THE ECONOMIC AND ENVIRONMENTAL EFFECTS OF COMMERCIAL CHARCOAL PRODUCTION IN THE UPPER WEST REGION OF GHANA

By

Lurimuah Stephen

(BA Integrated Development Studies)

A Thesis Submitted to the School of Graduate Studies

Kwame Nkrumah University of Science and Technology Kumasi,

in partial fulfilment of the requirements for the degree

of

MASTER OF SCIENCE IN

DEVELOPMENT POLICY AND PLANNING

College of Architecture and Planning

July, 2011

DECLARATION

I hereby declare that this thesis is my own work toward the MSc. Degree in Development Policy and Planning and that to the best of my knowledge it contains neither materials previously published by another persons or materials which have been accepted for the award of any other degree by this or any other university except where due acknowledgement has been made in the text.

Lurimuah Stephen (PG2001908)	.....	.....
(Name of Student and ID)	Signature	Date

Certified By:

Dr. K. O. Agyeman	.....	.....
(Name of Supervisor)	Signature	Date

Certified By:

Dr. Imoro Braimah	.....	.....
(Head of Department)	Signature	Date

ABSTRACT

Over exploitation of forest resources for commercial charcoal production is a worrying phenomenon in the Upper West Region of Ghana. The forest is rapidly becoming depleted due to the human quest for fuel wood. The fast disappearance of trees may influence climate change which, may in the long run affect crop yields and deepen poverty. This report therefore presents the findings of a study undertaken to examine the economic and vegetation effects of commercial charcoal production in the Upper West Region. The study covered three districts, namely Sissala West, Sissala East and Wa East. The selection of these districts was informed by the prevalence of commercial charcoal production in those areas. The researcher used both structured and unstructured questionnaires to collect data from the commercial producers. In addition to these, Focus Group Discussions, Key Informant Interviews and Observations were employed to obtain data from the target population. The study revealed that charcoal production is an income generating activity, although it presents dire environmental consequences to forest resources. The charcoal activity provides an average monthly income of GH¢200 per producer in the study area. Despite the economic impact the vegetation effects are enormous. Live trees, essential for the sustenance of lives are preferred over dead trees by charcoal producers because they produce quality charcoal. Again the method (earth mound) employed by commercial charcoal producers often causes fire outbreaks, destroying the already fragile forest. Additionally, charcoal producers widely use the shea tree, whose economic value cannot be overstated. Commercial charcoal production is dominated by rural households and therefore has some potential for serving as a major source of livelihood if sustainably handled. Therefore sustaining the industry will enhance rural livelihoods. To achieve a balance between forest protection and livelihood sustainability, there is the need for the adoption of efficient and appropriate technologies and strategies for charcoal burning. This will require government to introduce subsidy on the cost of acquiring improved technology like the kiln method. There is also the need to increase wood supply through the establishment of agro-forestry in farming areas and community woodlots. The production of charcoal should be limited to specialized parks or forests and should not be allowed in any forest as currently practiced.

ACKNOWLEDGEMENTS

Special thanks are due to the Almighty God for His blessing and wisdom for the realization of this important dream in my life. I am also particularly grateful to my supervisor, Dr. K O Agyeman, the Director of Development Policy and Planning, for his encouragement and technical guidance towards the realisation of this study. In fact, his expert advice and comments helped to refine, enrich and put this document in shape. His role gave me independence, provided focus and thoughtfully guided me through the development of this document.

I would also like to thank Mr. Clifford Amoako (Lecturer Department of Planning), Karl W. Wurster (PhD student, University of Maryland) and Salifu Dy Yaka: the District Director of MoFA, Sissala East District for their support, encouragement and guidance throughout the process. Their rich ideas and critiques helped shape this research. Many thanks are also due to the management of the Forestry Commission of Wa East, Sissala East and West Districts for their profound insight into the districts charcoal market and forest policy. These were integral to the development of this research.

Finally, I would never have reached this point without the support of my family and friends. Thanks to my parents for nurturing my passion for nature and the environment from an early age. Endless appreciation goes to my wife, Felicia and our lovely daughter Fortune, for their unwavering support, patience and constant source of inspiration.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

CH_4	Carbon Hydroxide
CO_2	Carbon Dioxide
CHAPOSA	Charcoal Potential in Southern Africa
E C	Energy Commission-Ghana
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
F G D	Focus Group Discussion
FSC	Forest Stewardship Council
GSS	Ghana Statistical Service
IPCC	Intergovernmental Panel on Climate Change
IDP	Internally Displaced Persons
KCJ	Kenya Ceramic Charcoal
LPG	Liquefied Petroleum Gas
MDGs	Millennium Development Goals
MOE	Ministry of Energy-Ghana
NCRC	Nature Conservation Research Centre
NCWD	National Commission on Women & Development
NGOs	Non Governmental Organizations
PHC	Population and Housing Census
UNFPA	United Nations Fund for Population Activities
UNFCCC	United Nations Framework Convention on Climate Change
SPEMP	Sustainable and Participatory Energy Management Project
USAID	United States Agency for International Development
VRA	Volta River Authority
W H O	World Health Organization
WISDOM	Wood fuel Integrated Supply/Demand Overview Mapping

CHAPTER ONE
GENERAL INTRODUCTION

1.1 Background to the Study.

The impact of wood fuel and its derivative (charcoal) on the energy requirements of developing nations cannot be underscored. It supplies about 95 percent of the domestic and commercial cooking energy needs in the developing countries (Food and Agriculture Organisation (FAO), 2000)).

The heavy consumption of wood energy by developing nations poses some threats to the natural forest cover. Though, it is obtained from renewable resource, the world's forests are disappearing faster than they are being replaced. The United Nations Food and Agricultural Organization (FAO) estimated that 11.3 million hectares of forests are lost annually to agriculture, commercial timbering and uncontrolled fuel wood production and consumption. Unfortunately, 90 percent of cleared forest are never replanted (FAO, 2000). Throughout Sub-Saharan Africa, deforestation and degradation resulting from increased population pressure, agricultural encroachment, and uncontrolled fuel wood harvesting including inefficient charcoal production methods are common. According to the FAO (2000), charcoal and fuel wood consumption in 1998 was estimated at 15.9 million m^3. This figure is expected to increase to 20.6 million m^3, an increase of roughly 30 percent over a 10-year period.

Information on the consumption patterns on wood fuels indicates that about 60 percent of the energy sources of Ghana come from wood fuels (Energy Commission, 2010). According to the Energy Commission (2010); there is a great imbalance between wood fuel consumption and yield. The report estimated that the overdependence of wood fuel for cooking particularly in the household and commercial sectors would increase wood fuel consumption levels to twice as much as the yield by 2016 if no immediate government policy is taken to conserve the wood fuel and increase yield.

Although charcoal and firewood will continue to provide the bulk of the country's cooking energy fuel for the foreseeable future, its long term prospect for sustained supply is threatened by deforestation and desertification in some parts of the country. Charcoal production has thus become an issue of grave concern to policy makers and implementers in

Ghana. Besides its cost implication, charcoal production poses a serious problem of continuous degradation of the natural environment through deforestation. Ghana's forest resources are subject to serious pressure, hence the need to consider long-term resource management options (NCRC, 1999).

Wood fuel supply and demand patterns are seriously unbalanced particularly in rural areas. As described by FAO (2001), denudation has occurred in large areas of the savannah surrounding towns and villages in the Brong Ahafo, Northern, Upper East and West regions of the country. It is known that large quantities of forest residues (estimated at 0.86 million tonnes in 2001) were destroyed as a result of charcoal production (Makhabane, 2002).

According to Pabi and Morgan (2002), the Government of Ghana has become increasingly concerned about the need for concerted action to preserve the country's wood fuel resources. Its stated objectives are: a) to manage the wood fuel resources by ensuring improved productivity, efficiency in transformation and distribution; and b) efficient use of these resources through the promotion of improved end-use devices and best practices.

The Energy Commission, a public institution established by an Act of Parliament (Act 541, 1997) and given the statutory mandate to manage and regulate the utilization of energy resources in Ghana, is considering measures to recommend policies to the Government for efficient and cost-effective utilization of the wood fuel resource. For the development of sustainable wood fuel policies, the Commission would need to update and reorganize the existing wood fuel data. These efforts are justified and must be implemented with the participation of charcoal burners. Unfortunately, indiscriminate approaches to charcoal production could present serious threats to the environment and thus affecting the sustainable development concept of the forest (Energy Commission, 2010).

The vegetation of the Upper West Region of Ghana, particularly the charcoal producing districts is rapidly losing its vegetation despite the efforts made by government and NGOs to sustain the forest cover (FAO, 2000; Resource Watch Agenda, 2010). The Resource Watch Agenda (2010) further maintain that the persistence of environmental problems in the Upper West Region is partly due to unchanging attitudes of the people and limited alternative sources of livelihood. Poor enforcement of local environmental by-laws and lack of synergy

in the implementation of environmental programmes by government agencies and NGOs leads rural communities to over exploit the forest resources to meet the increasing demand for charcoal in the local and international markets. Most rural dwellers who seek augmentation of their farming income, therefore venture into commercial charcoal production using the few available young economic trees such as shea trees. This calls for concerted efforts to curb the environmental threats with a sustainable approach.

1.2 Problem Statement

The exploitation of forest resources for fuel wood remains a hard-hitting challenge to most pastoral communities in Ghana (FAO, 2000). Human activities, such as charcoal production, are increasing the pace of deforestation. According to Resource Watch Agenda (2010), Ghana has lost more than 75 percent of her 8.2 million hectares of forest cover over the past few decades. The sustenance of the nation's forest is critical as replacement efforts (seen in afforestation programmes) does not commensurate extraction. Subsequently, Fondel, et al. (2008) argue that the depletion of the country's forest cover further negates the efforts by the Government of Ghana and her Development Partners to mitigate the effects of the increasing global temperatures.

Due to its effects on climate change, the exploitation of the forest resources for commercial charcoal production in the in the Upper West Region of Ghana has been a matter of national concern. This is because agriculture which is the mainstay of the people of the Upper West Region (employing about 70 percent of the labour force) is depended largely on the rainfall regime (GSS, 2009). Thus, an unfavourable rainfall regime, one of the indicators of climate change, threatens the livelihood of rainfall-dependent farming and would thus perpetuate the high incidence of poverty (estimated at 90 percent) in the Upper West Region (FAO, 2000; Ghana Statistical Service, 2008).

The Government of Ghana (2004) estimates that, about 50 trucks transport charcoal to markets beyond the Upper West Region in a week. Households produce about 20 maxi bags of charcoal per month and sell about 95 percent of the output either within or outside the region. The charcoal producing households earn an average of GH¢200 per month from the sale of about 10 maxi bags of charcoal whose raw materials are from the forests considered as common-pull resources. The destruction of the vegetation, driven by the household financial

gains (averaging GH¢200 per month) poses a worrying threat to the natural environment, especially in the Wa East, Sissala East and Sissala West Districts of the Upper West Region which produce about 70 percent of the charcoal from the Upper West Region. This assertion (i.e. threatened forest) is underpinned by the Resource Watch Agenda's claim that extractions from the forest outpace the rate of forest replacement (Resource Watch Agenda, 2010).

Explained by the inability to replace the resources extracted from the forest, the District Assemblies of the three study districts reveal that economic tree species (such as the shea and dawadawa) are being used for charcoal production (Wa East District Medium Term Development Plan 2010-2013; Sissala East District Medium Term Development Plan 2010-2013; Sissala West District Medium Term Development Plan 2010-2013). Furthermore, the potency of herbal health care system in the area is threatened. The situation is observably true as charcoal producers subject tree species of medicinal value to commercial charcoal production.

The foregoing analysis of commercial charcoal production has revealed that though the industry has serious environmental ramifications, it is a source of income to households in the Region. The purpose of this study therefore was to explore ways of maintaining a balance between environmental sustainability and the charcoal industry. The researcher thus identifies cases in the three study districts that elucidate both the environmental consequences and economic dimensions of the charcoal industry. A comprehension of the complexities of the industry informs the way forward toward environmental sustainable without compromising the income levels of charcoal producers.

1.3 Research Questions

This research largely addresses the following questions:

- What are the environmental effects of commercial charcoal production on local communities?
- What are the economic effects of commercial charcoal production on rural communities?
- What is the way forward?

1.4 Objectives of the Study

On the basis of the research questions, the goal of the study is to critically evaluate the economic and environmental effects of commercial charcoal production in the Upper West Region.

Specifically, the study seeks to achieve the following objectives:

- To assess the effects of charcoal production on vegetation in the communities within the Upper West Region.
- To assess the economic effects of commercial charcoal production within the region
- To recommend ways to minimize the identified negative effects.

1.5 Significance or Justification of the Study

This study has enormous significance that ranges from the global scale to the national. In view of the continuous global call to conserve the environment against the ever growing demand and supply of wood fuel with its ascending environmental threats, research of this sort is very crucial in achieving results that would inform the on-going discourse. The current efforts in combating global climate change are traceable to environmental shocks/imbalances. The study could contribute to the identification and formulation of global strategies, plans and programmes of action for the conservation and sustainable exploitation of biological diversity.

Secondly, research shows that the national forest of Ghana is rapidly depleting. Thus, in the last few decades, Ghana has lost close to 70 percent of its wildlife and about 75 percent of its 8.2 million hectors of forest (Resource Watch Agenda, 2010). Responsible factors for the situation include; unsustainable methods of charcoal burning, perennial bush fires, poor farming practices and logging. The research findings and recommendations could serve as important information in managing the situation.

Additionally, charcoal production is an important cross cutting issue and is never exhaustive through a single research. Therefore this study is aimed at contributing to research on the minimization of the negative environmental consequences of charcoal production. The entire study could serve as one of the reference materials for future researches. This would not only promote academic successes through a contribution the body of knowledge to academics and

policy makers, but would also help the rural communities to sustain their livelihood. There will therefore be the likelihood of maintaining micro-economic stability at local communities. The general hope is that, government agencies including the District Assemblies in the study area could also enact effective environmental and charcoal producing by-laws based on the research findings and recommendations.

1.6 Scope of the Study

1.6.1 Geographical Scope

The study is limited to three districts selected from the Upper West Region of Ghana. Specifically, the study was undertaken in Wa East, Sissala East and Sissala West Districts. These districts were carefully selected for this study due to their vast expanse of virgin savannah vegetation. The Districts therefore continue to be the hub of charcoal production in the Upper West Region (Wa East District Medium Term Development Plan 2010-2013; Sissala East District Medium Term Development Plan 2010-2013; Sissala West District Medium Term Development Plan 2010-2013).

1.6.2 Contextual Scope

The research focused on assessing the economic and vegetation impacts of charcoal production. The study examined the effects of charcoal production on the incomes of local communities as well as the environmental consequences the industry poses. The study indentified and recommended strategies for addressing core problems within the charcoal industry.

1.6.3 Time Scope

The study covered the period 2009 to 2011. The period was chosen bearing in mind the fragmented/informal and rural nature of the charcoal activities which could affect recollection responses.

1.7 Organization of the Study

The report is organised into five chapters. Chapter one contains the general introduction of the study. It covers the background to the study, problem statement, research's significance, among others. Chapter two contains relevant literature on commercial charcoal production reviewed by the author. Chapter two also addresses the conceptual and theoretical issues

regarding charcoal production from which lessons were learnt. Chapter three contains the methodology of collecting data relevant to charcoal production. It also contains the research design, sampling procedure, sample technique, units of analysis as well as the profile of the study area. The chapter enabled the study to gather relevant data for analysing the effects of commercial charcoal production in the Upper West Region. Chapter four is made up of data analysis on the effects of commercial charcoal production in study area. The data analysis was done through application of statistical tools such as the bar charts; pie charts etc, to enable the study transform the data into information. The study did this with the aim of obtaining findings or facts as well as the attainment of appropriate recommendations and conclusion on the topic. Finally, Chapter five comprises the summary of findings, recommendations and conclusion on the topic.

CHAPTER TWO
CONCEPTUAL FRAMEWORK ON ECONOMIC AND ENVIRONMENTAL EFFECTS OF COMMERCIAL CHARCOAL PRODUCTION

2.1 Introduction

Having established the general overview of the study in the previous chapter, this chapter seeks to provide broader information on the concepts and sustainable approaches of charcoal production. The chapter further examines institutional issues in sustainable biomass projects in other countries and the possibilities of replicating the strategies in Ghana. Global trends in fuel wood consumption and environmental effects emanating from charcoal production are examined in the chapter.

2.2 Concepts and Sustainable Approaches to Charcoal Production

To facilitate the understanding of the literature provided in this chapter, the study defined certain fundamental concepts on the topic. These concepts are as follows:

2.2.1 Nature and Process of Charcoal Production

Charcoal "is the general term for a range of carbonized materials, with varying combustion and dark properties" (Amanor et al, 2002). It is usually produced by raising the temperature of wood beyond the point at which many of its organic components become chemically unstable and begin to break down. The details of this process, called pyrolysis, are still incompletely understood. Most of the newly formed materials are vaporized. The material left behind is a black, porous charcoal that retains the original form of the wood but has just one fifth the weight, one half the volumes, and about one third of the original energy content (Amanor et al, 2002). To prevent most of the wood from igniting during production (pyrolysis), charcoal must be made in an environment of restricted air flow.

