IMPACT OF FUELWOOD CONSUMPTION ON VEGETATION COVER IN ZARIA AND ITS ENVIRONS, KADUNA STATE, NIGERIA

BY

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A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES, AHMADU BELLO UNIVERSITY ZARIA, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF MASTER OF SCIENCE DEGREE IN ENVIRONMENTAL MANAGEMENT

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DECLARATION

I declare that this study entitled **IMPACT OF FUELWOOD CONSUMPTION ON VEGETATION COVER IN ZARIA AND ITS ENVIRONS, KADUNA STATE, NIGERIA** was conducted by me in the Department of Geography. The information derived from the literature has been duly acknowledged and referenced. No part of this study was presented for the award of other Degrees or Diplomas in Ahmadu Bello University, Zaria.

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Researcher	Signature	Date

CERTIFICATION

This project dissertation entitled **Impact of Fuelwood Consumption on Vegetation Cover in Zaria and Its Environs, Kaduna State, Nigeria** by Aminu Dabo ABDUL-HADI meets the regulations governing the award of the degree of M.Sc. ENVIRONMENTAL MANAGEMENT of the Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

I dedicate this dissertation to my beloved family members.

ACKNOWLEGEMENT

First and foremost thanks be to Almighty Allah for taking me across this boundary successfully. I am grateful to my parents for the support rendered to complete the study and my progress in life. May Allah reward you abundantly, ameen.

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ABSTRACT

Fuelwood is a renewable form of energy that has continued to be the only energy option (especially for cooking) for most people in the developing countries. The study aimed at examining the impact of fuelwood consumption on vegetation cover in Zaria and its environs, Kaduna State, Nigeria. The study used questionnaire to collect data from 384 respondents in the study area. A time series analysis of Landsat satellite imageries of the study area from 1973-2014 using Remote Sensing (NDVI model) was used to identify hot spots of deforestation. The results indicate that the vegetation of the area has drastically reduced since 1970s. However, both the pattern and causes of the observed change were non-linear. Similarly, evidence from ground truthing investigation has shown that fuelwood collection is among the major factors of deforestation in the region with 39.9%, mainly due to lack of alternative energy sources in the region. The results further reveal that the source areas of fuelwood procurement are within the regions (Igabi, Soba and Giwa) among others but a times use to cross the local administrative boarder of the regions (Birnin-Gwari, Lere and Kauru) respectively. Cheaper, availability and affordability of fuelwood were found as factors responsible for fuelwood consumption. Results indicated a mean and standard deviation consumption rates for 13.44kg and 5.62kg per household per day in the study area respectively. The study also found irregular patterns of vegetation cover in 80% of the area under study with periods of remarkable vegetatal cover decreases between 1973 and 2014. The study found complex patterns of population distribution with a corresponding increase in demand for fuelwood. However, the direct effect of precipitation patterns across season was not found to be substantially affect the pattern of and rate of fuelwood consumption. The most prevailing factors were found to be limited alternative energy sources, poverty and space for agriculture activities. The study recommends that planting of more trees after cutting the existing ones is very important; Government should provide more job opportunities for people in the country; it should make alternative energy available; and Strong law enforcement that will discourage deforestation.

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ABBREBIATIONS

Abbrebiation	
AGO	Automotive Gas Oil
AVHRR	Advanced Very High Resolution Radiometer
CIA	Central Intelligence Agency
CFA	Communaute Financiere Africaine
DAPMAN	Depot and Petroleum Products Marketers Association of Nigeria
DPK	Dual Purpose Kerosene
ERS1	European Remote Sensing Satellite 1
ETM+	Enhanced Thematic Mapper Plus
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
FMANR	Federal Ministry of Agriculture and Natural Resources
FMEN	Federal Ministry of Environment
FORMECU	Forestry Management Evaluation and Coordinating Unit
GIMMS Global	Inventory Modelling and Mapping Studies
IEA	International Energy Agency
IPMAN	Independent Petroleum Marketers Association of Nigeria
JERS1	Japanese Earth Resources Satellite 1
LFCCs	Low forest cover countries
LPG	Liquefied Petroleum Gas
MSS	MultiSpectral Scanner
NAPIMS	National Petroleum Investments Management Services
NDA	Niger Dams Authority

NDVI	Normalized Difference Vegetation Index
NERC	Nigerian Electricity Regulation Commission
NESCO	Nigeria Electricity Supply Company
NFP	National Forest Policy
NGC	Nigerian Gas Company
NIRAD	Nigerian Radar project
NOAA	National Oceanic Atmospheric Administration
PPMC	Pipelines and Products Marketing Company
PPP	Purchasing Power Parity
PTDA	Petroleum Tanker Drivers Association
REMP	Renewable Energy Master Plan
SAVAN	Accident Victims of Nigeria
SFDs	State Forestry Departments
SPOT	Satellite Pour l'Observation de la Terre
TM	Thematic Mapper

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

Environment is the sum total of the condition within which living organisms live and interact with nonliving ones. The surroundings in which an organization operates includes air, water, land and natural resources. It also affects the life, nature, behavior and growth, development and maturation of living organism (Barrow, 1993; ISO 2010; Douglas and Holland, 2011).

Fuelwood is a renewable form of energy that has continued to be the only energy option (especially for cooking) for most people in the DC (Ali and Benjaminsen, 2004; Shackleton et al., 2006; Ghilardi et al., 2007 and 2009 and Maconachie et al., 2009). Results from recent studies of the Nigerian fuelwood situation suggest that the majority of the population has been moving back to the use of fuelwood in recent times. For example, a study conducted in Kano city in Northern Nigeria by Maconachie et al. (2009) which investigates the consumption pattern of fuelwood among households over at least two decades, revealed that most families, despite using other cooking fuels in the past, are now reverting to the use of fuelwood. There are various reasons for this, including among others, poverty and inconsistency in the supply of fossil fuels in the region. Increasing poverty has ever been reported in the developed countries as a driving factor in the use of fuelwood. Arabatzis et al. (2012) reported that because of the economic crisis in Greece, there is an increased consumption of fuelwood, especially in rural areas.

World Energy Consumption stands for the total energy used by the human civilizations across the globe. Organizations such as the International Energy Agency (IEA), the U.S. Energy Information Administration (EIA), and the European Environment Agency record and publish data regarding energy consumption periodically. Worldwide energy markets have witnessed increasing activities by the energy consumers because global primary energy consumption including commercial renewable energy rose, by 5.6% in 2010, the highest since 1973. China alone consumes 20.3% of the total global energy followed closely by the US at 19%. India consumes a mere 4.4% of the total with the global average consumption (excluding China and USA) at just 0.87%. The global consumption of fossil fuel has considerably increased and the United States accounts for 21.1% of the consumption rate. Coal and renewable energy like biofuels are also among the highly consumed energy in Africa, Asia and Latin America (Vision 20:20:20; Qamar and Siddiqui, 2012).

A report UNDP (2004) posited Nigeria as having a unique geographic location which endows her with a biodiversity that comprises the savannas (Sahel, Sudan and Guinea); forests (lowland rainforest, freshwater swamp forest, mangrove forest and coastal) and mountaine along the Eastern border with Cameroon and Central Nigeria.

Energy consumption patterns shows that Nigeria is challenged by limited alternative energy sources even though she is potentially endowed with sustainable energy resources. Among the energy resources in Nigeria are oil, gas, lignite, and coal bio-fuels, solar, hydropower, and wind (Okafor and Joe-Uzuegbu, 2010).

The patterns of energy use in Nigeria's economy was categorized in industrial, transport, commercial, agricultural, and household facets (Energy Commission of Nigeria, 2003). The household sector accounts for the largest share of energy use in the country - about 65%. This is largely due to the low level of development in all the other sectors. The major energy-consuming activities in Nigeria's households are cooking, lighting, and use of electrical appliances. Cooking accounts for a staggering 91% of household energy consumption, lighting uses up to 6%, and the remaining 3% can be attributed to the use of basic electrical appliances such as televisions and pressing irons (ECN, 2005). The predominant energy resources for domestic and commercial uses in Nigeria are fuelwood, charcoal, kerosene, cooking gas and electricity (Famuyide, Anamayi and Usman, 2011). Other sources, though less common, are sawdust, agricultural crop residues of corn stalk, cassava sticks, and, in extreme cases, cow dung. In Nigeria, among the urban dwellers, kerosene and gas are the major cooking fuels. The majority of the people rely on kerosene stoves for domestic cooking, while only a few use gas and electric cookers (Abiodun, 2003).

In the world's poorest countries, biomass fuels - firewood, agricultural residues, animal wastes, and charcoal - account for up to 90 percent of the energy supply, mostly in traditional or noncommercial forms. In developing countries, the lack of clean and affordable energy is a significant barrier to development and a major contributor to a host of environmental and human health problems (World Energy Association, 2001). Nevertheless, it is pertinent to note that fuelwood and other combustible and renewable resources were humankind’s first energy sources. However, wood is more flexible than other known energy sources and thus gains supremacy over other fuel resources mainly because it costs less and in some circumstances obtained free from the environment (Williams, 2003). According to

FAO (2001) estimates Africa's fuelwood consumption was 172 million m^3 in 1994, representing 2/3 of global consumption. The statistics is rising and with Nigeria contributing about 20% of Africa's total wood consumption.

Approximately 2.5 to 3.0 billion people (40 to 50 percent of the world's total) rely on wood for fuel, both for warmth and food preparation. In Africa, wood is depended upon up to 58% of all energy requirements and in many savanna areas, demand for wood supplies far exceeds the rate of growth (Williams, 2003). Regional analysis of the use of wood as a major source of energy requirements indicates that in Eastern, Western and Southern Africa, more than 90 percent of rural households depend on fuelwood and charcoal.

Approximately, 140,000,542 million people in Nigeria (Census, 2006) consumed about 39'700'206 tone/year of fuelwood which is equivalent to 0.284 tone/person/year i.e about 0.776kg/day. Similarly, Fuelwood in Kaduna State is the most highly consumed fuel, together accounting for about 1,722,904 t/year consumed per person in the State (Zaku, Kabir, Tukur and Jimento, 2007).

The effect of over reliance on fuelwood to the vegetation cover has led to loss of biodiversity, erosion and evolution of badlands, change in micro-climate and lastly land use shifts. Biodiversity loss is reflected on loss of valuable plants (Indiata, Eboigbe and Oriakhi, 2008). About 20% of Nigeria was previously covered with forests of the Guineo-Congonean type. Both authorized and illegal forestry operations together with agriculture have combined to drastically reduce the country's forest cover to barely 10% of its original extent. The annual rate of deforestation in Nigeria averages 3.5%. Based on this, it has been estimated that the country will lose all her forests by the year 2020 (NBSAP, 2006).

Exploitation of biomass for bioenergy is considered a major contributing factor to land/soil degradation in sub-Saharan Africa (World Bank, 1992). Annual soil loss due to erosion is reported at 290 metric tonne/hectare for steep slopes in Ethiopia, and between 10-20 metric tonne/hectare in West African gentle slopes (World Bank, 1989). These figures are very much higher than the acceptable rates of soil erosion in a relatively stable ecosystem.

Dependence on biomass can promote the removal of vegetation. The absence of efficient and affordable energy services can also result in a number of other impacts including health impacts associated with the carrying of fuelwood, indoor pollution and other hazards (e.g., informal settlement fires (IEA, 2002). In Africa, particular attention has been paid to firewood use in the semi-arid tropical regions (Sahel and savanna), since for many years firewood consumption was thought to cause desertification of the Sahel. However, it turned out that drought conditions existed before any expansion of firewood use (Benjaminsen, 1993).

This study therefore investigates the anthropogenic causation of deforestation using a case study area (see section 1.4). Reasons for the choice of the study area are highlighted in section 1.2 and section 3.1.1 respectively.

1.6 STATEMENT OF THE RESEARCH PROBLEM

The survival of rural dwellers and urban poor depends on finding enough wood to cook their meals. Fuelwood constitutes the main source of fuel for cooking by over 76% of the Nigerian population. In support of this, United Nations Development Programmes figures for 1993 showed that Nigeria consumed 262,783 metric tones of fuelwood compared with 7,210 tones for South Africa and 35,313 tones for Thailand.

Njomgang (1987) Evaluation of traditional energies in Cameroon, Found out that fuelwood is the primary source of energy for rural households and a major source of cooking fuel in urban areas in Cameroon. The estimated rate of use is 1.6kg/day/person and 0.0025 to $0.25m^3$/day/household. The report further revealed that an estimate of 200,000-$300,000m^3$/year was used in the littoral regions of Cameroon. Similarly, in Nigeria, Moss and Morgan (1981) reported that fuel wood provides energy for rural household, employment and income for rural farmers as well as part of the energy requirement for cooking in urban areas throughout the country.

A National Survey of ECN (2007) An assessment of the renewable energy masterplan for Nigeria. It showed that 60% of rural dwellers in Nigeria used over 50 million metric tones of fuelwood annually. The consumption rate has exceeded the replenishment rate through afforestation programmes. The rate of deforestation was about 350,000 hectares per year, which is equivalent to 3.6% of the present area of forests and woodlands, whereas afforestation is only at about 10% of the deforestation rate. The survey also indicated that sourcing fuelwood for domestic and commercial uses was a major cause of desertification in the arid-zone prone states and erosion in the southern parts of Nigeria.

Another survey by Zaku, Kabir, Tukur and Jimento (2007) Wood fuel consumption in Nigeria and the energy ladder: A review of fuel wood use in Kaduna State. The result shows that many people are finding it increasingly difficult to afford conventional fuels not only in the State but in Nigeria at large. However, the major reason why people used wood fuel as the alternative source for heat energy generation is poor income, poverty and like of adequate national grid.

David, Mitchell, Henry and Osazuwa (1997) worked on wood fuel usage and the challenges on the environment in Africa. Their study showed that there are possible environmental problems associated with the continuous use of wood as fuel. Some the environmental challenges include: release of GHG gases, particulates which are parts of air pollution, deforestation, desertification, land degradation an upshot of desertification and deforestation and lost of biodiversity, which is the bank for pharmaceutical drugs.

Abdul-Hadi (2009) he examined the household consumption rate of wood fuel in Zaria City Township. A descriptive statistics using arithmetic mean was used and the result showed that households utilize different types of energy sources, with fuelwood as the major. The study also revealed that an average consumption rate of fuelwood when the township had a population of 207,511 people was 7.2kg per household per day.

Abdulkadir (2009) examined wood fuel trade and consumption pattern in Tudun Wada Zaria. Arithmetic mean and Chi square analysis was used and it showed that there was an association between consumption rate and wood fuel trade. The study also revealed that an average consumption rate of fuelwood was 6.7kg per household per day. He also found out that households utilized different types of energy sources with fuelwood as the major because of its cheapest and reliable compared with other energy sources. The survey also confirmed that the major collection centre of wood fuel is Soba Local Government Area.

Ojo, Okonkwo, Oladele, Jayeoba, Suleiman and Yakubu (2012) have worked on the evaluation of wood fuel exploitation and its relative consumption pattern in Kaduna metropolis. A linear correlation using Pearson’s Product-Moment Correlation Coefficient Analysis was used and it showed that there is no significant relationship between fuel wood

exploitation and its relative consumption in Kaduna metropolis. From their results, it was found that fuelwood exploitation has a technique that is basic for sustainable utilization and it ensures a safe environmental standard unlike fossil fuel components in the environment.
Audu (2012) conducted a research on fuelwood consumption and desertification in Nigeria, and found out that there is a high proportion of over – exploitation of vegetation resources without adequate replacement. The result revealed fuelwood as the only means of domestic energy in desert – prone areas.

The gap left by other studies which motivates this research is that the other researches have concentrated on usage, trade and consumption pattern while this research intends to study the effects of fuelwood consumption on vegetation cover, bearing in mind that other factors may also contribute to the consumption rate like construction (building of houses and bridges), commercialization (hotels, restaurants and food sales), electricity poles and domestic use (cooking and room heating). But the uses of fuelwood lead to high consumption in Zaria and its environs. In the past years there was a thick vegetation cover in Zaria and its environs, also games were available as they enjoyed the protection of thick vegetation cover in the area. In addition, there were various flora and fauna species in the area but rapid urbanization characterized by population growth and increasing volume of socioeconomic activities as well as deforestation have reduced the vegetation cover in Zaria and its environs. It is observed that, no previous study has utilized the full range of methodologies listed above to examine the fuelwood problem across all scales from the national to local level, which is a contribution to knowledge that this present study offers.

However, despite numerous researches carried out on fuelwood (Njomgang, 1987; Zaku, Kabir, Tukur and Jimento, 2007; David, Mitchell, Henry and Osazuwa, 1997; Abdul-Hadi and Abdulkadir, 2009; Ojo, Okonkwo, Oladele, Suleiman, Yakubu and Audu, 2012) the impact of fuelwood consumption on vegetation cover in Zaria and its environs as whole is yet to be studied. Therefore the researcher sees the need and picked interest to study and to examine the impact of fuelwood consumption on vegetation cover. Based on that, the study shall provide answers to the following research questions:-

i. Where are the source areas for fuelwood in the region?
ii. What are the factors responsible for fuelwood consumption in the area?
iii. What is the rate of fuelwood consumption per household per day in the area?
iv. What is the rate of vegetation loss due to fuelwood consumption in the area from 1973 - 2014?

1.7 AIM AND OBJECTIVES

The aim of the research is to assess the impact of fuelwood consumption on vegetation cover in Zaria and its Environs. The aim were achieved through the following specified objectives which are to:

i. map the source regions where fuelwood is obtained from (1973 – 2014) in the study area,
ii. examine the factors responsible for the observed fuelwood consumption in the area,
iii. establish the rate of fuelwood consumption in the area,
iv. examine the relationship between fuelwood consumption and vegetation loss in the area from 1973 – 2014.

1.4 SCOPE OF THE STUDY

This study concerned with the examining the impact of fuelwood consumption on vegetation cover in Zaria and its environs, Kaduna State, Nigeria. The areas includes Zaria, Sabon Gari, Giwa, Kudan, Makarfi, Ikara, Soba and Igabi Local Government Area. The study only concentrated on the consumption rate of fuelwood and how its affect the vegetation cover. The study area covering the temporal scope of about five decades (1973, 1986, 1996, 2006 and 2014), using the technique of Remote Sensing (NDVI model).

1.5 SIGNIFICANCE OF THE STUDY

Uncontrolled population explosion especially in the developing countries. One of the environmental resources over–exploited in Nigeria without adequate replacement is vegetation particularly trees (National Bureau of Statistics, 2009). This is why the need and struggle for survival as well as the quest for more comfort are the major causes of environmental resources depletion in the world with particular reference to Nigeria.

It is envisaged that the outcome of the study shall be used by conservationist, Environmental Impact Assessment (EIA) experts, environmental planners, research units, scholars, students etc. Environmental planners will use it in facilitating decision making to carry out development with due consideration given to the natural environmental, social, political, economic and governance factors and provides a holistic frame work to achieve sustainable outcomes. Conservationist will use it to improve, protect, and conserve natural resources on private lands through a cooperative partnership with state and local agencies. It will be useful to government in providing the means of preventing and controlling deforestation in the study area and the nation by providing other means of energy. It serves as source of literature to anyone who wishes to write on the same or related topic.

The study uses multiple methodologies (Remote Sensing, Geographical Information Systems and a local survey using household survey and participant observation) to examine various aspects of the overall problem at different geographical scales. The combined methods serve as a triangulation strategy to identify causal linkages between changes in vegetation cover, fuelwood consumption and cooking fuel supply problems in the region. Past studies have used some of the methodologies, singly or in combination.

CHAPTER TWO

CONCEPTUAL FRAMEWORK AND LITERATURE REVIEW

2.1 CONCEPTUAL FRAMEWORK

2.1.1 Concept of Fuelwood

Fuelwood is a source of energy derived by burning wood materials like logs and twigs and is common among the rural dwellers. It is a traditional source of energy, which has remained the major source of fuel for over half of the world's population (Ogunsanwo and Ajala, 2002).

Fuelwood, charcoal and animal dung/sawdust are all biomass products (Sambo, 2009). Charcoal is a direct by-product of fuelwood and will therefore be discussed as a type of fuelwood resource in this study. Although Animal dung/sawdust forms part of the energy resource for household cooking in Nigeria, its use is insignificant (Sambo, 2009) compared to other cooking fuel types in the country and therefore it is not considered further here.

Most households in the DC lack access to modern energy types, therefore they rely on the use of traditional biomass fuels like crop waste, dung, and wood to meet their basic energy needs, especially for cooking. This statement was emphasized in the 2005 UNDP's Millennium Development Goals (MDGs) assessment report. The MDGs are sets of time-bound and measurable goals and targets for combating poverty, hunger, illiteracy, gender inequality, disease, and environmental degradation in the world (specifically the DC) by 2015 (UNDP, 2005). In particular, use of wood as a traditional cooking fuel is often regarded as inconvenient, despite being a significant source of energy in most DC (Fleuret, 1983; Eckholm, Foley, Bermard and Timberlake, 1984; Amatya,Chandrashekar, and Robinson, 1993; Amacher, Hyde 1993 and 1996; Mahiri, 2003; Kaschula, Twine, Scholes, 2005; Nash and Luttrell, 2006 and Palmer and Macgregor, 2009). A continued high level of fuelwood usage is an alarming situation. Gill (1985) indicated that fuelwood can compete directly with food crops in the DC in terms of demand on household budgets. Leach (1987) pointed out that the massive use and dependence on fuelwood in the DC is environmentally unsustainable (refer to section 2.2.2 below) and therefore regarded it as the most costly of all energy types. Both Gill's and Leach's statements are reflected in the 2011 UNDP MDGs report (BBC Hausa, 2011b), which highlighted the failure of some of the participating countries to meet the targets of the MDGs as expected.

The 2011 UNDP assessment of the MDGs has included Nigeria among those countries requiring further effort to improve their energy situation. Anozie, Bakare, Sonibare and Oyebisi *(*2007:1284) highlighted some of the efforts of the Nigerian government through its Energy Commission and the numerous other research contributions in addressing the energy situation. They concluded that the majority of the energy targets set by the government remained unmet, due to lack of policy implementation, general lack of awareness from consumers of the compelling need to conserve energy and lack of logistics and proper funding. All the four impediments to the improvement of the energy situation in Nigeria described by Anozie, Bakare, Sonibare, and Oyebisi (2007) focused on the laxity of the policy makers in either not funding the sectors efficiently or not policing the laws that would regulate the proper use of energy in the country. It is against this background that it is appropriate to provide an academic assessment of the salient issues in the Nigerian energy situation with particular emphasis on the traditional energy (fuelwood) situation, as wood is the major source of cooking energy for the households (Sambo, 2005 and FAO, 2011a).

2.1.2 Vegetation

The key focus of this study is the relationship between fuelwood consumption and vegetation change. Therefore, a broader definition of vegetation and where this study falls within this definition is quite important (given the broader concept of vegetation) in order to provide a context for the study. This definition incorporates both natural and manmade features on the earth surface as land cover. There have been numerous land cover classification systems (LCCS) that have resulted in either classifying only natural vegetation types, agricultural areas or broad land cover classification types (Di Gregorio and Jansen, 2000). The differences in the resulting classification systems derived from differing organisational requirements. Di Gregorio and Jansen (2000) designed a multi-user-oriented classification system that resolves discrepancies between the various organisational classification systems, through a process of standardisation.

In the initial phase of their classification they identified major land cover types, as follows;

- Cultivated and Managed Terrestrial Areas
- Natural and Semi-Natural Terrestrial Vegetation
- Cultivated Aquatic or Regularly Flooded Areas
- Natural and Semi-Natural Aquatic or Regularly Flooded Vegetation
- Artificial Surfaces and Associated Areas
- Bare Areas
- Artificial Water Bodies, Snow and Ice
- Natural Water Bodies, Snow and Ice

The eight major land cover types identified in their classification were tailored to the presence or absence of vegetation in terms of primarily vegetated and primarily non-vegetated areas. They describe the primarily vegetated areas as areas with a vegetative cover of at least 4% for at least two months of a year. While the primarily non-vegetated category comprises cover areas with a total vegetative cover of less than 4% for more than ten months of the year. The second phase of the classification categorized vegetated areas into four broad classes each with subclasses contrary to the conventional way of classifying vegetated areas as mentioned earlier. The main domains are:

- Grasslands: defined as plants without persistent stem or shoots above ground and lacking definite firm structure (Scoggan, 1978 in Di Gregorio and Jansen, 2000:87).

- Shrublands: defined as plants with persistent woody stems and without any defined main stem structure (Ford-Robertson, 1971 in Di Gregorio and Jansen, 2000:86).

- Woodlands: defined as perennial plants with stem(s) and branches from which buds and shoots develop (Ford-Robertson, 1971 in Di Gregorio and Jansen 2000:86).

- Forest: defined as perennial plants where trees cover more than 10 percent of the ground (Wright and Muller-Landau, 2006).

- Trees: defined as woody perennial plants with a single, well defined stem carrying a more-or-less-defined crown (Ford-Robertson, 1971 in Di Gregorio and Jansen, 2000:86) and being at least 3 to 5 m tall (Di Gregorio and Jansen, 2000:86 and Wright and Muller-Landau, 2006:289).

A summary of Di Gregorio and Jansen’s final phase of vegetation classification approach is presented in figure 2.1

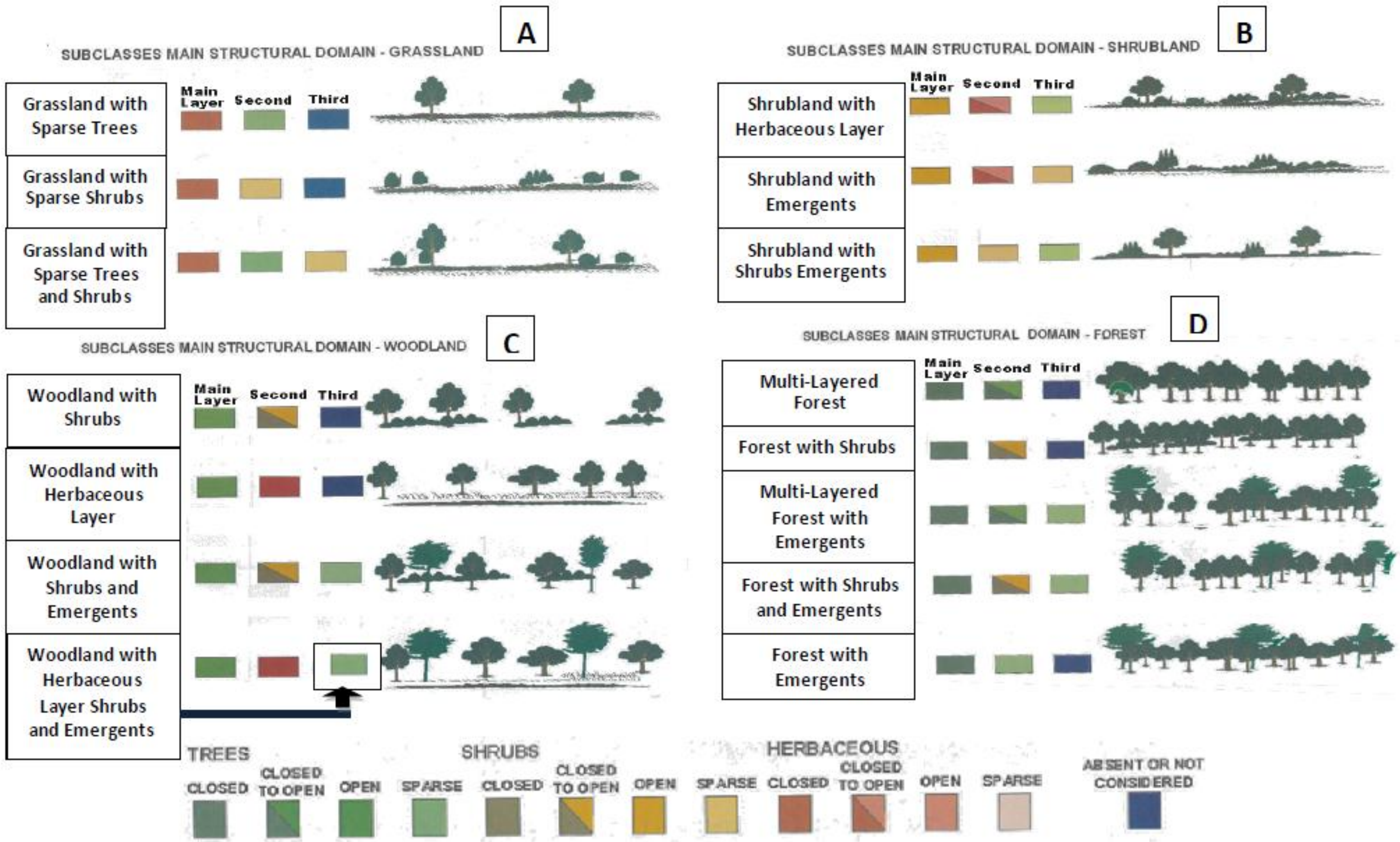


Figure 2.1: Description of Vegetation Types
Source: Adapted from Di Gregorio and Jansen (2000:163-168).

The subclasses (third phase of the classification) are described using the mixture of one or two of the main domains. The layers are described using a further sub-division in terms of closeness of the land cover types to each other as follows: Closed (> 60-70 percent are trees or shrubs with crowns interlocking, touching, or slightly separated); Open (between 70 to 60 percent (open) and 20 to 10 percent (very open) are trees or shrubs with the crowns not interlocking); and Sparse (between 20-10 percent (sparse) and 4 to 1 percent (scattered), in terms of plant cover).

The vegetation of this study area (Zaria and its Environs) includes woodlands, trees, shrubs, herbaceous or a combination of either two or all of these (see figure 2.1). This is broadly identified as part of the savanna vegetation region (Hess, Stephens, and Maryah, 1995, FAO, 2003 and FAO, 2009b). Rainfall lasts for about 5 months in a year (Hess, Stephens, and Maryah,1995), while the vegetation cover is over 4% (FAO, 2010b). Based on these facts, the area is considered to match the category of Sparse Woodland with Herbaceous Layers, Shrubs and Emergents (see figure 2.1 C) under the Di Gregorio and Jansen (2000) classification.

2.1.2.1 Forestry System in Nigeria

FAO recommends that every country should have forest covering at least 25 % of its total land area (FAO, 2010a); Nigeria has only 10% of its land area covered by forest and therefore does not meet this recommendation. For that reason, Nigeria is categorised among the countries referred to as low forest cover countries (LFCCs) (FAO, 2003 and FAO, 2010a). Furthermore, even within the 10% of land under forest, studies have shown that only about 1.3% of the country’s total land area (12,114 kilometre square) is considered undisturbed forest cover (FAO, 2003). This is an indication of how extensively the vegetation cover is utilised. A detailed history of Nigeria's forestry programmes is provided by FAO in its 2003 report entitled "*experience of implementing national forest programmes in Nigeria*". The report is discussed in sections 2.1.2.2 and 2.1.2.3 below.

2.1.2.2. History of Forest Management in Nigeria

The beginning of forest management in Nigeria dates back to 1887 when the office of woods and forest was opened in the then colony and protectorate of Lagos. The first forest decree came into effect in 1901. The decree was fashioned in 1916 with the aim of regulating the sale of timber and improvement of revenue through taxation. It also regulated the minimum girth allowed for exploitation (only mature trees of 100cm and above girth could be removed) and it mandated users to plant 20 more tree seedlings at each stump site. This was the practice up until 1926 when artificial regeneration through the "*Taungya*" system (a system of agriculture where crops are produced alongside with trees) was introduced. By 1940, forest reservation areas were completed in the high forest areas in Southern Nigeria, with the exception of Rivers state, where more areas were set up between 1960 and 1980.

The development of the forest area reserves was, however, much later (between 1950 and 1970) in the northern part of the country where savanna vegetation dominates. The slow and late development of forest reserves in the northern part of the country could be due to the unimportance of savanna vegetation to the export trade in forest logs, which was then very popular in the higher forest of the south.

After the country was divided into three administrative regions in 1954, each region was given the responsibility for the administration, monitoring, management and control of its forest resource, while the Federal Government (FG) was responsible for forestry research and institutions. A similar situation persists even today among the thirty six states and the Federal Capital Territory (FCT), where each state is tasked with the responsibility of safeguarding and controlling its forest areas. This pattern of control is the reason why the FG has no forest reserves of its own.

Prior to the 1970s, forest reserves embraced the activities of local communities, who were authorized to continue their former use of the forest as long as their practices did not affect timber production and forest management. This helps explain why, in the early period, forests in Nigeria, were managed with a high degree of effectiveness. In recent times, by contrast, especially after the Land Use Decree of the late 1970s (which emphasized that all land belongs to government), the efficiency of the sector began to deteriorate like most other public sectors in the country. By the mid 1980s, forest reserves were not properly maintained while management plans were either non-existent or abandoned.

