CHAPTER ONE

INTRODUCTION

1.1 Background to Study

Tropical forests face interminable challenges of remaining biologically diverse while sustaining global ecological functions. This is mainly due to ecological disturbances (biological or not) that alter the spatial patterning of ecosystems and the organisms found there. These disturbances shape the forest structure by making thousands of flora and fauna species go extinct every year and its full consequences on ecosystems are not totally understood (Schleuning *et. al,* 2008). Some of the major ecological disturbances include natural outbreaks of insects, fires and windstorms. Others more anthropogenic in origin such as construction works, use of chemically polluting substances have become increasingly important by the way they alter the environment leading to environmentally degrading outcomes like deforestation, erosion and extreme climatic events as droughts (Geist and Lambin, 2002; FAO, 1997). One such common activity on the African continent is the extraction and usage of fuelwood for domestic energy by much of its urban/rural poor (Ektveldt, 2011). Past research on fuelwood extraction has largely focused on its consequences for deforestation and climate change, while studies on fuelwood consumption have focused on household use and its effect on human health. However, studies on fuelwood extraction effects on vegetation and soils in different ecological zones are limited and not exhaustively examined. Research on fuelwood consumption differentials particularly between household and food vendors has also attracted little or no attention in the literature. This study was designed therefore to investigate the effects of fuelwood extraction on vegetation (forest and savanna); associated soils and fuelwood consumption differentials of households and food vendors in Oyo State.

1.2 Why the Choice of Fuelwood?

Fuelwood as a primary fuel has been in use for centuries in many developing economies. It consists of unprocessed woody biomass (mostly dead wood), and is often used to fuel small fires (May-Tobin, 2012). Charcoal on the other hand is distinct from fuelwood because it is a semi processed fuel made from burning wood in a low oxygenated environment. Both fuel types are often referred to as wood fuels.

As a significant forest product, there has been an intensification of fuelwood extraction activities which do not seem to be abating as local users rarely find affordable and acceptable alternatives (Eckholm, 1975; Leach and Gowen, 1987; Arnold *et. al,* 2003; FAO, 2005). These users, engendered by the rise in population growth in developing countries are key to a greater encroachment on environmental resources (Horst and Hovorka, 2009). This is particularly true in Nigeria where the recent increase in the cost of kerosene and its attendant scarcity has forced many low-income urban dwellers particularly in Northern Nigeria to resort to the use of fuelwood/ charcoal as their major cooking energy source (Maconachie, 2009; Naibbi, 2013).

Although, in the mid 1990's, this was thought to be a precursor to a soon coming energy crisis by the next decade (Horst and Hovorka, 2009), it turned out not to be a major driver of deforestation as widely thought. Yet the notion persists that increased users usually translates to increased pressure on vegetal resources which may then alter the plant-soil equilibrium that exist in the tropical environment (Aabeyir *et. al,* 2011). Such persistent wood fuel dependence does signify important consequences for local forest resources and scarcity has been reported in some areas (Kituyi *et. al,* 2001). Ultimately 'leapfrogging' past woodfuels to more use of modern fuels signal a country's level of economic growth and is inextricably tied to its development (Horst and Hovorka, 2009; Daioglou *et. al*, 2012). For many of the developing countries, a strong dependence on woodfuels coupled with a slow adoption of more modern energy forms are indicators of poverty within such populations (Gumartini, 2009). Since the popularity of fuelwood amidst the poor in these countries is due to their inability to afford other fuels for cooking, the implications for the energy-forest–development scenario remain precarious.

1.3 Statement of the Problem

Nigeria's heavy dependence on fuelwood has been a source of concern especially with regards to the wellbeing of its environment. Extant studies emphasizing the unabating large scale depletion of vegetal resources have further implicated the harvest and use of fuelwood as one of the driving catalysts for forest loss. Unless there is a widespread transitioning to modern fuels there is a serious threat of more irreversible changes to forests which may negatively affect the sustainability of both rural and urban livelihoods linked to fuelwood with time.

Despite the significance of this issue, there has been limited empirical studies on the link between urban fuelwood demand and environmental change, as well as the impact fuelwood extraction has on the environmental processes (Brown *et. al*, 2009; Zhou *et. al*, 2009; Wangchuck, 2011; Sahoo and Davidar, 2013; Spetch *et. al*, 2015; Sassen *et. al*, 2015). Although, Aweto (1995)'s review of fuelwood production in West Africa surmised that fuelwood activities generally impact unfavourably on the environment; there are few local empirical studies in West-Africa and Nigeria in particular.

Past studies on effects of fuelwood extraction such as Foley *et. al* (2002), reported regression in tree numbers and diameters in a study of two Sahelian village forests while Cline-Cole (1987), also detailed impacts on tree density and specie density in Northern Nigeria. None of these studies showed differentials in how fuelwood removals affected key vegetation parameters and soil properties of different exploited areas. It is probable that the removals of materials such as coarse woody debris may manifest differently in the long-term ecological condition of various extraction sites, giving losses of soil, nutrient, carbon and water resources (Brown *et. al*, 2009).

Furthermore, there is limited information about how comparatively the impact of such removals has been on soils in exploited areas under contrasting ecosystems (Forest versus savanna). This arises due to the conjecture that exploited savannas with their open structure can be expected to have increased soil respiration rates which may create differences in soil properties when compared with exploited forest areas (Noble and Randall, 1998). Findings from similar comparative studies in Indian savannas/dry forest biomass and semi-deciduous forests have suggested that spatial variability in wood harvesting may be a critical factor in deepening the understanding of local human-environment interactions (Saxena, 1997). More enquiries examining the relationship between the structural characteristics of trees and soil properties of these fuelwood exploited areas are required since plants usually have specific effects on edaphic properties (Ayres *et. al*, 2009).

Fuelwood consumption on the other hand has been well researched under the themes of health impacts and drivers for use (Morgan, 1983; Cline-Cole, 1987; Ayoub, 1988; Akintola *et. al*, 1996; Kersten *et. al*, 1998; Adelekan and Jerome, 2006; Gbadegesin and Olorunfemi, 2011). There are however no comparative studies found to correlate domestic and food vendor energy use patterns to tease out salient local-level variation and preference. These food vendors are a scarcely studied category of commercial users even though they are one of the major non-household users of fuelwood in the Ibadan metropolis (Kersten *et. al*, 1995). More research is needed to comparatively interrogate the relationship between fuelwood extraction, consumption and environmental change.

1.4 Justification for Research

This study characterizes the relationship between urban fuelwood demand and environmental change in vegetation and soils in south-western Oyo State. It shows how small-scale disturbances (extraction) affect the plant-soil interrelationships, tree species population (spatial structure and tree size) and specie composition. Since about 40% of the carbon available in the biosphere is found in forest soils and vegetation (FAO, 2005) human activities affecting the environment have become increasingly important catalysts to the ongoing climatic changes occurring due to the release of greenhouse gases. What makes fuelwood extractive impacts more significant is the fact that such disturbances though deemed small-scale have the potential when repeated many times over within an area to produce considerable environmental damage (Ruger *et. al*, 2008; Brites and Morsello, 2012; Bouget, Lassauce and Jonsell, 2012; Spetch *et. al*, 2015; Sassen *et. al*, 2015).

Conventionally, investigations into impact of fuelwood use on the physical environment have been interview/ questionnaire driven (Kersten *et. al*, 1998; Alamu and Agbeja, 2011; Orimogunje and Asifat, 2015). This current study however, has employed a mixed method approach involving both empirical testing and a few qualitative techniques to generate a more robust understanding of existing fuelwood issues. Furthermore, urban fuelwood demand differentials particularly for commercial and domestic users are important in deepening the understanding of how human impacts shape the existing urban energy landscape and extends the frontiers of previous research on the contemporary role of fuelwood in urban livelihoods in south-western Nigeria. The results will prove useful to city planners and policymakers in designing effective conservation strategies.

1.5 Research Aim and Objectives

The broad aim of the study is to investigate the effects of fuelwood extraction on vegetation (forest and savanna); associated soils and fuelwood consumption differentials of households and food vendors in selected parts of Oyo State

The following objectives were considered to achieve the aim, that is:

i. Characterize and compare effects of fuelwood extraction on vegetation (tree density, diversity, species composition and tree structure at savanna and forest extraction sites).

ii. Characterize and compare effects of fuelwood extraction on soils physico-chemical properties (Soil pH and organic matter levels) at savanna and forest extraction sites.

iii. Establish relationships between structural characteristics of trees and soil properties of fuelwood exploited areas.

iv. Determine the pattern of variation of household and food vendors'fuelwood consumption and preference in the Ibadan metropolis.

v. Compare the relationship between consumption and user characteristics (vendor sex, age, marital status, level of education, number of years in business, number of workers) of food vendors.

1.6 Research Hypotheses

1. There is no significant difference in vegetation characteristics (Tree density, diversity, species composition, tree structure) between fuelwood extraction sites and unexploited sites within and between both forest and savanna areas.
2. There is no significant difference in soil properties between fuelwood extraction sites and unexploited sites within and between both forest and savanna areas.
3. There is no significant relationship between structural characteristics of trees and soil properties of fuelwood extraction sites.
4. There is no significant variation in consumption and preference of fuelwood across households and food vendors in Ibadan metropolis.
5. User characteristics do not significantly influence consumption

1.7 Study Area

1.7.1 Location

This study was conducted in Oyo State, south-western Nigeria located between latitudes 6º55' to 8º45'N and longitudes 2º50' to 3º56'E. The State is bordered by other States as Osun in the east, Ogun in the south, Kwara in the north and the Republic of Benin in the west respectively (Fig 1.1).

The approach of studying both fuelwood extraction and consumption necessitated the use of several sites within the State since wood fuels have varied spatially-differentiated source and destination points. Ibadan, a major consumption center in Oyo State was chosen for the urban demand study while the extraction study was conducted in contrasting forest and savanna ecosystems. Two forest areas of extraction and control plots were chosen and the same procedure repeated for the savanna sites. The forest extraction site (A) was Alaja Village in the Arulogun Area in Akinyele LG (Ibadan) , while the natural forest stand of the Onigambari forest reserve was chosen as the forest control site(C) located in Oluyole Local Government Area (LGA) close to the southern part of Ibadan in Oyo State. The savanna extraction study was carried out at Ago Serafu, Iseyin (B) while the Old Oyo National Park (D), in the northernmost corner of Oyo Ile range served as the savanna control.

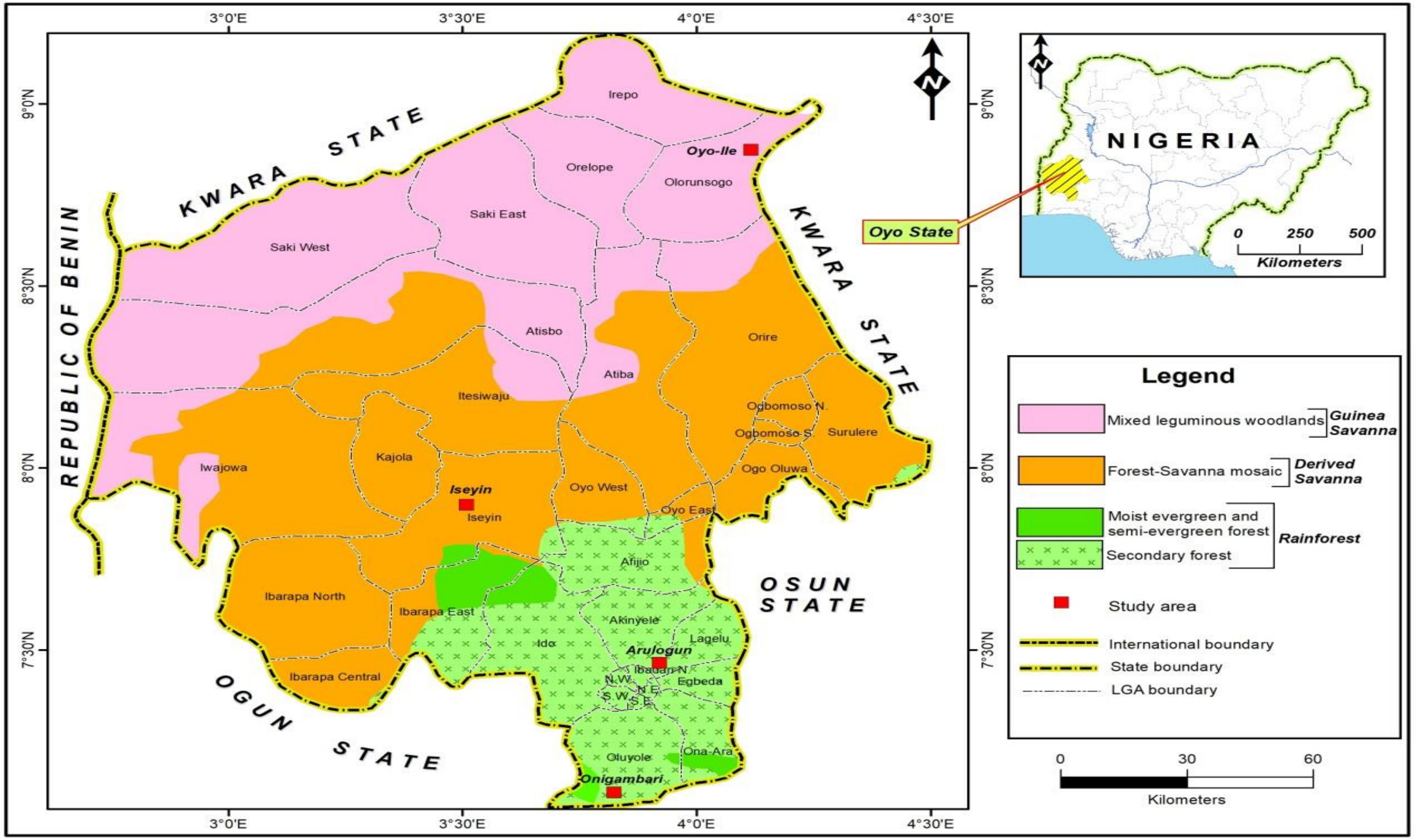


Figure 1.1: Oyo State showing Extraction and Control sample sites.
Source: Author's Analysis, 2015

1.7.2 Vegetation

Oyo State vegetation generally is classified under three types of vegetation: tropical rainforest, derived savanna and Guinea savanna. They are characterized by different flora and plant communities based largely on the amount of rainfall received by the area (Ayoub, 1988). The vegetal cover pattern changes from forest in the south to a Guinea savanna in the northern most parts of the State. Past vegetation was dominated by a dense tree cover with a profusion of low lying shrubs and geophytes (Ayoub, 1988) which was gradually eroded by farming activities (bush fallows) giving rise to much of the secondary forests available now in many parts especially of the forest region. The natural vegetation was removed and replaced by tree crops such as oil palm, cola, rubber, citrus, cacao, kolanut; cassava, maize as major food crops (Ezebilo, 2004). Currently, the southern well forested part of Oyo (housing Onigambari and Alaja sites) is still rich in biological diversity containing many tree species of commercial importance such as: *Sterculia tragacantha, Lophira alata, Daniellia oliveri, Afzelia africana, Triplochiton scleroxylon, Cylicodiscus gabunensis, Khaya ivorensis, Lovoa trichiloides, and Cola cordifolia*. Other known exotics including *Cedrela odorata, Gmelina arborea, Tectona grandis, and Eucalyptus spp,* can also be found in this zone (Salami *et. al*, 2016).

Oyo State has 18 forest reserves constituted by law are forest lands that originally belong to indigenous communities. Other gazetted areas set apart for conservation purposes include the State National Park and a Game reserve (Ezebilo, 2004). The Onigambari Forest Reserve was basically carved out by an 1899 resolution of the Ibadan city council and consolidated from different portions of forested land into a Forest Reserve in 1953 making a total area of 125.62 km^2 (Oduwaiye and Ajibode, 2005). The reserve is surrounded by villages as Aba-Igbagbo, Gbale-Asun, Ajibodu, Lagunju, Akintola, Okeseyi, Akinogbun, Amosun, Olonde Ige, Olaya, Onipede, and is about 17 km south-east of Ibadan. It is famed for its relatively unexploited forest plot within the reserve.

The Guinea Savanna area located in Serafu (in Iseyin area) is dominated by tall grassy vegetation (1 to 3 m high) fire tolerant trees and shrubs, usually less than 15m high in open woodland. Common species in this zone include *Vitellaria paradoxa, Acacia, Chrysophyllum albidum, Blighia spp, Parkia spp, Daniellia spp.* Similarly, lying between latitude $8^{0}10^{1}$ and $9^{0}05^{1}$North, longitude 3^{0} and $4^{0}2^{1}$ East, Old Oyo National park (OONP) located across Oyo and Kwara State is surrounded by towns as Saki, Iseyin, Igboho, Sepeteri, Tede and Igbeti. Composed mostly of low plains between 330m – 508m above sea level, the entire park lies in the southern part of the Guinea savanna with *Burkea africana, Afzelia africana, Piliostigma thonningii* as dominant vegetation species in the North west corner, species such as *Terminalia avicenniodes, Prosopis africana, Terminalia laxiflora* dominate the middle and north eastern sections. Outcrop vegetation also occurs with species such as *Adansonia digitata, Anogeissus leiocarpus, Acacia species* dominating.

1.7.3 Climate, Soils and Drainage

Oyo State has a sub- equatorial climate with a relatively high humidity and distinct wet- dry periods (November – March). Its daily temperature is usually about 21ºC- 35 ºC while its mean annual rainfall ranges between 800 mm to 1500 mm with a slightly longer dry season in the northern parts (Ayoub, 1988). The wet season usually begins in April and lasts till October while the dry harmattan season starts in November and lasts till March. Rainfall volume varies within the State. The southern part enjoys between 1200 mm and 1800 mm of rainfall. The northern parts have a lower average of 800 mm and 1500 mm of annual rainfall. Much of the State is underlain by soils derived mainly from pre-Cambrian rocks, especially hornblende biotite gneiss. The soils, especially in the forested areas of the southeastern section, have a high humic content (concentrated in the surface and sub surface soils) and often include clay, laterite and dark loam with a good structure. Northward the soils are lighter and become a mixture of laterite and fine grained loam and humus. Major rivers found in the State include the Osun, Ogun, Oyan, Ona rivers.

1.8 Background to Consumption Study in Ibadan.

Ibadan was spotlighted for the consumption study due to its unique status as Nigeria’s most populous indigenous city. Previously seen as the largest indigenous city in Sub Saharan Africa, it currently retains the distinction of also being cosmopolitan. Ibadan with a total land area of about 3123 km^{2}, is located on longitude $3^{0}54^{1}$ East of the Greenwich meridian and latitude $7^{0}23^{1}$ North of the Equator (Adelekan and Jerome, 2006). Ibadan is divided into 11 local government areas of which five are urban

(Ibadan South-East, Ibadan North, Ibadan North-West, Ibadan North-East, Ibadan South-West) with a land area of 463km^2 (Tomori, 2008), and six semi-urban (Akinyele, Lagelu, Ido, Egbeda, Ona Ara, Oluyole) which has a land mass of 2659.97km^2.

The physical landscape has prominent hills that generally lie across the city in a north-west and south-east manner. Drained by rivers Kudeti and Ogbere in the center, the city has other major rivers and lakes such as the Ona river and Lake Eleyiele in the Northwest, Asejire Lake at the city boundary and river Ogunpa running through the city as well. The city has a very dense network of roads. Formerly, it was predominantly a home of Yoruba people but now accommodates a large mixture of migrants who largely retain more of their rural cooking habits (Ayoub, 1988) involving woodfuels. More then 65% of the Oyo State lands are devoted to Agricultural related activities (Ezebilo, 2004). In the past, Ibadan’s economy focused basically on production of vegetables, cereals and yam. It was also a trade center for shea butter, salt and even manufactured goods, pots and ironworks (Fourchard, 2002). It has an established broad base of industries and has a number of wood processing industries making wood for electricity poles, furniture, paper and construction.

CHAPTER TWO

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Literature Review

2.1.1 Definitions and Terms.

The United Nations Food and Agriculture Organization (FAO, 2017), one of the main international organizations concerned with monitoring biomass energy data in developing countries at both the household level and ad hoc surveys classifies wood energy in different forms as biomass energy, woodfuel (fuelwood and charcoal*)*.

Biomass energy: These are fuels that have a non fossil, organic origin which includes wood, non-woody plant matter, organic waste, and or any processed by-products.

Woodfuel: This generally indicates different types of woody biomass used for energy purposes. Woodfuel consists of both *fuelwood* and *charcoal*. They are gotten from forests, shrubs and other trees.

Fuelwood: describes unprocessed woody biomass that is often cut to a usuable form and burned directly for energy purposes (Plate 1 and 2). Fuelwood is often interchangeably used with fuelwood.

Charcoal: This is processed woodfuel derived from wood and carbonized by heating it in the absence of sufficient oxygen for full combustion to occur.

Others include *wood-based fuels* mainly liquid and gaseous biofuels produced from woody biomass.

Leach and Gowen (1987), in the World Handbook defines these biomass fuels as *Traditional* fuels that may be bought and sold (commercialized) or gathered without financial payment from the environment. The *modern* fuels or non-traditional energy sources include coal, coke, electricity, liquefied petroleum gas (LPG), natural gas and kerosene.

Household: is a single grouping of people that eat from the same pot in the same home.

Food Vendors: are people who prepare and sell food for a living at a particular semi-permanent / temporary location. Food vendors have been purposively selected as the most representative group for commercial users for ease of data collection.

Commercial users are those that depend on fuelwood as primary energy sources for their businesses to function such as cottage industries, institutions, small-scale enterprises such as food processors, bakers, fish-mongers, food vendors (bukaterias).

Plate 1: Tree limb split off during storm being lopped off for fuelwood at Alaja Forest. Fieldwork, February 2015.

Plate 2: Key informant showing researcher how after extraction, large pieces of firewood are cut into smaller manageable size at Alaja Forest. Fieldwork, February 2015

2.1.2 Global perspectives on Woodfuel Energy

Energy issues resonate with global relevance as a critical component of Africa's development agenda and therefore national wood fuel extraction and consumption issues are important to meeting the twin millennium development goal of environmental sustainability and resource loss reduction (UNDP, 2005). While the world energy crisis from fluctuating fossil fuel prices has engendered moves to reduce fossil fuel consumption or find suitable alternatives to mitigate the environmental impacts of its use, Africa continues its unrelenting usage of wood fuels in tandem with rising fossil fuel prices. Both fossils and wood energy have in one way or the other negatively impacted on human wellbeing and economic development (Jones, 2015). Yet they remain the main avenues by which energy needs such as heating, lighting for homes, cooking, transportation and all forms of power for running industries are met globally. These and other human activities such as deforestation, agriculture generate gases that accelerate global warming and there are stronger calls for substitutions with cleaner alternative fuels and technologies. Biomass is the primary energy source in developing countries often providing 80% of total energy (Ghilardi *et. al*, 2009). This concentrated use is often inefficient with more than 70% of energy produced lost which eventually releases harmful indoor air pollutants into the atmosphere (Macfarlene, 2009).

The report on household energy and health by the World Health Organisation (WHO) emphasized how more than 3 billion people exposed to the risk of health related complications and roughly 1.5 million die prematurely due to indoor pollution resulting from increased use of traditional solid fuels (Modi *et. al*, 2006). Other salient impacts of charcoal production activities include use of child labour, work related injuries and gender disparities in income and education (Jones, 2015). When biomass is converted to energy using modern technologies, emissions of dangerous pollutants such as particulate matter, carbon monoxide, volatile organic compounds (VOCs) produced by combustion of fossil fuels are reduced to manageable proportions (Modi *et. al*, 2006). All these issues have galvanized more of the international community to keep calling for a quick reduction in usage of such fuels and development of alternatives more suited to environmental health.

2.1.3 The Energy, Forest and Fuel Nexus.

About 4 decades ago, the international community witnessed the widespread emergence of the woodfuel gap crisis hypothesis (Eckholm, 1975; FAO, 2003; Leach and Gowen, 1987) warning of an impending doom of fuel shortages as demand outstrips supply leaving the whole of Africa denuded of vegetal cover and the poor suffering immensely for energy needs. There were many calls for Governmental interventions in 2 main ways: to address demand reduction or to increase wood supply (Hosier and Kipondiya, 1993; Bensel, 2008; Arnold *et. al, 2003*). Many interventions took the form of promotion and dissemination of improved wood-burning stoves and encouraged inter-fuel substitutions (in a shift from woodfuels) with subsidies on fossil fuels as kerosene and liquefied petroleum gas (LPG) (Adelekan and Jerome, 2006). Interventions to increase supply supported by the massive worldwide campaign for reforestation resulted in increased tree planting on farms and plantations.

These programs were seemingly ill-conceived and in the long run failed to resolve the problems that brought them to the fore. This assertion implicating fuelwood use has often been by studies pointing out that much of the wood used are dead wood or wood from trees outside forests (TOFS) and more trees were being planted on farms by farmers in response to forest product scarcities (Arnold *et. al,* 2003 : 2006; Bensel, 2008)

Nonetheless the view still stands that as countries are becoming more urbanized, the increasing population pressure will cause a corresponding increase on environmental resources which may eventually threaten the delicate balance between resources and people generating a host of negative implications as stated earlier (Naughton-Treves *et. al,* 2007; Bailis, 2005; Ribot, 1998).

2.1.4 Links between Energy, Woodfuels and Poverty.

As an energy carrier, woodfuel remains especially important as a means to improve quality of life. Woodfuels as environmental resources from trees and forests usually have varied, spatially-differentiated source (rural) and destination (urban) points. Its shortages are thus basically rural in nature but convey backwash effects on urban communities giving rise to the rural-urban linkages that occur. The main users of wood for fuel are the poor who have little or no alternatives and are seemingly unable to stop or reduce their consumption (Eckholm, 1975; Leach and Gowen 1987; Arnold *et. al,* 2006; Horst and Hovorka, 2009; May-Tobin, 2012). Many have emphasized the strong relationship between poverty and fuelwood use (Ogwumike *et. al,* 2012). The orthodox view of the linkage between poverty and deforestation implicate the rural poor in the analysis of how forests get degraded and destroyed despite the tangible and intangible benefits they derive from them. This view which was in great circulation in the 1970's generally deemed poverty to be a pressing factor forcing the poor to decimate forests to meet their daily subsistence needs by forest product extraction (WCED, 1987). The pressure was reinforced by the users' limited access to arable land resources for investment and non sustainable uses of the forest (Scherr, 2000).

Incidentally, the poor in urban areas are the main end users of the wood traded off. These urban poor with reduced incomes have shown evidence of temporary increased demand for wood fuel products giving rise to a thriving trade and flow of woodfuels. Conceptually, urban demand had been cast in Von Thunen-sque overtones of woodcutting leaving concentric ring imprints of treeless voids in and around the city (due in part to added transport costs). Increased consumption would necessitate going further hinterland for more wood to cut which would necessarily be accompanied with increases in the price of wood. Although closely approximated in reality in Sudan (Bara), the general applicability of this theory has been questioned (Cline-Cole, 1987; Remedio, 2002). Generally price increases of wood lead to more consumption of charcoal as incomes rise and cities become larger (Arnold *et. al,* 2003: ESMAP, 2001).

Other counter narratives acknowledge the intersection of the poor and deforestation (Angelsen and Wunder, 2003: Arnold and Bird, 1999) but also point out that poverty usually has many different underlying causes and manifestations and these make it inaccurate to assume a direct causal relationship between poverty and forest degradation. There is much variation in the manner in which the poor use and manage forest resources; therefore creating a deeper understanding of deforestation requires locale specific investigations and analysis (Bembridge, 1990). Generally agricultural expansion has been found to be an important direct cause of land-use change in almost 96% of cases reviewed by Geist and Lambin (2002), and fuelwood extraction was rarely an important primary cause of deforestation. Inspite of prevailing concerns on the negative aspects of its use, poverty implications and impacts on women's health and the environment (Nash and Luttrel, 2006), woodfuels may also generate positive benefits if sustainably extracted, harnessed and sold (Gumartini, 2009). These include its being a cheaper energy source compared to other urban fossil fuels and a strong employer of low skilled rural labour in extraction, trading and charcoal manufacturing (Horst and Hovorka, 2009). Summarily, some dimensions of woodfuel use impacts are still unclear and not well understood due to a lack of reliable empirical data (Arnold *et. al,* 2003).

2.1.5 Fuelwood Studies in West Africa

It is known that the available wood resources in a country are circumscribed by the amount of forest resources available and West Africa is deemed to contain one of the highest potentials for wood energy in Africa (Mola-Yudego *et. al,* 2016). A review by Aweto (1995), emphasized the vast country to country variation of fuelwood production in West Africa and noted that fuelwood extraction was an activity prone to exacerbate environmental degradation yet continued to be fuelled by the devaluation of many currencies which ultimately make other modern fuels unaffordable for the poor. While this underscores the ecological importance of fuelwood activities there appears to be few comparable studies on impacts of fuelwood extraction on the vegetation in West-Africa and Nigeria. A forest inventory (Biocarbon and Rural Development (BIODEV) project) carried across Sierria Leone and Burkina Faso gave more insights into the State of two forests and results recognized the impact humans have on species distributions of trees as well as changes in forest structure (Melin *et. al*, 2016). In a similar study of Sahelian countries, ecological changes were noticed by local people in two village forests in Senegal under a World Bank rural fuelwood market project supervised by CIRAD Forêt (French National Centre for International Cooperation in Forestry and Agricultural research, formerly known as the CTFT), (Foley *et. al,* 2002). Results indicated that *Combretum nigricans,* a multipurpose tree reduced in numbers and tree diameter. Although some species appeared resilient to extraction, users such as artisans insist depletion in size and numbers have occured.

Tredennick (2014), empirically tested the ability of theoretical allometric scaling models to predict the relationships between morphological traits (e.g. stem diameter and height) of savanna trees important for rapid biomass assessments and ecological theory in Mali, West-Africa. Findings reveal variation in length/height scaling exponents, indicating an interaction between resource availability and selective pressure for rapid growth of savanna trees. Although, the savannas can often withstand tree harvest pressure, there was demographic shift to low biomass tree sizes. As stated previously, extant literature on fuelwood harvesting in Nigeria are limited. In Northern Nigeria, a seminal study on woodfuel in Kano and its hinterland (Cline-Cole, 1987) explored how demand for fuelwood was affecting local resource management systems and gave insights into consumption within the city. Using aerial photography and ground surveys, findings revealed an increase in tree density increase, timber girth and volume and species diversity. The study however did not look at the relationship between other tree growth characteristics (tree height, basal area) and fuelwood extraction nor the effect on soils of exploited areas. While it explored consumption amidst various users, it did not examine critically the role food vendors' play in patterns of consumption seen.