In most of the developing world, charcoal makers use traditional means or build temporary earthen kilns for each batch (FAO, 2000). The wood is stacked compactly in a pit or on the ground. The stack is covered with straw or other vegetation, and then buried under a layer of soil. It is ignited with burning embers introduced at one or more points at the bottom of the stack. The task of the charcoal maker throughout the ensuing "burn" is to open and close a

succession of vent holes in the soil layer to draw the fire evenly around the wood stack, heating the wood while burning as little of it as possible.

2.2.2 Sustainable Forest Management and Charcoal Production

The term sustainable resource management is a broad concept in development planning. This is because; it has different interpretations by different people and at different places. In development thinking, The Brundtland Commission sees it as a system of forest management that meets the needs of the present generation without compromising the ability of future generation to meet their needs (Todaro and Smith, 2009). The role of sustainable forest management in development was echoed by the United Nation's General Assembly Agenda 21 in 1997.

The UN General Assembly looked at the term based on some key principles such as:

Principle 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

Principle 2

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies. They have a responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

Principle 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

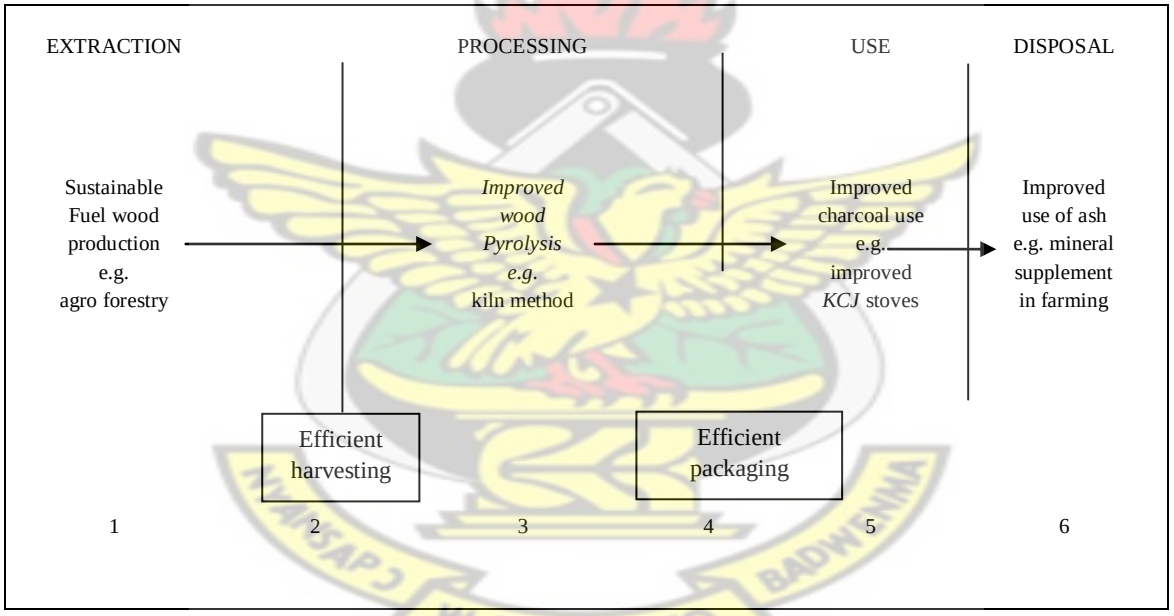
These principles reinforce the importance of forest resources to nations' social and economic development hence the need to sustainably use those resources for the benefit of the present generation without depriving future generation the opportunity to also take advantage of the benefits of forest resources. That is, the harvesting of fuelwood for present consumption

should not compromise the ability of future generation in getting access to forest resources for fuelwood.

Ayodele et al (2009) maintains that sustainable exploitation of wood fuels involves the production of charcoal without endangering the natural environment. They stressed that sustainable management of forest is the maintenance of forest area and its species composition over a certain period of time.

Sustainable fuel wood production and its efficient utilization can be achieved through adoption of improved energy technologies, with sustained efforts to eliminate waste of limited wood resources. Figure 2.1 critically analyzed this scenario.

Figure 2.1 Sustainable consumption schemes for charcoal production and utilization



Source: WHO, 1999.

There are several environmental and socio-economic benefits associated with each stage of Figure 2.1. The underlining interest is to achieve sustainable charcoal production and utilization. From Figure 2.1, when wood is obtained from the forest, using efficient ways by minimising destruction to other tree species, minimum waste will be generated. The wood is then converted into charcoal using improved/modern and efficient kilns after which proper handling needs to be ensured during packaging, storage and transportation to minimize waste. Charcoal easily crumbles depending on the quality. Finally, the charcoal produced needs to

be consumed using improved cook stoves such as the Kenya Ceramic Charcoal (KCJ) in Kenya, which is recommended by WHO for consuming relatively less charcoal during cooking.

A number of advantages can be associated with this life-cycle focused strategy as indicated further in Table 2.1. It is designed to minimize material and energy losses at the various life-cycle stages and could supply extra wood for competing demands. It has the potential for application in the entire sub-Saharan Africa region with a wide array of social, economic and environmental gains. If well designed and implemented, the approach is potentially cost-effective with high chances of success due to local community participation.

Table 2.1 General Benefits accruing from the various life-cycle stages in the system/ approach.

Stage	Activity	Stage Activity Benefits
1	Sustainable fuel-wood production	▪ Increased carbon sink and moisture reservoir. ▪ Enhanced household energy security. ▪ Entrepreneurial opportunities created through sales of poles and firewood. ▪ Increased soil fertility for food production.
2	Efficient biomass Harvesting	▪ Reduced wood residues/wastes. ▪ Sales of residues as firewood and wood chips or sawdust as raw material for chipboard etc.
3	Improved efficiency Pyrolysis	▪ Reduced CH_4 emissions to the atmosphere. ▪ Carbon sink preserved from avoided tree cutting. ▪ Less wood required to yield same amount of Charcoal.
4	Improved charcoal Handling	▪ Reduced charcoal crumbling during handling ▪ Income generating opportunity through briquetting of the pulverized charcoal.
5	Improved charcoal use (KCJ)	▪ 34 percent CO_2 reduction (reabsorbed by growing vegetation) ▪ 33 percent fuel saving ▪ 15 percent CO_2 reduction (improved health) ▪ Significant reduction of toxic gases (improved health) ▪ Monetary savings (26 percent per household per annum)
6	Innovative ash disposal	▪ Reduced dependence on costly mineral fertilizers

Source: WHO, 1999

The above system is designed to minimize material use and energy losses at the various life-cycle stages and could supply extra wood for competing demands. It has the potential for application in the entire sub-Saharan Africa region with a wide array of social, economic and environmental gains. If well designed and implemented, the approach is potentially cost-effective with high chances of success due to local community participation.

This study sees sustainable forest management as the use of forest resources in the manner that avoids or minimises adverse impacts on biodiversity. This study further views sustainable charcoal production as a system of producing charcoal that do not endanger the environment, but promotes efficient way of managing the wood fuel resources through methods that ensure improved productivity and efficiency in charcoal production. The charcoal energy needs for both the current and urban generation would be supplied without adverse implications for biodiversity conservation.

2.3 Prerequisites for Optimum Functioning of the Proposed Systems Approach

As implied from the on-going, the poor also have an opportunity to contribute to sustainable development in general and their own energy security in particular. However, implementing activities exactly as presented in Table 2.1 may be constrained by various barriers, which must be eliminated if the goal of achieving sustainable forest management is to be met. These include, *inter alia*, finances, awareness, technical capacities, and governance. Key barriers, however, are policy and institutional frameworks to oversee successful implementation and replication of project activities defined by the scheme in earlier analysis (Barnes et al, 2002).

2.4 Institutional Issues in Biomass Project Implementation and Replication

An institutional framework to coordinate the implementation and replication of prescribed activities at various life-cycle stages as indicated earlier in Figure 2.1 and Table 2.1 is necessary for effective charcoal production in every nation. Secondly, national energy and technology policies need to be harmonized to allow for cross border technology transfer and capacity building. Personnel exchanges among collaborating institutional entities would be promoted through such schemes. The KCJ has been a great success in Kenya while the relatively more efficient *Casamance* charcoal kilns have significantly spread in Senegal. These could be spread further in other African countries under appropriate institutional and policy frameworks.

Furthermore, land tenure policies in many countries in sub-Saharan Africa need to be streamlined or reformed in order to create development progress. Land tenure is a key source of conflicts in controlling and regulating natural resources consumption. But when a household has rights over a given land area, it can confidently develop it further through activities including modern farm forestry methods.

2.5 The Significance of Charcoal in National Development

Environmentalists feel that charcoal production should be stopped because of its destructive nature as presently practiced (Achard et al., 2002). However, Arnold and Persson (2003) asserted that both rural and urban dwellers in some developing countries have developed a strong appetite for charcoal use. Therefore attempts to ban the production or the use of charcoal will be mostly unsuccessful mainly due to the interplay of socio-economic interests. Since operators can use free raw materials (wood from natural forests or farm clearing) and turn them into a marketable commodity in high demand, there is the need to have much respect for the sustainability of the resource.

The Food and Agriculture Organisation (2000) points out that, charcoal is a very important energy source for households. Its saturation ranges from 54 to 71 percent in urban areas and it is the main fuel for more than 1 million families in Sub Saharan Africa. It was also noted as a valuable commercial fuel, with an annual turnover of some US$60 million at current market prices. The FAO assumed that if 80 percent of this amount corresponds to labour payments at US$1.50 per day, its production and marketing create some 144,000 permanent jobs earning twice the average minimum wage (US$0.75 per day) of most sub-Saharan African countries as of the year 2000.

Fuelwood use is dominant in rural households. More than 2.2 million families depend on it for cooking and heating, and at least 280,000 of them use it for small-scale processing activities, such as fish smoking, gari making, pito brewing, akpeteshi distillation, pottery making, oil extraction (from palm fruits, coconut, groundnut, shea butter), thus making a significant contribution to food preservation, food security and cash earnings for rural and urban people (FAO, 2000).

In addition, there are some 600, 000 small-scale enterprises in commercial activities, such as chop bars, street food and grills, which depend on fuel wood or charcoal as their main source of energy. Today wood energy still contributes directly to poverty reduction (Broadhead et al, 2001) especially in developing countries. In Ghana, it has been estimated that, wood fuel mainly in the form of charcoal and fuel wood make up 60 percent or more of the total natural energy consumption (Energy Commission, 2010). More than 2 billion people used fuel wood or charcoal as energy to cook and preserve food (Broadhead et al, 2001). Wood energy thus helps households in attaining food security.

A fuel wood shortage has in some cases reduced households to one cooked meal per day in South Africa (Broadhead et al, 2001). It was also reported that, as much as 575,000 persons are directly engaged at various levels by wood fuel production, full-time or part-time (paid or unpaid) across Africa.

On a global scale, Broadhead et al (2001) reported that out of 2 billion people who depended on wood for fuel mostly in developing countries, only 96 million were able to satisfy their minimum energy needs for cooking and heating through importations and exportations of charcoal.

Table 2.2 FAO Projections of Fuel wood (Firewood and Charcoal) Consumption to 2030 in the Main Developing Regions

Years	**1970**	**1980**	**1990**	**2000**	**2010**	**2020**	**2030**
Firewood (million cubic meters)							
South Asia	234.5	286.6	336.4	359.9	372.5	361.5	338.6
Southeast Asia	294.6	263.1	221.7	178.0	139.1	107.5	81.3
East Asia	293.4	311.4	282.5	224.3	186.3	155.4	127.1
Africa	261.1	305.1	364.6	440.0	485.7	526.0	544.8
South America	88.6	92.0	96.4	100.2	107.1	114.9	122.0
South Asia	234.5	286.6	336.4	359.9	372.5	361.5	338.6
Charcoal (million tons)							
South Asia	1.3	1.6	1.9	2.1	2.2	2.4	2.5

Table 2.2 Continued

Years	1970	1980	1990	2000	2010	2020	2030
Southeast Asia	0.8	1.2	1.4	1.6	1.9	2.1	2.3
East Asia	2.1	2.3	2.3	2.2	2.1	2.0	1.8
Africa	8.1	11.0	16.1	23.0	30.2	38.4	46.1
South America	7.2	9.0	12.1	14.4	16.7	18.6	20.0

Source: Broadhead et al. 2001

In 2001 the FAO began a significant effort to reassess their projections of fuel wood consumption. The FAO study shows a growing consumption of fuelwood worldwide, particularly in Africa (Broadhead et al, 2001). According to the FAO (2000), as cited by Broadhead et al. 2001, the quantities of charcoal needed by 2020 and 2030 in Africa alone is estimated at 38.4 and 46.1 million tons respectively (*See Table 2.2*). This shows that charcoal will continue to be a key source of household's domestic and commercial cooking energy form for most rural families in the developing world. The overall quantities involved, and the numbers still relying on fuel wood will continue to be very large.

The International Energy Agency (IEA) in 2001 also estimated that in 2030, biomass energy will still account for an estimated three quarters of total residential energy in Africa. Additionally, due to population growth, the number of people using fuel wood and other biomass fuel demand will rise by more than 40 percent during 2000–2030 to about 700 million. In Asia, despite declining consumption, there will still be an estimated1.7 billion users in 2030, while 70 million would be in Latin America (IEA, 2002).

Additional, Barnes et al, 2002 estimates that charcoal consumption is often growing faster than firewood consumption. Charcoal is becoming a much larger part of the fuelwood total in Africa and South America and, growing close to the rate of population growth. Significant variations between countries exist, but the general trend of decreasing per capita consumption of both fuelwood and charcoal with increasing income remains (Broadhead et al. 2001).

There is a kind of ladder of energy sources in the urban areas: from firewood at the bottom, through charcoal, kerosene and LPG, to electricity at the top (Kammen and Lew, 2005). People generally climb this ladder as their income increases. Therefore charcoal, which is infrequently used in the rural areas because of availability of free wood, is quite popular in urban areas because of higher income and other factors such as its lightness and non-smoking nature (FAO, 2000). As income rises, initially more fuelwood is consumed, but beyond a certain level its use decreases due to its substitution by other fuels (Kammen and Lew, 2005). According to Filmer and Pritchett (2001), price influences the amount of fuel that is consumed, but only minimally affects the choice between fuels.

Growing urban populations are relying on the more compact charcoal as the primary source of urban cooking energy (Kammen and Lew, 2005) with many transitioning from firewood to charcoal as the cost of wood increases in urban areas (Barnes et al., 2002). The Charcoal potential in Southern Africa (CHAPOSA) study estimated that consumption of charcoal grew during 1990–2000 by 80 percent in both Lusaka and Dar es Salaam. The proportion of households in Dar es Salaam using charcoal as their primary fuel increased from 50 to 70percent over the same period.

As indicated in Table 2.3, the growth of some countries requires more charcoal for domestic and commercial use. It is estimated that for every 1 percent increase in urbanization, there is a 14 percent correspondent increase in charcoal consumption (UNFPA, 2009). The high rates of urbanization prevalent in the region suggest that by 2050, more than 50 percent of Africans will reside in cities (UNFPA, 2009). High and ever-increasing demand for charcoal, coupled with improper forest management, and poor regulation of the trade present a solemn future for forests in Africa (UNFPA, 2009). In places where this combination of factors exists, the fuelwood crisis needs to be revisited.

Table 2.3 Principal countries importing and exporting charcoal

Importing countries	Quantity(Tonnes)	Exporting countries	Quantity(Tonnes)
Saudi Arabia	12,000	South Africa	10,000
Netherlands	14,000	Portugal	12,000
Sweden	16,000	Philippines	18,000
United Kingdom	21,000	Malaysia	19,000
Bahrain	27,000	Singapore	28,000
Japan	34,000	Sir Lanka	30,000
France	57,000	Indonesia	36,000
Malaysia	61,000	Thailand	70,000
West Germany	64,000	Spain	90,000

Source: FAO, 2000.

2.6 Environmental Impacts of Charcoal/ Fuel woods Production

Removal of woody biomass for fuel poses some far-reaching consequences on the structure and functioning of ecosystems worldwide. Fuelwood extraction has been cited for increasing soil erosion, reducing soil moisture content and decreasing soil fertility as nutrient leaching is increased (Angelsen and Kaimowitz, 1999). Vegetative cover and subsoil nutrients are also fast declining through the charcoal activities. These are then associated with more extensive effects including reservoir siltation, flooding, water shortages due to shifting ground water regimes (Oguntunde et al, 2008) and biological impacts such as reduced faunal abundance (Ogunkunle and Oladele 2004) and biodiversity. Additionally, in extreme cases such changes are expected to culminate in changes in weather patterns and, in drier regions, desertification (Angelsen & Kaimowitz, 1999), thus making the increased utilization of fuelwood by urban populations one of the most critical environmental issues sub-Saharan Africa must address.