2.1.2.3 The Present System of Forestry Administration in Nigeria

Forestry activities in Nigeria are administered through the three tiers of Government i.e. Federal, State and Local Government. At the federal level, the Federal Ministry of Environment (FME), which was created in 1999, is responsible for administering forestry at the national level through the Federal Department of Forestry (FDF). The latter was created in 1970 under the Federal Ministry of Agriculture and Natural Resources (FMANR). FDF was transferred from FMANR to FME in 1999 and mandated with formulating National Forest Policy and supporting the execution of projects funded by the FG. Other mandates of the FDF include advising and assisting the State Forestry Departments (SFDs) on certain national projects and contacts with international development agencies who assist Nigeria with funds and advice. The states are responsible for their forestry administration through the SFDs under the States' Ministries of Environment. At present, most states have forest reserves maintained by the SFDs, which are responsible for the technical functions of managing timber and wildlife resources, and revenue generation through taxation from the forestry sectors in their states. The smaller forestry departments in the Local Government Areas (LGAs) have the following mandates in the new National Forest Policy (NFP):

A) Setting up of wood lots to protect watersheds and river courses;

B) Protection of forests and farm trees in arable land against fire and illegal felling of trees; and

C) Protection of wildlife against poaching.

Having said earlier that the country operates a unified system of forestry operations through the three tier system of government, in reality there is a difference in the mode of operation between the north and the south. This is because the focus of administrative and forestry staff in the SFDs and LGAs differs from the north to the south. LGAs in the south have virtually no responsibility for managing their forest resources, but may receive part of the revenue generated from forest produce by the SFDs. In the north, the functions of LGA forestry services include revenue generation and forest preservation. The staff in the south where the high forests exist focused on log harvesting, while in the north, where a dispersed forest type dominates (savanna vegetation), they concentrate on the importance of forest resources for fuelwood, environmental protection and livestock production. Unfortunately, even with the new NFP that provides guidelines for safeguarding the forest areas and their resources, starting from the smallest unit of administration (LGAs) in the country, both SFDs and LGAs are faced with a lack of funds and personnel to carry out their tasks effectively. The few staff available also lack adequate training and exposure to modern forestry techniques (FAO, 2003 and FAO, 2010b).

One key problem in the north is the lack of comprehensive documentation of its forestry activities compared to the south (FAO, 2003). Over emphasized on the south, particularly in most FAO reports, is the result of attention being focused on the high forest areas of the south, which has left the less vegetated areas in the north neglected despite the pressing need for research there.

It is worth noting that even though there is an NFP in Nigeria (which was revised in 2006), there was no such forest policy at state level. In contrast, the states were allowed to establish their individual forest laws according to their needs (FAO, 2010a:300).

2.1.2.4. Vegetation Change

Table 2.1 provides a summary of some basic information about the state of Nigerian vegetation. From this table, it is apparent that Nigerian forest cover has consistently declined since the 1990s, at an average of 410,000 hectares (ha) per annum. FAO (2009a) reported that about 60 percent of the world's total wood removals (3,900 million cubic meters) from forests and trees outside forests are used for energy purposes (refer to table 2.1 for Nigerian situation).

At the global level, the total net change in forest area in the period 2000–2010 is estimated at -5.2 million ha per year, which is equivalent to a loss of more than 140 square kilometers of forest per day (FAO, 2010a:17). FAO maintains that this figure is lower than the total forest net change obtained from 1990 to 2000 (-8.3 million ha per year).

Similarly, the area of other wooded land decreased by about 3.1 million ha per year during the decade 1990 to 2000 and by about 1.9 million ha per year in the last decade (2000–2010) (FAO, 2010a:21-22). It is argued that the slower recent rate of decline is as a result of setting up of more plantations rather than a reduction in deforestation (Mather, 2003 and FAO, 2010a:17).

Another possible reason for the apparently slower decline could be due to more studies using Remote Sensing (RS) techniques (Mather, 2003), that have been used to construct a more accurate global forest cover map. Earlier reports by researchers in the field of deforestation had a tendency to exaggerate the forest change situation (Forsyth, 2003). However, some environmental groups have expressed concerns about reaching such conclusions about reductions in the rate of deforestation because of the fear that they can lead to a slowing down of active programmes against deforestation (Mather, 2003). In terms of regional net loss of vegetation, South America accounted for the largest proportion of the net loss, followed by Africa and Asia (FAO, 2010a). Table 2.2 below shows that Nigeria is among the top five countries in the world with the largest net loss of forest areas since 1990. This is not surprising, given that the majority of the country's wood removal is for fuelwood (see table 2.1). The country is moving back to the use of traditional cooking energy, which is why the volume of fuelwood collection rose from about 59,095,000 m3 in 1990 to about 70, 427, 000 m3 in 2005 (see table 2.1).

2.1.2.5. Deforestation

Figure 2.2 below illustrate the concept of deforestation in simple terms. Despite the huge interest in the study of deforestation among researchers, there are still controversies in the literature related to the definition of the term mainly because of the lack of standard definitions of what is a forest (Middleton, 2008:57). Wunder and Verbist (2003) and Middleton (2008) noted that according to FAO there are over 650 different definitions of a forest. The variation in the definitions is a consequence of the differences in the perception of the concept by the various countries whose data FAO relied upon for the forest assessments (refer to Middleton, 2008:58). Interestingly, despite these huge differences, FAO was able to provide a comprehensive definition of the term “forest” as an area of a minimum 0.5 ha, covered by a tree canopy of at least10 percent, with trees that can reach 5 meter height, and subject to the constraint that the area should not be under an alternative (e.g. agricultural or urban) use (FAO, 2000).

Table 2.2: Ten Countries with Largest Annual Net Loss of Forest Area, 1990-2010

Country	Annual change 1990–2000		Country	Annual change 2000–2010	
	1 000 ha/yr	%		1 000 ha/yr	%
Brazil	-2 890	-0.51	Brazil	-2 642	-0.49
Indonesia	-1 914	-1.75	Australia	-562	-0.37
Sudan	-589	-0.8	Indonesia	-498	-0.51
Myanmar	-435	-1.17	Nigeria	-410	-3.67
Nigeria	-410	-2.68	United Republic of Tanzania	-403	-1.13
United Republic of Tanzania	-403	-1.02	Zimbabwe	-327	-1.88
Mexico	-354	-0.52	Democratic Republic of the Congo	-311	-0.2
Zimbabwe	-327	-1.58	Myanmar	-310	-0.93
Democratic Republic of the Congo	-311	-0.2	Bolivia	-290	-0.49
Argentina	-293	-0.88	Venezuela	-288	-0.6
Total	**-7 926**	**-0.71**	**Total**	**-6 040**	**-0.53**

Source: FAO (2010a:21).

Table 2.1: Basic Information about Nigerian Vegetation

Demographic data of Nigeria

Land area [a] (1 000 ha)	Population (2008) [b]				GDP (2008) [c]	
	Total (1 000)	Density (Population/km 2)	Annual growth rate (%)	Rural (% of total)	Per capita (PPP) (US$) c	Annual growth rate (%)
91 077	151 212	166	2.4	52	2 099	6

Extent of forest and other wooded land 2010

Country area (1 000 ha)	Forest		Other wooded land Area	
	area (1 000 ha)	% of land area	area (1 000 ha)	% of land area
92 377	9 041	10	4 088	4

Trends in extent of forest 1990–2010

Forest area (1 000 ha)				Annual change rate					
1990	2000	2005	2010	1990–2000 (1 000 ha/year)	% [d]	2000-2005 (1 000 ha/year)	% [d]	2005-2010 (1 000 ha/year)	% [d]
17 234	13 137	11 089	9 041	-410	-2.68	-410	-3.33	-410	-4

Trends in removals of wood products 1990–2005

Industrial round wood - Total volume (1 000 m3) [e]			Wood fuel - Total volume (1 000 m3) [e]		
1990	2000	2005	1990	2000	2005
9 321	10 831	10 831	59 095	68 172	70 427

Value of wood removals (Five year average for 2003–2007)

Value of removals (million US$)	
Industrial round wood [f]	Wood fuel [f]
124	456

a Total area of the country excluding inland water bodies. The figures are from FAOSTAT (FAO, 2008). b *General Source:* FAOSTAT-PopSTAT (http://faostat.fao.org/site/550/default.aspx#ancor). c Per capita gross domestic product (GDP) is expressed at purchasing power parity (PPP). *Source:* World Bank (2010), IMF (2010); UNSD (2010) and CIA (2010). d Rate of gain or loss in percent of the remaining forest area each year within the given period. e Five year averages for 1988–1992, 1998-2002 and 2003–2007 respectively. f Five year average for 2003–2007.

N.B. The figures for 2000 and 2005 of industrial round wood under Trends in removals of wood products 1990–2005 appear the same because of the effect of rounding the total figures to the nearest 1000. However, it is an indication that the variation in the industrial wood removal is quite small since 1990 compared to fuelwood.

Source: Adapted from FAO (2010a).

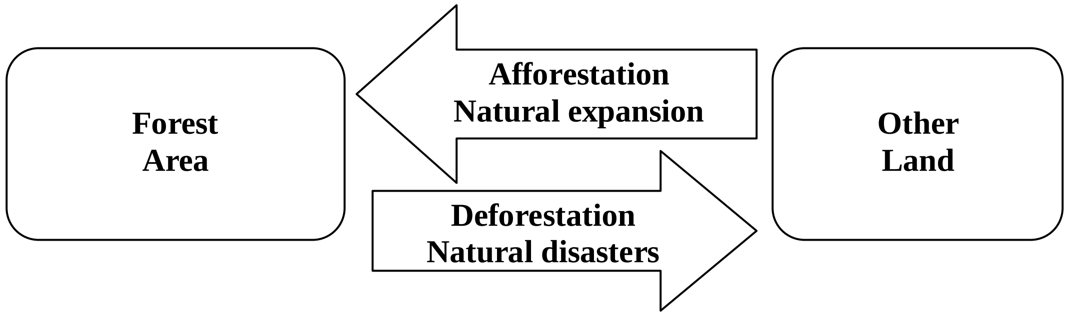


Figure 2.2: Forest Change Dynamics
Source: FAO (2010a:17).

From the definition, it can be observed that FAO considered both natural forests and forestry plantations as "forests" as long as they satisfy the quantitative criteria. Based on this definition, deforestation is considered to be the removal of tree cover from the forest- or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold (FAO, 2010a). On the other hand, authors like Forsyth (2003) and Middleton (2008) regarded the term “deforestation” as the conversion of a forest area to another land use, mainly by clearing the existing vegetation cover. This latter definition of deforestation seems more accommodating, because of the inclusion of the “phrase” clearing of the existing vegetation cover’ in the definition. Forsyth (2003:36) argues that this enables other forest ecosystems, such as the savanna to be considered also. Given this fact, Forsyth’s definition is adopted in this study, since it allows the inclusion of other vegetation types that are being cleared for various reasons. Since the FAO definition of deforestation is more rigid and confined to a specific definition of forest (tree canopy of at least 10%, with trees up to 5 meter height), it is not utilized in this study.

Neither definitions ignored the fact that deforestation has been attributed to the action of human beings. It is also important to distinguish between the clearance of different types of vegetation cover (forest, woodland, savanna, shrub land and grassland) instead of treating all kinds of vegetation the same. This is because the extent of wood extraction differs from one ecosystem to another based on a variety of factors.

For example, Amacher, Koskela and Ollikainen (2009) examined the implications of migration and insecure property rights for land use and deforestation in the tropical frontier forests. The authors concluded that illegal logging risks lead to deforestation. Even though they reported a decrease in forest cover in their study as a result of illegal logging, they also highlighted the complex nature of the concept of deforestation because, in their study area, government enforcement of forestry legislation reduced illegal logging, while greater private enforcement did not necessarily reduce deforestation. This shows the importance and the need for government intervention in the management of forests. They also reported, as would be expected, that forest with higher economic value are more subject to active deforestation. This applies, in the case of Nigeria, where the accelerating rate of vegetation clearance since 1990 has been attributed to the demand for fuelwood (refer to table 2.1).

2.2 LITERATURE REVIEW

2.2.1 The Shortage of Fuelwood

In the past, rising fuelwood demand was predicted to result in a whole range of negative environmental and socio-economic consequences, including persistent depletion of forest resources, increased wood collection times, and greater monetisation of fuelwood supplies requiring more cash from poor households (Hyman, 1993). Most of these negative perceptions were particularly pointed out by Eckholm (1975) in the late 1970s and emphasised by Eckholm, Foley, Bernard and Timberlake (1984) in their work entitled "*Fuelwood: The energy crisis that won't go away"*. Throughout the 1970s and a greater part of 1980s, the security and future sustainability of fuelwood demand was questioned, based on the assumption that in the near future, the majority of places in the DC would be deforested as a result of fuelwood collection (Gill, 1985 and Schulte-Bisping, Bredemeir and Beese, 1999). These assumptions and predictions were mostly based on very crude estimates and projections of supply and demand, so further empirical studies were needed to assess the fuelwood situation more accurately (Eckholm, Bernard and Timberlake, 1984).

Eckholm, Bernard, and Timberlake (1984) suggested that research interventions should focus more on the underlying causes of the fuelwood problem rather than just on the symptoms. This has paved the way for much research on the present use of and future prospects for fuelwood supplies. Notable studies include Mahiri and Howorth (2001); Ali and Benjaminsen (2004) and Bensel (2008). These cast doubt on Eckholm, Bernard and Timberlake (1984) ealier prediction of a future fuelwood crisis, and they have concluded that local fuelwood collection (using family labour) is not the primary cause of deforestation. Other contributing factors include forest clearance for agricultural land, housing construction, overgrazing and overpopulation, which vary in importance between different localities. However, they have all identified the importance of commercial fuelwood demand, in particular, as a potential contributor to over-exploitation of forest resources (the commercialization of fuelwood is discussed under section 2.2.5)

Some other studies have clearly shown fuelwood collection to be the major cause of deforestation, especially at a local level. For example, Amacher, Hyde and Kanel (1996; 1999); Ghilardi and Guerrero (2009) and Palmer and Macgregor (2009) have shown that the demand for fuelwood in their respective study areas (Nepal, Central Mexico and Namibia respectively) can only be met by the overexploitation of forest resources. A similar situation was observed much earlier in Botswana where the majority of the people were aware that sooner or later, acquiring firewood would become a very difficult task, based on their observations of the rate at which trees are fast disappearing (Jelwic and Van Vegtan, 1981). Unfortunately, none of these studies paid close attention to the size of the forest resource that had been overexploited as a result of fuelwood collection, so they were unable to show clearly the extent of the resulting forest degradation. It is therefore important to study the present and likely future impacts of fuelwood collection in relation to the forest size and/ or pattern of vegetation change, especially at a sub-regional level.

2.2.2 Fuelwood Consumption

Figure 2.3 below shows the natural shares of world fuelwood consumption. The wood energy considered in the statistic includes fuelwood, charcoal and black liquor1, which are measured in thousand metric tons of oil equivalent (TOE) - (1 metric TOE is defined as 41.868 Gigajoules which is equal to the amount of energy contained in 1 metric tonne of crude oil; 1 tonne of Fuelwood = 0.38 TOE).

From figure 2.3, it is obvious that the DC use more fuelwood than the developed countries, with most countries in Asia and Africa using fuelwood for at least 50% of their energy consumption. In contrast, the developed countries (Europe and North America) derive less than 10% of their energy needs from fuelwood. The major problem in the DC is the lack of viable alternative energy sources in the DC that could reduce the number of people that depend on fuelwood (Maconachie, Tanko and Zakariya (2009). The adverse effect of this is borne by the environment in the form of deforestation.

Studies of fuelwood conducted in different parts of Nigeria (major towns) that explored the patterns of use and change over time revealed an extending and changing exploitation pattern of fuelwood resources. Cline-Cole *et al*. (1987), Hyman (1993) and (1994), and Ogunkunle and Oladele (2004) found that fuelwood consumption in the north and south western parts (the Ibadan area in Oyo state) of Nigeria far exceeds sustainable production, and the deficit is only made up from areas of surplus (pockets of localised vegetation in the other parts of the country), which adds to the cost of the wood (Adeoti, Idowu, and Falegan, 2001; see section 2.2.4 also).

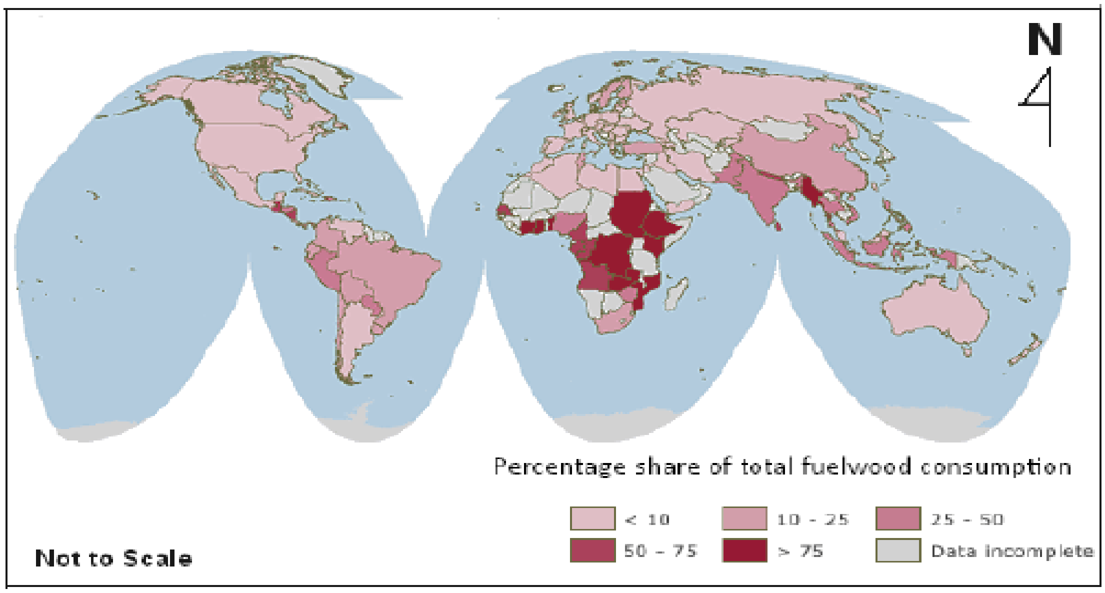


Figure 2.3: World Fuelwood Consumption
Source: International Energy Agency (IEA) (1996) cited in World Resources Institute (WRI) (2007).

Although consumption of fuelwood differs greatly even in the same region in a particular country (Eckholm, Foley, Bernard and Timberlake, 1984) availability plays a vital role in determining the consumption pattern of fuelwood (Mlambo *et al*., 2003). Eckholm, Foley, Bernard, and Timberlake indicated that in different countries, places with less fuelwood tend to use less than 500kg per head every year, while places with surplus use as much as 2000kg per head every year. Cline-Cole, *et al*. (1987) put the annual consumption rate of fuelwood per person at 360 kg in Kano, Northern Nigeria, in a survey they conducted in the early

1980s. A different study conducted by Kersten, Baumbach, Oluwole, Obioh, and Ogunsola (1998) at Ile-Ife, in the southern part of Nigeria fifteen years later found that every person used 515 kg of fuelwood per annum on average. These two results indicate that Nigeria falls below the consumption level for fuelwood in surplus areas suggested by Eckholm, Foley, Bernard and Timberlake, (1984). The two results also indicate that the northern part of the country has lower average consumption than the southern part. This is further illustrated in Figure 2.4.

FAO (2003) showed that apart from the southern part of Nigeria where the high forest is found there is no other region in the country that is self sufficient in the supply of fuelwood (figure 2.4). It is unclear how the increasing demands for fuelwood in the northern part of Nigeria (Guinea and Sudan Savanna) (Hyman, 1993; 1994) is to be met. While the Savannah area is large, its fuelwood production is declining compared to that of the high forest zone. This could be attributed to its increasing demand for fuelwood as a result of its population increase and the conversion of woodlands into farmland (land use change) (PBR, 2009 and FAO, 2010a).

However, if fuelwood supply in the northern part of Nigeria is shrinking as portrayed in figure 2.4, then what is the current and future outlook of fuelwood in the region and the country at large? This question needs to be answered if the country is to avoid running out of the common man's basic energy source (FAO, 2011a).

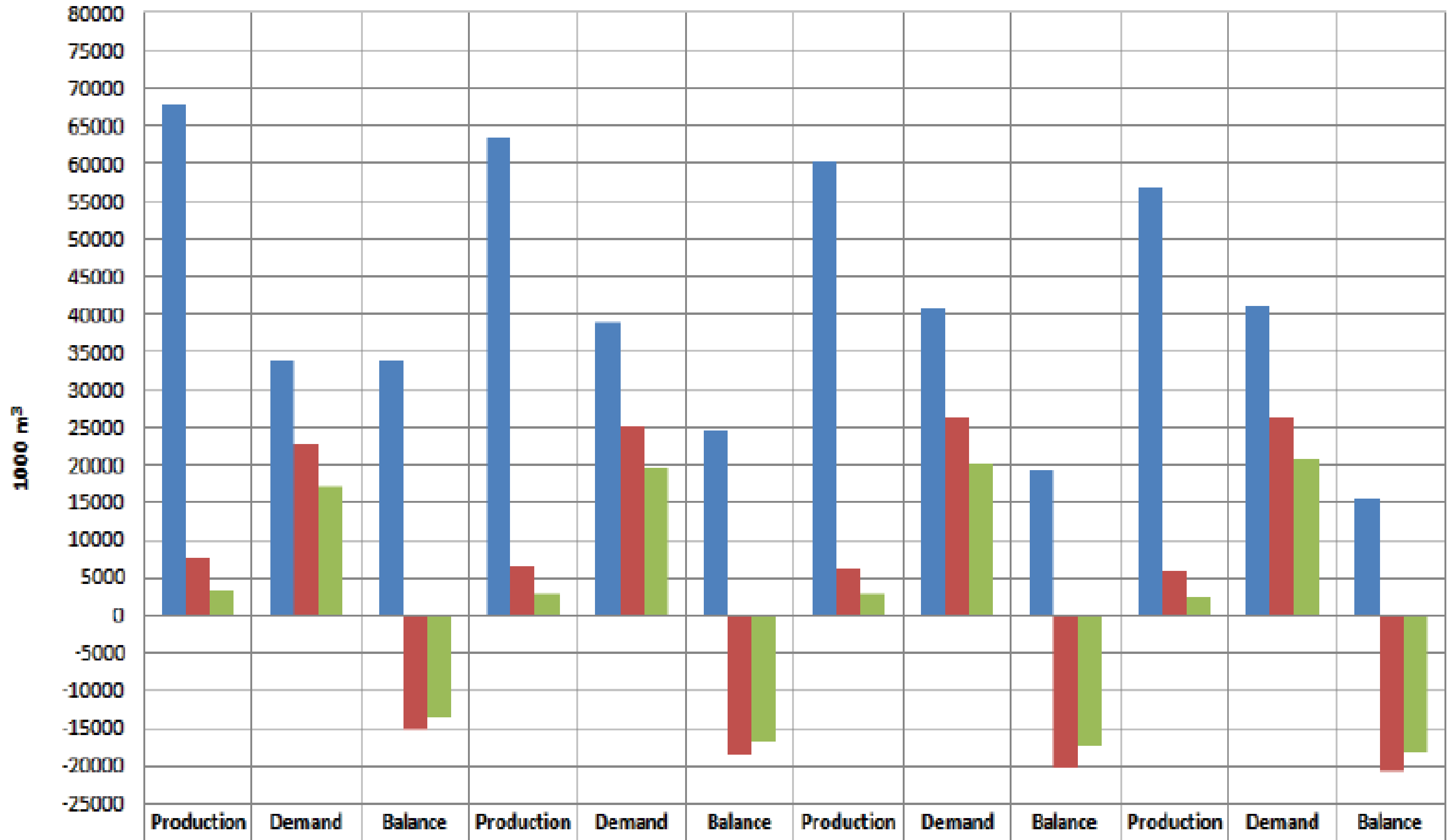
2.2.3 Fuelwood Demand

Fuelwood was the very first source of energy for mankind and it remains the most important single source of renewable energy, providing over 90% of the global total primary energy supply today, making it as important as all other renewable energy sources (hydro, geothermal, wastes, biogas, solar and liquid biofuels) (FAO, 2011a and FAO, 2011b). In Nigeria, as depicted in figure 2.4, the demand for fuelwood is higher because more than 80% of households use fuelwood for their cooking, making it the most used form of cooking energy (Sambo, 2008a). The over-dependence on fuelwood in the country has been attributed to its availability and affordability compared to the other sources of energy (see section 2.5). From the perspective of the consumer, the availability and affordability of the energy source matters as well as the type of energy (Sambo, 2008a).

2.2.4 Fuelwood Procurement

Fuelwood procurement involves the process of selecting, chopping, gathering and transporting fuelwood (Williams, 1983). This definition identifies the complex activities involved in sourcing fuelwood for domestic usage, which was in the past considered to be solely the task of women in Africa (Williams, 1983; Hyman, 1983; McClintock, 1987 and Brouwer, Hoorweg and Van Liere (1997). For example Williams' research on the social organisation of fuelwood procurement and use in Africa, highlighted that women are the dominant sex in executing the task of collecting and using fuelwood. His findings also showed that women collect the fuelwood from short distances and in small quantities as a daily routine.

However, with the recent change in the state of fuelwood (shortage, distance to collection centres and marketing as discussed in section 2.2.5), there is now a shift in the paradigm that women were the primary collectors of fuelwood in Africa (Cooke, Kohlin and Hyde, 2008).



	1995			2000			2005			2010		
	Production	Demand	Balance	Production	Demand	Balance	Production	Demand	Balance	Production	Demand	Balance
HIGH FOREST	67840	33895	33945	63518	38911	24607	60048	40832	19216	56565	41062	15513
GUINEA SAVANNA	7635	22808	-15173	6500	25033	-18533	6149	26271	-20122	5797	26417	-20620
SUDAN SAVANNA	3267	17054	-13787	2767	19577	-16810	2748	20118	-17370	2359	20660	-18301

Figure 2.4: Comparison of Ecological Regions Production and Demand of Fuelwood in Nigeria (1000m^3)
Source: Data adapted from Forestry Management Evaluation and Coordinating Unit (FORMECU) (1996).

In addition, the new fuelwood situation highlighted in the preceding sections presents some challenges that have resulted to the active participation of men in the collection process. Men now engaged in long distance travel to procure fuelwood as a means of earning money (Christensen, Rayamajhi and Meilby, 2009), using tools such as saws for cutting down the trees, and trucks to transport the wood (McClintock, 1987; Cline-Cole, 1987 and Christensen, Rayamajhi and Meilby, 2009). This lead to a much faster deforestation rate than the use of family labour to procure the fuelwood (refer to section 2.2.1). While recognising the fact that the use of sophisticated tools and vehicles would expedite the process of cutting and transporting tree logs, little has been reported on the activities of commercial fuelwood collectors in terms of tools usage and the labour involved. It is therefore very important to ascertain the level of usage of these tools and measure the extent of environmental degradation caused as a result of using them, especially in Northern Nigeria, which has already been declared unsustainable in terms of fuelwood production (FAO, 2003).

2.2.5 The Role of Fuelwood Commercialization on the Socio-economic Activities

Fuelwood prices differ in the same way that consumption of fuelwood differs noticeably among households even within the same region of a particular country (Hyman, 1983; Leach, 1987; Chomitz and Griffiths, 2001 and Christensen, Rayamajhi and Meilby, 2009). There are also no standard prices for fuelwood in the majority of the DC. For example, a survey conducted among 200 fuelwood merchants in Bangladesh showed that there was a huge difference in the price of fuelwood ranging between ten and one hundred percent (Leach, 1987). Fuelwood merchants determine the price and the consumer has no choice because of the scarcity situation, except to pay what is demanded (Shackleton *et al.,* 2006).

Implementation of policies in the DC to regulate fuelwood prices is therefore not a viable approach (see section 2.2.8). The greatest impact of price fluctuations is felt by the poor households, who are among the major consumers of fuelwood in the DC (Perez-Verdin, Kim, Hospodarsky and Tecle, 2009 and San, Spoann, Ly and Chheng, 2012). It is therefore not surprising that the impact of the commercialization of fuelwood on poorer households was described by Hegan, Hauer and Luckert (2003) using the concept of 'the tragedy of the commons' (Hardin, 1968), because it is a localised market where the vendors can easily manipulate the price, since there is no formal regulating body to check their excesses.

For example, in a survey conducted by Hyman (1983) of fuelwood sellers and commercial charcoal makers in the province of Ilocos Norte in the Philippines, the fuelwood market was found to be a dispersed small-scale industry, where the majority vendors only participated seasonally or as a part time job. Hyman (1983) and Shackleton *et al*. (2006) also confirm that fuelwood is sold in many non-standard units of measurement and retail prices vary with location, volume of sale, responsibility for delivery and special relationships between the seller and buyer. In addition, Christensen, Rayamajhi and Meilby (2009) argued that the future evolution of the fuelwood market is unpredictable and it will most likely be influenced by infrastructural changes like good road networks. They therefore stressed the need for future policy intervention to save poor families from the fuelwood vendors' excesses by moderating the prices of fuelwood as happens in other energy sectors. Research conducted by Shackleton *et al*. (2006) in South Africa, where there is already a good road network system, showed that fuelwood is already an organised market system and the retailers earn meaningful income and can even create jobs for the unemployed. Shackleton*et* *et al.'s* findings therefore indicate the viability of commercial fuelwood vending in providing income and job opportunities to poor households by creating more jobs.

Cuthbert and Dufournaud (1998) examined the consumption of fuelwood in some selected countries of Sub-Saharan Africa (SSA) from 1970 to 1990 and were able to determine the impact of income and price on fuelwood demand. Their results indicated that fuelwood would continue to remain a superior good for trade because of its situation (scarcity and demand) in the DC. Despite efforts to alleviate the problems caused by over-dependence on fuelwood in many DC (Shackleton *et al*., 2006), little has been achieved in terms of significant outcomes. As an example, Shackleton *et al*. states that most households in many parts of South Africa consume up to 1,200 kilograms of fuelwood per annum despite the availability of modern fuels and the state subsidization of electricity.

2.2.6 Seasonal Variation and Prices of Fuelwood

There is a wide acceptance now that the structural systems of commercial fuelwood supply in most DC are not fully documented (McCrary, Walsh, and Hammett, 2005). McCrary, Walsh and Hammett examined the movement of fuelwood to the major markets of Masaya in Nicaragua, and reported that there was a high dependency on the natural forest to maintain the supply of fuelwood. There was also a disparity in the demand pattern of fuelwood in the rainy and dry season, with the latter season dominating the activity of fuelwood trading. Similar findings have been reported by some researchers both recently and in the past. Some of these findings are highlighted below.

McCrary, Walsh and Hammett (2005) uses the figures of fuelwood traded at the peak of two different seasons in Masaya Nicaragua to determine the season that dominates fuelwood activity. They put the figures of fuelwood sold by vendors at 63,648 kg in a 5 day period in the dry season, while rainy season figures only accounted for 12,921 kg in a 5 day period. The two contrasting figures suggest that the activities of fuelwood are greater in the dry season than rainy season. A similar dry season demand pattern was earlier observed in Nigeria where reports indicated that there was a high demand for fuelwood in Northern Nigeria during the Harmattan season (dry winter period) (Polly, 1967 cited in Williams, 1983; Cline-Cole *et al.*, 1987 and Alabe, 1996). A survey conducted in the rural mountainous region of Nepal by Christensen, Rayamajhi and Meilby (2009:525) equally confirmed that fuelwood collection was observed to be very high in the dry winter season when the wood is relatively "dry and light". Kumar and Sharma (2009) also show that the winter period dominates in terms of fuelwood demand and consumption across different seasons in Garhwal Himalaya, as might be expected.

Based on these findings, it is clear that the collection and selling of fuelwood are mostly conducted in the dry winter seasons in a majority of DC. However, these studies do not pursue the implications of these patterns of activities. For example, is hoarding an integral part of commercial fuelwood supply strategies among vendors to meet the demand of the rainy season, and would such hoarding have any direct consequences for households in monetary terms? Questions such as these have not been considered in previous work.

2.2.7 Fuelwood Versus other Energy Types in Nigeria

Nigeria has already shown a tendency towards excessive total fuelwood consumption (see Tables; 2.1 above and 2.3 below), which according to Sambo (2008a) is due to population growth, low technical efficiency of the traditional cooking style and the lack of adoption of other sustainable cooking methodologies. While Sambo's (2008a) claims cannot be denied as part of the overall problem of fuelwood in Nigeria, one key factor he does not consider is the unreliability in the supply of alternatives to fuelwood in the country (see sections 2.2.8-2.2.9).

From Table 2.3, Nigeria has estimated forest and woodland reserves of 11 million hectares and produces about 0.110 million tonnes of fuelwood per day. While Nigeria's forest area as a percentage of its total land mass is less than 10% (FAO, 2010a), the fuelwood utilization in the country (0.120 million tonnes/day) surpasses its production, making it the only energy source in the country where utilisation surpasses production (Sambo, 2009).This is potentially catastrophic given that the country has been experiencing problems with its forest management (FAO, 2003), and most areas in the north have been declared unsustainable in terms of fuelwood production (FORMECU, 1996).