An important study by Ayoub (1988), documented patterns of energy consumption and fuel preferences in a rural energy survey of Oyo State and debunked the claim of an fuelwood energy crisis in the study area (the Ife, the Ibadan and the Ogbomoso zones). He however stated it could be a future possibility given the increasing dependence on woodfuels. He found variation in fuel preferences between the Ibadan and Ogbomosho zones which were not due to the ecological differences between them. It reports a scarcity of fuelwood supplies in the savanna part (Ogbomosho) and also records differences in species exploited for fuelwood giving significant species as *Celtis, Cacao, Ficus, Ire* and *Albizia* in the rainforest and *Hymenocardia, Acacia and Butyrospermum* in the Ogbomosho savanna mosaic. The study failed to show empirically how fuelwood extraction affected biodiversity of tree species population (tree structure and tree size nor its impact on soils.

A study on local disturbances in vegetation along the forest-savanna boundary in Oyo

State (Emuh, 2009; Egbinola, 2016) examined effects of human disturbance on species composition and patterns of diversity with the Shannon and Simpson's Index. Results showed a decrease in the species diversity from sites with mature vegetation to the areas of vegetation succession, irrespective of whether they contained forest or savanna vegetation. Also, species diversities was greater in the forest vegetation than in the savanna vegetation indicating that human disturbances in the region studied was leading to the establishment of savanna species and an elimination of forest species. Although there are few references to the expected impact fuelwood removals may have on soil quality (Brown *et. al,* 2009), inferences may be drawn from charcoal studies that suggest physical and chemical changes occur that eventually affect productivity (Oguntunde *et. al,* 2008; Ogundele *et. al,* 2012). As such, effects of such wood removals cannot be disregarded. Antii (2006), maintained that effects on soil fertility and site productivity can be measured by monitoring change in soil properties that are known to influence tree growth rather than measuring tree growth itself. Kebede *et. al* (2015), in his study on the effect of fuelwood removals on the status of soil fertility in Debis Watershed, Ethiopia showed that grazing and forest lands had lowered soil bulk density and particle density than deforested land, while chemical properties (organic carbon, CEC, total nitrogen, available phosphorus, sodium) were higher in forest soils than in grazing and deforested lands.

A similar assertion by Cardelus *et. al* (2009), indicated there are observable differences in the nutrient status of soils under different tree species and climes. As such, spatial variation in tree flora may bring about different effects of wood removals on soil chemical composition (Ogundele *et. al,* 2012). Therefore, differences may be expected in responses of the forest and savanna soils. An Indian comparative study between savannas /dry forest biomass and semi-deciduous forests further suggest spatial variability in wood harvesting may be a critical factor in deepening the understanding of local human environment interactions (Saxena, 1997). A significant shortcoming of most of the above mentioned studies was that they ignored the impact of fuelwood extraction on soil properties and did not fully explore comparatively how fuelwood extraction could shape tree population and morphology in both forest and savanna ecosystems therefore this study was conducted to fill the gap.

Equally as important as environmental change, urban fuelwood consumption is underlain by broad socio-economic processes that drive this demand for woodfuel unceasingly (Spetch *et. al,* 2015). Studying the dynamics of fuelwood extraction through the lens of socio-economic drivers becomes imperative because a clear understanding of why people behave the way they do must be sought before interventions to either encourage or discourage engagement in certain environmentally altering behavior can be done. A prime example is estimating the likely socio-economic impacts of efforts to reduce the fuelwood use on local people. Although the basic drivers of global use were known to be the low cost of procuring woodfuel and the ease of access to it (Gumartini, 2009), more studies of this socio-economic aspect signal its importance as a public revenue contributor that delivers social benefits and is needed to support the making of sound wood energy policies (Aatyi *et. al,* 2016). Asides income, other shaping factors influencing the behaviour of consumers include costs, availability and accessibility of alternative energy sources, prices, convenience, available species and vegetal resources in each region and even cultural habits generating variation in patterns of use over time and space (Leach and Gowen, 1987; Saxena, 1997; Shackleton *et. al,* 2007). The high degree of variability in consumption is a challenge to attempts at modeling energy demand as analyses based on the average situation are likely to be wrong in many cases (Morley and Hazas, 2011). Such aggregation often lose the finer details needed to fully deconstruct the consumption patterns observed hence the need for more local studies.

From the fuelwood consumption literature in West Africa, rural energy systems have been a focus (Ayoub, 1988; Morgan, 1983; Cline- Cole, 1987; Akintola *et. al,* 1996; Kersten *et. al,* 1998; Gbadegesin and Olufemi, 2011) and local energy consumption patterns have witnessed some changes due to dislocations in modern fuels (Adelekan and Jerome 2006; Oyerinde, 2010; Oyekale, 2012; Naibbi, 2013). While many attempts have been made to unravel factors influencing local household use of the fuel (Morgan, 1983; Cline-Cole, 1987; Ayoub, 1988; Akintola *et. al,* 1996; Kersten *et. al,* 1998; Adelekan and Jerome, 2006; Gbadegesin *et. al,* 2011), food vendors as the major commercial users of fuelwood have been scarcely studied. This significant smaller yet little studied population are dependent on woodfuels as primary energy sources for their day to day businesses to function such as cottage industries, institutions and small-scale enterprises such as food processors, bakers, fish-mongers, food vendors(bukaterias)(Cline-cole, 1987). Among the attempts at studying these commercial users within Nigeria, Siong *et. al* (2011), studied the energy use pattern of food vendors in Ibadan while Orimoogunje and Asifat (2015), explored the sources and patterns of fuelwood consumption in Iwo (Osun State). Both failed to comparatively analyse domestic and food vendor fuelwood consumption. This study therefore fills this gap, highlighting the significance of foodvendors as one of the major non-household users of fuelwood, correlating domestic and food vendor energy patterns to tease out the determinants of variation in use. It serves to deepen the understanding of fuelwood use dynamics and patterns in Nigeria.

2.1.6 Environmental impact of fuelwood extraction and use

Woody plants or trees often serve as a carbon neutral form of energy which absorbs carbon, acting as sinks for varying periods of time. When large-scale clearance of these trees or deforestation occurs in severe intensities, it may affect biological diversity resulting in habitat destruction, fragmentation of formerly contiguous habitats; and intensification of edge effects leading to species extinction (Ruuska, 2012). According to the US forest service (USFS, 1997), fuelwood collection may affect soils since twigs and sticks are the most important source of wood for nutrient cycling. These effects of collection may show up basically in four ways; esthetic (such as in creating fire rings and grass patches on surrounding), soil compaction (from trampling), removal of downwood (manifesting as impacts on nutrient cycling, moisture retention and soil fertility) and visual quality. Conclusions drawn contend that the effect of removal of downwood for fuelwood is not likely to affect significantly an ecosystem’s nutrient capital.

Localized impacts are said to be seen on the standing biomass depending on certain factors. Visible examples have been recorded in the case of refugees near forests who rapaciously extract wood and cause major environmental damage (UNHCR, 1997). Other recreational activities as hiking and camping which sometimes necessitate the extraction of fuelwood in temperate areas have also been known to generate impacts on soils and vegetation. This occurs often by trampling bringing soil compaction reducing porosity, increasing bulk density and penetration resistance (Cole, 2004). Timber production also impacts greatly on the biodiversity of forested areas when charcoal merchants selectively extract wood due to differing calorific and utility values of the wood (Alamu and Agbeja, 2011). Local utilization processes and procedures may not be very efficient and may affect the climate with its release of noxious gases such as charcoal making (Foley, 1985). There are documented differences in age structure, composition and physic-chemical properties of soils between charcoal hearths and forest lands in Pennsylvania following cessation of charcoal production in 1884 (Mikan and Abrams, 1995). Initial effects noticed was prevention of stump sprouting and delay in re-colonization due to extreme soil physical and chemical properties meaning alterations in soil chemistry have persisted over 110 years.

Brites and Morsello (2012), in their review of studies on the ecological effects of harvesting Non-Timber Forest Products from natural forests found more impact on the age structure, species composition and size of exploited populations. More effects were noticed on vegetation (fruits, leaves, tree barks) though the results cannot be generalized for the exploitation of other reproductive and vegetative parts as fuelwood. Bouget, Lassauce and Jonsell (2012), also in another study surmised that wood extraction is likely to impact habitat conditions in ways that affect biodiversity. Findings based on the synthesis of 88 papers reveal that extraction may on a landscape scale in boreal and nemoral forests jeopardize the diversity and amount of substrate available for saproxylic organisms to use as food and habitat. The edge effect may move further inward, threatening interior species populations.

In a Mexican study on cloud montane forest, a process based forest growth model was used to estimate potential long term impacts of extraction on forest size structure and community composition. Impacts were seen to increase linearly with harvested volume. Findings further showed the forest becoming more homogenous with the disappearance of old trees and an upward rise in the growth of non fuelwood trees. Spetch *et. al*, (2015) in a recent study provided an estimate of the potential impacts of fuelwood harvesting in the Brazilian Atlantic Forest. Interviewing 270 households over 7 rural communities, they examined the nature of the relationship between per capita income and both the likelihood of fuelwood consumption and the biomass of fuelwood consumed by rural populations. They sought to show the likelihood of rural populations relying on fuelwood as a function of the per capita income, the synergism between fuelwood harvesting and shifts in tree species composition due to land use changes.

Findings indicate that harvesting tended to be concentrated within early successional native tree species (80% of cited tree species) which seemed to be a small subset of the species repeatedly cited by households. Dependence on fuelwood was inversely correlated to per capita income categories such that those with higher living standards (earning more than US$ 139) were less likely to use fuelwood. Results suggest that fuelwood harvesting cannot be ignored as an important source of forest degradation in highly fragmented and densely populated landscapes such as the Brazilian Atlantic forest. The Brown *et. al* (2009), report on Australia reviewed existing inferential and correlative evidence available on coarse woody debris to infer impacts on soils. Findings highlight possible impact on soil fertility leading to losses in soil organic carbon (SOC). Suggestions were made for further research into the potential effects on ecosystem processes.

In Asia, Sahoo and Davidar (2013), evaluated the impact of local populations on vegetation structure and diversity of *Sal* dominated forests of Similipal Tiger Reserve and found species richness, diversity, basal area and stand density were lower in the exploited compared with the unexploited plots. Chettri *et. al* (2002), found that fuelwood extraction had distinct varying impacts on tree structure, regeneration of canopy tree species and productivity of woody biomass in different forests in India.

In China, Zhou *et. al* (2009), studied different levels of human disturbance on vegetation in near-natural forests, selectively logged forests, natural regeneration forests, and plantations. The results showed that the structure of forest stands was characterized by a large number of seedlings and saplings and impact was revealed in different abundance, evenness and richness of tree species along the altitudinal gradient.

In Bhutan, Wangchuck (2011), documented how fuelwood consumption impacts on standing biomass through a case study in Nasiphel at different elevations. There was selective consumption of blue spruce *Pinus wallichia* species for fuel. The impacts of these removals on African forests have rarely been studied. Of the few African studies found, Du Plessis (1995), examined the impact of removals of wood on the diversity of cavity-using vertebrate species (log dwellers) in the South African riverine forest habitats. Results indicate the rarity of encountering dead wood on forest floors due to collection by users with less than 10% of sampled trees containing any part as dead wood. There was a significant reduction of recorded true forest fauna species that use soft decaying wood as their homes. Shackelton *et. al* (1994), looked at the effect of disturbances sampled from four rural settlements in a savanna region of South Africa, examining the structure and species composition of the woody and herbaceous vegetation. Generally, diversity, density and height reduced as disturbance from animal grazing, trampling and harvesting occured. Overall species compositional changes were not directly related to disturbance intensity.

Using survey and interview techniques, Sassen *et. al* (2015), examined fuelwood extraction patterns on the edges of Mt Elgon National Park, Uganda. Results indicate impact vary across the park such that more dead wood is found as distance increases into the park. Certain species were over-exploited and removed not just for fuelwood but also timber. Forests may become more degraded in the foreseeable future with more unpleasant impacts on the users. In East Africa, Ndagalansi *et. al* (2007), examined the extraction of plant products (fuelwood, vegetables/ fruits, lianas, building poles etc) from two montane forest ecosystems (Uzungwa Scarp Forest Reserve and Bwindi Impenetrable National Park) using interviews and field surveys. Results show lower densities of eight commonly harvested species in exploited habitats. The environmental impact of this burgeoning increase in use of woodfuels reflect on the volume of wood resources harvested in a region which has the potential to manifest in the long-term ecological condition of an extraction site as loss of its soil, nutrient, carbon and water resources (Brown *et. al,* 2009).

In Togo, according to Fontodji *et. al* (2011), selective logging for charcoal production has led to the near extinction of default species at kiln sites which have currently been replaced by available ones. Soil physico-chemical (pH values) and porosity properties also changed after burning. Similar impacts of charcoal production have been reported on woody species structural characteristics in Togo (Kouami *et. al,* 2009) and pH levels of savanna soils in Nigeria (Ogundele *et. al,* 2012). Generally, due to the sparseness of literature on functional ecological impacts of removals, much of the information on soil changes expected is largely inferential (Brown *et. al,* 2009). Impacts may be varied due to factors such as site characteristics, scales and intensity of extraction. This may result in soil organic carbon and soil fertility decreases.

Generally, soil micro nutrients are essential in relatively small concentrations for optimum growth of vegetation as their occurrence in concentrated amounts may lead to toxicity. These elements are simply classified as functional elements that may indibit or activate enzymes necessary for the proper functioning of the soil.

There are varied reports on how removals of wood/logging have been seen to affect these trace elements, decrease organic C while leaving other nutrients untouched (Asadu *et. al*, 2015; Anderson and Spencer, 1991). This may occur more after forest clearance leading to nitrification. In some studies, increased exchangeable Ca have been reported in some cleared Nigerian forest soils probably resulting from stumps and trunks left from the original forest (Anderson *et. al*, 1991). Others assert that soil results are often contradictory showing that whole tree removals may have little or no impact on nutrient pools compared to stem only harvesting (Antii, 2006).
A few empirical studies on impact of extraction on vegetation available generally point to changes in the vegetal structure of forests when intense. Chettri *et. al* (2002), studied fuelwood extraction rates in Khangchendzonga Biosphere Reserve, India and found that variation in diversity, regeneration and productivity occurred among the vegetation types encountered. Zhou *et. al* (2009), examined human impact on forests at different elevations and findings showed how impact reduced as altitudes increased. Sahoo and Davidar (2015), explored the intensity of human pressure on vegetation and findings indicate as many as 87 of the known 90 tree species were being consistently harvested all year round. Fuelwood was adduced to be the main reason for extraction though other uses were recorded.

Furthermore, ecological differences seem to be markedly accentuated by the choice of tree species preferred by woodfuel harvesters and the predominant tree species left after extraction (Sahoo and Davidar, 2015). This also approximates the findings of Baroody (2013), on harvesting consequence resulting in specie dominance (Pine) induced by harvesting pressure on other species. Similarly in the rainforest zones of Ife and Ibadan, *Celtis sp* , *Ficus sp* , *Funtumia elastica* species are preferred for fuelwood, in the forest-savanna complex of Ogbomoso *Vitellaria paradoxa sp, Acacia sp and Hymencoardia acida sp* (Morgan, 1983), *Anogeissus leiocarpus* in Iwo environs (Oorimogunje and Asifat, 2015). An inevitable consequence of continuous extraction of these preffered species in these areas may be irreversible impacts on standing biomass. Generally, anthropogenic disturbances have been adduced as reasons for changes in specie distribution and growth in Cameroonian forests (Ndah *et. al*, 2013). Comparatively investigating the pattern of fuelwood extraction by 5 user groups in Ugandan forests, Naughton-treves *et. al* (2007), found that the households were the least environmentally degrading group of users due to their preference for fast growing species on fallows. The group with the heaviest negative impact on biological diversity was that of the charcoal producer who preferred old growth hardwood species ultimately leading to losses of natural forests.

In a counter argument, Specht *et. al* (2015), insist that though intense fuelwood harvesting by a lot of people within circumscribed forest areas has been implicated in severe environmental damages, it is not a sine qua non that extraction always lead to permanent environmental change. This is particularly so since African woodland systems are known for their resilience in withstanding disturbance (Bailis, 2005). Often harvesting impacts are not as degrading due to the collectors' preference for dead wood taken from areas where they are abundant (Horst and Hovorka, 2009). Supporting evidence from a 1993 Cebuano study showed that woodfuel production is not synonymous with deforestation as fuelneeds are derived from other sources (Bensel, 2008). The apparent forest loss seen was not singularly due to the harvesting of fuelwood by locals rather, more trees have been planted by landowners due to more commercial demand for fuelwood. Many times fuelwood is not sourced directly from forests as expected since supply inventories hold that much woodfuel in current use are not from forests but from scattered tree populations (TOFS) on farms, at waysides and in waste lands (FAO, 2007). Heavy forest losses occur as a result of neglect and mismanagement of the existing resource (FAO, 2009). Summarily, although fuelwood extraction is no longer deemed a major catalyst in land degradation, its reduction is still important to stemming further degradation (UNDP, 2005). It is obvious that knowledge about the ecological imprints of fuelwood extraction as it relates to soil fertility and tree communities in Africa is still fragmentary particularly since more local level information is necessary to better understand how small scale human disturbances affect landscapes.

2.1.7 The role of Woodfuels in Urban livelihoods

For many people that live or farm around such environments, forests are the primary source points for wood products and other NTFPs (Non Timber Forest Products). Many of these products are usually eaten or sold to provide supplemental income and may sometimes be all that poor families subsist on in lean times (Arnold and Bird, 1999). Woodfuels extraction is an important safety net for large numbers of poor people especially due to the accessibility to wood and the ease with which anyone may participate with no other skills other than picking and cutting. For the rural poor, woodfuels harvesting is a major source of livelihood (Remedio, 1993 ; 2002) deemed so due to its economic value in keeping an average family of six above the poverty line on $1 per day (Aiyeloja, 2009).

Charcoal production touted to be the second largest employer in rural areas after agriculture (Mugo and Ong, 2006; FPAN, 2010; Khundi *et. al*, 2010), is supplied to many large urban towns in the south-west such as Ibadan and others as Iseyin, Igbari, Iwere-ile, Aja-awa, Okeho, Ogbomosho, Ilero (Aiyeloja, 2009). Mainly used by Food producers, such as roasting (maize, yam, plantain), smoking (fish, Suya-meat) and tobacco curing, it also includes industrial users as Cement / Lime manufacturers and even steel industries for metal extraction. Non household use of woodfuels has mostly been to support local craft/ cottage industries. A shift in supplies of woodfuel for many of these users can be severe and threatening to their livelihoods. Vermeulen's work (2001) on scarcity of woodfuel supplies reported declines in pottery (Nepal), salt drying in Thailand, roadside catering, fish-smoking, extraction of palm oil in Ghana and a shift from smoke-drying to air-drying of cassava in Vietnam in the early 1980's. A further review on use patterns by Arnold *et. al* (2006), pointed out the gap in understanding the impacts of decline in use on urban markets and the need for more location or country specific studies to unravel the factors that inform the usefulness of woodfuels as a livelihood activity.

Although, further analysis of this activity has depicted such jobs as limited in scope which may not increase size wise beyond personal or family involvement, it will continue to be one of the few options left for the poor to generate income especially in urban environments. They are seen as temporary routes to survival that will become uneeded when better opportunities for making a living arise. Fuelwood sales are a main stay for many rural homes brought positive socio-economic effects and also meeting the subsistence needs of some urbanites. The general consensus is that as incomes rise in cities woodfuels will diminish in importance with better alternatives displacing it in the market (Arnold and Bird, 1999). Over time both extraction and trading of woodfuels will involve less low skilled, low income people and a few better placed people may turn it to a viable business opportunity.

2.1.8 Energy for Cooking in the Developing World.

The 1983 World Bank country assessment report identified household use of energy to be between 33% and 80% of all energy consumed with a large proportion of these users in the developing world since industrialisation increases incomes and drops household energy use to less than 30 % (Leach and Gowen, 1987). Urban residents generally have been seen to prefer more charcoal to fuelwood as the former is seen as having a greater calorific value, less particulate emission and much more easier to handle and transport (Bailis, 2005). Due to the extreme disparity that occurs in user assessments, it is quite hard to generate generalised information without some measure of distortion, and this makes local gathering of data essential and inevitable.

2.2 Household Consumption

Household users are a single grouping of people that eat from the same pot in the same home unit who use woodfuels to meet basic energy needs. Households are the basic unit that consumes the highest volume of woodfuels ranging between 30 - 99% of the total energy consumption (Leach and Gowen, 1987; Eckholm, 1975; Masera and Navia, 1997; Miah *et. al,* 2009; Mekonnen *et. al,* 2009; Chandra *et. al,* 2009; Khundi *et. al,* 2010; Zulu, 2010; Wangchuk, 2011). There is variation in the pattern of use of rural users (more dependent on fuelwood) and urbanites that rely mainly on charcoal (Ikurekong, Esin and Mba, 2009; Salami and Brieger, 2011). Household characteristics as size, composition, tastes interact with price and urbanisation to affect consumption (Arnold *et. al,* 2003; Mekonnen *et. al,* 2009; Godfrey *et. al*, 2010). Users (usually the poor) often lack affordable alternatives (Leach, 1987; Eckholm, 1975; Horst and Hovorka, 2009) and may adapt to dwindling supplies by consuming more foods that take less cooking time, skipping meals or using less desirable fuels. Household fuelwood use is typically twice the total energy consumption of commercial users (Anderson, 1986).

The Joint UNDP/World Bank Energy Sector Management Assistance Programme conducted extensive surveys using over 25,000 urban households between 1984 and 1997. It emphasized that there are different reasons adduced to levels of woodfuel use variability for different cities. It identified a general movement in use of woodfuels to liquefied petroleum gas and electricity being the final preferred choice of users. Findings highlight the slow decrease in global annual fuelwood consumption, while that of global charcoal annual consumption appears to be increasing. It pointed out however that previous surveys show weaknesses in the database often limiting the precision and scope of the analysis. Other studies have insisted that per capita fuelwood consumption formerly thought to be declining globally, is picking up in countries like Brazil due to a high rise in LPG and fossil fuel prices; while charcoal production is said to have a reducing role in deforestation due to increased sawmill residue use and increasing distances to suitable biomass sites (FAO, 2010). There are still projections that global consumption will double by 2030 at least for charcoal while a 24% increase is expected for fuel wood (Arnold *et. al,* 2006).

2.2.1Non Household Consumption

This segment of users has not been well studied in urban woodfuel literature even though some works have been done on street foods and the urban poor encapsulating essentially almost the same group. They are a significant group that need more light shed on their activities and fuel use patterns as they are important to the subsistence on many urban poor. Much of the sparseness in literature has been attributed to the fact that their consumption seems minute in comparison with the household and some measure of difficulty encountered in trying to characterize their location in space (Arnold *et. al,* 2006). They are now recognized as the user sector that can best absorb market price increases. While commercial consumption has been on the increase in cities as Hydebarad, it is on the decrease in others like Cebu, Phillipines (Remedio and Bensel, 1993; 2006; Arnold *et. al,* 2006). Remedio's research (1993) in Cebu identified important variables useful in conducting consumption surveys on businesses such as size, age, type of business. Generally, urbanisation is the key to the growth of this group in cities. As more people move into the cities from rural areas, they bring with them rural habits of cooking with fuelwood and little incomes with which to subsist. For survival, they seek daily a means of subsistence which requires a move to and from residences (mostly in the periphery) to other parts of the city where jobs may be found. In facing the often long commute from and back home, many resort to food vendors as providers of nutritional needs outside the homestead. Urban households generally spend 30% of their expenditure on feeding from such sources (DFID, 2002).

Generally, it is to be expected that foods cooked on the streets will be mostly by fuelwood, charcoal or kerosene (European Commission, 1986) and households that vend cooked foods will use double the energy of ordinary households (Tinker, 1997). There is variation in the main sources of energy reported to be used by this group in different countries for instance, in Bangladesh woodfuel, kerosene and LPG were the main fuels (Chowdhury and Chowdhury, 2001) while Kenya's main fuel was charcoal. Few attempts have been made to comparatively estimate the amount of woodfuels used in cooking by both commercial food establishments and urban households to annualize the factors influencing their present and future consumption (FAO, 2007), which is an important gap this study fills. An attempt to explore this gap in India was focused on energy, health and fuel savings among restaurants and households (Kowasari, 2013). Results indicate a measure of similarity in drivers for fuel choice, and health concerns were not significantly important in both choices.

2.2.2 The Nigerian Energy Consumption Experience

Studies on Nigeria show a consistent upward swing in its volume of woodfuel production (Dzioubinski and Chipman, 1999) with a constant annual consumption growth rate of 3.5% over a 13 year period (Arnold *et. al*, 2006). This high volume seems to be an outcome of natural increase within the population, large-scale retrenchment of workers in urban centers and sharp increases in the prices of modern fuels (Morgan, 1983; Nadoma, 1988; Kersten *et. al*, 1995; Adebulugbe and Akinbami, 1995; Akintola *et. al*, 1996; Adelekan and Jerome, 2006; Aina and Odebiyi, 1998; Akut, 2008; Olure, 2003). There is significant variation in consumption per time across seasons, by composition, size (Cline-Cole, 1986; Akintola *et. al*, 1996; Kersten *et. al*, 1998) as fuel choice is affected mainly by availability and affordability (Alabe, 1996; Adelekan *et. al*, 2006). There are markedly divergent views on which is the most common domestic cooking fuel used especially in urban areas. Kerosene was reportedly used by more than 48% of the urban population in different parts of South-western Nigeria (Oyerinde, 2010; Oyekale, 2012; Ogwumike *et. al*, 2012; Ajah, 2013; Amoah *et. al*, 2015; Emagbetere *et. al,* 2016) while others indicated that the use of multiple sources of fuel per household was more common in urban centers than the rural (Adewole *et. al,* 2002; Madukwe, 2014). Conversely, a return to fuelwood/charcoal had been reported given recent price spikes of kerosene and its attendant scarcity (Adelekan *et. al,* 2006; Maconachie, 2009; Naibbi, 2013).

An empirical study on the relationship between urban demands and local fuelwood management systems in Northern Nigeria (Cline Cole, 1986) gave insights on urban consumption, trade, ecology and management of wood fuels. Findings challenged the hypothesis of depletion of trees in the urban hinterland due to transport costs and showed how agro forestry changed the land cover of the area. Major non household users include food sellers, boarding schools and prisons with a wide range in volume used as 16 fuelwood bundles to as many as 3,200 bundles (350-7,000 kg) using a bundle conversion equivalent to be 22kg. Other consumption studies in contrasting forest and savanna ecosystems in Efon-Alaye/Ijebu-Jesa and Minna (Akintola *et. al,* 1996; Gbadegesin and Olufemi, 2011) point to kerosene as the primary household fuel, and a strong household preference for fuelwood. Informal businesses also used fuelwood but a higher volume of charcoal than households. Ile-Ife also housed a large number of commercial users as dyers, gari-makers who depend on fuelwood no matter their income level while restaurants and food sellers got over 90% of their energy supply from wood (Kersten *et. al*, 1998). There was no interest in fuel switching.

A noteworthy rural energy systems project based on 3 southern areas in Nigeria (Ife, Ibadan, and Ogbomosho) was done in 1983 by a team of international and local collaborators/academics focused on consumption and distribution among dealers, households, industries, offices, shops and institutions, to understand urban market influences on rural energy supply. They presented as part of their findings prevalence in the use of wood by informal industries with charcoal being reserved for a few special occasions. The rural area had a higher consumption level of fuelwood and kerosene than its urban counterpart (Morgan, 1983). This is similar to Ajah's finding of more biomass/fuelwood use in rural areas (Ajah, 2013). A smaller study (materializing from the extensive collaborative investigation) focused more on Oyo i.e Ibadan and Ogbomosho (Ayoub, 1988). It was directed at rural domestic consumption of different energy sources in two ecologically unique environments in Oyo State. Findings indicate little variation in consumption among households despite disparities in income levels, and even amidst the two contrasting ecological systems. Ogunkunle and Oladele (2004), also corroborate that in Ogbomosho households, there was a similarity in the different purposes fuelwood was used for but in different local governments, variation existed in the volume consumed. Yet recent studies of patterns of use suggest a departure from this. In Ibadan, research reflects variation in household consumption amidst the core and the periphery with higher volumes consumed by the periphery (Oyerinde, 2010).

Comparing areas within Ibadan, there are differences in volumes used among the urban, peri-urban and rural households in Ibadan with the most commonly used fuel as electricity and kerosene and wood least used (Oyerinde, 2001). The peri-urban and rural areas had a higher usage of wood than the core. Conversely, Azeez *et. al* (2014), claimed that up to 60% of a sample of 100 low income earners in Ibadan metropolis used fuelwood intensely. Oyekale *et. al* (2012), on the other hand insisted on the high use of kerosene by households and called for a fossil fuel subsidy as a means of ultimately reducing deforestation and indoor air pollution. In response to increasing commercial fuel prices over time, the general pattern of cooking energy consumption in low and middle-income households in Ibadan had changed (Adelekan and Jerome, 2006). Siong *et. al* (2011), also suggested that there existed significant variation across three LGA's in Ibadan and a high dependence on woodfuels and kerosene as cooking fuel by food vendors. Exploring this behavioral shift comparatively along the lines of why and if fuelwood is still relevant as a main energy source for cooking in Ibadan becomes imperative in this study.

2.3 Conceptual Framework

Early woodfuel narratives often begin with how incessant demand for the fuel in cities often result in scarcity of the wood in the surrounding environment requiring a widened search for supplies to meet needs and the emergence of fossil fuel markets as alternatives. This has been challenged by current studies that point out that in the light of local social and cultural realities, scarcity can hardly be said to be in place in these African countries (Horst and Hovorka, 2009; Bembridge, 1990; Bensel, 2008). Although, past forecasts about urban fuel preference suggest a change to more charcoal than fuelwood (Arnold *et. al,* 2003), with more defined extractive imprints on the physical environment, more studies are needed to unravel issues surrounding the woodfuel scenario. For this study of fuelwood, a number of themes have been used in explaining the interaction of the major contributory agents. For the physical effects of extraction, Soil-vegetation concept has been used while the social dimension can be adequately examined using the Driver Pressure State Impact Response (DPSIR) and the Multiple energy fuel stacking framework.

2.3.1 Soil-Vegetation Concept

How human-environment interactions shape existing landscapes is an important and challenging issue in ecological discourses. This is because human induced changes are one of the principal ways biodiversity gets altered. To get an understanding of how these changes occur requires a further look at the interrelatedness of the environmental components. These include mainly soil and ecosystem properties affected by five factors of potential biota, topography, climate, parent soil material and time. Human impact also influences these factors which in turn affects the kind of plant community formed in any area (Mueller-Dombois and Ellenberg, 1974). The way these habitat factors impact on ecosystems depend on other interactions among organisms in the ecosystem, nutrient resources, temperature modulators, disturbance regime and human activities (Lindermann *et. al,* 2006).