The subtler impacts of tree-cutting for fuelwood are much more relevant when discussing the ecological impact of cutting. The most important perhaps is change in species compositions as cutting influences the survival and reproduction of preferred fuel species relative to less preferred species. A study done in Nigeria, Burkina Faso, Mali, Niger and Senegal found

substantially different species compositions in farmed parkland and a nearby ecologically equivalent forest reserves (Kindt et al, 2008).

Tree species which do not coppice may disappear altogether. A study in Senegal noted that many tree species, particularly large trees have very few seedlings and therefore very low probabilities of regenerating naturally (Lykke, 1998). Another study in Ghana found that an important fuelwood species such as mahogany used by 80 percent of households in two villages in the savannah belt during the past decade was no longer available (Pabi and Morgan, 2002).

2.7 Draft Woodfuel Policies in Ghana

Woodfuels, consisting of firewood and charcoal, constitute the most important energy forms in Ghana. It contributes about 60 percent of total energy consumption in the country (Energy Commission, 2010). While woodfuels will continue to provide the bulk of Ghana's energy supply in the foreseeable future there is the need to put in place measures to deal with the negative impacts, such as deforestation and its associated impact on people's health and the environment. In Ghana numerous studies and draft policies are being conducted on fuel wood and charcoal harvesting but with limited targeted interventions and actual implementation in the country. This makes it practically difficult to regulate activities within the industry, hence the incidence of severe pressure on both the natural environment and the biodiversity (Energy Commission, 2010).

On the basis of these realisations, there is the need to ensure better management of woodfuel supply particularly, from the natural forest or woodlots through effective policies in order to achieve sustainable use of the resource. Current efforts are on addressing the following:

- Sustainability of sources of supply;
- Production of efficient technologies for wood fuel production and use;
- Substitution of traditional wood fuels with more modern fuels like LPG
- Efficiency in the transportation of wood fuel;
- Improved packaging and marketing; and
- Strong coordination in institutional and regulatory arrangements

The government's response to addressing the goals outlined above led to the formulation of a draft woodfuel policy in 2010. The draft policy seeks to ensure sustainability of biomass resource for the country. The policy categories are the following;

Production Technology

Ghana's policies on charcoal production tend to focus on raising the efficiency in charcoal production thereby increasing charcoal yields.

Policy Objective:

To introduce new and innovative ways of producing woodfuel more efficiently and cost effectively

Policy strategies:

- Energy Commission to provide technical assistance and funding for programmes to transfer improved carbonization technologies and higher levels of efficiency in the production, distribution and use of woodfuel
- Strengthen through technical assistance existing institutions for testing and certification of improved production and end use technologies for woodfuel
- Provide logistical support for the Agricultural Extension Officers to expand technical
    - assistance and the creation of awareness on the adoption of improved carbonization technologies to charcoal producers

End-use Technology

The traditional woodfuel stoves have low efficiencies and as well generate a lot of smoke in the cooking environment which leads to health hazards, especially respiratory diseases. Even though the improved stove is about 20 percent more expensive than the traditional stoves, the expected savings on fuel cost is said to be significant to pay off on the investment of the improved stoves. The policy on end use technology focuses on promoting the adoption of more efficient wood fuel cook stoves (Energy Commission, 2010)

Policy objectives

- To promote the use of more efficient but less expensive woodfuel cook stoves.
- To build capacity of improved cook-stoves manufacturers.

Policy Strategies

- Liaise and coordinate with relevant governmental and non-governmental agencies to train artisans in the production of improved stoves
- License or register commercial charcoal producers to enable the EC to support them to adopt improved production technologies
- Create public awareness on energy efficiency and conservation practices and health impacts (especially on women) in the use of woodfuel

Marketing

The woodfuel supply chain consists of feedstock owners, producers, dealers/transporters, bulk sellers, retailers and exporters. In the local market places, there are bulk and retail sale dedicated areas. Even though woodfuel is an inflammable energy product there is no fire precautionary measure in place for bulk marketing and transportation.

Policy objectives:

- To develop a comprehensive database for woodfuel supply and demand
- To minimise charcoal dust creation, environmental and health impacts
- To control fire outbreaks in the production and handling of charcoal

Policy Strategies

- Enact LIs and bye laws for the recycle or compacting of charcoal dust into briquettes, etc.
- Create awareness on health impacts of inhaling charcoal dust and other particulate matter and promote the use of protective mask for commercial handling of charcoal.
- Enact LIs and bye laws for improved packaging and labeling of charcoal.
- Enforce safety regulations in the production, transportation and marketing of charcoal.

From the draft policy, it is obvious that the Government of Ghana has realised the importance and need to regulate the charcoal industry. The policy seeks to ensure a balance between charcoal production and sustainable forest management.

2.8 Charcoal Production in Some Selected Countries around the globe

2.8.1 Commercial Charcoal Production in Senegal

In the area of charcoal production, Senegal has a lot of lessons to offer. Just as in many parts of Africa, nearly 95 percent of Senegal's growing urban population depends on charcoal as their primary cooking energy. Extraction of wood for charcoal production drives forest degradation. The Senegalese Government's response to this situation has been the creation of different forest management types with the ultimate goal of sustainably managing forests. (Lazarus et al, 1999).

Methods/ Technologies of Charcoal Production in Senegal

Charcoal has been produced in the Tambacounda region for at least 50 years (Malimbwi et al, 2001). The method of charcoal production has remained relatively constant over time. Charcoal is produced in a three step process. First, selected trees are cut. Second, the cut wood is stacked into a kiln and covered with a layer of grass and sand. Finally, the kiln is lit and left to burn slowly for up to three weeks. At this point the charcoal is ready to be collected into bags and sold either to charcoal merchants or individually along the roadside.

Kiln (Casamance) Preparation and the Harvesting of Trees

Charcoal is produced in a kiln. Kiln locations require enormous amounts of work to prepare. The ground directly underneath the kiln is usually loosened approximately 12 inches below the surface. This is a large amount of work because the laterite soil in the region is very hard and rocky. Because of the workload associated with preparing a kiln for charcoal production, many charcoal producers prefer to use the traditional method (Malimbwi et al., 2001).

Charcoal production and consumption via the systems approach

In the late 1980's, a wave of charcoal production began to sweep through the woodlands of Tambacounda. This region accounts for over 50 percent of the official charcoal quota (PROGEDE, 2005). The influx of charcoal production has been thought to cause severe degradation of over half of the wooded savannah and significantly altering the biology and habitat quality (Tappan et al., 2004).

Within the charcoal producing regions of Senegal a network of three government-regulated and one traditional forest management types are practiced; Rural Community Forests (RCF), Classified Forests (CF), Co-Managed Forests (CMF), and a large National Park (NP). The sustainable management (forest extraction has been conducted in a way that allows its inherent regeneration and continued ongoing supply) of the forest resource is the ultimate goal within each zone. For complete regeneration to occur, harvested land should be left idle for at least 8 years (Tappan et al. 2004). The varying management practices implemented in Senegal take this into account, but short of fencing off charcoal areas for re-growth.

At many sites a vast majority of the preferred species of a harvestable size are collected for charcoal production. Differing management plans call for selective logging to take place, leaving non-regenerating species and harvesting two-thirds of other species in the area, but in many instances well over 75 percent of the wood is harvested for charcoal production (PROGEDE, 2005).

In the community regulated landscape, wood is intensely harvested for charcoal production in very compact intense zones, closer to clear cutting (Malimbwi et al, 2001). On land managed by the Senegalese government and international development project, selective harvesting is required along with the use of the Casamance kiln, an alternative to the traditional kiln used outside these managed area. The Casamance kiln is believed to be more efficient in carbonizing the wood therefore increasing the output of the kiln by 10 – 30 percent (Kammen and Lew, 2005). This increase in efficiency combined with selective logging could result in a slightly larger extraction area, but a lesser degree of environmental impact. Areas classified as Classified Forest are theoretically off limits to charcoal production, but are often times used for charcoal production (Ribot, 1999). These areas exhibit the same extraction methods as the community regulated region. In national parks, no charcoal harvesting or production is allowed.

Rural Community Forest

Rural Community Forests are all areas that fall out of government managed lands. Most of the land is agricultural with some stretches of woodland and forests along river beds. Although this area is theoretically owned and controlled by local communities, more

specifically by rural councils, the reality is that the harvesting of wood is controlled and enforced by the Senegalese Forest Service.

Classified Forests

Classified Forests are present in all regions of Senegal (See Table 2.4). Here, the entire forest is grouped in three categories: *Fuelwood reserves*, *soil conservation areas* and *"dense vegetation"* (focused on the protection of vegetation and biodiversity). The limits of these forest areas are not well defined and control measures are insufficient to prevent illegal exploitation (Malimbwi et al, 2001). These factors, combined with insufficient rainfall in some areas have led to severe degradation of vegetation in some classified forests (Tappan et al. 2004). The Forest Service and rural councils then created management plans based on key issues such as management objectives and the determination of zones for specific uses (e.g., charcoal, firewood, wood for construction or furniture and non-timber products) or for outright protection.

Table 2.4 Classified Areas of Senegal

Region	**Region surface area (ha)**	**Number of classified forests**	**Area of classified forests (ha)**
Dakar	55,000	10	6,064
Diourbel	435,900	0	0
Fatick	793,500	15	187,676
Kaolack	1,601,100	23	528,240
Kolda	2,101,100	26	505,383
Louga	2,918,800	19	1,216,688
St. Louis	4,412,700	61	1,889,432
Tambacounda	5,960,200	17	1,635,819
Thies	660,100	13	98,926
Ziguinchor	733,900	29	119,420
Total	**19,672,200**	**213**	**6,237,648**

Source: Mbow et al (2008)

2.8.2 Commercial Charcoal Production in Ethiopia

Charcoal-making in Ethiopia has limited success stories to offer. This is because charcoal producers in Ethiopia do not follow any standardized methods or technology. In Ethiopia, a careful assessment of charcoal production through traditional method revealed an average

loss of 71 percent wood resources (Geller, 2004). Yields are negatively affected as a result of the application of the traditional method of charcoal production.

Unlike Senegal where the charcoal industry is regulated, the activities of traditional charcoal producers in Ethiopia are not regulated and this allows them to cut down trees indiscriminately. Several forest resources are consumed on daily basis, hence exposing the country's fragile forest to desertification (Geller, 2004).

2.8.3 Commercial Charcoal Production in Ghana

Wood fuels, consisting of firewood and charcoal, constitute the most important energy forms in Ghana. It contributes about 60 percent of total energy consumption in the country. While wood fuels will continue to provide the bulk of Ghana's energy supply in the foreseeable future, nevertheless, the environment suffers some negative impacts, such as deforestation and its associated impact on people's health and the environment.

Production Technology/ Method in Ghana

Virtually, all the charcoal produced in the country is by the earth mound method. By this method, wood is piled in an indigenous manner and then covered with leaves/sawdust, sand, and other combustible materials. This method is technically not efficient as it leads to a lot of wastes. A few steel kilns, however are in use at Daboase, owned by the Subri Industrial Plantation Ltd. This is a metallic cage equipment that is transferable and simple to operate with. It is very effective and efficient as it minimizes waste of wood and enhances quality charcoal production (Energy Commission, 2010). The government of Ghana recommends the adoption of this kiln method. However, the cost involved in acquiring the equipment remains a disincentive to its usage by producers hence the adoption of the Earth mound method (Energy Commission, 2010).

2.9 Theoretical Framework on Forest Resource Conservation

The theoretical underpinnings for sustaining the environment are rooted in national and global agreements/conventions. The prime focus is sustaining the environment through the adoption of appropriate approaches in charcoal production and other human activities that affect the natural environment. This thinking is reinforced by the MDG 7 (Ensuring Environmental Sustainability). Thus, in the development agenda, environment is seen as a

sensitive cross cutting issue and must therefore be integrated in the principles and policies of national programmes /projects. The basic aim is to reverse the loss of forest resources.

2.9.1 The Tragedy of the Commons

The concept of the Tragedy of the Commons is extremely important for understanding the degradation of our environment. The tragedy of the commons is a dilemma arising from the situation in which multiple individuals, acting independently and rationally consulting their own self-interest, will ultimately deplete a shared limited resource, even when it is clear that it is not in anyone's long-term interest for this to happen. This dilemma was first described in an influential article titled "The Tragedy of the Commons," written by ecologist Garrett Hardin in 1968.

Hardin's Commons Theory is frequently cited to support the notion of sustainable development, meshing economic growth and environmental protection, and has had an effect on numerous current issues, including the debate over global warming.

The basic idea espoused by the theorist is that if a resource is held in common for use by all, then ultimately that resource will be destroyed. "Freedom in a common brings ruin to all." To avoid the ultimate destruction, the human values and ideas of morality must be changed. This theory assumed that each human exploiter of the common (shared resources) was guided by self-interest. At the point when the carrying capacity of the commons was fully reached, an exploiter might ask himself, "Should I continue my actions?" Because the gain of so doing would come solely to him, but the loss from his actions would be "commonized" he will not give up his action. Because the privatized gain would exceed his share of the commonized loss, a self-seeking exploiter would not change his behaviour. Others reasoning in the same way, would follow suit. Ultimately, the common property would be ruined.

Even when exploiters understand the long-run consequences of their actions, they generally are powerless to prevent such damage without some coercive means of controlling the actions of each individual. Idealists may appeal to individuals caught in such a system, asking them to let the long-term effects govern their actions. But each individual must first survive in the short run. If all decision makers were unselfish and idealistic calculators, a distribution governed by the rule "to each according to his needs" might work.

The spoilage process comes in two stages. First, the non-angel gains from his "competitive advantage" (pursuing his own interest at the expense of others) over the angels. Then, as the once noble angels realize that they are losing out, some of them renounce their angelic behavior. They try to get their share out of the commons before competitors do. In other words, every workable distribution system must meet the challenge of human self-interest. An unmanaged commons in a world of limited material wealth and unlimited desires inevitably ends in ruin. Inevitability justifies the epithet "tragedy," which Hardin introduced in 1968.

This theory underpins the activity of charcoal producers. Fuel wood exploitation for charcoal burning results in forest destruction which charcoal producers are aware of but continue because of the selfish economic gains which however have general ramifications. The long term impacts thus do not matter to them.

2.10 Lessons from the Literature Review

From the foregone reviews, fuelwood and charcoal are very essential and will continue to be essential components of the energy supplies of most Third World economies in the foreseeable future. Charcoal will continue to remain a key source of domestic and commercial cooking energy source for most rural families in developing countries. Any attempts at banning the use of charcoal will be out of place. However, deforestation, in part due to fuelwood use, seriously threatens the environment and for that matter future supplies of fuelwood in many developing nations. The situation is being aggravated by the traditional methods of charcoal production. It is technically inefficient and promotes waste of natural resources, particularly in the case of Ghana and Ethiopia. As it stands, the environment is at risk of depletion.

Senegal was faced with similar problems and it led to the adoption of the sustainable management (forest extraction has been conducted in a way that allows its inherent regeneration and continued ongoing supply) of the forest resource. In Senegal, for complete regeneration to occur, the government ensures that harvested lands are left idle for at least 8 years. Classified Forests are present in all regions of Senegal. There, the entire forest is grouped in three categories: *Fuelwood reserves*, *soil conservation areas* and *"dense vegetation"* (focused on the protection of vegetation and biodiversity). The limits of these

forest areas are not well defined and control measures are insufficient to prevent illegal exploitation. These factors, have led to severe degradation of vegetation in some classified forests. The lesson learnt here is that the boundaries of forest areas that fall outside portions of forest that charcoal producers are allowed to use should be clearly defined and proper enforcement measures put in place to ensure that such areas are not tampered with by unauthorised persons.

The Casamance kiln which is used in carbonizing wood increases the output of the kiln by 10 – 30 percent. This increase in efficiency combined with selective logging limits waste and therefore results in a lesser degree of environmental impact.

In Ethiopia, a careful assessment of charcoal production through the traditional method revealed an average loss of 71 percent wood resources. Yields are negatively affected as a result of the application of the traditional method of charcoal production.
Improper regulation of the charcoal industry presents a dangerous problem to the natural environment in the country. Unlike Senegal where the charcoal industry is regulated, the activities of traditional charcoal producers in Ethiopia are not regulated and this allows them to cut down trees indiscriminately. Several forest resources are consumed on daily basis, hence exposing the country's fragile forest to desertification. Regulation of the charcoal industry has great environmental benefits.

The literature review process further revealed that the solution to the operational problems of the charcoal industry can be achieved through the adoption of sustainable options of charcoal production. These include the production and replenishing of lost forest species, the adoption of appropriate modern technologies and the involvement of government and civil society organizations in the formulation and education of charcoal burners on the environmental consequences of bad practices.