Also with the outcome of the 2005 UNDP MDGs report on the DC's energy situation, which stressed the need to reduce the high dependence on fuelwood, the future of Nigerian forests is not bright. The 2005 UNDP report on MDGs indicates that the majority of the countries participating in the MDGs project (including Nigeria) take little notice of the energy requirements of poor people, by only treating energy development within the context of large-scale infrastructure projects, without taking on board the traditional sources of energy in their policy decisions. The continued lack of commitment shown by most of the countries participating in the MDG's programme, to address the problem of energy deprivation is reflected in the energy poverty seen today in many countries (Florini and Sovacool, 2009; BBC Hausa, 2011a; Cherp, Jewell and Goldthau, 2011 and Scott, 2012). At present, more than 2.4 billion people worldwide rely on traditional biomass as their primary source of energy and more than 1.6 billion people have no access to electricity (UNDP, 2005; Brew-

Hammond and Kemausuor, 2009; FAO, 2010a, Kebede, Kagochi, and Jolly, 2010; Deichmann, 2011 and IEA, 2011). Based on these figures, it can be argued that a large segment of the world's population is deprived of improved energy services that can advance their economic growth and social equality. The UNDP (2005) report stressed the need for some development strategies in the procurement of energy in the participating countries that will address issues relating to fuel availability and rural energy development for easy access by the poor. The UN General Assembly's recent recommendation to designate an 'International Decade of Sustainable Energy for All' highlights the urgency and increasing momentum of this agenda (UN, 2012). The situation of energy access in Nigeria is discussed further below.

2.2.8 Fossil Fuel (Petroleum Products)

Fossil fuel resources are major economic assets worldwide (Sambo, 2005 and Sambo, 2008a). Petroleum resources, for example, have been the largest contributor to the Nigerian Federation accounts through export earnings and second largest contributor to the Gross Domestic Product (GDP) (Sambo, 2008a). Nigeria's oil reserves are estimated at about 36.22 billion barrels, while natural gas reserves are 187 trillion standard cubic feet (see table 2.3). The gas reserve is at least twice that of crude oil in energy terms (Nigerian National Petroleum Corporation (NNPC), 2010). NNPC is a corporate body responsible for organising the affairs of the Nigerian petroleum industry. In March, 1988 when the NNPC was reorganised by the government for the purpose of proper capitalisation and commercialisation, the Pipelines and Product Marketing Company (PPMC) was created (PPMC, 2010). PPMC is a subsidiary of NNPC tasked with the mandate of sourcing petroleum products and their distribution to all parts of the country at a uniform price

(PPMC, 2010). The mode of PPMC's operation is quite simple, because in theory, PPMC receives crude oil from the NNPC Corporate Service Unit called National Petroleum Investments Management Services (NAPIMS), which it then supplies to the NNPC local refineries in the country (PPMC, 2010). However, refined petroleum products were often imported into the country to supplement local production, due to the dilapidated state of the country's refineries (PPMC, 2010). The imported or locally refined petroleum products are then received by PPMC through import jetties or refinery depots and distributed by pumping the products through pipelines (5,120 km – total length) to the various depots and pump stations (23 depots and 8 pump stations, see figure 2.5) located all over the country, from where petroleum tankers transport the products to the filling stations (retail outlets). The PPMC's objectives (PPMC, 2010) include the following:

i) To provide excellent customer service by transporting crude oil to the refineries and moving refined petroleum products to the local markets efficiently at a low cost through a safe and well maintained network of pipelines and depots.

ii) To profitably and efficiently market refined petroleum products in the domestic as well as export markets, especially the Economic Community of West African States (ECOWAS) sub-region.

iii) To provide marine services and also maintain uninterrupted movement of refined petroleum products from the local refineries.

Table 2.3: Energy Reserves, Production and Utilisation in Nigeria

S/No	Resource Type	Reserves (Natural Units)	Geographical Location	Production Level (Natural Units)	Utilization (Natural Units)
1.	Crude Oil	36.22 billion barrels	South-South South-East South-West	2.06 million barrels/day	445,000 barrels/day
2.	Natural Gas	187 trillion standard cubic feet (SCF)	South-South	7.1 Billion SCF/day	3.4 billion SCF/day
3.	Coal and lignite	2.734 billion tonnes	Spread Nationally	insignificant	insignificant
4.	Tar Sands	31 billion barrels of oil equivalent	South-West	insignificant	-
5.	Large Hydropower	11,250 MW	North-Central	1,938 MW (167.4 million MWh/day)	167.4 Million MWh/day
6.	Small Hydropower	3,500 MW	Spread Nationally	30 MW (2.6 million MWh/day)	2.6 million MWh/day
7.	Solar Radiation	3.5 - 7.0 kWh/m2/day (485.1 million MWh/day using 0.1% Nigeria land area)	Spread Nationally	Excess of 240 kWp of solar PV or 0.01 million MWh/day	Excess of 0.01million MWph/day of solar PV
8.	Fuelwood	11 million hectares of forest and woodland	Spread Nationally	0.110 million tonnes/day	0.120 million tonnes/day
9.	Nuclear Element	Not yet quantified	North-East	insignificant	-

Sources: (i) Nigerian National Petroleum Corporation (NNPC) (2007), (ii) Renewable Energy Master plan (REMP) (2005) and (iii) Ministry of Mines and Steel Development (2008) all cited in Sambo (2009).

N.B: W= Watt; gives the power capacity; Wh= Watt-hour; gives the amount of energy produced or consumed; PV=Photovoltaic- The energy generated from the sun using solar panels; SCF= standard cubic feet; KW – kilowatt= 1000 MW; MW – Megawatt= 1000 KW; GW – Gigawatt= 1000 MW; TW – Terawatt= 1000 GW. **See box 2.2 for other sources of energy in the country.**

However, the task and objectives of the PPMC have not been fully achieved and instead the country constantly experiences irregularities in the supply of petroleum products (Ogbonnikan, 2012 and Okpi and Leke, 2012); shortages in the petroleum products pumped through the pipelines at the receiving destination (depots), a situation always attributed to sabotage and bunkering (Aroh *et al*., 2010); and tankers spilling petroleum products due to accidents on the major roads and cities in the country causing environmental issues and above all deaths etc. (Enogholase, 2011). These are some of the limitations of PPMC which are further discussed in sections 2.2.8.1 to 2.2.9 below.

Overall, fossil fuel remains the costliest energy type in Nigeria because of its high demand for both cooking, transportation, industries and lighting (Olise and Nria-Dappa, 2009). Olise and Nria-Dappa reported that the majority of poor households in African countries, including Nigeria, spend nearly 10-15 percent of their household income on the purchase of kerosene either for lighting (lamps) or for cooking (stoves). Olise and Nria-Dappa emphasised that the energy situation in Nigeria is more actually worse than has been revealed to the outside world. They presented their arguments on the basis of the household income ratio to their spending on energy and revealed that the poorest households earn about 1-2 US dollars per day and spend about 0.4 dollars per day on energy. This represents about 20-40 percent of the household's income spending on energy alone. Even though this figure seems to be high, the fact remains that the availability and acquisition of fossil fuel products in Nigeria is highly erratic due to the corruption that has become endemic in the NNPC (Ogbonnikan, 2012) - (see more discussion in sections 2.2.8.1 -2.2.8.3).

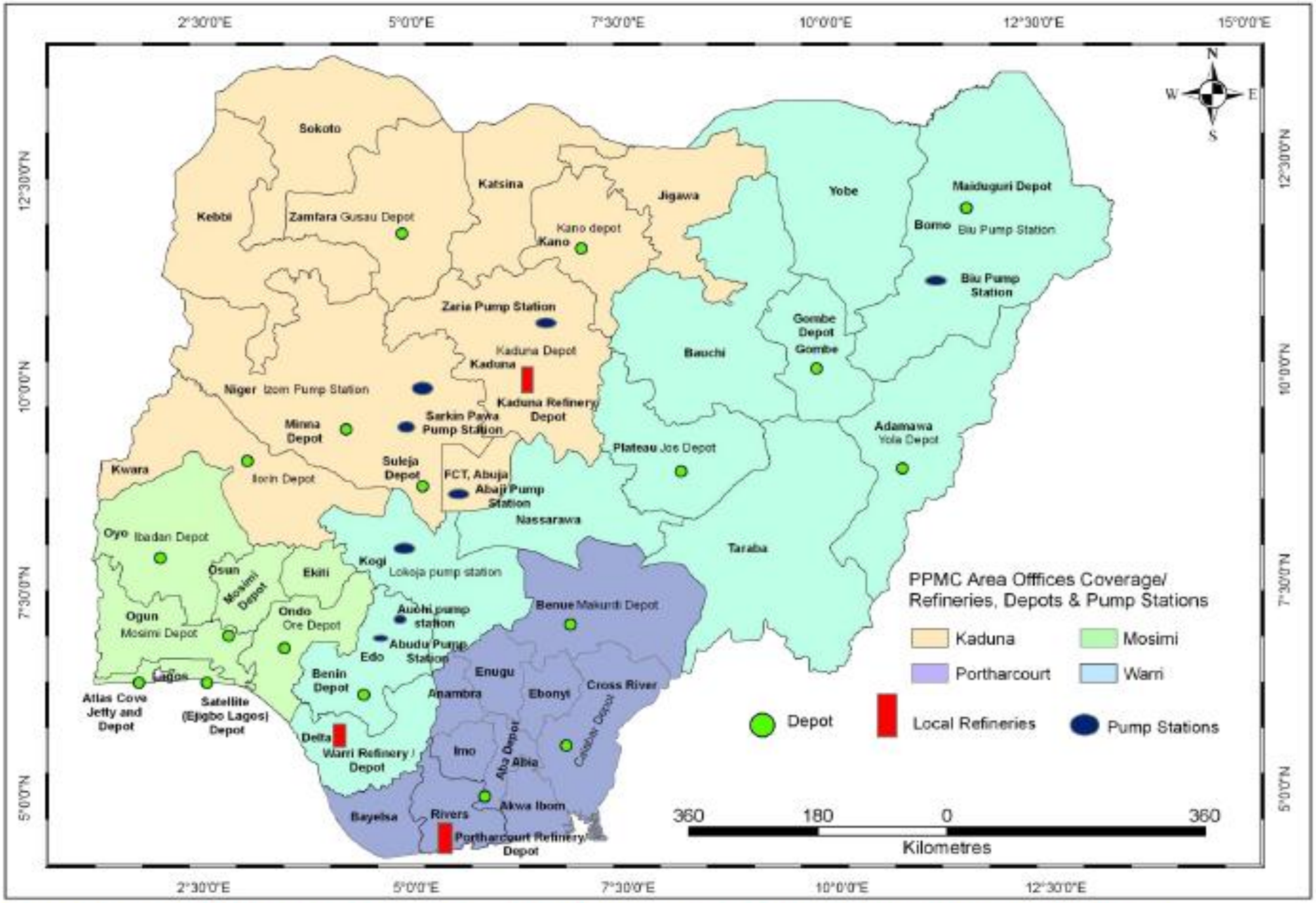


Figure 2.5: Geographical Distribution of Refineries, Petroleum Products Depots and Petroleum Products Pump Stations in Nigeria.
Source: Adapted from PPMC (2010).

2.2.8.1 Kerosene

Kerosene is the predominant energy source used in rural areas for lighting, while in urban areas it is used as a fuel in specific types of cooking stove (Olise and Nria-Dappa, 2009). There is strong evidence, as indicated by Sambo (2008a) of the use of small quantities of kerosene in both rural and urban areas for easy initiation of fuelwood combustion. Although the use of kerosene for cooking in Nigeria has been widely accepted (NAN, 2013b) there are problems which limit its availability to households. The Sweet Crude monthly edition of the Vanguard newspaper in Nigeria (July, 2011a) confirmed some of the issues hampering the availability of kerosene and other fossil fuels in the country and attributed all of them to the attitude of the marketers. The headline article entitled "*fuel subsidy gulps 1.3 trillion Naira ($ 8.38 billion) in 2010*" explained the defective role of the marketers in compromising the supply of the product to the public. Five market scenarios for Dual Purpose Kerosene (DPK) in Nigeria were described, as follows:

i) DPK is obtained at a subsidised price and sold as a Household Kerosene (HHK) at three times the price to consumers.

ii) DPK is blended with diesel to increase the volume of this fuel before it is sold at a deregulated pump price to the consumers. Diesel is the only fossil fuel that was deregulated in the country prior to the fossil fuel subsidy withdrawal in January, 2012 (BBC Africa, 2012).

iii) DPK that is meant to be delivered to the pump stations for household consumers is diverted and sold as aviation fuel.

iv) DPK is smuggled across the border because of the subsidy in Nigeria and sold at a much higher rate in neighbouring countries.

v) DPK is illegally transported across the border and then presented back to the NNPC as imported cargo for the purposes of claiming subsidy from the government.

Further evidence of these problems was provided by the Nigeria Minister of Petroleum Mrs. Allison-Madueke. During her confirmation interview with the Senate she disclosed that there was insufficient supply of kerosene in the country, and this was one of the most challenging issues facing the government (Abubakar, 2011). She also identified the problems associated with hoarding of kerosene by the marketers, which seriously affect the availability and supply of the product in the country. Further to this, she maintained that kerosene pricing will remain an issue even when kerosene is made available in the country in large quantity, because the type of kerosene (DPK) used in the country has the same quality as aviation fuel, which some corrupt marketers buy at a cheaper rate and sell at higher prices as aviation fuel.

Another issue related to kerosene scarcity in Nigeria is the wide circulation of adulterated and low quality kerosene that is available on the black market, which has been blamed for several explosions that have resulted in severe injuries and deaths in the country. Enogholase (2011) quoted the National coordinator of the Accident Victims of Nigeria (SAVAN), Dr. Eddy Ehikhamanor, who blamed the incidences of kerosene explosions in Nigeria on the management of NNPC. He specifically insisted that until the NNPC takes the issue of delivery and supply of kerosene very seriously, more Nigerians will continue to die from kerosene explosions. The problem is linked to pipeline theft and vandalism according to Dr. Ajuonuma, a spokesman of the NNPC:

"We wish to alert members of the public of the presence of adulterated kerosene in the market, especially in the Warri-Benin axis, as a result of the nefarious activities of pipeline vandals who attacked our Warri - Benin products pipeline and made away with kerosene mixed with Automotive Gas Oil (AGO) and Premium Motor Spirit (PMS). The vandals may bring the stolen product to the market for sale to unsuspecting members of the public. Such adulterated kerosene could cause explosions and fire accidents. The consequences of past kerosene explosions are still very fresh in our mind.....; we cannot afford to have a repeat of such tragic incidents. We are therefore appealing to members of the public to be vigilant and desist from procuring kerosene from unauthorized dealers and outlets so as to avoid getting the adulterated products into their homes" (NNPC, 2013).

2.2.8.2 Gas

Given Nigeria's large gas deposits (Table 2.3 above), the country's natural gas should have been used in such a way that households can benefit from its abundance. Instead, almost all of it is either traded for export revenue or used in the industrial sectors (Nigerian Gas Company Limited (NGC), 2011a) leaving the country's urban households to rely on the bottled gas cylinders that are unreliable in terms of supply, for their cooking needs (NAN, 2013b). The NGC was set up in 1988 as one of the 11 subsidiaries of the NNPC. It is mandated with the development of an efficient gas industry to fully serve Nigeria's energy and industrial sectors needs through an integrated gas pipeline network and also to export natural gas and its derivatives to the West African Sub-region (NGC, 2011b). Although the NGC has a clear mandate to supply more energy to the industrial sectors of the country, it is unfortunate that after twenty three years of its existence, it has only laid about 1,250 kilometres of pipelines serving mostly the industrial areas of the southern regions of the country (NGC, 2011a). NGC claim that the Oben-Ajaokuta-Geregu Gas Pipeline System will form the back-bone of the proposed Northern Pipeline System, which has not yet been built. NAN (2013b) quoted the Managing Director of Techno Oil, Mr Tony Onyeama, lamenting the low consumption level of cooking gas by Nigerians, who emphasised that "*the usage of cooking gas in Nigeria stands at 0.5kg per capita, compared to 3kg per capita in Ghana, 1.9kg in Cameroon, 5.5kg in South Africa and 44.4kg in Morocco".*

Overall, no widespread evidence has been found of gas pipelines supplying houses in Nigeria. However, in a verbal communication with one of the retired NNPC managers (who remained anonymous), it was confirmed that there was a project proposal for gas pipeline supplies, especially in the southern part of the country, through the NNPC. The pilot project started and ended in the NNPC quarters in the Warri area of Delta state in the southern part of Nigeria, serving only the top NNPC management residential quarters. Although the use of bottled gas among households is restricted to the wealthy in urban areas (NAN, 2013b), the issues associated with the procurement of gas are similar to those of kerosene mentioned earlier, where the government and marketers are seen as the central source of problem concerning the procurement of fossil fuels in Nigeria. Another reason given for the failure to make fossil fuel available is that the government subsidy is not serving its intended purpose but rather assisting the marketers to become even richer (Ogbonnikan, 2012 and Okonjo-Iwela, 2012). Section 2.2.9 examines fuel subsidies in Nigeria.

2.2.8.3 Distribution of Petroleum Products in Nigeria

In addition to the problems in procurement of fossil fuels, unreliable supply and distribution of all petroleum products also remains a significant challenge (Alohan, 2011a). In consequence poor people have to depend on expensive black market sources for their needs, and the government has failed to address the matter. The persistent scarcity is attributed to the close relationship that exists between the government and the marketers for their own benefit. This has a major implication for poor households' budgets. At present, the official price of kerosene (after subsidy) is 50 Nigerian Naira per litre, but it can hardly be found anywhere for that price and therefore people are forced to rely on the black market where it sells for about 300 percent of the official litre rate, depending on the state (Sango, 2011) (see table 2.4 for the history of fossil fuel prices in Nigeria).

Other problems associated with the unreliability of petroleum products supply in Nigeria are the issues of illegal oil bunkering (theft of crude oil) and smuggling of both the crude and refined petroleum products (Nwafor, Ogunjiuba and Asogwa, 2006). Garuba (2010:11) pointed out that illegal oil bunkering and smuggling became very popular in Nigeria during the Babangida regime (1986-1993) but have now reached their peaks. Political instability in Nigeria over the years provided a favourable operating environment for oil bunkering to thrive (Asuni, 2009).

Table 2.4: An Overview of Fossil Fuel Prices in Nigeria (1973-2015)

	Premium motor Spirit (PMS- petrol)	HHK	LPG (Cooking gas)
Year	Naira per litre	Naira per litre	Naira per 12.5kg
1973–78	0.10	0.08	31.2
1979–85	0.15	0.11	32.3
1986–89	0.40	0.11	40.0
1990	0.51	0.15	40.0
1991–92	0.60	0.40	80.0
1993	3.25	2.75	200.0
1994–97	11.00	6.00	200.0
1998–99	20.00	17.00	450.0
2000–01	22.00	17.00	1000.0
2002	26.00	24.00	1200.0
2003	40.00	38.00	1500.0
2004	43.00	50.00	1700.0
2007	65	50.00	N2,500
2012	97	50.00	N3,500
2015	87	65.00	N3,500

Sources: 1. Nigerian National Petroleum Corporation; and 2. Central Bank of Nigeria (CBN): Annual Reports and Statements of Accounts, various issues; Adapted from Adelekan and Jerome (2006:102); 3. Okpi and Leke (2012) and 4. Field Work, 2015

However, Garuba (2010) shows that the initial opportunity for the practice to develop was favoured by the domestic subsidy of Nigerian petroleum products and devaluation of the Nigeria Naira in the mid 1980s. During this time legally lifted products were diverted to more profitable markets across the porous borders of the Communaute Financiere Africaine (CFA) Franc countries surrounding Nigeria (i.e. Niger, Chad, Republic of Benin and Cameroun) (Nwafor, Ogunjiuba and Asogwa, 2006). These operations were mainly facilitated by government officials, with the assistance and cooperation of some oil company workers and their cronies (marketers) (Garuba, 2010). Although the operational structure of the business is not well articulated in research studies (Asuni, 2009) because of the secrecy surrounding the business, Garuba reported that studies in illegal oil bunkering and smuggling put the loss at around $7.7million daily to the Nigerian government's income. The report of the Nuhu Ribadu-led Petroleum Revenue Special Task Force submitted to the FG in November 2011 further confirmed the irregularities in the petroleum sector of the country (Leadership Editorial, 2012).

Another issue associated with petroleum product supply in Nigeria is the frequent union strike actions against the government (Nuhu-Koko, 2007). The key reason behind the strike actions is mostly disagreements between the government and the Nigeria Labour Congress (NLC) or the Trade Union Congress (TUC) over changes in policy that affect the people directly (like fuel price increases, wage increases or the dismissal of some workers) (Agbo, 2012 and Ogunmola, 2012). Lack of security is also a sensitive issue that is leading to strike action against the government; specifically, issues relating to attacks by the police and military officers, especially on tanker drivers whose organisation (the Petroleum Tanker Drivers Association (PTD)) intervenes by calling for a general strike action against the government (Agbo, 2012). The number of strike actions against the government in the past by the PTD, which is also a branch of the National Union of Petroleum and Natural Gas Workers (NUPENG) is large. However, most of the strikes by the PTD were not necessarily on issues relating to the PTD directly or its mother union NUPENG but rather a problem of the NLC of which NUPENG is a part (John, 2012). All the PTD's strike actions in the past specifically affect the supply of all petroleum products in the country, largely because they are the sole conveyors of such products from the depots, or Jetty tanks to the filling stations across the whole country (PPMC, 2010). As such, whenever there is a strike action, the national supply is reduced, filling stations are under-supplied and soon become empty and consequently the whole country is affected (John, 2012 and NAN, 2012d). Other petroleum union strike actions that also affect the supply of petroleum include the Independent Petroleum Marketers Association of Nigeria (IPMAN) and the Depot and Petroleum Products Marketers Association of Nigeria (DAPMAN) (NAN, 2012e).

2.2.8.4 Electricity

One of the effects of poor policy implementation is the erratic supply of electricity among the majority of households in SSA (Brew-Hammond and Kemausuor, 2009). With all their abundant energy resources, countries in the SSA are still struggling with meeting their electricity demand. In terms of households' access to electricity, IEA (2011) World Energy Outlook drew attention to the 1.3 billion people without access to electricity. In the SSA, only about 30% have access to electricity, making the region the lowest in the world in terms of its electrification rate (Brew-Hammond and Kemausuor, 2009). In Nigeria for example, most communities do not have access to electricity; and those that do cannot rely on the very poor supply from the country's electricity provider the Power Holding Company of Nigeria (PHCN) (Akarakiri, 1999, Sambo, 2008b and Olise and Nria-Dappa, 2009). This lack of access to efficient energy resources has had adverse impacts on the economic development of Nigeria (Olise and Nria-Dappa, 2009) where most of the industries are running on diesel generators with an added cost to their outputs (Sambo, 2008b). Electricity, being the third energy type in Nigeria in terms of significance in the household sector in the country (Sambo, 2008b) is mostly limited to states and local government headquarters and some towns, while the rural areas are served by the States' Rural Electricity Boards (Sambo, 2008a and Sambo, 2008b) with an even worse record in terms of supply.

A brief history of electricity generation in Nigeria summarised from the works of Akarakiri (1999) and Sambo (2008b) will help in understanding some of the complex issues involved. Electricity supply dates back to 1896 when it was first produced in Lagos by the colonial administrators (Sambo, 2008b). A central body known as the Electricity Corporation of Nigeria, now defunct, was later set up in 1950 to act as the central body to develop and supply electricity in the country (Akarakiri, 1999 and Sambo, 2008b). However, even at that time, other bodies like the Native Authorities, the Nigeria Electricity Supply Company (NESCO) and the Niger Dams Authority (NDA) had licenses also to produce electricity in some locations in Nigeria (Sambo, 2008b). NESCO, for example, is a private company that still exists today in some areas of Plateau state in the northern part of Nigeria supplying a few towns and some industries in the state capital (Jos) with electricity with a high degree of reliability. While the electricity produced by NDA (now defunct) was sold to the Electricity Corporation of Nigeria for distribution and sales to consumers (Sambo, 2008b).

In 1972, the National Electricity Power Authority (NEPA) was set up to take over the responsibilities for generation and distribution of electricity in the country from all existing organisations (Akarakiri, 1999), and in 2005, the name NEPA was changed to PHCN. Despite the long existence of electricity projects in Nigeria, its development is considered to be very slow compared to the nation's demand (Sambo, 2008b). The major reason for this is the laxity of the past military governments in making any commitment to the development of the sector (Sambo, 2008b). Sambo (2008b) indicated that before 1999 (the end of military rule in Nigeria) the power sector did not witness any substantial investment in terms of infrastructural development and the existing ones were not properly maintained. For example, in 2001 when the then government showed a commitment towards electricity generation and engaged in a thorough investigation of the sector, electricity generation was discovered to have declined down from the installed capacity of about 5,600MW to an average of about 1,750MW, compared to the national demand at the time of 6,000MW. It was further discovered that only nineteen out of the seventy-nine installed generating units were functioning at that time (Sambo, 2008b).

Other problems of the PHCN (related to social issues) that are considered to be responsible for the unannounced load shedding, prolonged and intermittent outages which most consumers of electricity in Nigeria have had to contend with over the years, can be summarized from the Nigerian National Bureau of Statistics, (NBS) (2010) as follows: a poorly-motivated workforce, vandalism and the theft of cables and other vital equipment, accidental destruction of distribution lines, illegal connections that resulted in over-loading of distribution lines, and non-payment of bills by the consumers. The combination of these problems has resulted in the present deplorable state of electrical power supply in the country (Otuchikere, 2013). Akarakiri (1999) reported that at full design capacity, the electric power stations in Nigeria should have been capable of producing about twice the electricity requirements of Nigeria plus those of neighbouring Niger, the Benin Republic and Chad.

Sambo (2008b:33) predicted the future of Nigerian Electricity demand using GDP projections and found that at a 13% GDP growth rate, Nigerian demand for electricity will rise from 5,746MW in 2005 to 297,900MW by 2030. The difference in the figures indicated that an increment of 11,686MW is required every year from 2005 to 2030 to meet the demand. The corresponding cumulative investment (investment and operations) cost for the 25-years period is estimated at about US$ 484.62 billion, which means an investment of about US$ 19.38 billion every year within the period (Sambo, 2008b). Although the model accounts for other energy needs in the country, it can be argued that it was based on an over-estimate of the real GDP rate of increase in Nigeria, which was only estimated at about 7.86 percent in the third quarter of 2010 (NBS, 2011). At a more realistic 7% GDP growth rate, Sambo (2008b) predicted the demand for electricity would rise from 5,746MW in 2005 to 119,200MW by 2030. This would require an investment of about of US$ 6.46 billion every year within the period, which will only be achievable if the economic opportunities in the country are improved to curtail some of the social and other energy issues in the country highlighted earlier, and corruption is reduced (Agba, Gbadebo and Ukaibe, 2012a). Brew-Hammond and Kemausuor (2009) warned that the government needs to develop other energy sectors while addressing the electricity situation in the country, otherwise the dream of meeting the demand of electricity for all will remain an illusion rather than reality, even if the money were available to fund the project.

However, the FG in 2012 have privatised the PHCN generation and distribution companies, and arrangements have been finalised to hand over to the core investors in the second quarter of 2013 (Anthony-Uko, 2013 and NAN, 2013a), Nigerians are desperately hoping to see meaningful improvements in their electricity supply as a result.

2.2.9 Overview of Energy Subsidies in Nigeria

Nwafor, Ogunjiuba and Asogwa (2006:3) examined two types of subsidies, the explicit and the implicit. Explicit subsidy is the difference between production cost and selling price. Implicit subsidy is the type of subsidy that is observed in the exploitation of wasting assets such as crude oil. It refers to the difference between the opportunity cost of a wasting asset and the present selling price. Nigeria has both types of subsidy which the government withdrew in January, 2012 (BBC Africa, 2012). Governments use their oil endowments through subsidy as a social means that is intended to benefit the large majority of the poor in their society as well as to promote industrial production (Birol, Aleagha and Ferroukhi, 1995 and Nwafor, Ogunjiuba and Asogwa, 2006). Although the Nigerian government's intention was good regarding oil subsidy, the subsidy was abused by certain individuals (Dada, 2012; Ogbonnikan, 2012 and Okonjo-Iwela, 2012), which is why it was eventually removed (partially). Prior to the subsidy withdrawal, the (present) Nigerian minister of Petroleum Mrs. Allison-Madueke argued that "*the subsidy is not getting to the masses it is created to take care of...; it is the retailers that are benefitting from it"* (Abubakar, 2011 and Sweet Crude, 2011a). Before her comments, Nigerian state governors had earlier advocated the total removal of oil subsidy in the country so that they could benefit from the money thus saved and be able to pay the newly introduced minimum wage of 18,000 Naira per month. This would avert strike action organised by the NLC, which represents less than 20 percent of the country's population (BBC Hausa, 2011b and Olanrewaju, 2011). The move by the state governors was, however, opposed by widespread condemnation from the general population (Olanrewaju, 2011). However, despite this condemnation, the government suddenly announced the withdrawal of its fuel subsidy on 1st January, 2012, which resulted in a sharp petrol price increase from 65 Naira 140 Naira (BBC Africa, 2012). After the announcement, there was a mass protest across the country that lasted for 16 days (BBC Africa, 2012). It was only after the leadership of the National Assembly intervened that the government partially backtracked on 16th January, 2012, by approving the reduction of the pump price of petrol to 97 Naira per litre.

The call for the removal of the oil subsidy among oil producing nations, especially DC, is not new. Birol, Aleagha and Ferroukhi (1995) indicated that the move started in the late 1970s and reached its peak in the 1980s. Birol, Aleagha and Ferroukhi who support subsidy removal, argued that the oil exporting countries of the DC have a high level of subsidy and low efficiency of energy use, resulting in the waste of resources needed for their development. Birol, Aleagha and Ferroukhi maintained that for the oil exporting DC to advance, they need to allow their energy pricing to reflect the opportunity costs, to enhance economic growth. They summarised the impacts of oil subsidies on economic growth, as follows (Birol, Aleagha and Ferroukhi,1995:210):

1. Subsidies for consumers bring about excessive domestic demand, which leads to lower export that consequently decreases the foreign exchange revenues which would have funded development activities.
2. Subsidies for producers bring about excessive supply, leading to a rapid depletion of the resources that provide the main source of earnings.

3. Subsidies do not necessarily reach the target poorer segment of the population. Rather, most of the beneficiaries are in the higher income groups of the society that can afford the unsubsidised oil.

Although Birol, Aleagha and Ferroukhi arguments were quite strong, given the present poor economic situation of Nigeria (FAO, 2010a), their arguments can be criticised for being unfair, because they were based on assumptions that did not reflect the situation of the Nigerian oil crisis and the economic hardship of the people (Nwafor, Ogujiuba and Asogwa, 2006 and Bisalla and Muhammad, 2012). Nwafor, Ogujiuba and Asogwa (2006) have shown that in Nigeria, the increase in the price of petroleum products resulted in the increase in the prices of all other goods and services. They therefore concluded that subsidy removal would increase national poverty, unless the money saved was used in a way that would bring about changes for the household economy.

Electricity is being subsidised in Nigeria in a similar way to fossil fuels. The government has recently announced it will cut down its funding of this subsidy, by deregulating the sector as part of its commitment to meeting the country's electricity demand (NBS, 2010, and Sweet Crude, 2011b). Sweet Crude (2011b) reported that the FG has released the sum of 177 billion Naira for subsidies to ensure an orderly transition from subsidy to market determined prices of electricity. As part of the subsidy removal process, the Nigerian Electricity Regulation Commission's (NERC) chairman, Dr. Sam Amadi, announced an increase in the electricity tariff from 1st July, 2011, from 8.50 Naira to 10.00 Naira per unit (Alohan, 2011c and Sweet Crude, 2011b). This announcement did not spark any civil unrest in the country like that for oil mentioned earlier, because most of the people had previously given up relying on the country's electricity supply.

Even though there are beneficial aspects of both deregulation and subsidy, Nigeria's current situation only favours the subsidy. This argument can be supported by Sango's (2010:18) claim that "*the government expectations that the removal of subsidy will solve the situation of fuel scarcity in the nation is wrong",* because when one looks at the situation of diesel supply that was deregulated some years ago, this fuel still faces similar problems to other petroleum products in terms of supply and availability in the country as discussed above. Unsurprisingly, therefore, the current petroleum scarcity in the country to date has not changed from its previous situation prior to the subsidy withdrawal (Agba, Awom and Ukaibe, 2012b).

2.2.10 Transition from Fuelwood to Fossil Fuel

The 1970s increase in the world prices of fossil fuel (Figure 2.6), (Nash and Luttrell, 2006 and British Petroleum (BP), 2009) was another factor that turned the attention of researchers to the study of the fuelwood consumption pattern in the world. However, what is lacking empirically, are studies that show the direct relationship between fuelwood consumption and fossil fuel prices.