Of these influences, disturbances play a major role as a direct or unintended influence that may be exerted continuously or in a regularly repeated manner on these environmental factors. An example is tree crown distortion by wild elephants, feral goat grazing effects on specie composition in Hawaii (Mueller-Dombois and Ellenberg, 1974). Human disturbances as wood removals therefore have the potential to affect ecosystem processes and such influences may be evaluated by analysis of specie responses to variation in single habitat factors as soils and vegetation. Although a lot of factors can be impacted by extraction of wood, two visible indicators of disturbance that are of paramount importance in this study are vegetation and soils. They are significant because they quickly reveal ecosystem degradation in the ecosystem (Zhou *et. al*, 2009).

Soil is the primary medium for plant growth, and formation providing anchorage for plant roots and supply of inorganic nutrient ions, water and oxygen necessary. Properties such as depth of the soil, porosity, soil air and moisture levels and amount of nutrients available have great influence on the types and abundance of vegetation that grow on any given soil (Linderman *et. al*, 2006). Measurable soil indicators used as surrogates for soil attributes are correlated with tree growth and are sensitive to impacts from land use practices. As such, it is the norm to measure organic matter content, soil pH, total nitrogen and other trace elements to detect changes in soil fertility (Antii, 2006). Plants on the other hand enrich soils by the decomposition of litter dropped and help maintain soil nutrients cycled through the system. Soil-Vegetation interrelationship is crucial to the stability of any ecosystem as it is a visible indicator of the state of the environment revealing impact of human activities on ecosystem processes (Ruuska, 2012; Ezebilo, 2004). A closer examination of plant dendrometric characteristics and diversity as primary indicators reveal the health of the ecosystem (Kouami *et. al,* 2009).

2.3.2 Concept of the multiple fuel energy consumption

Past studies have highlighted the prevailing influence of households as the main consumers of fuelwood and have sought to answer questions on what drives such use theoretically and empirically using different approaches such as the energy ladder hypothesis (Arnold *et. al*, 2006; Masera *et. al*, 2000), the Engle curves (Mekonnen *et. al*, 2009; Heltberg *et. al*, 2000) and other econometric analyses using energy demand functions in different energy sub sectors in different countries (Bohlin *et. al*, 2002; Adebulugbe *et. al*, 1995). There is a general consensus in literature that the household is the basic unit that consumes the highest volume of woodfuels. The key determinants of demand are;

a) The price of the fuel and the appliance to be fuelled,
b) The income of the user,
c) The availability of the fuel
d) Cultural preferences.

The most widely used hypothesis is that of the energy ladder which as a derivative of the economic theory of consumer behavior; potrays energy consumption as a movement from traditional sources to more sophisticated sources in a hierachical manner as incomes of users improves (Hosier and Kipondiya, 1993; Masera *et. al,* 2000). There will be a shift from consuming cheaper but less convenient fuels (wood, other biomass) to medium priced fuels (charcoal, kerosene) and finally to expensive cleaner fuels (LPG, electricity). There is an assumption that cleaner fuels are normal economic goods while traditional fuels are inferior. Literature points to income, fuel prices, government policies and user characteristics as important influence on how much a household consumes. More urbanites use more kerosene, LPG, and electricity than ruralites. Urban consumption is also often affected by government policies and prices than income. In Nigeria, literature identifies major energy sources for households to be fuelwood, kerosene, LPG and electricity following the energy ladder approach while there are little or no known references examining how food vendors make their energy choices for cooking and develop their transition patterns. A more recent hypothesis termed Fuel stacking or multiple fuel use thesis holds that households in countries as Nigeria often do not switch completely to modern energy sources but instead tend to consume a combination of fuels. This means households choose different fuels when needed than completely abandon one fuel in favour of another (Masera, 1997, 2000; Brouwer, 2004; Joon *et. al,* 2009; Mekonnen *et. al,* 2009). This meant more fuel types were used as incomes of the households grew. Contrary to the energy-ladder hypothesis, woodfuel types are not inferior; rather there is the need to focus on other factors besides household income (such as improved income and education) in policy design to enhance the likelihood of households to consume modern fuels.

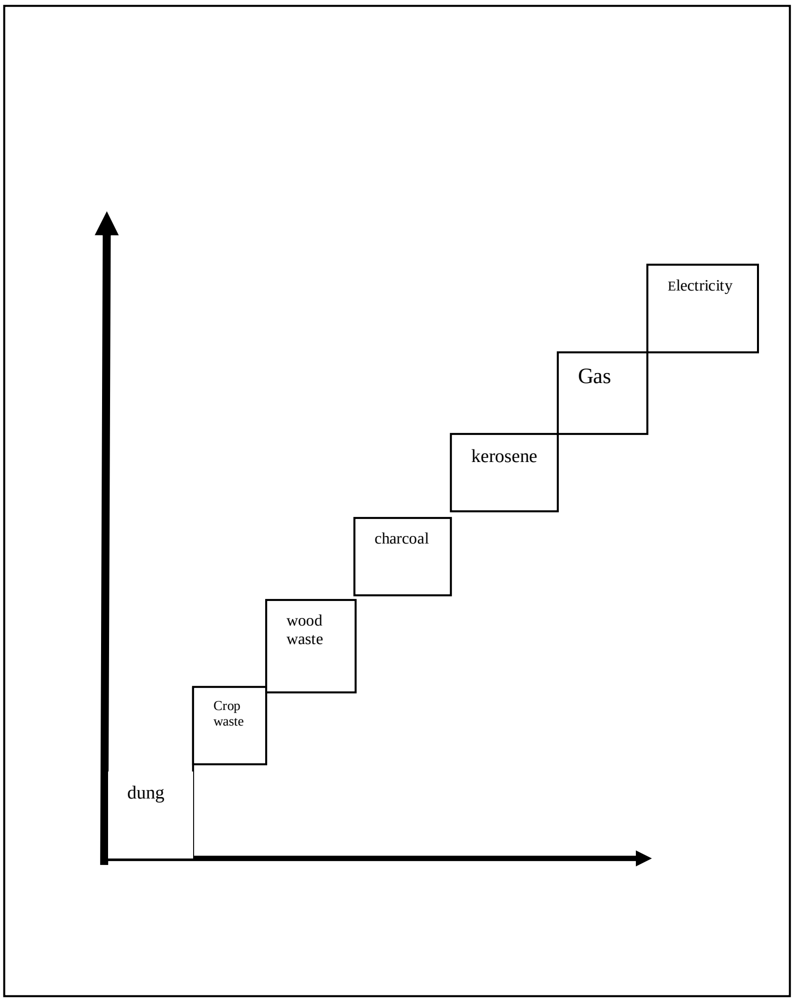


Figure 2.0: Schematic Representation of the Energy ladder
Source: Rajmohan and Weerahewa (2010)

2.3.3 The Driver Pressure State Impact Response (DPSIR) Theory.

DPSIR theory is a framework used as an intergrated approach for giving an overview of the impact of human choices on environmental quality. It is often used to capture the relationship between environmental factors and human activities in a simple manner. It has been used by several researchers to communicate policy relevant research to stakeholders about issues in the environment. Although the framework has been criticised for being too simplistic and ignoring key non-human drivers of environmental change (Svarstad *et. al,* 2007), it remains a useful construct for interpreting environmental change.

The root of the DPSIR framework was first developed under the Stress- Response framework created by Statistics Canada in the late 1970's. This later metamorphosed into DPSIR concept under the input of the European Environmental Agency (Svarstad *et.al,* 2007).There are five key interactive forces in the DPSIR construct, the first of which is the driving force that is often economic or social or environmental in nature. The others include Pressure, State, Impact and Response. The driving force usually manifests in the form of needs which may be primary or secondary in nature. Often birthed by the developments that occur in society, these needs have to be met through various human activities which eventually exert certain influences or pressures on the environment. These pressures often manifest as excessive depletion of environmental resources, pollution in the environment, human health compromises and degrading land use changes (Kristensen, 2004). This leads to changes in the physical, chemical and biological states of the environment (such as soil and ecosystem quality). These states have impacts on the health and functioning of the environment and many of these negative impacts eventually lead to policy changes i.e political responses.

For the purpose of this study, increased demand for cheap energy sources for daily susbsistence as a driving force can lead to the intensification of fuelwood extraction which results in pressures on the vegetation and soils of the particular area of focus. This can alter the physico-chemical condition of the soils as well as the structural characteristics of the surrounding vegetation (State). This ultimately may reflect as noticeable impacts on the health of the ecosystem and the societal responses may be more stringent laws on fuelwood use or extraction of wood in forests.

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This study was designed to investigate the effects of fuelwood extraction (forest and savanna) on vegetation characteristics, associated soil properties, and fuelwood consumption differentials between households (HH) and food vendors (FV) in Oyo State. This chapter presents the methodology used in both the bio-geographical part of the study entailing a field survey of fuelwood exploited areas and a social survey to determine fuelwood usage within the city.

3.2 Research Design

In studying changes in the environment, geographers have been found to use different methods depending on the type of data to be collected as well as the scale of what is required. Current approaches are more of an integration of both social and scientific methods (mixed methodology) to help assess man's environmental impact. While past fuelwood researches have been mostly interview/ questionnaire driven (Kersten *et. al*, 1998; Alamu and Agbeja, 2011; Orimogunje and Asifat, 2015), this study engages a mixed method approach using both empirical testing and qualitative techniques to generate a well rounded understanding of fuelwood issues.

Methods used included a vegetation inventory which is a stock take of vegetation composition, structure, and condition at one point in time, without any intended re-measurement (Alan, 2012). This being a cross-sectional study was focused on a time period in 2015 and did not observe trends.

3.2.1 Types and sources of data employed

Data utilized for this study comprises both primary and secondary data. The primary data included field measurement of vegetation samples and soil samples; observations, face to face administration of questionnaire for detailed socio-economic data collection. Secondary data utilized include maps, Canteen Workers data from the Oyo State Food Workers Association, statistics and literature. Two data collection periods took place for this study; first in January and February 2015 for the fuelwood extraction and the other in September and December 2015 for the consumption sampling.

3.3 Sampling of fuelwood extraction study area.

The choice of Oyo State for this multi-site study was informed by two factors;

(1) It has a distinctive characteristic of containing both dense tropical forest and derived savanna vegetation (Ayoub,1988)

(2) Present within the same bounded space in Oyo was Old Oyo National Park, Onigambari forest reserve with relatively unexploited vegetation. The reserves were specifically chosen due to their relatively stable ecological conditions which made for effective comparison of results of the study, contrasting the different ecosystem responses to fuelwood extraction. This enhanced the quality of the research (Zhou *et. al,* 2009). A fuelwood Exploited Forest (EF) ecosystem site in Igbo-Oloyin (Ibadan) and fuelwood Exploited Savanna (ES) site in Iseyin (Serafu) were each purposively selected based on the outcome of an Ibadan fuelwood merchants' survey. Control sites for exploited forest (CF) and control sites for exploited savanna (CS) were appropriately located in the forest reserves. Using a Garmin etrex 10 GPS, coordinates of each site delineated were taken for greater locational accuracy. A reconnaisance field survey was also done in the exploited sites (Serafu and Alaja) before the actual survey which yielded the indices of an abundance of fuelwood piles gathered near (Plate 3, Plate 4 and Plate 5) and on site marks of cut limbs, wood chips, fines and trunk removals of trees (Lykke, 1998; Chettri *et. al,* 2002; Sahoo and Davidar, 2013). Care was taken to ensure the selected sites were without sharp slopes and homogenous in terms of relief (Mueller-Dombois and Ellenberg, 1974; Westhoff and Maarel, 1978) and were known to be similar to the environmental conditions found in the reserves (Onigambari and Old Oyo national park, Oyo Ile). Oral permission to conduct the research was sought and received from the respective village heads and both written/ oral official approvals received from the National Park/Reserve (Appendix VIII).

Plot sizes have been shown to be important in conducting studies on vegetation (Otýpková and Chytrý, 2006) and a choice of 20m by 20m (400m^2) quadrat size was made due to the large nature of the specimens (trees). Within both forest and savanna fuelwood exploited sites, twelve plots were identified and marked along a 480m transect with a randomly established origin within the selected areas as represented in Fig 3.1 (USBLM 1999). These plots were representative of both forest and savanna in terms of tree species abundance, richness, density and soils to allow for a good comparison (Mueller-Dombois and Ellenberg, 1974). Twelve more samples were taken each from the forest and savanna reserve areas (control points) making a total of 48 plot samples in all. Only tree species ≥ 20cm within the quadrats were measured and enumerated. Plant identification was done by a taxonomist following Keay *et. al,* (1953) and Gbile, (1988).

Plate 3: Fuelwood harvested and piled by bush paths, roads sides at Alaja forest.
Source: Fieldwork, February 2015.

Plate 4. Iseyin savanna woodland showing piles of fuelwood by roadside.
Source: Fieldwork, January 2015.

Plate 5: Iseyin savanna woodland showing charcoal laden truck carrying produce out of area.
Source: Fieldwork, January 2015

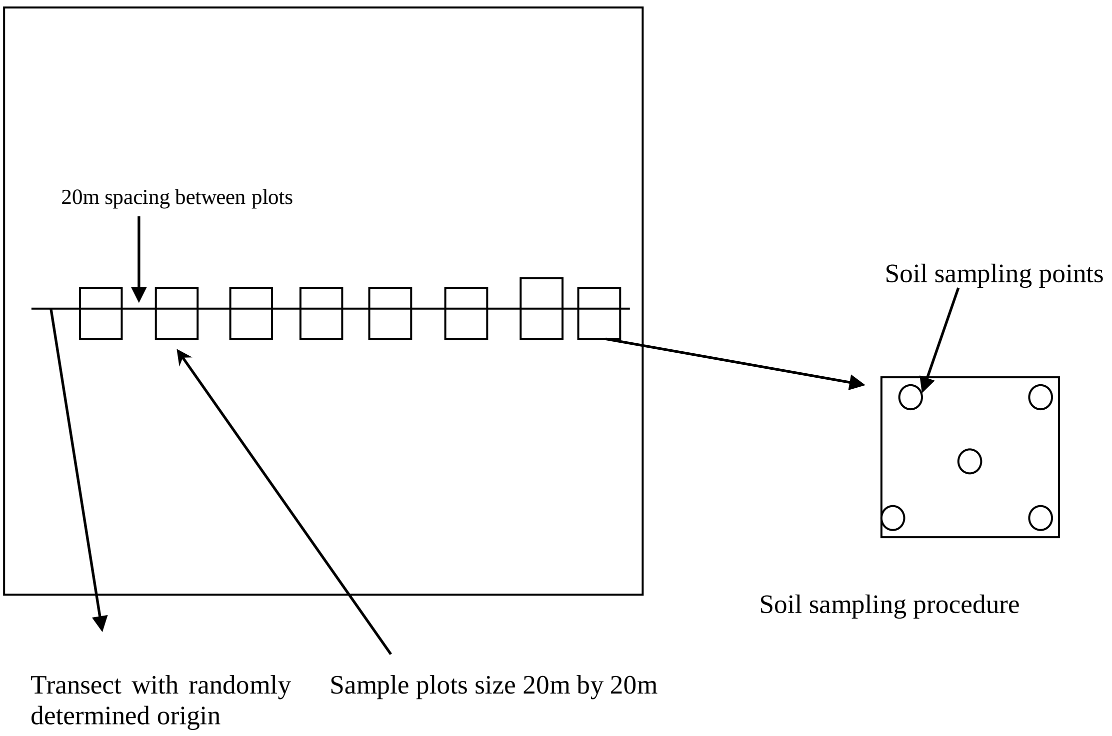


Figure 3.1 Diagrammatic Representation of Field data collection

3.3.1 Vegetation Data Collection

To understand the developmental status of the community, investigations into dendrometric changes in plant biomass were done using parameters detailed by Mueller-Dombois and Ellenberg (1974), as follows;

Tree Height

Tree height (m) was measured with a Hagar altimeter (Alan, 2012).

Girth at breast height

Girth at breast height (GBH) (cm) was determined from tree girth (cm) or circumference of each tree taken at the tree breast height (1.37m) above the ground. The tree girth was measured with a calibrated tape rule. The formula used to determine the dbh was;

$C/\pi = d$

Where,

C is the circumference or girth of the tree

π is Pie = 3.142

d is the diameter at breast height

Basal area

Basal area is the cross-sectional area of trees stem (trunk) at breast height. Basal area (m^2) was calculated from a known relationship with diameter at breast height using the formula Basal area (BA) = $\pi D^2/4$ or $g^2/4\pi$

Finding d = g/π

Where g is girth at breast height

d is a diameter at breast height

π = 3.142, 4 is a constant value.

Species composition

Species composition of tree species was determined by counting the number of individual species in each quadrat.

Tree Species Density

Density is simply the number of individual tree species per unit area and is generally reported as the number of trees per hectare. It is a useful expression of the numerical strength of a species and is used to determine the health of an ecosystem.

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrats}}{\text{Area of the quadrats in hectares}}$$

Species Diversity

The species diversity index (H') was computed using Simpson's index (Simpson, 1949).

The formula for computing Simpson's diversity index (D) was;

$$\mathbf{D} = \sum_{i=1}^{s} \frac{ni\,(ni-1)}{N(N-1)}$$

Where,

n*i*= the number of individuals of *i*th species

N = the total number of individuals.

The value of **D** ranges from 0 to 1 where 0 represents infinite diversity and, 1, no diversity. As such the interpretation of such values can be termed to mean bigger the values represent lower diversity.

Similarity Index

Similarity index of the tree species in the different forests and savannas was determined by Sorensen formula (Sorensen, 1948). Sorensen's index is expressed as;

$$SI = \frac{2C}{A+B} \, x \, 100$$

where

C = number of species in sites A and B;

A = number of species at site A and not in B;

B = number of species at sites B and not in A.

3.3.2 Soil Data Collection and Analysis

Soil samples were collected from five sample points in each plot where vegetation measurements had been taken (Fig 3.1). With the aid of a soil auger, samples were taken at a depth of 0-15cm of the top layer and bulked together to form a composite sample kept in well labelled polythene bags. Sampling was constrained to this layer since organic matter accumulation is concentrated here and there is little variability in C and N pools at further depths (Aweto, 1981(a); Pennock *et. al*, 2008). Twelve control samples were taken each from the forest and savanna reserve areas (control points) making a total of 48 soil samples. These were taken for laboratory analysis using standard methods to determine the physical and chemical properties of the soils. Among the physical soil properties that were determined, particle size distribution is the most stable and often used to capture the state of productivity of soils (Brady and Weil, 1999). The hydrometer method following Bouyoucos (1951), was used to analyze soil particle size. For the Bulk density and total porosity analysis, the core method was used (Arshad *et. al,* 1996) and water holding capacity as described in IITA Manual (1979). Exchangeable bases such as Sodium (Na), Potassium (K) and Calcium (Ca) were determined by flame photometry.

The atomic absorption spectrometer was used to determine Magnesium (Mg) while the Kjeldahl steam distillation method was used for determining total Nitrogen (N). Cation Exchange Capacity (CEC) was determined by the summation method (Chapman, 1965) and Available Phosphorous (P) was extracted with Bray and Kurtz solution (0.025M HCL to 0.03MN H_4F) using Murphy and Riley method (I.I.T.A 1979). The Organic matter (SOM), an important parameter that influences the chemical and biological properties of soils was determined using the wet oxidation method of Walkey and Black (1934), while soil pH was measured potentiometrically in 0.01M calcium chloride solution using 1;2 soil/water solutions. Extracts used for determining heavy metals (trace elements) were obtained by leaching soil samples using 0.1N EDTA and the concentrations of extractable trace metals such as Cobalt (Co), Copper (Cu), Lead (Pb), Iron (Fe), Manganese (Mn) and Zinc (Zn) in the solutions were determined using atomic absorption spectrometer (AAS) (U.S.D.A, 1972)

3.4 Fuelwood Consumption Sampling Procedure.

To derive realistic values for quantifying the role fuelwood plays in the livelihoods of households and commercial consumers, Ibadan was chosen based on two factors;

(1) According to Adelekan and Jerome (2006), Ibadan metropolis had been identified as the largest indigenous urban center in Africa found to have high consumption of fuelwood. Its core particularly has been known to depend heavily on fuelwood (Oyerinde, 2010) which further signals the need for more city oriented research.

(2) The availability of key local information on the organisational make-up of food vendors as well as previous secondary household consumption data which forms the basis for comparison (Ayoub, 1988).

To effectively show variation in fuelwood consumption amidst users, the study elicited samples from both household and commercial users (Kersten *et. al*, 1998). Due to the nature of and variability in size of commercial consumers, food vendors were purposively selected as the main respondents since they are known to be in the majority among commercial wood fuel users following Hyman's study (cited in Remedio, 1993). The main tool used for the survey was the questionnaire which was a useful tool for generating information from respondents over a wide area and also help in validating past assertions. Both types of questionnaire (food vendor and household) had questions related to socio-economic characteristics such as gender, age, educational level, fuelwood consumption, energy use habits, price and preference as well as awareness of the environmental implications of fuelwood extraction, location; education; housing; livelihoods, environmental awareness and opinion about conservation (Appendix IV, V). The survey was conducted within 200 households and 200 food vendor outfits. The questionnaire was administered on the household head or food business owner. Questions were drafted in English and later translated to Yoruba the most common language spoken in the area.

The sample sizes for both households and food vendors were limited to 200 each, given the conclusions from Ayoub's 1988 study on Ibadan, Ile-ife and Ogbomosho that relatively smaller samples would be just as effective in collecting needed information without jeopardizing the validity of the results (Ayoub, 1988). The researcher arrived at this conclusion after successfully generating replicable results using a smaller subsample (300) of a large data set of 6293 energy users using exact Random sample procedure to manage its unwieldiness in computing (Ayoub, 1988). For the household sample selection, a non random selection of target areas was done using a ward/area listing of each of the five local government areas within the core area of Ibadan (Adelekan and Jerome, 2006) from which the major street network was identified and a random origin taken. Every fifth house was selected for the survey until the quota for households was completed. For the commercial fuelwood users (food vendors) the sampling framework was derived from the listing of members of the Oyo State Canteen Workers Association headquartered at the secretariat in Oranyan, Ibadan South East LGA. The Association was categorised into five local governments within the Ibadan Metropolis including Ibadan North, Ibadan South East, Ibadan South West, Ibadan North West and Ibadan North East. Each Local government was further subdivided into zones for greater manageability and randomly sampled as seen from Table 3.1 (Listing of areas is shown in Appendix VI). The sampled food vendors all had shop/outlets and were not mobile food hawkers.

Table 3.1: Oyo state Canteen workers subdivisions and samples taken for study.

Lga	Total listed members (population)	Number of selected samples
Ibadan North	718	35
Ibadan Northwest	531	27
Ibadan Northeast	957	47
Ibadan Southeast	1159	57
Ibadan Southwest	700	34

Source: Oyo state Canteen Workers Association, Oranyan, Ibadan.

3.4.1 Fuelwood Consumption Data Collection.

Different methods of determining domestic fuelwood consumption have been studied (Fox, 1984) and the weight survey method was found to be the most accurate but laborious. Although the annual recall method generally overestimated quantities by factor of 1.95 attributable to socio-physical factors, it was recommended as the most practicable with occasional weighed measurements done to improve accuracy (Fox, 1984). To generate fuelwood consumption data for this study, the recall method was combined with weighing to give more robustness to the data. A 50kg handspring balance was used to weigh the bundles of fuelwood on each household/ vendor site to generate an average bundle /weight constant. Respondents were asked to recall how many bundles had been used for that day and this figure was multiplied by the weight constant to estimate the daily consumption for that particular user (Njiti and Kemcha, 2003). Simultaneously, the remaining unburnt logs of the last used bundle (if any) were weighed and subtracted from the daily consumption to reduce overestimation (Kersten *et. al* 1998, method III).

For charcoal, the method of setting apart fuel enough for a day's use and the remnant weighed the next day (Remedio, 1993; Kityo, 2004) was not fully applicable in this case as many of the vendor respondents would not keep to only using from the restricted pile. Many were suspicious of the effect of using such fuel on their sales for the day. As such, the daily recall method was also used in combination with the weighing method. Most vendors had a clear idea of how much was used per day due to its importance in profit maximization. This recall figure was multiplied by the average weight of the respondent's charcoal bag to get the average daily consumption. To estimate consumed quantities less than a full bag, the remnant fuel after the days cooking was weighed and subtracted from the average weighed charcoal bag used by the respondent.

3.5 Data Analysis for Fuelwood Extraction.

The following research hypotheses were tested with inferential statistics using the Statistical Package for the Social Science (SPSS) software version 20 and the Data analysis module in Microsoft Excel 2007 to analyse the data.

Hypothesis 1: There is no significant difference in vegetation characteristics (Tree density, diversity, species composition, tree structure) between fuelwood extraction sites and unexploited sites in both forest and savanna areas.

Parameters used in testing the hypothesis include the mean values of specie composition, plot specie number, tree density and tree count, key specie count, plot specie diversity, mean dendrometric characteristics (Basal area, girth at breast height and tree height) found in each forest. Results were tested using Student's t-test (Gregoire, 1999; Pitman *et. al,* 2002). Descriptive statistics was used to describe the mean values of the parameters of tree structure of both forest and savanna plots. Tables, averages and simple percentages were employed to assess and explain the mean value distribution of the vegetation properties. Patterns of spatial variation between the forest vegetation pairs and between the savannas pairs were captured using Size Class Distribution (SCD).

Hypothesis 2: There is no significant difference in soil properties of fuelwood extraction sites and unexploited sites in both forest and savanna areas. This was also tested using Student's t-test.

Parameters used in testing the hypothesis include the mean values of physical soil properties such as particle size composition, bulk density, total porosity, water holding capacity; as well as those of the soil chemical properties (soil pH, organic matter, Nitrogen, Zinc, Iron, Copper, Exchangeable sodium, Exchangeable potassium, available phosphorus, CEC) Statistical testing was done with the students's t-test. Descriptive statistics was used to describe the mean values of each soil property and results comparatively displayed in tables, averages and simple percentages.

Hypothesis 3: There is no significant relationship between structural characteristics of trees and soil properties of fuelwood extraction sites.

Parameters used for to test this hypothesis include the mean values of each plot sample for both vegetation and soils. The relationship between the tree parameters and soil properties was assessed with Detrended Correspondence correlation analysis using the Paleontological Statistics (PAST) software (Hammer *et. al*., 2001) version 2.17c (2013). To incisively investigate the interrelationships of environmental parameters and abundance of another parameter such as in soil-vegetation relationships, the multivariate analytical tool Detrended correspondence analysis (DCA) has been used by a number of researchers (Eni *et. al,* 2012; Sherry and Henson, 2005) to derive answers on the nature, strength and type of relationships that occur between multiple variables. The focus is on the relationships between two sets of variables.

3.5.1 Fuelwood Consumption Data Analysis

Hypothesis 4: There is no significant variation in consumption of fuelwood across households and food vendors in Ibadan metropolis.

Descriptive statistics module using the Statistical Package for the Social Sciences (SPSS) software was used to determine the basic distributional characteristics of each variable identified such as demographics, primary energy sources for cooking, pattern of fuelwood use and expenditure on fuelwood across the five LGAs. A Co-efficient of Variation analysis was done to test for variation between mean vendor consumption and mean household consumption across the five local governments using the average daily weights of fuelwood (kg) consumed. Student t test was used to test the results. The location of each respondent was also taken with a GPS handheld device to generate data which was processed using the Geographic Information System (GIS) software Arc GIS to produce the map of sampled food vendors in the city.

Hypothesis 5 which states that user characteristics do not significantly influence consumption was tested using multiple regression analysis.

Parameters used include vendor sex, age, marital status, level of education, number of years in business and number of workers.

CHAPTER FOUR

EFFECTS OF FUELWOOD EXTRACTION ON FOREST AND SAVANNA VEGETATION AND SOILS

4.1 Introduction

This chapter discusses the effects of fuelwood extraction on vegetation; specifically on tree species composition (number of species), density, diversity, richness, and similarity index of trees found under the savanna and forest plots. It also discusses the effect of fuelwood extraction on physical properties of soil namely particle size composition (clay, sand and silt), bulk density, water holding capacity and porosity; as well as chemical properties. The approach adopted was to compare the properties of soils and vegetation in the extraction zones with those of the control areas to infer the effects of extraction on the environment. The following sections present the results and discussion.

4.2 Objective One

This was to characterize and compare effects of fuelwood extraction on vegetation (tree density, diversity, species composition and tree structure at savanna and forest extraction sites.

4.2.1 Species composition, tree density, tree count and number of tree species in forest and savanna vegetation in Oyo State.

The species composition for each of the four areas determined by counting the number of occurrences of each particular species is found in Table 4.1. Table 4.2 also shows the number of species found per plot, while details of the local names and families are presented in Table 4.3. The species composition of trees in the two forests (Exploited Alaja and Control Onigambari reserve) were made up of seventy one (71) species altogether and the total population was 325 while the exploited and control savanna plots had thirty seven (37) species with a total population of 216. This finding is similar to those of other scholars showing that forest areas have a higher number of species per area than savannas (Adejuwon and Adesina, 1988; Ratnam *et. al*, 2011). Comparatively, the tree population in the exploited forest plots was lower (73) than in the Control plots (159), and key species common to both woodlands showed variation in tree count and abundance (Fig 4.1). Although both sites had 11 tree species in common, specie richness recorded for the exploited forest plots was lower (43 species) than for the control plots (45 species).

These findings support other forest research results that highlight tropical forests to possess low specie densities, high diversities while manifesting very little degree of trees clumping (Ratnam *et. al,* 2011; Keay, 1953; Emuh and Gbadegesin, 2009). On the converse, the two savannas had higher species density and a higher degree of commonality in number of tree species (17) for both exploited and control plots. Variations observed include lowered specie richness in the exploited savanna plots (23) as against the control plots (27); lowered mean specie value of 4.2 for the exploited plots as against 6.8 for the control plots. Species seen to have higher tree counts in the exploited forest plots than the control forest include *Albizia zygia* and *Antiaris toxicaria*. This observation on forest composition belie an important distinction about small scale disturbances as fuelwood extraction, that is such activities do impact on specie richness and density in a strong measure but are much less destructive than charcoal production and timber harvesting (Kersten *et. al*, 1998; Alamu and Agbeja, 2011 ; Orimoogunje and Asifat, 2015).

Comparatively, the exploited and control forests exhibited slightly different patterns of specie composition. Alaja (exploited forest) reflected the characteristics of a secondary forest (surrounded by homesteads and agricultural lands) seen in the presence of local preferred trees as *Baphia nitida, Albizia zygia, Alchornea cordifolia, Newbouldia laevis.* Many typical pioneer trees (*Ceiba petandra*) were missing and most of the dominants (*Antiaris toxicaria*) noticed were multipurpose trees that occurred in single stands throughout the forest. In comparison, Onigambari natural forest plot appears to be a secondary forest that has taken on similar characteristics to mature rain forest vegetation. This was reflected in the high number of seral and primary species found, of which many had large diameters as corroborated by Salami *et. al*, (2016).

