PRESBYTERIAN UNIVERITY COLLEGE, GHANA

FACULTY OF DEVELOPMENT STUDIES

DEPARTMENT OF ENVIRONMENTAL AND NATURAL RESOURCES MANAGEMENT

FUELWOOD HARVESTING PRACTICES AND HUMAN RELIANCE IN NAVRONGO FOREST DISTRICT

BY

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A Dissertation submitted to the Department of Environmental and Natural Resources Management of the Faculty of Development Studies, Presbyterian University College, Ghana in partial fulfilment of the requirements for the award of a Master of Science Degree in Natural Resources Management

BY

KWABENA ADU-BONNAH

SEPTEMBER 2020

DECLARATIONS

Candidate's Declaration

I hereby declare that this Dissertation is the results of my own original research and that no part of it has been presented for another degree in the university or elsewhere.

Name: KWABENA ADU-BONNAH

Candidate's Signature:................................. Date:....................................

Supervisor's Declaration

I hereby declare that teh preparation and presentation of the dissetation were supervised in accordance with the guidelines on supervision of dissertation laid down by the Presbyterian University College, Ghana .

Name: Prof. Edward D. Wiafe

Supervisor's Signature:................................ Date:................................

ABSTRACT

Global interest in fuelwood as a renewable biomass energy resource has soared in recent times because it can be developed and used sustainably. Ghana's forest resources are subject to many pressures, and therefore there is a need to consider sustainable long-term resource management options. Fuelwood remains the primary source of energy in both urban and rural areas within the study area. The current research aimed at gaining insights into the fuelwood harvesting activities in some selected rural communities in the Navrongo Forest District. Using a structured interview questionnaire comprising closed-ended questions, 246 actors from 20 local communities were interviewed across four political districts. Overall, 32 tree species belonging to 20 families were listed as tree-species commonly harvested and preferred as fuelwood. The study revealed that the most preferred tree-species for fuelwood were mainly indigenous trees, which were generally low in distribution in the area. The famous “Rosewood” (*Pterocarpus erinaceus*) currently listed by the IUCN as an endangered tree-species was found to be locally valued for its quality flaming and charcoal producing characteristics. Furthermore, there were more male actors (53.3%) in fuelwood harvesting activities than females (46.7%). Majority (52%) of the actors were least educated and in their late 40years. Knowledge of environmental conservation among the actors was high, and fuelwood harvesting constituted a significant part of their livelihood. Based on this study, less economic indigenous tree-species such as *Anogeisus leiocarpus* possess superior fuelwood characteristics, and they may be considered for inclusion in future energy plantation programs in the study area.

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DEDICATION

I dedicate this work to my wife and kids.

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CHAPTER ONE

INTRODUCTION

The primary use of the world's wood is not as building materials or paper, but as fuel. It is a pattern both ancient and modern and one that is not likely to change in the next several decades (Agea *et al.*, 2010; Matthews *et al.*, 2000). Wood has been used as fuel for millennia in both developed and underdeveloped countries worldwide (Erakhrumen, 2011). Burning of wood is the most extensive use of energy derived from solid fuel biomass and used for cooking and heating in many places around the world in a stove or an open fire (Ouma & Gottwald 2009). It is also used as a fuel in many industrial processes and occasionally for fuelling steam engines and steam turbines that generate electricity. Global interest in fuelwood as a renewable biomass energy resource has soared in recent times because it can be developed and used sustainably (Erakhrumen, 2011). As a sustainable energy source, fuelwood is viable for generating electricity in areas with easy access to forest products and by-products (Obiri *et al.*, 2015).

Fuelwood is consumed by more than Two billion people globally (Jin *et al.*, 2017). Global fuelwood consumption is estimated at 1.8 billion m^3. This comprises 7% of the world's total primary energy consumption, with 76% of it being used in developing countries, particularly in Africa (IEA, 2019; Erakhrumen, 2011). Faced with sharp fluctuations in fossil energy prices, wood for energy is becoming increasingly competitive and attractive for several reasons. Firstly, unlike fossil fuels, wood is a renewable energy resource whose availability is increasing, in particular in Europe (Aguilar, 2018). Secondly, the use of energy from wood does not contribute to global warming. Although it emits carbon dioxide on combustion, wood is also a natural source of carbon dioxide absorption through forest growth. In the face of increasing environmental concerns, wood is a perfect substitute for polluting fossil fuels. Finally, forestry to produce wood for energy creates more jobs than are generated by other forms of energy (Sepp *et al.*, 2014).

The primary source of energy in both urban and rural areas within Developing Countries is biomass (FAO, 2007). Biomass is commonly available in two forms: charcoal and fuelwood. Charcoal is the energy that is made from wood, while fuelwood is collected and used directly from the field (Njenga & Mendum 2018). Fuelwood gathered from forested areas is the most important source of domestic energy for the developing world (Heltberg et al., 2000). African countries still heavily rely on fuelwood to meet their basic energy needs. An estimated 60-85% of Africans use fuelwood as their primary source of fuel (Asamoah et al., 2016). In most rural households, women collect and consume fuelwood for household use (Imran & Ozcatalbas, 2020; Das *et al.*, 2019). Approximately 60 percent of the world's total wood removals from the forest and outside forests are used for energy purposes. While the developed countries use only 30 percent of wood produced for energy, the developing countries use 80 percent for the same purpose (Ahuja & Tatsutani, 2009). The bulk of energy supply in Ghana is met from biomass, including firewood and charcoal. In Ghana, firewood accounts for about 71% of total primary energy supply and about 60 percent of the final energy demand (Asumadu-Sarkodie & Owusu, 2016).

Many households use several biofuels. The reasons for doing so vary considerably, including cultural preferences and availability as well as economic factors (Malla & Timilsina, 2014). Firewood currently accounts for a more significant share of global energy consumption than all other forms of “renewable” energy combined. The overwhelming majority of this consumption, however, is based on the traditional use of wood and charcoal in developing countries. Due to the low efficiency of such use and the often-poor quality of associated resource management, much of the firewood consumption is unsustainable (Démurger & Fournier, 2011).

1.1 Background to the Study

A great deal of effort has been directed at improving access to alternative forms of energy and encouraging households to switch to them (Amissah-Arthur & Amonoo, 2016); nevertheless, traditional biomass (fuelwood utilization) will continue to constitute a significant source of energy for the foreseeable future, especially in sub-Saharan Africa (FAO, 2017). Consequently, strategies are needed to enable the traditional biomass sector to both improve efficiency and manage fuelwood resources more sustainably. Wood is society’s oldest source of energy (Pain, 2017). Its use for cooking and heating remains vital to the daily energy needs of over two billion people in developing countries. Ghana's forest resources are subject to many pressures, and therefore there is a need to consider sustainable long-term resource management options (Ghana Forestry Commission, 2017). Throughout sub-Saharan Africa, deforestation, and degradation resulting from increased population pressure, agricultural encroachment, uncontrolled, and wasteful fuelwood harvesting, including inefficient charcoal production, are common (Yalew, 2015; Rudel, 2013).

1.2 Statement of Problem and Justification

The expansion of Ghana's agriculture and Industrial sectors has brought enormous economic growth to the detriment of the environment leading to issues such as deforestation (Ghana Forestry Commission, 2017). According to FAO (2015), Ghana recorded annual deforestation rates of 0.4 % and 0.6 % for the periods of 2005-2010, and 2010-2015 respectively. The Global Forest Watch estimated tree cover loss of 753,074, 783,408, 950,486 and 560,080 ($tcha^{-1}$) for the years 2016, 2017, 2018 and 2019 respectively. According to UNEP (2019), the heavy reliance on wood-fuel has contributed to this unsustainable trend of deforestation. This, in the long term, may lead to a national ecological disaster if sustainable measures are not put in place.

Although the exploitation of wood resources for fuelwood is not the main cause of deforestation, there are indications that the preferred fuelwood species are gradually disappearing (Kwarteng, 2015). The Energy Commission of Ghana estimated that Ghana is likely to consume more than 25 million tonnes of firewood and charcoal by the year 2020. Most of these firewood supplies are however, anticipated to come from standing stocks (15 million tonnes from standing stock and 10 million tonnes from natural regeneration according to the Energy Commission of Ghana (2006). This means that firewood supply currently is no longer coming from regeneration but standing stocks. The implication is a direct depletion of standing stocks with its repercussion increase in deforestation rate.

1.3 Purpose of the Study

According to the Population and Housing Census (PHC) conducted in 2010, 73.3% of households in the Kasssena Nankana West District rely on wood, whereas 11.9% use charcoal and 10.5 percent use crop residue as their primary sources of cooking fuel (Ghana Statistical Service, 2012). The heavy dependence of a large segment of the population in the District on wood base fuel serves as a significant environmental issue in the area and has become a severe threat to the ecosystem (UNDP, 2004). Wood dominates as fuel probably because of easy access, especially to the rural population (which constitutes a more significant proportion of the district's population) and its inexpensive nature. Households using wood as a source of energy for cooking remained significant for both urban and rural areas in Ghana (Abdul-Wakeel *et al.*, 2019; Kwakwa, Wiafe, & Alhassan 2013).

Following the 2010 Statistical Survey Report on household energy requirements across the country, the government of Ghana became concerned about the need for concerted action to preserve the country's wood resources. Its stated objectives are a) to manage the fuelwood resources by methods ensuring improved productivity, efficiency in transformation and distribution, and b) efficient use of these resources through the promotion of improved end-user devices and best practices (Ofori-Nyarko, 2010). However, our preliminary studies in the district revealed that data on firewood demand, preferred tree species, harvesting methods, supply sources, management, and conservation practices are very scarce, unreliable, thus making it very difficult to undertake relevant fuelwood management planning activities.

1.4 Research Questions

1. What is/are the main socio-economic characteristics of the actors in the fuelwood harvesting activities?
2. What are the preferred qualities for selecting and harvesting commonly used tree-species as fuelwood?
3. What harvesting methods, tools, and trading points are used by actors in the fuelwood activities?
4. How much human effort is expended by actors in the fuelwood harvesting activity?
5. What perceptions exist among actors on the environmental impacts of the fuelwood harvesting activities?

1.5 Significance of the Study

Fuelwood utilization and consumption is a critical component of Ghana's energy policy. All biomass energy as an alternative to fossil fuel has its advantages and disadvantages. The diversification of biomass energy is an alternative in itself. Future energy development will be context-specific based on locally available resources, most probably biomass energy from established woodlots. This, therefore, calls for the need to investigate the preferred wood species and their characteristics for planning and decision purposes at both the Community, District, and National levels. The social, economic, and environmental impacts of wood collection activities are also worth investigating.

General Objective

This research aims at gaining insights into the fuelwood harvesting activities in some selected rural communities in the Navrongo Forest District in order to facilitate management decisions on fuelwood harvesting activities and to safeguard the environment against degradation.

The specific objectives of this study were:

1. To determine the main socio-economic characteristics of the actors involved in the fuelwood activities in the study area.
2. To identify the commonly preferred qualities of tree-species harvested for fuelwood by the actors in the study area.
3. To examine the method used, parts harvested, the main trading points, as well as the channels used by actors in obtaining permits for fuelwood collection.
4. To assess the actor's knowledge of environmental conservation and their perceptions on the impact of tree cutting as fuelwood on their environment.

1.6 Limitations of the Study

The difficult aspect of the study was mainly about getting access to the research respondents. This is because most of the interviews were conduct directly on the field where fuelwood harvesting was taking place. In some cases, the respondents were encountered in the process of conveying the harvested wood, thereby making the administration of the question cumbersome. Another major limitation of the study had to do with the location and language barrier. The participants were mainly locals who could only understand and speak one of the local languages (i.e., Kasim, Nankan or Buili) which is predominantly spoken in the area. This had an influence on the understanding of the participants as well as their responses. An understanding of the questions and its interpretation into different languages could have had an influence of the responses provided by the participants in this study. Time and accessibility to a wider section of the targeted communities in the remote areas was a major challenge during the study, however, the current results of this study give a general representation of the fuelwood harvesting situation in the area and the result of any future study could yield similar results.

1.7 Delimitation of the Study

In some local communities' principal researchers (strangers) are not easily permitted to interact with a segment of the community members (e.g., women) unless known to the local people. To ensure full participation of the target population (both women and men) in this current study, locals (Field Assistants) were recruited from the communities and trained to administer the questionnaires in the local dialects. This approach helped in eliminating or reducing the researcher's research participant gap that often exists in community or social research.

In terms of the geographical focus, the study area was ideal with the number of individuals who participates in the harvesting of fuelwood as a livelihood support activity on daily basis. To deal with time constraints during the data collection period, 12 field assistants were trained and engaged for the fieldwork across the selected communities. Each trained field assistant could speak at least one of the local dialects fluently hence could interpret the questions to the participants.

1.8 Organization of the Study

The study is organized into six chapters as follows; Chapter One give a general introduction on the fuelwood harvesting practices from a global to a local perspective. It highlights the background of the study, the problem statement, significance of the study, objectives of the study and the expected outcomes. Chapter Two covers a review of related articles from previous studies that provides support for the study from a broad perspective. It also outlines and discusses the various methods and approaches that have been applied by other researchers to understand the fuelwood issues from different locations. Chapter Three describes how the study was conducted by the student. Chapter Three provides details on the study area, types and sources of data used, sample size and sampling procedures, data collection and analytical tools. Chapter Four illustrates the outcomes of the study presented in a narrative form through tables, figures, statistics, charts, graphs. Chapter Four also discusses the findings from the relative to previous studies. The Chapter is set to compare and contrast the results of the study with that of other researchers. The Chapter evaluates and examines the outcomes of the study with respect to the current theoretical position on the issue and also on the basis of conservative practice. Chapter Five provides a summary of the study outcome and focuses on the researcher’s position based on the outcomes of the study. Chapter Five also provides details on the inferences drawn and lessons learnt by the researcher based on the outcome of the study.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

2.0 Introduction

A good number of studies have been conducted about fuelwood utilization in different parts of Ghana and elsewhere around the world. This chapter highlights some of the main issues that have been discussed by earlier studies to serve as a foundation for the current study.

2.1 Definition of Fuelwood

In this current study, fuelwood is defined as all types of fuels originating directly or indirectly from woody biomass. The main types of wood-fuel in less-developed regions of the world are fuelwood and charcoal. Fuelwood is wood-fuel in which the original composition of the wood is preserved; it includes wood in its natural state and residues from wood-processing industries (FAO, 2004).

2.2 Fuelwood Collection and Deforestation

The total land area of Ghana had 34 percent, originally rainforest coverage (Amuah, 2011). Since the colonial era, the exploitation of timber for commercial purposes has been part of the Ghana economy. It is only since the start of the Economic Reforms Programme (ERP) in 1983 that deforestation has become a serious concern because of the over-exploitation of forest resources (Amuah, 2011). Forest resources in Ghana are being depleted at a faster rate than before compared to other developing countries. Since 1981, the average annual rate of deforestation in Ghana is estimated at 2.0 percent compared to 0.9 percent for all tropical forests, 0.6 percent for Zaire, and 0.6 percent for Brazil (Amuah, 2011; Yiridoe & Nannag, 2001). The high forests of Ghana have lost about 4,9 million hectares (as of 2010), with an annual deforestation rate of approximately 2% (FAO, 2010). In Ghana, efforts by the government to reduce deforestation have yielded limited success. This primarily is because many of the initiatives were misguided, and failed to deal with deforestation as a complex, dynamic, and interwoven process (Marfo, 2010).

2.4 Forests and Rural Livelihoods

Fuelwood production have been age-old activities in most parts of the Developing World for subsistence and commercial purposes. Studies in India, Pakistan, and Kenya have shown that wood and other biomass resources generate at least 20 times more local employment within the national economy than other forms of energy, per unit consumed. This is due to the vast amount of unskilled manpower or labour required for harvesting, processing, transporting, and trading of this fuel (Obiri *et al.*, 2015). In Ghana, fuelwood gathering and sale coupled with fuel-based income-generating activities, are significant livelihoods in forest fringe rural communities (Amuah, 2011). Poverty levels are generally high in Ghana, with 30 percent of the population living on less than 1 US dollar a day and 54 percent living on less than 2 US dollars a day (Ghana Statistical Service, 2018). Forty-nine percent of the Ghanaian population live in rural areas (Ghana Statistical Service, 2012), with 39.2 % of them being poor or living at the poverty line (World Bank, 2017). Many of the rural populations rely on adjacent forest resources, mainly, fuelwood as a secondary income source to supplement farm income (Obiri *et al.*, 2015).

In Ghana, fuelwood constitutes about 70% of the energy consumed (Energy Commission, Ghana 2006). Fuelwood is a significant source of domestic energy in rural areas as it is used for cooking, heating, and lighting as well as energy for rural enterprises (Wiafe & Kwakwa, 2013). Seventy-three percent of Ghana's population uses fuelwood wood for domestic activities in rural and (Ghana Statistical Service, 2012). In urban areas, fuelwood is the primary source of energy for commercial activities, particularly for processing enterprises as well as service industries and institutions with some domestic consumption. According to (FAO, 2017) more than 2.2 million households depend on fuelwood or charcoal for cooking and heating in Ghana, 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). Fuelwood thus makes a significant contribution to food preservation, food security, and cash earnings for rural and urban people. Besides, there are also about 600, 000 small-scale enterprises in commercial activities, such as chop bars, street food, and grills, which depend on fuelwood or charcoal as their primary source of energy (Afolabi 2017; Broadhead *et al.*, 2001).