CHAPTER THREE
RESEARCH METHODOLOGY AND PROFILE OF STUDY AREA

3.1 Introduction

After establishing the conceptual issues of the study, this chapter examined the research methods /approach adopted for sourcing data or information in order to accomplish the study objectives and questions. The chapter contains the research design, definition of the target population, sample size, sampling techniques and data collection technique/instruments as well as the profile of the study area.

3.2 Research Design Approach

A case study design was adopted for the study. The Case study design is a research methodology and also an investigative tool that is commonly used in studying social phenomena (Babbie and Mouton, 2004). The study saw case study as a research strategy that facilitates investigation on a phenomenon within its real-life context. Thus, the Case Study Design permits an in-depth investigation of individuals, groups, or events which may be descriptive or explanatory.

The study saw this research design as the most relevant approach of collecting and analysing data and reporting the results on the commercial charcoal production within the study area. The study further saw this design as appropriate for providing clear understanding of the issues being studied in the Upper West region.

3.3 Key Variables of the study

A variable is an empirical property which can take on two or more values. Thus, if a property can change either in quality or quantity, it can be termed as a variable in a research (Babbie and Mouton, 2004). Simply put, a variable is a concept that should have the attributes of being measured. In the case of this study, output levels of charcoal, incomes, method of production were some of the variables measured. The others included source of raw material and quantity of trees used per production (See Table 3.1).

Table 3.1 Research Variable, Definition and Purpose

S/N	Variable	Definition/Indicators	Purpose
1	Method of Production	The method refers to ways and techniques of charcoal production in the study area.	Knowing the techniques usually adopted by charcoal producers during charcoal production would enable the researcher to establish the nature of environmental damage associated with charcoal production.
2	Output Levels	Weekly, Monthly and Yearly production levels. This is mostly measured by bags and or basins.	This helped the researcher to ascertain facts on the quantity of bags of charcoal that may be expected over a certain period of time and its implication on the environment and charcoal producers.
3	Income Levels	This refers to the financial gains from charcoal production. Measured with assets obtained through the production and sale of charcoal. Cost per bags of charcoal.	The main purpose was to help the study to establish the financial impacts of charcoal production to the players of the industry. This was seen necessary to the study as it helps in ascertaining facts on the contributions of charcoal to households' income levels.
4	Quantity of Trees used per Production	It refers to quantum/estimates of logs needed in order to maintain a constant supply of charcoal over a period of time. Average logs used over a period of time.	This has helped the study to identify the extent of forest destruction and the recommendations necessary for sustaining the charcoal business.
5	Sources of Raw Material	This refers to the constant availability of tree species for charcoal production. Extinction of vegetative cover through charcoal business.	This aided the study assess the extinction rate and damaged caused by charcoal production.

Source: Authors, Construct 2010

3.4 Unit of Analysis

The unit of analysis for the study were, charcoal burners and sellers. In order to attain a credible study, some state agencies including the Forestry Commission; Game and Wildlife Division; Energy Commission; District Assemblies were also part of the empirical units for data acquisition.

3.5 Sampling Procedure

The researcher purposively selected three administrative districts (Wa East, Sissala East and Sissala West) all within the Upper West Region for the study. The districts were purposively selected due to their forest potentials that support charcoal production. Respondents were then randomly selected and interviewed in their respective communities within each of the three districts where charcoal production becomes a permanent business. The random sampling was chosen following its advantages (fairness to the unit of analysis).

3.5.1 Sampling Frame

The sampling frame was made up of all commercial charcoal producers in the three districts (Wa East, Sissala East and West Districts) within the region. The data on the commercial charcoal burners were obtained from the Forestry Commissions and environmental related NGOs in the respective districts. The data revealed that about 526 commercial charcoal producers operating in the three districts (Wa West, Sissala East and Sissala West). The selected number of respondents is indicated in Table 3.2.

3.5.2 Sample Size Determination

The choice of fairly representative sample for a study is critical for generating results that reflect characteristics of the entire population. The researcher, being guided by this fact, carefully selected representative sample that justified generalization of findings. The researcher carried out his investigations on an established comprehensive list of commercial charcoal burners provided by the Forestry Commission/ NGO's within the study districts. The study considered this as an appropriate primary sampling frame for its purpose. As indicated in Table 3.2, a sample size of 500 commercial charcoal producers were randomly selected from the officially recognised five hundred and twenty six (526) commercial charcoal producers in the three districts using a confidence level of 99 percent with a margin of error of 1 percent (0.01) (see appendix 2 for details of how the sample size of 500 was

determined). Appendix 1 indicates a list of selected communities and number of respondents in each community.

Table 3.2 Sample Size for the Three Districts

S/N	District/Location	No. of Communities Involved	Total Number of Certified Commercial Charcoal Producers	Sample Size	Questionnaires Administered	Response Rate
1	Wa East	17	203	195	195	100
2	Sissala East	16	144	135	135	100
3	Sissala West	15	179	170	170	100
	Total	**48**	**526**	**500**	**500**	

Source: Forestry Commission Wa East, Sissala East and West Districts/Author's construct

As indicated in Table 3.2, the response rate was 100 percent. This was recorded as a result of the one-on–one interview used by the researcher during the data gathering.

3.5.3 Sampling Techniques

Charcoal production in the study area is informal in nature. It is predominant in areas with good forest cover where the materials are drawn. The study employed a multi-stage sampling technique. Primarily, the study adopted purposive sampling technique in the choice of the study districts within the region. The factors that informed the choice of the districts are the availability of raw materials that encourage charcoal production in those districts. Again, the Sissala's have had a long history of charcoal production in the Upper West region hence the choice of the three Sissala dominated districts.

Finally, in order to maintain fairness and accuracy, the study adopted simple random sampling technique in selecting the required number of respondents for the research. The technique was applied on the recognised list of charcoal producers obtained for each district. Serial numbers were assigned to each charcoal producer on the list district by district. The serial numbers assigned were written on pieces of paper and put into a container and

thoroughly shuffled and picked one at a time without replacement until the required number for each district was obtained.

3.6 Data Collection Methods/Techniques and Sources of Data

The study adopted both primary and secondary sources of data in order to accomplish the study objectives. The primary data were collected through direct observations, interactions and interviews sessions using questionnaires; Focus Group Discussions (FGD) see appendix 8f)) and transect walks to and fro charcoal producing sites. These techniques were adopted to collect data from commercial charcoal producers, the Forestry Commission, District Assemblies and Energy Commission. This enabled the study to establish the extent to which charcoal producers understand and adopt sustainable practices of charcoal burning.

The secondary sources on the other hand involved published and unpublished documentations such as reports and journals that provided the conceptual framework and a definite meaning to the topic. The secondary sources provided information on the list of commercial charcoal producers; charcoal production activities in other developing countries; Government of Ghana's draft Bio-energy Policy for the year 2010 etc. Thus these were very good complements to the primary data.

Table 3.3 Institutions Contacted

Institutions	**Questionnaires Administered**
District Forestry Commission	3
Energy Commission	1
Wa East District Assembly	1
Sissala East District Assembly	1
Sissala West District Assembly	1
Total	**7**

Source: Author's Construct 2010

3.7 Method of Data Analysis and Reporting

The study systematically harmonised the data in a manner that they could meaningfully address the study objectives and questions. The data collected from the primary sources were first edited to minimize human /arithmetic errors. The integrated set of relationships

between the various categories of people and activities being investigated on the topic provided a framework for analysis as well as a range of tools for assessment. Some statistical tools such as bar graphs, frequency distribution tables and bar charts were mainly employed. Also the use of the measure of central tendency (mean) was used to determine the monthly average incomes of charcoal producers. These tools enabled the study to analyse the data considering the variables measured and objectives set. All analysis was done to establish factors that necessitate commercial charcoal production and its environmental implications/consequences.

3.8 Profile of the Study Area

3.8.1 Introduction

After successfully determining the kind of methodology together with the research tools needed to elicit data and information for the study, this portion of chapter delve into the profile/overview of the study area (where the methodology has been applied). Basically this section describes the geographical locations/size, demographic characteristics and the economy of the three districts under study.

3.8.2 Location and Size of the Study Districts

Profile of Wa East

The Wa East District was carved out of the Wa Municipality and made an autonomous district by L.I 1746 in July 2004. The district is remotely located in the south eastern part of the Upper West Region. Its capital is Funsi, about 115km away from Wa, the regional capital (*See Figures 3.1&3.3*). The district shares boundaries with West Mamprusi to the northwest, West Gonja to southeast and the Sissala East district to the north. It has a landmass of about 1,078km², which lays between latitudes 9º 55”N and 10º 25”N and longitude 1º 10”W and 2º 5”W. The remoteness of the district relative to other districts of the region has deprived it of basic social and economic infrastructure and services (Wa East DMTDP, 2006-2009).

Profile Sissala East

The Sissala East District is located in the north-western part of Ghana in the Upper West Region. The district capital is Tumu. The District is strategically positioned as it shares a 300 kilometre border with Burkina Faso.

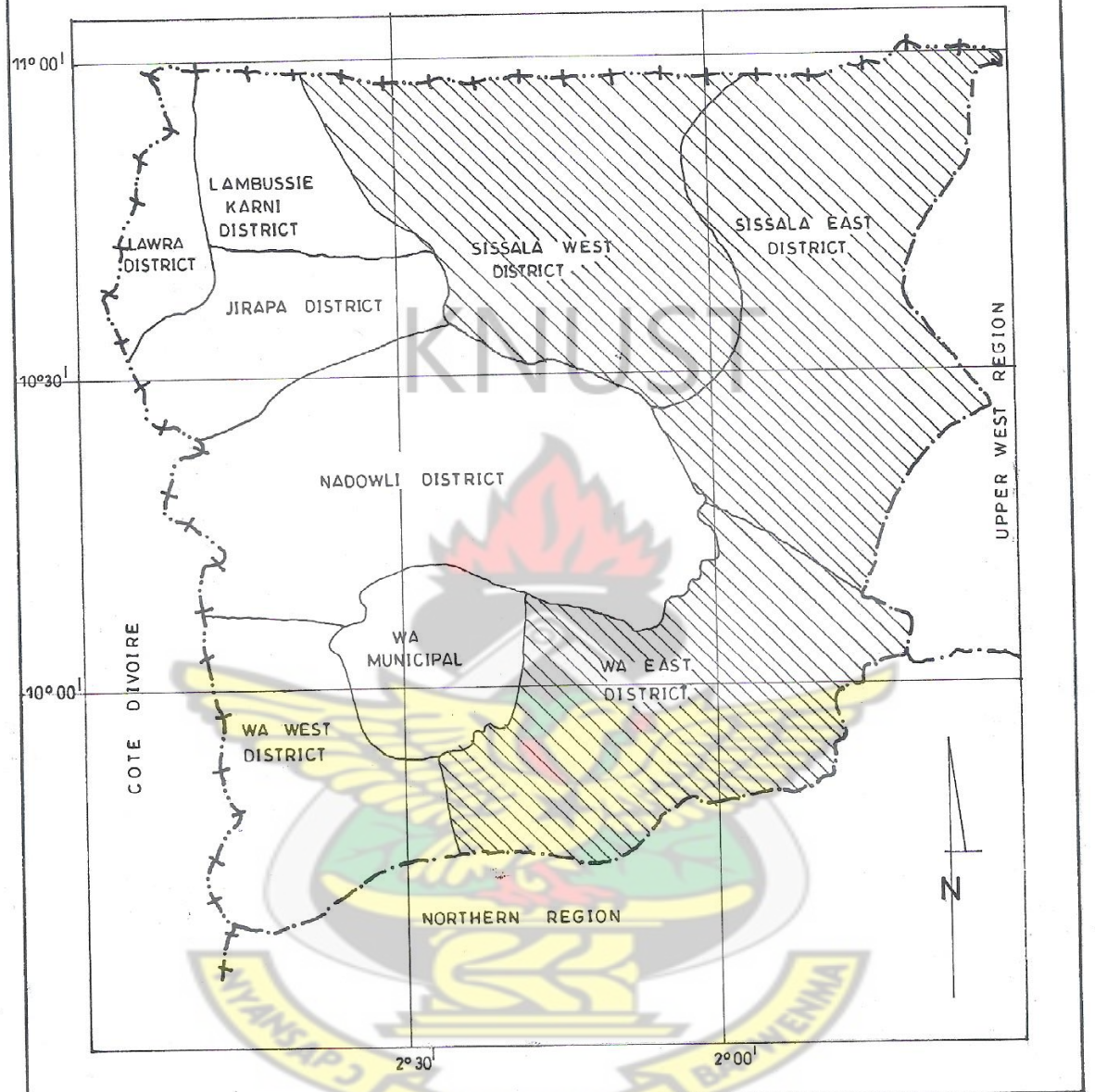
To the east, it shares boundaries with Kassena Nankana and Builsa districts in the Upper East Region. Its extreme south-eastern portion shares a boundary with West Mamprusi District of the Northern Region. As indicated in Figures3.1 & 3.2, its neighbours in the Upper West Region are Wa East and Nadowli districts to the south and Sissala West district to the west. It falls between Longitudes 1.30^0 W and Latitude. 10.00^0 N and 11.00^0 N. The district has a total land size of 4,744 sq km – representing 26percent of the total landmass of the region. Interestingly, Sissala East District shares all types of boundaries, including inter districts, inter regions and international. This makes it unique (Sissala East DMTDP, 2006-2009).

Profile of Sissala West

The District is located in the north-eastern part of Ghana. It lies approximately between Longitude 213°W and 2.36°W and Latitude 10:00N 11:00N. It shares boundaries with the Jirapa Lambussie District to the west, Sissala East District to the east and Burkina Faso to the north and Wa East District to the south (*See Figures 3.1&3.4*).

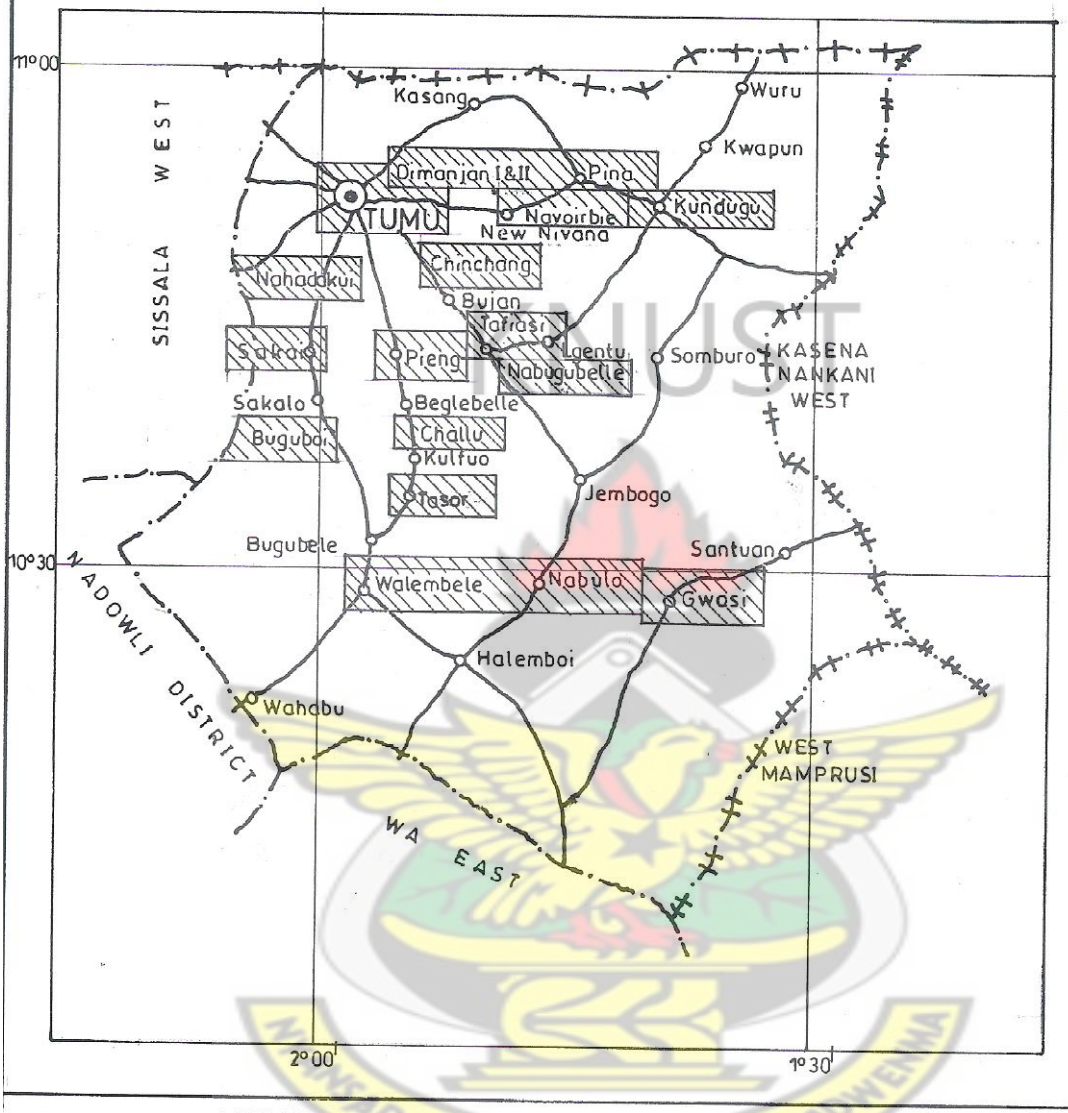
The district sharing border with Burkina Faso will facilitate cross border socio-economic activities. However, this has its own implications for health and crime wave. It covers a total Land area of 411,289km, which is about 25percent of the total landmass of the Upper West Region (Sissala West DMTDP, 2006-2009).