Summarily, a forest-savanna comparison seen from Table 4.2 reflects greater species erosion in the exploited savanna plots than the forest plots. Previous findings from other climes in Asia (Sahoo and Davidar 2013) and India (Chettri *et. al*, 2002) also suggest a greater extraction pressure on biomass in open canopy forests than on closed canopy forests due in part to a high number of tourist camps and settlements along the reserve. Conclusively, it can be seen that human disturbances in form of fuelwood extraction impacts on tree population and specie richness of both forest and savanna regions but with different intensities.

Table 4.1. Species composition and number of tree species in forest and savanna vegetation in Oyo State.

S/N	Species	Onigambari (Forest)	Alaja (Forest)	Oyo-Ile (Savanna)	Serafu (Savanna)
1	*Acacia hockii*	-	-	4	-
2	*Afzelia africana*	1	-	5	3
4	*Ajadin,ajade*	-	-	-	1
5	*Albizia ferruginea*	3	1	-	-
6	*Albizia zygia*	2	11	-	-
7	*Alchornea cordifolia*	-	2	-	-
9	*Alophylus africana*	-	4	-	-
10	*Alstonia boonei*	4	-	-	-
11	*Anacardium occidentale*	-	-	-	4
12	*Ancistrophyllum secundiflorum*	-	-	1	-
13	*Anogeissus leiocarpus*	-	-	2	7
15	*Anthocleista djalonensis*	-	1	-	-
16	*Antiaris toxicaria var africana*	1	10	-	-
17	*Abo*	-	-	-	2
18	*Asa funfun*	-	1	-	-
19	*Asasa*	1	-	-	-
20	*Azadirachta indica*	-	-	-	8
20	*Blighia sapida*	2	2	-	-
21	*Blighia unijugata*	-	8	-	-
22	*Bombax buonopozense*	1	-	-	-
23	*Bosqueia angolensis (trilepisium)*	8	5	-	-
24	*Bridelia micrantha*	-	2	-	-
25	*Bridellia ferruginea*	1	-	6	6
26	*Burkea africana*	-	-	6	16
27	*Buse*	-	-	-	1
28	*Cedrela odorata*	3	-	-	-
29	*Ceiba pentandra*	3	1	-	-
30	*Celtis mildbraedii*	2	-	-	-
31	*Chordea alliodora*	1	-	-	-
32	*Chrysophyllum albidum*	2	1	-	-
33	*Citrus medica*	-	1	-	-
34	*Cola gigantea*	5	-	-	-
35	*Cola millenii*	8	1	-	-
36	*Cola nitida*	1	5	-	-
37	*Cordia millenii*	3	-	-	-
38	*Cussonia arborea*	-	-	1	-
39	*Dalbergia lactea*	-	2	-	-
40	*Dallium guinesis*	1	-	-	-
41	*Daniella ojea*	2	-	-	-
42	*Daniellia oliveri*	-	-	13	7
43	*Deibola pinnata*	1	-	-	-

44	*Detarium microcarpum*	1	-	-	-
45	*Dialium guineense*	1	-	-	-
46	*Dichrostachys cinerea*	-	-	1	-
48	*Disthemonantus benthamianus*	-	-	1	-
49	*Entada abyssinica*	-	-	-	1
50	*Entandrophragma sp*	8	-	-	-
51	*Ficus capensis*	-	-	10	4
52	*Ficus exasperata*	-	4	-	-
53	*Ficus mucuso*	-	4	-	-
54	*Funtumia elastica*	12	8	-	-
55	*Gardenia ternifolia*	-	-	4	-
56	*Gliricidia sepium*	-	4	-	-
57	*Hymenocardia acida*	-	-	18	1
58	*Isoberlinia doka*	-	-	2	-
59	*Kleptofoli*	1	-	-	-
60	*Landa osan*	1	-	-	-
61	*Lecaniodiscus cupanioides*	-	4	-	-
62	*Lonchocarpus sericeus*	-	8	1	-
63	*Lophira lanceolata*	-	-	3	5
64	*Malacanta eli*	2	-	-	-
65	*Maranthes polyandra*	-	-	2	-
66	*Massularia acuminata*	2	-	-	-
67	*Milicia excelsa*	-	1	-	-
68	*Milletia thonningii*	-	5	-	-
69	*Myrianthus arboreus*	-	1	-	-
70	*Monterea*	-	1	-	-
71	*Morinda lucida*	-	3	-	-
72	*Morus mesozygia*	-	1	-	-
73	*Newbouldia laevis*	2	4	-	-
74	*Olax subscorpioidea*	1	-	-	-
75	*Parkia biglobosa*	-	1	3	2
76	*Phyllanthus discoideus*	-	1	-	3
77	*Piliostigma thonningii*	-	-	6	2
78	*Piptadeniastrum africanum*	1	-	-	-
79	*Prosopis africana*	-	-	5	-
80	*Pseudocedrela kotschyi*	5	-	2	-
81	*Pterocarpus angolensis*	-	-	1	-
82	*Pterygota macrocarpa*	5	-	-	-
83	*Psidium guajava*	-	1	-	-
84	*Hura crepitans*	-	2	-	-
85	*Pycnanthus angolensis*	3	3	-	-
86	*Rauvolfia vomitoria*	-	2	-	-
87	*Ricinodendron heudelotii*	7	-	-	-
88	*Securidaca longipedunculata*	-	-	-	3

89	*Senna siamea*	-	3	-	-
90	*Spondias audit*	-	-	1	1
91	*Spondias mombin*	-	4	-	-
92	*Sterculia tragacantha*	8	-	-	-
93	*Sasa*	1	-	-	-
94	*Strychnos spinosa*	-	-	4	-
95	*Tabernaemontanan pachysiphon*	4	5	-	-
96	*Terminalia avicennioides*	-	-	20	2
97	*Terminalia superba*	-	2	-	-
98	*Tetracera pototoria*	1	1	-	1
99	*Treculia monadelfia*	3	5	-	-
100	*Triplochiton scleroxylon*	12	2	-	-
101	*Vitellaria paradoxa*	-	-	25	3
102	*Vitex doniana*	-	-	2	1
103	*Vitex ferruginea*	-	-	-	2
104	*Zanthoxylum xanthoxyloides*	3	-	-	-
105	*Zeltis zenkeri*	9	4	-	-
	TOTAL	**148**	**140**	**159**	**73**

Source: Author's Analysis, 2015

Plate 6. Typical species of the savanna: *Daniellia oliveri* at Serafu, Iseyin savanna woodland.
Source: Fieldwork, January 2015

Plate 7: Typical species of the savanna: *Acacia hockii* at Serafu, Iseyin savanna woodland.
Source: Fieldwork, January 2015

Table 4.2. Number of Tree species in forest and savanna fuelwood extraction and control plots (20m x 20m) in Oyo State.

Plots	Serafu Savanna	Oyo-ile(Control) Savanna	Alaja Forest	Onigambari (Control)Forest
1	4	13	10	10
2	5	8	11	8
3	3	10	4	14
4	3	6	7	14
5	7	7	7	8
6	8	5	7	18
7	2	7	14	11
8	4	4	8	9
9	6	4	9	11
10	1	7	12	6
11	4	5	10	6
12	3	6	11	7
Mean/S.E	**4.2 (0.6)**	**6.8(0.75)**	**9.2(0.78)**	**10.1(1.0)**
C.V.(%)	**49**	**38**	**30**	**36**

Source: Author’s Analysis, 2015

Table 4.3. Species' common and local names of Tree species found in forest and savanna fuelwood extraction and control plots in Oyo State.

Species	Local Names	Family
Acacia hockii	*Ede*	*Mimosaceae*
Afromosia laxiflora	*sedun*	*Leguminosae*
Afzelia africana	*Apa*	*Caesalpinioideae*
Ajadin,ajade	*Ajadin,ajade*	
	Ayunre weere,	
Albizia ferruginea	*Banabana*	*Mimoasceae*
Albizia zygia	*Ayunre*	*Mimoasceae*
Alchornea cordifolia	*Ijan*	*Euphorbiaceae*
Alcornia laxiflora	*Pepe*	*Euphorbiaceae*
Alophylus africana	*Ekan ahoro*	*Sapindaceae*
Alstonia boonei	*Ahun*	*Apocynaceae*
Anacardium occidentale	*Kaju*	*Anacardiaceae*
Ancistrophyllum secundiflorum	*Okuku*	*Arecaceae*
Anogeissus leiocarpus	*Ayin*	*Combretaceae*
Anthocleista nobilis	*Sapo*	*Loganiaceae*
Anthocleista djalonensis	*saapo*	*Gentianaceae*
Antiaris toxicaria var africana	*ooro*	*Moraceae*
Asa funfun	*Asa funfun*	
Azadirachta indica	*dongoyaro*	*Meliaceae*
Baphia nitida	*iyere osun*	
Blighia sapida	*Isin igbo*	*Sapindaceae*
Blighia unijugata	*Isin oko*	*Sapindaceae*
Bombax buonopozense	*eso olu kondo*	*Bombacaceae*
Bosqueia angolensis(Trilepisium.m)	*lahoro*	*Moraceae*
Bridelia micrantha	*Ira*	*Euphorbiaceae*
Bridellia ferruginea	*Ira odan*	*Euphorbiaceae*
Burkea africana	*Asapa*	*Caesalpiniaceae*

Buse	*buse*	
Byrsocarpus coccineus	*Amuje-wewe*	*Connaraceae*
Carpolubea lutea	*osunsun*	
Cassalia kolly	*isape agbe*	
Cassia cameroonia		
Cedrela odorata		*Meliaceae*
Ceiba pentandra	*Araba*	*Bombacaceae*
Celtis mildbraedii		*Sterculiaceae*
Celtis wightii		*Ulmaceae*
Chordea alliodora		
Chrysophyllum albidum	*agbalumo*	*Sapotaceae*
Citrus medica	*goingoin*	*Rutaceae*
Clausena anisata	*atapari obuko*	*Rutaceae*
Cleistopholis patens	*Apako*	*Annonacaceae*
Cnetis ferrugina	*Akara Aje,Oyan aje*	*Connaraceae*
Cola gigantea	*Obi agbaya*	*Sterculiaceae*
Cola millenii	*Obi edun*	*Sterculiaceae*
Cola nitida	*obi*	*Sterculiaceae*
Combretum smethmannii	*agbon igbo*	*Combretaceae*
Cordia millenii	*Omo*	*Boragineaceae*
Cussonia arborea	*Sigo, siga*	*Araliaceae*
Dalbergia lactea	*Igi ojiji*	*Laguminosae*
Dallium guinesis	*aaran*	*Fabaceae*
Daniella ojea	*asunwole*	*Caesalpiniaceae*
Daniellia oliveri	*iya*	*Caesalpiniaceae*
Deinbollia pinnata	*lagbao,ogiri egba*	*Sapindaceae*
Detarium microcarpum	*Aluki, Arira*	*Ceasalpiniaceae*
Dialium guineense	*Awin*	*Meliaceae*
Dichrostachys cinerea	*Ajagboluuti*	*Mimosaceae*
Diospyros monbuttensis	*Oganapa*	*Ebenaceae*
Disthemonantus benthamianus	*Aayan*	*Ceasalpiniaceae*
Dracaena arborea	*peregun*	*Dracaenaceae*
Elaeis guineensis	*Ope*	*Arecaceae*

Entada abyssinica	*gbengbe*	
Entandrophragma sp	*Ako ijebu*	*Meliaceae*
Euphorbia convolvuloides	*buje*	*Euphorbiaceae*
Ficus arperacter		
Ficus capensis	*opoto*	*Moraceae*
Ficus exasperata	*ipin*	*Moraceae*
Ficus mucuso	*Obobo*	*Moraceae*
Funtumia elastica	*Ire*	*Apocynaceae*
Gardenia ternifolia	*Oruwan*	*Rubiaceae*
Gliricidia sepium	*Agunmaniye*	*Papilionaceae*
Graywei mullis	*itakun okere*	
Holarrhena floribunda		*Apocynaceae*
Hymenocardia acida	*Orupa*	*Hymenocardiaceae*
Isoberlinia doka	*baabo*	
Kleptofoli	*Igi efo*	
Landa osan	*Landa osan*	
Lecaniodiscus cupanioides	*Aaka*	*Sapindaceae*
Lonchocarpus cyanescens	*elu*	*Papilionaceae*
Lonchocarpus sericeus	*Ipapo, Paapo*	*Papilionaceae*
Lophira lanceolata	*Pahan, Pehen*	*Ochnaceae*
Macaranga barteri	*Asasa*	*Euphorbiceae*
Malacanta alnifolia	*ilaka ile*	
Malacanta ternifolia		
Malanthera scandens	*abo*	*Asteraceae*
Mallotus oppositifolius	*Eja, orokoro*	*Euphorbiaceae*
Manilkara obovata		*Sapotaceae*
Maranthes polyandra	*Idofun*	*Chrysobalanaceaes*
Massularia acuminata	*Pako ijebu*	*Rutaceae*
Milicia excelsa	*Iroko*	*Moraceae*
Milletia thonningii	*Ito*	*Papilionaceae*
Myrianthus arboreus	*ewe ade*	*Cecroplaceae*
Monodora myristica	*Abo odan*	*Annonaceae*
Monodora tenifolia		*Saphidaceae*

Monterea	*Abo/dodo fufun*	
Morinda lucida	*oruwo*	*Rubiaceae*
Morus mesozygia	*Igi aiye*	*Moraceae*
Napoleona fuggeli		
Nauclea latifolia	*Egbesi*	*Rubiaceae*
Newbouldia laevis	*Akoko*	*Bignoniaceae*
Olax subscorpioidea	*Ifon*	*Olacaceae*
Parkia biglobosa	*Igba*	*Mimosaceae*
Phyllanthus discoideus	*Awe*	*Euphorbiaceae*
Piliostigma thonningii	*Abafe*	*Caesalpiniaceae*
Piptadeniastrum africanum	*agboyin*	*Mimosaceae*
Prosopis africana	*Ayan*	*Mimosaceae*
Pseudocedrela kotschyi	*Emigbegiri*	*Meliaceae*
Psidium guajava	*guava*	*Myrtaceae*
Pterocarpus angolensis	*Ara*	*Papilionaceae*
Pterygota macrocarpa	*poroporo*	
Hura crepitans	*Kerebuje tyre moto*	
Pycnanthus angolensis	*Akomu*	*Myristicaceae*
Rauvolfia vomitoria	*Asofeyeje*	*Apocynaceae*
Ricinodendron heudelotii	*Erinmodo, epu*	*Euphorbiaceae*
Securidaca longipedunculata	*ipeta*	*Polygalaceae*
Senna siamea		*Caesalpiniaceae*
Spathodea campanulata	*onuru*	*Bignoniaceae*
Sphenocentrum jollyanum	*Akerejupon*	*Menispermaceae*
Spondias audti		*Anacardiaceae*
Spondias mombin	*Iyeye*	*Anacardiaceae*
Sterculia tragacantha	*Koko igbo, alawefon*	*Sterculiaceae*
Strychnos spinosa	*Orombo Igbo*	*Loganaceae*
Tabernaemontanan pachysiphon	*Dodo*	*Apocynaceae*
Terminalia avicennioides	*idin*	*Combretaceae*
Terminalia ivorensis	*afara dudu*	*Combretaceae*
Terminalia superba	*afara*	*Combretaceae*

Tetracera pototoria	*Opon*	*Dillenlaceae*
Tetrapleura tetraptera	*gidan, Aidan*	*Fabaceae*
Treculia africana	*rere*	*Moraceae*
Treculia chodifollia		
Treculia monadelfia		
Triplochiton scleroxylon	*Arere*	*Sterculiaceae*
Umbellatum piper	*ewe efon*	
Urena lobata	*Akerielu*	*Malvaceae*
Vitellaria paradoxa	*Emi*	*Sapotaceae*
Vitex doniana	*Ori*	*Verbenaceae*
Vitex ferruginea	*Oriko, Orieta*	*Verbenaceae*
Zanthoxylum xanthoxyloides	*Ata pagara*	*Sterculiaceae*
Zeltis midberi		*Apocynaceae*
Zeltis zenkeri	*ita*	*Ulmaceae*

Source: Author's Analysis, 2015

Variations in key species were found in both the forests and savannas. In the savanna plots, *Vitellaria paradoxa* had the highest number of individuals per species (28 individuals) followed by *Terminalia avicennioides* (22), *Burkea africana* (22), *Daniellia oliveri* (20) and *Hymenocardia acida (19).* All except *Burkea africana* were more abundant in the exploited savanna than in the control plots but notably in juvenile sizes. This is likely to be a consequence of human disturbance opening up more of the woodland to insolation thereby encouraging greater net primary productivity and quicker regeneration. Other dominant species also seen in the exploited savanna plots were *Anogeissus leiocarpus,* and *Azadiracta indica*. By contrast, dominant species encountered in the Oyo-ile savanna control plots were *Burkea africana, Daniellia oliveri, Terminallia avicennoides* with the most abundant being *Burkea africana* (16) (Figure 4.1). Typical species for the savanna include *Acacia hockii* and *Daniellia oliveri* (Plate 6 and 7).

Some uncommon species as *Vitex doniana, Entada abyssinica, Tetracera potatoria* were seen in the exploited savanna (Serafu) in very low counts. This may be due to the assertion that sometimes disturbance may allow the stimulation of more exotic species in intermediate stages (Teketay *et. al,* 2016; Pitman *et. al,* 2002). The exploited savanna (Serafu) appeared to be in a recovery stage given the high number of juveniles found while its counterpart control plots (Oyo-ile) had a number of pioneer species in moderate numbers such as *Hymenocardia acida, Burkea africana* with a few dominant species as *Terminallia avicennoides, Daniellia oliveri*. The Oyo-ile plots seemed to be in early succession with a few isolated mature successional species of *Isoberlinia doka, Afzelia africana, Anogeissus leiocarpus* (GBH over 100cm) approaching the middle storey in height, making an early progression towards becoming a dry forest. This seems slightly different from Egbinola's report (2016) of savannas found at forest- savanna boundaries within the same localities retaining similar specie types regardless of their ages and status. It appears that unhindered access to forest is a major factor in specie composition change as the savanna control site was relatively distant to major village sites. The most obvious impact discernable from the comparison of both savanna sites is that there is higher intense alteration of tree size class structure and in a lesser fashion species erosion, both of which are evidences demonstrating the effects of extraction on vegetation. Higher homogeneity of species were observed in EF (CV=30%) compared to ES (CV=49%).

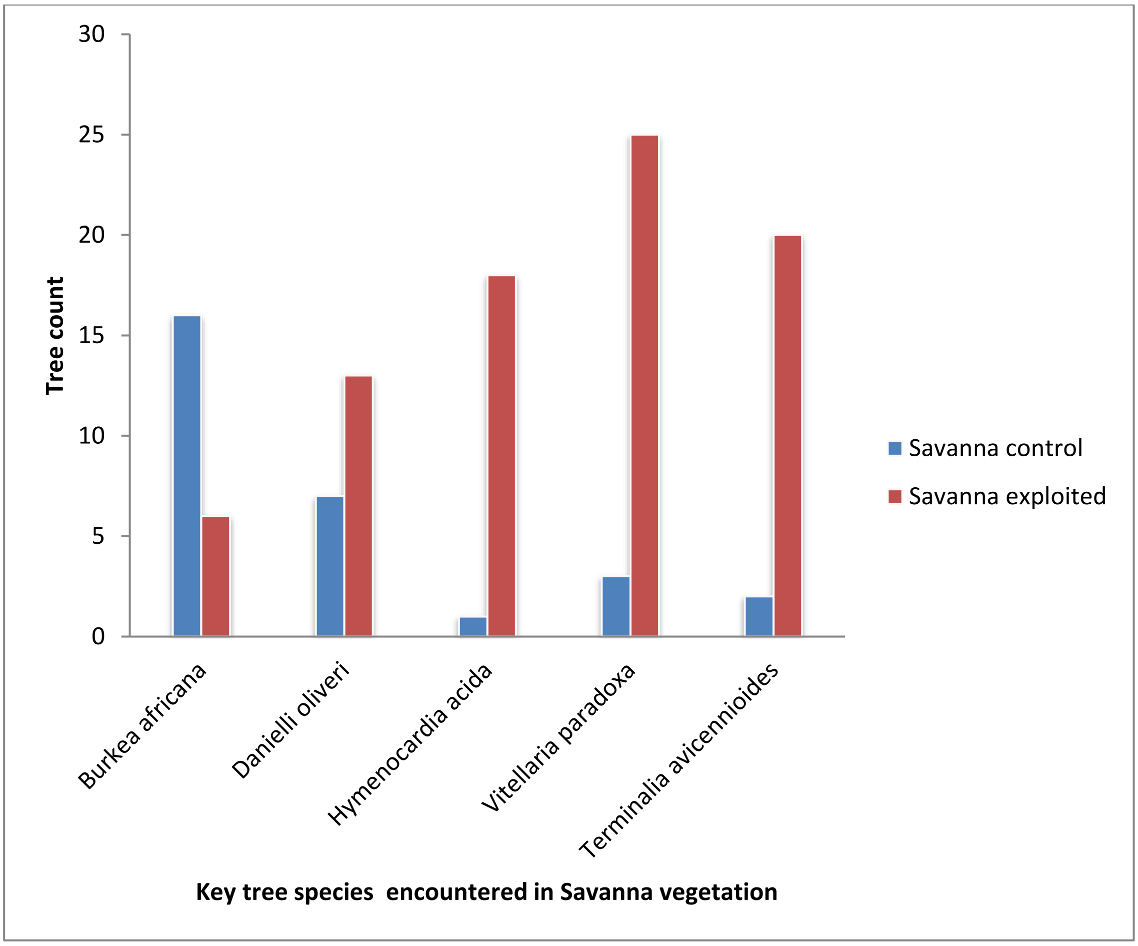


Figure 4.1: Variation in Frequency of Key Tree species common to the two Savanna areas.

Source: Author's Analysis, 2015

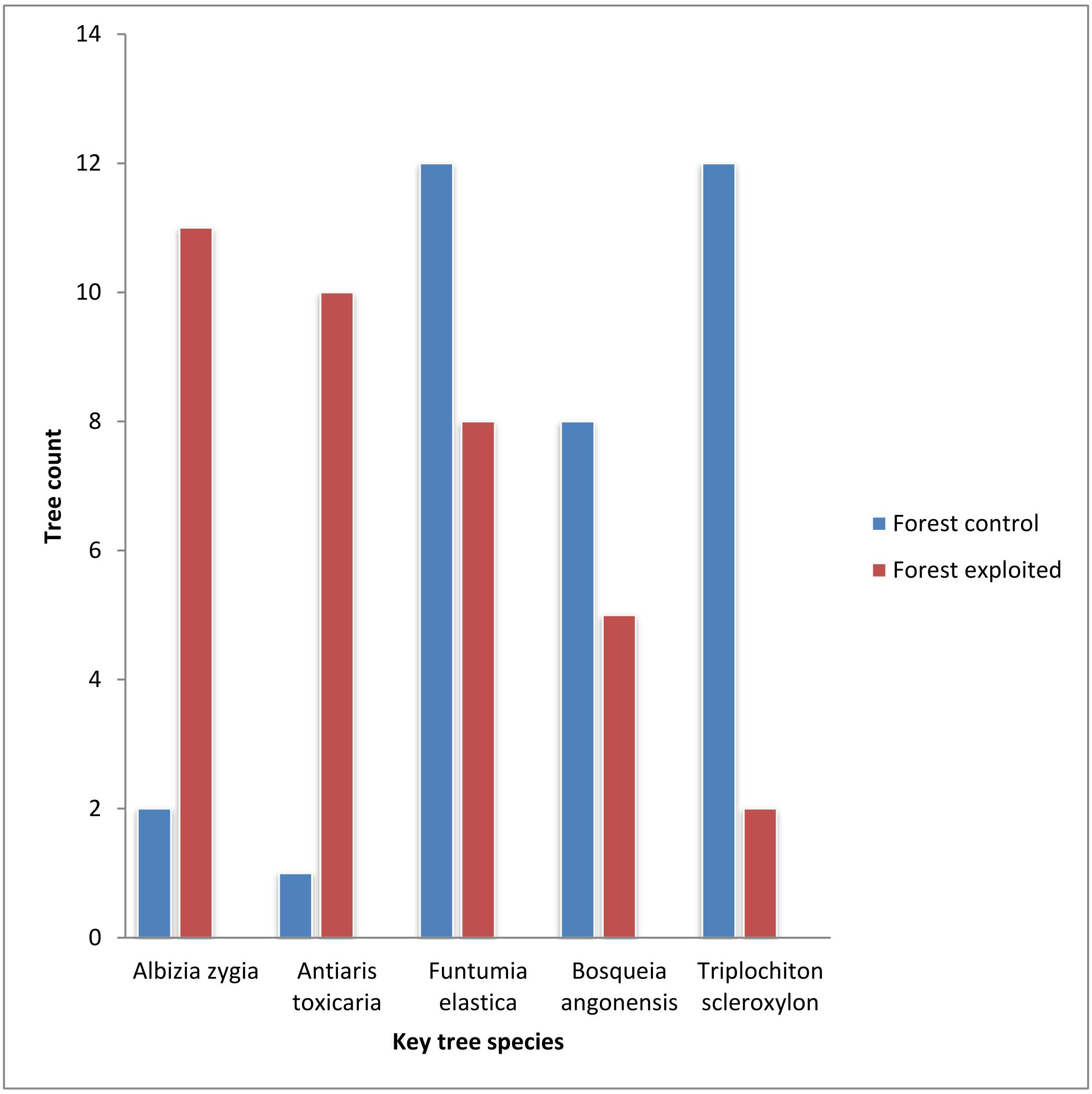


Figure 4.2: Variation in Frequency of Key Tree species common to the two Forest areas.
Source: Author's Analysis, 2015

As expected both exploited and control forests were strikingly different from the savannas in composition. The most abundant species seen in the control forest was *Funtumia elastica* (12) and *Triplochiton scleroxylon* (12) (Fig 4.2). Conversely, in the exploited forest area *Albizia zygia* (11) was the most abundant tree specie with other dominant species being *Antiaris toxicaria, Blighia unijugata, Cola nitida, Gliricidia sepium, Newbouldia laevis* and *Lonchocarpus sericeus.* Typical species absent in the exploited forest but found at the control plots include *Sterculia tragacantha, Alstonei boonei, Ceiba pentandra, Cola millenii, Cola gigantea, Entandrophragma spp, Ricinodendron heudelotii, Pterygota macrocarpa.*

When compared, the forest control plots exhibited more richness in species (45) and higher tree population (148) than seen in the exploited plots (Table 4.1).The species number recorded for each forest was almost twice that of the exploited savanna. Significant typical/indigenous species missing in the exploited forest that were found in the control plots include *Daniellia ogea, Alstonia boonei, Entandrophragma sp, Pterygota macrocarpa, Sterculia tragacantha, Zanthoxylum xanthoxyloides, Ricindenodron heudelotii, Terminalia superba, Piptadeniastrum africanum, Massularia acuminata, Malacanta eli.*

Table 4.4: Tree count in forest and savanna fuelwood extraction and control plots in Oyo State.

PLOTS	Serafu (Exploited savanna)	Oyo-ile (Control savanna)	Alaja (Exploited forest)	Onigambari (Control forest)
plot1	5	22	18	17
plot2	8	15	12	10
plot3	4	18	5	18
plot4	5	7	9	17
plot5	9	15	11	8
plot6	12	13	9	20
plot7	3	13	17	13
plot8	5	8	9	10
plot9	9	11	11	14
plot10	1	13	13	7
plot11	7	10	13	7
plot12	5	14	13	7
Mean	6.08	13.25	11.66	12.33
SD	3.0	4.1	3.6	4.8
Density (m.ha^{-1}) **152331**	**290**	**308**		

Source: Author's Analysis, 2015

Tree density is an expression of the numerical strength of a species and this is seen in Table 4.4. For the forests, many of the dominant species found in both sites showed a much lower density in the exploited plots compared to the control as seen in Table 4.4, suggesting human induced species erosion had occurred (Wessels *et. al,* 2011; Shackleton *et. al*, 1994; Scholes, 1987). Similar results were obtained for the savannas such that for both the forest and savanna exploited sites, lower tree densities were recorded when compared with those found in the control plots. This finding is in consonance with other research on effect of disturbance on trees (Chettri *et. al*, 2002). There was a highly significant variation in the tree species density between both savanna plots using the student t test ($p<0.05$) as well as the forest.

Tree counts in the Oyo ile control savanna area revealed a slightly higher number of trees even more than the forest though they were smaller in size and maturity as reflected by the mean girth and basal area (Table 4.6). As mentioned earlier, this appears to be a sign of sequential progression of the savanna woodland turning into a dry forest. The occurrence of a high number of savanna juveniles may also be attributed to the effect of suppression by wild fires (Hennenberg *et. al,* 2005) leading to a more pronounced grass-tree co-existence. This is further supported by the key pioneer species found in the savanna reserve. Furthermore the forest plots due to their broadened canopy shield juveniles from reaching insolation and therefore restricts productivity. From the foregoing, it appears disturbance seems to have impacted more on the abundance of key species in the savanna plots. Other works have also reported disturbance as a factor that may alter tree species distribution such as a change in composition from mature forest species to savanna species due to farming, bush burning and other human disturbances (Egbinola, 2016) and other forms of ecosystem alteration (Omoro, 2012; Baroody, 2013).

4.2.2 Tree species diversity in forest and savanna fuelwood extraction and control plots in Oyo State.

As seen from Table 4.5, both the exploited and control savannas recorded some measure of diversity as all values were greater than zero. The exploited savanna however had a slightly lower mean diversity value of 0.79 compared with the control savanna value of 0.86. A similar result was seen in the forests, with the control forest (Onigambari) generating a much higher mean diversity value of 0.97 than the exploited site (Alaja, 0.85) since it was a relatively unexploited rainforest. This finding was also supported by the effective number of tree individuals and species recorded ($p<0.05$), Table 4.5. The data reveals that the total number of tree species in the exploited savanna was 73, under the control savanna was 159, while for the forest, the exploited plots had 140 and its control plots had 149 tree stands. In comparing both forests and savannas, the forests had higher diversity values, which is largely susbstantiated by the fact that the most distinctive feature of tropical forests is the large genetic pool from which abundant species can be found.