For centuries fuelwood production and marketing in Ghana have been done by subsistence and commercial entities whose activities have remained mostly informal with scarcely any management procedures to ensure sustainability (Obiri et al., 2015). This has resulted in extensive exploitation of fuelwood resources with increasing demand over the years. Ghana is one of the countries with high per capita fuelwood demand in West Africa (Kabo-Bah & Diji 2018; Anang *et al.*, 2011). However, supply-consumption trends from

2006-2012 show a mean surplus of 4.1kilotonnes of fuelwood not consumed after extraction (Figure 1) (Energy Commission, Ghana 2013). This means that the fuelwood supply often exceeds demand. The excess possibly goes to waste from the decomposition of the wood. The annual per capita fuelwood consumption is estimated to be 1.0 m^3 round wood equivalent (FAO, 2010).

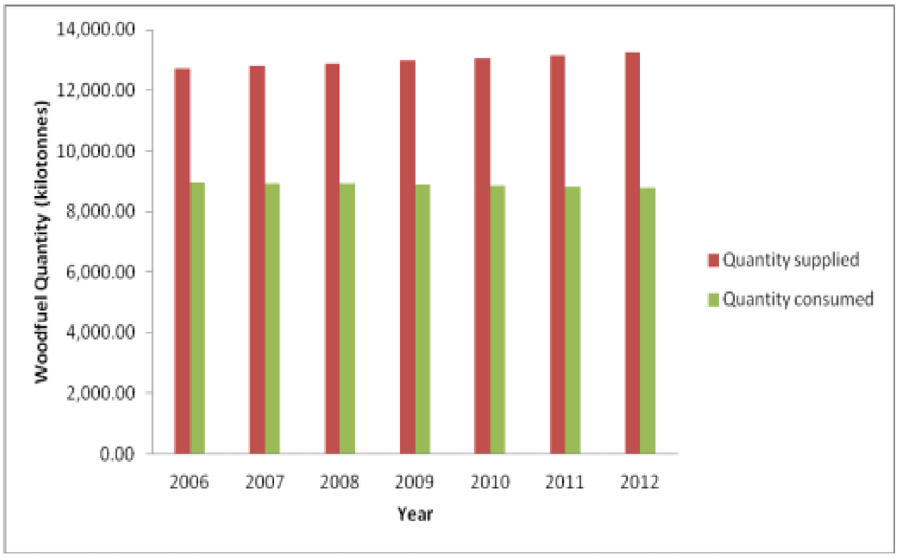

Figure 1: Showing supply-consumption trends from of fuelwood and charcoal from 2006-2012 (Source: Ghana Energy Commission Report, 2013)

2.5 Household Dependency on Fuelwood

According to the Resource Watch Agenda (2010, as cited in Lurimuah, 2011), Ghana has lost more than seventy-five percent of its estimated 8.2 million hectares of forest cover due to the imbalances between extraction and replacement of forest resources. It is also reported that the majority of households in African, including Ghana, depend on traditional fuels to meet their daily energy needs, which is likely to continue for many years to come (Abdul-Wakeel et al., 2019; Ouedraogo 2017). As indicated by (Erakhrumen, 2011), the consumption of wood-fuel by households for cooking and other forms of domestic heating and production processes is very much crucial in most Sub-Saharan African countries (SSA). Available records estimate that over ninety percent of the persons in Africa depend on either firewood or charcoal for cooking and other heating needs (FAO, 2018).

In Ghana, the bulk of energy supply is from wood-fuel, which accounts for about sixty-five percent of the country's energy supply mix (Singh et al., 2015; Agyeman et al., 2012). The number of households that will rely on wood-fuel for the supply of their daily energy requirements is anticipated to increase incessantly (Food and Agricultural Organisation (FAO, 1999) cited in (Erakhrumen, 2011). As a coping strategy, families living in poverty endemic areas tend to diversify their livelihood sources. Commercial wood harvesting and charcoal production are, thus, a significant source of alternative livelihood providing incomes to support households, especially during the long dry seasons (Kiruki *et al.*, 2019; Smith *et al.*, 2017; Obiri et al., 2014). (Guo, 2007) adds that fuelwood gathering and charcoal production are often not a significant source of income for rural households but rather a source of off-farm income in the long, lean seasons.

Existing information, according to the Food and Agriculture Organisation, FAO, (2014), indicates that fuelwood accounts for about 90% of the timber harvested in most developing countries (FAO, 2014). Guo (2007) in a study found that charcoal producers mainly obtained the wood free from the forest and farmlands. The entire society endures the consequences from the use of the forests as a common-property resource, while benefits accumulate to the individual user of the forest resource. Emanating from the use of the forests as common-property resources and the excessive use of fuelwood as household cooking fuel, the Energy Commission (Energy Commission Ghana, 2013) reveals that there is an imbalance between wood-fuel consumption and yield in Ghana. The Commission also predicts that the over-dependence on wood-fuel would increase consumption levels four times as much as that consumed in 2000 by 2020.

Demand for wood-fuel in Ghana in 2000 was about 14 million tons but was projected to rise to between 38-46 million tons by 2012 and 54-66 million tons by 2020. The anticipated growth in wood-fuel consumption is in accordance with the FAO,'s prediction of a constant increase in charcoal consumption in SSA (FAO,, 1999 cited in (Erakhrumen, 2011). Otto-Danquah (2010) found that the significant charcoal producing areas in Ghana is showing physical signs of forest depletion because of over-extraction from the forest without commensurate replacement.

2.6 Household Energy preferences

The energy ladder model has been used as a basis for explaining household fuel choice in the past by researchers (Choumert *et al.*, 2017). With high dependence on household income, the energy ladder model affirms that the process of household energy choice passes through three main stages. The first stage of the ladder is marked by dependence on biomass. In the second stage, households move to what is termed "transition" fuels such as kerosene, coal, and charcoal. Such a move is motivated by an increase in household incomes, deforestation, and urbanization (Hiemstra-van der Horst & Hovorka 2008). In the third and final stage of the process, the households switch to LPG, natural gas, or electricity (Heltberg, 2003). Even though the energy ladder model has been praised for its ability to show a strong relationship between income and fuel choices, it is also strongly criticized on the ground that one is likely to misinterpret the term fuel choice with fuel switch (Heltberg, 2003) which according to (Njong & Johannes 2011) denotes an introduction of higher fuel to phase out traditional fuels.

Israel (2002) argues that women may have stronger preferences for using a cleaner energy source than fuelwood, given their greater involvement in cooking (Abebaw, 2007). On the other hand, Njong and Johannes (2011, as cited in Wiafe & Kwakwa, 2013) in their study argued that households headed by women were more likely to use firewood for cooking because "social norms discourage men from participating in fuelwood procurement and cooking." Accessed literature is also not clear on the effect of gender of the household head on fuelwood use because it cannot be determined a priori. However, older people tend to develop a habit for traditional heating and cooking more than younger households (Démurger & Fournier, 2010), and thus a positive relationship between age and fuelwood usage is expected to occur.

The number of dependent children is expected to have a positive effect since the larger size is likely to increase household fuelwood usage (Abebaw, 2007). The marital status of the respondent, which is a binary variable, takes on the value of 1 if the respondent is married or cohabitating and zero if single or widowed. It is expected to have a negative effect on fuelwood usage since the two may pull resources together and acquire alternative energy for domestic activities such as cooking. The level of education of an individual is expected to have a negative effect on fuelwood usage, as seen from studies like (Njong & Johannes, 2011). The reason is that "education may change the taste in favour of modern fuels or it may improve a decision maker's understanding of the costs and benefits of using modern energy to family welfare such as health" (Abebaw, 2007). Onoja *et al.*, (2012; Abebaw, 2007) in their research on household energy choices reported that a higher level of household income would expectedly reduce the utilization of fuelwood (greenwood). Household heads who are employed are less likely to use firewood because they are more likely to make more money than their unemployed counterparts (Njong & Johannes, 2011) and thus can afford alternative energy sources. From literature, electricity utilization takes on the value of one (1) if the household uses electricity and zero (0) if the household does not use electricity. This is expected to reduce the usage of fuelwood because of the convenience involved. Similarly, LPG usage takes on the value of one (1) if the household uses it and zero (0) if the household does not use LPG, and this is likely also to reduce fuelwood usage (Wiafe & Kwakwa, 2013).

2.7 Review of The Fuelwood Sector in Ghana

Fuelwood forms the main energy source for cooking for most households in Ghana. Fuelwood is obtained from deadwood in the fallow, from woods cut in clearing the fallow for the new farm, from species specifically cultivated or preserved for firewood, and from branches lopped and pruned from large trees (Ndayambaje & Mohren, 2011). Women are primarily responsible for the collection of firewood and its utilization in cooking. However, the collection of firewood is a shared responsibility, and men frequently bring fuelwood home when returning from work on the farm plot (Kwarteng, 2015). So many fuelwood species of variable quality have been identified to be in use in Ghana, including Cashew nut, *Talbotiella spp, Cassia spp, Azadirachta* *indica spp*, and *Albizia spp*. High-grade firewood has the qualities of burning efficiently, slowly, and without creating much smoke. The best firewood species are considered to include; *Celtis zinkeni, Azadirachta indica, Odum (Militia excelxa), Mahogany (Enthandrophragma spp),* and some Citrus spp. However, many of these are not in common use or have other important uses such as fruits or wood (lumber). Most farmers make a compromise between the quality of firewood and availability or rely on fast-growing exotic species (Kwarteng, 2015).

According to the Ghana Energy Commission's (2003) report, there were sharp increases in fuelwood consumption from 15.9 million cubic meters to 20.6 million cubic meters, that is, 30% within ten years (1988 – 1998) period (Energy Commission Ghana, 2003). The alarming rate of forest degradation (see Fagariba et al., 2018; Insaidoo *et al.*, 2012) coupled with the high demand for fuelwood resources triggered the government of Ghana to become increasingly concerned about the need for concerted efforts to preserve the country's fuelwood resources with the following objectives:

1. To manage the fuelwood resources by methods that will ensure improved productivity, efficiency in transformation and distribution,

2. Efficient use of fuelwood resources through the promotion of improved end-user devices and best practices.

Nevertheless, data on fuelwoods are very scarce and where available are not very reliable, thus, making it very difficult to undertake relevant planning activities and environmental impact assessment activities on fuelwood use (FAO, 2018). The Energy Commission has been established as a public institution under the Act of Parliament 1997 and been given the statutory mandate to manage and regulate the utilization of energy resources in Ghana. The Energy Commission, since its formation, has been considering measures to develop and recommend national policies for the efficient and cost-effective utilization of the fuelwood resources (Kwarteng, 2015; Manso-Howard, 2011).

2.8 Value of Fuelwoods

An understanding of the technical potential and versatility of wood as a source of fuel is a pre-requisite to a meaningful economic analysis of projects involving the conversion of the establishment of forests for the production of energy (Sepp et al., 2014). Wood is composed principally of cellulose and lingo-cellulose together with gums, resins, inorganic matter and a variable amount of moisture, the amount depending on the kind of wood, the season in which it is cut and the extent to which it has been allowed to dry (Matuana & Stark, 2015). The simplest and easiest way of obtaining forest energy is from the combustion of wood. Fuelwood can be obtained from any tree, whether occurring naturally or planted, either directly from the forest or waste material produced at sawmills and wood-using industries.

2.9 Fuelwood as A Renewable Fuel/Energy

The sharp price increases of fuels and tradable goods in the late 2000s sparked off by oil producers' exercise of their monopolistic might, comes as a timely warning of the likely effect on the world economy of a predictable general shortage of hitherto easily-obtainable fossil fuels. Increasing supplies of energy are needed to maintain a basic standard of living for a rapidly expanding world population and economic growth, but it is known that coal, gas, and oil reserves cannot continue to indefinitely meet the significant part of the world's energy needs according to the Organization for Economic Co-operation

Development (OECD, 2011). The forecasted economic crisis, if allowed to develop, will have severe repercussions upon the developing world in its struggle to raise the living standards and will shake the structure of the affluent society to its foundations.

Manso (2007) in a review of fuelwood literature noted that it was not imperative to develop vast supplies of nuclear energy for mankind’s survival as has been suggested by some authorities because renewable sources of energy offer a safer and environmentally more satisfactory solution to the long-term energy supply problem and taken together with a prudent population policy, the renewable sources of fuel if well planned and fully developed, could provide for all the energy needs of the world. Evidence shows that it is feasible and practicable to have a gradual replacement of energy from fossil fuel by supplies from renewable sources and as such economically and socially acceptable, especially in countries with low population densities and adequate forests. The reserve of energy held by forests is more than twenty times greater than the world’s current annual consumption of energy from all sources and the world’s forests incorporate solar energy into organic material from which can be obtained solid, liquid and gaseous fuels at an annual rate for an excess of the world’s present economic needs (Earl, 1975).

The developing world depends on fuelwood to supply 90% of its energy needs. If energy as a component of the many benefits obtainable from mixed forests and energy plantations is to become a valuable part of the world’s energy budget in the future, the forest policies of many countries need to be adjusted to fulfill this role. Many studies and researches have been done in the area of forest as providers of timber, its chemical and physical properties, but less if not, nothing has been done in the holistic assessment of forest as major stores and suppliers of energy. Therefore, the potential of this vast reservoir of energy needs to be placed in perspective and how it can be managed to ensure its continuity must be researched.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The following chapter presents a description of the study area in terms of geographical location, population, vegetation, rainfall patterns, and general economic and agricultural activities in the study area. The chapter further provides details on the sampling procedures, sample size determination, and data analysis tools employed in this study. The research methods employed in the collection of primary and secondary data are also presented in this chapter.

3.1 Study Area

The study was conducted in the Navrongo Forest District, which consists of four (4) political Districts, as indicated in the Table 1 (pg. 26) and shown in a graphical form in Figure 2 (pg. 25).

The Navrongo Forest District is located in the Western portion of the Upper East Region. It shares a common boundary with the Bolgatanga Municipal to the East, Sissili District on the West, Walewale District on the South, and Burkina Faso in the North.

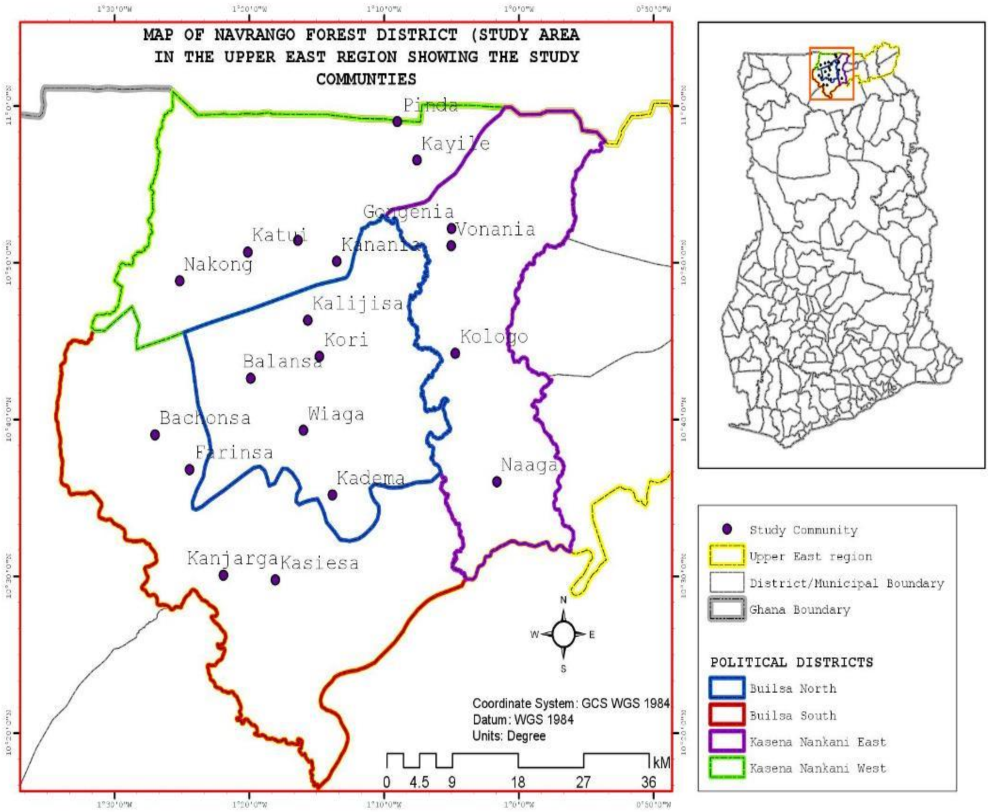

Figure 2: Map of The Study Area Showing Political Districts and Communities

Source: Field Survey (2020) and Map produced by Wulnye Clement (2020)

Table 1: **Political Districts and Their Capitals Within the Study Area**

Political District	District Capital
Kassena Nankana Municipal (KNM)	Navrongo
Kassena Nankana West (KNW)	Paga
Builsa South District (BSD)	Fumbisi
Builsa North District (BND)	Sandema

Source: Field Survey (2020)

Table 2: Communities and Their Geographic Coordinates

Communities	Latitude	Longitude
Bachonsa	10.65001113	-1.449950042
Balansa	10.71038255	-1.331613976
Chiana	10.85680321	-1.273041775
Farinsa	10.61327586	-1.407091569
Gongenia	10.86944087	-1.08308589
Kadema	10.58616732	-1.230388748
Kalijisa	10.772	-1.261
Kanania	10.83455362	-1.225041454
Kanjarga	10.5011102	-1.365116408
Kasiesa	10.49587265	-1.3011374
Katui	10.84436741	-1.335104732
Kayile	10.94223921	-1.125805313
Kologo	10.73681798	-1.078371214
Kori	10.73360611	-1.246467445
Naaga	10.60041049	-1.026883079
Nakong	10.81370472	-1.419303497
Pinda	10.98304498	-1.149957846
Vonania	10.85122224	-1.083453505
Wiaga	10.65491095	-1.266084897

Source: Field Survey (2020)

The vegetation is predominantly Guinea Savannah in nature and characterized by a prolonged drought period (8 – 9 months duration) in a year during which the period is marked by frequent bushfires (Kansanga et al., 2019; Yiran & Stringer, 2016).