FIG. 3.1 DISTRICT MAP OF UPPER WEST REGION SHOWING THE STUDY DISTRICTS



SOURCE Wa Municipal Assembly

FIG. 3.2 MAP OF SISSALA EAST DISTRICT SHOWING THE STUDY COMMUNITIES



LEGEND

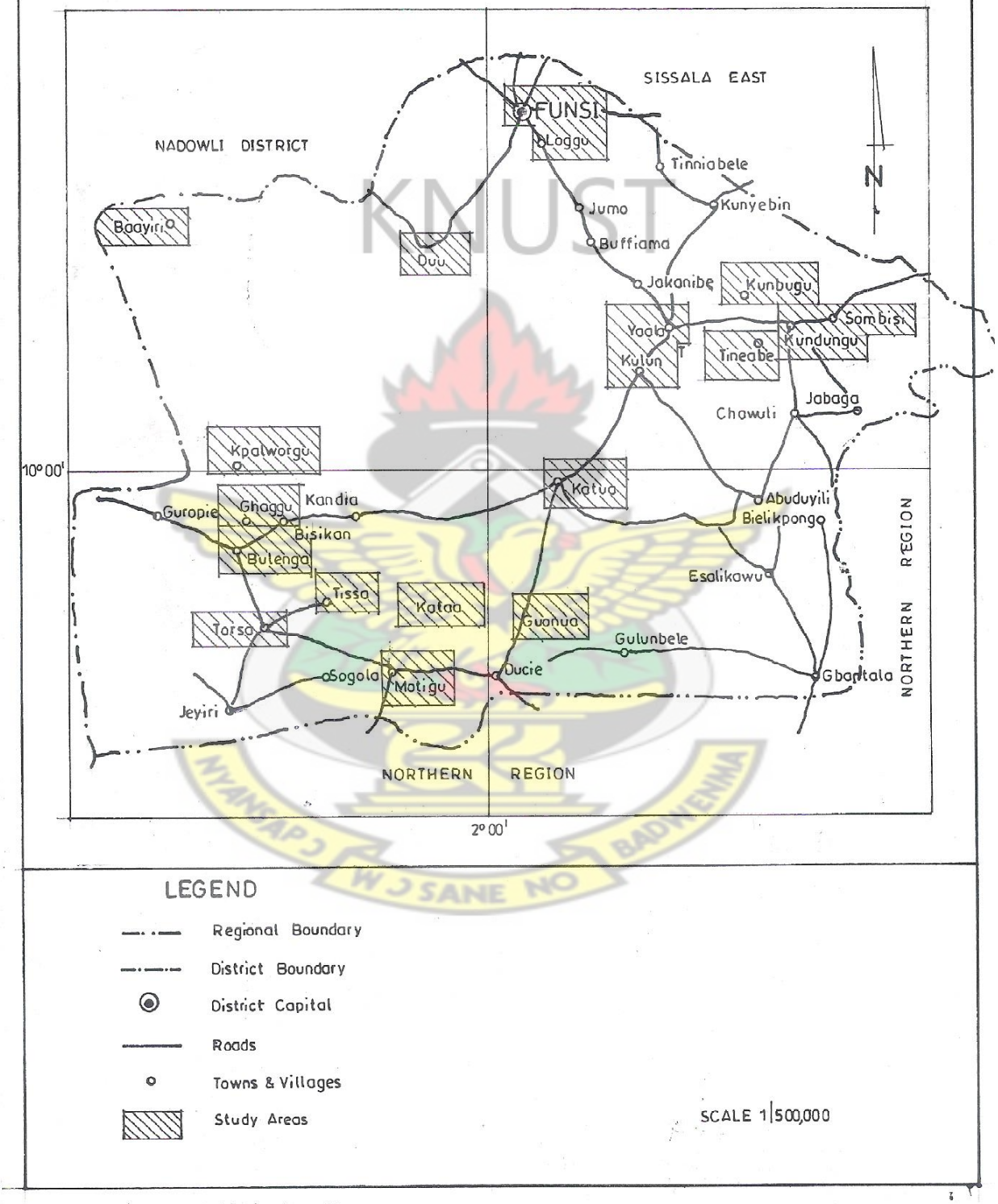
- International Boundary
- Regional Boundary
- District Boundary
- District Capital
- Roads
- Towns & Villages
- Study Areas

N

SCALE 1 | 375.000

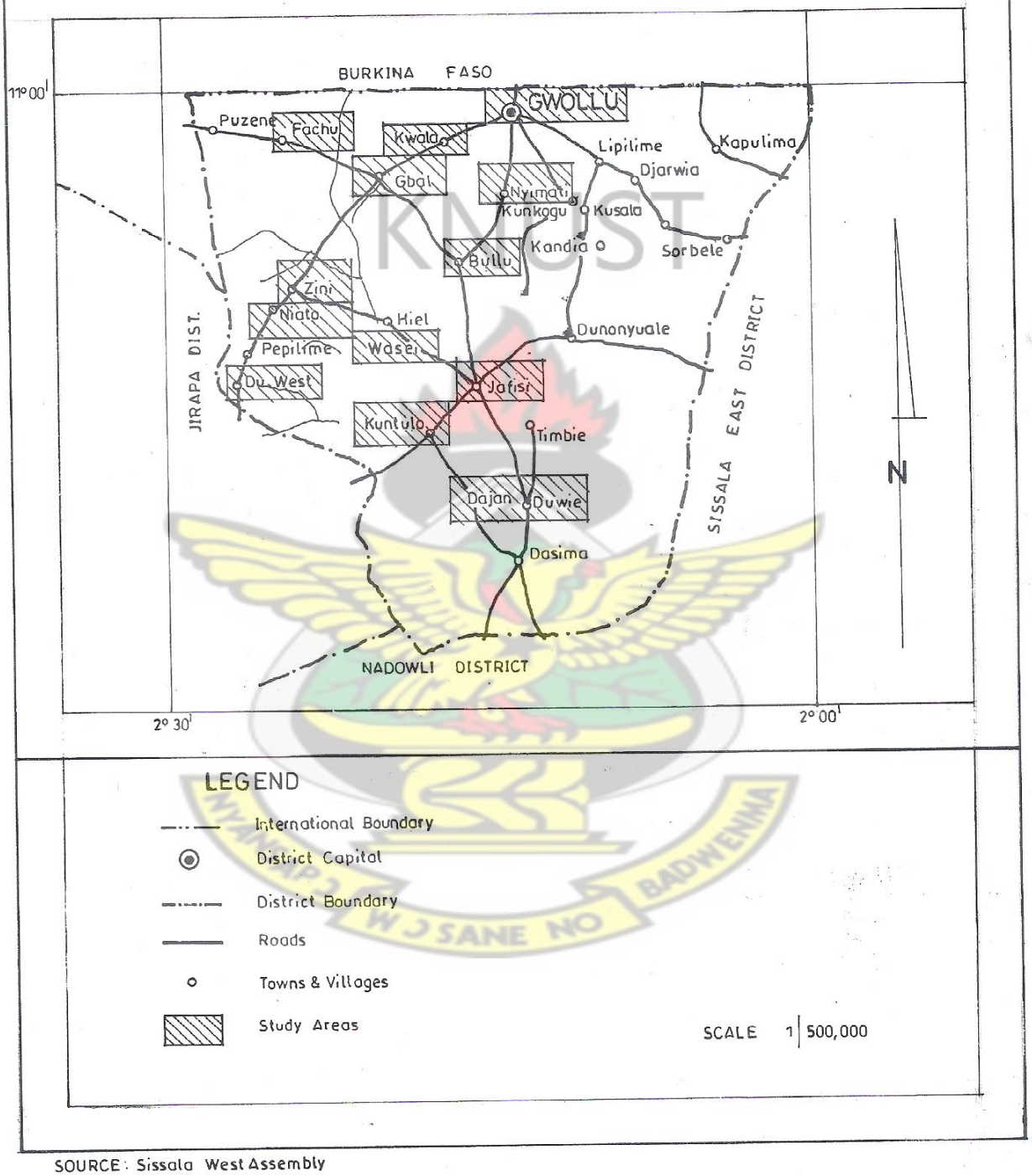
SOURCE : Sissala East District Assembly

FIG 3.3 MAP OF WA EAST DISTRICT SHOWING THE STUDY COMMUNITIES



SOURCE: Wa East District Assembly

FIG. 3.4 MAP OF SISSALA WEST DISTRICT SHOWING THE STUDY COMMUNITIES



SOURCE: Sissala West Assembly

3.8.3 Demographic Characteristics of the Districts

As indicated in Table 3.4, the population of the various districts is relatively stable. In the case of Wa East, the population was 60,947in 2000, with an annual growth rate of 1.7 percent by the 2000 PHC. Thus, the district's population growth rate is lower than the national growth rate of 2.6 percent.

The population figures for Sissala East and West were 42,395 and 43,047 respectively as shown in Table 3.4. Both recorded an average growth rate of 1.7percent as against 2.7percent for the national (PHC, 2000). The two districts have a Population Density of about 12 persons per square kilometre, which is much lower than the regional population density of 31 persons per square kilometre. The districts are entirely rural with scattered settlements patterns.

Table: 3.4 Populations of the three Districts (2000, 2007, 2008 and 2009).

Year Area	2000	Rate (%)	2007 Projected	Rate (%)	2008 Projected	Rate (%)	2009 Projected
Wa East	60,947	1.7	68786	1.7	70,057	1.7	71,330
Sissala East	42,395	1.7	49,014	1.7	50,061	1.7	51,111
Sissala West	43,047	1.7	49,033	1.7	50,019	1.7	51,025

Source: GSS, 2009

3.8.4 Vegetation, Climate and Rainfall

The three Districts are located within the Guinea Savannah vegetation belt. The vegetation is depicted by isolated woodlands, short thick trees, shrubs and grasses. The common economic trees in the districts include sheanut, baobab, kapok, dawadawa, acacia, neem and ebony, mangoes, cashew and acheaple which are usually fire resistant trees. Over 30percentof the natural vegetation has been destroyed by annual bush burning, inappropriate farming practices, indiscriminate cutting of trees for wood, charcoal and poor animal husbandry practices (UNDP, 2009). The consequence of these human practices is that the districts are faced with the problem of environmental degradation. As a measure to address this problem, Plan Ghana and The Friends of the Environment in Agro-Forestry (NGO's), have initiated projects aimed at promoting tree-planting by individuals and organizations in these districts.

The districts experience the tropical equatorial climate, which prevails throughout the northern part of Ghana. Temperatures are high all-year, ranging between 15c^{o}-45c^{o}. The

temperatures are lowest in December/January, while the highest occur in March /April. The average monthly temperatures are 38ºc.

The Harmattan, which is characterized by cold and dry dusty-wind with occasional haze occurs between November and April every year. During this period, the forest becomes susceptible to wild fires due to chronic lack of moisture in the atmosphere. With these conditions charcoal burning and other human activities easily trigger bush fires.

The area has a single rainfall regime from May-October. The average annual rainfall is about 1,200mm/year and they are torrential, erratic and stormy. The single rainfall regime does not make farming all year round possible. Most farmers therefore become redundant during the long dry season (from November to May). Around this period more able-bodied persons engage themselves in charcoal and hunting activities in order to maintain their livelihoods. This implies the need for intervening actions (irrigation facilities etc) in the districts to provide employment opportunities during this period.

3.8.5 Wood Energy Needs and Sources

The sources of energy in the study area for domestic and commercial purpose are electricity, kerosene, fire wood/ charcoal. Information gathered revealed that about 80 percent of households in all the three districts use fuelwood and charcoal for cooking purposes (DMTDPs, 2006-2009).

In the Sissala East and West Districts, estimates by the VRA indicates that, only about 11percent of communities have access to electricity, while that of Wa East District is yet to be established. The LPG is yet to be a domestic cooking energy source to these districts due to its scarcity. Gas tankers cannot reach out to the areas as a result of bad roads.

3.9 Summary

The three districts are located within the guinea savannah vegetation belt. The districts therefore experience a tropical equatorial climate which prevails throughout the northern part of Ghana with relatively high temperatures all year round. The area has a single rainfall regime from May to October with an average annual rainfall of 1,200mm.The major energy sources for cooking are fuelwood and charcoal.

CHAPTER FOUR
DATA ANALYSIS ON THE EFFECTS OF COMMERCIAL CHARCOAL PRODUCTION IN THE UPPER WEST REGION

4.1 Introduction

Having analysed the profile of the study area, this chapter analyses the relevant data obtained through the field survey into the desired information. The analysis of the data collected was done around the study objectives. These included analysing the economic and vegetation impacts of commercial charcoal production; as well as the methodology adopted in producing commercial charcoal. This was done to enable the establishment of meaningful facts, findings and conclusion on the study.

4.2 Age and Sex Distribution of Charcoal Producers

As indicated in Table 4.1, persons in different age and sex categories are engaged in commercial charcoal production. By carefully analysing the various age and sex categories, the study identified that majority (32%) of the commercial charcoal producers are within the age group 30-39. For those within this age bracket, 22 percent are males while 10 percent constitute females. Next to this is the age group 20-29 which is represented by 20 percent of the total respondents (12% males against 8% females). However, the study identified that age group 60 and above recorded the least number of 3 percent.

The youth group (age 20-49) employs about 73 percent of people within the commercial charcoal production industry. As observed in the study, charcoal production is an activity that requires extensive manual labour. Trees are felled, transported and prepared for charcoal production. Mounds are prepared as traditional kilns before the charcoal can be produced (See plates 4.3, 4.4a and 4.4b). All these require exuberance and that underscores why the industry is dominated by the youth (representing 73 percent of the sample population). The above trend also provides evidence that commercial charcoal production is a male (66%) dominated activity.

Table 4.1 Ages and Sex Distribution of Commercial Charcoal Producers

	Wa East Frequency					Sissala East Frequency					Sissala West Frequency					TOTAL					
Sex / Age Group	T0ttal Resp.	Male	% Male	Female	% Female	Total Resp.	Male	% Male	Female	% Female	Total Resp.	Male	% Male	Female	% Female	Male	% Male	Female	% Female	Total resp.	Over all %
10-19	8	5	3	3	2	11	8	6	3	2	18	15	9	3	2	28	6	9	2	37	7
20-29	36	21	11	15	8	30	18	13	12	9	35	20	12	15	9	59	12	42	8	101	20
30-39	71	52	27	19	10	40	25	19	15	11	47	31	18	16	9	108	22	50	10	158	32
40-49	43	26	13	17	9	28	17	13	11	8	36	24	14	12	7	67	13	40	8	107	21
50-59	30	19	10	11	6	20	12	9	8	6	30	22	13	8	5	53	11	27	5	80	16
60 and above	7	7	4	0	0	6	5	4	1	1	4	3	2	1	1	15	3	2	0	17	3
Total	**195**	**130**	67	**65**	33	**135**	**85**	63	**50**	37	**170**	**115**	68	**55**	32	**330**	66	**170**	34	**500**	**100**

Source: Author's Construct September, 2010

4.3 Background of the Commercial Charcoal Producers

Information obtained through Focus Group Discussion (FGD) revealed that charcoal production in the area is historic. The study established that the production of charcoal was initially for domestic energy supply, with huge dead logs or trees as main raw materials. However with time, especially as the population grew and the need for energy for the urban dwellers increased, charcoal began to gain its earnest commercial value. The demand and supply of charcoal began rising and producers began cutting live trees for the production of charcoal.

Participants at a FGD in the Sissala East district did indicate that charcoal production is a long standing inter-generational self-wealth creation affair in their communities. "Commercial charcoal production in our area has no definite start date. We were born into it".

4.3.1 Ethnicity of Charcoal Producers

The study further identified three ethnic groups are involved in charcoal production. These include the Sissalas, Dagabas and Wales. As indicated in Figure 4.1, the Sissala ethnic group is very actively involved in commercial charcoal business as compared with the other ethnic groups in the region. The Sissala's dominance is the possible reason for the attribution of charcoal production and sale to the Sissalas.

