995). The Quest for Natural Forest Management in Ghana, Cote d'Ivoire and Liberia" (Wageningen: The Tropenbus Foundation).

- Partidário, M.R. (2003). Elements of an SEA framework-improving the added value of SEA. *Environmental Impact Assessment Review*, 20,647-663
- Pearson, T., Walker, S., Brown, S. (2005). Sourcebook for land use, land-use change and forestry projects. *Arlington: Winrock International and the Bio-carbon fund of the World Bank.*
- Prentice, I.C., Farquhar, G.D., Fasham, M.J.R., Goulden, M.L., Heimann, M., Jaramillo, V.J., Kheshgi, H.S., LeQuéré, C., Scholes, R.J. and Wallace, D.W. (2001). The carbon cycle and atmospheric carbon dioxide. Cambridge University Press. Lehtonen, A., Makipaa, R., Heikkinen, J., Sievanen, R. and Liski, J. (2004). Biomass expansion factors (BEFs) for Scots pine, Norway spruce and Birch according to stand age for boreal forests. *Forest ecology management*, 188: 211-224.
- Putnam, R. (1993). *Making Democracy Work* (Princeton: Princeton University Press).
- Quacou, I.E. (2017). Unsustainable management of forests in Ghana from 1900-2010. *International journal of environmental monitoring and analysis*. Vol. 4, No. 6, 2016, pp. 160-166. doi: 10.11648/j.ijema.20160406.14.
- Rajvanshi, A. (2003). Promoting public participation for integrating sustainability issues in environmental decision-making: The Indian experience. *Journal of Environmental Assessment Policy and Management*, 5(3), 295–319.

- Riegel, J. B., Bernhardt, E., Swenson, J., (2013): Estimating Above- Ground Carbon Biomass in Newly Restored Coastal Plain Wetland Using Remote Sensing. *PLoS one*, 8(6), e68251.
- Ron, A., Rae, J. P., Agyemang, K., Griffis, J. R. (2010). *Technical Report on the Kibi Goldfields Mine Kwabeng Gold Project Ghana, West Africa*. Retrieved February 20, 2013, from <http://chevyrockengineering.com>.
- Saner, P., Loh, Y.Y., Ong, R.C. and Hector, A. (2012). Carbon stocks and fluxes in tropical lowland dipterocarp rainforests in Sabah, Malaysian Borneo. *PLoS One* 7, e29642.
- Sadler, B., & Verheem, R. (1996). *Strategic Environmental Assessment: Status, Challenges and Future Directions*. Publication No. 54, Ministry of Housing, Spatial Planning and the Environment. The Hague, Netherlands.
- Schep. S., Guzmán, A., Beukering, P.V., Moel, D.H., Eiselin, M., Ayesu, S., Birikorang, G. and Ansah, K.B. (2016). The Economics of the Atewa Forest Range, Ghana. Living Waters from the Mountain Protecting Atewa Water Resources. *IVM Institute for Environmental Studies R-16/03*.
- Schlesinger, W.H (1990). Evidence from Chronosequence Studies for a Low Carbon-Storage Potential of Soils. *Nature* 348: 232–234.

Schlesinger, W.H. & Bernhardt, E.S. (2013). *Biogeochemistry: An Analysis of Global Change. Third 4715 Edition. Academic Press, New York.*

Sheil, D. and Murdiyarso, D. (2009) 'How Forests Attract their Rain: An Examination of a New Hypothesis', *BioScience*, Vol. 59, No. 4, pp. 341–347.

Siaw., D. (2001). State of Forest Genetic Resources in Ghana, FAO, IGPRI/SAFORGEN, DFSC and ICRAF, *Forest Genetic Resources Working Paper, 17.*

Sierra, C.A., del Valle, J.I., Orrego, S.A., Moreno, F.H., Harmon, M.E., Zapata, M., Colorado, G.J., Herrera, M.A., Lara, W., Restrepo, D.E., Berrouet, L.M., Loaiza, L.M. and Benjumea, J.F. (2007). Total carbon stocks in a tropical forest landscape of the Porce region, Colombia. *Forest Ecology and Management, 243: 299-309.*

Smith, M. J. (1993). *Pressure, Power and Policy: State Autonomy and Policy Networks in Britain and the United States* (London: Harvester Wheatsheaf).

Smith, E. K. (1996). *The Evolution of Policy into Practice: A Case Study of Ghana's Forest Policy*. Paper presented at the African Forestry Policy Forum, August 29th – 30th, 1996 Nairobi.