3.2 Method

3.2.1 Target Population

The study aimed to obtain data from individuals who engage in fuelwood production for both household use and commercial purposes. In this research, participants were interviewed across four (4) political districts in the Navrongo Forest District, namely Kassena Nankana Municipal Assembly, Kassena Nankana West District, Builsa South District, and Builsa North District. The study was conducted across 20 selected communities in Navrongo Forest District. The Communities under the Forest District are about ninety percent (90%) rural (Ghana Statistical Service, 2018). The predominant ethnic groups in the district are the Kassena, Nankana, Buili, and the Mamprusi. Other ethnic groups include the Kantosi, the Moshie, the Builsa, the Zambramas, and a small number of migrant workers from neighboring Burkina-Faso.

3.2.2 Data Collection

The data for this study was obtained from primary (field survey data) and secondary sources (published and unpublished documents). The study combined quantitative and qualitative approaches to ensure that the weaknesses of one approach are offset by the strengths of the other (Sangasumana, 2019). A descriptive study method was adopted because it made it possible to explore the issues from different perspectives (Snyder 2019; Kim et al., 2017). The Respondents were randomly selected, which could more be described as an opportunistic sampling technique (Palinkas et al., 2015). The respondents were mostly encountered either conveying harvested wood or in the process of harvesting wood or selling firewood along the roads leading to the communities.

3.2.3 Data Collection Instrument

A structured questionnaire comprising closed-ended questions was used to collect quantitative data from participants. The questionnaire covered the demographic characteristics of the respondents, species preferred as fuelwood, harvesting sources, the ready availability of the preferred species, management mechanisms, role of the institutions, and conservation mindfulness of Respondents and perceptions on the impact of fuelwood harvesting on the environment. The interviews were conducted in the local languages, which were predominantly spoken in the areas which included Kasim, Nankan, and Buili. The designed questionnaire was first given to Language experts at the Navrongo

Senior School and Sandema Senior High School for translation into the local language. Additional six research assistants who could speak the Kassim, Nankan, and Buili languages were engaged to administer the questionnaires at the household level. An English version of the question used for the survey is presented in the Appendix I in this dissertation.

3.2.4 Sample Size

The study targeted three hundred (300) respondents as an appropriate sample size for analysis and 246 participants were interviewed. The sample size varied from one community to the other, looking at the community sizes. An average number of 13 respondents was targeted per each community. Additionally, the number of communities selected per district was dependent on available information on the level of engagement of the community members in the fuelwood business. A few numbers of respondents represented communities with fewer households. Respondents for this study were all local community members who engaged in the harvesting of fuelwood within the four (4) political districts.

3.2.5 Research Population

Table 3 shows the distribution of respondents by districts and communities. Respondents were selected purposively and interviewed from 20 communities based on prior information about the inhabitant's involvement in fuelwood collection activities. An average of 12.3 respondents was interviewed from each of the communities.

Table 3: Illustrates Distribution of Respondents by Political District and Communities

Political district	No. of Communities Surveyed	Names of Communities	No. of Respondents	Percentage
Kassena Nankana Municipal Assembly	6	Naaga	57	23.2
		Gongenia	10	4.1
		Kanania	2	.80
		Doba	7	2.8
		Kologo	21	8.5
		Vonania	9	3.7
		Chiana	13	5.3
Kassena Nankana West Assembly	5	Katui	16	6.5
		Nakong	14	5.7
		Pinda	10	4.1
Builsa South	3	Kanjarga	14	5.7
		Kasiesa	10	4.1
		Bachonsa	10	4.1
Builsa North	6	Balansa	3	1.2
		Kalijisa	8	3.3
		Kori	11	4.5
		Wiaga	15	6.1
		Farinsa	5	2.0
		Kadema	8	3.3
Total	20		246	100

Source: Field Survey (2020)

3.3 Data Analysis

The IBM SPSS Statistics version 25.0 was used to analyse the quantitative data, while descriptive statistics were used to present the results

(SPSS Inc. Released 2009). The data was sorted, coded, and entered into SPSS. The data was checked for anomalies such as missing entries by generating simple frequency tables. Once all the missing or wrongly entered variables were corrected descriptive analysis were conducted. Results from the analysis are presented in Tables, Charts, and Bar graphs.

3.4 Research Ethics

As an ethical norm in social research, all interviews were conducted following the informed-consent rule. Prior to each interview, the purpose of the study was briefly explained to the participant, and once verbal consent was obtained, interviews were conducted. Participants were assured of their anonymity, and confidentiality hence names of participants were omitted from this dissertation. Additionally, participation was opened to all and not limited by gender, political affiliation, religious orientation, and disability. While writing the introduction, literature review, and discussion sections of this dissertation, sentences/phrases were adopted from related articles by other authors and duly referenced in the reference list. All research participants were duly acknowledged by the researcher.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the findings from the study in a general perspective. The chapter describes the demographic characteristic of the Respondents, followed by brief descriptions of the findings according to the set objectives. The findings are presented in the form of tables, pie, and bar charts with descriptive explanations expressed in percentage of the responses.

4.2 Socio-demographic characteristics of the actors involved in the fuelwood harvesting activities in the study area.

Gender

Overall, 131 of the Respondents representing 53.3% were males, and 115, representing 46.7% were female (Figure 3).

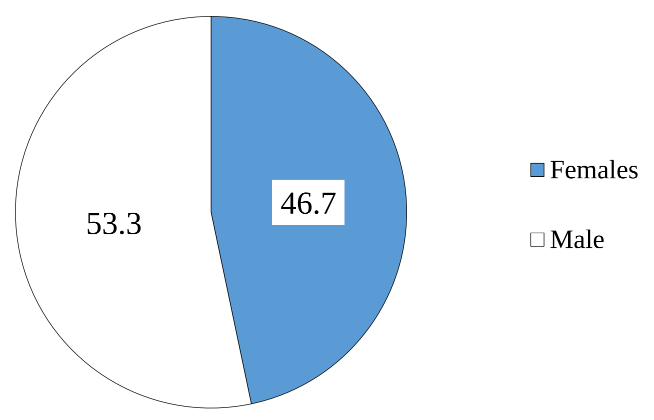

Figure 3: Gender of Respondents

Source: Field Survey (2020)

Age Grouping of Respondents

Among the interviewed respondents, 52 representing 21.1% were age 45 years and above, whereas 49 representing 19.9%, 46 representing 18.7% and 42 representing 17.1% each were in the age categories of 30-34 years, 25-29 years and 35-39 years respectively. The least recorded was those in the age category of 24 years and lowered, which was represented by 10.2% of the responses, as shown in Figure 4.

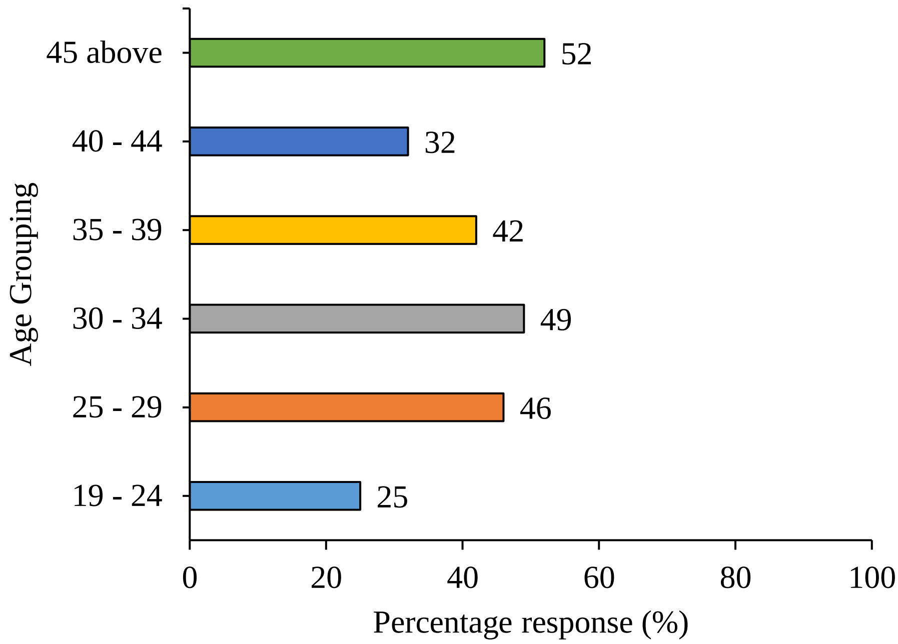

Figure 4. Age Groupings of Respondents

Source: Field Survey (2020)

Highest Level of Education attained by respondents

The data revealed that more than half, that is, 128 of the respondents representing 52% indicated they had no formal classroom education whereas 77 representing 31.3% indicated having had formal education to JHS level. Similarly, 20 and 13 of the respondents representing 8.1% and 5.3% respectively indicated having attained education to SHS level and MSLC level. Figure 5 shows the levels of education and the respective percentage representations.

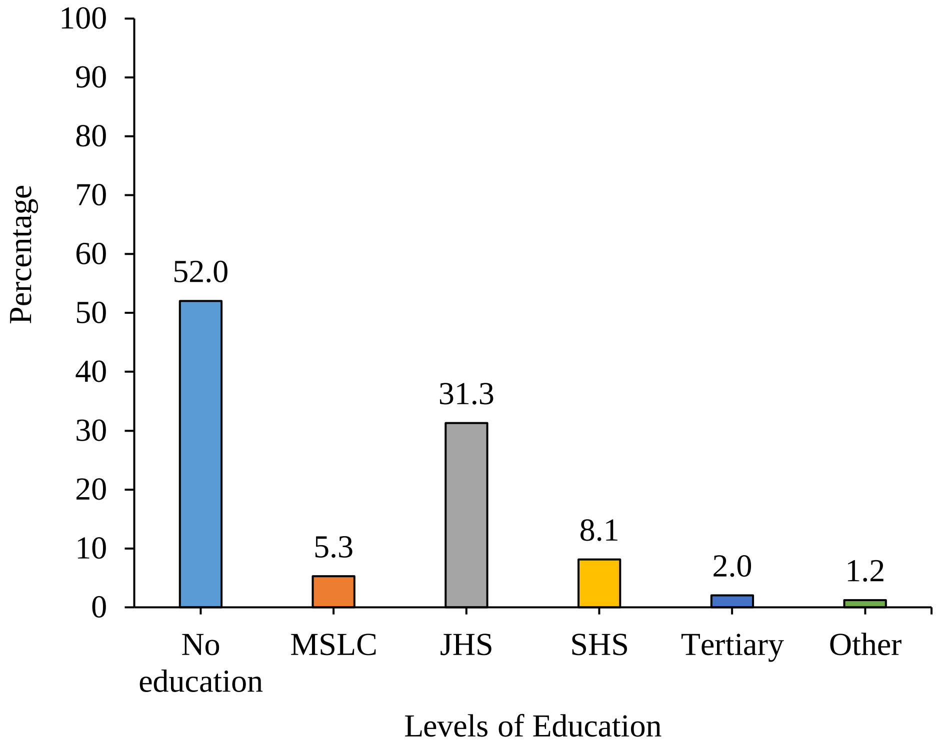

Figure 5: Levels of Education Attained by The Respondents

Source: Field Survey (2020)

Marital Status of The Respondents

The majority of the respondents, that is 184 representing 74.8% indicated they were married, whereas 30 representing 12.2% mentioned they belonged to the single status. The least were those in the separated category representing 2.4%. Figure 6 provides details on the marital status of the respondents.

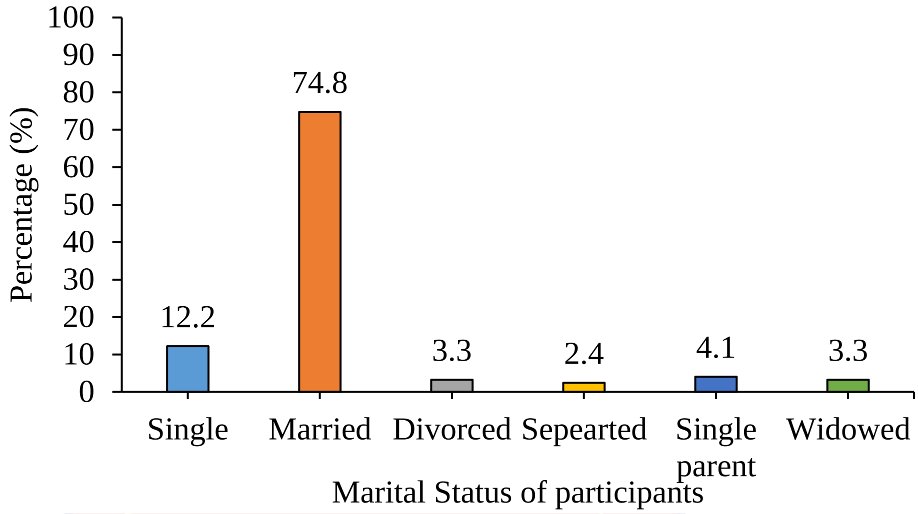

Figure 6: **Marital Status of Respondents**

Source: Field Survey (2020)

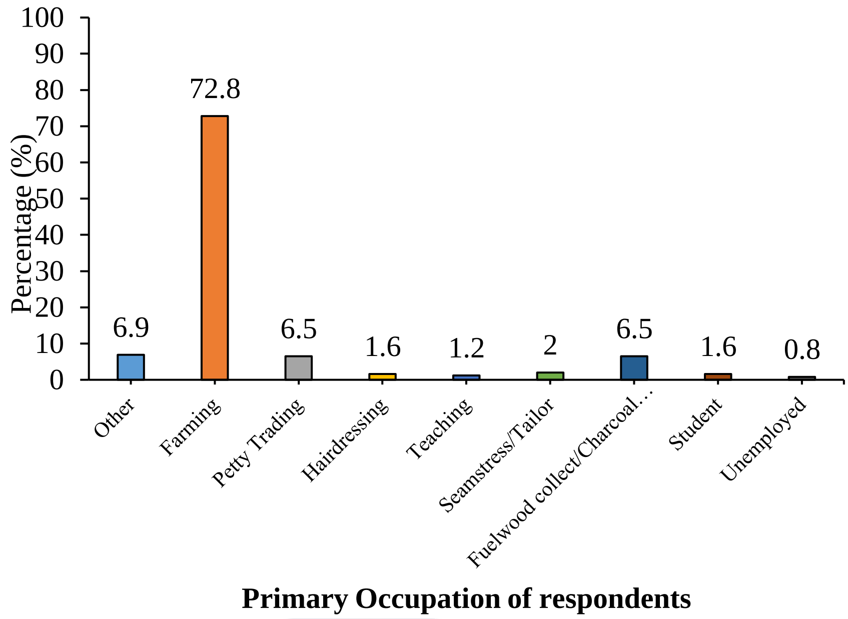

Figure 7. **The Primary Occupation of the Respondents**

Source: Field Survey (2020)

The primary occupation of respondents

The data revealed that the majority of the respondents, 179 representing 72.8% were generally farmers. Overall, fewer numbers 16 representing 6.5% of the respondents were revealed to be full-time engaged in fuelwood harvesting as a primary occupation (Figure 7, pg. 44).

Similarly, the data revealed that more than half of the respondents were primarily involved in different forms of livelihood activities such as teaching, petty trading, hairdressing, sewing, driving, masonry, and carpentry occupations aside engaging in fuelwood harvesting whereas 2 of the respondents representing 0.8% indicated they had no primary occupation. Figure 7 details the primary livelihood activities engaged in by the respondents.

4.1.2 Main Traits of The Actors Involved in The Fuelwood Activities

A general picture developed from the current study was that the male actors primarily dominate the fuelwood harvesting practice among the actors in the study area. The dominance of the male actors, as observed from the current study, could be attributed to the conventional ideology about masculine and feminine types of work, which is very prominent in numerous local communities in the study area. The men actors were involved primarily in harvesting and splitting of round wood, and they are less involved in trimming, gathering of deadwood, bundling, and carrying in headloads. The overall pattern emerging from the current study leads to the inference that women dominate the wood-fuel distribution process, that is, undertaking the conveying and sales of the wood compared to the men. Men, on the other hand, make a smaller contribution, and, in some cases, the associated tasks are performed together with the women. Secondly, since it is often the traditional norm that women do not climb trees in many local communities, any wood harvesting requiring climbing is considered men's work hence the differences observed during the study. The women in this study also declared that such work as climbing to harvest tree branches and splitting of round wood was a difficult task; hence was left for the men.