Since, forests generally have larger number of species in a given area than found in the drier savannas (Scholes, 1987; Barbour *et. al,* 1982; Ayoub, 1987) the general expectation is that of a greater consequence of disturbance in savannas with fewer species than the forest (Hennenberg *et. al,* 2005). Although, Zhou *et. al,* (2009) reports less human impact on diversity at higher altitudes compared to lower sites, in this study both exploited forest and savanna showed a discernable drop in diversity levels when compared with control points. This is similar to the report of Emuh and Gbadegesin (2009), showing a decrease in diversity characteristics irrespective of whether areas examined were forest or savanna based. Since specie diversity measures are important indicators of the health of an ecosystem (Salami *et. al,* 2016), the slightly lowered diversity indices for both ecosystems confirm the presence of moderate human pressure on the vegetation. The response of each area to extraction however differs as seen from the results, and is similar to a conclusion by Wessels *et. al* (2011), on the impact of human utilization differs across observed sites.

Table 4.5: Species diversity of observed vegetation in the two ecosystems affected by fuelwood extraction and the control plots.

Plots	SERAFU (Exploited Savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	0.9	0.936	0.02	0.941
2	0.893	0.886	0.985	0.929
3	0.833	0.922	0.90	0.967
4	0.80	0.952	0.944	0.985
5	0.05	0.838	0.928	1.00
6	0.925	0.795	0.944	0.99
7	0.67	0.897	0.971	0.985
8	0.90	0.786	0.72	0.98
9	0.917	0.746	0.964	0.96
10	1.00	0.885	0.987	0.95
11	0.858	0.867	0.962	0.95
12	0.8	0.846	0.974	1.00
Mean	**0.79**	**0.863***	**0.85**	**0.97***
S.Dev	**0.25**	**0.06**	**0.27**	**0.02**
S.E	**0.07**	**0.02**	**0.08**	**0.01**
Specie Number	23	27	43	45

*Significant at 0.1%. Source: Author's Analysis, 2015

4.2.3 Sorensen's similarity index of Forest and Savanna vegetation

The Sorensen's similarity index of vegetation in the forest and savanna is presented in Table 4.6.

The analysis reveals that the similarity index in the savanna vegetation between exploited and unexploited plots was 44%; while that of the forest was lower at 38%. This finding gave a fair indication of the overlap or homogenous nature of the species of both savanna sites (Beta diversity). The forests exhibited a lower index of 38% probably as a reflection of the fact that tropical rainforests generally have higher gene pools with a higher capacity to conserve biodiversity (Barbour *et. al*, 1942).

4.2.4 Variation in Mean dendrometric characteristics of Tree Species in forest and savanna fuelwood extraction and control plots in Oyo State.

Plant dendrometric characteristics and diversity have often been used as primary indicators that reveal the health of an ecosystem (Kouami *et. al,* 2007. Three main characteristics were used in this study to generate more information about the tree structure of the two wood communities investigated which are mean girth, basal area and height of both the exploited area and control plots in both forest and savanna vegetation (Table 4.7, 4.8, 4.9).

4.2.5 Girth of trees in the four sampled areas.

Table 4.7 shows the girth values of trees for the four sampled areas. For the savanna areas, the trees found in the exploited plots were all below 30cm with an average girth of 25.3cm (Fig 4.7). Conversely, the control savanna plot trees showed a much larger girth dimension with an average girth of 48.5cm. Similarly, the exploited and control forests showed a wide disparity in girth sizes as the control plot trees were roughly two times in size than the exploited plot trees. Comparatively, more variation was found between the exploited and control forests than was seen in the exploited and control savannas ($p<0.05$). The analysis therefore revealed that the mean values of girth of trees decreased with the occurrence of fuelwood extraction.

4.2.6 Height of trees in the four sampled areas.

Savanna tree heights have been known to be usually less than 5m (Keay, 1953). The exploited savanna plots had an average of 4.84m in height, while those of the control area were higher at an average height of 6m. Similarly for the forests, the control plots were significantly taller (averaging 20.74 in height) than the exploited area trees (10.4m) and were averagely twice as high as trees in the exploited area trees ($p < 0.001$). This result reflects the impact of extraction on both forest and savanna trees to be a lowering of heights.

Table 4.6: Sorensen's Similarity Index (SID) of forest and savanna vegetation.

Landuse	**Exploited Savanna**		**Control Savanna**		**Exploited Forest**		**Control Forest**	
	SID	**SID (%)**	**SID**	**SID (%)**	**SID**	**SID (%)**	**SID**	**SID (%)**
Exploited Savanna	1	100						
Control Savanna	0.44	44	1	100				
Exploited Forest	-	-	-	-	1	100		
Control Forest	-	-	-	-	0.38	38	1	100

Source: Author's Analysis, 2015

Table 4.7: Mean girth of tree species in forest and savanna fuelwood extraction and control plots in Oyo State.

Plots	**Serafu (Exploited Savanna)**	**Oyoile(Control Savanna)**	**Alaja (Exploited Forest)**	**Onigambari (Control Forest)**
1	26	39.18	69.7	188.9
2	23.9	49.13	47.5	132.8
3	27.95	40.5	63.4	122.4
4	25	76.3	39.6	142.6
5	27.1	48.1	41.4	184.4
6	25.8	35.13	53.3	110.8
7	25.3	68.03	52.9	131.9
8	25.8	58.25	71.5	125.7
9	23.6	50. 93	50.4	90.3
10	24	49.3	50.4	93.2
11	23.6	51.71	43	78.3
12	25.6	42.58	53.7	144.7
Mean	**25.3(0.39)***	**48.5(3.78)**	**53.0(3.02)***	**128.8(9.86)**
SE	**0.39**	**3.78**	**3.02**	**9.86**
t-test	1.03			
$t_{(11)}$			64.03	

Significant at 0.01%, Source: Author’s Analysis, 2015

Table 4.8: Mean height of tree species in forest and savanna fuelwood extraction and control plots in Oyo State

Plots	Serafu (Exploited savanna)	Oyoile (Control savanna)	Alaja (Exploited forest)	Onigambari (Controlforest)
1	5.42	6.65	11.75	27.1
2	4	6.2	9.7	27.45
3	3.65	6.05	11.6	18.15
4	4.16	5.77	14.6	20.35
5	4.44	5.58	9.65	26.42
6	4.41	4.76	8.92	20.25
7	4.83	6.87	9.81	25.02
8	4.66	6.5	9.2	17.12
9	7.13	6.58	10.45	17.78
10	4.2	5.7	8.4	10.48
11	5.21	5.88	7.19	22.25
12	5.92	5.72	9.22	16.5
Mean	**4.84(0.27)***	**6.02(0.17)**	**10.04(0.55)***	**20.74(1.45)**
SE	**0.27**	**0.17**	**0.55**	**1.45**
t-test	4.36			
t_{11}			19.40	

*Significant at 0.01%, Source: Author's Analysis, 2015

Table 4.9. Mean Basal area values of tree species in forest and savanna fuelwood extraction and control plots in Oyo State.

Plots	Serafu (Exploited Savanna)	Oyoile (Control Savanna)	Alaja (Exploited forest)	Onigambari (Control forest)
1	0.06	0.24	0.62	3.43
2	0.05	0.3	0.3	1.77
3	0.07	0.16	0.37	1.85
4	0.05	0.66	0.15	2.83
5	0.06	0.24	0.16	4.82
6	0.05	0.1	0.31	1.73
7	0.05	0.45	0.28	1.87
8	0.05	0.37	0.47	2.19
9	0.04	0.24	0.25	0.92
10	0.05	0.22	0.49	0.97
11	0.05	0.25	0.17	0.53
12	0.05	0.17	0.3	4.97
Mean	**0.05(0.002)**	**0.28(0.04)**	**0.32(0.04)**	**2.32(0.42)**
SE	**0.002**	**0.04**	**0.04**	**0.42**

*Significant at 0.01%, Source: Author's Analysis, 2015

4.2.7 Basal area of trees in the four sampled areas.

Tree height in ES was shorter at 4.8±0.3m than CS 6.0±0.2m; also shorter at EF 10.04±0.5m than CF 20.7±1.4m. There were significant differences in Tree height for EF ($t_{(11)}$=19.40) and ES ($t_{(11)}$=4.36). Furthermore, the basal area values for both the exploited forest (0.32cm) and savanna areas (0.05cm) were noticeably smaller than their control area equivalent (forest 2.32cm, savanna 0.28cm). There were significant differences in DBH in ES (t_{11}= 64.03) and EF (t_{11}= 1.03). DBH in EF was also smaller at 25.3±0.4cm than CF 48.5±3.8m; EF 53.0±3.0cm also smaller at than CF 128.8±9.8cm. As such, the fuelwood extraction impact was also clearly seen in the reduction of the tree basal areas within the exploited areas. As these findings in Tables 4.7, 4.8, 4.9 show, extraction impacted on tree structural characteristics with the resulting effect of smaller sized trees in exploited areas. It was noticeable that regardless of whether the exploited area was savanna or forest, existing trees were smaller sized. In corroborating this finding, Sassen *et. al*, (2015) found a reduction in basal area of preferred species as distance increased inside the park .thereby leading to the inference that disturbance leads to smaller sized trees. In tandem with this finding, Tredennick (2014), also reports a demographic shift to noticeably low biomass tree sizes from the model analysis of savanna and forest trees following increased tree harvest. Some other studies insist that disturbance brings a trend of decreasing diversity and density with increasing girth class i.e sizes in mangrove vegetation (Feka *et. al*, 2011).

4.2.8 Spatial variation in Size Class Distribution of tree species in forest and savanna fuelwood extraction and control plots in Oyo State.

To further visually highlight the variation in tree characteristics found in each area, the tree size class distribution analysis was done as seen in the Figures 4.3 and 4.4 using girth frequencies and classes in Figures 4.5, 4.6, 4.7.

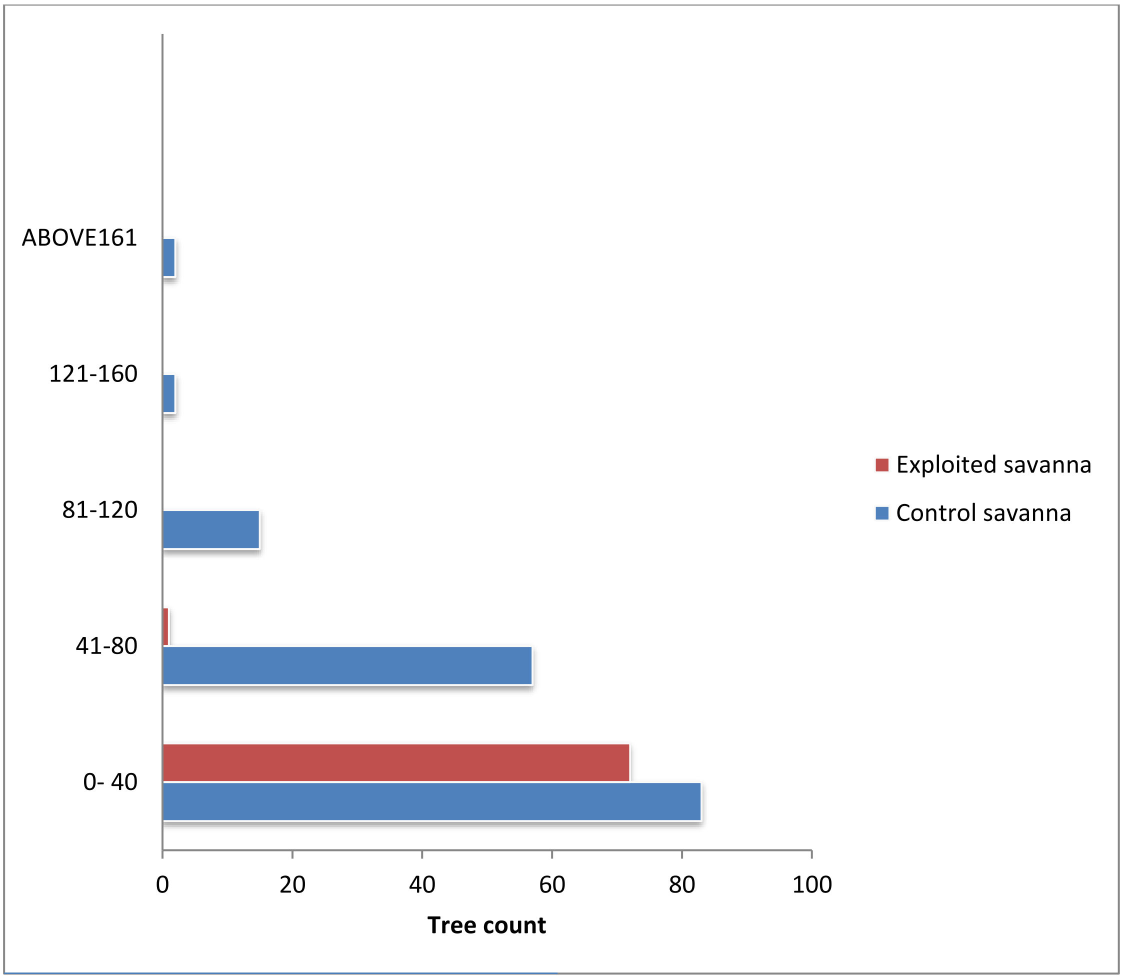


Figure 4.3: Variation in Girth Class Distribution between the Savanna Sites.
Source: Author's Analysis, 2015

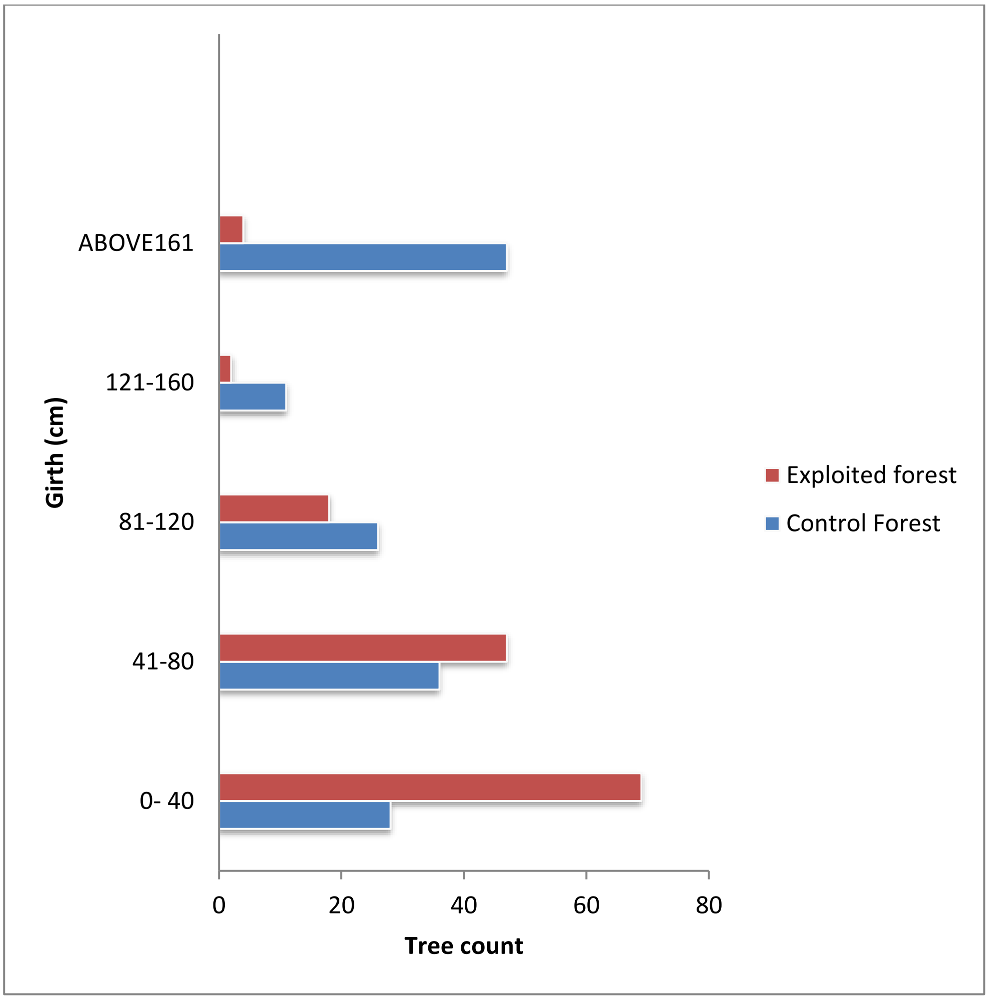


Figure 4.4: Variations in Girth Class Distribution between the Forest Sites
Source: Author's Analysis, 2015.

For the exploited savanna area (Serafu), results indicated a conspicuous absence of trees beyond GBH 48cm with the most mature tree found being a single occurrence of Daniellia oliveri of 48cm in girth (Figure 4.3). Majority of the trees were saplings and small trees (GBH < 40cm, n = 72trees) and more than 50% were under 4m in height. This reflects findings that constant removals keep surviving plants small sized (Mueller-Dombois, 2002; Hennenberg *et. al*, 2005). The high number of saplings recorded also point to productivity that appears to be aided by the removals of mature tree class sizes. When such large sizes are absent, the inhibiting influence their canopies have on the growth of juveniles will be reduced thereby increasing species survival. To further reflect the variation within the distribution of the few available trees, histograms for each site were constructed as seen in Figure 4.5, 4.6, 4.7 and 4.8 following Tsheboeng and Murray-Hudson (2013). From Figure 4.5, the histogram for the exploited savanna reflected the bell shaped nature of its distribution with fewer saplings than small trees.

The control forest (Oyo Ile) clearly reflected a reverse J shape in its distribution with fewer saplings, a higher number in middle classes than the very large individuals (Figure 4.6). Conversely, both the exploited forest (Fig 4.7) and control forest (Fig 4.8) showed a richer composition of trees although the exploited plots reflected a reverse J shape in distribution with most trees being small in size. The control forest site had an irregular mix with both large and small sized trees represented in all size classes suggesting it was a relatively mature and stable forest (Tsheboeng *et. al*, 2013).

Figure 4.7 showed a difference between both forests being one of very low incidences of giant sized trees (above 160cm in diameter) and a missing class (120cm – 160cm) which is indicative of a long term wood removal process and reflects what appears to be a communal management of forest lands with moderate harvesting pressure. These findings reflect Hennenberg *et. al*'s results in Northern Ivory coast (2005) who looked at the size class distribution of dominant species as *Anogeissus leiocarpus, Dialium guineense, Combretum nigricans,* and found a clear spatial sequence of the dominant tree species from the forest exterior border towards the interior.

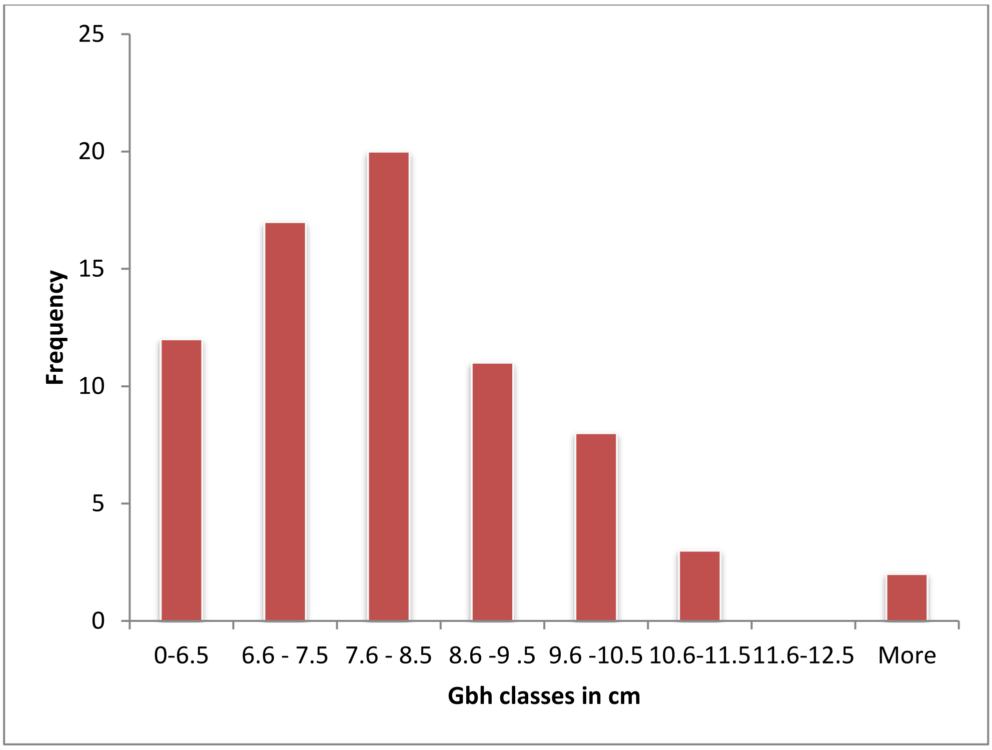


Figure 4.5: Frequency and Girth classes of trees in the Exploited savanna site

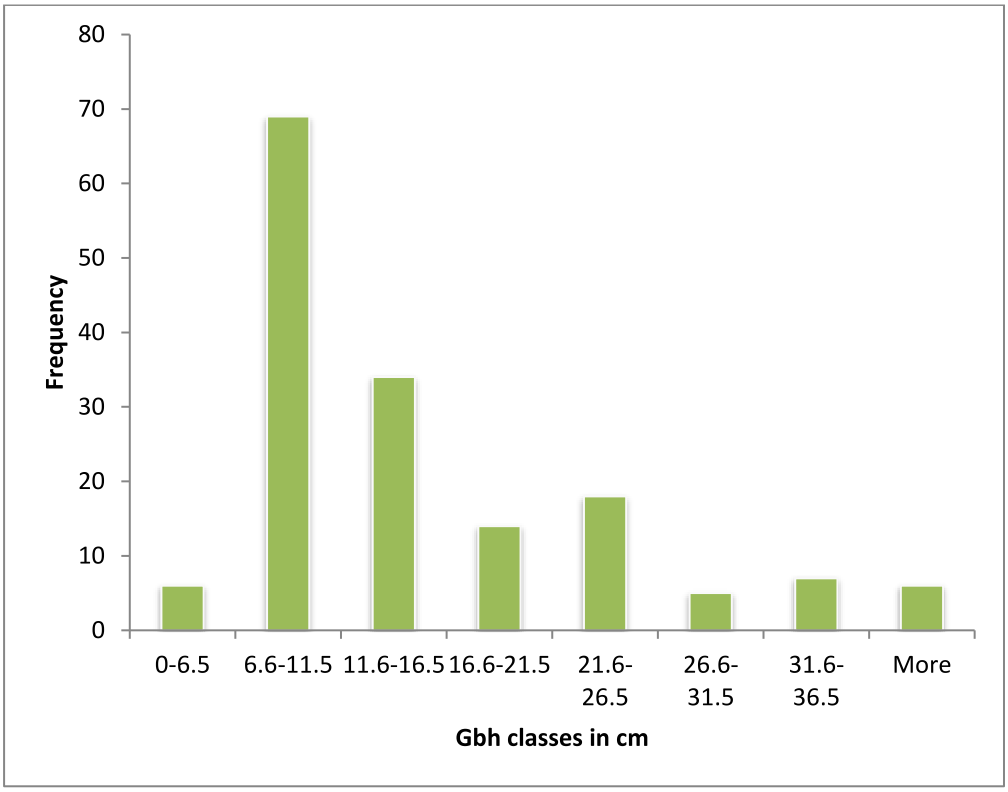


Figure 4.6: Frequency and Girth classes of trees in the Unexploited savanna site.

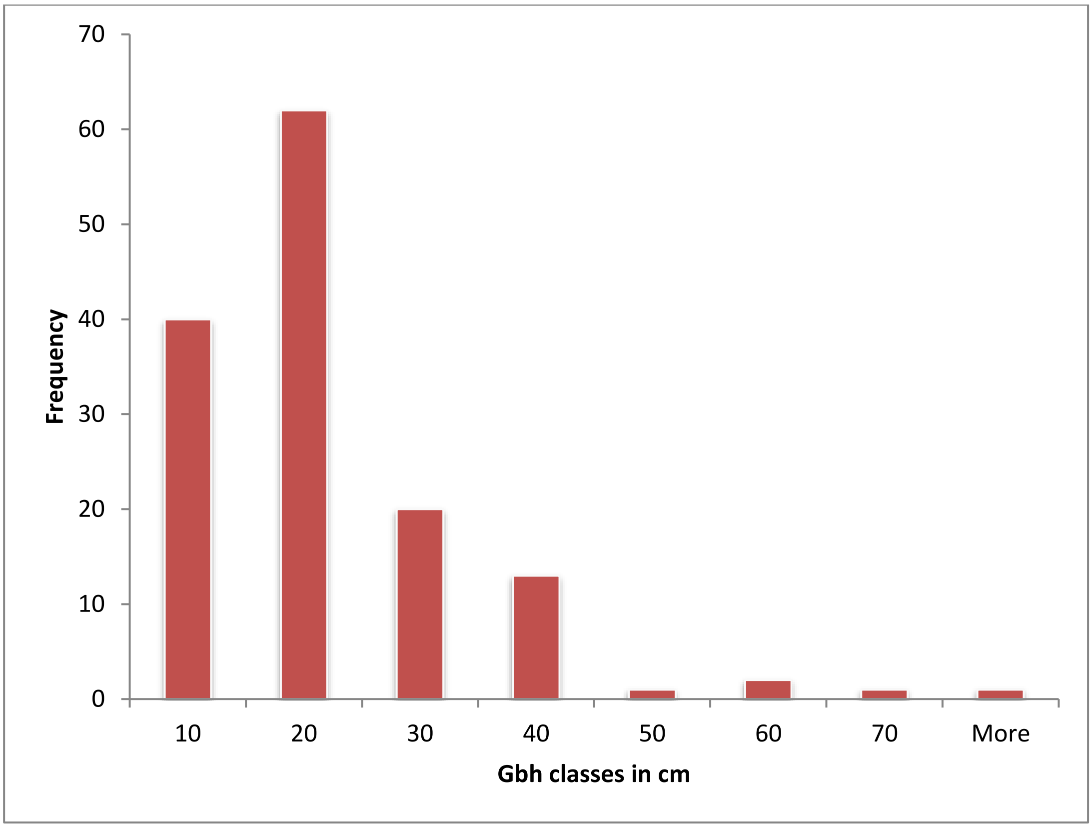


Figure 4.7: Frequency and Girth classes of trees in the Exploited forest site.

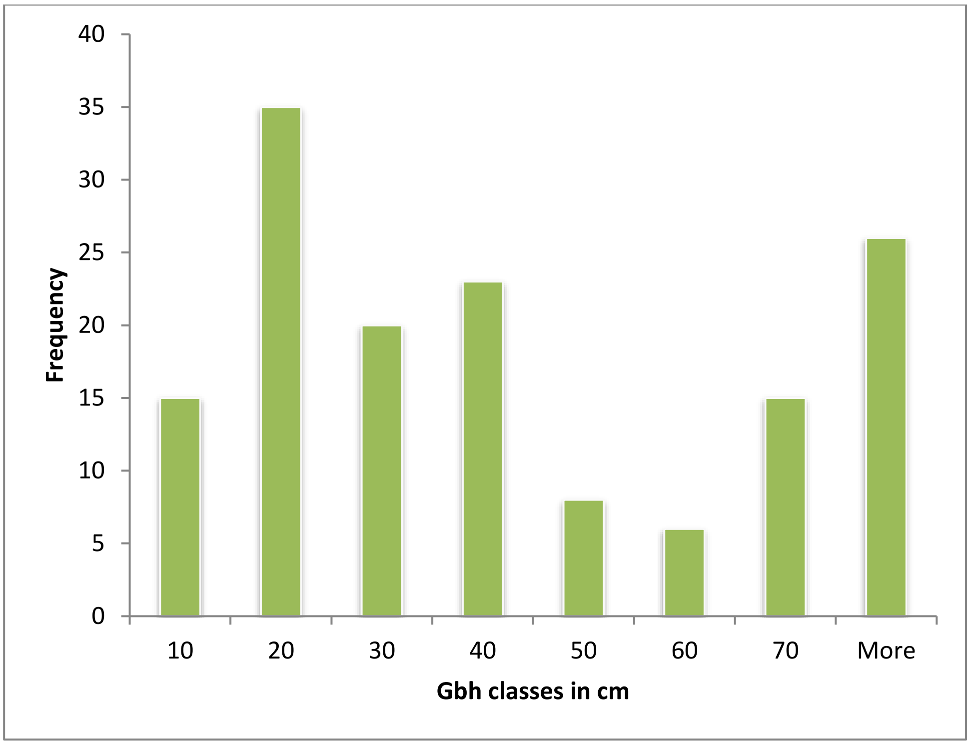


Figure 4.8: Frequency and Girth classes of trees in the Unexploited forest site.

4.2.9 Summary of Effects on Vegetation and Implication

Applying the DPSIR framework to explore the results reveal how the various components are suitably adapted to illustrate the model. The main driver identified in the study is the increasing need for affordable cooking fuels which leads to more demand for fuelwood to be extracted to meet these needs. The extraction activity when intensified creates pressure that alters both physical and socio-economic states of the affected environment. Changes observed in the physical environment particularly vegetation point to more species erosion and higher alteration of tree size class structure especially in the exploited savanna than the forest. This is similar to Hennenberg *et. al,* (2005) which emphasizes that the general expectation is that there will be a greater consequence of disturbance in savannas with fewer species than the forest. The effect of fuelwood extraction on vegetation has been generally deleterious in both forests and savanna areas with noticeable simplification of vegetation structure (tree height, basal area and diameter), changes in tree species composition and count, diversity and a demographical change to smaller sized tree species. Implications are that if extraction pressures continue unabated, Nigerian forests will lose more of its biodiversity and complexity as a tropical resource which may limit its usefulness. Given the strong plant- soil interrelationships that exist, inferences on differences in soils of such impacted areas varying in character from unexploited soils can be made. Consequently, the examination of such soils in both ecosystems forms the focus of the next section.

4.3 Objective two

This was to ascertain if there are significant differences in soil properties between wood fuel extraction sites and unexploited sites within and between forest and savanna areas

4.3.1 Effects of fuelwood extraction on physical properties of Soils

This section discusses the effect of fuelwood extraction on physical properties of soil namely particle size composition (sand, silt, clay) bulk density, water holding capacity and porosity.

Table 4.10: Mean Values of Physical properties of Soils (0-10cm) at Forest and Savanna sites in Oyo State.