Nevertheless, there is research evidence that indicates that the money spent on the purchase of fuelwood by poor households in the developing countries (DC) is large (Leach, 1987 and Adeoti, Idowu and Falegan, 2001), mainly as a result of the unreliability in the supply of fossil fuels that are meant to substitute for fuelwood in most parts of the DC (Leach, 1987). In recent years, there has been an increasing concern over rising fuelwood prices, supply shortfalls and the environmental impacts of fuelwood use (Hyman, 1994), which have fed a growing interest in switching to the use of other forms of energy. One of the top priorities is switching over to the use of petroleum products and other forms of renewable energy.

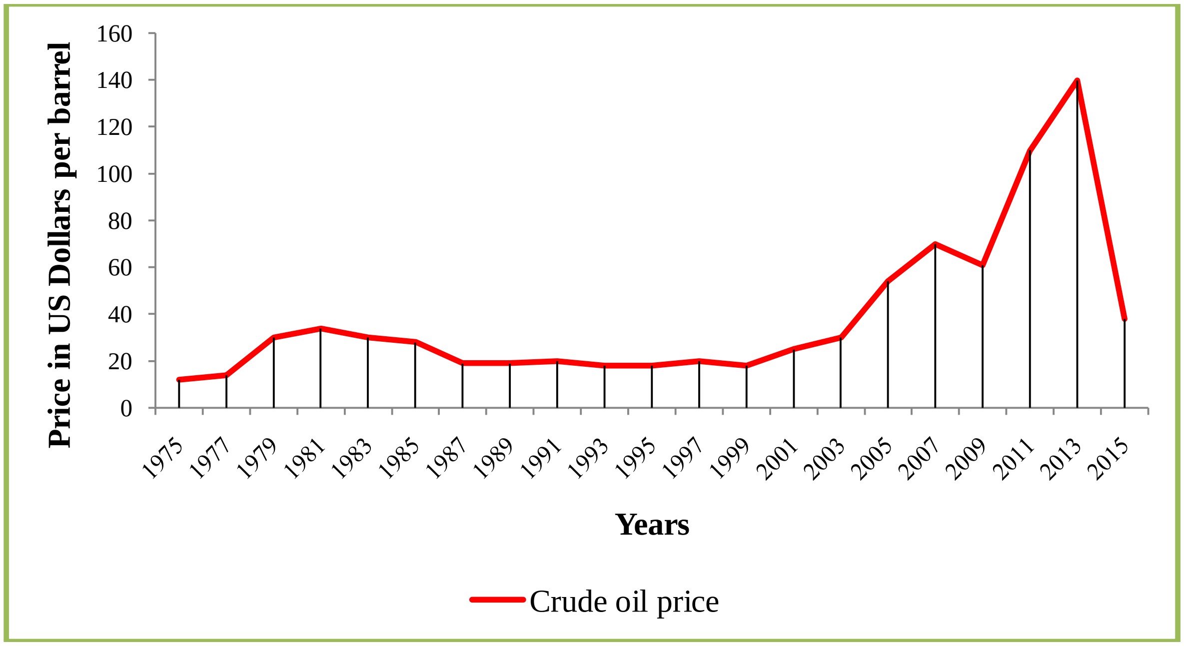


Figure 2.6: Annual price of crude oil
Source: Adapted and Modified from Naibbi, 2013

It is obvious that if the supply and price of petroleum products is reliable in the DC, many people may be willing to switch over to their use. For example; most DC have already adopted policies that will encourage people to use more fossil fuel for domestic purposes, but the outcome has not been encouraging (Nash and Luttrell, 2006). Leach (1987) proposed in a study entitled, 'Energy and the urban poor' the idea of implementing a policy that would increase the price of fuelwood to encourage people to use fossil fuels.

As indicated earlier in Nigeria the government has adopted the policy of subsidizing petroleum fuels (Adeoti, Idowu and Falegan, 2001) in terms of distribution and pricing in order to achieve a uniform price throughout the country (Ehinomen and Adeleke, 2012:236). Despite all the encouragement and subsidies, no consistency has ever been achieved in fossil fuel supply (Adeoti, Idowu and Falegan, 2001 and Ehinomen and Adeleke, 2012). In the light of this, switching to the use of fossil fuels (gas and kerosene) in Nigeria has proved to be very slow, hence the reason for the dependence on the use of fuelwood by households (Hyman, 1994 and Hiemstra-van der Horst and Hovorka, 2009).

However, the situation is not the same for all the DC, China for example, which accounted for the world's highest energy consumption in 2008 (BP, 2009), is doing well with its energy transition in rural areas. Jiang and O'Neill (2004) noted that although the Chinese transition programme from the use of fuelwood to other fossil fuel is very slow, the future is bright because of the wide acceptance of the programme by the people and consistency in the supply of fossil fuels.

It is worth emphasising here that the problem of petroleum products in the DC certainly lies with the supply of such a commodity. As BP Chief Executive Tony Hayward stated in the 2009 'statistical review of world energy', *"the production of petroleum products far exceeds the consumption"*. Given this fact, it is still not always clear why the supply of petroleum products is unreliable and unstable in most parts of the DC. In the case of Nigeria, the situation is fairly understandable, based on what has been said earlier and the political and socio-economic problems of the country over the last decade, which have seriously affected the regulatory bodiesin charge of the supply, distribution and marketing of petroleum products at all levels (Bisalla and Muhammad, 2012). However, the existing literature does not explain whether the existing supply strategy for fossil fuels on regional basis has any effect on varying consumption patterns of fuelwood in Nigeria.

CHAPTER THREE

STUDY AREA AND METHODOLOGY

3.1 THE STUDY AREA

3.1.1 Location

Zaria and its Environs comprise of eight (8) Local Government Areas of Kaduna State, Nigeria and they are Zaria, Igabi, Sabon Gari, Giwa, Kudan, Makarfi, Ikara and Soba. It is located between Latitude 10^0 20′ - 11^0 40′ North and Longitudes 7^0 00′ - 8^0 40′ East (See Fig. 3.1). It boardered by Kano State on the north and northeast, to the east by Kubau LGA, to the south by Kauru LGA, to the southeast by Kajuru LGA, to the west by Birnin Gwari LGA, to the southwest by Chikun, Kaduna South and Kaduna North LGA, and to the northwest by Katsina State (See Fig. 3.2). The town and its environs located in northern part of Kaduna State. The plain of Zaria and its Environs is an undulating one, which is gently rolling and has numerous valleys and streams (Wright and McCurry, 1970).

Zaria and its Environs was selected for investigation here, the choice of these areas was primarily because they have not previously been examined in the literature on vegetation degeneration and fuelwood consumption in Kaduna State.

3.1.2 Climate

Zaria and its environs belongs to the tropical continental type of climate corresponding to Koppen's tropical savannah or tropical wet and dry climate zone (AW), characterized by strong seasonality in rainfall and temperature distributions. It has two distinct seasons: the dry or harmattan season (October to March) and wet season (April to September). The seasons generally coincide with the southward and northward movement of the surface transition between the hot, moist tropical maritime southeasterly air-mass (MTS) of southern

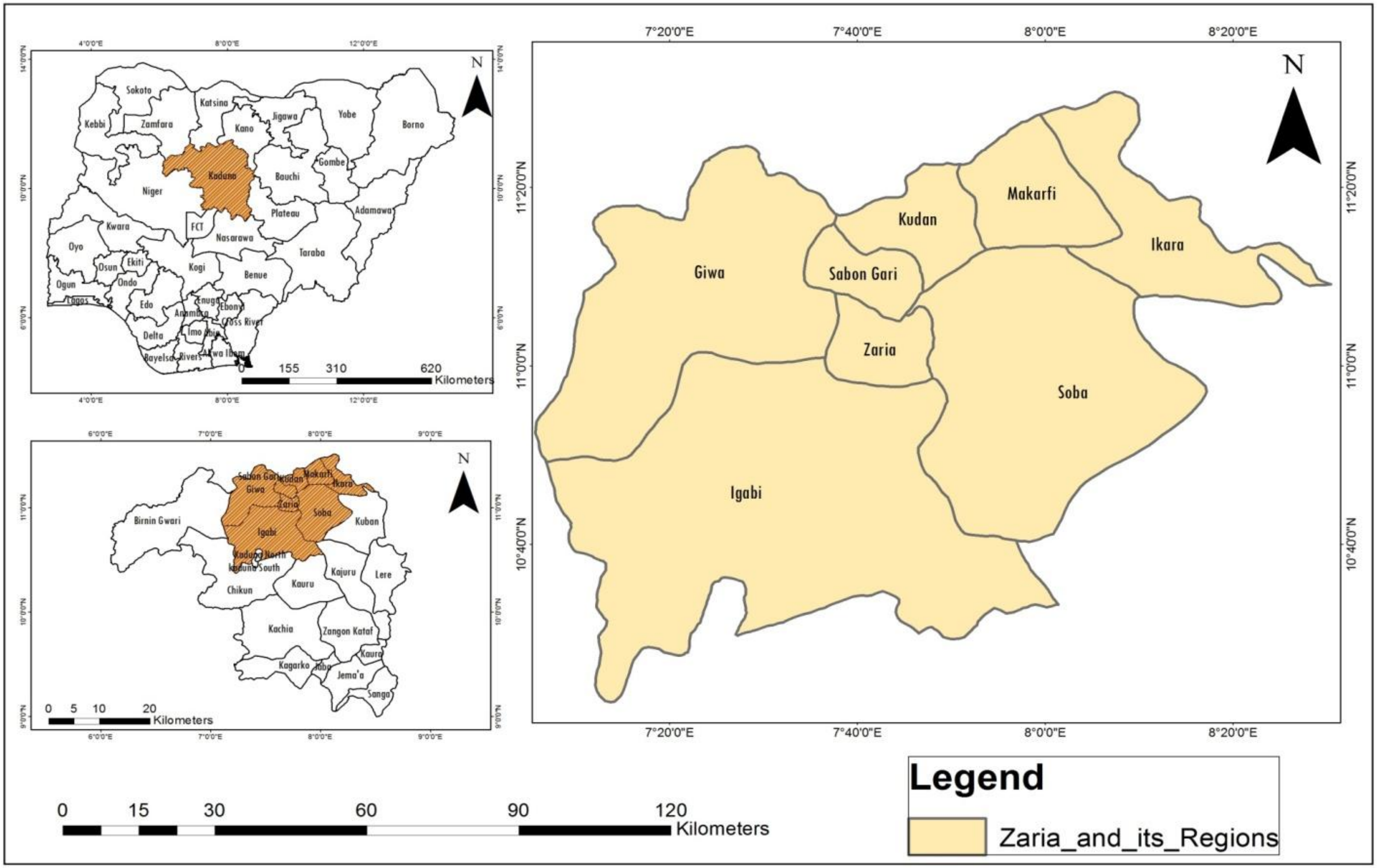


Figure 3.1: Study Area.
Source: Adapted and modified from administrative map of Kaduna.

hemisphere of Atlantic Ocean origin and the cold, drier Tropical continental air-mass (CTS) blowing out of the Sahara Desert known as Inter-tropical Discontinuity (ITD). Mean annual rainfall is about 1,000mm but inter-annual fluctuations may be high. Mean monthly temperature is about 27^0C but it is highest between the months of March and May, which represent the hot dry period. It is lowest in December/January reaching about 22^0C (Kowal and Kassam, 1978).

3.1.3 Releif and Drainage

The geology of the study area is part of the basement complex geology of central Nigeria. It is composed of older high grade metamorphosed gneiss interspersed by belt of young metasediment of mainly quartzite and schist. The region is underlain by older granitic crystalline, metamorphic rocks of Precambrian to low Paleozoic age (Oguntoyinbo, 1978). It also consists of gneisses which has suffered intense weathering and have remained stable for millions of years. The prolonged weathering under tropical bioclimatic condition has produced rolling plains dotted with residuals of different origin (Mortimore, 1970).

Zaria and its Environs lies on the central high plains of Hausa land, of height ranging from 550 to 750meters showing a general regional slope to the south and a relative relief of 30 to 45 meters. The plains on which Ikara is situated are parts of the vast, gently undulating plains scenery, which extends almost unbroken from Sokoto to Lake Chad and beyond, from South of Kaduna to the Tidueddi Scarp near Agades. At first sight, they seem remarkable only for their usual monotony and apparent geomorphic simplicity. However, a closer field examination reveals considerable variation in both surface form and composition (Oguntoyinbo, 1978).

3.1.4 Soil

The soil type of Zaria and its environs is reddish ferruginous in nature. The lower part of the soil is derived in situ from underlying weathered gneiss and still contains pieces of quartz and mica. The upper part is a mixture of the same material together with transported, probably windblown particles. Across the soil profile, below the horizon of clay accumulation lays one of iron accumulation. The first sign of this is the appearance of red mottles and lower down, hard iron concretions are found. There are also the fadama soils which vary in texture and have been formed from alluvial materials along river valleys. These soils are mostly dark grey clays with poor to very poor drainage and are found along the banks of the rivers Galma and Kubanni (Klinkenberg, 1970).

3.1.5 Vegetation

The natural region in which Zaria and its environs lies is termed by plant-geographers the Northern Guinea Savannah zone, a designation which implies a woodland vegetation type characterised by the presence of *Isoberlinia doka*, *Isoberlinia tomentosa* and *Upaca togonensis*, with well developed grass layer of tufted and low ground cover of *Andropogoneae*. Also typical of the Savanna woodlands are a group of plants which generally flower before the onset of the rains and whose tops die back annually and are burnt off during the fires. These are the cryptophytes which include the bulbous and rhizomatous plants and the very typical sub-shrubs (suffrutices) such as *Cochlospermum tinctorium* and *Adenodolichos paniculatus*. Many of the savanna trees can also exist for years in a suffrutex form but unlike the suffrutices their shoots are perennial and will develop into trees when conditions are suitable (Jackson, 1970). There are also specific tree species, which are mainly found in the northern part of the country such as *Tamarindus* *indica,* shea butter, mango, cashew, baobabs, locust bean, neem, eucalyptus etc. (see table 4.4)

3.1.6 Population

According to the 2006 National population census, Zaria and its environs has population of 2,184,172 people made up of 1,117,571 male and 1,066,601 female, the distribution of population by L.G.A Shows that Igabi with the largest land area has only 22.6% of the total total population of Zaria and its environs, closely followed by Zaria L.G.A. 20.8%, Makarfi and Sabon Gari 16.4% and 14.9% respectively. Soba and Giwa L.G.A make up 12.8% and 12.5% of the population respectively.

A look at the population growth rate shows that the annual growth rate in the Zaria area is 3.0% this implies that the population of Zaria would be expected to double within 30 years.

3.1.7 Basic infrastructures

Zaria and its environs have witnessed tremendous changes and developments due to its profound influence as an educational centre. With the influx of people from different parts of the world, the provision of basic amenities such as water, electricity, well tarred and dual carriage roads (more especially Zaria) by government has increased immensely over the years. These activities have led to the clearance of trees and lost of smaller vegetation. Zaria and its region being nodal town serve as a link to other parts of Northern Nigeria. Government-owned hospitals such as the Ahmadu Bello University Teaching Hospital, Gambo Sawaba General Hospital, General Hospital Giwa, St. Lukes Chapel hospital among others and privately-owned health centres and pharmacies provide effective and affordable medical services. There are also accommodation lodges such as Zaria Hotel, New Zaria Motel, Kongo Conference Hotel, Jim Harrison Hotel, Zazzau Royal Chalets and Tee Jay

Palace Hotel; and many guest inns are scattered around the town. First and new generation banks such as First Bank PLC, United Bank of Africa, Bank PHB, Guaranteed Trust Bank, Zenith Bank, Oceanic Bank, Stanbic IBTC, Access Bank etc, are available for business and financial transactions; more banks are being built for greater efficiency. Also major and periodic markets of Sabon Gari, Samaru, Zaria city, Giwa, Soba, Makarfi among others Departmental stores, restaurants, filling stations provide commercial services (Field Work, 2015).

Despite being an administrative, commercial, transportation and manufacturing centre; it is Zaria's educational function that today most influences its character and gives it distinction as an urban settlement. The most important central place activity of all is education, for which Zaria and its environs is the greatest centre of Northern Nigeria. The environs, more especially (Zaria Urban Area) is home to educational institutions such as Ahmadu Bello University, the largest university in Nigeria and the second largest on the African continent, but by no means the oldest institution in Zaria. The institution is very prominent in the fields of Agriculture, Science, Finance, Medicine and Law. Zaria and its Region is also the base for the Federal College of Aviation Technology and Training Centre, Nigeria Colleges of Education, Kaduna State Polytechnic, Research Institutes and Ahmadu Bello University Teaching Hospital Shehu Idris College of Health Science and Technology Makarfi (SICHSTM), Ameer Shehu Idris College of Advance Studies Zaria, National Teachers Institute (NTI), Police Defence Academy (annex, Kudan), Jaji Military Cantonment, among others offer so many people from different cultural backgrounds, sources of livelihood in and around Zaria. Zaria is also home to the great Barewa College which was the best secondary school in the whole of Northern Nigeria, Science School Kufena, Nigeria Turkish

International College Rigachikun among others. It formed a solid educational foundation for our great leaders of yester-years such as Sir Ahmadu Bello among many. The number and variety of institutions is an evidence of the general importance of education in Zaria and its Region. All these institutions can be considered as 'city- forming' as the greater portion of students come from outside Zaria and its Region. The presence of the only Federal Government Girls College in Kaduna State, the only Nigerian Military School in Northern Nigeria, the Army Depot and other military outfits cannot be ignored (Abubakar, 2013 and Field Work, 2015).

In terms of communication, Zaria and its Region has its own broadcasting station of the Nigeria Television Authority (NTA) and radio stations that keep people well informed. The Nigerian Telecommunications (NITEL) has been the sole provider of telephone services for decades, mostly restricted to homes and offices. However, with the advancement in world technology, privately-owned Global Satellite Media (GSM) has pioneered to provide services, reaching most of the populace. Mobile phones have made communication affordable and more effective, making life much easier for people (Abubakar, 2013 and Field Survey, 2015).

Table 3.1: Distribution of schools and hospitals in the study area

Areas	Schools			Hospital/P.H.C.
	Primary	Secondary	Tertiary	
Giwa	210	33	-	49
Igabi	280	37		70
Ikara	157	12	2	45
Kudan	89	7	2	37
Makarfi	121	14	1	39
Sabon Gari	59	35	7	30
Soba	231	14	-	46
Zaria	117	31	8	75

Source: Field Work, 2015

3.1.8 Economic Activities

Agriculture is the most important economic activity and it forms the basis of hausa economy. About 80% of the population in Zaria and its Region can only own a small farm. According to Norma Yahaya (1986) 'some of the factors determining farm size in Zaria includes the size of the family and the labour force, length of time each household is prepared to work and the availability of financial resources. The crops grown by the farmers include sorghum, cowpea, maize, groundnuts, rice, millet, beans, soya beans, e.t.c which are also the main food crops.

The bulk of agricultural productions in the areas is undertaken by small scale farmers most of who's labour force, management and capital originates from the household. The farmers in the study area constitute the poorest segment of the society (Mortimore 1970).

Agriculture practice is followed by the small scale industries and crafts work which are labour intensive but provide employment opportunities. Some industries include transportation, blacksmithing, dyeing e.t.c. there were also modern industries such as block making industries, bakeries and sachet water, business organizations includes banks, supermarkets, chemists, shops, restaurants, cinemas e.t.c.

3.2 METHODOLOGY

3.2.1 Reconnaissance Survey

Reconnaissance survey was carried out to have knowledge of the study area. It also helps to obtain available relevant firsthand information of the physical and human aspects of the study area. The aim of the household survey was to provide data to answer the research questions which were set out to address the objectives.

3.2.2 Types of Data

The types of data obtained in the study area are

i. Satellite imageries of Zaria and its Region with 5m resolution (spot-5) for 1973-2014
ii. Source area were fuelwood is obtained
iii. Rate of fuelwood consumption by household
iv. Data on the factors responsible for choosing fuelwood as a means of energy

3.2.3 Sources of Data

Primary data were obtained from satellite images (Landsat images MSS and TM) covering the study area from 1973-1996 and ETM for 2006 and Landsat for 2014 (PATH 188, ROW 52), (PATH 188 ROW 53), (PATH 189 ROW 52) and (PATH 189 ROW 53)-Worldwide Reference System (WRS) used in this study were acquired from the archives of the U.S Geological Surveys' (USGS) Earth Explorer (USGS, 2010). The Landsat programme is a series of earth-observing satellite missions jointly managed by National Aeronautics and Space Administration (NASA) and the USGS (NASA, 2011). More details on the explanation of the activities and characteristics of Landsat can be found on USGS' websites (glovis.usgs.gov).

The Landsat images used in this study (1973, 1986 and 2014- MSS; 1996- TM and 2006- ETM+) were collected in a Tagged Image File Format (TIFF) as separate bands which are then stacked together (on a yearly basis) into a single image in ERDAS Imagine Software before the commencement of any analysis.

The development of items in the semi-structured questionnaire was guided by the aim and objectives of the study. In addition, In depth interview was conducted to target concerned end users and sellers among others in order to explore issues related to fuelwood consumption rate and its effects in the area.

Secondary Data Sources in the study were sought from literature in published and unpublished thesis, journals, magazine, newspapers, maps, conference papers and other relevant documents.

3.2.4 Sample Size and Sampling Techniques

National Population Commission (2006) reported Zaria and its Region as having population of 1,890,902, using the growth rate of 3% for the state. The projected population (2014) of the study area is 2,767,343 within eight Local Government Areas of greater Zaria. Questionnaire was administered to respondents across the area that is Zaria, Sabon Gari, Giwa, Kudan, Makarfi, Ikara, Soba and Igabi using the Krejcie and Morgan (1970) method of determination of the sample size who recommended that for a population size of between 1,000,000 and above a sample size of 384 should be taken. The questionnaire was administered to respondents based on the population size (the higher the population, the higher the number of copies questionnaire allocated to the area) as shown in Table 3.2

Due to the absence of reliable population data/figures for the electoral wards in the study area, the number of copies questionnaire allocated to each LGA was shared equally among the selected wards.

NPC recommends the use of population projection due to the fact that Nigerian census data suffers inadequacy.

$$\mathbf{Pt = Po\ (1 + r)^{n}}$$

Where: **Pt** = population of the year i.e. 2014

Po = previous population i.e. 2006

r = growth rate i.e. 3%

n = interval between **Pt** & **Po** i.e. 8years

Based on the above method, the projected population of the study area for the year 2014 is 2,767,343 people. The numbers of questionnaire administered were proportionate to the population of each area. Thus:

Proportion = $\frac{n}{N} \times 384$

Where: **n** = population of the area

N = total population of the areas

Table 3.2: Sample Size by Local Government Area

Areas	**Population (2006)**	**Projected population (2014)**	**Sample Size**	**Percentage (%)**
Giwa	286,427	362,903	50	13
Igabi	430,229	545,100	76	20
Ikara	193,926	245,704	34	9
Kudan	138,992	176,102	24	6
Makarfi	146,259	185,310	26	7
Sabon Gari	286,871	363,465	50	13
Soba	293,270	371,573	52	14
Zaria	408,198	517,186	72	19
Total	**2,184,172**	**2,767,343**	**384**	**100**

Source: National Population Commission, 2006

Two research assistants in each ward were trained and engaged for the study. The nature of data collected by these assistants consisted essentially of information from respondents directly and monitoring the quantity of fuelwood used. The assistant were both males. Each team conducted survey in two wards within the study area (Zaria and its Environs). For sample point's, systematic sampling was employed in selecting the wards from each LGA of study area. List of wards of every Local Government Area were arranged alphabetically and every other fifth ward was choosen as a sample for the questionnaire administration.

The respondents for the main survey were selected randomly (by visiting as many households as possible in the sixteen electorate divisions highlighted in Table 3.3) with no regard to any probability in the selection process. Therefore, the selection of the respondents was by chance, and only households that showed interest in responding to the questionnaire were interviewed. This kind of sampling was referred to as "convenience sampling" which Robson (2011) described as the most widely used, but the least satisfactory method of sampling.

In an attempt to get information about how commercial fuelwood dealers in the study area, a separate questionnaire was designed for the commercial activities point owners in a similar format to the household questionnaire described in appendix II. The aim of the survey is to find answers to the research questions originally posed in chapter one.

3.2.5 Methods of Data Analysis

The data obtained from the respondents was analyzed to achieve the stated objectives:

Objective I: map the source regions where fuelwood is obtained in the area. The data required to achieve this objective was obtained from questionnaire administration to household. The results obtained were presented the map and explained descriptively.

Objective II: examine the factors responsible for fuelwood consumption pattern in the area. The data for this objective was got from questionnaire administration household, while the results obtained were presented descriptively in form of percentages calculations and bar graph.

Objective III: establish the rate of fuelwood consumption in the area. The data required to achieve this objective was got from personal interview and questionnaire administration, the data was subjected to mean and standard deviation to arrive at the rate per household and the results obtained were presented and explained using bar graphs.

Table 3.3: Sample Population

LGA	S/N	WARDS	LGA	S/N	WARDS
GIWA	1	Danmahawayi	**MAKARFI**	1	Dan Damisa
	2	Galadimawa		2	Dan Guzuri
	3	Gangara		3	Gazara
	4	Giwa		4	Gimi
	5	**Idasu**		5	**Gubuchi**
	6	Kadage		6	Gwanki
	7	Kakangi		7	Makarfi
	8	Kidandan		8	Mayere
	9	Panhauya		9	Nasarawan Doya
	10	**Shika**		10	**Tudun Wada**
	11	Yakawada	**SABON GARI**	1	Ang. Gabas
IKARA	1	Auchan		2	Basawa
	2	Ikara		3	Bomo
	3	Janfalan		4	Chikaji
	4	Kurmin Kogi		5	**Dogarawa**
	5	**Kuya**		6	Hanwa
	6	Paki		7	Jama'a
	7	Pala		8	Jushi
	8	Rumi		9	Muchia
	9	Saulawa		10	**Samaru**
	10	**Sayasaya**		11	Zabi
IGABI	1	Apaka	**SOBA**	1	Gamagira
	2	Birnin Yero		2	Garu
	3	Gadangayan		3	Gimba
	4	Gwaraji		4	Kinkiba
	5	**Igabi**		5	**Kwasallo**
	6	Kerewa		6	Maigana
	7	Kwarau		7	Rahma
	8	Rigchikun		8	Richifa
	9	Rigasa		9	Soba
	10	**Sabon Birni**		10	**Tudun Saibu**
	11	Turunku		11	Turawa
	12	Zangon Aya	**ZARIA**	1	Ang. Fatika
KUDAN	1	Doka		2	Ang. Juma
	2	Garu		3	Dambo
	3	Hunkuyi		4	Dutsen Abba
	4	Kauran Wali North		5	**Gyellesu**
	5	**Kauran Wali South**		6	Kauran Sarki
	6	Kudan		7	Kufena
	7	Likoro		8	Kwarbai A
	8	Sabon Garin Hunkuyi		9	Kwarbai B
	9	Taba		10	**Limancin Kona**
	10	**Zabi**		11	Tudun Wada
				12	Tukur Tukur
				13	Wucicciri

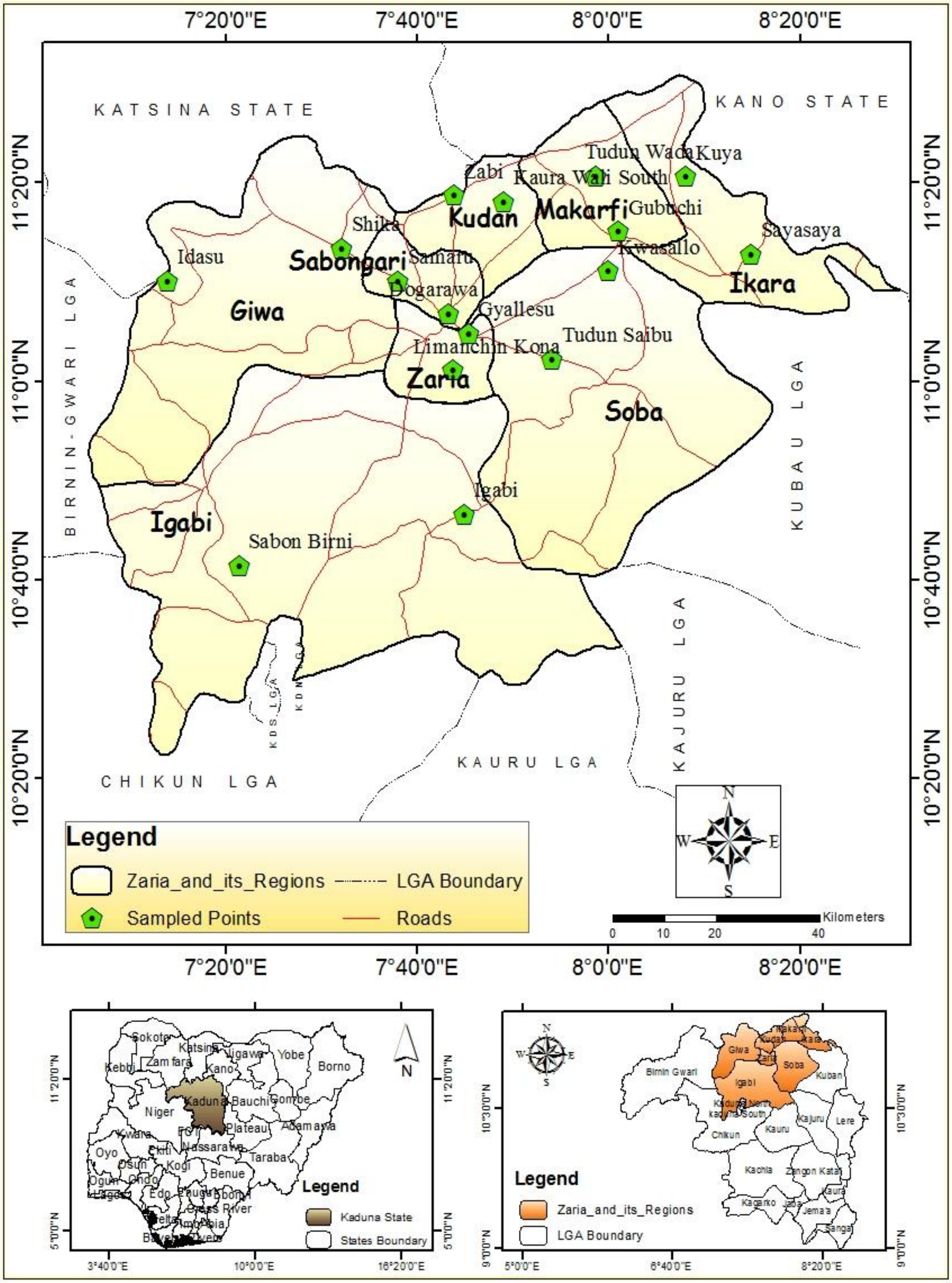


Figure 3.2: Study Area Showing the Sampling points
Source: Adapted and modified from administrative map of Kaduna.

$$\boldsymbol{Mean} = \frac{\sum \boldsymbol{x}}{\boldsymbol{n}}$$

Where: $\sum$ = summation

$\boldsymbol{x}$ = total quantity of fuelwood consumed

$\boldsymbol{n}$ = total number of household

$$\boldsymbol{S.D} = \sqrt{\frac{\sum(\boldsymbol{X}-\overline{\boldsymbol{X}})^2}{\boldsymbol{n}}}$$

Where: **S.D** = standard deviation

$\sum$ = summation

$\boldsymbol{n}$ = total number of household

Objective IV: examine the relationship between fuelwood consumption and vegetation loss in the area from 1973 – 2014. Change detection analysis (supervised landuse/landcover classification) was used to show the rate of vegetation cover loss, health and density (NDVI) using the resulted values generated from satellite imagery. To compare these sets of data from 1973 – 2014.

The magnitude of changes was calculated as: C= B-A

Where:

C= is the magnitude of change

B= Base year (1973, 1986, 1996, 2006 and 2014)

A= Reference year

Percentage of changes (E)

$$E = \frac{C}{base\ year \times 100}$$

Where

C= magnitude of change

$$\text{Annual rate of change (D)} = \frac{C}{number\ of\ \ years\ between\ the\ period}$$

Where:

C= magnitude of change of each urban land use divided by the number of years between the periods i.e. 13 years for 1973-1986, 10 years for 1986-1996, 1996-2006, and 8 years for 2006- 2014 and 1973-2014 for 41years.

The change map was obtained by overlaying the map of urban extent of 1986-2000, 2000-2013 and 1986-2013 and also the map of vegetation extent of 1986-2000, 2000-2013 and 1986-2013.

Normalized Difference Vegetation Index (NDVI) is an important index in Remote Sensing technology. It is most widely used in vegetation studies as an indicator of vegetation health and density. It has also gained a wide usage as an indicator of vegetation degradation.