Respondents in this study also mentioned that splitting wood cannot be done by women alone because splitting large billets is a hard task. However, the role of female actors in the fuelwood harvesting activities in the area cannot be overlooked as they continue to play a significant part in the value chain. The assertion is in corroboration with findings by Obiri et al., (2015), when they reported that in most parts of Ghana, men and women have different demands on energy due to the existing socio-cultural and traditional roles. Thus, women do most of the cooking, and therefore they are heavily involved in fuelwood collection. Finally, the differences in the numbers of male and female actors could be attributed to the observation of traditional protocols during the study. In most of the local communities, male researchers were not permitted to interact with the female actors when their husbands were present. Hence the males (household heads) were interviewed instead.

The educational history of the actors also confirms the perception that fuelwood harvesting is a job for the less privileged or otherwise less educated persons in society. A more significant number of the actors were found to be illiterates or otherwise less educated, and this could be contributing to the heavy dependence of a more significant segment of the actors on wood base fuel. This assertion is in corroboration with research findings, which found that the level of education of an individual is expected to have a negative effect on fuelwood usage (Israel, 2002; UNDP & World Bank, 2003; Njong & Johannes, 2011). The reason is that "education" may change the taste in favor of modern fuels, or it may improve a decision maker's understanding of the costs and benefits of using modern energy to family welfare such as health" (Abebaw, 2007).

The observed age differences also depict the type of persons who were engaged in fuelwood collection in the study area. Overall, there were more elderly actors, and this could be attributed to the fact that in most of the communities surveyed, the youth were mostly engaged in other lucrative livelihood activities and harvesting of fuelwood as a secondary option. This assertion conforms to a report by Démurger and Fournier (2010), who stated that older people tend to develop a habit for traditional heating and cooking more than younger households and thus a positive relationship between age and fuelwood usage is expected to occur.

The more significant numbers of the actors were married, therefore indicated that the majority of the actors were busily finding energy supplements for their homes. This was, however, not unexpected as fuelwood harvesting has remained an age-old household activity in most parts of the developing world for subsistence and commercial purposes. Studies elsewhere in India, Pakistan, and Kenya have shown that wood and other biomass resources generate at least 20 times more local employment within the national economy. This is due to the considerable amount of unskilled manpower or labour required for harvesting, processing, transporting, and trading of this product according to the Energy and Sustainable Development Africa (ESDA, 2005).

4.2 Commonly Preferred Tree-Species for Fuelwood

A total of 246 respondents participated in the survey to categorize commonly used tree species as fuelwood. Overall, 32 tree-species belonging to 20 families were recorded as the ideal tree species commonly harvested and used as fuelwood.

Table 4: Tree Species Commonly Harvested and Utilized as Fuelwood, With the Local Names, The Local Dialect, Scientific Names, And Family Names

Local Name	Local Dialect	Common Name	Species Scientific Name	Family Name	Freq	Percent (%)	Percent of Cases
				VERBENACEAE			
Kanka	Kasim	West African black plum (Black berry)	Vitex doniana	Verbenaceae	2	0.3	0.8
				MALVACEAE			
Kafuro		Red Kapok Tree	Bombax costatum	Malvaceae	10	1.4	4.5
Guon		Kapok	Cieba pantandra	Malvaceae	5	0.7	2.1
Tuo	Buili	Baobab	Adansonia digitata	Malvaceae	15	2.1	6.2
				RUBIACEAE			
Taaruk	Buili	Unknown	Mitragyna inermis	Rubiaceae	11	1.5	4.5
Kantonbwe	Buili	Unknown	Gardenia aqualla	Rubiaceae	1	0.1	0.4
				STERCULIACEAE			
Kampulug	Buili	Unknown	Sterculia setigera	Sterculiaceae	1	0.1	0.4
Local Name	Local Dialect	Common Name	Species scientific Name	Family Name	Freq	Percent (%)	Percent of Cases
				COMBRETACEAE			
Kogo	Buili	Unknown	Terminalia avicennioides	Combretaceae	19	2.7	7.9
				FABACEAE			
Kpikplug	Buili	African mahogany (Papao)	Afzelia africana	Fabaceae	4	0.6	1.7
Kalankolo	Buili	Sweet detar or Tallow tree	Datarium microcarpum	Fabaceae	14	2.0	5.8
Chakura	Buili	Unknown	Pericopsis laxiflora	Fabaceae	7	1.0	2.9
Kancholo	Buili	Senya	Daniellia oliveri	Fabaceae	2	0.3	0.8
Sana/ Pusika/		Tamarind	Tamarindus indica	Fabaceae	18	2.5	7.4
Falantiyo/ Sabora		Cassia spp	*Senna siamea*	Fabaceae	36	5.0	14.9
Aponkye biscuit		Thorny tree	*Faidherbia albida*	Fabaceae	8	1.1	3.3
				EBENACEAE			
				EBENACEAE			
Gaab	Kasim	African Ebony	Diospyros mesipilifomis	Ebenaceae	29	4.1	12.0
				LOGANIACEAE			
Kampoa	Buili	Green Monkey orange	Strychnos spinosa	Loganiaceae	1	0.1	0.4
				RUBIACEAE			
Kantongo		Unknown	Gardenia erubescens	Rubiaceae	4	0.6	1.7
				CAESALPINIACEA E			
Tanyano		Wild seringa	Burkea africana	Caesalpiniaceae	1	0.1	0.4
				ANACARDIACEAE			
Kachigo		Unknown	Lennea acida	Anacardiaceae	1	0.1	0.4
				MORACEAE			

Table 4 continued

Local Name	Local Dialect	Common Name	Species Scientific Name	Family Name VERBENACEAE	Freq	Percent (%)	Percent of Cases
Kapera		Ficus tree	Ficus gnaphalocarpa	Moraceae	1	0.1	0.4
				ZYGOPHYLLACEAE			
Kangogu	Buili	Desert date or Egyptian Balsam	Balanites aegyptiaca	Zygophyllaceae or Balanitaceae	1	0.1	0.4
				LEGUMINOSAE			
Sabarizonno		Thorny tree	Acacia gourmaensis	Leguminosae-Mimosoideae	4	0.6	1.7
Gaab/ Tintaga	Buili	Rosewood	*Pterocarpus erinaceus*	Leguminosae-Papilionoideae	22	3.1	9.1
				COMBRETACEAE			
Siek/Luuga/ Loa/Siisa	Kasim/ Buili	Anogeisus	Anogeisus leiocarpus	Combretaceae	140	19.6	57.9
Vosanga		Unknown	Combretum *micranthum*	Combretaceae	47	6.6	19.4
				SAPOTACEAE			
Taanza/ Chami/ Songo		Shea tree	Vitellaria paradoxa	Sapotaceae	70	9.8	28.9
				MELIACEAE			
Kuoka/Pieno/Pono		African mahogany	Khaya senegalensis	Meliaceae	66	9.3	27.3
Falantiyo		Neem	Azadirachta indica	Meliaceae	85	11.9	35.1
				MIMOSACEAE			
Duah/ Dawadawa/ Sunno	Kasim	African Locust bean	Pakia biglobosa	Mimosaceae	22	3.1	9.1
				ANACARDIACEAE			
Mangota	English	Mango	Mangifera indica	Anacardiaceae	5	0.7	2.1
				LAMIACEAE			
-	English	Teak	Tectona grandis	Lamiaceae	46	6.5	19.0

Source: Field Survey (2020)

Among the revealed trees were three (3) exotic species, which include *Acacia, Tactona grandis, and Azadirachta indica* whereas 28 were indigenous trees. Table 4 provides details on the tree species with their local names (in different dialects spoken in the area), common English or trade names, scientific names, family names, number of times mentioned, and the percentage representations. From the data, the commonly harvested and most preferred tree species for fuelwood among the respondents was *Anogaissus leiocarpus,* which is predominantly occurring in most of the areas where the survey was conducted. When asked to choose among the list of tree species, the most preferred tree species as fuelwood, *Anogaissus leiocarpus* topped the list with 140 mentions representing 19.6% out of the thirty-two species recorded. Using the multiple response approach, this represents a percent case of 57.9%, whereas 11.9% with a total percent case of 35.1% mentioned *Azadirachta indica* as the most preferred tree species harvested as fuelwood. Other species mentioned include Khaya senegalensis, *Vetileria paradoxa*, *Combretum spp.*, *Pterocarpus erinaceus (Rosewood),* Tamarindus indica, *Tectona grandis, Pakia boglobosa, Afzelia africana*, etc. Table 4 provides details on the list of tree species recorded during the study.

4.2.1 Key Qualities of The Most Preferred Tree-Species Harvested for Fuelwood

The present study revealed that *Anogaissus leiocarpus*, *Azadirachta indica*, Khaya senegalensis, *Vetileria paradoxa*, *Combretum spp.*, *Pterocarpus erinaceus (Rosewood)*, *Tamarindus indica*, *Tectona grandis, Pakia boglobosa,* and *Afzelia Africana* were listed as best fuelwood tree species in the area. Significant among the tree species commonly harvested and preferred as fuelwood was the "rosewood" species *(Pterocarpus erinaceus)*, a highly valued economic tree species listed by the IUCN as endangered. Though the species was not commonly found in most of the areas, as established by the actors, it was most preferred for its combustible characteristics. This finding, however, was considered an environmental threat to the survival of the species.

Most of the actors in the present study were found to be knowledgeable with the tree/shrub species they preferred for fuelwood in terms of their combustible and calorific characteristics. All the preferred species (e.g., *Anogaissus leiocarpus*, *Pterocarpus erinaceus*, *Vetileria paradoxa*, *Burkia africana*, *Daniella oliveri*, *Afzelia africana*, and *Combretum* spp.) were indigenous while a few others made mention of exotics such as Cassia spp species, *Azardaricha indica* and *Eucalyptus* spp. Elsewhere, Yikii *et al.*, (2006) also reported a preference for a mixture of exotic (e.g., *Eucalyptus* spp.) and indigenous species (e.g., *Combretum mole and Combretum collinum*) for firewood by tobacco growing households in northwestern Uganda. FAO (1984) in a report associated peoples' preference for indigenous tree species for fuelwood to most exotic tree species for firewood to their slow combustion rates, which results in much heat. This claim was also evident from the present study, where most of the indigenous species commonly harvested were credited by the actors for having excellent combustible characteristics such as the production of quality flame and the ability to burn for longer periods.

Similarly, the actor's indigenous knowledge on wood qualities showed that trees species that exhibited good burning qualities were most preferred, followed by those species that produce less smoke or less irritating smoke. During the interactions with the actors, it was learned that some tree species tend to produce smoke that could make one feel dizzy when inhaled. Such species were not preferred. The study revealed that *Anogaissus leiocarpus* was the first (1st) most mentioned and preferred tree species by the actors harvested as fuelwood for its high burning qualities. The actors were of the view that it was hard and lasted longer in the tripod. It was also mentioned to have high-quality charcoal hence preferred by most of the charcoal producers in the study area. The widespread utilization and reliance of the actors on *Anogaissus leiocarpus* as preferred fuelwood might be due to its high abundance in the study area as well as the preference for its high-quality charcoal in the local towns.

Additionally, *Azadirachta indica, Khaya senegalensis, Tectona grandis, Senna siamea, Combretum micranthum, Pterocarpus erinaceus, Daniella oliveri,* and *Afzelia Africana* were all among the list of trees mentioned by the actors as preferred tree species as fuelwood and for the production of charcoal, and hence remains a high targeted species by the actors in the study area. The shea nut tree (*Vitellaria paradoxa*), which according to the actors is traditionally forbidden from being harvested as fuelwood in all the towns where the study was conducted, remained a targeted species by some of the actors interviewed during the study. From the current study, *Vitellaria paradoxa* remains the third (3^{rd}) most preferred tree species in terms of the number of times the respondents mentioned it. In all *Vitellaria paradoxa* was mentioned 70 times representing 9.8%, that is, 28.9% of the total cases (refer to Table 4) mentioned. As a result, charcoal producers more selectively use this species. The actors during the surveys indicated a preference for *Senna siamea*, but due to its limited occurrence in the areas where fuelwood is commonly harvested in the survey communities, it was not highly ranked by the actors. Again, due to scarcity some of the less economical but high-quality tree species preferred by the actors in the study area, fuelwood harvesters, and charcoal producers are more inclined towards the harvesting of high valued economic tree species (e.g., *Pterocarpus erinaceus, Daniella oliveri,* and *Afzelia Africana)* which call for environmental concerns.

4.2.2 Important Qualities for Selecting Certain Tree Species as Fuelwood

To understand the respondents' perceptions of the essential qualities considered in choosing and harvesting certain trees as fuelwood, the respondents were first asked to indicate (Yes or No) whether they harvest all tree species as fuelwood or not. The study revealed that not all the respondents were harvesting all tree species as fuelwood. The majority of the respondents, that is, 163 representing 66.3% answered “No” whereas 83 representing 33.7% answered, “Yes” (refer to Figure 8).

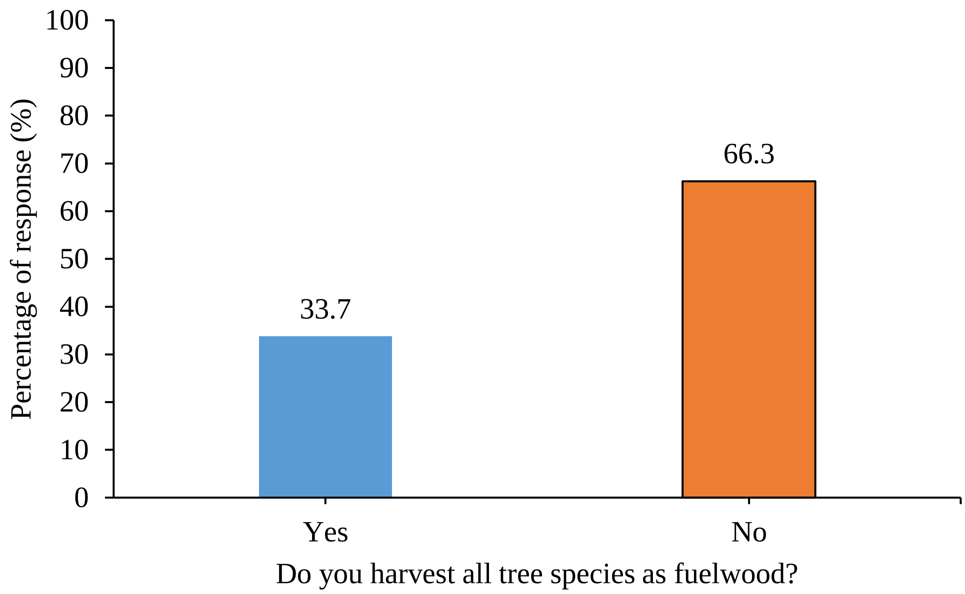

Figure 8: **Tree Species Harvesting Preference**
Source: Survey Data (2020)

As a follow-up, the respondents who indicated “No” were asked to indicate one reason each for not harvesting all tree species as fuelwood. The study revealed eight main reasons why not all tree species were considered and harvested by the majority of the respondents as fuelwood (Figure 9).

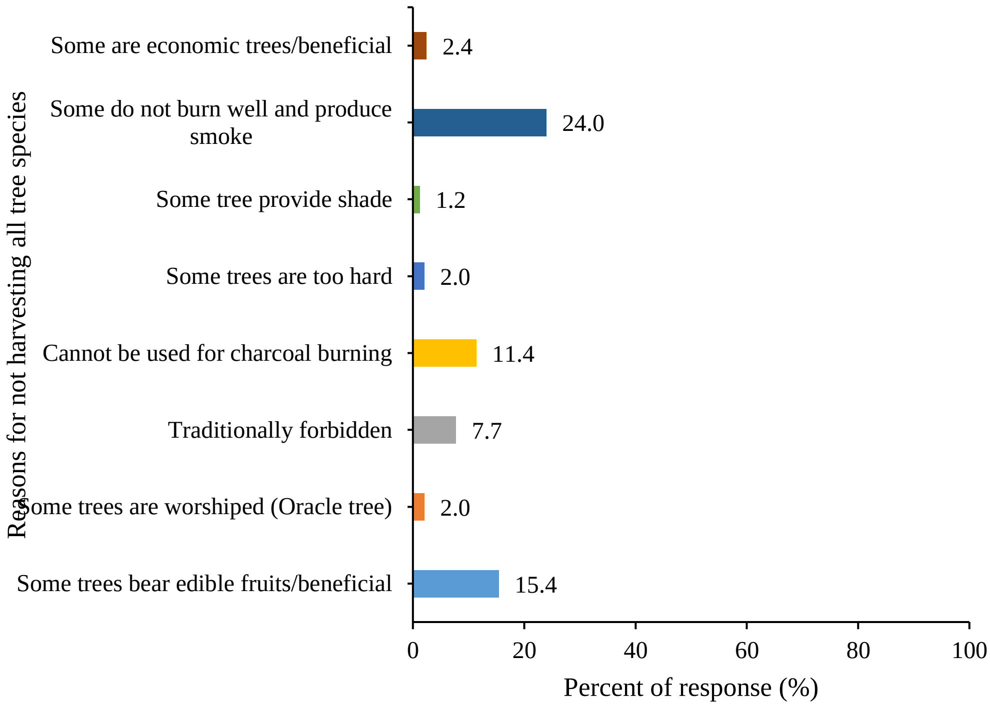

Figure 9: Reasons for Not Choosing All Tree Species as Fuelwood

Sources: Field Survey (2020)

4.2.3 Qualities for Choosing Certain Tree-Species Over Others as Fuelwood

When asked to indicate one quality for choosing particular tree-species over others as fuelwood, 143 representing 58.1% of the respondents said they would choose species that "burn well without producing smoke that irritates the eyes and make you feel dizzy". In contrast, 41 and 35 respondents each representing 16.7% and 14.2% respectively said they usually select tree-species that produce less smoke and tree-species that last longer in the tripod respectively. The other wood qualities mentioned by the respondents are presented with their respective percentage responses in Figure 10.