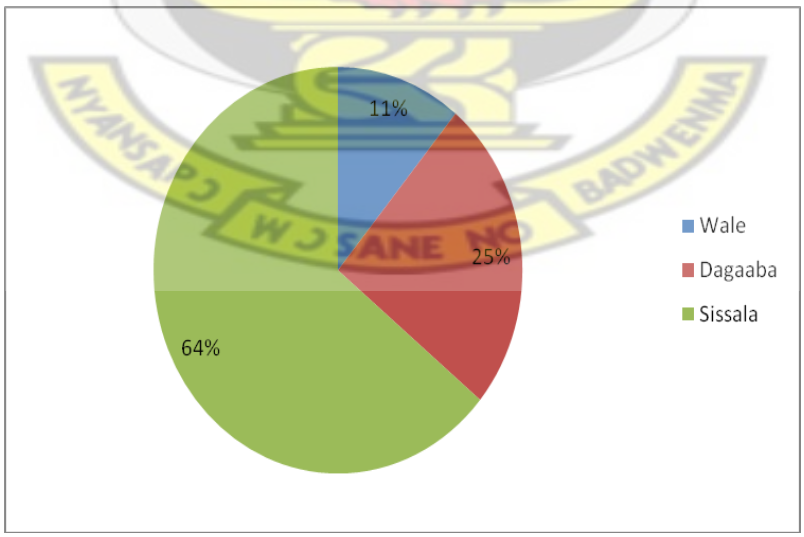


Figure 4.1 Ethnicity of Charcoal Producers

Source: Field survey September, 2010

4.4 Effects of Commercial Charcoal Production on the Vegetation

The study observed that the wood land resources are experiencing an extensive degradation through the unsustainable methods of charcoal production. Apparently, there are changes in the vegetative biodiversity: gradually disappearing flora, yearly observed rainfall variability and complained reduction in farm yields among others. The study again identified that the traditional method of charcoal production adopted by charcoal producers as well as their preference for particular tree species are some of the key known factors destroying the vegetation.

4.4.1 Method of Charcoal Production in the districts

The vast majority (99 percent) of charcoal producers in the study area use the traditional/earth mound method of charcoal production (*refer to Figure 4.2*). Charcoal is produced through a series of traditional methods and processes. The processes as outlined by a commercial charcoal producer, who was a key informant, are below:

"Commercial charcoal production process often commences with the selection of well-endowed trees location by the charcoal producer. The identified trees are then cut or harvested over a period of time for free. Some of the selected woodlands are family owned or communal lands where acquisition of permits is not often necessary.

Secondly, the cut wood (usually about 1m long) are sorted by diameter and stacked next to the burning site, as indicated in Figure 4.3. The wood is then stacked into a dug-out earth pit or heap on a relatively flat plain up to a reasonable height and covered with a layer of grass/ leaves and sand (See Figures 4.4 a & b). Thus, the logs are piled on a relatively flat area of land with fresh leaves and grasses well covered over the logs. A heap of sand is then gently used to cover the entire heap leaving two very small openings for fire to be lit and smoke exit respectively. As indicated in Figures 4.4 (a and b), several amounts of top soil and shrubs are needed to cover a single heap.

Finally, the fire is then lit from the opening. After the entire woods/logs catch fire the hole is sealed with small sticks and grasses. As indicated in Figures 4.4 (a & b), the process is then closely monitored both day and night for about 10-15 days, depending on the size and

moisture content of the wood during carbonizing. Gradually the logs burn into the required charcoal.

During the process, a series of vents are created in each earth mound. This is done to allow proper ventilation and continued burning for up to a week or two depending on the size of the woods and the heap. If the earth kiln is not vented properly, it can either smother the fire before carbonization takes place or burn too hot, causing over burning, leaving only a pile of ashes. The process of carbonizing is completed when it stops smoking and cools. At this point, the charcoal worker begins raking and separating the dirt and debris from the newly formed charcoal, as seen in Figure 4.4 (a & b). Between two and four days are spent in this process, depending on the size of the labour available. The charcoal is then collected into bags and sold either to charcoal merchants or individually along the roadside".

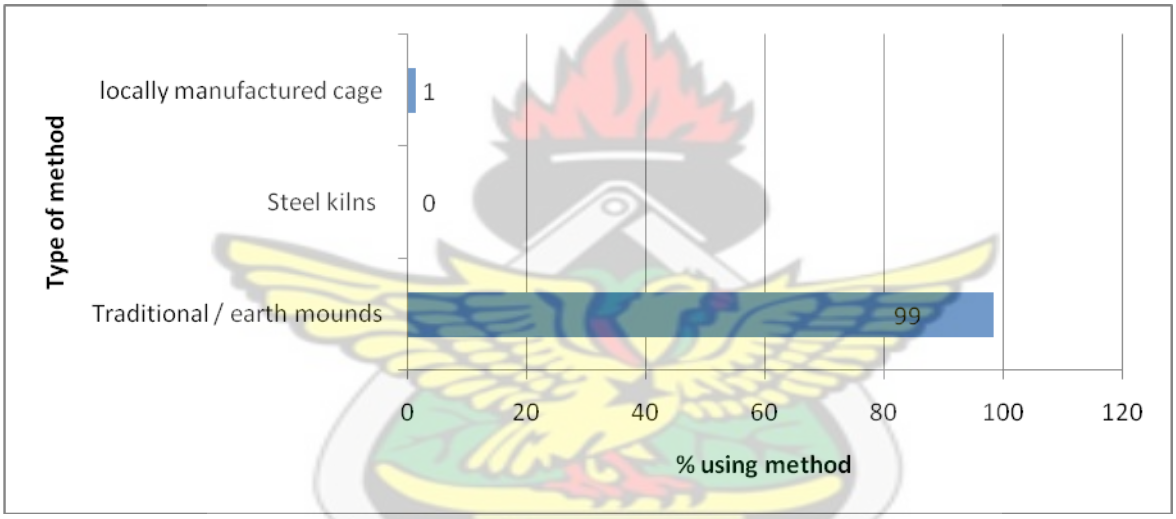


Figure 4.2 Methods used during charcoal production

Source: Author's Construct, September, 2010

Figure 4.3 Sorted Woods for Charcoal Production

Source: Author's Construct, September, 2010

Figure 4.4 (a) Earth mount method of charcoal production being used in the Wa East District

Source: Author's Construct, September, 2010

Figure 4.4 (b) Earth mount method of charcoal production being used in the SissalaEast and West Districts

Source: Author's Construct, September, 2010

Figure 4.5 Finished Products (Charcoal)
Source: Author's Construct, September, 2010

The earth mound method of charcoal production inflicts damage to the vegetation. As observed from major charcoal producing sites in the study area, this process has several weaknesses. These weaknesses contribute immensely to the degradation of the natural environment. An interaction with charcoal producers during a focus group discussion (see appendix 8f) showed that the method could trigger bushfires through the vents and other

openings. Some producers also pointed out that in cases where producers mishandled the fires, bush fires easily resulted, destroying vegetation. Additionally, this method is inefficient as it encourages a lot of resource waste. The study saw these as immediate indications of serious threats to the flora.

In addition to cutting trees for charcoal production, the researcher observed that forbs and herbs are also at risk during charcoal processing. The process usually damages the surface of the top soil and shrubs, as a result of digging and burning during the production cycle. Moreover, the mound areas will not re-vegetate for several decades even as rain drenches.

It was observed that young trees were devastated, landscape full of burned stumps, cut branches, abandoned logs, and vehicle trucks criss-crossing large trucks of lands (*See Figures 4.3 & 4.5and Appendix 8*). The excessive depletion of the trees is apparent and poses threats of serious environmental consequences in the area, as the main sources of wood supply is the fragile natural forest. The roads used by the trucks which come to cart the commodity are made by the same trucks searching for and carrying charcoal from remote areas leaving behind destroyed and misused land surface. The study sees this as an indication of the environmental degradation and deforestation taking place in the area.

4.4.2 Wood Sources for Commercial Charcoal Production

As indicated in Figure 4.6, a variety of trees needed for charcoal production are harvested from the natural forest. The survey identified that as many as 88 percent of charcoal producers use live trees which are felled in the natural forest. Through a Focus Group Discussion (see appendix 8f), participants revealed that no fee is paid for harvesting trees, unlike in the forest zone where these resources are purchased. It was further revealed that lands from which trees are harvested are usually family owned or communal lands. Information obtained from a key informant revealed that community members feel there is no need to acquire permits since the lands belong to them.

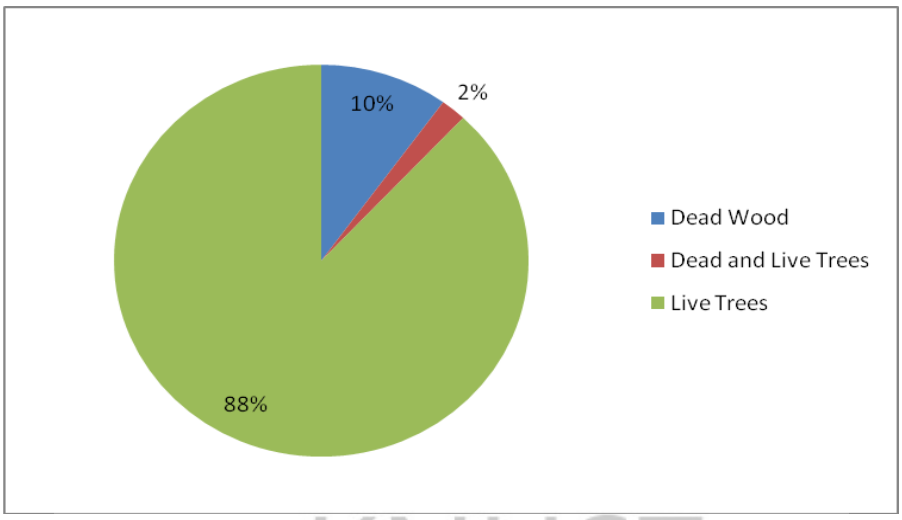


Figure:4.6 Sources of Trees/Wood for Charcoal Production
Source: Author's Construct September 2010

As indicated in figure 4.7 (a &b) the common methods of harvesting these trees at the time of the study were by means of cutting at about 40 cm above the ground level. Major tools used for harvesting the trees are axes, cutlasses and at times chainsaws. These methods of tree harvesting for charcoal hardly make it possible for tree rejuvenation, since the entire stems of the trees are often chopped off.

(a)   (b)

Figure: 4.7(a &b) Live Trees Being Harvested for Charcoal Production
Source: Author's Construct September 2010

When the 88 percent (*See Figure 4.6*) of the charcoal burners who cut live trees were enquired on why they use live trees, they indicated that they had no alternative; as deadwood are almost completely exploited to exhaustion. They also indicated that live trees are easier to fell than deadwoods.

4.4.3 Forest Sustainability Measures

Interventions by Charcoal producers to sustain the forest are limited in the area. As indicated Table 4.2, 88 percent of charcoal producers believe that trees regenerate (natural process) after cutting. As a result of this, they do not see the need to make conscious efforts to replant trees after cutting them. The only forest sustainability measure adopted by the people is agro-forestry. However, the particular tree used for this intervention is the mango plant which unfortunately cannot be used to sustain the charcoal industry. The study sees this situation as a threat to the natural forest as trees are being exploited without commensurate replacement.

Table 4.2 Forest Sustainability Measures in the study area

Interventions	**Frequency**	**Percentage**
Forestry/Agro-forestry	60	12
Community woodlots	0	0
Natural process	440	88
Total	**500**	**100**

Source: Author's Construct September 2010

4.4.4 Preferred Tree species used for Charcoal production

As indicated in Figure 4.8, charcoal producers have strong preference for shea trees in the production of charcoal in the study area. The shea tree, which is crucial for the sustenance of the vegetation and livelihoods in the area, is mostly destroyed. During the study, it was discovered that the shea tree is mostly preferred by charcoal consumers and as a result 48 percent of producers prefer to use the tree. With this prevailing situation, the shea tree is faced with exhaustion in the study area.

The Mahogany, another important tree, mostly used in the housing industry is also confronted with extinction. Twenty two percent of charcoal producers interviewed indicated their strong preference for the mahogany tree. As indicated in Figure 4.6, other trees such as the Neem and Daniellia, which are not as important as the shea and mahogany trees, are not exploited much.

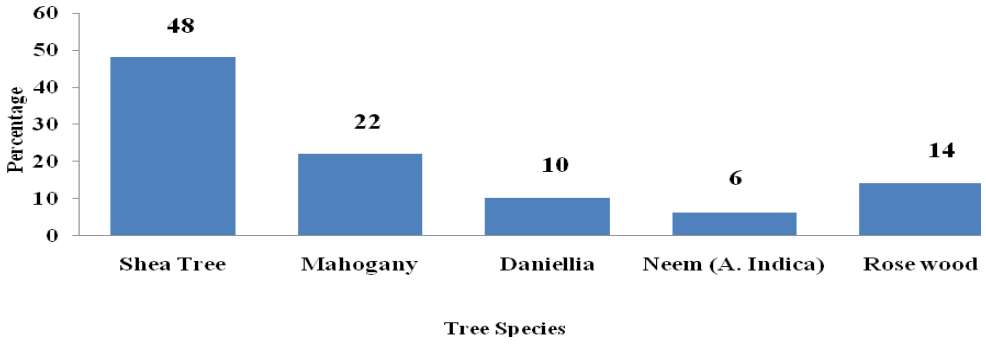


Figure: 4.8 Preferred Tree species of Charcoal
Source: Author's Construct September 2010

4.5 Perceived Causes of Forest Degradation

As indicated in Table 4.3, all the charcoal producers acknowledged that the forest around them was degrading. The study took the respondents through a situational analysis of the phenomenon. According to charcoal producers, the principal drivers of forest change include: fire (64%), charcoal activity (18%), grazing (16%) and clearing for agriculture (2%) as shown in Table 4.3.

When questions were asked (at FGD) about the status of the forest twenty years ago, participants talked about the past when large trees like mahogany, baobab etc were abundant; times when antelopes and other wildlife were present; times when it was not safe to venture into the forest because of the abundance of predators. Statements such as the above and this were common: "When we were young, we dare not travel far from the village because we knew there were dangerous animals like lions and buffalos in the bush. Now they are no longer here. No one is scared of the bush anymore. There are no animals. I even want to say that the bush has disappeared. What we have now cannot be truly called the bush. This is nothing. This is no longer the bush." Herbs are lost around us unless you travel far into the bush".

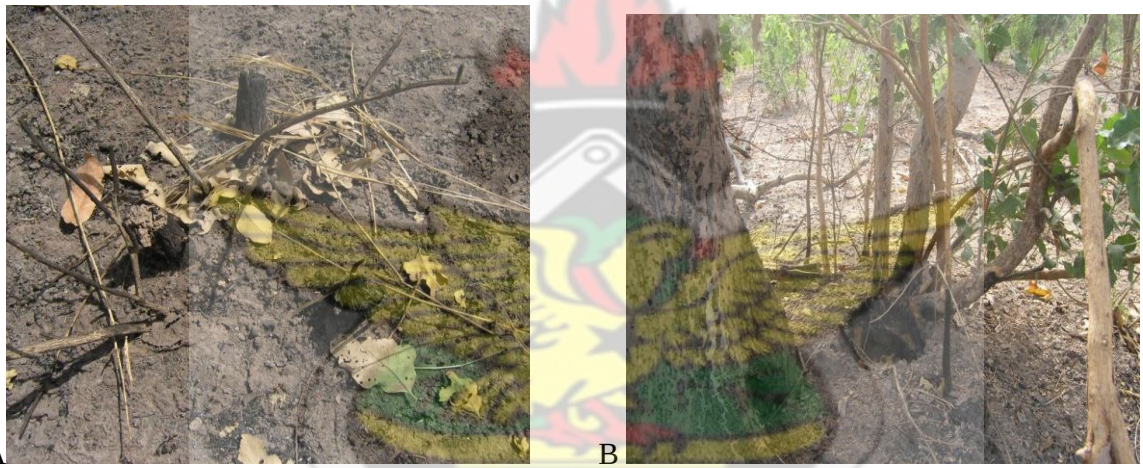
Participants at FGD also spoke of the lack of large, harder wood trees in the current forest. "In the past, these trees were abundant producing lots of shade, fodder for livestock, timber for roofs, and fruit", some participants stated. Presently, people felt that most of these were missing from the surroundings. There was an abundance of smaller trees that re-grew well, but the bush lacked the larger trees that do not re-grow after cutting. "You can easily see that lots of big trees are disappearing – mahogany, baobab, neem and other very important trees.

Another tree that we used to make the roofs of houses, much like cane that can be up to 10 meters long and we used to make flutes out of the smaller portions of it, but it is no longer here. It is those who cut the trees for timber who reduced the forest." – (*view of a key informant*).