It uses the principle that healthy vegetation absorbs most of the incident visible light emitted by the sun, and reflects a larger portion of the near Infra red light. Unhealthy or sparse vegetation reflects more visible light and less near-Infrared light. The difference between healthy or well stocked vegetation and that of unhealthy or sparse vegetation can be assessed by means of the NDVI as

$$NDVI = (NIR – RED) / (NIR + RED)$$

OR

$$\text{NDVI} = \frac{(\text{NIR Band} - \text{RED Band})}{(\text{NIR Band} + \text{RED Band})}$$

Where NIR is the near-Infra red reflectance and RED is the reflectance of the Red portion of the Visible light in the Electromagnetic Spectrum (EMS). The NDVI is a dimensionless index, so it values ranges from -1 to +1 (Meneses-Tovar, 2011) with higher value indicating denser and healthier like in tropical forests, moderate values showing shrubs and grassland, while very low values of 0.1 and below are typical to water and non-vegetated areas. In order words, high values are indicators of high photosynthetic activity and low values are indicators of low photosynthetic activities.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 INTRODUCTION

In this Chapter attempt has been made to explain the socio-economic characteristics of the households in Zaria and its region. The result of the data analyzed are presented and discussed to achieve the objectives of the study.

4.2 SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

These socio-economic characteristics include sex, age, level of education, occupation, income level and size of the family. They are presented in the tables while discussion follows.

Table 4.1 reveals that the gender of the respondents was 84% males, while 16% were females. This greater variation is in line with the religious and cultural ethics in the study areas where males serve as head of the household except in some localities where females function as household heads as either widows or divorcees and as such males engage commonly in commercial activities in the study than their female counterpart.

Age plays a critical role in the business of firewood because adults are more likely to engage in the business than dependent age group. Table 4.1 shows the distribution of respondents by age. The age group 40-49 years has the highest proportion of 38%, followed by age group of 30-39 years, with 25% and 60+ years having the lowest distribution of 5%. In all, 83.0% of the respondents are within the age bracket of 20-49 years. This is a clear indication that the population sampled is a youthful population. This pattern of age distribution is not abnormal because the adult age groups are more engaged in the fuelwood issues.

With respect to level of education this sometimes reflect the energy utilization pattern of people. Table 4.1 reveals that 28.6%, 21.9 and 21.9% of the respondents have Primary, Secondary and Adult literacy education respectively. Only 14.8% and 12.8 have tertiary and No formal education. This implies that majority of the respondents are literate but surprising because as Zaria and its Region is home to many tertiary institutions as well as an Islamic educational centre and ranks the second highest in educational facilities in the whole of Kaduna State that provide education for a huge population of the study area but few have tertiary education.

Education is a key determinant of the lifestyle and societal status an individual enjoys. It does not only provide opportunities for personal advancement, awareness of social opportunities and higher non-familial aspirations but also new outlook, freedom from tradition, willingness to analyze institutions, values and patterns of behavior and growth of rationalism. Educational attainment is perhaps the most important characteristic of respondents because many phenomena such as reproductive behavior, use of contraception, child’s health, and proper hygienic habits are related to the education of respondents (NDHS, 2008).

With respect to occupation Table 4.1 also shows a cleared result, thus in most cases occupation determines the level of income of a personal though there is a link between occupation of people and type of energy to be use as well as consumption. That is the higher the occupation the higher the income and thus the types of energy to be use.

Table 4.1: Socio-economic Characteristics of the Respondents

	ENVIRONS																	
	GIWA (N=50)		IGABI (N=76)		IKARA (N=34)		KUDAN (N=24)		MAKARFI (N=26)		S/ GARI (N=50)		SOBA (N=52)		ZARIA (N=72)		CUMMULATIVE DATA	
	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Sex																		
Male	47	94	63	83	27	79	24	100	19	73	41	82	41	79	61	85	**323**	**84**
Female	3	6	13	17	7	21	-	-	7	27	9	18	11	21	11	15	**61**	**16**
Age																		
20 – 29	6	12	14	18	6	18	3	12.5	4	15	9	18	16	30.7	23	32	**81**	**20**
30 – 39	13	26	18	24	9	26	6	25	7	27	11	22	12	23	19	26	**95**	**25**
40 – 49	21	42	31	41	15	44	9	39.5	11	42	19	38	16	30.7	23	32	**145**	**38**
50 – 59	7	14	10	13	2	6	3	12.5	3	12	7	14	5	9.6	5	7	**42**	**11**
60 above	3	6	3	4	2	6	3	12.5	1	4	4	8	3	6	2	3	**21**	**5**
Literacy level																		
Adult literacy	15	30	12	16	10	29	8	33	5	19	7	14	17	33	10	14	**84**	**21.9**
Primary	15	30	20	26	9	26	4	17	7	27	19	38	13	25	23	32	**110**	**28.6**
Secondary	5	10	27	36	6	18	3	13	3	11	11	22	8	15	21	29	**84**	**21.9**
Tertiary	7	14	17	22	4	12	2	8	2	8	9	18	3	6	13	18	**57**	**14.8**
No formal	8	16	-	-	5	15	7	29	9	35	4	8	11	21	5	7	**49**	**12.8**
Occupation																		
Farming	23	46	21	28	14	41	16	67	17	65	9	18	21	40	17	24	**138**	**36**
Business	11	22	20	26	7	21	4	17	3	12	19	38	19	37	27	37	**110**	**29**
Civil service	9	18	28	37	9	26	3	12	5	19	15	30	9	17	23	32	**101**	**26**
Others	7	14	7	9	4	12	1	4	1	4	7	14	3	6	5	7	**35**	**9**
Income (₦)																		
< 18, 000	19	38	13	17	15	44.1	7	29	9	35	13	26	11	21.2	15	21	**102**	**27**
18,000-27,000	9	18	11	14.5	4	11.8	9	38	5	19	14	28	13	25	15	21	**80**	**21**
28,000-37,000	11	22	8	11	3	8.8	5	21	5	19	7	14	9	17.3	11	15	**59**	**15**
38,000-47,000	7	14	30	39.5	7	20.6	-	-	3	12	2	4	8	15.4	15	21	**72**	**19**
48,000 above	4	8	14	18	5	14.7	3	12	4	15	14	28	11	21.2	16	22	**71**	**18**
Family size																		
1 – 5	7	14	14	18	5	15	3	12	4	15	11	22	11	21	12	16.7	**67**	**17**
6 – 10	13	26	9	12	3	9	7	29	3	11.5	9	18	9	17	9	12.5	**62**	**16**
11 – 15	11	22	23	30	10	29	9	18	9	35	12	24	23	44	25	34.7	**122**	**32**
16 – 20	9	18	17	22	13	38	4	17	7	27	9	18	4	8	9	12.5	**72**	**19**
21 above	10	20	13	17	3	9	1	4	3	11.5	9	18	5	10	17	23.6	**61**	**16**

Source: Field Work, 2015.

Table 4.1 shows respondents engaged in farming constituting 36% of the sample, followed by 29% of those doing business. Only 26% were civil servant; this low response is because Zaria and its Region is a semi urban and rural area with abundant farmland due to its nature. The table further shows that 9% of the respondents are involved in one form of economic activity or the other. Employment, whether formal or informal, is one source of empowerment for men and women alike.

The result also shows that majority (36%) of the respondents were farmers and does not have any kind of activity apart from it, thus this is an indication of solely depends or shows the kind of energy to be used as stated earlier that occupation will determine the level of income as well as the type of energy to be used.

Income which is a major factor determining the living standard, hence household energy has correlation with standard of living as indicated in Table 4.1

The Zaria and its Environs has eight LGA their income level varies from ₦18,000 to ₦48,000. Those found with very high income are basically government officials. The table also explains that majority of the respondents earn less than ₦18,000 monthly which is below the national minimum wage which constitute 27% and only 18% of the respondent earn above ₦48,000 monthly and this is due to the nature of their employment, as most of them were farmers and business men and women. However, it was clearly understood that lack of capital, inadequate support from the government, unemployment coupled with poor economic and commercial spirit discourages major investments which eventually affects income level and standard of living of most of the respondents in the study area which also make them to rely solely as well as reasonable amount of their income on purchase of fuelwood.

In contrast, the family size of the respondents determine the quantity of fuelwood to be consumed in a house, usually large family are expected to cook several times in a day and hence demand for fuelwood.

Figure 4.2 indicates that out of the 384 households that responded to the questionnaire (no missing respondents), the number of households that use fuelwood is 297 (77.3%).

In contrast, Table 4.1 reveals that the cumulative household size in Zaria and its Environs is that majority of the household with a size of 11-15 people constitute of 32%, followed by19% of the respondents had between 16-20 people per household; then 17% had between 1-5 people per household; and lastly 6-10 and above 21 people per household were constitute with 16% each respectively. From the table, there is an association between fuelwood use and larger households, this is because the larger the size of the house, the larger the quantity of fuelwood used in a particular household and as such it was confirmed that household all with family sizes of less than 6 people in the households) do not use fuelwood for their cooking. In contrast all households with more than 6 people use fuelwood for their cooking.

4.3 SOURCE AREAS OF FUELWOOD

The following areas were cited by the commercial fuelwood dealers as their collection centres, Figure 4.1 shows clear features as presented below.

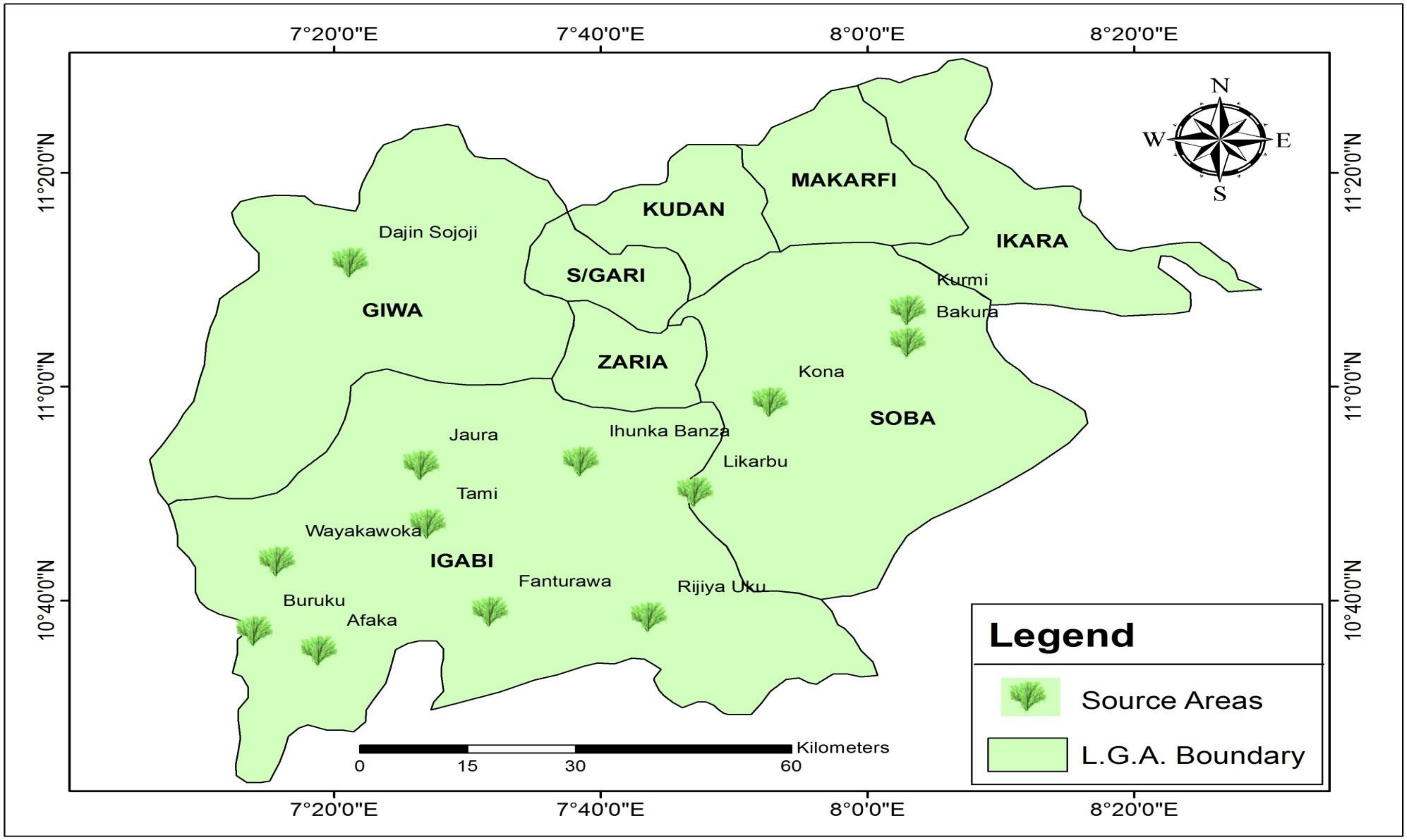


Figure 4.1: Areas where fuelwood are obtained

Source: Field Work, 2015

In contrast, majority (50%) of the source areas where fuelwood are obtained were found to be Igabi which shows several forest by the commercial point owners which constitute about eight locations, then 25% from Soba LGA with about four different forest areas, which followed by 6.25% in Giwa LGA with the least forest point. Three different LGA outside the study area's which constitute 18.75% were also mentioned by some of the commercial fuelwood dealers as their source areas i.e. Kadage, Kudaru and Muya forest all in Kauru, Kubau and Birnin Gwari LGA respectively but they were not showed in figure 4.1 because they were not among the study area.

However, the study area has eight different LGA but only few of them (three) LGA that the entire Greater Zaria solely depend to collect the fuelwood. This is an indication that fuelwood collection has drastically cleared the vegetation cover in the remaining five LGA were no single was cited by the commercial fuelwood dealers (see Figure 4.1 and Figure 4.17).

Even though fuelwood consumption is not the only factor that leads to reduction in vegetation cover, but it may be the most strongest among others. Below are some of the plate cited by the author during a survey to some of the forest areas in the study area (see plate I and II)

4.3.1 Distance to Fuelwood Procurement Centre's and the Type of Vehicles Used in Conveying the Wood

The distance that the vendors travel in order to procure the fuelwood ranges from 50km to 250km and the types of vehicle used are shown in Table 4.2 and 4.3 respectively.

Plate I:

Plate II: Plate III:

Plate I, II and III: A visit to Dajin Sojoji Giwa LGA
Source: Field Work, 2015.

4.3.1.1 Distance Covered to Collect the Wood

This study has categorised fuelwood procurement distance into households that obtained their fuelwood from the vendors in the market and households that obtained their wood from their farmland or forest. It was revealed that the majority (70%) of the households in the study area obtained their fuelwood from the market. This contradicts some of the findings of Jelwic and Van Vegtan (1981); Leach (1987); Ghilardi *et al.* (2009) and Palmer and Macgregor (2009), who reported fuelwood collection among households using family labour as part of the causes of deforestation in their respective study areas. Even though, the finding in this study concurred with some of these researchers in relation to the high demand of fuelwood among households in their respective study areas, the findings here contrary to their findings noted the active role of commercial fuelwood collection in the study area, which is assumed to be a major cause of deforestation. The commercialisation of fuelwood collection was also reported by Ali and Benjaminsen (2004) and Bensel (2008) in their respective studies as a major cause of deforestation.

Table 4.2: Distance Covered to Collect the Wood

DISTANCE (KM)	ENVIRONS																	
	GIWA		IGABI		IKARA		KUDAN		MAKARFI		S/ GARI		SOBA		ZARIA		CUMMULA TIVE DATA	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
50 – 100	1	7	1	7									2	13			**4**	**27**
101 – 150			2	13							1	7			1	7	**4**	**27**
151 – 200																		
201 – 250											1	7			2	13	**3**	**20**
250 Above							1	7									**1**	**7**
Total	**1**	**7**	**3**	**20**			**1**	**7**			**2**	**14**	**2**	13	**3**	20	**12**	**81**

Source: Field Work, 2015.

Key:
F: Frequency

Table 4.2 shows that four out of twelve vendors (from Giwa, Igabi and Soba) said they use to travel about 50-100km to collect the wood, another set of four vendors (from Igabi, Sabon

Gari and Zaria) also travell as far as 101 – 150km to procure the wood, and three out of twelve vendors (from Sabon Gari and Zaria) revealed that they travelled for about 201 – 250km to harvest the wood while a single vendor out of twelve confirm that he travells to a far distance of 250km above to procure the wood for sell.

Overall, the vendors sometimes travel up to 250km from their town in order to collect and supply fuelwood this contradicts the findings of Naibbi (2013) who reported fuelwood collection among vendors sometimes travel to 200km and most of them travel just within the local administrative boundaries.

4.3.1.2 Mode of Transport used in Conveying the Wood

Due to the distance to the procurement centres, Donkeys, ford, motor cycle, Pick-up van and trucks were used to convey the fuelwood to the market. The choice of the vehicle depends on the size of the load and the nature of the terrain leading to the collection centre. Below is a list of the types of vehicles used in conveying the goods from the forest area (see Table 4.3 and Plate IV and V for illustrations).

Table 4.3: Mode of Transport Used in Conveying the wFuelwood

DISTANCE (KM)	ENVIRONS																	
	GIWA		IGABI		IKARA		KUDAN		MAKARFI		SABON GARI		SOBA		ZARIA		CUMMULATIVE DATA	
	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%	F	%
Donkey	1	6.67															**1**	**7**
Ford			1	6.67							1	6.67	1	6.67	1	6.67	**4**	**27**
Motor cycle	1	6.67	1	6.67													**2**	**13**
Pick-up Van											1	6.67			1	6.67	**2**	**13**
Truck	1	6.67	1	6.67			1	6.67			1	6.67	1	6.67	1	6.67	**6**	**40**
Total	**3**	**20**	**3**	**20**			**1**	**7**			**3**	**20**	**2**	13	**3**	20	**15**	**100**

Source: Field Work, 2015.

Also, as suggested by Cooke *et al*. (2008); Christensen *et al.* (2009), the old orthodoxy of African women and children as being the primary collectors of fuelwood is losing ground in the wider fuelwood supply strategy, due to the present long distance travel involved in the procurement of fuelwood in the majority of African countries. The supply of fuelwood in the study area was observed to be an organised pattern that took advantage of the scarcity of vegetation within shorter distances from the towns, in order to maintain the supply to the already existing market.

This study also agrees with the findings of McClintock (1987); Cline-Cole *et al.* (1987); Christensen *et al*. (2009) and Naibbi (2013) who indicated the use of trucks in their respective study areas as a means for transporting the fuelwood from the distant forest to the towns. Cline-Cole *et al*. (1987) for example, described the supplying distance hinterland of Kano's fuelwood to have extended up to a radius of 600km, with the highest daily supply of about 425 tons in the hot dry season (March-April) of 1983. This was also confirmed in this study, where all the vendors acknowledged that the hot dry season is very good for stocking the wood as against other seasons (See Table 4.3)

Conversely, the distance and volume of the fuelwood determine the type of truck to be used for the conveyance of the goods. It is worth noting that distance of fuelwood is higher in price as confirmed by one user who bought a full truck. The increase in the price of distantly fetched fuelwood could be a strategy used by the vendors to compensate for the cost of transport since there was not any official regulatory body that manages fuelwood prices. However, on a related development as observed in Kano, Cline-Cole *et al.* (1987:10) revealed that: "*the less populated woodland areas are favoured by specialist traders in firewood, who send trucks in on payment of very small fees to the local authorities (bribery* *and corruption allegation re-surfaced). After payment for the wood, labour and other costs, profit margins are wide enough to compensate for distance transport costs, at the prevailing retail prices*". This also indicated the potential of the vendors to exploit the household buyers for their own financial benefit.

PlateIV: Motor cycle as means of transportation used in carrying fuelwood)
Source: Field Work, 2015

Plate V: Truck as transportation means used in carrying fuelwood)
Source: Field Work, 2015

- “*Donkey*”- (fuelwood commercial dealer from Giwa LGA) were using Donkey in conveying the wood from the forest to the consumers. Donkeys are sometimes used most especially during the rainy season due to the nature of the road.

- “*Ford*”- with the exception of Giwa LGA, all the vendors from the other LGA’s were using ford in conveying and distributing the goods to the buyers.

- “*Motor cycle*”- with the exception of other LGA’s, Giwa and Igabi LGA’s were using motor cycle in conveying and distributing the goods to the buyers. See Plate iv

- “*Pick-up van*”- (Four respondents from Zaria, Sabon Gari, and Soba LGA) were all using pick-up van in conveying and distributing the goods to the town then to various consumers/buyers.

- “*Truck*”- it is bigger than other mode of conveying the woods and was used to all by fuelwood commercial dealers across the areas in the study area.

4.3.3 Fuelwood Business

Although commercial fuelwood activity is seen as a factor determining the scarcity and severity of the fuelwood situation in the DC (Christensen *et al.* 2009), the viability of the industry in terms of job opportunity and poverty alleviation was overshadowed in the existing literature. This study concurred with Shackleton *et al.’s* (2006) suggestion on the relevance of the industry as an organised business that provides job security for many families. This can be illustrated from the total number of the existing employees found within the groups of vendors interviewed here.

Fuelwood vending as described by all vendors serves as an employment opportunity to support their families. However, they have all portrayed the business as a tough one, because it requires intensive manual labour. On the other hand, they have all reported that they also engage in farming activities during the rainy season.

Plate VI: Interviewing dealer along 'Dajin Sojoji' Giwa LGA
Source: Field Work, 2015.

A fuelwood commercial dealer from Soba LGA for example, added that: "*for me it is a full time job that I inherited from my father, who coached me to be an expert fuelwood collector..., I started the Job since I was 15 Years old".* On the contrary, respondent number eight mentioned that: *"I only participate fully in the business on a weekly basis (on market days which is every Thursday in Giwa town)*".

Respondents two and six (Zaria and Sabon Gari) further commented on other reasons that attract them to the business as follows: "*to supply fuelwood to the people… because it is the only alternative source of cooking fuel for the ordinary people and they have been in the business for over 20 years*".

Another potential reason for the high number of people in the business is the profit involved as a result of a conspiracy between the vendors and the government officials through bribery. The procurement of fuelwood in the study area is full of bribery and corruption allegations, because the vendors are scared of the forest officials who have the powers to prosecute them. In contrast, the forest officials (who are faced with difficulties that ranges from poor funding to inadequate training and lack of exposure to modern forestry techniques - FAO, 2003 and FAO, 2010; refer to chapter 2:2.1.2.3 for more detail) exploits their mandate of protecting the forest by collecting bribe from the vendors, who are regarded as the culprits. This provides a favourable avenue for the symbiotic relationship that exists between the two parties. However, in my opinion, the bribery allegations in the business needs to be addressed and the business of fuelwood vending should be legitimised by the government and regarded as an advantage to the economy of the people, through proper organisation of the business. A model was proposed by Chomitz and Griffiths (2001) in N'Djamena, Chad; and by Shackleton *et al.* (2006) in South Africa for the management of the vegetation of the respective countries, which integrates all the stakeholders (including the vendors) in the programme. Although the success of these models are yet to be assessed; a similar approach can be modified to suit the Nigerian context, given that the commercial activities of fuelwood will be inevitable especially in the northern part of the country in the near future (Maconachie *et al*., 2009).

4.4 FACTORS RESPONSIBLE FOR FUELWOOD CONSUMPTION

This was highlighted earlier in this study where the majority (77.3%) of the households were reported to be relying on fuelwood regardless of their economic or social status. However, economic status of the family and increasing family size was seen as an important indicator of fuelwood use in this study. In contrast, those households with less than 6 people have choices they can make.

4.4.1: Fuelwood as a Major Source of Energy

The over dependence on the use of fuelwood in the study area like most places in Northern Nigeria was the product of numerous issues concerning fossil fuel supply and affordability as well as income and size of the of the household. See Figure 4.2 for more information from the study area.

In Giwa LGA, Figure 4.2 reveals that two set of 10% of the respondents were using both charcoal and kerosene respectively as their primary source of energy, 74% were using fuelwood while 6% fall under others which comprises (saw dust, animal dung, crop residue, etc), but 0% were neither used electricity nor gas.

In Igabi LGA, the Figure 4.2 also shows that 6.6% were using coal as their major source of energy, 77.6% were using fuelwood, 9.2% were using kerosene and another 6.6% were using ether saw dust, animal dung, and crop residue.

In Ikara LGA, its indicates that 0% were neither used coal, electricity nor gas as their primary source of energy, 85.3% were using fuelwood, 8.8% were using kerosene while 5.9% were using ether saw dust, crop residue, corn stalks and so on.

In Kudan LGA, Figure 4.2 also confirm that Gas, Electricity, coal, saw dust and animal dung as well as crop residue are not used by household as fuel of domestic use, 87.5% were using fuelwood, 12.5% were using kerosene.

In Sabon Gari LGA, Figure 4.2 reveals that 4% of the respondents were using coal, three set of 2% of the respondents were using both electricity, gas and others which comprises (saw dust, animal dung, crop residue, etc) respectively as their primary source of energy, 82% were using fuelwood while 8% were using kerosene.

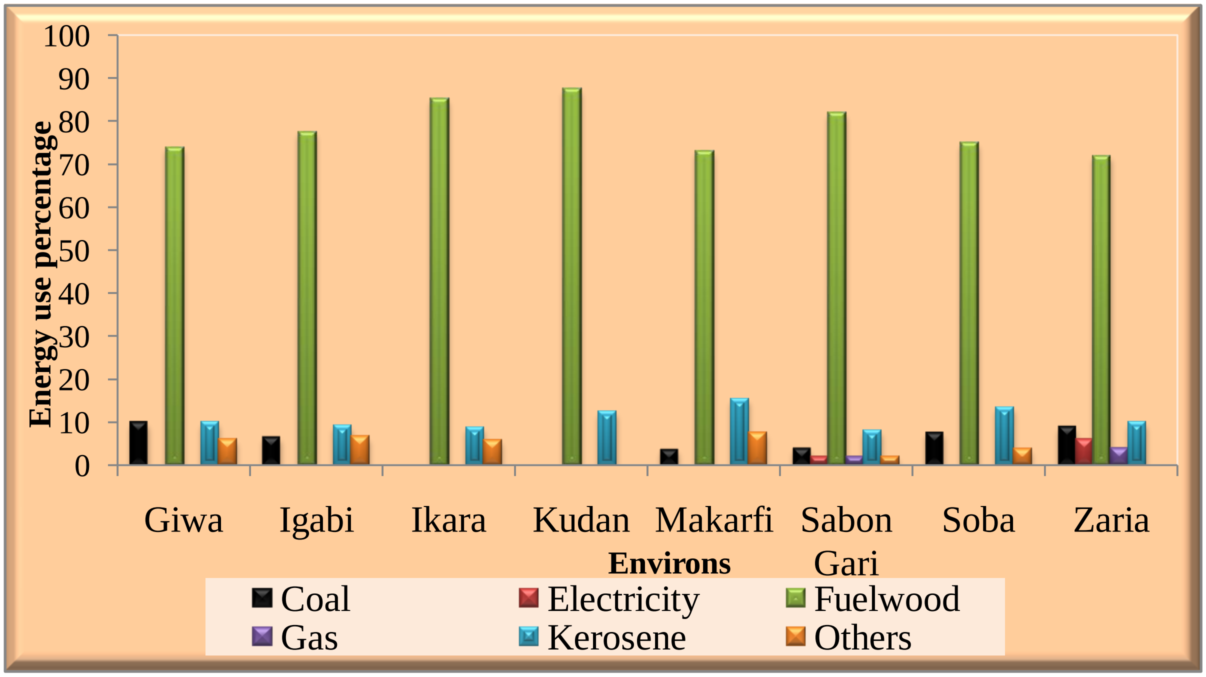


Figure 4.2: Distribution of respondents with their major source of energy.
Source: Field Work, 2015.

In Makarfi LGA, the result in Figure 4.2 also indicates that gas and electricity are not used by household as fuel of domestic use, 3.8% were using charcoal, 73.1% were using fuelwood, 15.4% were using kerosene while 7.7% were using ether saw dust, crop residue, corn stalks and so on.

Plate VII: Interview a respondent at Tudun Saibu, Soba LGA
Source: Field Work, 2015.

In Soba LGA, the result in Figure 4.2 also indicates that 7.7% were using coal, 75% were using fuelwood, 13.5% were using kerosene while 3.8% were using ether saw dust, crop residue, animal dung and so on.

In Zaria LGA, Figure 4.2 reveals that 9% of the respondents were using coal, 6% of the respondents were using electricity, 72% were using fuelwood, 4% were using gas, 10% were using kerosene while 0% was neither used saw dust, crop residue nor animal dung.

Cumulatively, Figure 4.2 also confirms that fuelwood is the major energy used which account for 77.3% of the total respondents in the study area, follow by kerosene with 10.4%, and coal with 6% while others (saw dust, crop residue, animal dung), electricity and gas were accounted for 4%, 1.3% and 1% respectively.

Even though the use of charcoal for cooking was reported by only a few households (6%) who cook for less than 6 people, the majority have indicated that they use it in conjunction with fuelwood. Alabe (1996) reported a similar findings in the study area about two decades ago, where he noted that charcoal was extensively used among households during the harmattan season for heating, while some few households (with small families) also use it to cook. Although the use of charcoal for cooking among the majority of its users in the study area was for complementary purpose, it is also worth noting that charcoal use in the area is now gaining popularity among the small households. This is likely due to the size of the charcoal cooking stoves used among households in the study area as highlighted by a few households that uses it (normally small in size and can only be use with small cooking pots).

Similarly, a few households in this study also reported that they use animal dung locally called “Kandilo” and the stalks from their crop residues during the dry season to complement fuelwood supply. it can be argued that its use is more confined to the rural areas.

Apart from using fuelwood for cooking, most households also use modern cooking fuels such as kerosene, gas and electricity in conjunction with fuelwood. The majority of the households indicated that they use kerosene for starting the fire (when cooking with fuelwood) especially in the rainy seasons. Other items such as polythene bags, scraps of plastic pieces and papers are also used for starting the fire.

The use of electricity was next to kerosene in the study area in terms of importance followed by gas. However, the provision of these fuels in Nigeria is insufficient (see chapter 2: 2.2.8-2.2.8.4), which is part of the reasons why none of the fossil fuels was used in isolation without complementing it with fuelwood in the study area (see Figure 4.2 and 4.3).

Furthermore, from the energy sources highlighted in figure 4.2, fuelwood appeared to be the only form of cooking energy that can serve the needs of even the poor and households with large population, as demonstrated by many households in the study area. Additionally, with the recent withdrawal of fuel subsidy in Nigeria in January 2012, the prices of fossil fuel soared; this has the implication of committing more people to depend even more on fuelwood (see chapter 2: 2.5.1.3 and 2.5.3). Therefore, in the future if the situation does not change, it is likely that the vegetation in the study area would decline further.

4.4.2: Reasons for the choice of fuelwood

Given the current status of the country's weak infrastructure, economic development (Eroke, 2012) and lack of alternative energy sources (Maconachie *et al.*, 2009), the price of fuelwood is far less than that of the alternative energy sources of kerosene, gas and electricity which is why most people depend on fuelwood as their only cooking fuel option (Casse *et al.*, 2004).

Although, some authorities have argued that the use of fuelwood is largely found in lower income families in the DC (Adelekan and Jerome, 2006; Kowsari and Zerriffi, 2011 and Sovacool, 2011), which contrasts with the ways fuelwood is being used in the developed countries. Couture *et al.'s* (2012) study of the use of fuelwood for heating among families in France shows a reverse relationship between fuelwood use and income, because affluent families use fuelwood for pleasure rather than from necessity. The present findings contrast with both these studies,

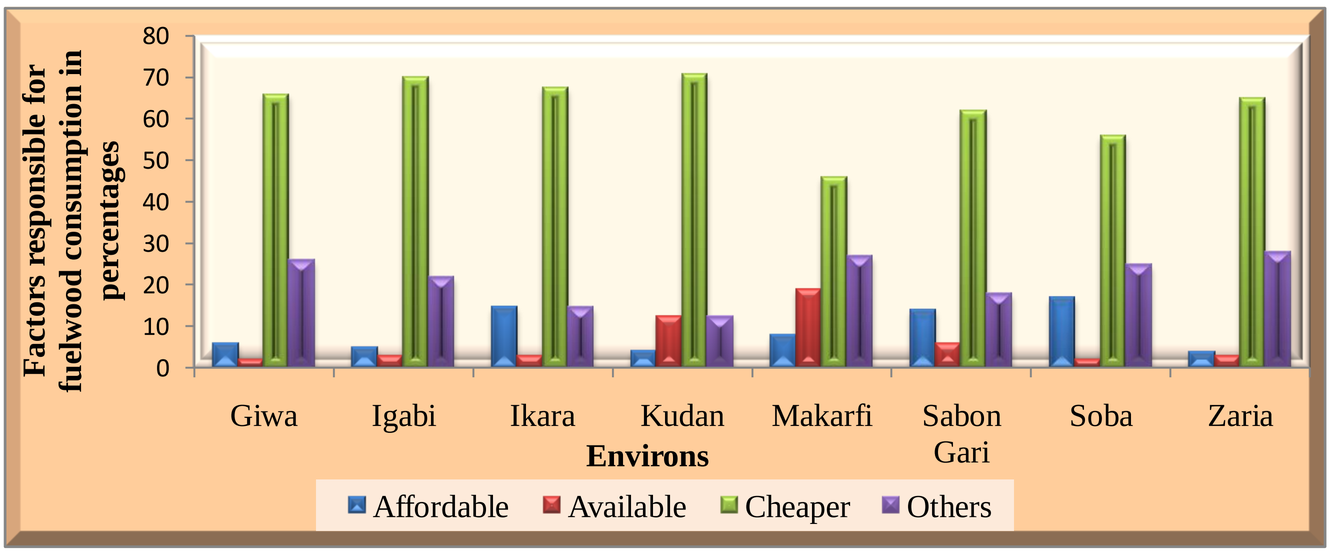


Figure 4.3: Reasons for the choice of fuelwood
Source: Field Work, 2015

because the difference between the rich and the poor in terms of fuelwood use is negligible, especially in the northern states of Nigeria, where even the affluent families, have to rely on fuelwood for their cooking, due to the shortage of modern fuel supply (Maconachie *et al.*, 2009).