- Smith, F.W., Long, J.N. (2001). Age-related decline in forest growth: an emergent property. *Forest Ecology and Management*, 144(1-3): 175-181.
- Temeng V.A., Abew J.K., (2009). A review of alternative livelihoods projects in some mining communities in Ghana. *Eur J Sci Res*. 35:217–228.
- Teye, J.K. (2008) Forest resource management in Ghana: An analysis of policy and institution. (*Unpublished Phd thesis*) University of Leeds.
- Therivel, R., Wilson, E., Thompson, S., Heaney, D., & Pritchard, D. (1992). Strategic Environmental Assessment. London, Earthscan.
- Therivel, R. (2004). *Strategic Environmental Assessment in Action*. London: Blackwell.
- Tropenbos International-Ghana (2007). Restoration and sustainable management of forest in Ghana. Proceedings of an international conference held in Elmina, Ghana, from July 5-7, 2005, Tropenbos International– Ghana Workshop Proceedings, Kumasi, Ghana.
- Tolbert, C. J. (2002). "Rethinking Lowi's constituent policy: governance policy and direct democracy" *Environment and Planning: Government and Policy* 20: 75-93.

- Thomlinson, J.R., Serrano, M.I., Lopez, T.D.M., Aide, T.M., and Zimmerman, J.K. (1996). Land-use dynamics in a post-agricultural Puerto Rican landscape (1936-1988). *Biotropica*, 525-536.
- Tulyasuwan, N., Henry, M., Secrieru, M., Jonckheere, I., & Federici, S. (2012). Issues and challenges for the national system for greenhouse gas inventory in the context of REDD+. *Greenhouse Gas Measurement and Management*, 2(2-3), 73-83. doi: 10.1080/20430779.2012.716298
- Wright, S.J. (2005). Tropical forests in a changing environment. *Trends in Ecology and Evolution*, 20: 553-560.
<http://www.worldbank.org/en/topic/forests/brief/forests-and-economic-development>.
- Todaro., M and Smith., S. (2009). Economic Development. 10th Edition. Pearson Education, Edinburgh, England.
- Therivel, R., Wilson, E., Thompson, S., Heaney, D., & Pritchard, D. (1992). Strategic Environmental Assessment. London, Earthscan.
- United Nations Environment Programme (UNEP) (2002). Africa Environment Outlook. *Past, present and future perspectives*, UNEP, Nairobi, Kenya. Pp131.

United Nations Development Programme (UNDP) (2014). *Ghana Millennium Development Goals Report*. Accra: UNDP.

United Nations Development Programme (UNDP) (2015). *Ghana Millennium Development Goals Report*. Accra: UNDP.

Walker, W., A. Baccini, M. Nepstad, N. Horning, D. Knight, E. Braun, and A. Bausch. (2011). *Field Guide for Forest Biomass and Carbon Estimation*. Version 1.0. *Woods Hole Research Center, Falmouth, Massachusetts, USA*.

Wang, Y., & Hsieh, Y.-P. (2002). Uncertainties and novel prospects in the study of the soil carbon dynamics. *Chemosphere*, 49(8), 791-804.

Whitehead, D., Baisden, T., Beare, M., Campbell, D., Curtin, D., Davis, M.R., Hedley, C.B., Hedley, M., Jones, H., Kelliher, M.F., Saggar, S., Schipper, L.A. (2010). *Review of Soil Carbon Measurement Methodologies and Technologies, Including Nature and Intensity of Sampling, their Uncertainties and Costs*. Prepared for the Ministry for Primary Industries by Landcare Research. *ISBN No: 978-0-478-40450-0*.

World Bank (2006). *Ghana Country Environmental Analysis*. *Environmentally and Socially Sustainable Development Department*.

World Bank. (2008). *Sierra Leone - Mining Sector Reform: A Strategic Environmental and Social Assessment*. Washington, DC. © World Bank. <https://openknowledge.worldbank.org/handle/10986/8087> License: CC BY 3.0 IGO.”

World Bank. (2014). We Support Putting a Price on Carbon.

Yachori, B. (2017). Urban Planning Capacity Development’s Response to Emerging Issues of Urbanisation in the Wa and Lawra Townships of Upper West Region.

Yao, M. K., Angui, P. K. T., Konate, S., Tondoh, J. E., Tano, Y., Abbadie, L., & Benest, D. (2010). Effects of Land use types on soil organic carbon and nitrogen dynamics in Mid-West Cote D'Ivoire. *European Journal of Scientific Research*, 40(2), 211-222.