Table: 4.3 Perceived causes of Forest Degradation

Perceived causes of forest cover change	Frequency	Percentage	Ranking
Fire	320	64	1
Charcoal Activity	90	18	2
Grazing	80	16	3
Clearing for Agriculture	10	2	4
Total	**500**	**100**	

Source: Author's Construct September 2010



A B

Figure: 4.9 (a & b) Examples of Effects of Fire on Regeneration

Source: Author's Construct September 2010

The study revealed that many charcoal producers have limited knowledge about the effects of their activities on forest change. Only 18 percent (*See Table 4.3*) believe charcoal production is a factor responsible for foreign change. The rest of them (82%) attribute the degradation of forest to other causes such as grazing, fire and farm clearing. Participants tend to forget that their activities could as well trigger bush fires, which 64 percent believed was the major cause of forest degradation (*See Table 4.3*). Refer to Figure 4.9a and Figure 4.9b for the effects of bushfire on regeneration.

4.6 Economic Effects of Charcoal Production

The study further looked at the effects charcoal production has on the economic lives of charcoal producers. This was seen to be the motivation for engaging in charcoal production. Among the issues examined are the quantity of bags (maxi bag) churned out per production, contribution of charcoal production to the incomes of producers and assets bought or acquired from charcoal revenues. The study revealed that 66 percent of commercial charcoal producers are males, indicating male dominance in the industry.

4.6.1 Charcoal Production Levels in the Study Districts

For the wholesale trade, charcoal is often sold in maxi bags. Depending on the type and quality of charcoal, the study identified that the weight may range from 32 to 60 kg, but usually the average is 50 kg for charcoal from the study area. It was also determined that, an average of ten (10) maxi bags of charcoal is usually obtained from a single production process (*See Appendix 8*).

Charcoal production in the study area is a serious economic activity. Though the one-on-one interview it was identified that charcoal producers are able to carry out two productions within a month, generating an average monthly output of twenty maxi bags (2*10 bags per producer). Based on the average quantity of bags (10 maxi bags) produced per production, coupled with the indicated bi-monthly charcoal production, output levels for 2010 was determined (*See Table 4.4*). Several maxi bags of charcoal were produced in the year 2010. Per the number of producers interviewed in 2010, Wa East, Sissala East and West Districts realized monthly output levels of 3,900, 2,780 and 3,489 maxi bags respectively.

Table: 4.4 District Charcoal Production Levels (2010)

District	No. of Commercial Charcoal Producers interviewed	Quantity Produced (Maxi Bags)	
		Monthly	Yearly
Wa East	195	3,900	46,800
Sissala East	139	2,780	33,360
Sissala West	170	3,489	40,800
Total	**500**	**10,169**	**120,960**

Source: Author's Construct September 2010

4.6.2 Incomes Generated from Charcoal Production

During both Focus Group Discussion and one-on-one interviews, the commercial charcoal producers cited the financial returns they receive from their activity as the reason why they engage in charcoal production. Participants at the FGD indicated that the charcoal business has been of great benefit to them and their families. The FGD revealed that, a maxi bag of charcoal was sold at GH¢10.00 in 2010 across the three districts studied.

As indicated in Table 4.5 charcoal producers earn an average yearly income of GH¢ 2,400 in each district. This translates into an average monthly income of GH¢200 per producer. Also, the charcoal industry produced a total yearly average income of GH¢1,209,600 in the three districts. In effect, the charcoal industry averagely contributed GH¢1,209,600 to the areas' micro economy in 2010. Based on this, the study concluded that the charcoal industry, in spite of its environmental harm is a very important economic activity for rural economies. It has the potentials of reducing rural unemployment as well as contributing to improving living conditions. However, as indicated earlier in the study, charcoal production constitutes serious environmental challenges in the area. The very existence of the industry could affect agricultural outputs, which has been the mainstay of the people.

Table: 4.5 Average Yearly Income levels obtained from Charcoal Production

District	**Number of Charcoal Producers**	**Average Price per maxi bag** **GH¢**	**2010 Quantity (Maxi bags) of charcoal produced**	**Total Value** **GH¢**	**Annual Earnings income per producer** **GH¢**
Wa East	195	10	46,800	468,000	2,400
Sissala East	139	10	33,360	333,600	2,400
Sissala West	170	10	40,800	408,000	2,400
Total	**500**	**10**	**120,960**	**1,209,600**	**2,400**

Source: Author's Construct September 2010

4.6.3 Other benefits emanating from Charcoal Production

The charcoal industry has been of significant benefit to the lives of charcoal producers. According to charcoal producers at a FGD, the industry enables them to acquire basic items necessary for their sustenance. The statement of a participant is expressed below; "Assets, such as bicycles, motor bikes, roofing materials are all acquired with *charcoal money*". "We

also use *charcoal money* to buy livestock for keeping". Again charcoal producers pointed out how the business makes it possible for them to buy consumer goods like food stuffs, clothing, children's educational needs; water and sanitary facilities. "Without this business we wouldn't be able to buy all these", a participant remarked.

4.7 Areas of Further Research

Having realised the environmental impacts associated with charcoal production from the study, it is deemed extremely important in examining the impacts of charcoal activities on climate change, in the case of any future studies. This is particularly in conformity with the United Nations Framework Convention on Climate Change (UNFCCC) Article 2 which states: "The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner".

Economic analysis has been widely applied across the climate change domain – analyses of the economic cost of climate-related damages, the costs and benefits of mitigation options, the costs and benefits of adaptation options, the economic implications of policy design and instrument choice, the economic consequences of alternative architectures for international treaties on climate policy, and the economics of decision-making under uncertainty are primary examples. A number of climate change reports have assessed these analyses, and this tradition should be continued by individuals and institutions. The aim of this cross-cutting theme therefore would be to provide comprehensive and consistent information regarding activities of charcoal production. This would be relevant and could also inform the consideration of Article 2 of the UNFCCC on the key vulnerabilities and multinational development impact of the charcoal industry.

.

CHAPTER FIVE

SUMMARY OF FINDINGS, RECOMMENDATIONS AND CONCLUSION

5.1 Introduction

Following the analysis of the research data in the previous chapter, this chapter summarises the main findings and the emerging issues from the study. On the basis of these findings, some recommendations have been made as some possible actions that can help manage the emerging issues. The findings have been classified under the study objectives and the research questions to facilitate understanding.

5.2 Study Findings

The goal of the study is to critically assess the vegetative and economic effects of charcoal production. The findings informed recommendations on exploring sustainable options of ensuring adequate charcoal supply.

5.2.1 Effects of charcoal production on Vegetation

The issue of deforestation due to charcoal production and other human factors is a critical one. The effects are usually difficult to reverse. As indicated in the previous chapter, several important tree species are fast disappearing through commercial charcoal production. This is made possible, in part due to the unregulated/uncoordinated practice of charcoal production coupled with bush fires which destroys the vegetation.

i) The methods of charcoal production in the area

The vast majority (99 percent) of charcoal producers in the study area use the traditional method of charcoal production. This method, also known as the earth mound method threatens the forest resources sustainability. The method is wasteful and reduces the general yields of charcoal production as compared with the modern methods (like the kiln) of charcoal production as practiced in countries such as Senegal. An interaction with charcoal producers during a Focus Group Discussion (see appendix 8f) showed that the method often triggers bushfires through the vents and other openings created in the process of making the mounds. Producers admitted that, the process usually damages the surface of the top soil and shrubs, as a result of the digging and burning during the production cycle. Moreover, the mound areas do not re-vegetate for several decades even when the rainfalls are enough to support regeneration of the vegetation.

ii) Wood Sources for Commercial Charcoal Production

The study has identified that majority (about 88 percent) of charcoal producers use live trees which are felled from the natural forest treated as common-pull resources. The study further identified that no fee is paid for the harvested trees. As indicated in figure 4.7 (a & b) the common methods of harvesting trees were by means of cutting at about 40cm above the ground level. Major tools used for harvesting the trees are axes, cutlasses and at times chainsaws. These methods of tree harvesting for charcoal hardly make it possible for tree rejuvenation.

iii) Inadequate Forest Sustainability Measures

Interventions by Charcoal producers to sustain the forest are limited in the area. Eighty eight percent of charcoal producers believe that trees regenerate (natural process) after cutting. As a result of this, they do not see the need to make conscious efforts at replanting trees after cutting them. The only forest sustainability measure adopted by the people is in the area of agro-forestry where only mango trees are grown for their fruits.

iv) Preferred Tree species used for Charcoal production

Charcoal producers have strong preference for shea trees in the production of charcoal in the study area. The shea tree which is crucial for the sustenance of the vegetation and livelihoods in the area is mostly destroyed. It was discovered that 48 percent of producers prefer to use the tree. With this prevailing situation, the shea tree is faced with extinction in the near future.

5.2.2 Economic Effects of Commercial Charcoal Production

The study further looked at the benefits charcoal production has on the economic situations of charcoal producers. This was seen to be the motivation for engaging in charcoal production.

i) Charcoal Production Levels in the Study Districts

The research indicated that charcoal is often sold in maxi bags. Depending on the type and quality of charcoal, the weight may range from 32 to 60 kg, but usually the average is 50 kg for charcoal from the study area. It was also determined that, an average of ten (10) maxi bags of charcoal is usually obtained from a single production process.

At a Focus Group Discussion, it was established that charcoal producers are able to carry out two productions within a month, each production process generating an average output level of ten maxi bags. The average monthly quantity of charcoal produced per producer was twenty maxi

bags. Per the number of producers interviewed in 2010, Wa East generated the highest quantity of charcoal (46,800 maxi bags) in the year 2010.

ii) Incomes Generated from Charcoal Production

The study again identified that a maxi bag of charcoal was sold at GH¢10.00 in 2010 across the three districts studied. Charcoal producers on the average produce ten (10) maxi bags of charcoal per single production. Again, they are able to undertake two productions within a month and this earns them an average monthly income of GH¢ 200 per producer. The charcoal industry averagely contributed GH¢1,209,600 to the micro economy of the study area in 2010.

iii) Other benefits emanating from commercial charcoal production

According to charcoal producers at a FGD, the industry enables them to acquire basic items necessary for their sustenance. Incomes from charcoal production enable them to acquire assets, such as bicycles, motor bikes, roofing materials among others. Again charcoal producers pointed out how the business makes it possible for them to buy consumer goods like food stuffs, clothing, children's educational needs; water and sanitary facilities.

5.4 Recommendations

Based on the findings and problems identified, the study put forward the following recommendations. The points recommended are some actions that could help address the environmental and social impacts of charcoal production.

- There is the need for charcoal producers to adopt modern methods of charcoal production in the charcoal producing area. Adopting modern methods such as the kilns ensures efficiency in the conversion and production of charcoal. The current system of charcoal production and tree harvesting promote waste of large volumes of wood, which of course increases the negative effects of charcoal business on the dwindling forest resources. The Ministry of Environment, Science Technology should formulate policies for protection and development of the charcoal sector. The Government of Ghana should consider subsidizing the cost of the improved kilns and be involved in the dissemination of new technologies. This will maximize the economic benefits from the charcoal industry without compromising ecological sustainability.

- There is also the need to increase wood supply through agro-forestry in farming areas by introducing village, community woodlots. The depletion of woodland resources due to charcoal

production is one of the most serious environmental issues in the study area. There is a need to prevent the indiscriminate cutting of live trees in order to ensure that the forest is conserved. The production of charcoal should be limited to specialized parks or forests and should not be allowed in any forest as currently practiced. The implementation of this proposal should be championed by the Forestry Commission in collaboration with the Ministry of Environment Science and Technology, Ministry of Lands and Natural Resources and community leaders and members.

- There should be massive awareness creation on forest resource management. Communities should be empowered to take the responsibility for protecting the environment. This will contribute to slowing down the current rate of deforestation. The initiative should be spearheaded by the Ministry of Environment, Science and Technology and the Ministry of Lands and Natural Resources in collaboration with the District Directorate of Agriculture Unit (DADU) under the Ministry of Food and Agriculture. Forest resource management should be considered as a civic responsibility and should be taken up by the National Commission for Civic Education in its education routine. Thus, these stakeholders in forest conservation should place more emphases on managing forest resources in collaboration with the local people. Their participation in the interventions and decisions that will have impact on them is crucial for creating a sense of ownership and hence sustainability. An aspect of this management might be that charcoal should be burnt only by people with permits in specified areas, as charcoal production has become widespread occupation among pastoral communities.

- Opinion leaders in production communities should be given a role in forest management through voluntary patrolling of the production sites to avoid indiscriminate felling of trees for charcoal production. Through the District Assembly, the applicants for permits should dispatch letters to the Ministry of Lands and Natural Resources who will then issue the license in consultation with the community elders. Applicants in their applications should indicate their plans and practical ways of replacing the resources they extract from the forest for charcoal production. The researcher believes that this strategy would slow down the rate of deforestation in the charcoal producing areas.

- Furthermore, both the district authorities and local community elders should visit and evaluate the situation of charcoal production sites. The successful implementation of this management scheme will enable the elders to regain control of the natural resources.

- Forest and woodland rehabilitation programmes by Environmental Protection Agency (EPA) and Ministry of Lands and Natural Resources are also very necessary. It is very crucial to implement Forest and woodland rehabilitation programmes/interventions through the establishment of grazing reserves, biodiversity reserves and fast growing tree planting programme. This will not only create employment opportunities for pastoral communities, but will also contribute to the maintenance of the environment and continuation of forest cover in one form or another. Again full participation of communities in all stages of such intervention is very critical.

- It is necessary to institute an information registration system by the Energy Commission and other stakeholders like the Energy Foundation, the Ministry of Lands and Natural Resources and Ministry of Environment, Science and technology that would include effective data on the quantities of charcoal produced and traded, the number of stakeholders and their dependents, values involved and benefit sharing along the supply chain to aid the decision making processes. An option would be the implementation of a survey at a national level that would also systematize the information on production and usage technologies in the country and the Upper West Region in particular.

5.4 Conclusion

The extensive cutting of tree species for charcoal has resulted in adverse ecological consequences. The major factor driving this worrying destruction to the natural environment is the financial returns charcoal producers derive from their activities. Further degradation of wood species without corresponding replacement will reduce the capacity of tree resources to provide pasture and energy requirement for livestock and society. This in turn would lead to massive human sufferings.

The destruction of the vegetation also has an impact on wildlife survival and ecological stability. The disappearance of plants and bush will mean the extinction of many of these wildlife species since the habitats are continuously threatened. Future generation may stand the disadvantage of seeing the mystic creation of nature in both plants and wildlife.

The method adopted by charcoal producers (earth mound) often triggers bush fires, causing severe damage to the already suffering forest. Government should develop policies for protection and development of the charcoal sector; subsidize the acquisition of improved kilns and promote the dissemination of new technologies. This will minimise the vegetation effects of charcoal

production whilst maximising the economic benefits from the industry. Proper regulation and control of forest resources will help achieve this. Again, developing good poverty reduction interventions in rural communities in the Upper West region will prevent the situation of many people taking up charcoal production which could have dire consequences on the natural environment.

REFERENCES

Achard, F., H. D. Eva, H. J. Stibig, P. Mayaux, J. Gallego, T. Richards & J. P. Malingreau (2002). *Determination of deforestation rates of the world's humid tropical forests.Science,* New York, 297**,** 999-1002. Steinway Publishing Ltd.

Amanor K., Brown D. and M. Richards (2002). *'Poverty Dimensions Of Public Governance and Forest Management in Ghana***'**, Final Technical Report, DFID Natural Resource Systems Research Programme, Project R7957 Overseas Development Institute, London, and the Institute of African Studies, University of Ghana, Legon.

Angelsen, A. & D. Kaimowitz (1999). *Rethinking the causes of deforestation: Lessons from economic models. World Bank Research Observer,* 14**,** 73-98.

Arnold J.E. M. (2006). *Wood fuels, livelihoods, and policy interventions:* Changing Perspectives-Elsevier publishing Ltd :Global Rights Department, London .

Arnold, M. & R. Persson (2003). *Reassessing the fuelwood situation in developing countries. International Forestry Review,* 5**,** 379-383.

Ayodele, A., P. Oguntunde, A. Joseph & M. D. Dias (2009), *Numerical Analysis of the Impact of Charcoal Production on Soil Hydrological Behavior, Runoff, Response and Erosion Susceptibility*. *RevistaBrasileira De Ciencia Do Solo,* 33**,** 137-145.

Babbie, E. and Mouton, J. 2004. *The Practice of Social Research.* Cape Town: Oxford University Press Southern Africa.

Barnes, D. F., K. Krutilla & W. Hyde (2002). *The urban energy transition: energy, poverty and the environment in the developing world.* Washington, DC: World Bank.

Broadhead, J., J. Bahdon& A. Whiteman (2001). *Woodfuel consumption modelling and results Annex 2. In Past trends and future prospects for the utilization of wood for energy. Global Forest Products Outlook Study*. Rome: FAO.

Cecelski, E. (2000). "*Household energy: new perspectives, gender perspectives.* Report Prepared for the National Renewable Energy Laboratory. Published by US Department Of Energy-USA NREL/SR-550-26889.

Energy Commission (2010), *Bio-energy Draft Policy for Ghana,* Accra, 10, 25.