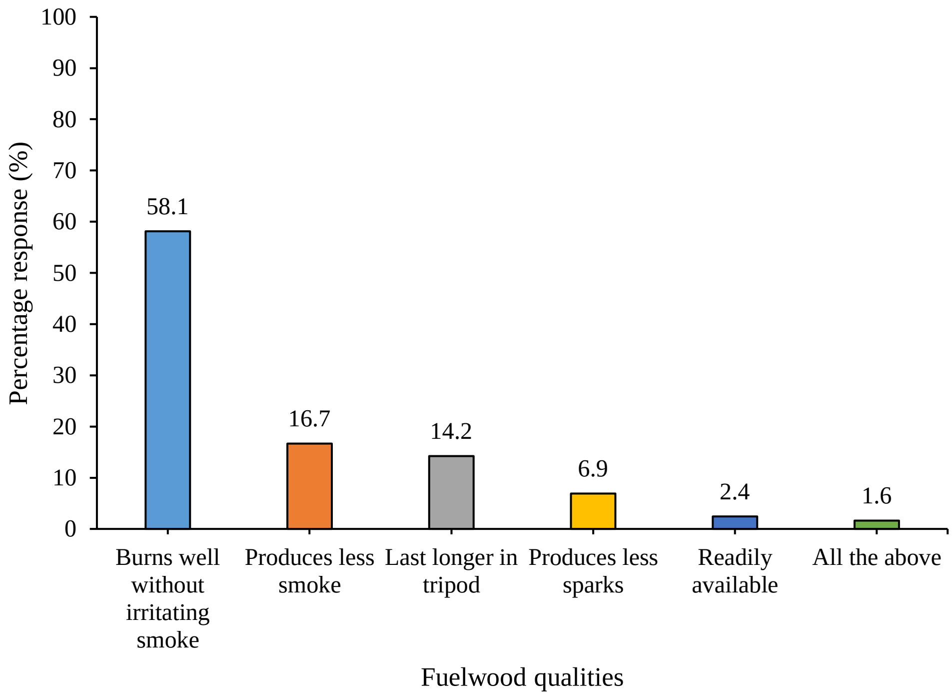

Figure 10: Qualities for Choosing Certain Tree Species Over Others as Fuelwood

Sources: Field Survey (2020)

4.2.4 Channels Used by The Actors to Obtain Permits to Harvest Fuelwood

Again, the study intended to find out how the actors were getting permits to harvest fuelwood in the study area. The data revealed that 48% of the respondents were taking permission from the landowners/private individuals to allow them to harvest trees for fuelwood whereas 33.3% of them said they obtain a permit from the Kobo Naabas or Tigatu (that is, the Sub chiefs) to have access and harvest trees for fuelwood. Again, the data revealed only 8.5% and 7.7% of the respondents mentioned obtaining permits from a Forestry staff or take no permit before harvesting fuelwood and the least representing 2.4% said they obtained permits from the District Assembly to harvest trees for fuelwood (Figure 11).

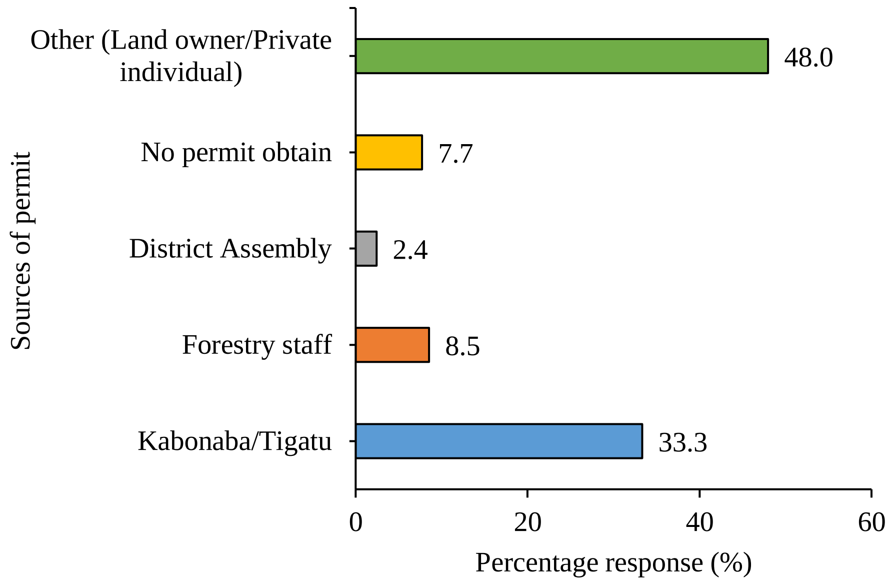

Figure 11: Fuelwood Harvesting Permit Acquisition

Sources: Field Survey (2020)

4.3 Method for Fuelwood Harvesting

The study revealed that the actors were not using sophisticated equipment for harvesting. The harvesting methods and tools used for harvesting were found to be traditionally crafted equipment. Since the majority of the people were using simple tools like cutlasses and small axes, they could only harvest small-diameter trees and shrub species. For the few that were using chainsaws for the harvesting of fuelwood, this current study showed a negligible concern, but the district forest through its field officers need to monitor and regulate their operations. The fewer numbers of actors using chainsaws could mean that most of them were engaging in subsistence harvesting of fuelwood and not for large scale commercial purposes to augment their daily livelihoods. This assertion calls for a closer assessment into the economic motives of the actors to understand better the activities of fuelwood collectors and its contribution to livelihoods within the study area in a future evaluation. The use of simple harvesting tools could also mean that the actors were mainly poor households who could not afford to buy or hire chainsaw machines to crosscut and harvest fuelwood in large quantities.

The study has shown that most of the tree species commonly harvested by the actors have coppicing characteristics hence influencing the parts commonly harvested. Cutting off the main stem (tree bole), and climbing to cut the tree branches was found to be the most standard practice among the actors. Since most of the tree easily coppice after cutting, there seems to be a continual supply of harvestable wood for the actors to rely on. However, the prolonged drought period, which lasts for almost nine (9) months and the frequent bush fires in the forest reserves as well as off-reserve areas, tend to render tree stumps dead, resulting in scarcity of the preferred species.

Similarly, the study revealed that actors tend to walk long distances in search of fuelwood. This study has shown that the least distance walked or covered to harvest fuelwood as indicated by the actors in the study was 1km, and the maximum distance was 6km. Additionally, the average distance required per harvesting trip was 3.7 km. It can be reasoned that the long distances covered in search of trees to harvest as fuelwood tend to affect the quantity of wood that could be harvested and conveyed by the actors. Similarly, since most of the actors were subsistence harvesters, fuelwood harvesting and sale were found to be impacting on their livelihoods in terms of income generation. Hence, most of the fuelwood were sold at market places, roadsides, and at individual homes. Some actors were also supplying fuelwood as a cheaper energy source to food vendors, local beer (pito) brewers, secondary school kitchens, etc. These multiple chains of supply points also illustrate the importance of these actors in the society as they tend to meet the daily energy demands of several individuals.

4.4 Harvesting Practices Among Actors in The Fuelwood Business

4.4.1 Main Sources of Fuelwood

When asked to indicate their primary sources for gathering fuelwood, the data revealed that 95 and 86 of the respondents each representing 38.6% and 36.2%

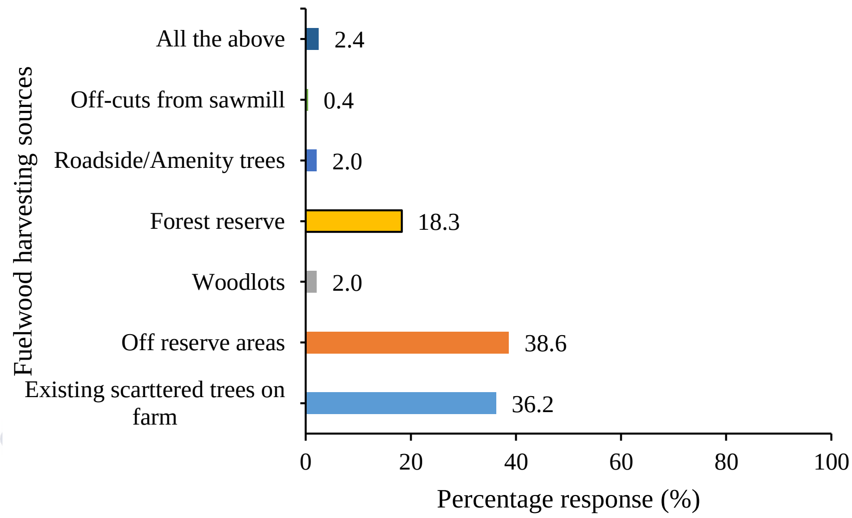

Figure 12: Sources of Fuelwood

Source: Field Survey

respectively indicated they harvest fuelwood primarily from off-forest reserve areas and from scattered trees on their farmlands. Similarly, 45 representing 18.3% of the respondents mentioned harvesting trees from forest reserve areas. The least, 1 of the respondents representing 0.4% mentioned harvesting off-cuts at sawmills as fuelwood as shown in Figure 12.

4.4.2 Type/State and Parts of Trees Commonly Harvested as Fuelwood

The data revealed that 117 representing 47.6% of the respondents said they harvest dry or dead trees (falling branches, dead logs) as fuelwood whereas 91 representing 37% said they usually harvest wet/greenwood (cutting of fresh standing trees) and leave them at the site to get dry before collecting them as fuelwood.

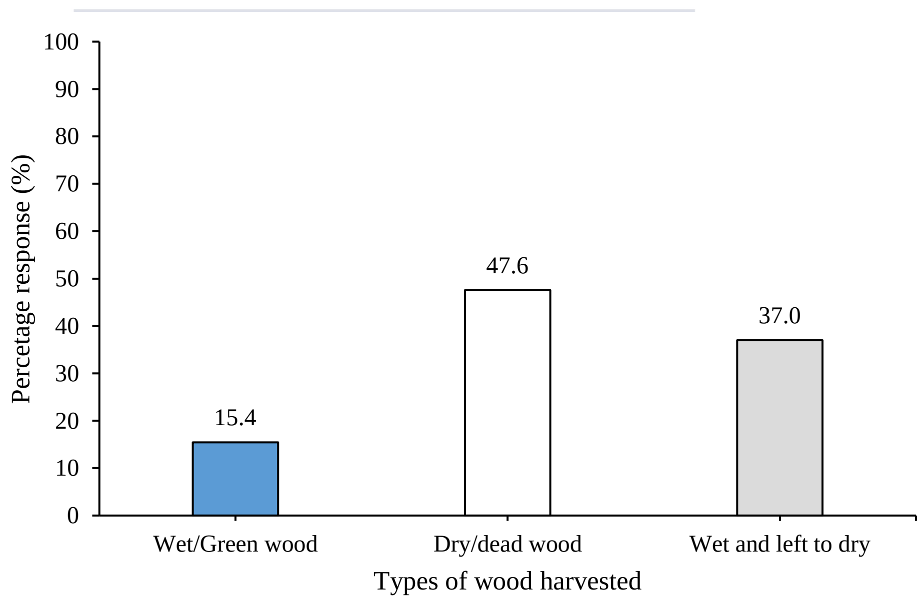

Figure 13: Wood Species Harvested as Fuelwood

Source: Field Survey (2020)

Similarly, 38 of the respondents representing 15.4% said they harvest only fresh or wet wood as fuelwood (Figure 13). The data further revealed that tree branches were the major part of trees gathered as fuelwood which was mentioned by 125 of the respondents representing 50.8% of the total responses whereas 70 of the respondents representing 28.5% mentioned they harvest the whole tree (by felling) before gathering parts as fuelwood. Again 51 representing 20.7% mentioned they harvest both branches and tree stems as fuelwood as shown in Figure 14.

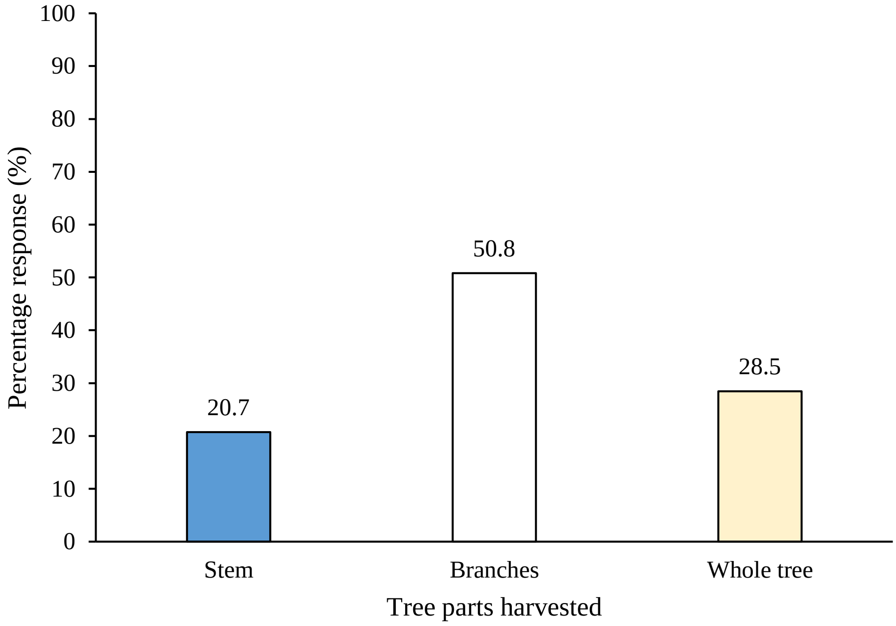

Figure 14: Tree Parts Harvested as Fuelwood

Source: Field Survey (2020)

4.4.2 Tools Commonly Used for Harvesting of Fuelwood

Similarly, when the respondents were asked to indicate the tools commonly used during harvesting of fuelwood, the data showed that 125 representing 50.8% and 106 representing 43.1% of the respondents respectively mentioned they use cutlasses and small handheld axes for harvesting. Other tools and methods used by the respondents to harvest fuelwood are shown in Figure 15.

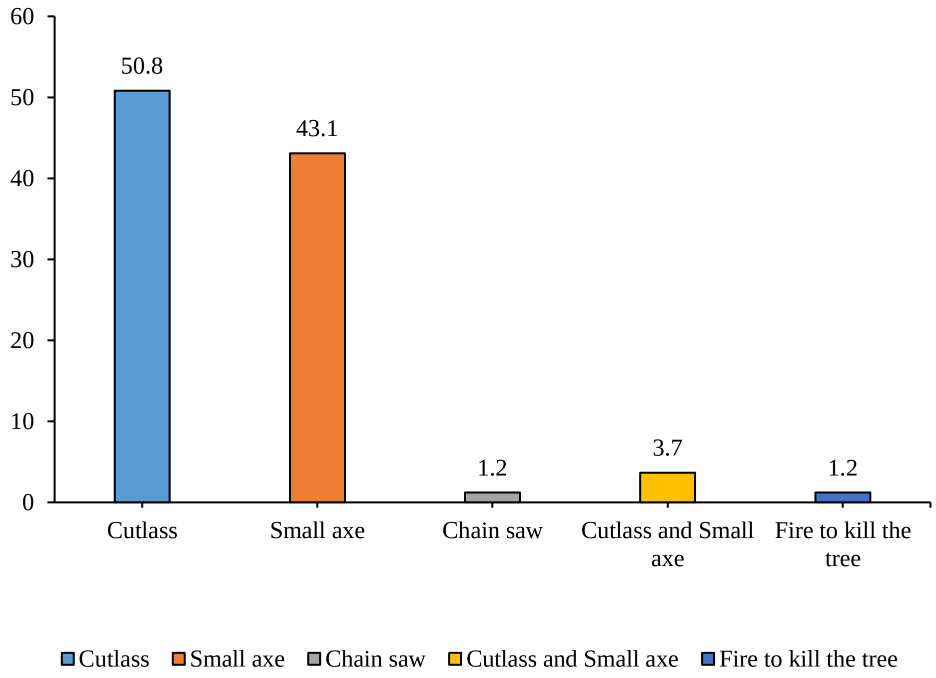

Figure 15: Tools Used for Harvesting Fuelwood

Source: Field Survey (2020)

4.5 Regulation of Fuelwood Harvesting and Conservation Practices in The Study Area

The respondents were again asked to indicate whether there were traditional laws that regulate the harvesting of individual trees as fuelwood in their traditional or local areas. The data revealed that traditional or customary laws to regulate the harvesting of trees as fuelwood was in existence. In all, more than half of the respondents, that is, 215 representing 88% answered "Yes" there were traditional regulatory measures on fuelwood harvesting in their communities. Nevertheless, 30 representing 12% of the respondents answered "No," indicating no traditional regulatory measures on fuelwood harvesting in their communities (Figure 16).