Mean Value of Soil Parameter	**FOREST**				**Level of Significance Forest**	**SAVANNA**				**Level of Significance Savanna**
	Onigambari (Control)	**Coefficient of Variation(%)**	**Alaja (Exploited)**	**Coefficient of Variation(%)**		**Oyo Ile (Control)**	**Coefficient of Variation(%)**	**Seraph (Exploited)**	**Coefficient of Variation(%)**	
Clay (%)	6.8±2.9	**42.6**	8.4±3.2	**38**	N.S	6.33±1.2	**19**	8.9±3.2	**36**	N.S
Silt (%)	16 ±2.8	**17.5**	13.9±5.1	**36.7**	N.S	7.9±2.4	**30.4**	7.9±1.9	**24**	N.S
Sand (%)	77.5±9.1	**11.7**	77.3±7.4	**9.5**	N.S	85.8±2.5	**2.9**	83.2±4.2	**5.0**	N.S
Bulk density (g/cm^3)	1.35±.08	**7.4**	1.38±.06	**4.3**	N.S	1.38±0.1	**4.3**	1.45±.02	**1.37**	0.01
Porosity (%)	52.1±3.3	**6.3**	51 ± 7.2	**14.1**	N.S	52.8±3.3	**6.25**	47.8±1.9	**3.9**	0.01
Water holding capacity (%)	49.5±1.7	**3.4**	48.1±11.8	**24.7**	N.S	49.5±1.7	**6.7**	47.3±1.4	**2.9**	0.01

*N.S = Not Significant ** Standard error value Source: Author's Analysis

4.3.2 Particle size composition

An examination of the soil particle size composition of both exploited and control savanna soils (Table 4.10) reveal their textural similarities, both being predominantly sandy (over 80%). Table 4.12 shows the slight variation in the mean values of clay suggesting that the soils have similar textural composition and are derived from the same parent material.

Similarly, the forest soils were also sandy in texture although with lower sand constituents than the savannas (77%, $p<0.01$) (Figure 4.13, 4.14). Both forest soils were also very texturally similar in their sand and clay constituents and were not significantly different. From the CV values, the forest soils appear moderately homogenous. This emphasizes the homogeneity of the parent material, climate, topography and vegetal cover of both. As such, any observable difference in both sets of data would be due to the removal of the wood component in the soil and therefore the inference can be made that fuelwood extraction will likely make soils in exploited areas more heterogeneous.

4.3.3 Bulk density

Numerous studies have pointed out that savannas generally exhibit high bulk densities occasioned by low organic matter levels which is a central factor in determining fertility and nutrient status (Jones, 1973).

The exploited savanna soil had low organic matter level (about 1.8g/kg) and consequently a high bulk density of 1.45 compared to the unexploited woodland with 1.38(gm/cm^3). This difference is also reflected in the lowered water holding capacity of the exploited soil. The mean values of bulk density obtained from the two forests were 1.38 and 1.35 (gm/cm^3) for exploited and unexploited plots respectively (Table 4.15). The unexploited forest soils were more stable with more organic matter (30.4g/kg), moisture (49.5%) and porosity (52%) levels. The higher bulk density levels recorded in both forest and savanna exploited lands may be due to removal of the woody component as fuelwood thereby leading to lowered organic matter content. This in addition to trampling may cause increased compaction of the soil leading to less aggregation, and less root penetration and therefore less pore spaces (Ayorinde, 2012; Adejuwon and Adesina, 1988). Similar findings along these lines have been reported in comparing natural forest soils compared to grazing land and deforested land (Kebede *et. al*, 2015)

Table 4.11: Clay content (%) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	7.4	8.0	11.4	6.0
2	9.4	6.0	9.4	4.0
3	7.4	8.0	5.4	8.0
4	9.4	6.0	5.4	12.0
5	15.4	6.0	7.4	8.0
6	9.4	6.0	5.4	8.0
7	13.4	6.0	5.4	4.0
8	11.4	8.0	5.4	6.0
9	7.4	6.0	7.4	12.0
10	5.4	6.0	11.4	2.6
11	5.4	6.0	13.4	6.6
12	5.4	4.0	13.4	4.6
Mean	**8.9**	**6.3**	**8.4**	**6.8**
SD	**3.21**	**1.2**	**3.2**	**2.9**

Source: Author’s Analysis, 2015

Table 4.12: Silt content (%) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	9.4	5.4	17.4	13.4
2	7.4	5.4	15.4	17.4
3	5.4	3.4	11.4	17.4
4	5.4	7.4	11.4	15.4
5	9.4	7.4	11.4	15.4
6	5.4	7.4	9.4	17.4
7	11.4	9.4	9.4	15.4
8	7.4	11.4	9.4	15.4
9	9.4	11.4	15.4	14.4
10	7.4	9.4	15.4	23.4
11	9.4	9.4	13.4	13.4
12	7.4	7.4	27.4	13.4
Mean	**7.9**	**7.9**	**13.9**	**15.9**
SD	**1.9**	**2.4**	**5.1**	**2.8**

Source: Author’s Analysis, 2015

Table 4.13: Sand content (%) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	**SERAFU (Exploited savanna)**	**OYOILE (Control savanna)**	**ALAJA (Exploited forest)**	**ONIGAMBARI (Control forest)**
1	83.2	88.6	71.2	80.6
2	83.2	88.6	75.2	78.6
3	87.2	86.6	83.2	74.6
4	85.2	86.6	83.2	76.6
5	75.2	86.6	83.2	74.6
6	85.2	86.6	81.2	80.6
7	75.2	84.6	85.2	85.6
8	81.2	80.6	85.2	52.6
9	83.2	82.6	77.2	74
10	87.2	84.6	73.2	80
11	85.2	84.6	65.2	82
12	87.2	88.6	65.2	90
Mean	**83.2**	**85.8**	**77.4**	**77.5**
SD	**4.2**	**2.5**	**7.4**	**9.1**

Source: Author's Analysis, 2015

Table 4.14: Bulk density (%) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	1.45	1.44	1.44	1.31
2	1.47	1.39	1.39	1.33
3	1.46	1.36	1.36	1.4
4	1.45	1.3	1.3	1.42
5	1.45	1.36	1.36	1.41
6	1.43	1.35	1.35	1.38
7	1.42	1.46	1.46	1.43
8	1.4	1.47	1.47	1.45
9	1.44	1.28	1.28	1.36
10	1.46	1.35	1.35	1.34
11	1.43	1.4	1.4	1.22
12	1.48	1.42	1.4	1.2
Mean	**1.45**	**1.38**	**1.38**	**1.35**
SD	**0.02**	**0.06**	**0.06**	**0.1**

Source: Author's Analysis, 2015

4.3.4 Total porosity

From Table 4.15, results revealed that total porosity was consistently higher (52.1% in unexploited forest and 52.8% in the unexploited savanna) than the plots where disturbance had occurred. The forest values showed a slight variation that was not statistically significant. The savanna results were significant different at ($p<0.01$) which can be adduced to the high bulk density indicative of low porosity and soil compaction. Generally, this is associated with increased runoff on such soils due to the resulting surface crusting and inhibition of water into the soil.

4.3.5 Water holding capacity

The unexploited forest had a water holding capacity level of 49.5% which was slightly higher than the exploited forest(48.1%) even though it was not statistically significant (Table 4.16). The savanna plots exhibited the same trend (49.5% unexploited and 47.3% exploited) ($p<0.01$). This variation could be attributed to varying bulk densities as well as the difference in soil organic matter levels and soil texture composition

Table 4.15: Porosity (%) of the topsoil(0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	48	49	58	49
2	46	52	56	52
3	47	56	48	56
4	46	55	46	55
5	46	56	44	56
6	49	54	50	54
7	50	47	42	47
8	52	46	40	46
9	46	53	52	53
10	47	54	54	54
11	49	52	60	52
12	48	51	62	51
Mean	**47.8**	**52.8**	**51**	**52.0**
SD	**1.9**	**3.3**	**7.2**	**3.3**

Source: Author's Analysis, 2015

.

Table 4.16: Water holding capacity (%) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	47	48.3	52	48.3
2	48	50.3	51	50.3
3	48.3	51.2	47.37	51.2
4	48	51	45.84	51
5	48.15	51.7	45.2	51.7
6	48.3	50.9	48.38	50.9
7	47.5	48	43.52	48
8	49.25	45.84	36.53	45.84
9	44.3	48.2	49.25	48.2
10	45.3	50.5	49.8	50.5
11	46	49.25	53.35	49.25
12	47.5	49	54.6	49
Mean	**47.3**	**49.5**	**48.07**	**49.51583**
SD	**1.4**	**3.3**	**11.9**	**1.7**

Source: Author's Analysis, 2015

4.4 Effects of fuelwood extraction on chemical properties of Soils

This section discusses the effect of fuelwood extraction on chemical properties of soil namely soil pH, organic matter, Nitrogen, Zinc, Calcium, Iron, Copper, magnesium, available phosphorus, CEC, manganese, Exchangeable sodium, Exchangeable potassium, Exchangeable aluminium. Table 4.17 presents the summary of these properties.

4.4.1 Soil pH

From the Table 4.18, it is observed that the mean value of soil pH in the exploited savanna soil was 7.5 while in the unexploited was 7.4. The soil pH generally in the savanna study area was more neutral with no significant difference in the values. The unexploited forest had a mean pH level that was neutral while the exploited forest was slightly acidic by comparison (pH 6.6, $p < 0.01$).

Table 4.17: Mean Values of Chemical properties of Soils (0-10cm) at Forest and Savanna sites in Oyo State.

Chemicals	**FOREST**					**Level of Significance**	**SAVANNA**					**Level of Significance**
	Onigambari (Control)	**Coefficient of Variation (%)**	**Alaja (Exploited)**	**Coefficient of Variation (%)**	**t-test** t(11)	**FOREST**	**Oyo Ile (Control)**	**Coefficient of Variation(%)**	**Seraph (Exploited)**	**Coefficient of Variation(%)**	**t-test** t(11)	**SAVANNA**
PH (H_20)	7.3±0.4	**5.4**	6.6±0.5	**7.5**	5.2	0.01	7.4±0.2	**2.7**	7.5±0.3	**4.0**	5.0	N.S
Org. Carb. (g/kg)	30.4±10.7	**35.0**	21.2±4.9	**23.0**	2.4	0.1	2.3±0.76	**30.1**	1.8±0.4	**23.5**	6.4	0.1
Na(cmol/kg)	0.7 ±0.35	**42.8**	0.9 ±0.1	**11.1**	5.3	0.1	0.5 ±0.2	**40**	0.8 ±0.2	**25.0**	10.5	0.01
Mg(cmol/kg)	2.7 ±0.8	**29.6**	2.9±0.82	**27.5**	0.7	N.S	2.1±0.63	**28.5**	2.8 ±1.4	**50.0**	7.28	0.1
P(mg/kg)	57.2 ±8.9	**15.5**	59.4±10.8	**18.0**	28.1	N.S	17.8±3.2	**17.9**	18.6±5.0	**26.8**	42.4	N.S
Cu(cmol/kg)	10.8 ±1.5	**14.8**	4.3 ±1.6	**34.8**	12.9	0.01	9.35 ±0.23	**2.1**	2.4±1.9	**75**	14.4	0.01
Fe(mg/kg)	272 ± 82	**30.4**	240 ±76	**31.6**	7.8	N.S	72.52±26.9	**37.1**	145.8±32.6	**22.3**	28.2	0.01
Ca(cmol/kg)	4.4 ±0.21	**4.5**	0.9 ±0.68	**77.7**	5.3	0.01	2.6 ±1.1	**42.3**	1.2 ±0.9	**75**	17.9	0.01
CEC(cmol/kg)	17.5±0.96	**5.1**	13.5 ±4.1	**89**	3.4	0.01	15.4 ±2.3	**110**	12.5 ±4.6	**127**	3.4	0.1
K(cmol/kg)	0.5 ±0.17	**40**	0.2 ±0.1	**50**	23.3	N.S	1.8 ±0.19	**11.1**	1.8 ±0.2	**11.1**	22.5	N.S
Mn mg/kg	118.2 ±20.8	**17.5**	211.5±77.9	**36.9**	4.1	0.01	117.4±14.5	**12.4**	155.0±75.3	**48.5**	30.4	N.S
Zn mg/kg	7.2 ±2.8	**38.8**	3.4 ±1.9	**55.8**	14.4	0.01	1.7 ±0.97	**52.9**	1.9 ±2.3	**121**	6.9	N.S
Total Nitrogen g/kg	28.21±11.13	**39.3**	16.6 ±0.5	**25.9**	4.2	0.01	2.01 ± 0.4	**25**	1.96 ±0.8	**40.8**	182	N.S
ExchAcidity(cmol/kg)	9.16 ±0.9	**9.8**	7.0±3.54	**50.5**	6.8	0.1	9.91±2.2	**21.6**	5.34± 2.3	**43.4**	9.16	0.01
Exch Al.(cmol/kg)	8.7±1.0	**11.7**	6.5±3.4	**52.4**	4.2	0.1	9.6±2.1	**22.3**	5.9± 3.1	**50.8**	0.31	0.1
Exch H+(cmol/kg)	0.3±0.1	**33.3**	0.5±0.1	**26**	4.8	0.01	0.35± 0.1	**37**	0.48±0.1	**22.9**	8.71	0.1

Table 4.18: Soil pH (H_2O) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	**SERAFU (Exploited savanna)**	**OYOILE (Control savanna)**	**ALAJA (Exploited forest)**	**ONIGAMBARI (Control forest)**
1	7.34	7.17	6.97	6.64
2	7	7.24	6.38	6.73
3	7.5	7.24	6.58	6.77
4	7	7.29	6.25	7.43
5	7.36	7.61	7	7.23
6	7.03	7.49	7.56	7.56
7	7.42	7.83	6.08	7.56
8	8.02	7.21	6.15	7.75
9	7.8	7.38	6.33	7.79
10	7.63	7.3	6.19	7.71
11	7.9	7.29	6.99	7.32
12	7.4	7.29	6.58	6.97
Mean	7.5	7.4	6.6	7.3
SD	0.3	0.2	0.5	0.4

Source: Author's Analysis, 2015

4.4.2 Organic carbon

Organic carbon concentrations in the soils in savanna and forest is shown in Table 4.19 which reveals that the mean value of organic carbon in the exploited savanna soil was 1.7g/kg compared to the control which was 2.3 g/kg. The forest both exhibited far higher levels of organic carbon due to the accumulation of more labile soil organic matter (nutrient humus) from litterfall. The mean value of organic carbon in the unexploited forest was higher at 30.4g/kg while the exploited showed a statistically significant decrease (21.2g/kg) ($p<0.1$). A similar result was found in Ethiopia with forested lands having greater organic status than exploited or grazing lands (Kebede *et. al*, 2015). Both results were statistically significant.

4.4.3 Total nitrogen

From the Table 4.20, the mean value of total nitrogen in the exploited savanna soil was 1.96g/kg compared to the control savanna as 2.0g/kg. The difference was not statistically significant and may have arisen due to chance. The forests on the other hand were significantly varied as the unexploited sample gave a higher value of 28.2g/kg compared to the exploited plot (16.6g/kg). This is probably due to the progressive build-up of total nitrogen in the topsoil from litterfall decomposition, mineralization and some external inputs such as profuse growth of nitrogen fixing plants (Aweto, 1981b). The lower concentration of total N in the savanna soils therefore may be as a result of the removals of wood and the consequent organic matter dimunition. This finding is similar to Kebede *et. al* (2015), who reported that natural forest soils have higher contents of total nitrogen since the forest ecosystem is dominated by nitrogen fixing trees which may result in more biological nitrogen fixation.

Table 4.19: Organic carbon of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	1.43	1.75	23	24.21
2	2.2	1.21	22.8	16
3	2.7	1.81	21.5	17.16
4	1.8	1.56	15.8	30.55
5	1.7	2.66	27.7	25.15
6	1.5	2.43	27.3	29.48
7	2.2	3.26	12.8	38.38
8	1.6	3.39	15.6	40.66
9	1.7	2.92	17.5	49.59
10	1.4	1.98	19.4	44.65
11	1.4	3.26	26.6	25.85
12	1.3	1.62	24.3	23.5
Mean	**1.7**	**2.32**	**21.2**	**30.4**
SD	**0.4**	**0.7**	**4.9**	**10.7**
t-test(t_{11})	2.4		6.4	

Source: Author's Analysis, 2015

Table 4.20: Total Nitrogen of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited Savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	1.64	2.19	13.2	23.1
2	1.1	2.17	21	14.9
3	1.7	2.04	26.6	16
4	1.45	1.47	17	19.5
5	1.55	2.66	16.1	24.1
6	1.32	2.62	14.2	24.8
7	3.15	1.17	21.2	37.3
8	3.28	1.45	15.1	39.6
9	1.81	1.64	16.5	48.5
10	1.87	1.83	13.5	43.6
11	3.15	2.55	13	24.8
12	1.51	2.32	12.1	22.4
Mean	**1.96**	**2.0**	**16.6**	**28.2**
SD	**0.8**	**0.5**	**4.3**	**11.1**

Source: Author’s Analysis, 2015

4.4.4 Available phosphorous

From Table 4.21, the concentration analysis of available phosphorous reveals that the mean value of available phosphorous in the exploited savanna soil was 18.6mg/kg slightly varied from the unexploited area (17.8mg/kg). These low concentrations could be attributed to the decrease in organic matter content down the soil depth as organic matter has been known to influence the concentration of available phosphorous and total nitrogen (Ayorinde, 2012; Kebede *et. al*, 2015). The forests generally had higher levels of available P. This may also be due to the fact that forests have larger biomass and therefore are able to generate more litter fall and also absorb more available P. There was no significant variation in the concentration of available phosphorous for both forest and savanna.

4.4.5 Exchangeable calcium

Table 4.22 revealed the mean value of the concentration of exchangeable calcium in the savanna plots to be generally low with the control having a higher mean value at 2.6cmol/kg while the exploited was at 1.2cmol/kg. The control forest had the highest value at 4.4cmol/kg compared to the value for the exploited area of 0.9cmol/kg. Generally, the higher concentration of exchangeable calcium in the forest can be attributed to the fact that it is a divalent cation that exhibits relatively low mobility. It usually is one of the more dominant exchangeable cation in forest soils in southwestern Nigeria (Aweto, 1981b).

4.4.6 Exchangeable magnesium

Table 4.23 revealed the mean value of the concentration of exchangeable magnesium in the savanna plots to be generally low with the control having a lower mean value at 2.1cmol/kg while the exploited was significantly higher at 2.8cmol/kg($p<0.1$). Similarly for the forests, the control forest exhibited almost the same levels (2.7cmol/kg) as the exploited soils (2.9cmol/kg) given that the difference between them was not significant.

Table 4.21: Available phosphorous (mg/kg) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	14.48	18.6	66.82	45.66
2	19.33	18.89	44.8	62.14
3	16.91	16.17	48.61	40.12
4	14.33	16.43	69.95	57.8
5	19.41	18.08	67.34	56.42
6	15.36	12.62	42.2	58.33
7	17.42	18.16	54.16	70.47
8	18.82	20.66	57.98	65.09
9	18.6	13.51	55.2	60.75
10	33.54	25.08	77.58	46.53
11	17.72	16.9	62.83	58.67
12	16.83	18.45	65.26	64.92
Mean	**18.6**	**17.8**	**59.3**	**57.2**
SD	**5.0**	**3.2**	**10.7**	**8.9**

Source: Author's Analysis, 2015

Table 4.22: Calcium (cmol/kg) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	0.57	3.61	1.28	4.53
2	0.79	3.35	0.63	4.6
3	0.46	3.39	0.67	4.52
4	0.46	3.18	0.5	4.7
5	0.66	3.26	1.6	4.56
6	0.25	3.23	2.49	4.55
7	1.35	3.25	0.2	4.56
8	2.76	3.32	0.26	4.5
9	1.41	1.17	0.24	4.37
10	2.58	1.18	0.41	4.16
11	2.5	1.14	1.12	4.1
12	0.7	1.2	1.19	4.05
Mean	1.2	2.6	0.9	4.4
SD	0.9	1.1	0.7	0.2

Source: Author's Analysis, 2015

Table4.23: Exchangeable magnesium (cmol/kg) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	**SERAFU (Exploited savanna)**	**OYOILE (Control savanna)**	**ALAJA (Exploited forest)**	**ONIGAMBARI (Control forest)**
1	2.18	1.1	1.91	3.14
2	2.85	1.76	3.86	0.72
3	2.21	1.71	3.42	1.93
4	1.92	1.53	2.8	2.78
5	3.2	1.76	4.03	2.37
6	1.57	2.13	3.75	3.36
7	3.45	2.55	2.14	3.3
8	4.99	1.92	2.3	3.68
9	2.18	3.1	1.89	3.29
10	6.01	3.26	2.02	2.41
11	2.11	2.44	3.18	2.93
12	1.95	1.98	3.51	2.99
Mean	**2.8**	**2.1**	**2.9**	**2.7**
SD	**1.4**	**0.6**	**0.8**	**0.8**

Source: Author’s Analysis, 2015

4.4.7 Exchangeable potassium

Table 4.24 revealed the mean value of the concentration of exchangeable potassium in the savanna plots to be generally low with both exploited and the unexploited samples having a mean value at 1.8cmol/kg. There was no significant difference between the two soils. For the forests, the mean level of potassium was less in the exploited soil at 0.2cmol/kg than the control (0.5cmol/kg). Generally, forest trees make a high nutrient demand on exchangeable potassium in forest soils and its concentration was observed to be the least among all the exchangeable bases in the study area.

4.4.8 Exchangeable sodium

Table 4.25 revealed the mean value of the concentration of exchangeable sodium in the both forest and savanna plots to be generally low. For the savanna soils, the exploited samples had a mean value of 0.8cmol/kg while the control was slightly lower at 0.5cmol/kg which was statistically significant ($p<0.01$). There was also a significant variation between the exploited soil samples of 0.9cmol/kg and the control at 0.7cmol/kg ($p<0.1$).

4.4.9 Cation exchange capacity

Table 4.26 revealed the mean value of the concentration of CEC in the exploited savanna soils to be a mean value of 12.5cmol/kg while the control was significantly higher at 15.4cmol/kg. The difference between the two means was statistically significant ($p<0.1$). There was asimilar result for the forest which had a significant variation between the exploited soil value at 13.5cmol/kg and the control at 17.5cmol/kg ($p<0.01$). The removal of woody substances may affect the level of organic matter and therefore CEC of the soil since there is a strong correlation between these nutrients (Kebede *et. al*, 2015; Asadu *et. al*, 2015).

Table 4.24:Exchangeable potassium (cmol/kg) of the topsoil(0-10cm) in Forest and Savanna sites in Oyo State.

Plots	**SERAFU (Exploited savanna)**	**OYOILE (Control savanna)**	**ALAJA (Exploited forest)**	**ONIGAMBARI (Control forest)**
1	1.79	1.64	0.16	0.34
2	1.72	1.56	0.21	0.35
3	1.63	2.25	0.2	0.25
4	1.99	1.56	0.17	0.47
5	1.96	1.76	0.26	0.73
6	1.82	1.83	0.24	0.47
7	1.86	1.89	0.35	0.67
8	2.17	1.71	0.25	0.59
9	1.26	1.71	0.34	0.71
10	2.12	1.65	0.21	0.27
11	1.71	1.93	0.21	0.69
12	1.79	1.95	0.25	0.54
Mean	**1.8**	**1.8**	**0.2**	**0.5**
SD	**0.2**	**0.2**	**0.1**	**0.2**

Source: Author's Analysis, 2015

Table 4.25: Exchangeable sodium (cmol/kg) of the topsoil(0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	0.87	0.3	0.87	0.86
2	0.83	0.19	0.83	1.09
3	0.78	0.27	0.74	0.963
4	0.79	0.23	0.78	0.18
5	0.78	0.3	0.83	0.21
6	0.74	0.53	0.83	1.06
7	0.28	0.71	0.96	0.25
8	0.96	0.51	0.91	0.52
9	0.68	0.77	0.91	0.75
10	0.91	0.65	0.91	0.43
11	0.96	0.84	0.91	0.72
12	0.74	0.71	0.91	1.09
Mean	**0.8**	**0.50**	**0.9**	**0.7**
SD	**0.2**	**0.2**	**0.1**	**0.3**

Source: Author’s Analysis, 2015

Table 4.26: Cation Exchange Capacity(cmol/kg) of the topsoil(0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	10.61	12.57	19.1	17.87
2	11.39	12.91	14.68	17.16
3	10.28	14.77	17.28	16.83
4	8.71	14.51	12.64	17.33
5	12.8	12.38	20.82	16.27
6	14.58	16.75	13.3	17.84
7	11.04	17.66	12.19	17.18
8	9.78	19.2	9.38	17.69
9	9.63	14.58	9.15	18.32
10	25.62	16.9	7.79	16.27
11	15.88	18.03	10.14	19.84
12	9.78	13.94	15.16	17.67
Mean	**12.5**	**15.4**	**13.5**	**17.5**
SD	**4.6**	**2.3**	**4.1**	**0.9**

Source: Author’s Analysis, 2015

4.5 Manganese

Table 4.27 revealed the mean value of the manganese concentration in the exploited savanna soils to be 155mg/kg while the control was lower at 117.4mg/kg but it was not statistically significant. For the forest, the difference between the two means of the exploited (211mg/kg) and control soils (118 mg/kg) was statistically significant ($P<0.01$). The higher concentration of Mn in the exploited forest areas may probably be associated with high levels of litterfall observed as well as the leaching of the nutrient from the stand canopy by rainfall back into the soil (Anderson *et. al*, 1991).

Table4.27: Manganese (mg/kg) of the topsoil(0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	147	105	141	127
2	191	118	313	136
3	146	124	174	127
4	61.8	117	209	129
5	82.7	111	308	170
6	104.7	134	122	105
7	214	122	146	101
8	344	104	153	100
9	110	125	167	107
10	199	109	177	100
11	128	93	292	110
12	132	147	336	106
Mean	**155**	**117**	**211**	**118**
SD	**75.3**	**14.5**	**77.9**	**20.7**

Source: Author's Analysis, 2015

4.5.1. Iron

Results from Table 4.28 showed the mean value of Fe in the exploited savanna soils to be 155mg/kg which was almost double the unexploited mean level (72.5mg/kg) but it was not statistically significant. The forest also had a statistically significant variation between the exploited soil value at 72.5mg/kg and the control at 145.8mg/kg ($p<0.01$). In the forest, the exploited soils had twice as low the Fe content of unexploited soils. Puri (1961), observed that Fe was often present in high amounts in leached tropical soils and there is usually a decrease of Fe when soil pH increases. Fe as one of the most abundant element in the earth's crust with variable oxidation States of Fe^{2+} and Fe^{3+} and can scarcely be replaced by any other element. This is also influenced by the level of acidity in the area under study.

4.5.2 Copper

Results from Table 4.29 showed the mean value of Cu in the exploited savanna soils to be low at 2.4mg/kg which was significantly different from the mean value of the unexploited soil (9.3mg/kg)($p< 0.01$). The forest also had a statistically significant variation between the exploited soil value at 4.3mg/kg and the control at 10.8mg/kg ($p<0.01$).

4.5.3 Zinc

The mean levels of zinc in both savanna soils are similarly low with no statistical difference between them. The relatively low concentration of zinc in the savanna area may be as a result of the low level of organic matter, the sandiness of the soil and level of soil pH as high pH value limits the availability (Puri 1961). Conversely, higher acid soluble zinc concentrations seem to favour lower soil pH as seen in the exploited and control forest mean values which are higher than those of the savanna. The variation between both forests is statistically significant at $p<0.01$.

Table4.28: Iron (mg/kg) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	107	44.2	385	221
2	118	103	288	233
3	137	63	180	231
4	149	59	261	288
5	124	67.5	208	255
6	142	65.1	372	311
7	176	141	170	303
8	173	71	202	305
9	106	85.2	139	285
10	218	71	227	70
11	163	54.9	206	392
12	136	45.4	242	374
Mean	**145.8**	**72.5**	**240**	**272**
SD	**32.6**	**26.9**	**76**	**82.9**

Source: Author's Analysis, 2015

Table4.29: Copper (mg/kg) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	0.67	9.18	4.83	9.21
2	2.24	9.4	5.02	9.54
3	2.52	9.23	2.91	8.81
4	1.05	8.95	2.61	11.83
5	1.88	9.11	5.29	10.06
6	1.37	9.31	5.99	10.78
7	5.07	9.58	2.2	12.59
8	7.07	9.13	2.66	11.76
9	2.15	9.67	2.87	12.16
10	2.24	9.4	5.8	8.53
11	1.37	9.63	5.61	12.96
12	1.15	9.57	6.35	11.87
Mean	**2.4**	**9.3**	**4.3**	**10.8**
SD	**1.8**	**0.2**	**1.5**	**1.6**

Source: Author's Analysis, 2015

Table4.30: Zinc (mg/kg) of the topsoil (0-10cm) in Forest and Savanna sites in Oyo State.

Plots	SERAFU (Exploited savanna)	OYOILE (Control savanna)	ALAJA (Exploited forest)	ONIGAMBARI (Control forest)
1	0.75	1.04	1.8	6.79
2	1.8	1.09	4.24	6.88
3	0.61	1.33	1.67	4.38
4	0.52	1.18	1.42	12.2
5	1.51	1.19	6.96	5.52
6	0.54	0.89	2.6	6.67
7	3.61	1.41	2.01	7.58
8	8.45	0.82	2.47	7.86
9	1.2	2.85	1.99	10.59
10	2.41	2.81	3.94	2.05
11	0.95	2.65	5.73	10.36
12	0.6	3.68	5.82	5.56
Mean	**1.9**	**1.7**	**3.4**	**7.2**
SD	**2.3**	**0.9**	**1.9**	**2.8**

Source: Author's Analysis, 2015

4.5.4 Summary of effects on soils.

Summarily, the results bring to light the point that forest soils tend to have more nutrient levels and lower bulk densities than savannas which is similar to previous studies (Ayorinde, 2012; Jones, 1973; Scholes, 1987). Following the DPSIR framework earlier explained, fuelwood extraction as disturbance has generated pressure on soils reflected in significant differences in soil physical and chemical properties for ES soils for P (t_{11}= 28.1), Ca (t_{11}= 5.3), K (t_{11}= 23.3), Na (t_{11}= 5.3), Ex Al (t_{11}= 4.2), Ex Ac (t_{11}= 6.8), Fe (t_{11}= 7.78), Cu (t_{11}= 12.96). There was a general decrease of nutrients in fuelwood exploited forest soils. On the converse, exploited savanna soils however reflected a minute increase in a few micronutrients (sodium, magnesium, iron, manganese) which is a departure from the findings of Kebede (2015), in Ethiopia as well as the reported effects of charcoal production which depletes the nutrient status and destroys soil structure (Oguntunde *et. al*, 2008; Ogundele *et. al*, 2012; Oriola and Omofoyewa, 2013; Koami *et. al*, 2009; Ruuska, 2012). This may be due to coinciding of the sampling period with the annual burning of the savanna areas to enhance grass production (Joubert and Zimmermann, 2002) which may have also led to increases in soil nutrient levels beyond the level of pre-burn soils (Aweto, 1981a). Both exploited savanna and exploited forest soils were negatively affected by extraction. The soil chemical properties in exploited forest and savanna varied while physical properties in the exploited forest (except clay and bulk density) were unchanged. Chemical changes in exploited soils were more pronounced irrespective of the ecosystem type. As such the overall impact is to reduce soil fertility in areas of intense extraction. To further deepen the understanding of how fuelwood extraction affects plant-soil interrelationships since it reflects on vegetation and soil properties, a Detrended correspondence analysis was performed as detailed in the next section.