Figure 4.3 shows that in Giwa LGA, 6% of the respondents said they were using the fuelwood because they can afford it, 2% said because of its availability, 66% of the respondents respond that is cheaper compared to fossil fuels, while 26% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the table by others.

In Igabi LGA, 5% of the respondents said they were using the fuelwood because they can afford it, 3% said because of its availability, 70% of the respondents noted that is cheaper compared to fossil fuels, while 22% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the figure by others.

In Ikara LGA, 14.7% of the respondents said they were using the fuelwood because they can afford it, 3% said because of its availability, 67.6% of the respondents said that is cheaper compared to fossil fuels, while 14.7% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the table by others.

In Kudan LGA, 4.2% of the respondents said they were using the fuelwood because they can afford it, 12.5% said because of its availability, 70.8% of the respondents respond that is cheaper compare to fossil fuels, while 12.5% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the table by others.

In Makarfi LGA, 8% of the respondents said they were using the fuelwood because they can afford it, 19% said because of its availability, 46% of the respondents respond that is cheaper compare to fossil fuels, while 27% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the table by others.

In Sabon Gari LGA, 14% of the respondents said they were using the fuelwood because they can afford it, 6% said because of its availability, 62% of the respondents respond that is cheaper compare to fossil fuels, while 18% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the table by others.

In Soba LGA, 17% of the respondents said they were using the fuelwood because they can afford it, 2% said because of its availability, 56% of the respondents respond that is cheaper compare to fossil fuels, while 25% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the table by others.

In Zaria LGA, 4% of the respondents said they were using the fuelwood because they can afford it, 3% said because of its availability, 65% of the respondents respond that is cheaper compare to fossil fuels, while 28% of the respondents were using either coal, electricity, gas, kerosene etc as their primary source of energy as indicated in the table by others.

As observed earlier by Cline-cole *et al*. (1987); Mortimore (1990); Alabe (1996); Casse *et al*. (2004); Maconachie *et al*. (2009) and Arabatzis *et al*. (2012), this study also confirmed that the majority (77.3%)of households relied on fuelwood for two main reasons, 1) the economic situation in the country, and; 2) unreliability in the supply of modern cooking fuels.

The economic situation lies with the fact that the majority of households are low and minimum wage earners (see section 4.2.5), which places them in a vulnerable economic situation given that the prices of modern cooking fuels are always on the rise, with no substantial improvement in the economic situation of the households. The economic situation of households together with the irregular supply of fossil fuels in the northern part of Nigeria due to many factors, were among the reasons for the high dependence on fuelwood in the study area (Cline-cole *et al*., 1987 and 1988; Nichol, 1990; Hyman, 1994; Alabe, 1996; Odihi, 2003 and Maconachie *et al*., 2009). The unreliability in the supply of fossil fuel to the study area is similar to that of Kano and many other northern parts of Nigeria. The issue of petroleum products supply in the northern part of Nigeria can be summarised with the quotation from Maconachie *et al.* (2009:1096) based on the response they received from the spokesperson of the Kano Independent Marketers of Petroleum Product in 2008, where he mentioned that - "*out of the estimated 110 official trucks that were meant to transport about 3.632 million litres of Hosehold Kerosene (HHK) to Kano daily, only about 2-3 trucks (around 66,000 to 99,000 litres) reach Kano daily*."

4.4.3: Species of preference in Fuelwood Business

The prefered type of wood species used for fuelwood are presented in the Table 4.4, although the households have no choices of their preferred fuelwood type, the most preferred species of tree among others are: *prosopis Africana, Anogeissus leicarpus, Guiera senegalensis, Piliostigma reticulatum, Combretum and Bauhinia rufescens (Jalahe).* These species are prefared because of their high quality in terms of heat output, good combustion and their potential to produce less smoke even when they are wet (during rainy season) (Alabe, 1996).

Table 4.4: Species preference for use and sell

Hausa Name (Local Name)	Botanical Name	English Name
Adduwa	*Balanites aegyptiaca*	Desert date
Baushe	*Terminalia spp*	-
Chediya	*Ficus thonningii*	-
Doka	*Isobalina doka*	
Dorawa	*Parkia biglobosa*	Locust tree
Gawo	*Faidherbia albida*	Winter thorn
Kanya	*Diospyros mespiliformis*	West African Ebony
Kargo	*Piliostigma reticulatum; p.thonningii*	-
Kirya	*Prosopis Africana*	False locust
Dogon yaro	*Azadirachata indica*	Neem tree
Madachi	*Khaya senegalensis*	Mahogany
Makarho	*Daniella olivera*	-
Malga	*Mangnifera*	-
Mangoro	*Magnefera indica*	Mango tree
Marke	*Anogeissus leiocarpus*	Chewstick tree
Sabara	*Guiera senegalensis*	-
Taura	*Datarium microcarpum*	-
Tsamiya	*Tamarindus indica*	Tamarind
Wuyan damo	*Combretum molle; c.glutinosum*	-

Source: Field Work, 2015; Names confirmed from Naibbi (2013).

However, amongst some households in Idasu village (Giwa LGA) and Sabon birni (Igabi LGA) who believed that neem tree, referred to as "Dogon yaro" by the Hausa people, is a tree in the mahogany family with broad dark brown stem and widely spread branches, "*it can easily be established without irrigation in Northern Nigeria and grows rapidly, providing fuel and timber in just about 5-7 years..... and unlike most other native trees and shrubs in Africa, the neem trees are seldom damaged by wandering animals*" (Radwanski, 1969:507). The tree was introduced to Northern Nigeria through the government afforestation programme in order to prevent desertification and to provide shades in the towns (Odihi, 2003). However, given its high potential of growing very fast in the arid areas, the tree is now gaining much popularity among households who mentioned it as being an important fuelwood source. It is worth mentioning that the neem tree also has other economic benefits among households in Nigeria through its numerous potential by-products (medicines, factory chemicals, oil etc) (refer to Radwanski, 1969 and Salako *et al*., 2008, for more details on the economic potential of the neem tree).

However, these important tree species identified by the households are becoming scarce in the study area, because even among the households that do not notice their scarcity. The majority have confirmed that fuelwood is always available but the prices are rising. This evidence provided by the households also introduced part of the complex pattern of fuelwood collection by the vendors who have to cross administrative borders to procure the wood. This was equally reported by Cline-cole *et al.* (1987) and Maconachie *et al.* (2009) in Kano, where some of the procurement distance was far beyond the administrative boundary of Kano. However, as confirmed by one of the vendors, "*the increasing procurement distance in sourcing these particular types of wood species is an indication that they are becoming scarce when one compared the situation in the past few decades, where they can be found within a short distance"*.

4.4.4: Number of years spent in firewood usage as well as business

The variation of years spent on fuelwood used among households and those in the business were presented in Figure 4.4

Figure 4.4 shows that 5% of the households were being using the wood as a fuel between 1-10years, 14% of them said they spent about 11-20years and 25% were vendors, 12% of them said they spent about 21-30years and 17% were vendors, 46% of them said they have been using for the period of over 30years and 58% of the vendors said they were in the business for over 30 years also, while 23% were others (those using either gas, charcoal, electricity etc).

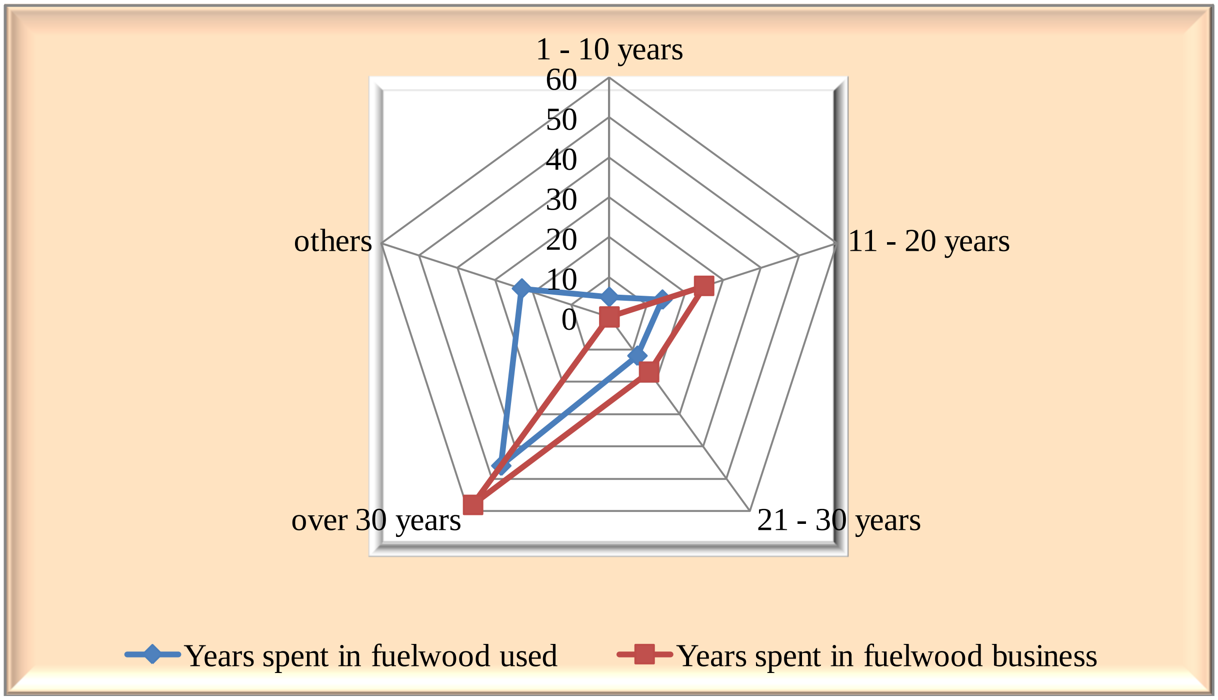


Figure 4.4: Number of Years Spent in Fuelwood Usage as Well as Business
Source: Field Work, 2015.

4.5 QUANTITY OF FUELWOOD CONSUMPTION

4.5.1 Seasonal Variation of Fuelwood Use and Sold

The variation of fuelwood consumption among households in the various seasons is presented in Figure 4.5 and the business of fuelwood activities varied in terms of the three seasons as experienced in the study area (Table 4.5).

Figure 4.5 suggests that fuelwood use is higher all the seasons than other seasons (46%). In contrast, only a few families (5%) attributed a higher use of fuelwood in the hot dry season. Also, some families (8%) reported a higher fuelwood use in the rainy season.

In contrast to the seasonal variation in fuelwood pricing, about 41% of the households reported that they use more fuelwood during the harmattan season than the rainy season (see Figure 4.5). This was as a result of reasons other than cooking (heating and water boiling).

For example, the majority of the households confirmed that charcoal, made from the remnants of the

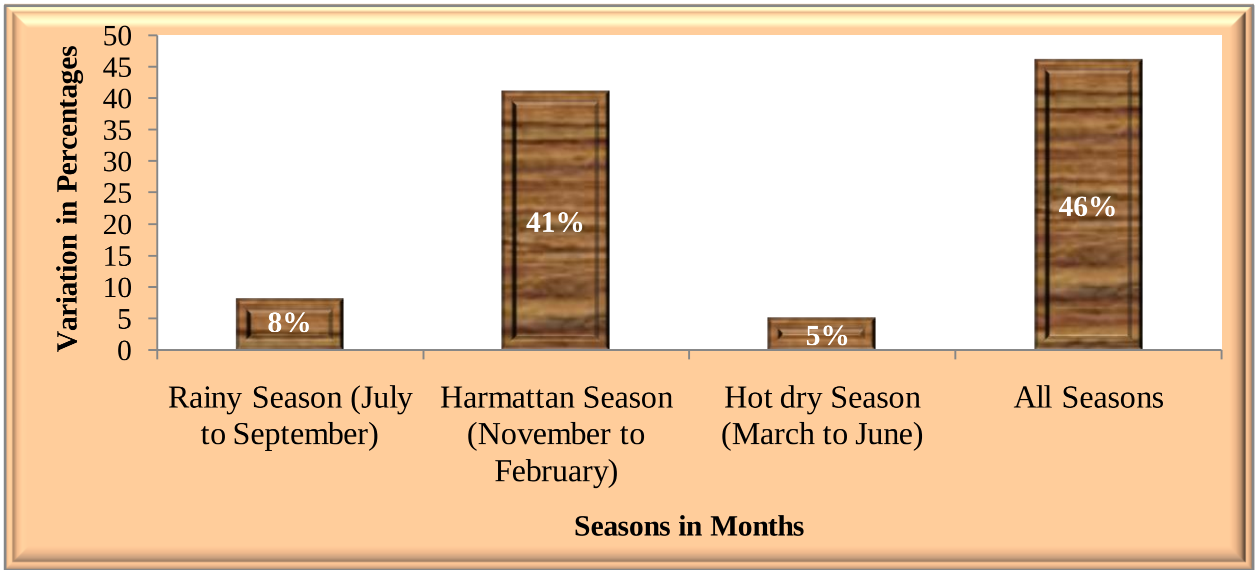


Figure 4.5: Seasonal Variation of High Fuelwood Use
Source: Field Work, 2015

wood they used during cooking was also used in warming their houses during the harmattan season. Others indicated that during late evening conversations (outside their homes) with friends, they also use wood to warm themselves in the harmattan season. Similar findings were previously reported by Cline-Cole *et al.* (1988) and Alabe (1996) in the northern part of Nigeria. In addition, Alabe (1996) equally reported the role of festive periods in the amount of fuelwood used. This was also reported by a few households when they were asked to expand on some of their responses. They revealed that festivals (i.e. wedding, naming ceremonies, fasting periods and the two Eid periods); and occasions such as a new birth (where the tradition in the area is for the new mother to take hot bath twice a day and also to continue using warm water (as drink) for a period of between forty to fifty days) equally plays an important role in the way households use more fuelwood than the normal periods. This was also among the reasons why the actual per household consumption of fuelwood in the study relied on an estimate.

However, a few households among the 8% that use more fuelwood during the rainy season explained that they used more fuelwood in the rainy season due to farming activities, when more food is required by the farmers working in the fields.

Table 4.5: Study area's seasonal variation of commercial fuelwood activities

Season of the year	Procurement activity	Business activity (selling)
Rainy Season	Poor	Excellent
Harmattan Season	Good	Good
Hot Season	Excellent	Poor

Source: Field Work, 2015

The vendors confirmed that the market price of fuelwood is determined by the season. For example, the rainy season and harmattan seasons are the most profitable seasons in terms of fuelwood purchase compared to the hot dry season when the purchase price drops low. The Rainy season purchase is higher because of the low supply from the forest due to inaccessibility of the roads leading to the collection sites (seasonal floods). Below are examples of how the respondents narrated the situation.

While fuelwood pricing is higher in the rainy season, the activities of fuelwood collection are higher in the dry season, which the vendors related as follows:

1. Rainy season- This is a difficult season for the procurement of fuelwood, because the roads leading to the inner forest are inaccessible due to seasonal flooding which makes transportation difficult (earth roads). Other issues affecting the procurement of fuelwood in the rainy season is the farming activities. During the rainy season, the majority of the labourers that process the wood move on to the farms (All Respondents).

2. Harmattan season- This is a good season for the procurement of fuelwood because of its availability (no restrictions as in the rainy season) and there is high demand for fuelwood. Therefore, trading in this period is also profitable (All Respondents).

3. Hot season- (Normal activity) - This season is not good for the business of fuelwood in terms of selling, because the demand is less (All Respondents). However, the stockpiling (hoarding) of fuelwood for use in the rainy season occur in the hot season. The hot season was therefore regarded as the best season for the procurement of fuelwood.

4.5.2 Quantity of fuelwood consumption and average daily spending

The mean ($\bar{X}$) and standard deviation (S.D) calculation was applied to the data to determine the average fuelwood consumption per household per day in Zaria and its environs (see Figure 4.6, plate VIII-IX and appendix III - X) which was used as a basis for generalization. Fuelwood still remains an important cooking fuel in Nigeria, which in terms of consumption compared to other energy sources (see Figure 4.2. above), is quite high (Bugaje, 2006 and NPC, 2010). The fuelwood situation in Nigeria has been monitored and reported in the past with virtually all the researchers affirming the significance of fuelwood in the household energy demand particularly in the northern part of the country (Morgan, 1978; Bdliya, 1987; Cline-cole *et al*., 1987 and 1988; Nichol, 1989 and 1990, Mortimore, 1990; Cline-cole *et al.*, 1990 a and b; Cline-Cole, 1998; Odihi, 2003 and Maconachie *et al*., 2009).

The consumption pattern of fuelwood in the study area was similar to those reported by previous researchers in Northern Nigeria. For example, figure 4.6 below revealed the quantity of fuelwood used among households which show that the majority of the households use large quantities of fuelwood. This coincided with the findings of Alabe (1996) and Odihi (2003) where they both ascertained the high consumption of fuelwood in

Yobe State. The finding here, which also shows that households with many people are more likely to be using fuelwood in a substantial quantity was also earlier reported by Kutuyi and Kirubi (2003) in Kenya and San *et al.* (2012) in Kampong Chnang Province of Cambodia.

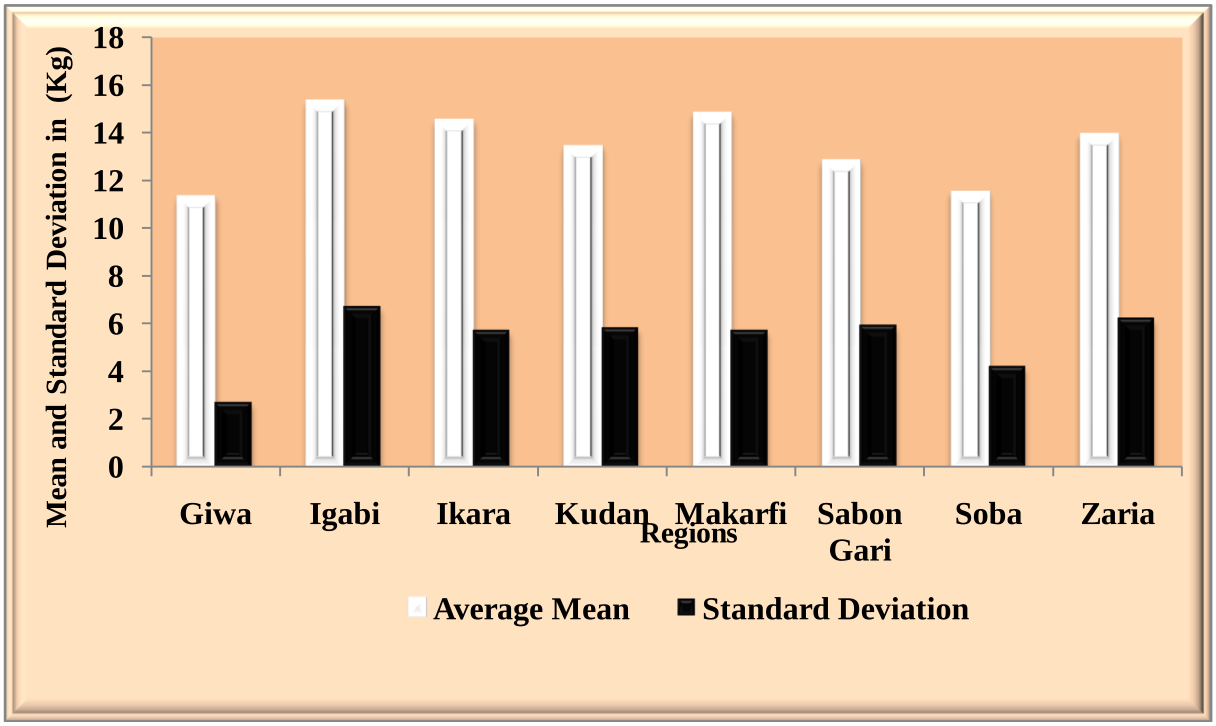


Figure 4.6: Average mean and standard deviation of fuelwood used per HH/day
Source: Field Work, 2015

Overall, the average quantity (mean and standard deviation) of fuelwood consumption for the entire environs was 13.44kg and 5.62kg per household per day respectively. Plate VIII-IX and appendix III - X shows photographs and tables of how the fuelwood were measures and how the data was calculated respectively.

Plate VIII

Plate IX

Plate VIII and IX: Photographs of how the fuelwood were measured by the household
Source:Field Work, 2015

4.5.2.1 Family Expenditure on fuelwood per day

The fuelwood procurement strategy has for long remained a contentious point of discussion among researchers (see chapter 2: 2.2.4). Earlier report by Cline-Cole *et al.* (1987) in Kano where the majority of the households buy their fuelwood from the market rather than relying on family labour. This result revealed two suggestions in the study area; 1) either the study area's households are already facing the shortages of wood supply, which is why they have to rely on the commercial vendors who fetch it from far distant places at an additional cost; or; 2) there was a shift in the earlier paradigm held among most earlier researchers regarding fuelwood acquisition process that emphasised the use of predominantly family labour (more especially women and children) in supplying household needs. This study only fully agrees with the first suggestion, because 100% of the households who answered questions 9(a) and 14 (appendix I) buy their fuelwood from the market irrespective of their economic status. However, based on the responses obtained 9(a) and 14 (appendix I) from the households that solely or partially relied on family labour for their supply, none of the respondents mentioned about relying on his wife or children in the wood supply from farmlands or forest. This could be due to the cultural belief of most households in the study area (predominantly Muslims) which placed the task of food and related items supply (sourcing of household needs) fully on the husband.

Figure 4.7 below, shows the spending pattern on fuelwood from monthly household income. The result of this study also found that only 12% of the households interviewed spend less than 50 Naira from their monthly income on the purchase of fuelwood daily, 20% of the households interviewed spend between 51-100 Naira from their monthly income on the purchase of fuelwood daily, 28% of the households interviewed spend between 101-151 Naira from their monthly income on the purchase of fuelwood daily, 17% of the households interviewed spend more than 151 Naira from their monthly income on the purchase of fuelwood daily, while 23% were others (those using either gas, charcoal, electricity etc).

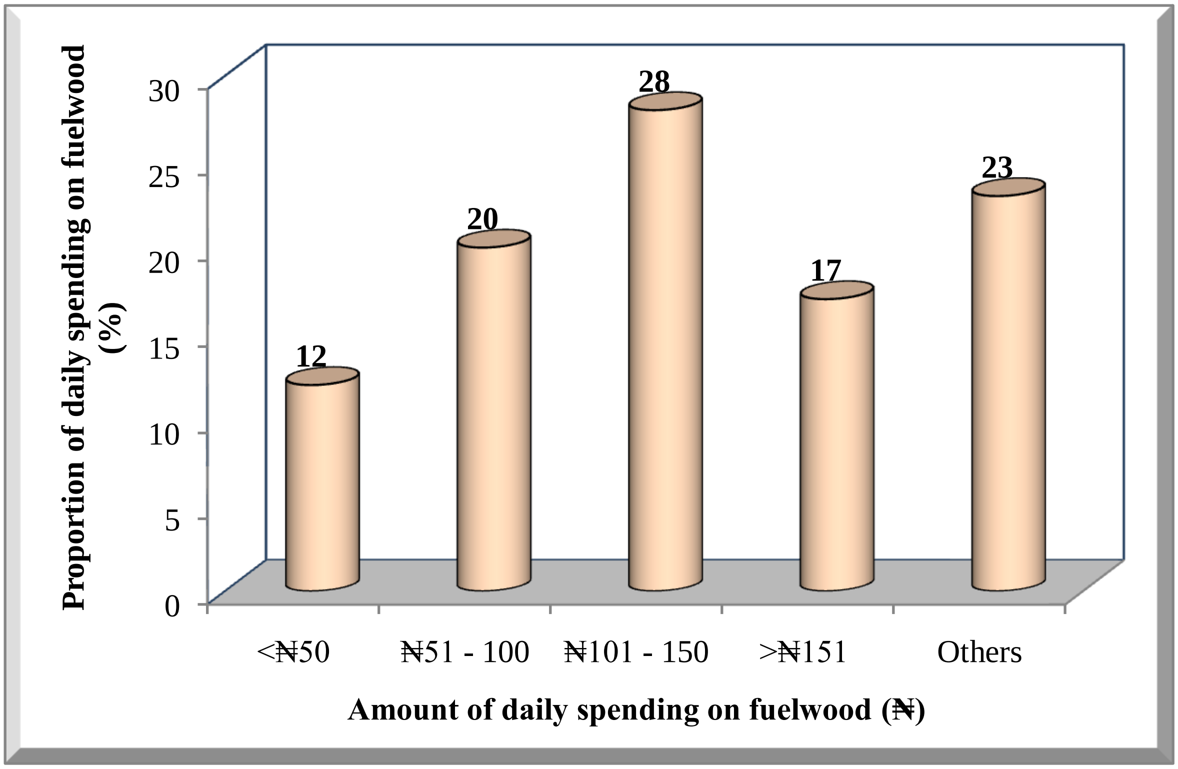


Figure 4.7: Proportion of daily spending on fuelwood purchase per household per day in naira
Source: Field Work, 2015

Overall, Figure 4.7 it is revealed that the majority of the households spend between 101–150 Naira of their monthly earnings on the purchase of fuelwood, while a few households spend less than 50 Naira of their monthly income on the purchase of fuelwood. A monthly deduction of the total household’s earnings that goes to fuelwood purchasing alone is high enough to qualify fuelwood as a scarce commodity in the study area. Mortimore (1990) has earlier cautioned that the expenditure on the procurement of fuelwood in Northern Nigeria will continue to rise in the long run unless there is a change in the supply of the modern cooking fuel types to the region. The present household expenditure on fuelwood purchasing also confirmed Mortimore’s earlier position, given that no significant changes have occurred in terms of the supply of the modern fossil fuels in the region. Refer to (table 4.1) for more explanation for the monthly income and household size of the respondents.

4.6 RELATIONSHIP BETWEEN FUELWOOD CONSUMPTION AND VEGETATION LOSS IN THE STUDY AREA FROM 1973 – 2014

The literature reviewed in chapter two identified the need for repeated studies of the vegetation of the northern dry belt of Nigeria as a result of over exploitation and the vulnerability of the region in sustaining its future supply of fuelwood. Such studies can be useful to both policy makers and researchers in prioritising management mechanisms in the worst affected areas. This section presents the results of the analysis undertaken using Remote Sensing (RS) that explores the trend of vegetation change from 1973 to 2014 in Zaria and its environs as demonstrated in chapter 3.

4.6.1 Vegetation Change Patterns

The NDVI is a dimensionless index, so it values ranges from -1 to +1 (Meneses-Tovar, 2011) with higher value indicating denser and healthier vegetation like in tropical forests, moderate values showing shrubs and grassland, while very low values of 0.1 and below are typical to water and non-vegetated areas. In order words, high values are indicators of high photosynthetic activity and low values are indicators of low photosynthetic activities.

Figures 4.8 to 4.12 are the resulting Normalized Difference Vegetation Index (NDVI) images after applying a filter on them. The pixel colours (green and red) are the products of the assignment of the NDVI images of 1973, 1986, 1996, 2006 and 2014 (Figures 4.8 to 4.12) components of the RG package in the ERDAS Imagine Software (Figures 4.8 to 4.12) (refer to chapter 3: 3.5.1 for more detail).

The values (legend in figures 4.8 to 4.12) describe the dimension index of the study area's vegetation cover in each of the five decades in terms of high, medium and low vegetation respectively from the resulting NDVI images.