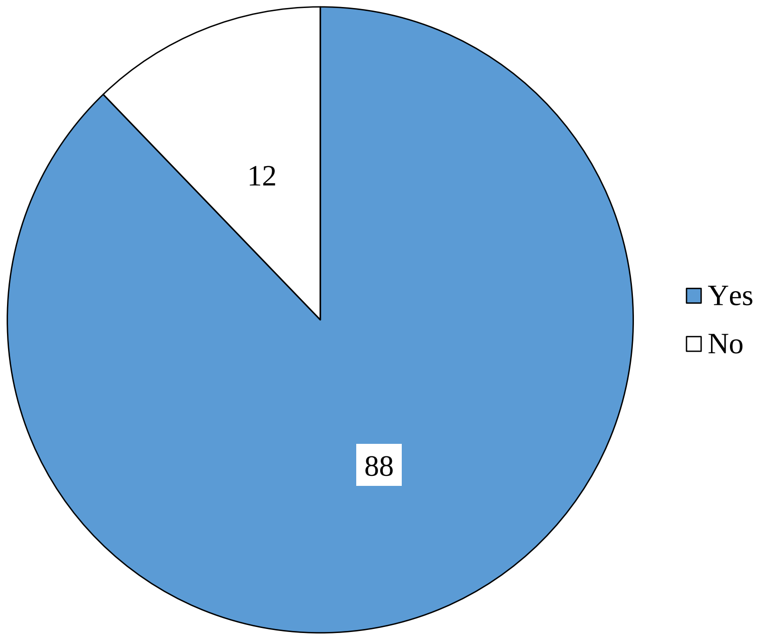

Figure 16: Awareness of Traditional Laws Regulating Tree Harvesting

Source: Field Survey (2020)

Similarly, when the respondents were asked to indicate whether they were engaging in tree conservation practices in their various communities to ensure environmental sustainability, the data revealed that a more significant proportion of the respondents, 194 representing 78.9% answered “Yes.” In contrast, 49 representing 21.1% answered “No” to the question. The respondents were further asked to indicate the type of tree conservation methods they were practicing, and the data revealed that the majority of the respondents were practicing six (6) different tree conservation methods (Figure 17).

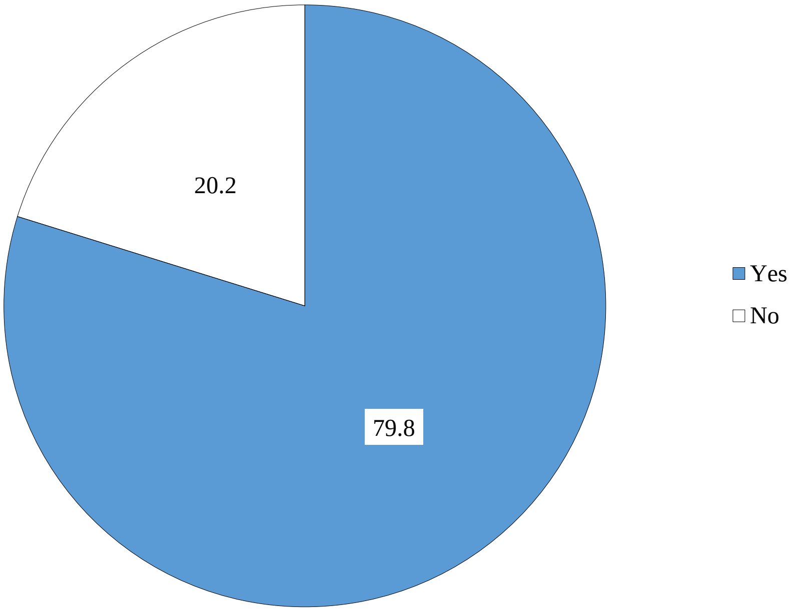

Figure 17: Compliance with Conservation Practices

Source: Field Survey (2020)

Among the 194 respondents who answered to the question, more of the respondents 84 representing 34% said they were practicing planting of trees around their communities (amenity planting) whereas 66, and 35 each representing 26.8% and 14.2% respectively said they were practicing the Farmer managed natural regeneration (FMNR) and planting of trees after cutting. The other conservation practices mentioned by the participants were fairly represented, as shown in Figure 18.

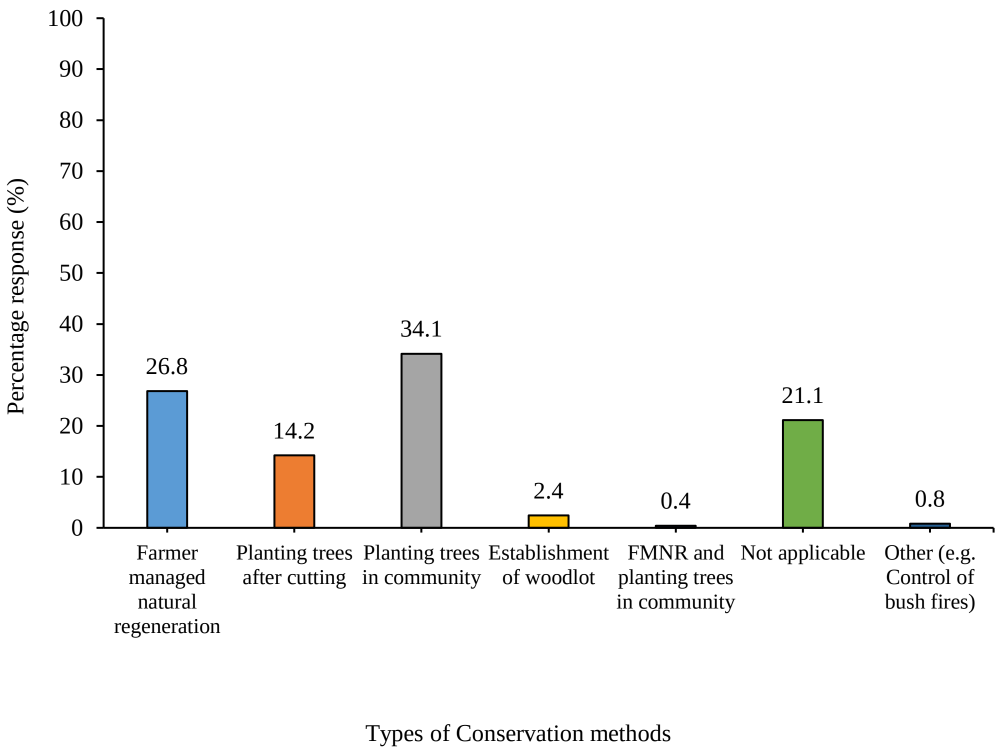

Figure 18: Tree Conservation Methods/Practices

Sources: Field Survey (2020)

Fifty-two (52) of the respondents representing 21% (shown in Figure 18 "Not applicable") were further asked to give reasons why they were not practicing any the tree conservation methods. The most reason mentioned by the respondents was lack of awareness followed by long drought period experienced in the area (that is, between 8 to 9 months), lack of planting materials (seedlings), lack of water and fencing materials, and limited access to personal land, etc. It was also revealed from the data that 4 representing 7.7% mentioned that they were not interested in planting trees whereas 3 representing 5.8% were of the view that trees grow naturally.

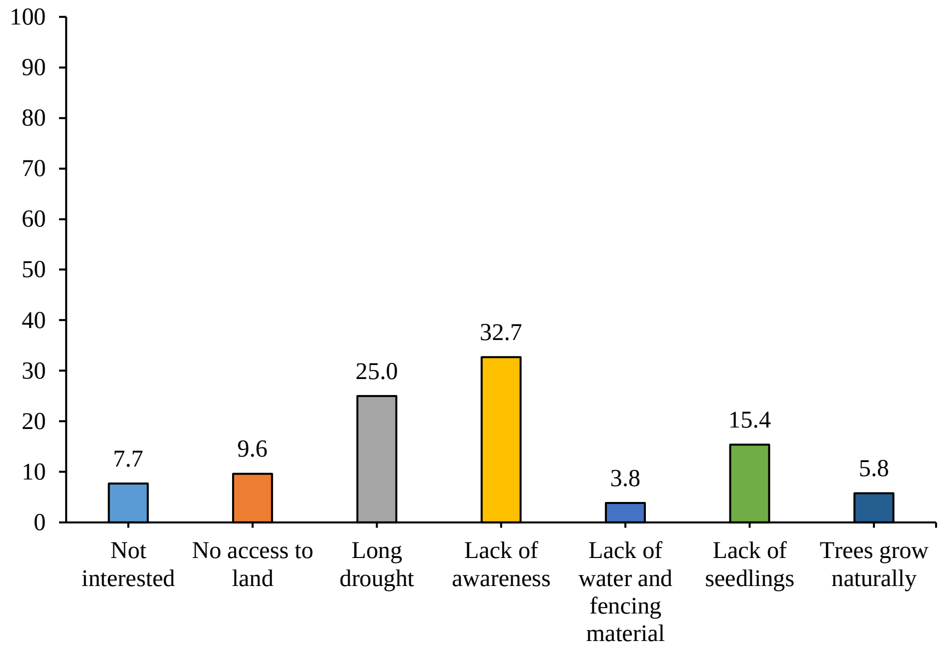

Figure 19: Reasons for Not Engaging in Tree Conservation/Planting

Sources: Field Survey (2020)

4.6 Respondents Knowledge About the Impact of Fuelwood Harvesting on The Environment

As shown in Figure 20, when asked to mention one environmental impact of fuelwood harvesting on the environment, the data revealed that the actors (respondents) generally had a fair knowledge of the impact of their fuelwood harvesting activities on the environment. The data revealed that 82 representing 33.3% had knowledge that fuelwood harvesting causes deforestation. Similarly, 70 and 46 of the respondents each representing 28.5% and 18.7% respectively had knowledge that fuelwood extraction causes reduced rainfall (erratic rainfall pattern) and soil fertility loss. Other environmental effects mentioned by the respondents are shown in Figure 20.

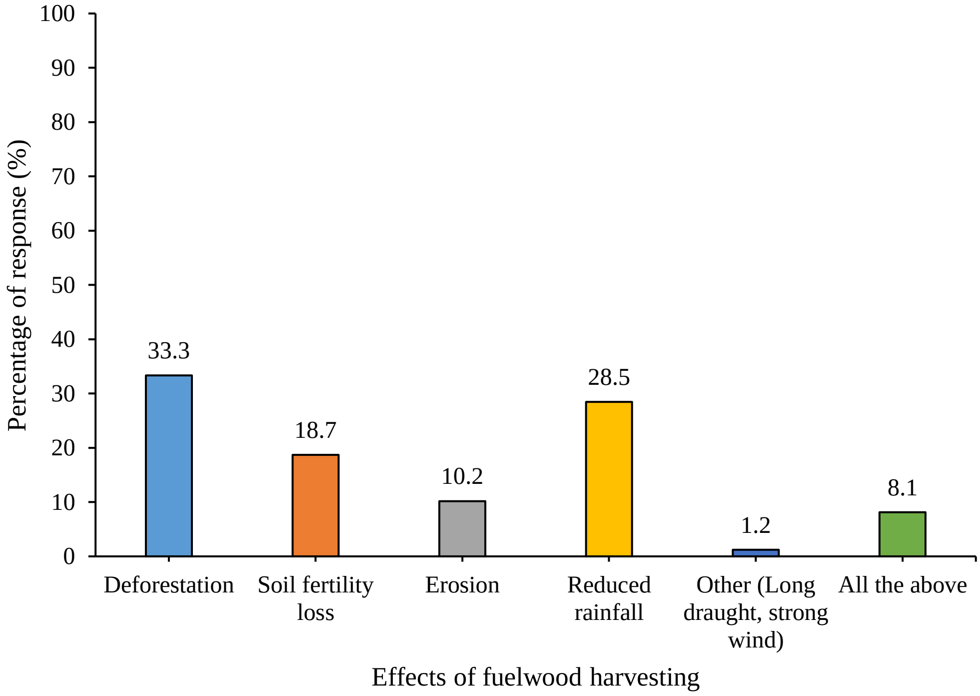

Figure 20: Opinions on The Effects of Fuelwood Harvesting on The Environment

Source: Field Survey (2020)

4.6.1 Human Reliance on Fuelwood as A Livelihood in The Study Area

The study further sought to ascertain how much effort is often expended by the actors to harvest fuelwood in terms of average time spent and average distances walked per day, the frequency of harvesting, and the trading points where fuelwood is sold.

4.6.1 Frequency of Harvesting Fuelwood by Respondents

The data revealed that more of the respondents, 106 representing 43.1% said they go to harvest fuelwood at least once every week whereas 80 representing 32.5% and 40 representing 16.3% respectively said they go to harvest fuelwood twice or three times every week. Similarly, 20 representing

8.1% said they go to harvest fuelwood more than three times every week (Figure 21).

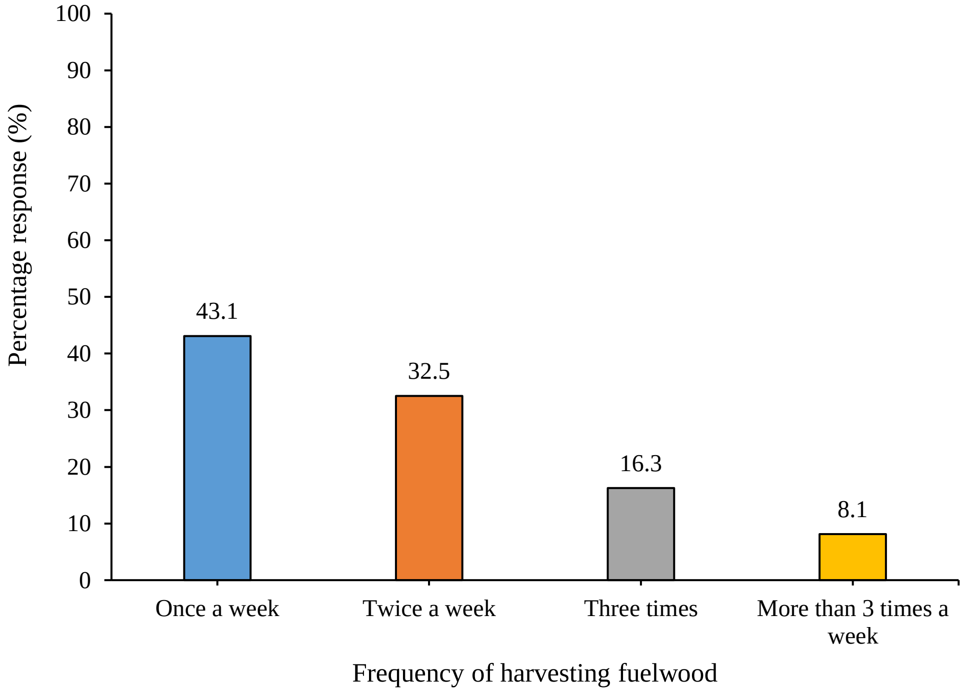

Figure 21: Frequency of harvesting fuelwood by the respondents

Source: Field Survey (2020)

4.6.2 Average Time Expended to Harvest Fuelwood Per Harvesting Trip

Similarly, when the respondents were asked to indicate how much time they expended per harvesting trip, the data revealed that more of the respondents, 72 and 63 representing 29.3% and 25.6% said they spent more than 2hrs and 3hrs respectively harvesting fuelwood in a day (Figure 22). That is an average of 2.75hrs is expended per harvesting trip per each of the respondents with a minimum 1hr, and a maximum of 5hrs per harvesting trip is expended.

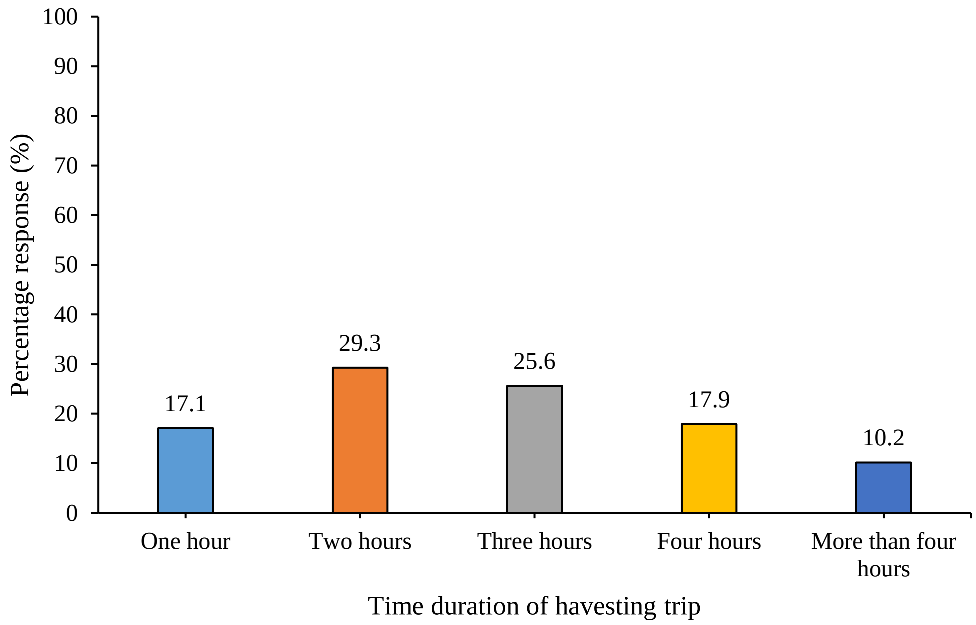

Figure 22. Average Time Spent Per Harvesting Trip

Source: Field Survey (2020)

4.6.3 Average Distance Walked to Harvest Fuelwood

Again, the respondents were asked to indicate the average distance (estimated in kilometers) covered per harvesting trip in a day. The data revealed that more of the respondents, 76 representing 30.9%, said they walked at least 2km to harvest fuelwood per day. In contrast, 54, 51, and 40 representing 22%, 20.7%, and 16.3% respectively said they walked at least 3km, 4km, and 1km per harvesting trip in a day (Figure 23). The least distance walked or covered to harvest fuelwood as indicated by the respondents was 1km and the maximum distance was 6km, whereas the average distance walked per harvesting trip was 3.7km.