4.6 Objective Three

This was to characterize the relationship between structural characteristics of trees and soil properties of fuelwood extraction sites in forest and savanna areas. The mean values of all soil and vegetation parameters were used in running the Detrended canonical analysis on the Paleontological Statistics (PAST) software (Hammer *et. al*., 2001) version 2.17c (2013) to investigate the interrelationships and abundance of environmental parameters. The technique uses a constrained ordination technique as an extension of the original correspondence analysis. It seeks for explicit relationships between multiple variables and explains how much of gradients in specie data can be explained by environmental variables (Jongman *et. al*, 1995).

4.6.1 Relationships between tree characteristics and soil properties at extraction and control plots in Savanna sites.

From Table 4.31 results of the savanna detrended correlation analysis showed the first axis had an eigenvalue of 65.35%. Findings from the analysis of savanna data reveal that potassium (K) seems positively related to tree height and diversity. Generally, tree growth characteristics had strong correlations with nutrients as Iron, Manganese, Zinc, Sodium, CEC and exchange aluminium. Properties as porosity, organic carbon, water holding capacity and soil pH were strongly associated with areas with more clay content and reduced sandiness.

Table4.31 Summary Table of Eigenvalue of detrended correspondence analysis showing savanna soil-vegetation relations

0	Axis 1	Axis 2
Eigenvalue	0.03	0.01
% of Variance explained	65.37	30.45
Significance of pvalue	0.61	0.25
Canonical coefficients		
sp_richness	1.75	-0.52
tree_diameter	-0.76	-0.62
tree_height	-0.07	1.59
Diversity	-0.08	2.13
plot_density	1.32	-1.06

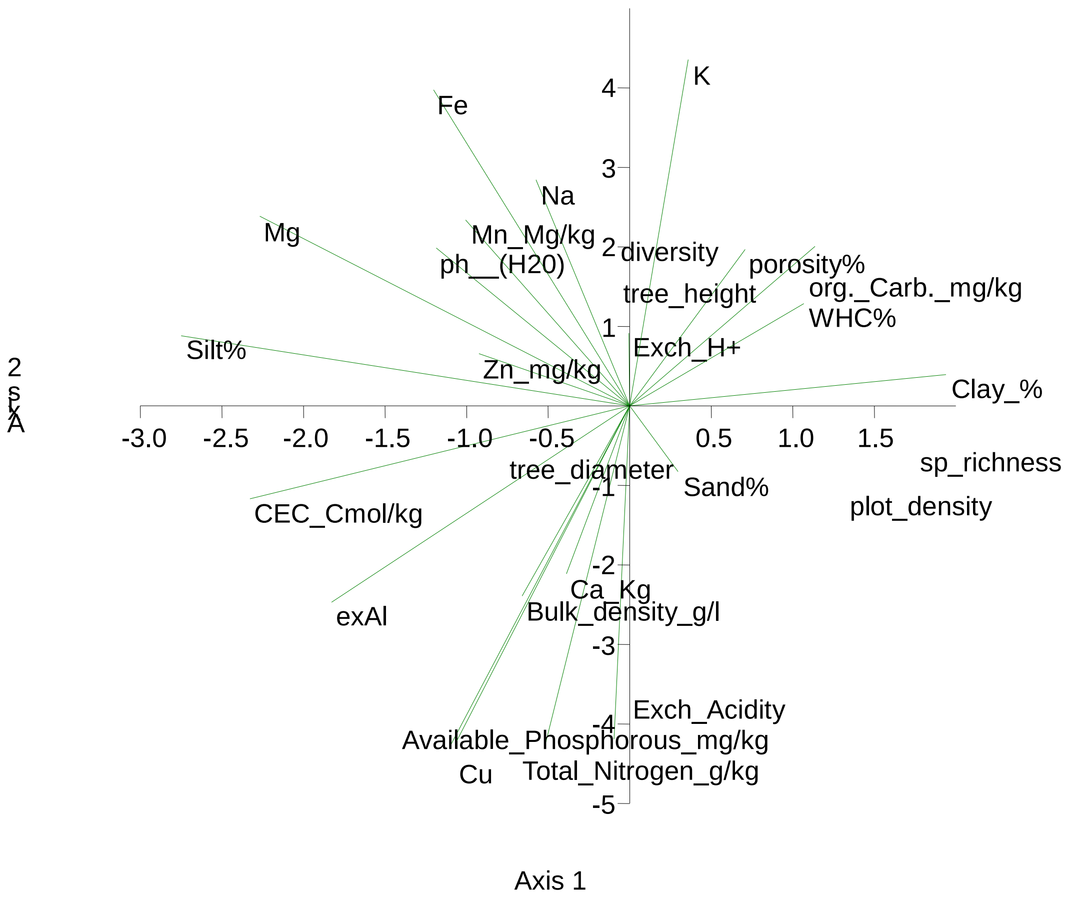


Figure 4.9. Bi-plot map of the DCA for the soil- vegetation relationship of the savanna area.Source: Author's Analysis, 2015

4.6.2 Relationships between tree characteristics and soil properties at extraction and control plots in Forest sites.

From Figure 4.10, the analysis of forest data presented in the bi-plot figure revealed that clay was the most significant explanatory variable seen such that a higher number of tree species were thriving on more clayey soils than other types. Also, larger trees (tree diameter) tend to grow in soils with higher levels of organic carbon, silt, porosity, and water holding capacities. Soil chemistry does appear to influence tree growth being seen in larger trees associated with sites of high nutrient status.

Table 4.32 Summary Table of Eigenvalue of detrended correspondence analysis showing forest soil-vegetation relation

0	Axis 1	Axis 2
Eigenvalue	0.04	0.01
% of Variance explained	78.82	18.5
Significance of p value	0.2178	0.88
Canonical coefficients		
sp_richness	2.03	-0.51
tree_diameter	-0.66	-0.68
tree_height	-0.13	1.59
Diversity	1.53	0.15
plot_density	1.97	-0.21

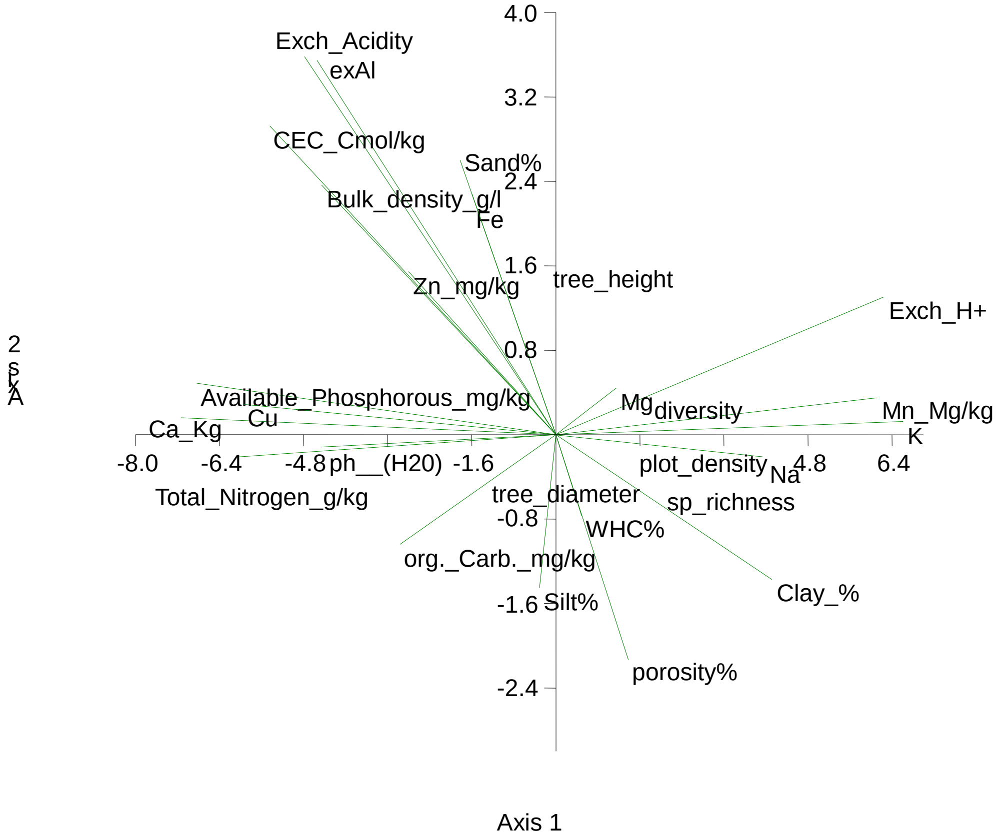


Figure 4.10 Bi-plot map of the DCA for the soil vegetation relationship of the forest area.Source: Author's Analysis, 2015

4.6.3 Summary of Detrended Correlation Analysis

From the results presented above, it can be inferred that there is a significant relationship between soil properties and the structural characteristics of trees even in fuelwood exploited areas. The correlation result for exploited savanna indicated a positive association between potassium, tree height and diversity, while in the exploited forest clay deposits were positively associated with large tree diameter and high specie number. Therefore the study has established that fuelwood extraction impacts on soils and vegetation and even the observed interrelationships between them. The focus of the next section now turns to understanding the social dimension of fuelwood use by comparatively exploring the socio-economic characteristics of the two main users of fuelwood to understand the interplay between human and ecological interactions in the study area.

CHAPTER FIVE

ENERGY USE PATTERNS OF HOUSEHOLD AND FOOD VENDORS IN IBADAN

5.1 Introduction

This chapter discusses how fuelwood is used within homes and small-scale commercial establishments i.e food vendors in Ibadan city. The comparative focus is on demographics, variation in energy sources, fuel preference and actual consumption. A further look at the relationship between user characteristics and fuelwood consumption was also done.

5.2 Objective Four

It was to determine the pattern of variation of domestic and commercial fuelwood consumption and preference in the Ibadan metropolis.

5.2.1 Demographics of Respondents in Ibadan (Households and Food vendors)

From the Table 5.1, it was seen that more than 90% of the household respondents were married females (Tables 5.2 – 5.6). The age spread was wide with more than 60% of respondents between 29 and 48years. A further 24% were above 48 years. Although 16.2% of these respondents had no formal education, a larger percent (83.8) had some form of education varying from primary school level to the tertiary level. This may possibly be due to the high level of urbanization and access to tertiary education in a cosmopolitan city as Ibadan. Typical urban household in Ibadan had roughly 5.1 people as family size. A fewer percentage (21%) had not more than 3 people in their household while the remaining 19.5% had more than 7 people living together in the home.

Table 5.1: Socio-economic Characteristics of Urban Household Heads and Food vendors in Ibadan (Mean values)

	Household	Vendor
Age	40.8 ± 0.8	45±10.5
Family size	5.1 ± 0.8	-
Gender (Male)	18 (9%)	2(1%)
Gender(Female)	182(91%)	198(99%)
Average Level Educ	Secondary school (77, 38.5%)	Primary (80, 40%)
Marital status (ave)	Married (181, 90.5%)	Married (190, 95%)
Fuelwood users	10(5.0%)	113 (56.5%)
Charcoal users	4(2.0%)	68 (34%)
Kerosene users	164(82.0%)	5 (2.5%)
Gas users	15(7.5%)	14 (7.0%)
Mixed users	7 (3.5%)	-
Monthly Fuelwood use range	7.6kg – 120kg	28kg – 1792kg
Monthly Charcoal use range	108-180kg	18- 5000kg

Table5.2:Age Grouping of Household Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-28 years	31	15.5	15.5	15.5
	29-38 years	60	30.0	30.0	45.5
	39-48 years	61	30.5	30.5	76.0
	49-58 years	31	15.5	15.5	91.5
	59-68 years	13	6.5	6.5	98.0
	69-78 years	3	1.5	1.5	99.5
	79-88 years	1	.5	.5	100.0
	Total	200	100.0	100.0	

Table5.3: Level of Education of Household Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
	no formal	33	16.5	16.5	16.5
	primary school	53	26.5	26.5	43.0
Valid	secondary school	77	38.5	38.5	81.5
	Tertiary	37	18.5	18.5	100.0
	Total	200	100.0	100.0	

Table 5.4: Marital Status of Household Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Single	11	5.5	5.5	5.5
	Married	181	90.5	90.5	96.0
	Widow	7	3.5	3.5	99.5
	separated	1	.5	.5	100.0
	Total	200	100.0	100.0	

Table 5.5: Sex of Household Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	182	91.0	91.0	91.0
	Male	18	9.0	9.0	100.0
	Total	200	100.0	100.0	

Table 5.6: Household Size of Household Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1-3 people	42	21.0	21.0	21.0
	4-6 people	121	60.5	60.5	81.5
	7-9 people	33	16.5	16.5	98.0
	above 9 people	4	2.0	2.0	100.0
	Total	200	100.0	100.0	

Conversely, for food vendors, a significant proportion (38.5%) was in the 36-45 age bracket (Tables 5.7 – 5.11). The average vendor was 45 years old. Food vendoring is dominated by females (99 %) compared to males (1 %). There is a large age spread between vendor respondents that varied between 25 years and 87 years, although the activity appears to be dominated by the thirty-five to forty-five years age bracket. Forty percent had just primary school education and 26.5% had no formal education. Ninety five percent of the respondents claimed to be married which was slightly different from the information generated from the interviews with most key informants. Some of these key informants also opined that food vendoring was a strenuous job that often generated underlying tensions in their domestic affairs, which often led to the demise of many marriages while pursuing business or they made do with business operations below optimum capacity to keep both ends functional. Therefore avoiding the social stigma associated with divorce, or single parenting may have influenced the responses on marital status.

Table 5.7: Age Grouping of Vendor Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	25-35 years	35	17.5	17.5	17.5
	36-45 years	77	38.5	38.5	56.0
	46-55 years	54	27.0	27.0	83.0
	56-65years	27	13.5	13.5	96.5
	66-75 years	7	3.5	3.5	100.0
	Total	200	100.0	100.0	

Table 5.8: Marital Status of Vendor Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Married	190	95.0	95.0	95.0
	Divorced	3	1.5	1.5	96.5
	Separated	4	2.0	2.0	98.5
	Widowed	3	1.5	1.5	100.0
	Total	200	100.0	100.0	

Table 5.9: Level of Education of Vendor Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No formal education	53	26.5	26.5	26.5
	Primary	80	40.0	40.0	66.5
	Secondary	56	28.0	28.0	94.5
	Tertiary	11	5.5	5.5	100.0
	Total	200	100.0	100.0	

Table 5.10: Sex of Vendor Respondents.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	2	1.0	1.0	1.0
	Female	198	99.0	99.0	100.0
	Total	200	100.0	100.0	

Table 5.11: Number of Workers employed by Vendor Respondents

		Frequency	Percent	Valid Percent	Cumulative Percent
	1-3	158	79.0	79.0	79.0
	4-6	28	14.0	14.0	93.0
Valid	7 and above	14	7.0	7.0	100.0
	Total	200	100.0	100.0	

5.2.2 Variation in Primary Energy source used for cooking by Households and Vendors.

Cooking is generally one of the main domestic activities that use up a great deal of energy. Past trends have often identified household fuel use as the main consumer of fuelwood and often times neglected other significant non-householders as food vendors (Remedio, 1993). Results of the study reveal a sharp change in the main fuels households use as their primary source of energy for cooking when compared with past data on energy sources.

From Figure 5.1 and Table 5.13, it is clear that there has been a noticeable domestic shift to fossil fuels (i.e kerosene) which is also made more apparent by the fact that 82.5% of respondents always use kerosene for their daily cooking needs compared to 6% fuelwood and (2%) charcoal users. This finding is similar to the result of a recent study on energy consumption inferring a 50% use of kerosene as a main order fuel by urban households (Ogwumike *et. al*, 2014). An Ile-ife study also reported a 23% household use of fuelwood and 64% household use of kerosene (Kersten *et. al*, 1998). The results of this study is in consonance with Adelekan's report on fuel switching (2006) from the pre 1993 period till current times.

These results reveal a significant change over a 45 year period as previous data from the 1970's found household fuelwood use to be 95%, while 3% of users used kerosene (Morgan, 1983; Ayoub, 1988). The point of departure from findings of previous studies is that the level of domestic fuelwood use may have dropped below what was reported in 2006 as seen from Table 5.12. This may be due to the coping and adaptive strategies many respondents adopted inspite of the incessant upward price reviews of fossil fuels. For some the 'urbanness' of their rented living quarters do not permit the use of open air combustion types of fuels as prohibited by their landlords due to the soot, smokiness and resulting de-facing of such houses with soot. A few respondents also mentioned the health hazards associated with the use of such fuels such as chest pain, difficulty breathing.

Conversely for food vendors, the results of the study indicate over 56% of such respondents are heavily reliant on fuelwood as a primary cooking fuel and are significant consumers of fuelwood. A further 34% of food vendors favoured charcoal instead. Although there are no known comprehensive past records of food vendor consumption in Ibadan, Ayoub (1988), and Kersten *et. al,* (1998)in Ile Ife recorded a significant use of wood (about 90%) by urban commercial groups including food vendors in the early nineties. The data was however not fully disaggregated. Charcoal generally has of late been given a strong consideration by households needing an affordable second order fuel following the price dislocations of fossil fuels (Adelekan, 2006). Gas use for cooking has also witnessed an increase in use especially for households rather than food vendors (Kersten *et. al,* 1998).

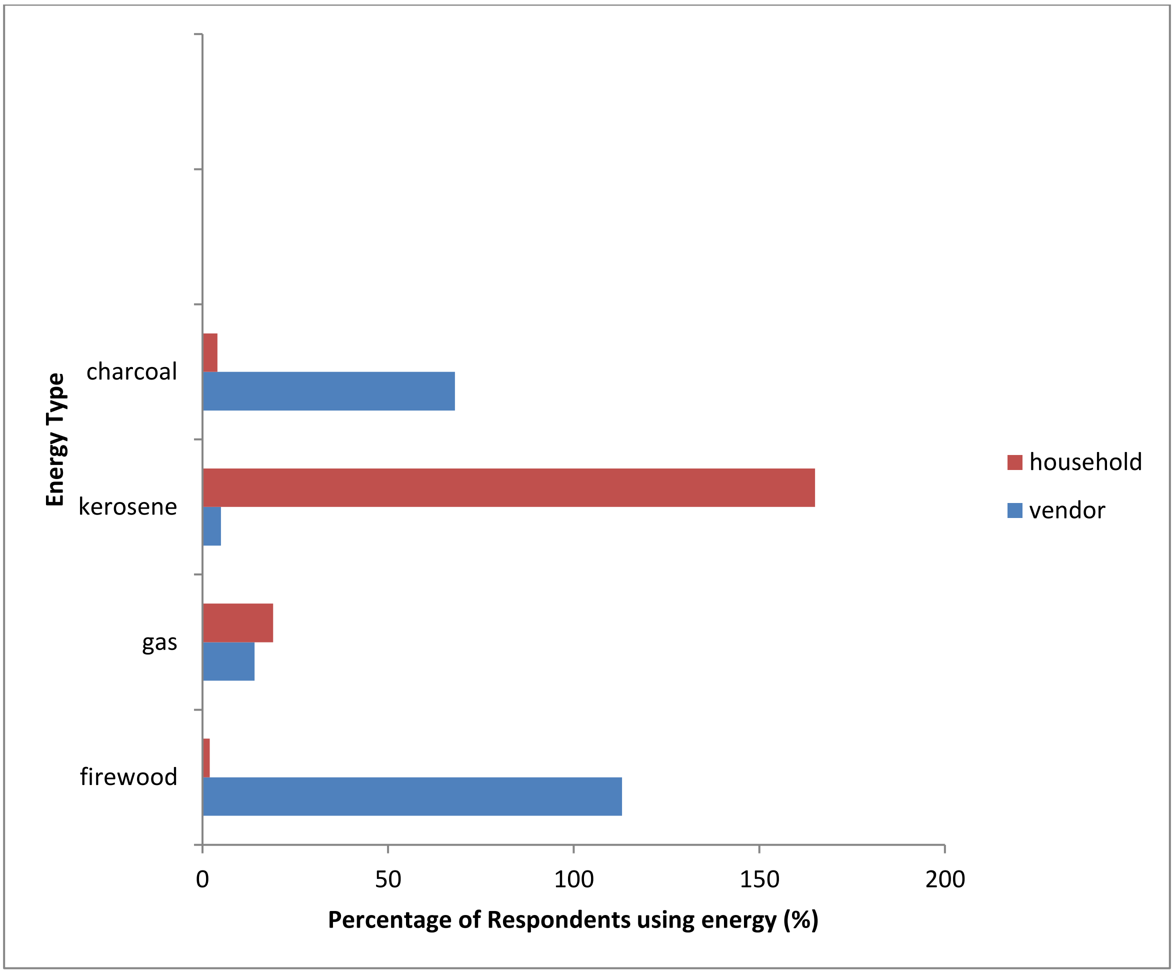


Figure 5.1: Types of energy used by food vendors and households in Ibadan.
Source: Author's Analysis 2015

Table 5.12: Household Trend in use of 1st order cooking fuels before 1993 to 2015 in Metropolitan Ibadan

	Before 1993	**1993-97**	**1999**	**2015**
Fuelwood	20	122	34	10
Charcoal	7	45	2	4
Kerosene	331	165	223	164
Gas (LPG)	56	10	23	15
Electricity	3	21	8	-
Others	-	45	14	7
NoResponse	12	15	4	-
Total number	**420**	**420**	**420**	**200**

Source: 1. Data (before 1993, 1993 – 97, 1999), Adelekan *et. al*, (2006) based on simple frequencies.

2. 2015 Data, Author's fieldwork.

Table 5.13: Distribution of Respondents by Cooking Energy Type

	Fuel type	NW	SW	NE	SE	North	Total Users
		Local Government Areas					
1st order users HOUSEHOLD	Fuelwood	0(0.0%)	2(1.0%)	3(1.5%)	2(1.0%)	3(1.5%)	**10(**5.0%)
	Gas	7(3.5%)	1(0.5%)	3(1.5%)	1(0.5%)	3(1.5%)	**15**(7.5%)
	Kerosene	26(13.0%)	35(17.5%)	34(17.0%)	37(18.5%)	32(16.0%)	**164**(82.0%)
	Charcoal	0(0.0%)	2(1.0%)	0(0.0%)	0(0.0%)	2(1.0%)	**4**(2.0%)
Mixed users HOUSEHOLD	Fuelwood /kerosene	2(1.0%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	**2**(1.0%)
	Kerosene and gas	1(0.5%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	**1**(0.5%)
	Gas/kero/charcoal	1(0.5%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	**1**(0.5%)
	Gas and kerosene	3(1.5%)	0(0.0%)	0(0.0%)	0(0.0%)	0(0.0%)	**3**(1.5%)
	Total	**40 (20.0%)**	**40 (20.0%)**	**40 (20.0%)**	**40 (20.0%)**	**40 (20.0%)**	**200 (100.0%)**

1st order users VENDOR		NW	SW	NE	SE	North	**Total Users**
	Fuelwood	16(8.0%)	11(5.5%)	31(15.5%)	40(20.0%)	15(7.5%)	113(56.5%)
	Gas	2(1.0%)	5(2.5%)	2(1.0%)	0(0.0%)	5(2.5%)	14(7.0%)
	Kerosene	1(0.5%)	1(0.5%)	1(0.5%)	1(0.5%)	1(0.5%)	5(2.5%)
	Charcoal	8(4.0%)	17(8.5%)	13(6.5%)	16(8.0%)	14(7.0%)	68(34.0%)
	Total	**27(13.5%)**	**34(17.0%)**	**47(23.5%)**	**57(28.5%)**	**35(17.5%)**	**200(100.0%)**

Plate 8: Cooking with fuelwood at Ajangboju, SE Ibadan.
Source: Author's Analysis September, 2015

Plate 9: Food vendors' use and temporary storage of fuelwood in piles at Ode-Aje, SE Ibadan.
Source: Author's Analysis, September 2015

Plate 10: Food vendor using charcoal for cooking in large coal-pots (stored in sacks) at Agbowo, Ibadan North.
Source: Author's Survey. September 2015

5.2.3 Variation in pattern, volume and expenditure of fuelwood use among households and food vendors across the five LGAs in Ibadan metropolis.

A closer look at fuelwood use across the five LGAs revealed different patterns of use in frequency, volume and expenditure for both households and food vendors (Table 5.13). For the households, the discernable pattern of variation across different areas of Ibadan is not in consonance with the assertion by Ayoub (1988), that no significant variation in fuelwood consumption exists. In comparison to findings from Adelekan's study on Ibadan (2006), there seems to be a reduction in domestic use (Table 5.12). The pattern of use across the five local government areas showed the North with many low to medium income dwellings that used less than 10kg per week (Table5.14). NE had more conspicuous users who utilized more than 30kg of fuelwood per week and were the largest users in the metropolis. The NW had no recorded household using fuelwood as all the interviewed respondents used modern fuels. The average weekly fuelwood consumption for the sampled households is 13.77kg ±10.5, while the monthly range was 7.6 – 120kg (55±40.2 kg).

On the other hand, the majority of food vendors (56.5%) used fuelwood ranging in volumes from 7kg to 448kg weekly (Fig 5.4). In terms of spread, the SE area harbours the largest number of users following the proportion of respondents sampled (Plate 8, 9), while the North consumed the highest volume of fuelwood of all the areas (Plate 10). More than 80% of respondents used below 100kg in a week while heavy users consuming about 400kg weekly were found in the N, NW and SE. To effectively test for variation between the households and food vendors, a Co-efficient of Variation analysis and student t tests were performed. Table 5.16 shows the mean fuelwood consumption (kg) of both groups across the five local governments and this result was used to run a coefficient of variation (CV) analysis to effectively compare variability in each sample. The CV for both household and food vendors exhibited variation in differing degrees as the CV for food vendors was notably higher signifying a wider spread of variability and dispersion relative to the mean than for the households. There was a significant difference in the weekly fuelwood consumption as households' consumption (13.77±10.0) was significantly lower than FV (84.1kg±103) (t_{69}=5.38).

From Table 5.14 most of the sampled households spent less than 2000 Naira weekly while from Table 5.15, more than 60% spent less than 4000Naira on fuelwood weekly and the SE area accomodates 27.4% of these users. The largest spenders were few and were located mostly in the North (such as Secretariat, Bodija /Oju irin area).