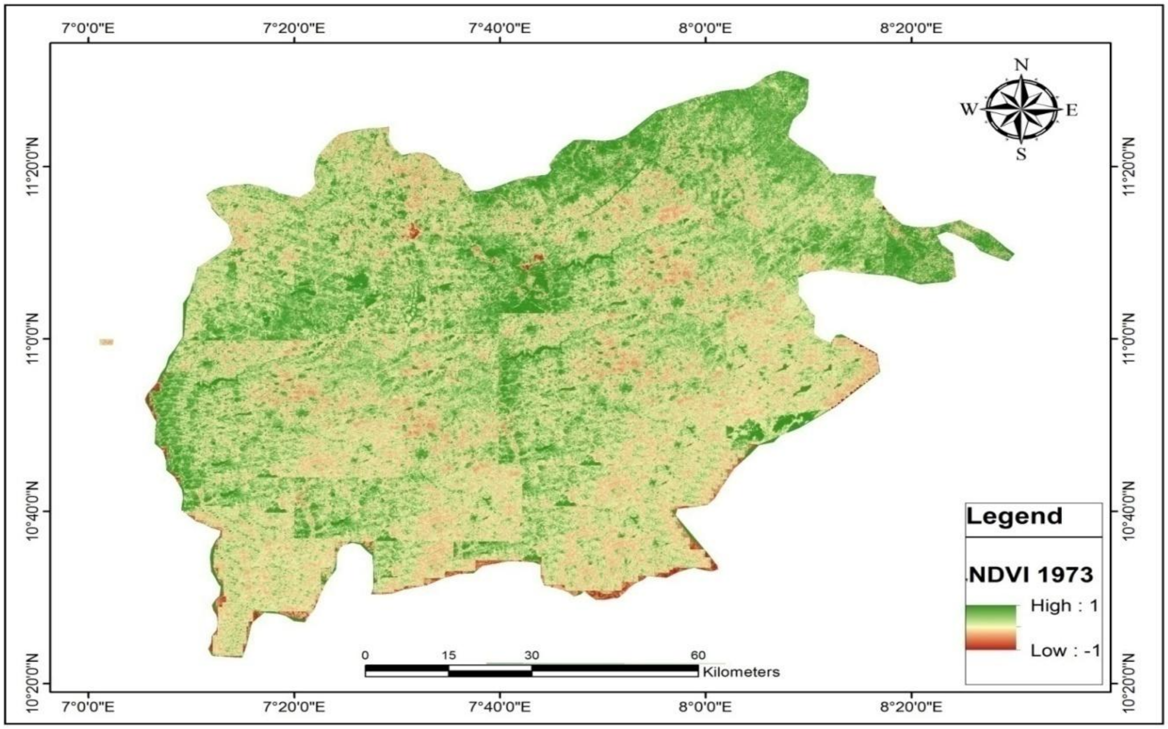


Figure 4.8: NDVI Resulting Image 1973

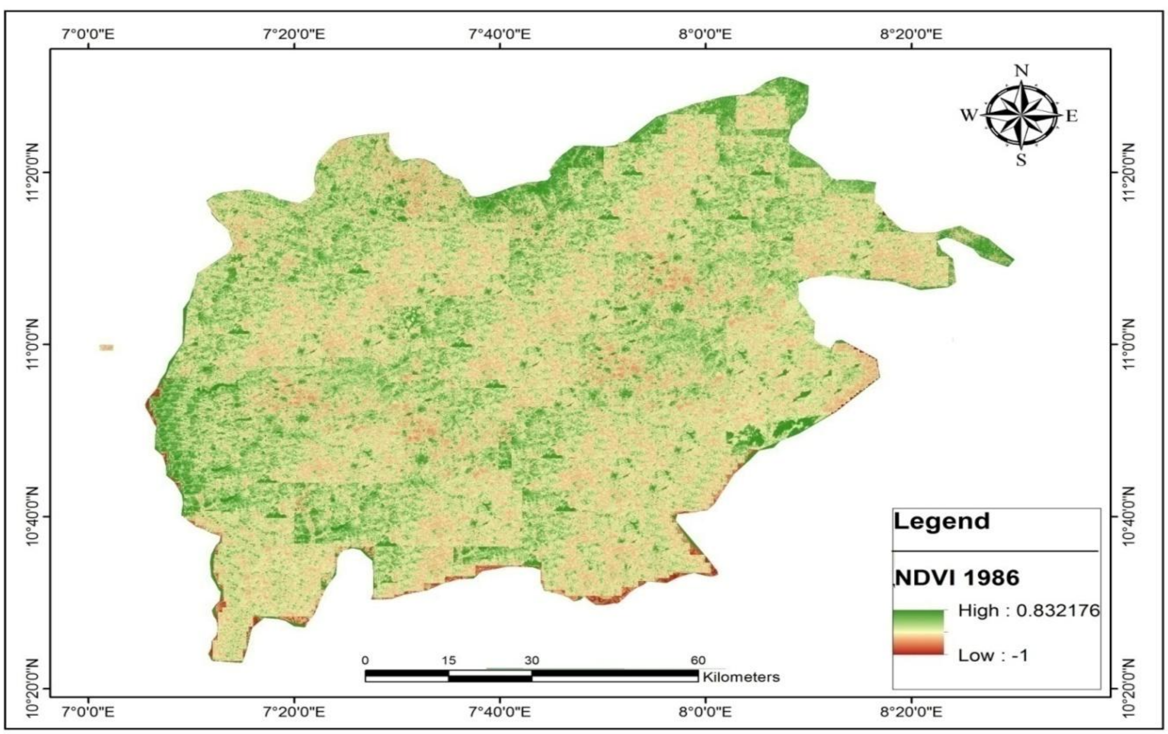


Figure 4.9: NDVI Resulting Image 1986

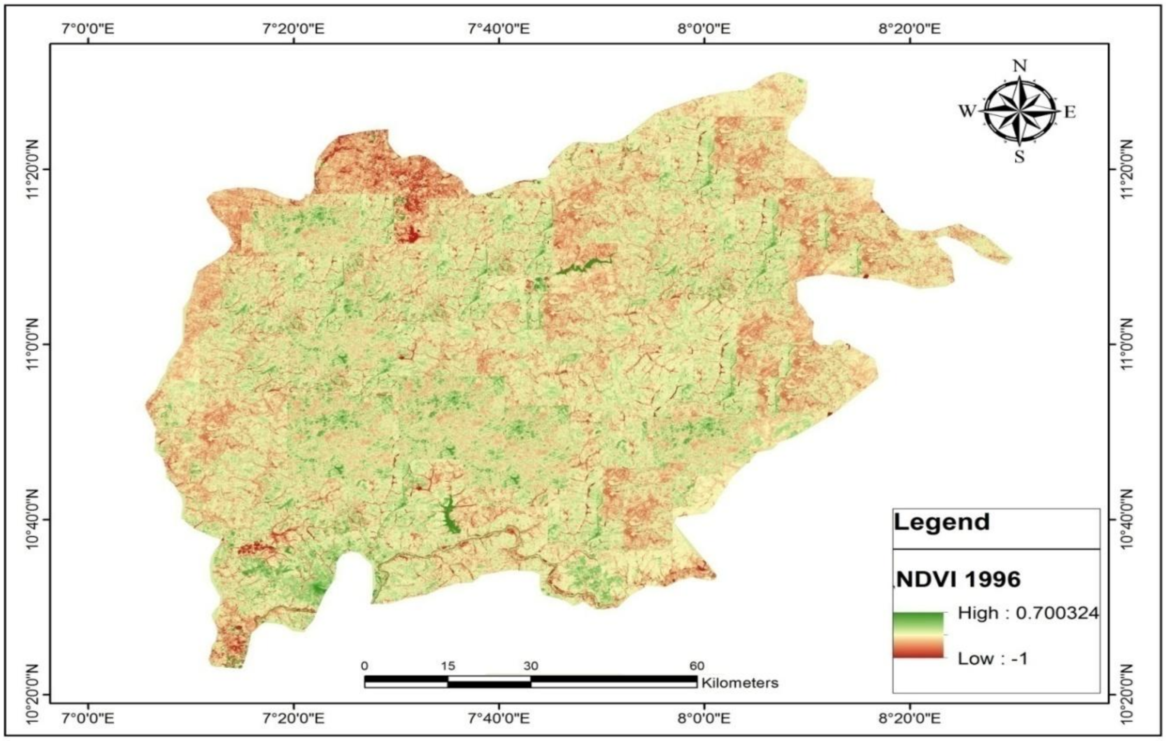


Figure 4.10: NDVI Resulting Image 1996

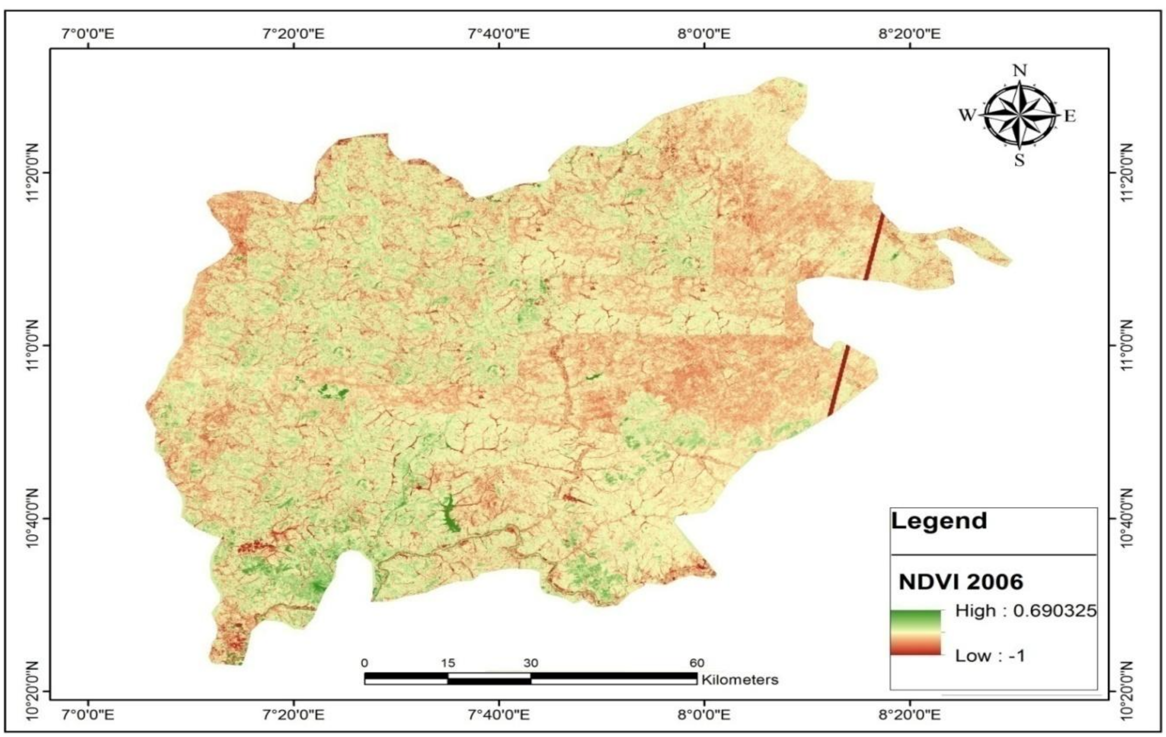


Figure 4.11: NDVI Resulting Image 2006

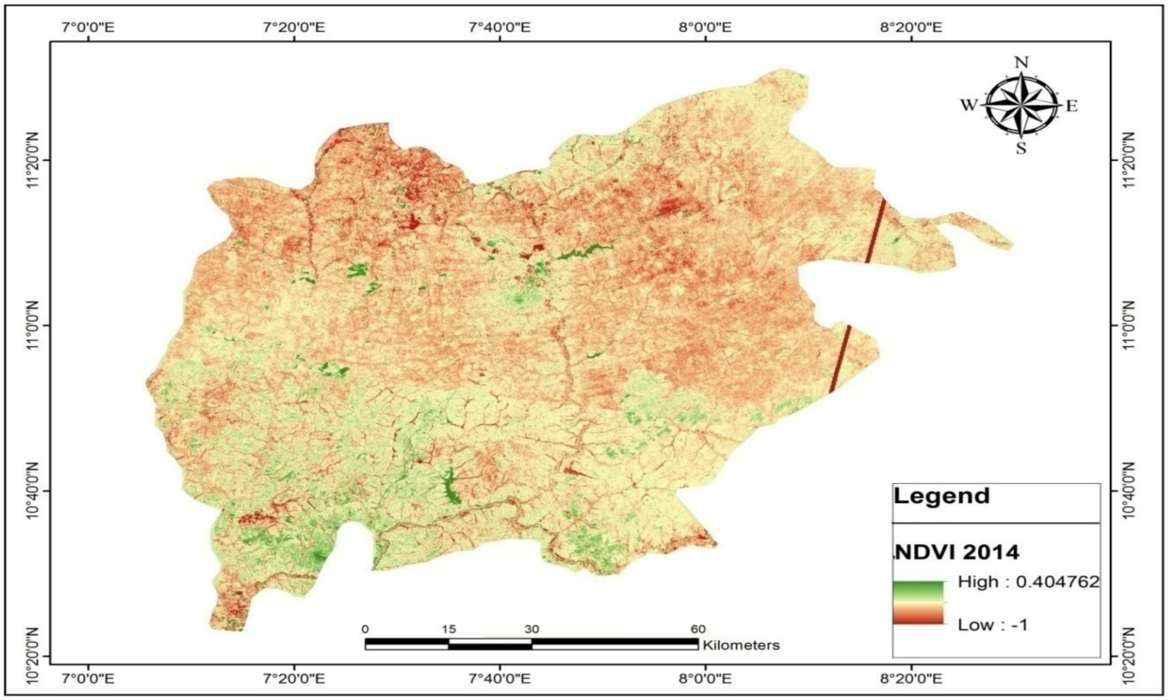


Figure 4.12: NDVI Resulting Image 2014

From figures 4.8 to 4.12, the interpretation of colours such as; green and red revealed a vegetation change pattern in only one direction, which is an indication of either a decrease or an increase of vegetation between two years or throughout the five decades period.

The percentage of the study area's vegetation cover was estimated using the ERDAS Imagine RG routine based on the pixels values of the resulting colours of the NDVI images.

Red colour is an indication of the absence of vegetation (i.e. water bodies, bare surface or buildings) and is therefore representing no/low vegetation throughout the epochs.

Green colours indicate vegetation cover maintenance in terms of high (trees) and medium (shrubs) respectively throughout the entire periods.

From the NDVI Resulting Image (Figure 4.8 to 4.12), it shows that there was a reduction in the vegetation cover study area's after the first year by 0.167824 from 1973-1986 (Figure

4.8 and Figure 4.9). Similarly, there was a reduction of vegetation cover after the second year by 0.131852 from 1986-1996 (Figure 4.9 and Figure 4.10). Likewise, there was a reduction of vegetation cover after the third year by 0.009999 from 1996-2006 (Figure 4.10 and Figure 4.11) and also, there was a reduction of vegetation cover after the fourth decades by 0.285563 from 2006-2014 (Figure 4.11 and Figure 4.12), which means that the vegetation was drastically reduced in size between 2006 and 2014.

Overall, the NDVI images further revealed that the resulting values was drastically reduced by 0.595238 (from 1 to 0.040762) for the periods of five decades (1973 to 2014).

4.6.2 Mapping the Development of Vegetation Change Patterns

The vegetation change maps are presented in Figures 4.13, 4.14, 4.15, 4.16 and 4.17 A close observation of the maps indicate that the 2014 map (Figure 4.17) shows a massive reduction in the vegetation cover with areas around Sabon Gari and Kudan in the North central, Makarfi and Ikara in the North-East and Zaria in the central area of the map all having their vegetation cover reduced compared with similar places in 1973 (Figure 4.13), 1986 (Figure 4.14) and 1996 (figure 4.15) when the vegetation cover is large. The minimal increase in the vegetation cover in 1986 (Figure 4.14) as compared with 1973 (Figure 4.13) is quite difficult to visually differentiate on the two maps. Nevertheless, the maps serve as the key to the visual impression of vegetation change that has occurred in the area since 1973.

Figure 4.18 shows the area of vegetation change patterns in square kilometers (Sq. Km) from 1973-2014. The results which followed a similar pattern with the area percentage change reported earlier in section 4.1.3 shows that the study area's vegetation cover has reduced from 4953.02 km^2 to 2678.90 km^2 respectively from 1973 to 2014.

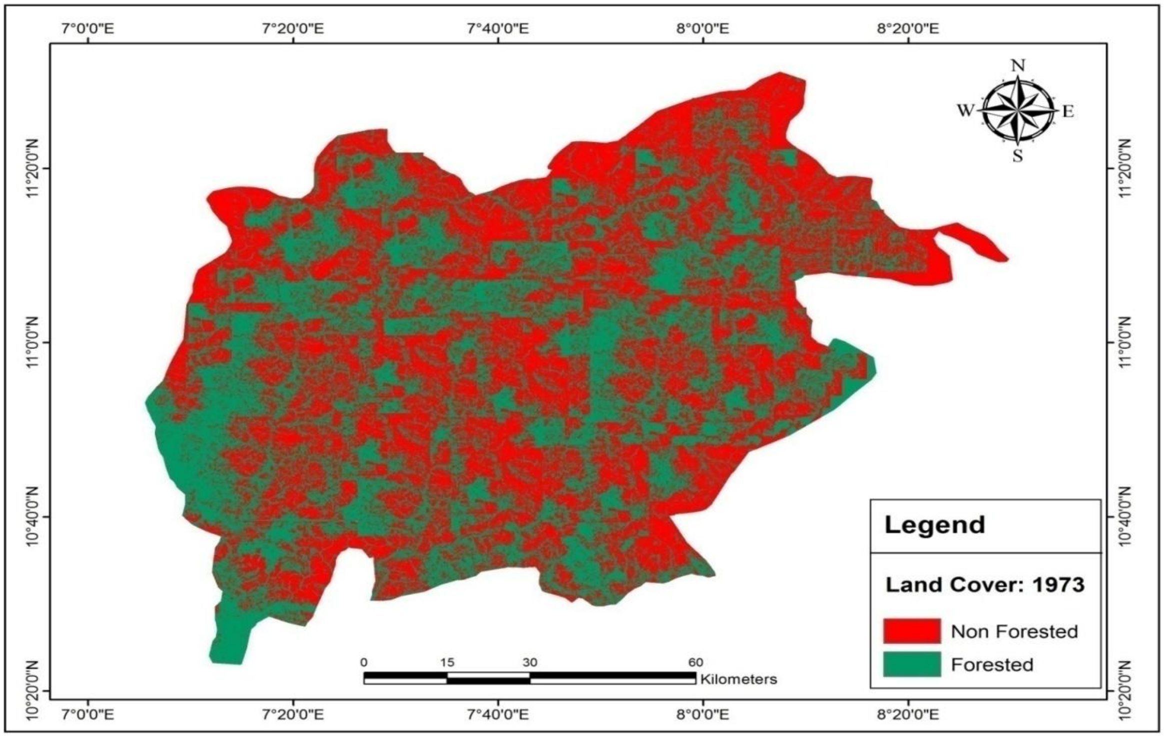


Figure 4.13: Vegetation Pattern: 1973

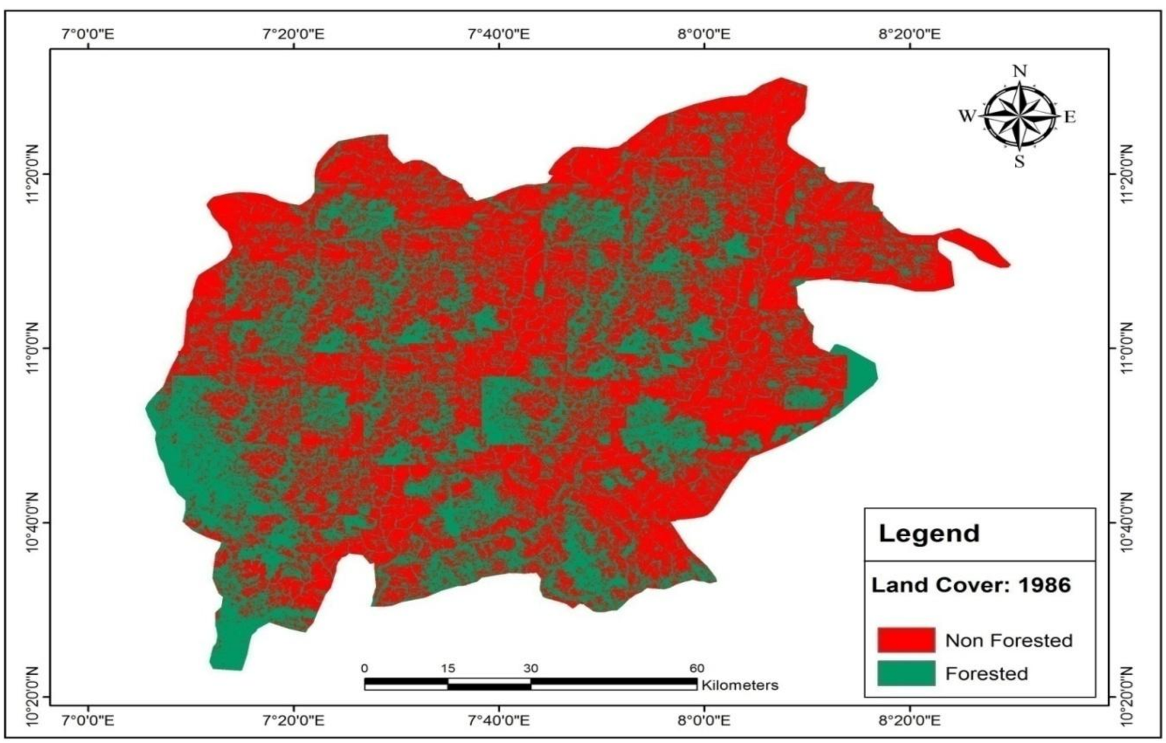


Figure 4.14: Vegetation Pattern: 1986

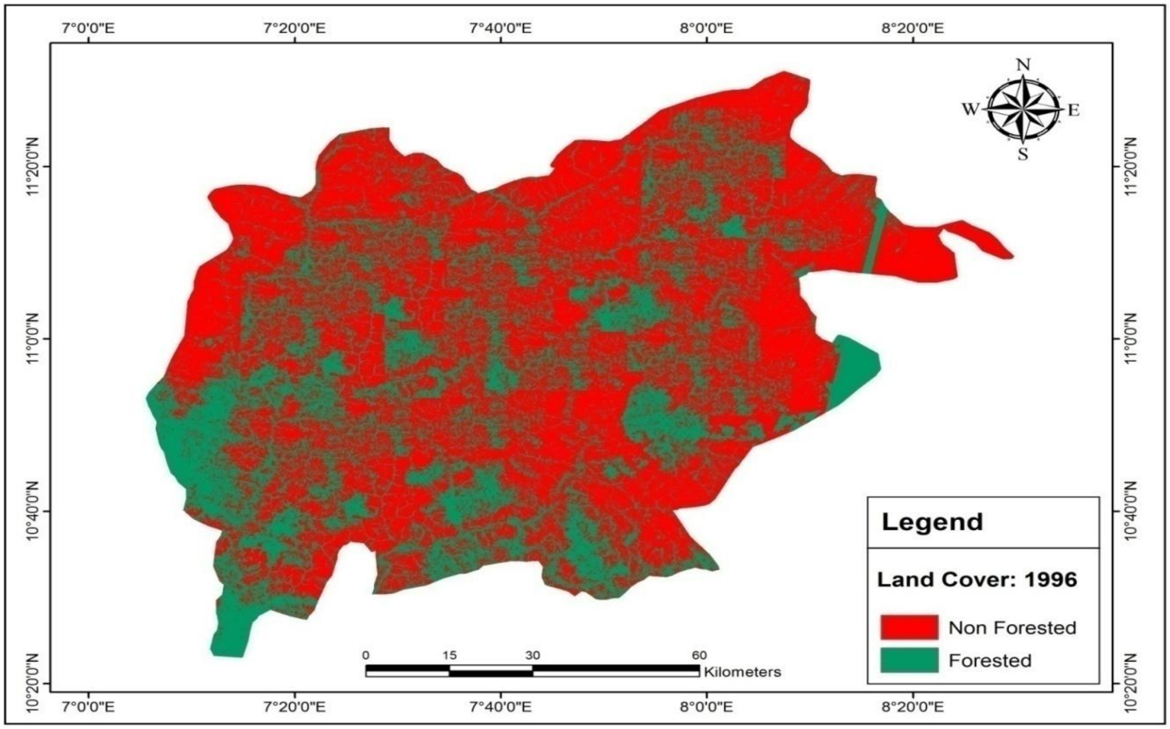


Figure 4.15: Vegetation Pattern: 1996

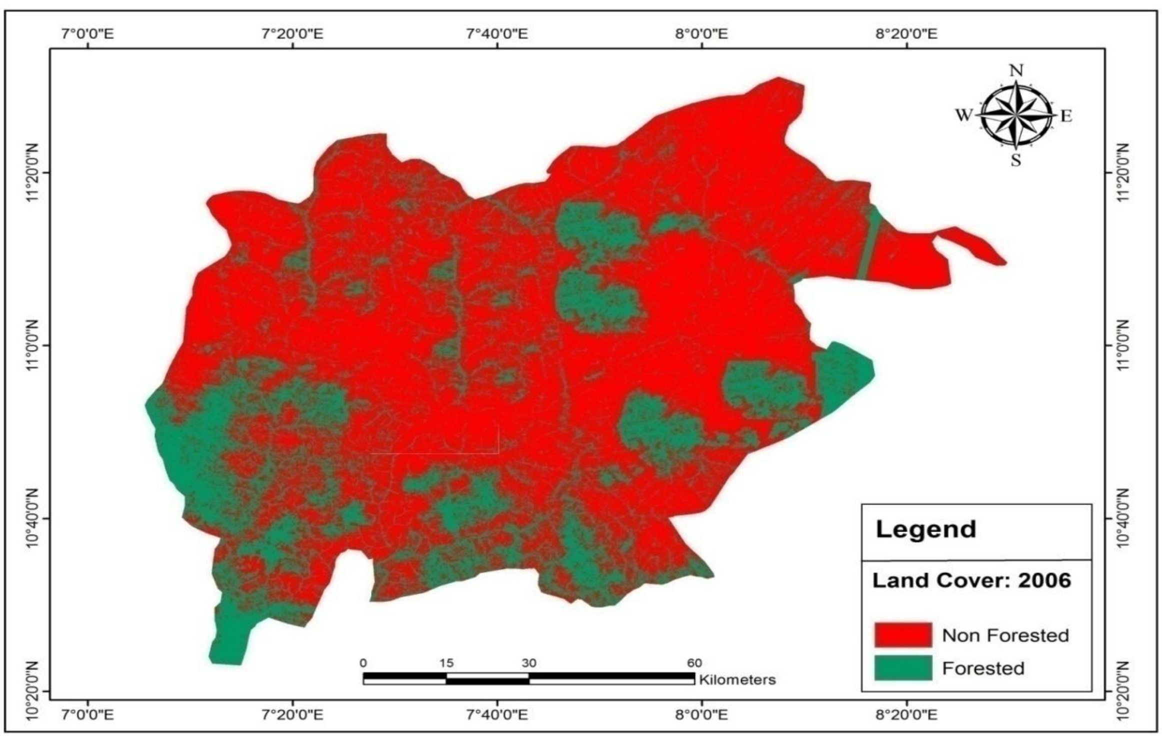


Figure 4.16: Vegetation Pattern: 2006

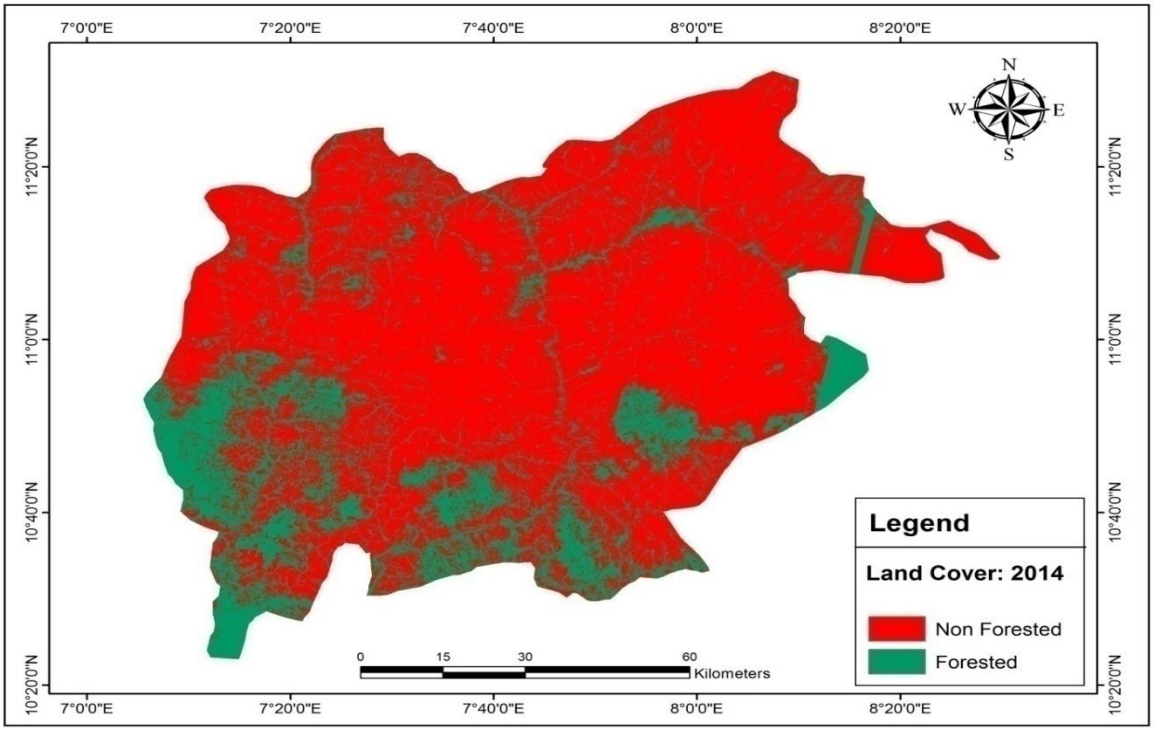
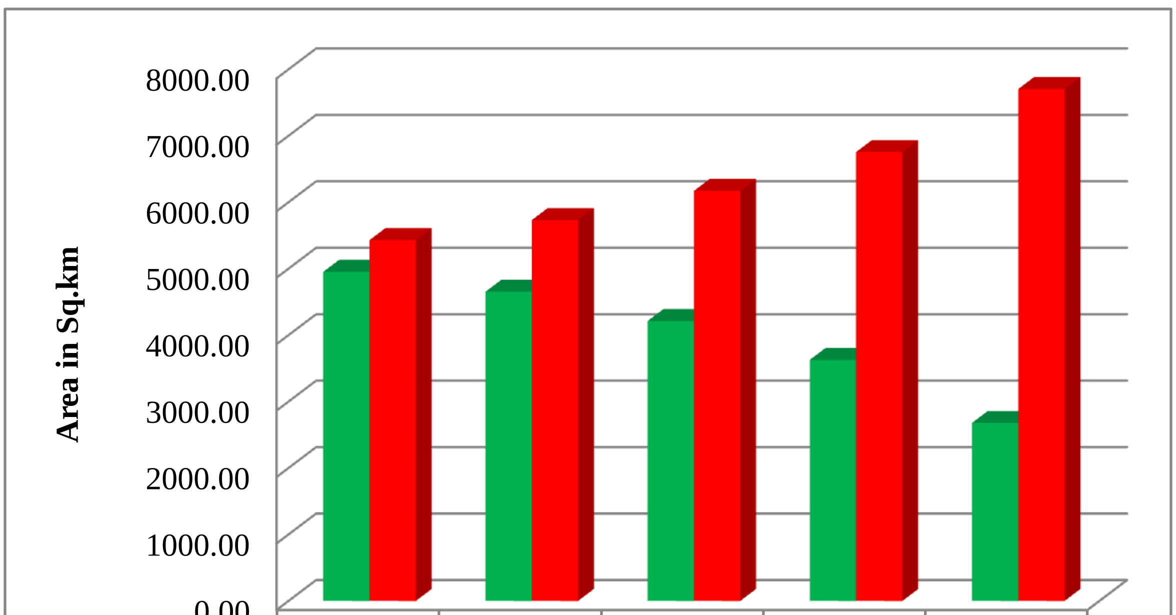


Figure 4.17: Vegetation Pattern: 2014



	1973	1986	1996	2006	2014
Forested	4953.02	4652.92	4212.63	3628.00	2678.90
Non-Forested	5431.09	5731.19	6171.48	6756.11	7705.21

Figure 4.18: Vegetation Pattern: 1973-2014

Table 4.6: Forested and non-forested areas in sq km and percentages from 1973-2014

Cover/Years	1973-1986	%	1986-1996	%	1996-2006	%	2006-2014	%	1973-2014	%	Rate of Change
Forested	-300.100	-6.1	-440.3	-9.5	-584.625	-13.9	-949.107	-26.2	-2274.1	-45.9	-1.147
Non-Forested	300.100	5.5	440.3	7.7	584.625	9.5	949.107	14.0	2274.1	41.9	1.046

4.6.2.1 Percentage and Square Kilometer (sq. km) of Vegetation Area Changed

The percentage of the study area's vegetation change was calculated from the results obtained in section 4.6.2. The area of vegetation change for each decade is illustrated in Figure 4.18 above. The results revealed that about -300.100sq km (-6.1%) of the study area was lost with vegetation in 1973-1986. This percentage increased up to -440.3sq km (-9.5%) from 1986-1996. The years of 1996-2006 and 2006-2014 witnessed an increased of vegetation cover lost with -584.625sq km (-13.9%) and -949.107 sq km (-26.2%) respectively (see Table 4.6).

Overall, the result from the same table (4.6) shows that the cumulative value of the total vegetation cover lost of the whole decades were -2274.1sq km (-45.9%). This shows that the study area vegetation cover were losing 1.147sq km every year.

So, if care not taken by the next few decades we are going to lose the entire vegetation cover this is because population are increasing while demand of wood for fuel are also increasing without adequate replenished of the wood, as such record have never showed an increased of the vegetation cover since 1973 (Figure 4.8 to 4.18 and table 4.6)

4.6.3 Environmental Awareness (Deforestation)

The response from the survey revealed that only a few families (8%) indicated their ignorance of the changes to the study area's vegetation in recent times. In contrast, about 92% of the households in the study area maintained that the vegetation of the study area has reduced in recent times compared to the last two to three decades. This higher awareness among the households could be attributed to the economic reality facing most families in the study area, who recently have to pay more to the vendors that travel long distances to procure the wood. Nevertheless, a few observers among them (respondents) have a different way of saying it, one of them has this to say; "*people are increasing and the demand for fuelwood is ever increasing because there was no substitute at an affordable price....; in the past (about 30 years ago) one can hardly wander freely in the forest because of the density of the vegetation cover, but now.... (He nodded his head several times and smiles... before he continues), one can ride a horse freely from all directions in our nearby forest with his eyes close... If he so wishes without any fear of running into a tree*". This statement although somehow exaggerated, was a revelation on how some of the people feel about the changes of their surrounding vegetations in the area. This higher awareness about deforestation among households was equally reported earlier by Alabe (1996) and Odihi (2003) in some parts of Borno and Yobe states; and more recently by Maconachie *et al.* (2009) in Kano.

4.6.3.1 Causes of Vegetation Changes

Figure 4.19 presents the various respondents' reasons for the potential cause(s) of vegetation reduction. From the figure, about 40% pointed to fuelwood collection as the key factor affecting vegetation change. Nearly all the respondents described their responses in the following terms: "very high demand for fuelwood by the households causes deforestation"; or "the inappropriate cutting down of trees to meet the high demand for fuelwood without replacing them, causes deforestation".