Yuliasmara, F., Wibawa, A., & Prawoto, A. (2009). Carbon stock in different ages and plantation system of cocoa: allometric approach. *Pelita Perkebunan (a Coffee and Cocoa Research Journal)*, 25(2). <https://doi.org/10.22302/iccri.jur.pelitaperkebunan.v25i2.132>

Zhou, Y., Pei, Z., Su, J., Zhang, J., Zheng, Y., et al. (2012) Comparing Soil Organic Carbon Dynamics in Perennial Grasses and Shrubs in a Saline-Alkaline Arid Region, Northwestern China. *Plos one* 7 (8): e42927

Zhi, J., Jing, C., Lin, S., Zhang, C., Liu, Q., DeGloria, S., D., Wu, J., (2014). Estimating Soil Organic Carbon Stocks and Spatial Patterns with Statistical and GIS Based Methods. <https://doi.org/10.1371/journal.pone.0097757>

APPENDICES

Appendix 1

Interview Guide for the Municipal Assembly and Forestry Commission

Policy Formulation

1. Is there any policy document that guides the trend of development plans and projects in the municipality?

Yes No Not sure Don't know

2. With reference to question one, if “Yes”, are you familiar with the entire development policy document?

Very Familiar Slightly familiar Not familiar

3. How long has this policy been operational in the municipality?

.....
.....
.....

4. What is the goal of the municipal medium term development policy?

.....
.....

.....
.....

5. Are you personally involved in the formulation of the medium term development policy?

Yes No

If yes, what was your contribution to the policy.....

.....
.....
.....

6. Are you aware of the national forest policy?

Yes No

7. With reference to question 6, if “yes” how does the current Municipal Medium Term Development Policy integrate forest management principles into the PPPs.

.....
.....
.....
.....

8. Are you aware of the goals of the national forest policy?

Very familiar Slightly familiar Not familiar

9. What is the general municipality's perception on deforestation and forest resource exploitation?

Environmental degradation Socio-economic Growth Wildlife extinction

Other.....
.....
.....

10. Do you think the current development PPPs are appropriate to addressing forest and environmental management?

Strongly agree Slightly agree Not agree Not sure

11. Have you heard about alternative livelihood support project initiatives ?

Yes No

12. If yes, does the municipality have a local alternative fund livelihood support projects?

Yes No Not sure Don't know

13. Are the local communities involved in the policy formulation?

Yes No Not Sure Don't know

If yes, state why and

how.....

.....
.....

.....and if no, state

why.....

.....
.....

14. Which groups or organisations (NGOs, donor organisations etc.) take part in medium term development policy for the municipality?

.....
.....
.....

15. How often do policy makers accept demands made by the indigenous people in the municipality?

Always Seldom Never

16. What is the general perception on forest resource exploitation in the municipality?

Environmental degradation Socio-economic growth Other

Specify.....

.....

17. Do you hold public education to sensitise the municipality on environmental management?

Yes No Not sure Don't know

18. Do you think climate change is of concern in the municipality?

Yes No Not sure

19. Which aspect of climate change effect is of most concern to the municipality based on question (18) above?

Agricultural productivity

Soil conservation

Availability of drinking water

Wildlife habitat

Provision of environmental services

Influx of pests and diseases

Abiotic damages

Forest regeneration success

Other

(specify).....

20. Has there been any climate change adaptation programme in the municipality?

Yes No Don't know Not sure

21. What has been some of the best environmental practices advocated for in the municipality?

.....
.....
.....
.....

22. Since the inception of the current medium term development policy, what has been the degree of deforestation in the municipality?

Highly declining Slightly declining Not declining Not
sure

23. What has been the commitment efforts towards forest conservation and protection in the past two decades?

Very Efficient Efficient Minimal Weak

Institutional Progress

24. Do you consider the municipality as independent in formulating policies, plans and projects in the municipality?

Yes highly independent Slightly independence No

If no, please give a reason for your answer

.....
.....
.....

25. What is the level of resource availability (financial and technical) for the municipality's activities

High Moderate Low

26. Which resources are inadequate.....
.....
.....

27. Have you ever received any training on socio-economic development and forest management?

Yes full training Yes partial training No training

28. Based on question 27, if yes, how often do you organise such trainings for the assembly personnel and the municipality?

Very often Slightly often Not often

29. What is the key driver towards improved land management in the municipality?

Wildlife protection	<input type="checkbox"/>	Ecosystem regulatory services	<input type="checkbox"/>
Forest regeneration capacity	<input type="checkbox"/>	Increase agricultural yield	<input type="checkbox"/>
Poverty reduction	<input type="checkbox"/>		

Other.....
.....
.....