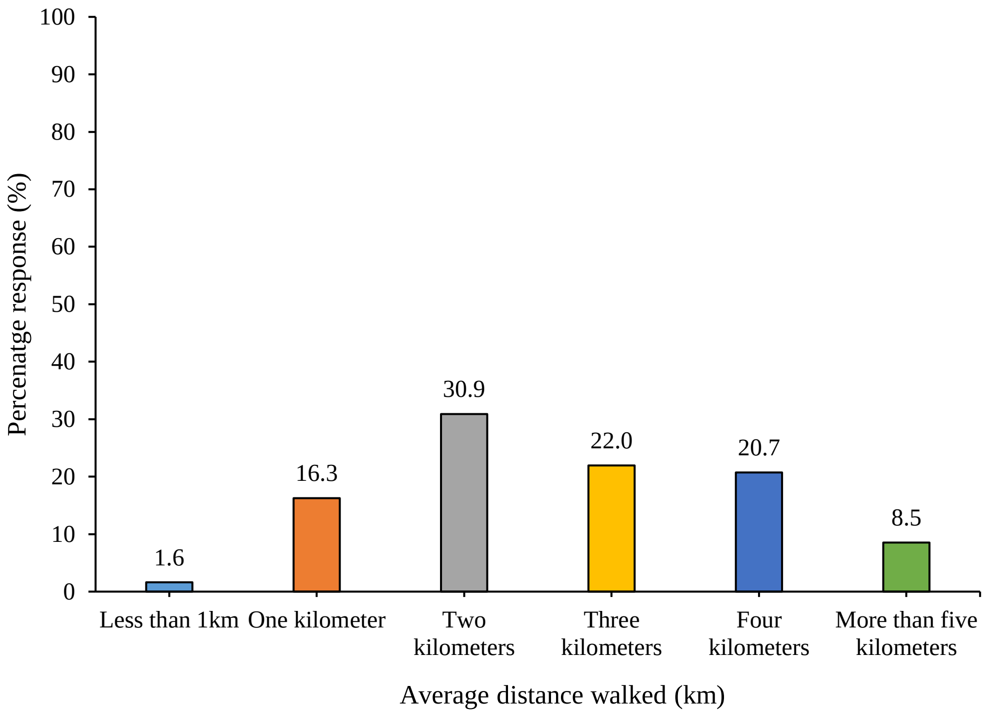

Figure 23. Distances Covered/Walked Per Day to Harvest Fuelwood

Source: Field Survey (2020)

4.7 Methods of Transporting Harvested Fuelwood

The data revealed that the primary means of transporting fuelwood by the respondents was by carrying the wood on their heads as this was mentioned by 100 of the respondents, which represents 40.7% of the responses. Similarly, transporting the harvested wood using donkey cart and motor king was mentioned by 64 and 62 of the respondents representing 26% and 25.3% respectively. The least mentioned means of transporting fuelwood by the respondents was the use of bicycles, which was mentioned by only 5 representing 2% of the responses.

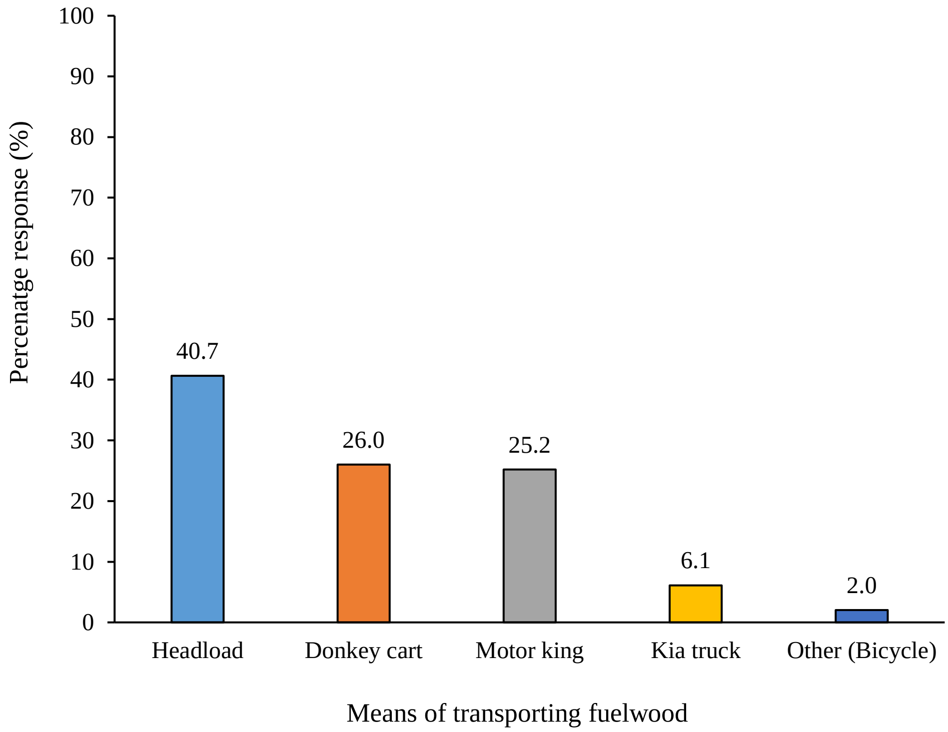

Figure 24. Means of Transporting Harvested Fuelwood

Source: Field Survey (2020)

4.8 Main Trading Points or Sales Destinations

As shown in Figure 25, when asked to mention where harvested fuelwood is usually sold or traded, the data revealed that the majority of the respondents sold their fuelwood at the nearest market to their community. Overall, 126 of the respondents representing 51.2% said they sell their fuelwood at the closest market. However, the data also revealed that not all the respondents were harvesting fuelwood for income generation (commercial purpose). Harvesting for domestic purposes at their homes was mentioned by 24 of the respondents representing 9.8%. Other sale points mentioned are represented in Figure 25.

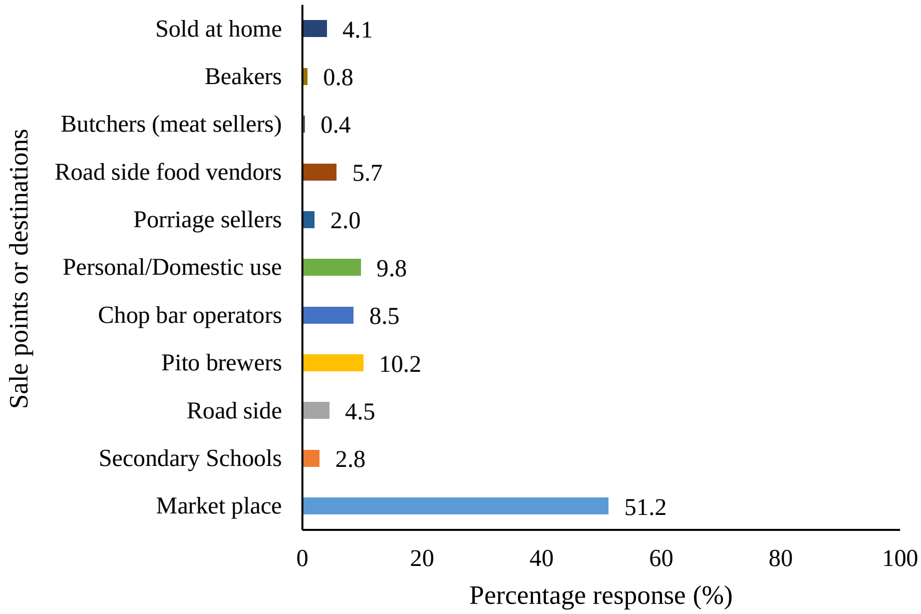

Figure 25. Fuelwood Sale Points or Final Destinations

Source: Field Survey (2020)

4.9 Actor's Knowledge of Environmental Conservation and Their Perceptions on The Impact of Tree Cutting as Fuelwood on Their Environment

Generally, the study showed that respondents were aware of the impact of their actions on the environment and their livelihoods as a whole. A good number of the actors were of the view that their farmlands had lost fertility resulting in low crop yields attributing it to the loss of trees yet the act of cutting or removing all trees from their farmlands to make it easy to plough was predominant in the study area. A few others also indicated that cutting down of trees for fuelwood has led to deforestation and erratic rainfall patterns over the past 10years. The area experiences close to 9months of the dry season, which also affects their daily livelihoods as mentioned by some of the actors during one-on-one interactions. One key aspect of the fuelwood activities in the area that was not mentioned by the respondents in this study is the health hazards contributed by fuelwood harvesting and its usage. Since it was not one of the objectives of this current study, not much could be said.

The study revealed that the establishment of woodlots either by communities or individuals was limited in the area as the actors did not mention this as a source from where wood was harvested. This corroborates a statement by Marfo (2010) that in Ghana efforts by the government to reduce deforestation have yielded limited success, primarily because many of the initiatives were misguided and failed to deal with deforestation as a complex, dynamic and interwoven process.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The current study aimed at gaining insights into the fuelwood harvesting activities and its contributions to rural livelihoods in some selected rural communities in the Navrongo Forest District. The study revealed that fuelwood harvesting and trade formed an important aspect of livelihood for several households in the study area. Nonetheless, poor harvesting practices, lack of regulation and proper management of the fuelwood resources could lead to future energy crisis in the area. Immediate and appropriate collaborative efforts aimed at restoring the degraded landscapes are recommended to save the environment from further degradation.

5.2 Conclusion

The study showed that more male (53.3%) actors were engaging in fuelwood harvesting than females (46.7%) in the study area. Furthermore, there were fewer educated (literates) engaging in the fuelwood harvesting activities in the study area. The actors in this current study were mainly harvesting fuelwood for subsistence usage than those for commercial purposes. Most (52%) of the actors were in their late adulthood, with fewer young people participating in the fuelwood activities. The majority of the actors were found to be married, which could mean that they were harvesting fuelwood to meet their household energy demands for cooking and heating.

The current study has brought to the fore issues about fuelwood harvesting and management within the Navrongo Forest District. The study revealed that the species commonly preferred are dwindling in terms of numbers (occurrence rate) and becoming rarer across all the twenty surveyed communities. Furthermore, there is a heavy reliance on a large population on a limited source of fuelwood supply, which is the forest reserves and trees on-farms within the study area. The study also revealed that local authorities (Community Chiefs/Leaders) were having greater control over giving permits to individuals to access and harvest fuelwood in the study area which presents an excellent opportunity for institutions such as the Forestry Service Division, Energy Commission and the District Assemblies to collaborate with then in the effective management of the forest resources in a more sustainable way. This is because the actors tend to fear the local authorities (Chiefs) in their various communities due to the stiff punishments that may come with an offense when taken to the palace. The involvement of older or aged generation in the fuelwood harvesting activities could mean a decreasing taste for the usage of fuelwood by the end users and a lean towards more efficient forms of energy for cooking. However, this assertion cannot be overemphasized as the unemployment rate in the study area continue to be high across the larger segment of society.

On the whole, the current study showed that the higher numbers of the actors were practicing or otherwise knowledgeable about one form of tree conservation practice that could contribute to future environmental conservation. The study showed that overly, current education on climate change, wildfire prevention, and ensuring environmentally responsible behaviours organized for the communities was going down with the people. Nevertheless, more needs to done, particularly across the four political districts where the study was conducted. On the issue of institutional roles in managing fuelwood resources, the study revealed that there is a need for the Forest Service

Division to step up its efforts. Thus, to get more communities involved in its environmental conservation and tree planting effort through the adoption of workable collaborative initiatives.

5.3 Recommendations

Based on the observations and results obtained from the field and the analysed data, respectively, the following recommendation are made.

Suggestions for Further Research

1. The present study revealed that more than ten highly valued economic tree species, as well as multipurpose livelihood trees, were listed as the best fuelwood tree species in the study area. This kind of study can be conducted in the future by combining local preferences of fuelwood species with scientific assessment in determining fuelwood qualities. Such a study will direct conservation efforts and help in providing an alternative use for less valued, and fast-growing tree species to meet the energy demands of the actors in the study area.
2. A similar study should be conducted by a student on the field to assess the current ecological conservation status of the tree species commonly harvested and preferred as fuelwood.

Recommendations for Policy and Practice

1. A stronger collaboration should be promoted by the Forest Services Division (FSD), the National Commission for Civic Education (NCCE), Local Authorities and the District Assemblies to draw a road map for the management of fuelwood resources within the district. This will enable the communities to establish and manage

their own woodlot stands and reduce environmental degradation. The FSD on the hand will be able to monitor and assess the its effectiveness in promoting the REED+ agenda in the region.

2. Appropriate technical measures and support should be made available by both Forest Services Division and the District Assemblies to support the actors and communities to go into woodlot plantations development. This will help in providing alternative livelihoods within the local communities and also increase revenue from charcoal and fuelwood production in the district.
3. Finally, the Energy Commission should intensify its awareness-raising efforts on the need to conserve trees. This will enable actors to switch to more efficient cook-stoves and cheaper energy forms across the district.

REFERENCES

Abdul-Wakeel K., Alhassan, I. D., & Gertrud B. (2019). 'An Econometric Analysis of Domestic Fuel Consumption in Ghana: Implications for Poverty Reduction'. *Cogent Social Sciences* 5 (1). https://doi.org/10.1080/23311886.2019.1697499.

Abebaw, D. (2007). 'Household Determinants of Fuelwood Choice in Urban Ethiopia: A Case Study of Jimma Town'. *The Journal of Developing Areas*, 117–26.

Afolabi, K. J. (2017). 'Evaluating Economic and Environmental Cost And Benefits Of Commercial Charcoal Production In Atebubu Forest District, Ghana.' Joensuu: University of Eastern Finland.

Agea, J. G., Kirangwa, D., Waiswa, D. & Akais C. O. (2010). 'Household Firewood Consumption and Its Dynamics in Kalisizo Sub-County, Central Uganda'.

Aguilar, F. X., (2018). In Food and Agriculture Organization of the United Nations, and United Nations, eds. 2018. *Wood Energy in the ECE Region: Data, Trends and Outlook in Europe, the Commonwealth of Independent States and North America*. New York: United Nations.

Agyeman, K. O., Owusu A., Imoro B., & Stephen, L. (2012). 'Commercial Charcoal Production and Sustainable Community Development of the Upper West Region, Ghana'. *Journal of Sustainable Development* 5 (4). https://doi.org/10.5539/jsd.v5n4p149.

Ahuja, D., & Marika T. (2009). 'Sustainable Energy for Developing Countries'. *SAPI EN. S. Surveys and Perspectives Integrating Environment and Society*, no. 2.1.

Amissah-Arthur, J., & Amonoo, J. A. (2016). 'Study of the Social and Poverty Impacts of Energy Interventions on Rural Communities in Ghana'. Kumasi Institute of Technology and Environment (KITE).

Amuah, N. E. E. H. (2011). 'The Potential of Agroforestry in Fuelwood Production for Domestic and Income Generation Activities – A Case Study of Three Communities in the Sunyani District of the Brong Ahafo Region Ghana'. Dissertation submitted to Kwame Nkrumah University of Science and Technology, Kumasi, Ghana

Anang, B. T., Akuriba, M. A. & Alerigesane, A. A. (2011). 'Charcoal Production in Gushegu District, Northern Region, Ghana: Lessons for Sustainable Forest Management'. *International Journal of Environmental Sciences* 1 (7): 1944–1953.

Asamoah, B., Nikiema, J., Gebrezgabher, S., Odonkor, E. & Njenga, M. (2016). *A Review on Production, Marketing and Use of Fuel Briquettes*. International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE).

Asumadu-Sarkodie, S., & Owusu P. A. (2016). 'A Review of Ghana's Energy Sector National Energy Statistics and Policy Framework'. Edited by Shashi Dubey. *Cogent Engineering* 3 (1). https://doi.org/10.1080/23311916.2016.1155274.

Broadhead, J., Bahdon, J. & Whiteman, A. (2001). 'Fuelwood Consumption Modelling and Results. Annex 2 in Past Trends and Future Prospects for the Utilization of Wood for Energy.' Working Paper GFPOS/WP/05. Global Forest Products Outlook Study. Rome, Italy: FAO.

Choumert, J, Combes P. M. & Le Roux, L. (2017). 'Energy Ladder or Energy Stacking: A Panel Data Analysis of Tanzanian Households' Energy Choices'.

Karabee, D., Greeshma P., & Sanderine, N. (2019). 'Human Energy and Time Spent by Women Using Cooking Energy Systems: A Case Study of Nepal'. *Energy* 182 (September): 493–501. https://doi.org/10.1016/j.energy.2019.06.074.

Démurger, S., & Fournier, M. (2011). 'Poverty and Firewood Consumption: A Case Study of Rural Households in Northern China'. *China Economic Review* 22 (4): 512–23. https://doi.org/10.1016/j.chieco.2010.09.009.

Energy Commission, Ghana (2003). '"Fuelwood Use in Ghana: Outlook for the Future"'. Accra, Ghana.

Energy Commission Ghana (2006). 'Stategic National Energy Plan 2006-2020; Energy Supply to the Economy'.