FAO (1996)**. "***Policy Statement on Gender and Wood Energy***"**, Regional Wood Energy Development Programme in Asia, (www.fao.org/sd/egdirect date accessed 04/06/2010).

FAO (2000). "*The challenge of rural energy and poverty in developing countries***",** World Energy Council/Food and Agriculture Organization of the United Nations, London.

FAO (2001). *Report on Workshop on Combating the Effects of Drought and Desertification in Developing Countries***.** Kampala, 16-19.

Filmer, D. & L. H. Pritchett (2001*). Estimating wealth effects without expenditure data - Or tears*: An application to educational enrolments in states of India. *Demography,* 38**,** 115-132.

Frondel, M., Christoph M.S. & V. Colin (2008). *"A Regression on Climate Policy - The European Commission's Proposal to Reduce CO2 Emissions from Transport"* pages Ruhr Economic Papers 0044, pg. 1 – 23, Rheinisch-Westfälisches Institut für Wirtschaftsforschung, Ruhr-Universität Bochum, Universität Dortmund, Universität Duisburg-Essen. http://repec.rwi-essen.de/files/REP_08_044.pdf date accessed 24/04/2010.

Geller, H. **(**2004). Policies for advancing energy efficiency and renewable energy use in Ethiopia. *Energy Policy*, 32 (12): 1437–50, London

Government of Ghana, Northern Savannah Biodiversity project (NSBCP). Progress report. 2004, Natural resource management in the savannah Zone Bioscience,25-30Ghana Statistical Service (2009), *Ghana Living Standards Survey,* 45-50.

Ghana Statistical Service (2008). *Ghana Living Standards Survey Report of the Fifth Round (GLSS 5),* Accra, Ghana Statistical Service.

IEA (2002). *World Energy Outlook* 2002. International Energy Agency.

Kammen, D. M. & D. Lew (2005). *Review of Technologies for the Production and Use of Charcoal. Renewable and Appropriate Energy Laboratory Report*. http://rael.berkeley.edu/files/2005/Kammen-Lew-Charcoal-2005, date accessed 12th May 2011

Kindt, R., A. Kalinganire, M. Larwanou, M. Belem, J. M. Dakouo, J. Bayle & M. Karee (2008). Species accumulation within land use and tree diameter categories in Burkina Faso, Mali, Niger and Senegal. *Biodiversity and Conservation,* 17**,** 1883-1905.

Lazarus, M., S. Diallo & Y. Sokona (1999). *Energy and Environment Scenarios for Senegal. Natural Resources Forum,* 18**,** 31-47.

Lykke, A. M. (1998.) *Assessment of species composition change in savannah vegetation by means of woody plants' size class distributions and local information. Biodiversity and Conservation,* 7**,** 1261-1275.

Makhabane, T**. (**2002). *"Gender and sustainable energy issues in Africa: perspectives for the World Summit on Sustainable Development",* Regional Paper prepared for the WSSD, ENERGIA Network, www.energia.org/pubs/index.asp date accessed 25/07/2010).

Malimbwi, R. E., Misana, S., Monela, G., Jambiya, G., Nduwamungu, J. (2001). Charcoal Potential in Southern Africa. Morogoro, Tanzania: Sokoine University of Agriculture.

Mbow, C., O. Mertz, A. Diouf, K. Rasmussen & A. Reenberg (2008). *The history of environmental change and adaptation in eastern Saloum-Senegal-Driving forces and perceptions. Global and Planetary Change,* 64**,** 210-221.

Nature Conservation Research Centre (NCRC 1999). *Environmental Challenges in Ghana. Assessment of the impacts of Charcoal Fuel Production in the savannah zone,* 22, 45-50

Ogunkunle, A. T. J. & F. A. Oladele (2004). *Ethnobotanical study of fuelwood and timberwood consumption and replenishment in Ogbomoso,* Oyo State, Nigeria. *Environmental Monitoring and Assessment,* 91**,** 223-236.

Oguntunde, P. G., B. J. Abiodun, A. E. Ajayi & N. van de Giesen (2008)Effects of charcoal production on soil physical properties in Ghana. *Journal of Plant Nutrition and Soil Science-Zeitschrift Fur Pflanzenernahrung Und Bodenkunde,* 171**,** 591-596.

Pabi, O. and E. A. Morgan (2002)*Land-cover change in the Northern Forest-Savannah Transition in Ghana'*, commissioned technical report for the NRSP R7957 Project www.nrsp.org/pubs/index.rsp :date accessed 20/11/2010).

PROGEDE. (2005). Senegal Sustainable and Participatory Energy Management Project (PROGEDE). World Bank. Dakar.

Resource Watch Agenda (2010). *Poverty Reduction through Civil Society Advocacy in Natural Resources and Environmental Governance in Ghana,* Edition 4, 2-6.

Ribot, J. C. (1999). *Markets, states and environmental policy; the political economy of charcoal in Senegal.* In *Energy and Resources*. Berkeley, CA: University of California, Berkeley.

Robert van der Pla, (1995). *Energy Issues /Burning Charcoal Issues.* The World Bank Group, EPD Energy Note No-1 (date accessed 12/04/2010).

Sissala East District Assembly (2006-2009). *District Medium Term Development Plan,* Unpublished.

Sissala West District Assembly (2006-2009). *District Medium Term Development Plan,* Unpublished.

Tappan, G. G., M. Sall, E. C. Wood & M. Cushing (2004). *Eco-regions and land cover trends in Senegal*. *Journal of Arid Environments,* 59**,** 427-462.

UNDP/NED (1988). *The Charcoal Cycle, Baseline Study Final Report***,** Accra,65-69

UNDP (2009) *Assessment report on climate change in the Upper West and East Regions of Ghana.*

UNFPA (2009). *United Nations World Population Report. ed*. U. Nations. United Nations.

Wa East District Assembly (2006-2009). *District Medium Term Development Plan.*

World Bank Report (1990). *Rural Energy and Development: Improving Energy Supplies*-Washington DC.ISBNO.-8213-3806-4

APPENDIX – I

MOST AFFECTED COMMUNITIES BY COMMERCIAL CHARCOAL PRODUCTION IN THE STUDY AREA

District	Communities/localities	District	Communities/localities	District	Communities/localities
Sissala East	Tumu-capital	**Wa East**	Funsi – Capital	**Sissala West**	Gwollu –Capital
	Dimanjan I & II		Loggu		Jafisi
	Pina		Yaala		Duwie
	Navoirbie		Kundugu		Kuntulo
	Kundugu		Duu		Dajan
	Nahadakui		Sombissi		Nyimatii
	Chinchang		Tineabe		Bulu
	Tafiasi		Kulun		Jafisi
	Nabugubelle		Tuasah		Fachu
	Sakai		Kataa		Kwala
	Pieng		Baayiri		Zini
	Challu		Guonua		Niato
	Tasor		Kpalworgu		Gbal
	Nabulo		Tiisah		Wasei
	Gesi		Chaggu		Du West
	Wellembelle		Katua		
	Bugubio		Motigu		
			Bulenga		

Source: Forestry Commission, Sissala East, Sissala West and Wa East Districts

APPENDIX 2 CALCULATION OF SAMPLE SIZE

S/N	District/Location	No. of Communities Involved	Total Number of Certified Commercial Charcoal Producers	Sample Size	Questionnaires Administered	Response Rate
1	Wa EAST	17	203	195	195	100
2	Sissala East	16	144	135	135	100
3	Sissala West	15	179	170	170	100
	Total	**48**	**526**	**500**	**500**	

$n=N/1+N*ð^{2,}$ where n=sample size, N=sample frame and ð=margin of error
with a confidence level of 99%
Sample frame=526
Margin of error=0.01
therefore $n=526/1+526*0.01^2$
= 499.7= 500
Hence 500 commercial charcoal producers constituted the sample size

APPENDIX 3 CALCULATION OF AVERAGE NUMBER OF BAGS OF CHARCOAL PER PRODUCTION

Range of bags per Production	frequency(f)	Mid-Point(x)	fx
1_4	55	2.5	137.5
5_7	70	6	420
8_10	110	9	990
11_15	265	13	3445
Total	500		4992.5

Average no. of charcoal produced per production= $\sum fx/f$ =4992.5/500
=9.984
Therefore, average no. of bags = 10 bags

APPENDIX 4.RESEARCH QUESTIONNAIRES

TOPIC:
THE ECONOMIC AND VEGETATION EFFECTS OF COMMERCIAL CHARCOAL PRODUCTION IN THE UPPER WEST REGION

Introduction:
This questionnaire seeks to ascertain information from key individuals like you in aid of an academic study (thesis) for the award of an MSc degree at the KNUST. In the light of this, I hope you would furnish me with quality information to make this study successful please.
Please kindly write in the space provided where applicable and tick in the box where appropriate.

(I) PERSONAL DATA OF RESPONDENT

1. Sex: (a) male ☐ (b)female ☐

2. Age:

(a) 10-19 ☐ (d) 40-49 ☐

(b) 20-29 ☐ (e) 50-59 ☐

(c) 30-39 ☐ (f) 61 + ☐

3. How long have you been in charcoal production?
……
……
……
……

(II) *SOURCES OF TREES/WOOD FOR CHARCOAL PRODUCTION*
The target respondents here are mainly commercial charcoal burners.

4. Is charcoal burning your main economic activity?

(a) Yes ☐ (b) No ☐

5. (i) Are all trees/wood favourable for charcoal burning?

(a) Yes ☐ (b) No ☐

4. (ii) (If no) is it possible for you to mention the various types/species of trees used for charcoal production (Local or English name)?

(a) .....

(b) .....

(c) .....

(d) .....

(e) .....

5. (a)(If yes to 4 (i)), Are there some preferred species of trees/wood to others?

(a) Yes ☐ (b) No ☐

(b) If yes can you list them and state the reasons why this is so.?

(a) .....

(b) .....

(c) .....

(d) .....

(e) .....

6. (a) Do consumers prefer some category of charcoal to others?

(a) Yes ☐ (b) No ☐

(b) If so, why? .....

.....

7. What are the sources of wood for charcoal production?

(a) .....

(b) .....

(c) .....

(d) .....

(e) .....

8. (a) Which of the above sources is the most viable and why?

(a)....., (b)....., (c)..... and (d).....

(c) Why.....
.....

9. What methods do you use for charcoal processing?

(a) Traditional earth or saw dust mound procedure ☐

(b) Mobile metal kiln method ☐

(c) Pit kiln method ☐

(d) Others (specify).....

10. Which of the above is most preferred and why?

(a) ☐

(b) . ☐

(c) . ☐

(d) Why? .....

11. (i) Which specific parts of the tree/ wood are mostly used in charcoal processing?

(a) Branches, & ☐ (e) Roots ☐

(b) stems ☐ (f) All the above ☐

(c) leaves ☐

12. (ii) Which part is usually preferred?

Please specify and why? .....

(III) WELFARE ISSUES RELATING TO CHARCOAL PRODUCTION

13. (i) Do you think Charcoal business contributes to your welfare?

(a) Yes ☐ (b) No ☐

(ii) If yes, in what ways does it support you?

(a) .....
(b) .....
(c) .....
(d) .....
(e) .....
(f) .....

14. How many maxi bags of charcoal do you usually harvest from a single production?

(a) 1-4 ☐ (c) 8-10 ☐

(b) 5-7 ☐ (d) 11-15 ☐

15. About how much do you usually sell a bag of charcoal?

(a) Gh¢ 8 ☐ (b) Gh¢ 9 ☐ (c) Gh¢ 10 ☐

16. About how much income do you usually generate per production?
.....

17. How often do you engage in charcoal production in a year?

(a) When in need of money ☐ (c) Dry season ☐
(b) All the timed ☐

18. Where do you often burn/produce the charcoal?

(a) Around the house ☐ (b) In the bush ☐

(b) Farm plots ☐

19. Could you give some reasons to your answer in the above question

(a) .....

(b) .....

20. Where do you usually sell the charcoal produced?

(a) District capital market (head loads& vehicles) ☐

☐

(b) Outside the district (Bolgatanga & Wa by vehicles)

(IV) LOCAL PERCEPTIONS & KNOWLEDGE ON SUSTAINABLE USE OF RESOURCE; TREE SPECIES

21. Do you sometimes experience difficulties in obtaining the wood you need for charcoal production?

(a) Yes ☐ (b) No ☐

If yes, what do you think has accounted for this?

.....

.....

22. Have you ever received training on how to improve upon your charcoal business?

(a) Yes ☐ (b) No ☐

23. Do you replant trees sometimes after cutting some for charcoal production?

(a) Yes ☐ (b) No ☐

24. (i) In your own view do you think it's necessary to be planting trees purposely for charcoal production?

(a)Yes ☐ (b) No ☐

(ii) Give reasons for your answer……

……

.....

.

25. Do you have any knowledge on wood-lots?

(a) Yes ☐ (b) No ☐

26. If yes, how many wood-lots are in your area?

.....

.....

.....

27. Do you think it is beneficial for charcoal burners to form themselves into associations?

(a) Yes ☐ (b) No ☐

28. Give reasons for your answer

….....

….....

.....…….....

(V)IMPACTS OF CHARCOAL PRODUCTION ON THE ENVIRONMENT

29 Do you know whether charcoal production reduces forest cover?

(a) Yes ☐ (b) No ☐

If yes, what are some other possible reasons for this?

.....

.....

……

……

30. What do you think is the cause for difference?

(a) Charcoal activities ☐ (b) Bush Fire ☐

31. In your own way, what needs to be done?

(a)……..

(b)……..

(c)……

THANK YOU VERY MUCH FOR YOUR EFFORT (AYEKOOO).

APPENDIX 5: CHECKLIST FOR THE REVIEW OF GHANA'S BIO ENERGY POLICIES ENERGYCOMMISSION

This checklist is to help the researcher examine the economic and vegetation effects of commercial charcoal production in the upper west region

1) As a government establishment, what is your mission.....
   .....
2) Does your organisation have some specific policies for the production and use of bio energy in the country Yes ☐ ☐ No
3) If yes, could you outline them.....
   .....
   .....
4) Which year were the policies outlined formulated.....
5) What are the goals and objectives of the policies.....
   .....
6) Could you outline the strategies for the achievement of the goals.....
   .....
   .....
7) Do you currently have any bio-energy related interventions Yes ☐ No ☐
8) If yes, could you describe them.....
   .....

APPENDIX 6: CHECKLIST FOR THE ASSESSMENT OF DISTRICT ASSEMBLY'S REGULATIONS ON COMMERCIAL CHARCOAL PRODUCTION

NAME OF INSTITUTION/DA.....

This checklist is to help the researcher examine the economic and vegetation effects of commercial charcoal production in the upper west region

1) As a government establishment, what is your mission statement.....
   .....
   .....
2) Does your organization have some specific bye laws on charcoal production?
   Yes ☐ No ☐
3) If yes, could you mention them.....
   .....
4) What are the goals and objectives of the bye laws.....
   .....
5) Could you outline the strategies for their enforcement.....
   .....
6) Do you have any challenges in the implementation of these bye laws
   Yes ☐ No ☐
7) If yes, could you describe them.....
   .....
8) What measures are in place to address the challenges.....
   .....

APPENDIX 7: CHECKLIST FOR THE ASSESSMENT OF FORESTRY COMMISSION'S DECENTRALISED PROGRAMMES ON COMMERCIAL CHARCOAL PRODUCTION

NAME OF DISTRICT.....

This checklist is to help the researcher examine the economic and vegetation effects of commercial charcoal production in the upper west region

1) Do you have the incidence of charcoal production in your district?

   Yes ☐ No ☐

2) If yes, as a natural resource based establishment, do you have district programmes on mitigating the effects of commercial charcoal production

   .....

3) What are the goals and objectives of the programmes.....

   .....

4) Could you outline the strategies for their implementation?.....

   .....

5) Do you have any challenges in the implementation of these bye laws

   Yes ☐ No ☐

6) If yes, could you describe them.....

   .....

7) What measures are in place to address the challenges.....

   .....

APPENDIX: 8 CHARCOAL PRODUCTION & MARKETING IN PICTURES: CASE OF SISSALA EAST AND WEST DISTRICTS

(a) Earth Mount Method of Charcoal Production in the District

(b) Rural Women Packaging Charcoal at the Roadside for Sale

(c) Roadside Seller at Dimajang in the Sissala East District – UWR

(d) Women engaged in negotiation with middle sellers for good price @ Kunchorgu – Sissala East District UWR

(e) KIA Track heavily carting charcoal out of Sissala East District Capital -Tumu and Heading for Bolgatanga

(f) Households engaged in dialogue during FGDS in Santijan in the Sissala East District - UWR

(g) Donkey Carts Transporting Charcoal and other goods from Sub-districts to District Capital-TUMU

(h) A little boy helping the mother to sell charcoal at the roadside on a market day

(i) Donkeys taking a rest after their usual carting of charcoal to TUMU market

(j) Charcoal for Sale @ Kuntulo - Sissala West