30. Which actors are chiefly involved in the improved land management interventions in the municipality?

- (a) Local government
- (b) Individual landowners
- (c) Traditional authorities
- (d) Environmental NGOs
- (e) Forestry Industrialists and businessmen

What is their activity, why, and how is it carried out?

What.....
.....
.....

Why.....
.....
.....

How.....
.....
.....

Legitimacy of Intervention

31. How will you rank the level of disparities between the stated forest conservation and the actual policy outcomes?

High Moderate Low

32. Do you think the institutional arrangement in the municipality allow for effective policy implementation?

Yes No Don't know Not sure

33. Is it always possible to apply institutional regulations strictly in your work operations?

Yes No

34. How often do you get cases of illegal activities in the forest?

Very often Seldom Never

35. Have there been a situation where you think your interest or the interest of the indigenous people have been in conflict with the stated forest management plans?

Yes No

.....
.....

(i). In such situations, whose interest do you try to please?

.....
.....
.....

36. What suggestion would you want to make with regards to forest management practice in East Akyem municipality

.....
.....
.....
.....

Appendix 2

Questionnaire for Respondents

Tick the appropriate answer options are given and provide answers where blank spaces are left.

Personal Data

1. Sex..... Male Female
2. Age..... less than 18 18-25 25-35 40 and
Above
3. Status of Residency..... Native Migrant Other
4. Employment Status..... Employed Unemployed

State your
occupation.....

5. Income levels
- i. GH¢100 and below
- ii. GH¢100-300
- iii. GH¢300-500
- iv. GH¢500-700
- v. GH¢700 and above

6. Educational level

- i. Junior High School certificate (JHS) and below
- ii. JHS certificate-Diploma
- iii. Diploma-First Degree
- iv. First Degree and above

7. Committed relationship status

- i. Single (never married)
- ii. Married/domestic partnership
- iii. Widowed
- iv. Divorce
- v. Separated

General State of Management

8. Does your household rely on some forest resource for sustenance?

Yes No

9. Based on question 8, if yes, do you obtain permission before entering the forest for these resources?

Yes No

If no, please explain

why.....

.....
.....

10. Are you aware of a forest management regulation PPPs in the municipality?

Yes No Don't know Not sure

11. Are you aware of the forest management PPPs objectives?

Yes No Not aware

12. Do you think it is possible for people in the municipality to comply with all rules in the forest management policy?

Yes No Don't know Not sure

13. Do you think the forest management PPPs affect the general livelihood of the people in the community?

Yes No Don't know Not sure

If yes, how does it affect the

livelihood.....

.....
.....
.....

14. Do you enjoy some benefit sharing from the conservation PPPs?

Yes No Don't know Not sure

If yes, in what way do you enjoy these benefit

sharing.....

.....

.....

15. Have there been any livelihood support activities to provide alternative

livelihood sources in the municipality as part of the forest conservation PPPs?

Yes No Don't know Not sure

If yes, what are some of these livelihood support

activities.....

.....

.....

16. Are you involved in any incentive bound initiative to engage in forest management practices in the municipality?

Yes No

17. In what regard do you consider forests?

Cultural resource Socio-economic resource
Environmental/Ecological resource

Other.....
.....
.....

18. Do you think there has been a change in the general vegetation cover of the area in the past two decades?

Yes No Don't know Not Sure

19. Which land use activity in the municipality principally contributes to deforestation and forest cover encroachment?

Mining Agriculture Lumbering Settlement
Other

.....
.....

20. How do you perceive forest decline?

Environmental decay Socio-economic growth

Wildlife Extinction

Other.....
.....
.....

21. Have you noticed a change in the micro-temperature and rainfall patterns in the community in the past decade?

Yes No Not sure Don't know

22. Has there been any sensitization program to educate the community on forest management and land management practices?

Yes No Not sure Don't know

23. Are you aware of any intervention by the assembly to restore degraded landscapes and conserve forest cover?

Yes No Not sure Don't know

If yes, what are some of these

interventions.....

.....
.....

24. How has the forest management PPPs in the municipality stalled the economic development of the indigenous people?

Highly Moderately Lowly

25. Have often do you see people engaging in illegal activities in the forest

Always Seldom Never

If in the affirmative, what activities were they undertaking?

.....
.....
.....

26. How will you rank the beneficial impact of the forest conservation PPPs in the municipality?

Excellent Very Good Fairly good Poor

27. How will you rank your effort towards forest conservation in the municipality?

Very Efficient Moderate Minimal Weak

If you have undertaken any conservation practice intervention, please state;

.....
.....
.....