Energy Commission Ghana (2013). '2013 Energy (Supply and Demand) Outlook for Ghana'.

Erakhrumen, A. A. (2011). 'Global Increase in the Consumption of Lignocellulosic Biomass as Energy Source: Necessity for Sustained Optimisation of Agroforestry Technologies'. *ISRN Renewable Energy* 2011: 1–8. https://doi.org/10.5402/2011/704573.

Energy for Sustainable Development Africa (ESDA, 2005). National Charcoal Survey: Exploring the Potential for a Sustainable Charcoal Industry in Kenya. Nairobi: ESDA

Fagariba, C. J., Song, S. & Serge K. G. S. (2018). 'Livelihood Economic Activities Causing Deforestation in Northern Ghana: Evidence of

Sissala West District'. *Open Journal of Ecology* 08 (01): 57–74. https://doi.org/10.4236/oje.2018.81005.

FAO (2004). 'Sustainable Fuelwood for Food Security. A Smart Choice:green, Renewable and Affordable'. Working paper.

FAO (2007). 'Forests and Energy in Developing Countries'. Forests and energy working paper 2.

FAO (2010). 'Global Forest Resources Assessment 2010. Main Report'. FAO, Forestry Paper 163. Rome, Italy.

FAO (2014). *Enhancing the Socioeconomic Benefits from Forests*. State of the World's Forests 2014. Rome: FAO.

FAO (2015). *Global Forest Resources Assessment 2015.* http://www.FAO,.org/3/a-i4808e.pdf.

FAO (2017). 'Incentivizing Sustainable Wood Energy in Sub-Saharan Africa; a Way Forward for Policy-Makers'.

FAO (2018). 'The State of the World´ S Forests-Forest Pathways to Sustainable Development'.

Ghana Forestry Commission (2017). 'Ghana's National Forest Reference Level'. National REDD+ Secretariat.

Ghana Statistical Service, GSS (2012). 'Population and Housing Census: Summary Report of Final Results'. Accra.

Ghana Statistical Service, GSS (2018). 'Ghana Living Standards Survey round7 (GLSS 7); Poverty Trends in Ghana 2005-2017'.

Guo, E. (2007). 'Potential of Woodlot Establishment in meeting the Practical and Strategic Gender Needs of Women in the Upper West Region of Ghana'. *Studies in Gender and Development in Africa* 1.

Heltberg, R. (2003). 'Household Energy Use in Developing Countries: A Multicountry Study'. ESMAP Technical Paper 042. The World Bank.

Heltberg, R., Arndt, T. C. & Sekhar, N. U. (2000). 'Fuelwood Consumption and Forest Degradation: A Household Model for Domestic Energy Substitution in Rural India'. *Land Economics* 76 (2): 213–32.

Hiemstra-van der Horst, G., & Hovorka, A. J. (2008). 'Reassessing the "energy Ladder": Household Energy Use in Maun, Botswana'. *Energy Policy* 36 (9): 3333–44. https://doi.org/10.1016/j.enpol.2008.05.006.

IEA (2019). 'World Energy Outlook, Paris'. https://www.IEA,.org/reports/world-energy-outlook-2019.

Imran, M., & Ozcatalbas, O. (2020). 'Determinants of Household Cooking Fuels and Their Impact on Women's Health in Rural Pakistan'. *Environmental Science and Pollution Research* 27 (19): 23849–61. https://doi.org/10.1007/s11356-020-08701-8.

Insaidoo, T. F. G., Ros-Tonen, M. A. F., Hoogenbosch, L. & Acheampong, E. (2012). 'Addressing Forest Degradation and Timber Deficits: Reforestation Programmes in Ghana'. *ETFRN News* 53: 230–239.

Israel, D. (2002). Fuel choice in developing countries: Evidence from Bolivia. Economic Development and Cultural Change, 50: 865–890.

Jin, S. L., Schure, J., Ingram, V. & Yoo, B. (2017). *Sustainable Fuelwood for Food Security: A Smart Choice: Green, Renewable and Affordable*. Rome: Food and Agriculture Organization of the United Nations.

Kabo-Bah, A., & Diji, C. J. (2018). *Sustainable Hydropower in West Africa: Planning, Operation, and Challenges.* Academic Press.

Kansanga, M., Andersen, P., Kpienbaareh, D., Mason-Renton, S., Atuoye, K., Sano, Y., Antabe, R. & Luginaah, I. (2019). 'Traditional Agriculture in Transition: Examining the Impacts of Agricultural Modernization on Smallholder Farming in Ghana under the New Green Revolution'. *International Journal of Sustainable Development & World Ecology* 26 (1): 11–24. https://doi.org/10.1080/13504509.2018.1491429.

Kim, H., Sefcik, J. S. & Bradway, C. (2017). 'Characteristics of Qualitative Descriptive Studies: A Systematic Review: QUALITATIVE DESCRIPTION: SYSTEMATIC REVIEW'. *Research in Nursing & Health* 40 (1): 23–42. https://doi.org/10.1002/nur.21768.

Kiruki, H. M., van der Zanden, E. H., Kariuki, P. & Verburg, P. H. (2019). 'The Contribution of Charcoal Production to Rural Livelihoods in a Semi-Arid Area in Kenya'. *Environment, Development and Sustainability*, November. https://doi.org/10.1007/s10668-019-00521-2.

Kwakwa, P. A., Wiafe, E. D. & Alhassan, H. (2013). 'Households Energy Choice in Ghana'. *Journal of Empirical Economics* 1 (3): 96–103.

Kwarteng, E. (2015). 'Fuelwood Value Chain Analysis Literature Review Report. The USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island and SNV Netherlands Development Organization. GH2014_SCI010_SNV.'

Lurimuah, S. (2011). 'The Economic and Environmental Effects of Commercial Charcoal Production in the Upper West Region of Ghana'. PhD Thesis, Kumasi, Ghana: Kwame Nkrumah University of Science and Technology.

Sunil, M. & Govinda, R. T. (2014). *Household Cooking Fuel Choice and Adoption of Improved Cook-stoves in Developing Countries: A Review*. The World Bank.

Manso-Howard, B. (2011). 'The Potential Contribution of Non-Timber Forest Products (NTFP) Especially Wood-fuel, To the Revenue Generation Base In The Forestry Sector. (A Case Study in The Sunyani Forest District)'. Kumasi, Ghana.

Marfo, E. (2010). *Chainsaw Milling in Ghana: Context, Drivers and Impacts*. Wageningen, the Netherlands: Tropenbos International.

Matthews, E., Payne, R., Rohweder, M. & S Murray. 2000. 'Pilot Analysis of Global Ecosystems: Forest Ecosystems.' *World Resource Institute*.

Matuana, L.M., & Stark, N.M. (2015). 'The Use of Wood Fibers as Reinforcements in Composites'. In *Biofiber Reinforcements in Composite Materials*, 648–88. Elsevier. https://doi.org/10.1533/9781782421276.5.648.

Ndayambaje, J. D., & Mohren, G. M. J. (2011). 'Fuelwood Demand and Supply in Rwanda and the Role of Agroforestry'. *Agroforestry Systems* 83 (3): 303–20. https://doi.org/10.1007/s10457-011-9391-6.

Njenga, M, & Mendum, R. (Ed.). (2018). *Recovering Bioenergy in Sub-Saharan Africa: Gender Dimensions, Lessons and Challenges*. International Water Management Institute (IWMI). CGIAR Research Program on Water, Land and Ecosystems (WLE).

Njong, A. M, & Johannes, T. A. (2011). 'An Analysis of Domestic Cooking Energy Choices in Cameroon.' *European Journal of Social Sciences* 20 (2): 336–47.

Obiri, B. D., Nunoo, I., Obeng, E., Owusu, F. W. & Marfo, E. (2014). 'The Charcoal Industry in Ghana: An Alternative Livelihood Option for Displaced Illegal Chainsaw Lumber Producers'. *Tropenbos International, Wageningen, The Netherlands*.

Obiri, D., Owusu-Afriyie, B., Kwarteng, E. & Nutakor, E. (2015). 'Fuel Wood Value Chain Report. The USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island and SNV Netherlands Development Organization. GH2014_SCI011_SNV.', 157.

OECD (2011). 'Green Growth Studies: Energy'.

Onoja, A. O., & Idoko, O. (2012). 'Econometric Analysis of Factors Influencing Fuel Wood Demand in Rural and Peri-Urban Farm Households of Kogi State'. *Consilience* 8: 115–27.

Otto-Danquah, K. A. (2010). 'Current Status of Charcoal Demand and Supply, and Initiatives on Improved Cook-Stoves. A Presentation Made during a Kickoff Meeting for TEC/ESMAP Survey on the Energy Access and Productive Uses for the Urban Poor'. Accra, Ghana.

Ouedraogo, N. S. (2017). 'Africa Energy Future: Alternative Scenarios and Their Implications for Sustainable Development Strategies'. *Energy Policy* 106 (July): 457–71. https://doi.org/10.1016/j.enpol.2017.03.021.

Ouma, G., & Gottwald, F. T. (2009). *Agrarian Science for Sustainable Resource Management in Sub-Sagaran Africa*. Edited by Lang Peter. Vol. 3.

Pain, S. (2017). 'Power through the Ages'. *Macmillan Publishers Limited* S51.

Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N. & Hoagwood, K. (2015). 'Purposeful Sampling for Qualitative Data Collection and Analysis in Mixed Method Implementation Research'. *Administration and Policy in Mental Health and Mental Health Services Research* 42 (5): 533–44. https://doi.org/10.1007/s10488-013-0528-y.

Rudel, T. K. (2013). 'The National Determinants of Deforestation in Sub-Saharan Africa'. *Philosophical Transactions of the Royal Society B: Biological Sciences* 368 (1625): 20120405. https://doi.org/10.1098/rstb.2012.0405.

Sangasumana, P. (2019). 'Methodological Issues Pertaining to the Application of Qualitative Techniques in Forced Migration Studies'. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3450034.

Sepp, S., Sepp, C. & Mundhenk, M. (2014). 'Towards Sustainable Modern Wood Energy Development'. *Global Bioenergy Partnership. Bonn, Germany*.

Singh, G., Nouhou, S. A. & Sokona, M. Y. (2015). 'Ghana Renewables Readiness Assessment'. International Renewable Energy Agency (IRENA).

Smith, H. E., Hudson, M. D. & Schreckenberg, K. (2017). 'Livelihood Diversification: The Role of Charcoal Production in Southern Malawi'. *Energy for Sustainable Development* 36 (February): 22–36. https://doi.org/10.1016/j.esd.2016.10.001.

Snyder, H. (2019). 'Literature Review as a Research Methodology: An Overview and Guidelines'. *Journal of Business Research* 104 (November): 333–39. https://doi.org/10.1016/j.jbusres.2019.07.039.

UNEP (2019). 'Review of Fuelwood Biomass Production and Utilization in Africa: A Desk Study'. Nairobi, Kenya: United Nations Environment Programme.

UNDP (2004). Liquefied petroleum gas (LPG) substitution for fuelwood in Ghana—opportunities and challenges; a brief analysis of the LPG sector in Ghana. Infolink 1. Environment and Energy.

United Nations Development Program (UNDP) & World Bank (2003). Household fuel use and fuel switching in Guatemala. Unpublished manuscript.

Wiafe, E.D., & Kwakwa, P. A. (2013). 'Fuelwood Usage Assessment among Rural Households in Ghana'. *Spanish Journal of Rural Development*, 41–48. https://doi.org/10.5261/2013.GEN1.04.

World Bank (2017). 'World Bank Annual Report 2017'. Annual Report. End Extreme Poverty. Boost Shared Prosperity.

Yalew, A.W. (2015). 'The Perplex of Deforestation in Sub-Saharan Africa'. *Journal of Tropical Forestry and Environment* 5 (1). https://doi.org/10.31357/jtfe.v5i1.2494.

Yiran, G. A. B., & Stringer, L. C. (2016). 'Spatio-Temporal Analyses of Impacts of Multiple Climatic Hazards in a Savannah Ecosystem of Ghana'. *Climate Risk Management* 14: 11–26. https://doi.org/10.1016/j.crm.2016.09.003.

Yiridoe, E. K., & Nannag, D. M. (2001). 'An Econometric Analysis of the Causes of Tropical Deforestation: Ghana'. Chicago, IL.

APPENDIX A

DATA COLLECTION INSTRUMENT

Fuelwood Harvesting Practices and Human Reliance in the Navrongo Forest District

QUESTIONNAIRE FOR FUELWOOD COLLECTORS/USERS

Questionnaire Id: ……………………………… Interviewer: ……………………………………… Community/Village Name: ……………………………………………………………………………...

Date: ……………………………………... GPS Code: ……………………………………………………………………………………..

INTRODUCTION

Good day Sir/Madam. This interview is being conducted to obtain data on fuelwood use in and around this community. The results will serve as a basis for informed decision on the management of our natural resources. Please be assured that the answers to each of the questions that I will be asking will remain confidential between yourself and the Project Team. Thank you

Section A:

Demographic Information		
Gender	Male Female	[ ] [ ]
Age of respondent (*write the age given by the respondent*)	…………………………………………..	
Educational level attained by respondent	No education MSLC JHS SHS Tertiary Other	[ ] [ ] [ ] [ ] [ ] [ ]
Marital status of respondent	Single Married Divorced Separated Single parent Widowed	[ ] [ ] [ ] [ ] [ ] [ ]
Respondents main occupation (*indicate primary occupation*)	………………………………………………………	

Respondents secondary occupation (*indicate occasional occupation*)	……………………………………………………

SECTION B

1. Do you use all tree species for fuelwood (*tick answer*)? Yes [ ] No [ ]

If 'Yes', mention some wood species commonly harvested for fuelwood in this area.

………………………………………………………………………………………

……………………………

If 'No', give some reasons why

………………………………………………………………………………………

…………………………………………………………………………

2. What qualities motivate you to choose a particular tree over the other as fuelwood?	Burns well [ ] Produces less smoke [ ] Lasts longer in tripod [ ] Produces less/little sparks [ ] Readily available [ ] Other (specify) ………………………………………………………………

3. What is your opinion on the availability of the tree species mentioned in **Question 1** above?

Species Name	Very uncommon (1)	Not common (2)	Neutral (3)	Common (4)	Very Common (5)

4. What is your most preferred wood species for fuelwood (*choose from the list above **question 1***)?

………………………………………………………………………………………

………………………………………………………………………………………...

………………………………………………………………………………………
………………………………………………………………………………………

Ascertain sources of obtaining harvesting permit and fuelwood collection	
5. Which of the following sources do you commonly obtain permit when you want to harvest fuelwood?	Kabonaba/Tindana/Tigatu [ ] Forestry staff [ ] District Assembly [ ] Assemblyman [ ] Other (private individual) [ ]
6. Which of the following is/are your main sources of fuel wood collection/gathering? (*you can tick more than one answer)*	Existing scattered trees on farmland [ ] Off Reserve Areas [ ] Planted woodlots [ ] Forest reserve [ ] Road side (Amenity) trees [ ] Off-cuts from sawmills [ ]

7. What is your opinion on the supply condition of fuel wood trees from these sources in the area? (*Tick where applicable)*

Supply Source	Very low	Low	Neither	High	Very high
Existing scattered trees on farmland					
Planted woodlots					
Forest reserve					
Road side (Amenity) trees					
Off-cuts from sawmills					
Others					

State and tools commonly employed by collectors	
8. In which form do you harvest or collect fuelwood (tick as applicable)	Dry state [ ] Wet state [ ]
9. Which of these tools do you use for harvesting fuelwood?	Cutlass [ ] Small axe [ ] Chainsaw machine [ ]

	Other (*specify*) …………………..……………………
10. Which part of the tree do you harvest? *(Select as many as applicable)*	Stem [ ] Branches [ ] Whole tree [ ] Other (specify)……………………………

SECTION C

The role of the local institutions in managing fuel wood harvesting in the area	
11. Does your community have laws on the harvesting of certain tree species?	Yes [ ] No [ ]
Determine respondent's conservation mindfulness	
12. Do you engage in conservation practices to ensure the sustainability of tree species?	Yes [ ] No [ ]
13. If yes, which of these conservation methods do you practice?	Farmer managed natural regeneration [ ] Plant trees after cutting [ ] Planting trees in the community [ ] Woodlot establishment [ ] Other (specify) ………………………………………………
Ascertain respondent's perception of the impact of fuelwood gathering on the environment	
14. What is your opinion on the impact of fuelwood harvesting on the environment?	Deforestation [ ] Soil fertility loss [ ] Erosion [ ] Reduced rainfall [ ] Other (*specify*) …………………………………………………..
Fuelwood harvesting rate	
15. How often do you collect fuel wood?	Once a week [ ] Twice a week [ ] Three times a week [ ]

	More than three times a week [ ]
16. What is the maximum time you spend on one harvesting trip?	One hour [ ] Two hours [ ] Three hours [ ] Four hours [ ] Other (specify) ……………………………………
17. What distance do you travel to harvest fuel wood?	1 kilometer [ ] Two kilometers [ ] Three kilometers [ ] Four kilometers [ ] Other (*specify*) [ ]

Means of transporting fuelwood	
18. Which mode of transportation do you use to convey the fuelwood load after harvesting?	Head load [ ] Donkey cart [ ] Motor King [ ] Kia Truck [ ] Other, specify [ ]

19. Where do you sell your fuelwood?

……………………………………………………………………………………………..