Population increase has been reported by 17% of the respondents as the cause of deforestation, who emphasized that the size of the population has substantially increased in recent times compared to the past. They claimed that the demand for fuelwood and housing by the increased population, can only be met by the existing vegetation resources, hence the reason for the vegetation reduction. Poverty and lack of job opportunity is reported by

11.6% of the respondents, who emphasized that the massive unemployment, poverty and lack of support from the government affect the way in which the vegetation is being used. The lack of other alternative sources of cooking fuel is reported by about 7.1% of the respondents as a factor responsible for deforestation. They stressed that poor supply, and inaccessibility of other sources of fuel attracts more people to use fuelwood, which in effect reduces the vegetation of their surroundings. Interestingly, overgrazing and ineffective law enforcement on deforestation that prior to the commencement of the survey, were assumed to be largely responsible for the majority of the deforestation, were each reported by 3.1 and 4.3% respectively of the respondents as being a reason for deforestation. The ineffective law enforcement (in safeguarding the forest) was demonstrated by the respondents in terms of lack of good governance and the large scale corruption in the forestry regulatory agencies (refer to chapter 2:2.2.1)

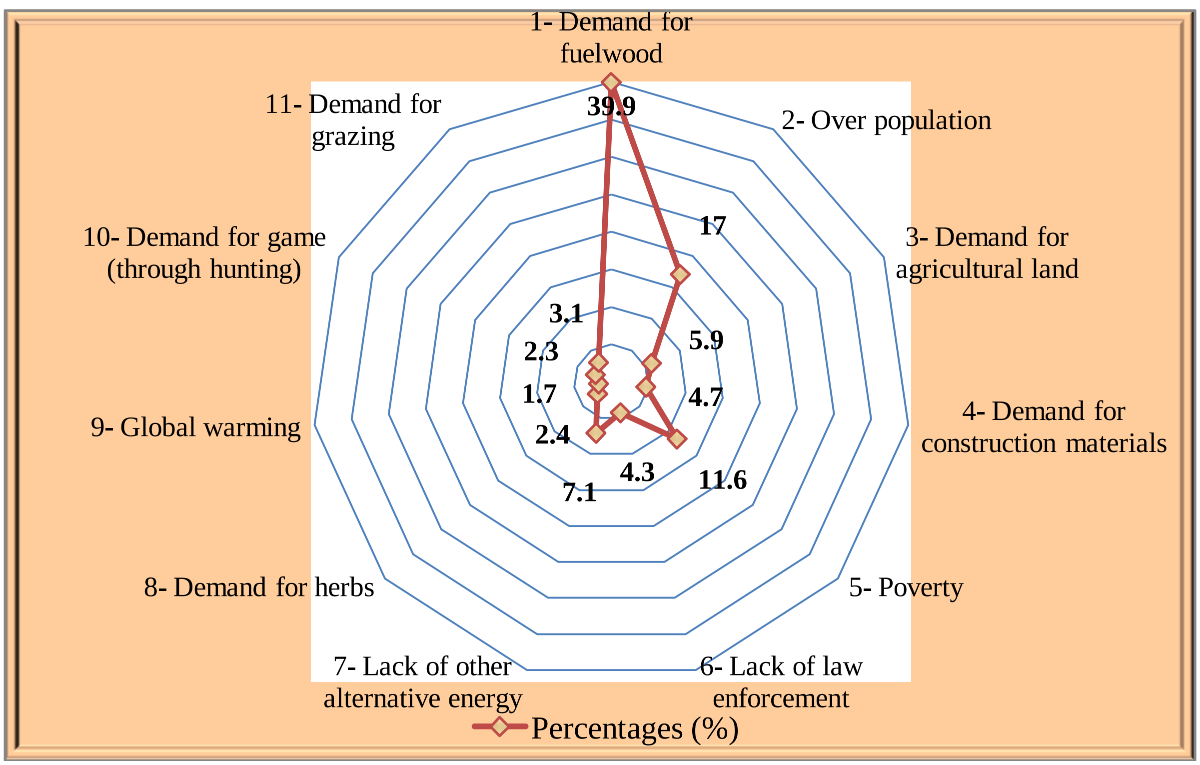


Figure 4.19: Causes of Vegetation Changes
Source: Field Work, 2015

Although the demand for agricultural land and construction materials was reported as two of the most influential factors of deforestation, less than 6% and 5% of the respondents agreed that it has any significant influence on the study area's vegetation reduction. Demand for herbs and game as represented by 2.4% and 2.3% respectively were also factors responsible for vegetation reduction of the study area. Climate change or rainfall reduction due to global warming ("Duumamar yanayi"- Hausa language phrase, for global warming, as mentioned by the respondents), is the least influential factor for deforestation in the study area according to the respondents. Only less than 2% of the respondents reported "Duumamar yanayi" as a factor responsible for vegetation reduction in the area despite the prolonged widely circulated media awareness campaigns in the country.

4.6.3.2 Ways of Reducing the Effect of Deforestation

Responses to the possible measures for combating deforestation are illustrated in figure 4.20

From the figure, about 36% pointed afforestation as the best way of combating deforestation. The respondents revealed their responses in the following ways: "*planting of more trees after cutting the existing ones is very important"*; "*encouraging the replacement of trees and discouraging people from cutting them"*. One important response that summarised them all, and even added some suggestions, who mentioned that:

"*planting of more trees in the farms will give farmers a sense of ownership. The farmers and the fuelwood suppliers should also be encouraged to practice a selective method of cutting the trees, which will assist them to monitor the progress of their tree resources*". This is a very good suggestion, which was also stated by respondent number two among the commercial fuelwood vendors.

According to 20.1% of the respondents, the increase in the supply of fossil fuel will reduce deforestation. Such responses, include among others, the following: 1) "*government should try to stabilise the provision of other alternative sources of energy (electricity, fossil fuels and coal) at an affordable price, which will encourage people to stop using fuelwood";* 2) *"government should make alternative energy available, in order to reduce the over dependence on fuelwood*".

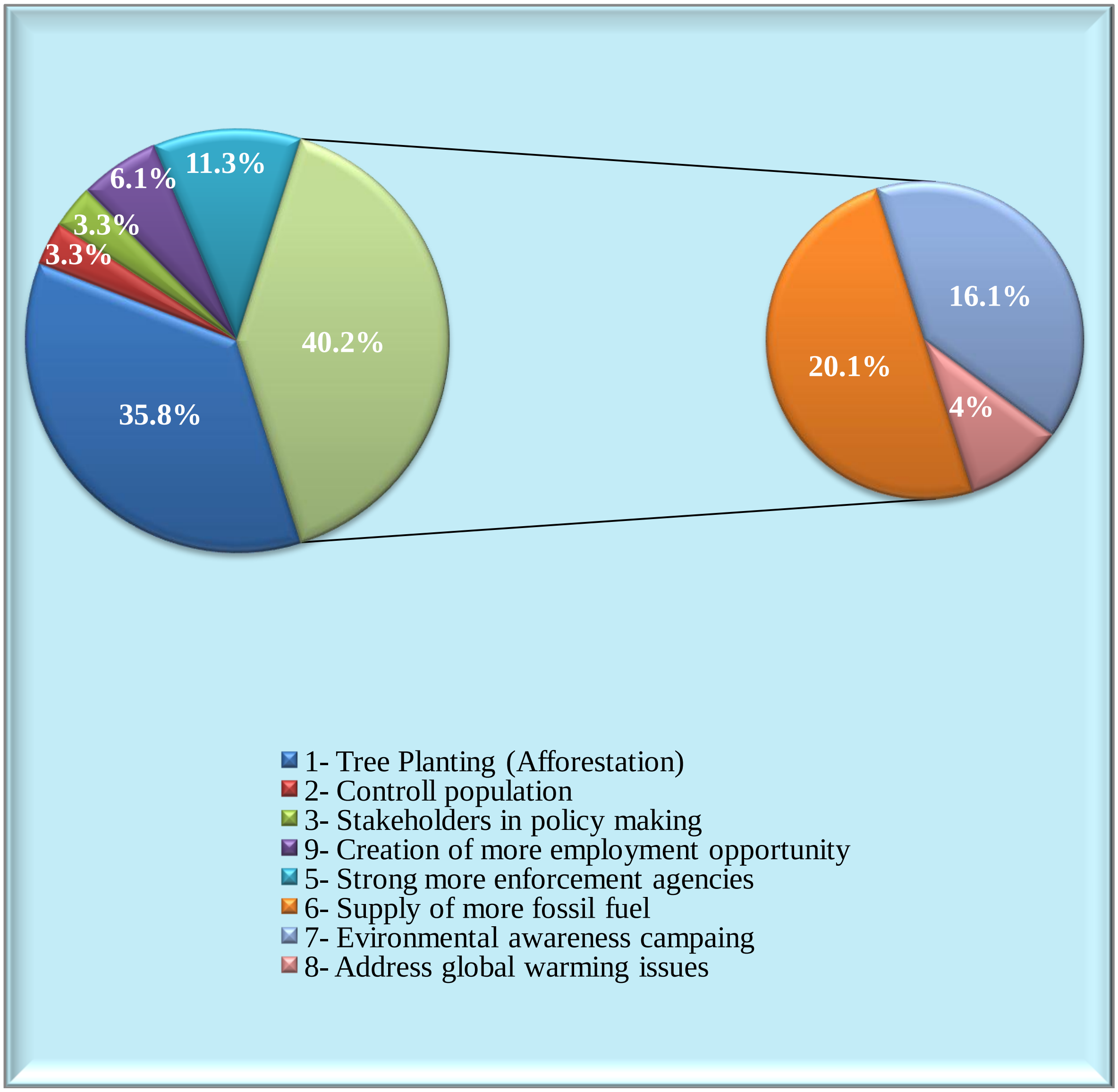


Figure 4.20: Measures to Combat Vegetation Changes in the Study Area
Source: Field Work, 2015

Environmental awareness campaigns and effective law enforcement of the existing forest resources that will protect them from deforestation, accounted for 16.1% and 11.3% of the total responses respectively. Jointly, they accounted for about 28% of the total response rate, which is high enough to indicate the perception of a much needed effort from the policy makers to intervene. The responses relating to environmental awareness were highlighted in the following ways: 1) "people should be encouraged to plant more trees"; 2) "*government should put more emphasis on its tree planting campaign awareness through media and other sources, which will encourage people to plant more trees...".* On the other hand, the responses on the law enforcement was mentioned in the following way; *"government should enforce laws that will discourage the cutting down of trees, and encourage planting of more trees where necessary...".*

Poverty reduction and job creation were identified by 6.1% of the respondents as ways of reducing deforestation. Poverty alleviation was emphasized in the following way: "*government should provide more job opportunities for people in the country, in order to improve their purchasing power of the alternative energy sources*".

Combating global warming was reported by 4% of the population as an important way of reducing deforestation. The factors with the lowest influence in combating deforestation according to the respondents are population control and inclusion of all stakeholders in the policy decision making, each accounting for 3.3% of the total responses. The inclusion of all stakeholders in the policy decision making was related in the following way: "*government should include the fuelwood vendors in any forest policy decision making and desertification awareness campaigns*". The revelation of population control and inclusion of all stakeholders in the policy decision making as the lowest factors in deforestation control came as a surprise, given that they are both important factors of deforestation.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

This Chapter synthesizes the empirical findings and conclusions that have emerged from the evaluation of the effects of fuelwood consumption on the vegetation cover in Zaria and its Environs (ZE). The results of the chapters comprehensively fulfilled the aim and the objectives of the study by providing answers to the research questions originally posed (chapter 1: page 9). For example, the results of chapter 4 highlighted the study area's vegetation change pattern from 1973 to 2014, and also demonstrated some of the social, economic and political (SEP) factors that are contributing to the regional (ZE) dependence on fuelwood. This current chapter further summarizes the achievements of the research findings and the impact that the result might have on policy makers. Recommendations are also provided and final thoughts of the research's limitation and its future direction are also highlighted.

5.2 SUMMARYOF THE FINDINGS

From the findings, the vendors sometimes travel up to 250km from their town in order to supply fuelwood. The majority (81.25%) of the supply centres highlighted by the fuelwood commercial dealers were within the local administrative boundaries of the study area but few (18.75) were from outside the local administrative boundaries.

Cheaper, availability and affordability of fuelwood was said as factors responsible for fuelwood consumption. Other factor is related to the low supply of fossil fuel in the region. The results indicate that the mean ($\bar{X}$) and standard deviation (S.D) for consumption rate were 13.44kg and 5.62kg per household per day in the study area.

The findings also revealed that the majority (77%) of the environs predominantly use fuelwood for their cooking. However, while there is a limited supply of modern cooking fuel in the country, the used of fuelwood in the majority of the environs is cheaper, affordable and available. Other factor is related to the low supply of fossil fuel in the region. For example as highlighted in Figure 4.3 in section 4.4.2

There is high demand and consumption of fuelwood in the study area. Also, the families are already facing difficulties in terms of fuelwood procurement, where the majority (65%) of them buys their fuelwood from the vendors at higher prices. In addition, they also spend a substantial amount (₦200) daily of their monthly income on the purchase of fuelwood while the few (12%) that fetched their fuelwood from the common forest using family labour reported that they travel long distances in order to fetch the wood.

The study (like its predecessors) also revealed that regardless of the variation of the seasons in a typical year, the majority (80%) of the households rely on fuelwood. However, most households (46%) use more fuelwood always than other seasons of the year largely because of the additional requirements for heating and boiling of water for bathing, followed by harmattan season (41%). The study also found that more fuelwood is used during festivals and occasions such as child birth, as described in section 4.5.1

In contrast to the high demand or use of fuelwood in the harmattan season, the majority (41%) of the households believed that the prices are higher during the rainy season than the other seasons of the year. Part of the reason for this was the poor condition of the access roads leading to the procurement areas and the temporary changing of engagement by the fuelwood labourers in farming activities.

The procurement of fuelwood is carried out in all three seasons. However, the activity seems to slow down in the rainy season due to the difficulty of accessing the forest and the temporal migration of the labourers to farming activities. The demand for fuelwood is high in the rainy and harmattan seasons and less in the hot dry season. However, the hot season was recognized as the best season for stockpiling the wood for the high demand period of the rainy season.

The interpretation of the NDVI image results reported here, revealed an irregular pattern of vegetation cover in this part of the state (Zaria and its Environs). Periods of remarkable vegetation decrease have been identified between 1973 and 2014. However, a complex pattern of population increase, and an increasing demand for fuelwood appeared to be the most important factors in explaining the vegetation changes observed.

5.3 CONCLUSION

The collection pattern of commercial fuelwood in the study area, has changed from that of traditional household collectors to an organized trade and from the clearing of dead woods to the cutting down of live trees in order to meet with the high demand, using simple tools.

The results show that both modern (some) and traditional cooking fuel types are widely used in Zaria and its environs, although to widely varying degrees. The environs, are deprived of modern fuel supply and are therefore more dependent upon the traditional fuels for their cooking. This of course has implications for cooking fuel poverty, emanating from the fossil fuel supply strategy, which is precarious in the country.

Overall, this study once again reiterated the importance of commercial fuelwood vendors in active deforestation, because they are the main suppliers of fuelwood in the study area. This necessitates the exploration of the activities of the fuelwood vendors, as part of the wider fuelwood study progress of this study, in order to further understand their potential contribution to deforestation in greater detail.

The collectors are mostly locals who rely on simple modes of transportation systems to travel long distance in order to convey their goods to their buyers. In this way, fuelwood vending is found to provide critical support to their incomes, and a key source of low-cost energy (Hiemstra-van der Horst and Hovorka, 2009). However, this situation was perceived to be a major factor in the accelerated process of environmental degradation (deforestation). Although there are laws enacted in order to discourage both the collection and trading of fuelwood in most DC, little has been achieved to stop this practice, which can be attributed to lack of awareness from the policy makers, of the relevance of commercial fuelwood activities to the economy. Only a few researchers have pointed out the importance of commercial fuelwood in the socio-economic activities of the DC. Therefore, the authorities do not seem to be fully aware of the job opportunities in the business, which this chapter tried to highlight.

Overall, the RS analysis has indicated the pattern of vegetation change in the study area from 1973 to 2014. The RGB-NDVI results also demonstrated empirically the complex nature of the vegetation change pattern of the area which has never been reported or discussed in the past using an approach similar to that utilised here.

5.4 RECOMMENDATIONS

Although, some of the past Nigerian government’s policies have supported deforestation; the government also has in place policies that are aimed at improving the forest reserves and the restoration of forest areas in the country. Such policies as reported in chapter 2: 2.1.2.1-2.1.2.3 include among others, the government support for afforestation programme since the 1970s.

It should be understood that the daily acquisition of fuelwood carried out in the majority of Zaria and its environs, combined with the scarcity of fossil fuels requires an urgent solution. While there are various ways of finding a long term solution to the problem, one possible way to reduce this hardship is:

i. Planting of more trees after cutting the existing ones is very important; encouraging the replacement of trees and discouraging people from cutting them.
ii. Planting of more trees in the farms will give farmers a sense of ownership. The farmers and the fuelwood suppliers should also be encouraged to practice a selective method of cutting the trees, which will assist them to monitor the progress of their tree resources.
iii. Government should try to stabilize the provision of other alternative sources of energy (electricity, fossil fuels and coal) at an affordable price, which will encourage people to stop using fuelwood.
iv. Government should make alternative energy available, in order to reduce the over dependence on fuelwood.
v. Government should put more emphasis on its tree planting campaign awareness through media and other sources, which will encourage people to plant more trees.
vi. Government should enforce laws that will discourage the cutting down of trees, and encourage planting of more trees where necessary.

vii. Government should provide more job opportunities for people in the country, in order to improve their purchasing power of the alternative energy sources.

viii. Government should include the fuelwood vendors in any forest policy decision making and desertification awareness campaigns.

ix. Part of the early suggestions for the solution was to either, increase the supply of fuelwood; or to reduce its demand.

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APPENDIX I: Fuelwood consumption Questionnaire

DEPARTMENT OF GEOGRAPHY
AHMADU BELLO UNIVERSITY, ZARIA

Dear Respondent,

I am a M.Sc. student of the above mentioned Department carrying out a research on the ***"Effects Of Fuelwood Consumption Rate On Vegetation Cover In Zaria And Its Region"***. I solicit your cooperation to respond to the following questions by ticking (√) at the appropriate item and where necessary, you fill in the blank spaces. All information given will be treated confidentially as the research work is only for academic purpose.

Thank you.

SECTION A. PERSONAL INFORMATION

Name of Settlement………………………. Local Govt. Area………………………

1. Gender
   (a) Male ☐ (b) Female ☐

2. Age (year)
   (a) 20 – 29 ☐ (b) 30 – 39 ☐ (c) 40 – 49 ☐ (d) 50-59 ☐ (d) 60 + ☐

3. Levels of Education
   (a) Adult Literacy (b) Primary (c) Secondary (d) Tertiary (e) others (specify)…….

4. Marital Status
   (a) Single ☐ (b) Married ☐

5. Indicate number of children/dependence ☐

6. Occupation
   (a) Farmer ☐ (b) Business ☐ (c) Civil service ☐ (d) Others (specify) ☐

7. Average monthly income
   (a) < ₦18,000 ☐ (b) 18,000-27,000 ☐ (c) 28,000-37,000 ☐ (d) 38,000-47,000 ☐

   (e) 48,000 above ☐

SECTION B. FAMILY USE OF FUELWOOD

8. Do you use fuelwood as a primary source of energy?
   (a) Yes ☐ (b) No ☐

9. If yes why?

(a) its cheaper ☐ (b) its available ☐ (c) its affordable ☐ (d) Other (specify) ☐

10. If no, what are the other forms of energy source do you use?
(a) Electricity ☐ (b) kerosene ☐ (c) coal ☐ (d) gas ☐ (e) Other (specify) ☐

11. How long have you been using fuelwood?
(a) 1-10 year (b) 11-20years (c) 21-30 years (d) over 30years

12. What species of wood do you prefer to use as fuelwood?
(a) ☐ (b) ☐ (c) ☐ (d) ☐

13. Which time of the year you use more fuelwood than normal?
(a) Cool dry season ☐ (b) Hot dry season ☐ (c) Rainy season ☐ (d) ☐ Indifferent

C. QUANTITY & COST OF FUELWOOD CONSUMPTION

14. How much (quantity) fuelwood on average does your household use per day? (in kg) ☐

15. How much do you spend on the purchase of fuelwood per day? (in Nigerian Naira)
(a) < 50 ☐ (b) 51-100 ☐ (c) 101-150 ☐ (d) >150 ☐

THANK YOU VERY MUCH FOR YOUR COOPERATION AND TIME

APPENDIX II: Interview schedule for commercial fuelwood vendors

DEPARTMENT OF GEOGRAPHY
AHMADU BELLO UNIVERSITY, ZARIA

Dear Respondent,
I am a M.Sc. student of the above mentioned Department carrying out a research on the ***" Effects Of Fuelwood Consumption Rate On Vegetation Cover In Zaria And Its Region."***.I therefore, solicit for your cooperation. All information given will be treated confidentially as the research work is only for academic purpose.

Thank you.

SECTION A. FACTS ABOUT FUELWOOD BUSINESS PROFILE

1. Why are you in this business?
For example because of profit or there is no other job available.

Please specify ☐

2. Is this the only business you do to support yourself and your family?
(a) Yes ☐ (b) ☐

If No please specify others ☐

3. For how long have you been in the business?
(a) 1 – 10yrs ☐ (b) 11 – 20yrs ☐ (c) 21 – 30yrs ☐ (d) over30yrs ☐

4. From where do you get the fuelwood?
☐

5. What distance do you travel to harvest fuelwood? (in Km)
(a) 5-10 ☐ (b) 11-15 ☐ (c) 16-20 ☐ (d) 21-25 ☐ (e) 26 and above ☐

6. What sort of transportion do you use in conveying the wood?
(a) Pick up van ☐ (b) Ford ☐ (c)Truck ☐ (d) Others (specify) ☐

7. Indicate mode of sales.
(a) Wholesale only ☐ (b) Retail only ☐ (c) Wholesale and retail ☐

8. What species of tree do you prefer to sell?
(a) ☐ (b) ☐ (c) ☐ (d) ☐

Why? ☐

9. Is the business profitable or otherwise?
Please specify [ ]

10. Which season of the year does the fuelwood sell most? [ ]

11. what do you consider to be the primary purpose of wood harvest?
[ ]

SECTION B. QUESTIONS ABOUT ENVIRONMENTAL AWARENESS

(Deforestation)

12. Do you get a formal permit to harvest fuelwood?
(a) Yes [ ] (b) No [ ] if yes, from who? [ ]

13. Do pay any charges to the authority as part of this business?
(a) Yes [ ] (b) No [ ]

14. Have you noticed any changes in the vegetation pattern compared to past?
(a) Yes [ ] (b) No [ ]

15. What do you think are the causes of these changes?
[ ]

16. What measures do you think can be taken to combat these changes?
[ ]

THANK YOU VERY MUCH FOR YOUR COOPERATION AND TIME

APPENDIX III: Quantity of fuelwood consumption in kilograms for GIWA

x	$(x - \bar{x})$	$(x - \bar{x})^2$
5	-6.282	39.463
16.25	4.968	24.681
15	3.718	13.823
12.5	1.218	1.483
7.5	-3.782	14.303
5	-6.282	39.463
7.5	-3.782	14.303
8.75	-2.532	6.411
8.75	-2.532	6.411
8.75	-2.532	6.411
10	-1.282	1.643
10	-1.282	1.643
10	-1.282	1.643
10	-1.282	1.643
10	-1.282	1.643
11.25	-0.032	0.001
10	-1.282	1.643
12.5	1.218	1.483
10	-1.282	1.643
12.5	1.218	1.483
12.5	1.218	1.483
11.25	-0.032	0.001
11.25	-0.032	0.001
12.5	1.218	1.483
13.75	2.468	6.091
12.5	1.218	1.483
11.25	-0.032	0.001
11.25	-0.032	0.001
12.5	1.218	1.483
10	-1.282	1.643
13.75	2.468	6.091
13.75	2.468	6.091
13.75	2.468	6.091
15	3.718	13.823
15	3.718	13.823
15	3.718	13.823
13.75	2.468	6.091
10	-1.282	1.643
15	3.718	13.823
440		**276.189**

$$\bar{X} = \frac{\sum x}{n} = \frac{440}{39} = 11.282 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{276.189}{39}} = \sqrt{7.08}$$

= 2.66 Kg

APPENDIX IV: Quantity of fuelwood consumption in kilograms for IGABI

x	$(x - \bar{x})$	$(x - \bar{x})^2$
8.75	-6.563	43.073
6.25	-9.063	82.138
7.5	-7.813	61.043
3.75	-11.563	133.703
6.25	-9.063	82.138
3.75	-11.563	133.703
5	-10.313	106.358
3.75	-11.563	133.703
5	-10.313	106.358
2.5	-12.813	164.173
2.5	-12.813	164.173
10	-5.313	28.228
10	-5.313	28.228
10	-5.313	28.228
6.25	-9.063	82.138
7.5	-7.813	61.043
10	-5.313	28.228
13.75	-1.563	2.443
13.75	-1.563	2.443
12.5	-2.813	7.913
18.75	3.437	11.813
15	-313	0.098
15	-313	0.098
16.25	0.937	0.878
18.75	3.437	11.813
17.5	2.187	4.783
15	-313	0.098
16.25	0.937	0.878
13.75	-1.563	2.443
15	-313	0.098
16.25	0.937	0.878
13.75	-1.563	2.443
13.75	-1.563	2.443
15	-313	0.098
16.25	0.937	0.878
20	4.687	21.968
22.5	7.187	51.653
23.75	8.437	71.183
22.5	7.187	51.653
20	4.687	21.968
20	4.687	21.968
22.5	7.187	51.653
20	4.687	21.968
21.25	5.937	35.248
23.75	8.437	71.183
21.25	5.937	35.248
22.5	7.187	51.653
22.5	7.187	51.653
23.75	8.437	71.183
18.75	3.437	11.813
21.25	5.937	35.248
21.25	5.937	35.248
20	4.687	21.968
22.5	7.187	51.653
23.75	8.437	71.183
20	4.687	21.968
20	4.687	21.968
21.25	5.937	35.248
23.75	8.437	71.183
903.5		**2526.85**

$$\bar{X} = \frac{\sum x}{n} = \frac{903.5}{59} = 15.313 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{2526.847}{59}} = \sqrt{44.33}$$

= 6.66 Kg

APPENDIX V: Quantity of fuelwood consumption in kilograms for IKARA

x	$(x - \bar{x})$	$(x - \bar{x})^2$
6.25	-8.275	68.476
2.5	-12.025	144.601
6.25	-8.275	68.476
6.25	-8.275	68.476
12.5	-2.025	4.101
8.75	-5.775	33.351
18.75	4.225	17.851
15	0.475	0.226
13.75	0.775	0.601
10	-4.525	20.476
16.25	1.725	2.976
13.75	0.775	0.601
11.25	-3.275	6.55
10	-4.525	20.476
18.75	4.225	17.851
20	5.475	29.976
20	5.475	29.976
20	5.475	29.976
21.25	6.725	45.226
21.25	6.725	45.226
22.5	7.975	63.641
10	-4.525	20.476
12.5	-2.025	4.101
15	0.475	0.226
11.25	-3.275	6.55
11.25	-3.275	6.55
21.25	6.725	45.226
23.75	9.225	85.901
21.25	6.725	45.226
421.25		**932.526**

$$\bar{X} = \frac{\sum x}{n} = \frac{241.25}{29} = 14.525 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{932.526}{29}} = \sqrt{32.156}$$

$$= \mathbf{5.67\ Kg}$$

APPENDIX VI: Quantity of fuelwood consumption in kilograms for KUDAN

x	**$(x - \bar{x})$**	**$(x - \bar{x})^2$**
3.75	-9.642	92.968
2.5	-10.892	118.636
2.5	-10.892	118.636
12.5	-0.892	0.796
16.25	2.858	8.168
16.25	2.858	8.168
17.5	4.108	16.876
10	-3.392	11.506
8.75	-4.642	21.548
10	-3.392	11.506
7.5	-5.892	34.716
10	-3.392	11.506
20	6.608	43.666
18.75	5.358	28.708
20	6.608	43.666
15	1.608	2.586
18.75	5.358	28.708
20	6.608	43.666
15	1.608	2.586
18.75	5.358	28.708
17.5	4.108	16.876
281.25		**694.194**

$$\bar{X} = \frac{\sum x}{n} = \frac{281.25}{21} = 13.392 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{694.194}{21}} = \sqrt{33.056}$$

= 5.75 Kg

APPENDIX VII: Quantity of fuelwood consumption in kilograms for MAKARFI

x	**$(x - \bar{x})$**	**$(x - \bar{x})^2$**
3.75	-11.052	122.147
5	-9.802	96.079
20	5.198	27.019
20	5.198	27.019
18.75	3.948	15.587
15	0.198	0.039
20	5.198	27.019
18.75	3.948	15.587
6.25	-8.552	73.137
12.5	-2.302	5.299
7.5	-7.302	53.319
13.75	-1.052	1.107
12.5	-2.302	5.299
15	0.198	0.039
25	10.198	103.999
21.25	6.448	41.577
16.25	1.448	2.097
15	0.198	0.039
15	0.198	0.039
281.25		**616.447**

$$\bar{X} = \frac{\sum x}{n} = \frac{281.25}{19} = 14.802 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{616.447}{19}} = \sqrt{32.445}$$

= 5.69 Kg

APPENDIX VIII f: Quantity of fuelwood consumption in kilograms for SABON GARI

x	$(x - \bar{x})$	$(x - \bar{x})^2$
25	12.25	150.062
20	7.25	52.562
21.25	8.5	72.25
2.5	-10.25	105.062
5	-7.75	60.062
8.75	-4	1.6
20	7.25	52.562
16.25	3.5	12.25
18.75	6	36
20	7.25	52.562
7.5	-5.25	27.562
3.75	-9	81
5	-7.75	60.062
6.25	-6.5	42.25
6.25	-6.5	42.25
5	-7.75	60.062
15	2.25	5.062
16.25	3.5	12.25
20	7.25	52.562
18.75	6	36
16.25	3.5	12.25
20	7.25	52.562
16.25	3.5	12.25
10	-2.75	7.562
6.25	-6.5	42.25
10	-2.75	7.562
10	-2.75	7.562
7.5	-5.25	27.562
15	2.25	5.062
18.75	6	36
15	2.25	5.062
12.5	-0.25	0.062
8.75	-4	16
18.75	6	36
7.5	-5.25	27.562
15	2.25	5.062
12.5	-0.25	0.062
18.75	6	36
15	2.25	5.062
13.75	1	1
18.75	6	36
522.75		**1406.93**

$$\bar{X} = \frac{\sum x}{n} = \frac{522.75}{41} = 12.75 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{1406.926}{41}} = \sqrt{34.315}$$

= 5.86 Kg

APPENDIX IX: Quantity of fuelwood consumption in kilograms for SOBA

x	$(x - \bar{x})$	$(x - \bar{x})^2$
15	3.526	12.433
25	13.526	182.953
23.75	12.276	150.7
3.75	-7.724	59.66
5	-6.474	41.913
6.25	-5.224	27.29
15	3.526	12.433
16.25	4.776	22.81
15	3.526	12.433
15	3.526	12.433
5	-6.474	41.913
7.5	-3.974	15.793
8.75	-2.724	7.42
13.75	2.276	5.18
8.75	-2.724	7.42
13.75	2.276	5.18
10	-1.474	2.173
13.75	2.276	5.18
10	-1.474	2.173
8.75	-2.724	7.42
10	-1.474	2.173
10	-1.474	2.173
10	-1.474	2.173
11.25	-0.224	0.05
12.5	1.026	1.053
8.75	-2.724	7.42
10	-1.474	2.173
7.5	-3.974	15.793
11.25	-0.224	0.05
10	-1.474	2.173
10	-1.474	2.173
12.5	1.026	1.053
12.5	1.026	1.053
12.5	1.026	1.053
10	-1.474	2.173
11.25	-0.224	0.05
11.25	-0.224	0.05
12.5	1.026	1.053
13.75	2.276	5.18
447.5		**683.979**

$$\bar{X} = \frac{\sum x}{n} = \frac{447.5}{39} = 11.474 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{683.979}{39}} = \sqrt{17.538}$$

= 4.19 Kg

APPENDIX X : Quantity of fuelwood consumption in kilograms for ZARIA

x	$(x - \bar{x})$	$(x - \bar{x})^2$
8.75	-5.192	26.957
25	11.058	122.279
25	11.058	122.279
5	-8.942	79.959
3.75	-10.192	103.877
7.5	-6.442	41.499
6.25	-7.692	59.167
7.5	-6.442	41.499
23.75	9.808	96.967
20	6.058	36.699
20	6.058	36.699
23.75	9.808	96.967
22.5	8.558	73.239
20	6.058	36.699
21.25	7.308	53.407
18.75	4.808	23.117
20	6.058	36.699
16.25	2.308	5.327
23.75	9.808	96.967
15	1.058	1.119
16.25	2.308	5.327
15	1.058	1.119
20	6.058	36.699
20	6.058	36.699
21.25	7.308	53.407
21.25	7.308	53.407
23.75	9.808	96.967
22.5	8.558	73.239
23.75	9.808	96.967
22.5	8.558	73.239
8.75	-5.192	26.957
7.5	-6.442	41.499
7.5	-6.442	41.499
6.25	-7.692	59.167
16.25	2.308	5.327
15	1.058	1.119
12.5	-1.442	1.119
15	1.058	1.119
11.25	-2.692	7.247
13.75	-0.192	0.037
16.25	2.308	5.327
15	1.058	1.119
17.5	3.558	12.659
18.75	4.808	23.117
16.25	2.308	5.327
15	1.058	1.119
15	1.058	1.119
11.25	-2.692	7.247
13.75	-0.192	0.037
17.5	3.558	12.659
13.75	-0.192	0.037
15	1.058	1.119
725		**1978.024**

$$\bar{X} = \frac{\sum x}{n} = \frac{725}{52} = 13.942 \text{ Kg}$$

$$S.D = \sqrt{\frac{\sum(X-\bar{X})^2}{n}} = \sqrt{\frac{1978.024}{52}} = \sqrt{38.039}$$

= 6.1678 Kg

APPENDIX XI: Sample Size Determining from a Given Population

Table for Determining Sample Size from a Given Population

N	***S***	***N***	***S***	***N***	***S***
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	650	242	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—***N*** is population size, ***S*** is sample size.
Source: Krejcie and Morgan (1970)