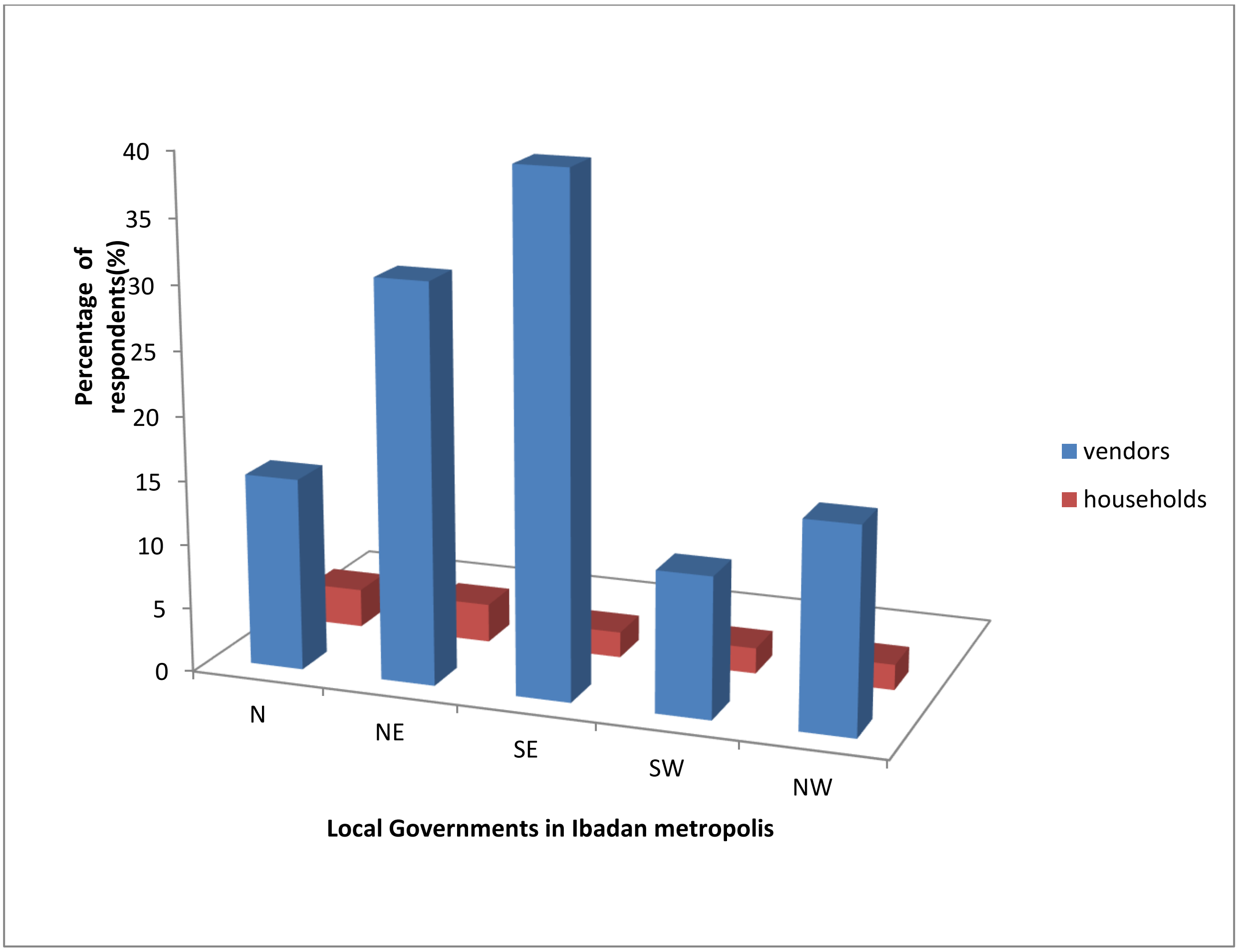
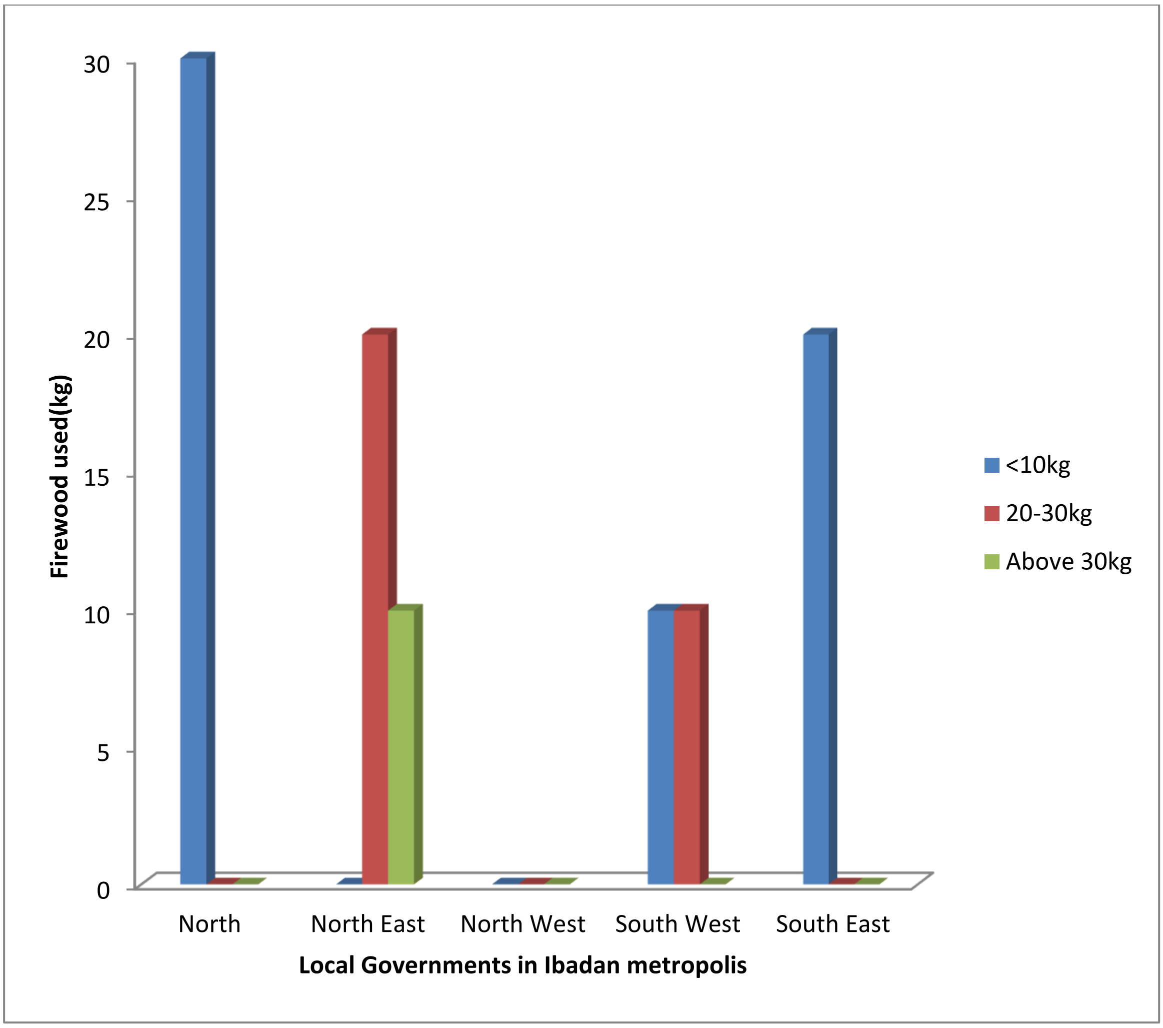
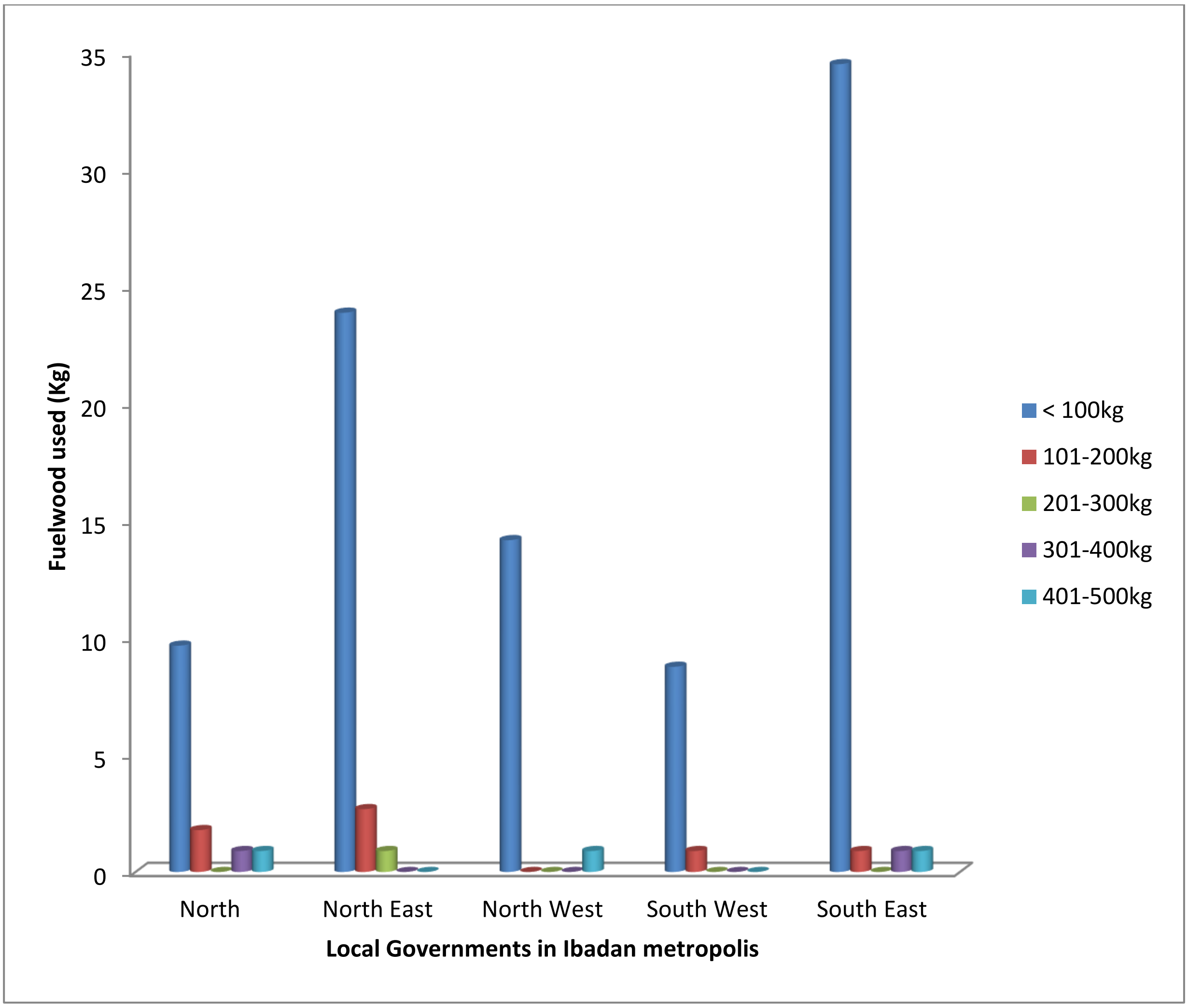


Figure 5.2 Fuelwood use for cooking across the five LGAs in Ibadan metropolis.



Fuelwood range; Highest = 30kg, Lowest = 1.9kg. Mean (13.8 ±10.5).

Figure 5.3: Household fuelwood consumption across the five LGAs in Ibadan metropolis



Fuelwood consumption range: Highest = 448kg, Lowest = 7kg. Mean (84.14±103.0).

Figure 5.4: Fuelwood consumption by Food Vendors across the five LGAs in Ibadan metropolis

Table 5.14: Household Expenditure on fuelwood per week

Amount in Naira (₦)	SW	NE	LGAs SE	North	NW	Total
<1000	1(10.0%)	0(0.0%)	0(0.0%)	1(10.0%)	0(0.0%)	2(20.0%)
1000-2000	1(10.0%)	1(10.0%)	2(20.0%)	2(20.0%)	0(0.0%)	6(60.0%)
3001-4000	0(0.0%)	2(20.0%)	0(0.0%)	0(0.0%)	0(0.0%)	2(20.0%)
Total	**2(20.0%)**	**3(30.0%)**	**2(20.0%)**	**3(30.0%)**	0(0.0%)	**10(100.0%)**

Source: Author's Analysis, 2015; Exchange rate of $1 to N237 as at July 2015.

Table 5.15 Vendor Expenditure on fuelwood per week

	LGA					Total
(₦)	**N**	**NE**	**SE**	**SW**	**NW**	
< 2000	2(1.8%)	13(11.5%)	10(8.8%)	4(3.5%)	10(8.8%)	39(34.5%)
2001-4000	6(5.3%)	12(10.6%)	12(10.6%)	2(1.8%)	3(2.7%)	35(31.0%)
4001-6000	1(0.9%)	0(0.0%)	11(9.7%)	1(0.9%)	1(0.9%)	14(12.4%)
6001-8000	2(1.8%)	4(3.5%)	4(3.5%)	3(2.7%)	1(0.9%)	14(12.4%)
Above 8000	4(3.5%)	2(1.8%)	3(2.7%)	1(0.9%)	1(0.9%)	11(9.7%)
Total	15(13.3%)	31(27.4%)	40(35.4%)	11(9.7%)	16(14.2%)	113(100.0%)

Source: Author's Analysis, 2015; Exchange rate of $1 to N237 as at July 2015.

Table 5.16: Variation in mean fuelwood consumption of households and food vendors across five local government areas in Ibadan metropolis.

	HOUSEHOLD CONSMP(KG)	**C.V. (%)**	**St.Dev**	**FOODVENDOR CONSMP(KG)**	**C.V. (%)**	**St.Dev**
North	5.13	0.55	2.81	166.4	0.90	151.21
NorthEast	21.16	0.41	8.75	85.53	0.93	79.68
NorthWest	0.00	0.00	0.0	51.93	1.81	94.18
SouthEast	12.00	0.00	0.0	70.22	1.42	99.77
SouthWest	17.40	1.02	17.8	65.44	0.82	53.42
Mean weekly Consumption (kg)	**13.77**		10.03	**84.14**		103.09

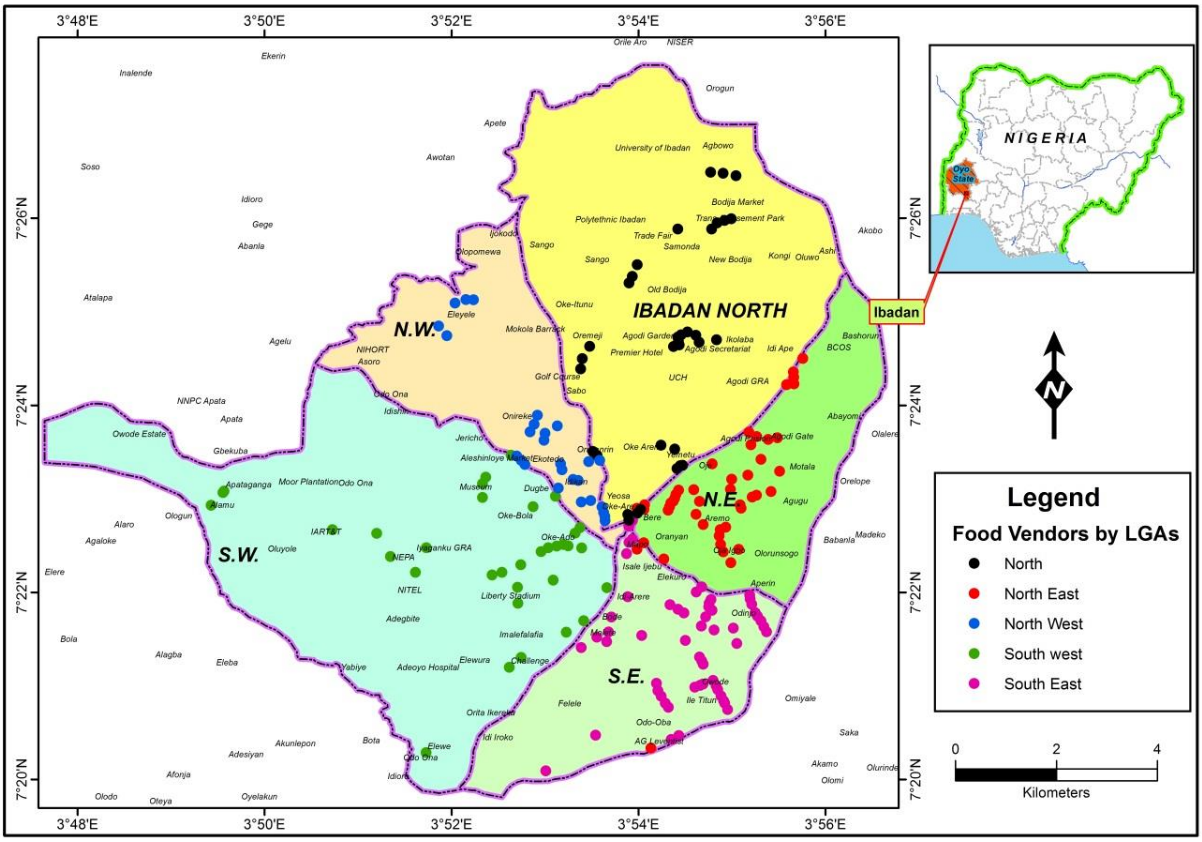


Figure 5.5: Distribution of Sampled Food Vendors across Ibadan Metrópolis.

5.2.4 Variation in pattern, volume and expenditure of Charcoal use among Households and Food vendors across the five LGAs in Ibadan metropolis.

The greater users of charcoal as seen from Figure 5.6 are vendors, as barely 2% of households make it a first order fuel. Of the household respondents sampled, only 4 users were recorded to use charcoal as a primary fuel all of which use less than 10kg in a week (Table 5.16). The average daily quantity consumed is 5.0±2.2kg with the range spreading from 3bags per month to 5 bags in a month. From the weighings done in the field, a full sack of charcoal ranges from 35-36kg which when calculated translates to 108-180kg for the average household. Expenditure usually ranges from 5000 – 10,000 Naira in a month. 34% of all vendors make it their primary fuel source for cooking (Figure 5.6). 97% of the vendors use less than 100 kg per month.

Food vendors had an average consumption of 33.8 ±26.5(kg) and a range of 0.5bags - 155 bags in a month. From the weighings done in the field, a full sack of charcoal ranges from 35-36kg which translates to a range of 18kg in weight consumed to over 5000kg per month. From observation of consumption across the five local goverments, there was considerable variation in volumes used. The Southwest L.G had the highest quantity used (25%) but with all respondents using under 100kg of charcoal per month. 23.5% of South East users also consumed under 100kg. North and North East users account for 3% of the very high user group (almost 200kg per month). This is supported by the results of the highest consumers of fuelwood who are also from the same local governments. Accordingly from Table 5.17 and 5.18, 29.4% of food vendors spend between 20,001 and 40,000 Naira monthly on charcoal. A greater share was spent by users who expend less than 20,000 in a month on charcoal (58.8 %). Of these, the North still accommodates the few (3%) larger spenders (above 60,000Naira every month). Figure5.8 shows the spatial distribution of vendor fuelwood users across Ibadan metropolis. The heavy users represented by larger circles are clustered in the North, forming hubs around educational centers and business districts.

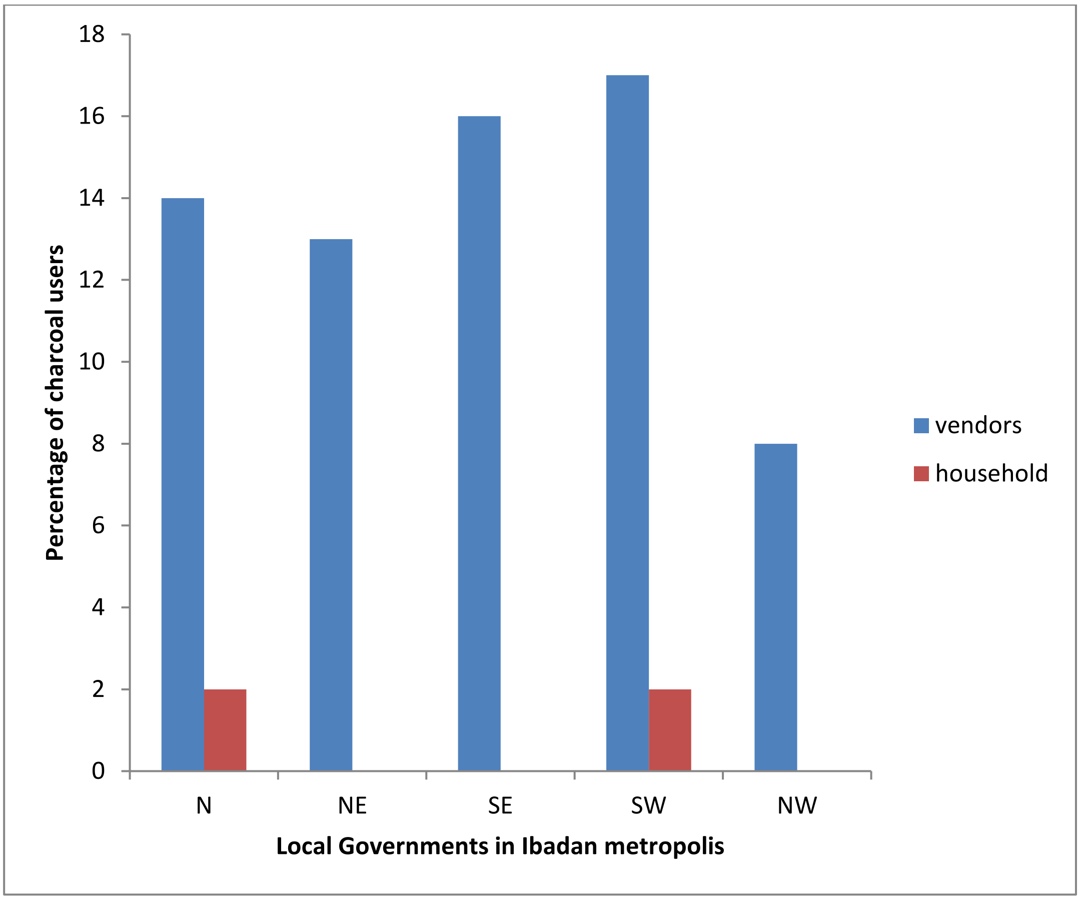
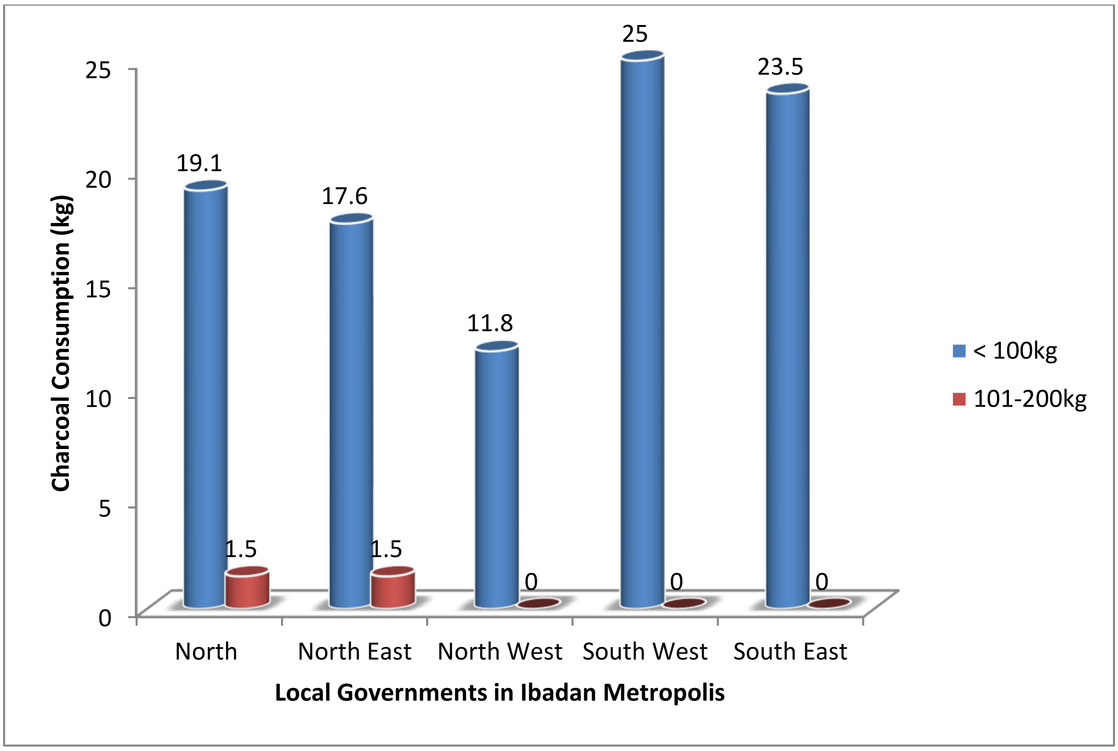


Figure 5.6: Charcoal Users across the Five LGAs in Ibadan metropolis.



Charcoal consumption monthly range; Highest = 155 bags, Lowest = 0.5bags. Mean (33.8 ±26.5).

Figure 5.7: Food Vendors Charcoal Consumptionacross the five LGAs in Ibadan Metropolis.

Table 5.17: Household Expenditure on charcoal per month

Amount (₦)	**SW**	**North**	**LGAs** **NE**	**SE**	**NW**	**Total**
1000-2000	2(50.0%)	2(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	4(100.0%)
Total	**2(50.0%)**	**2(50.0%)**	0(0.0%)	0(0.0%)	0(0.0%)	**4(100.0%)**

Source: Author's Analysis, 2015; Exchange rate of $1 to N237 as at July 2015.

Table 5.18: Vendor Expenditure on charcoal per week

Amount (₦)	LGA N	NE	SE	SW	NW	Total
< 2000	6(8.8%)	3(4.4%)	2(2.9%)	8(11.8%)	6(8.8%)	25(36.8%)
2001-4000	1(1.5%)	1(1.5%)	1(1.5%)	4(5.9%)	0(0.0%)	7(10.3%)
4001-6000	1(1.5%)	4(5.9%)	8(11.8%)	1(1.5%)	1(1.5%)	15(22.1%)
6001-8000	0(0.0%)	3(4.4%)	2(2.9%)	2(2.9%)	0(0.0%)	7(10.3%)
Above 8000	6(8.8%)	2(2.9%)	3(4.4%)	2(2.9%)	1(1.5%)	14(20.6%)
Total	14(20.6%)	13(19.1%)	16(23.5%)	17(25.0%)	8(11.8%)	68(100.0%)

Source: Author's Analysis, 2015; Exchange rate of $1 to N237 as at July 2015.

Table 5.19: Vendor Expenditure on charcoal per month

Amount (₦)	LGA					Total
	North	NE	SE	SW	NW	
< 20,000	8(11.8%)	6(8.8%)	7(10.3%)	12(17.6%)	7(10.3%)	40(58.8%)
20,001-40,000	2(2.9%)	5(7.4%)	8(11.8%)	4(5.9%)	1(1.5%)	20(29.4%)
40,001-60,000	2(2.9%)	2(2.9%)	0(0.0%)	1(1.5%)	0(0.0%)	5(7.4%)
Above 60,000	2(3.0%)	0(0.0%)	1(1.5%)	0(0.0%)	0(0.0%)	3(4.4%)
Total	14(20.6%)	13(19.1%)	16(23.5%)	17(25.0%)	8(11.8%)	68(100.0%)

Source: Author's Analysis, 2015; Exchange rate of $1 to N237 as at July 2015.

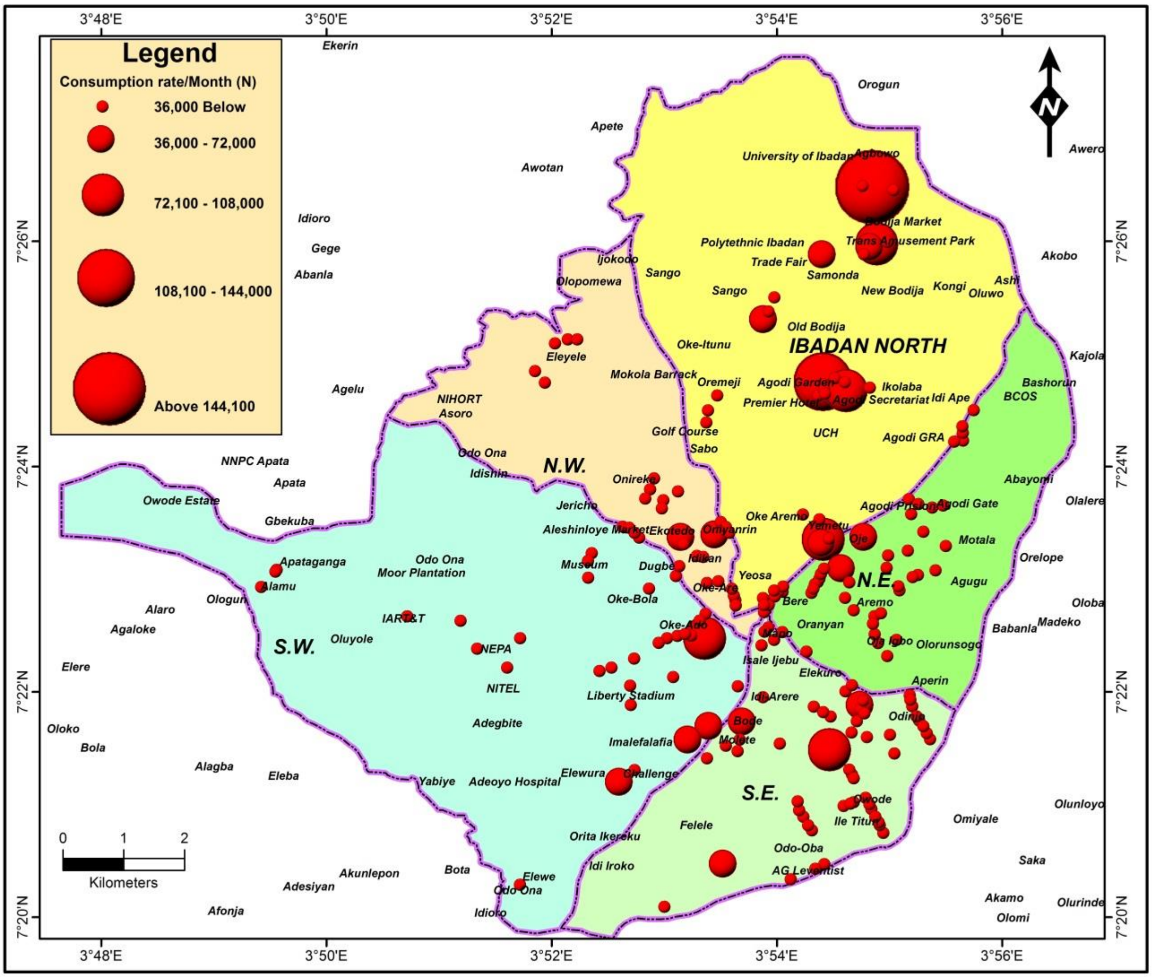


Figure 5.8: **Food Vendor Expenditure on Fuelwood consumed across the Five LGAs in Ibadan Metropolis.**

5.2.5 Variation in fuel preference among Households and Vendor respondents in Ibadan

Cooking fuel preference can be cast as a measure of the available fuel supplies and the user's access/ ability to obtain them (Ayoub, 1988). It is often seen as a predictor of future fuel consumption trajectories and is identified by the users' indicated choice if all impediments to access were removed. The results of the study revealed that the most preferred domestic fuel was Gas with about 72% of Household respondents preferring it (Figure 5.9). This is similar to a previous study by Ayoub (1988), on Ibadan residents. His findings revealed bottled gas as the most preferred fuel for cooking, followed by electricity and kerosene (61 percent and 48 percent respectively) leaving fuelwood least preferred. Kerosene was a secondary fuel choice for cooking due to its reliability as respondents' perceived fuel supplies, fuel costs, and fuel availability in their immediate habitat (Ayoub, 1988). In this current study however, due to fear of explosions with gas use, 27% of household respondents preferred kerosene for its availability and affordability (Figure 5.9). The remaining users opted for either electric stove or charcoal. This result compared with findings of Ayoub (1988), suggested a pattern of fuel preference that has remained relatively stable over time. Similarly, food vendors preferred gas overwhelmingly (74%) but preferred charcoal (14%) and fuelwood (9%) as second order fuels even more than kerosene (Figure 5.10). The higher level of gas preference also suggests the uptake of advocacy efforts to encourage fuel switching to non-fuelwood fuels. Future fuel shifts by households will most likely be tailored along more fossil fuel use if access remains available. Conversely, food vendors need more advocacies to encourage engagement with fossil fuels than fuelwood.

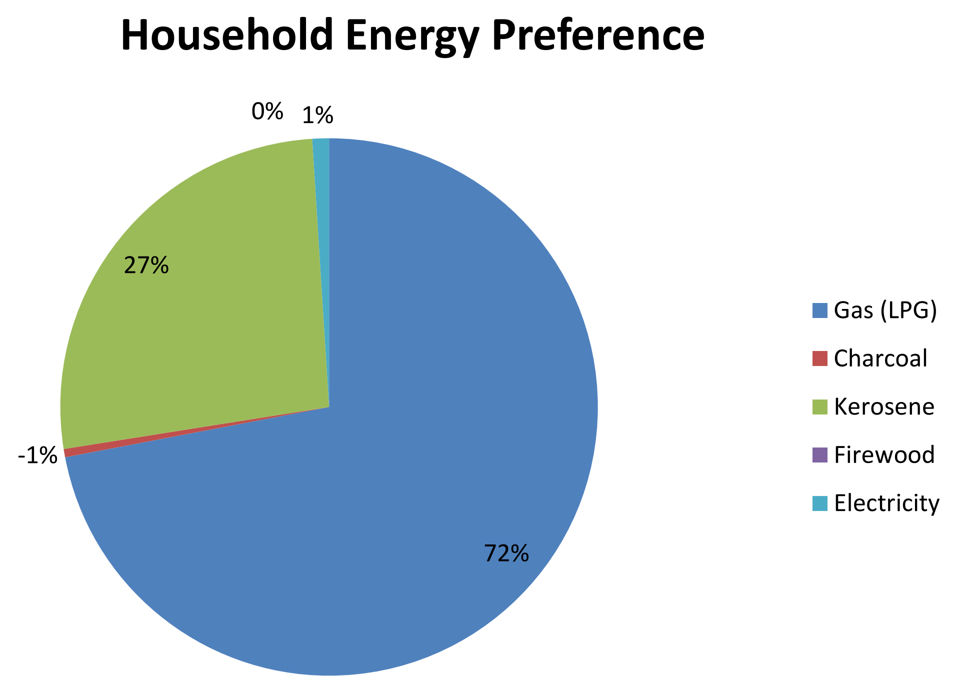


Figure 5.9: Sampled Fuel Preference of Households in Ibadan metropolis.

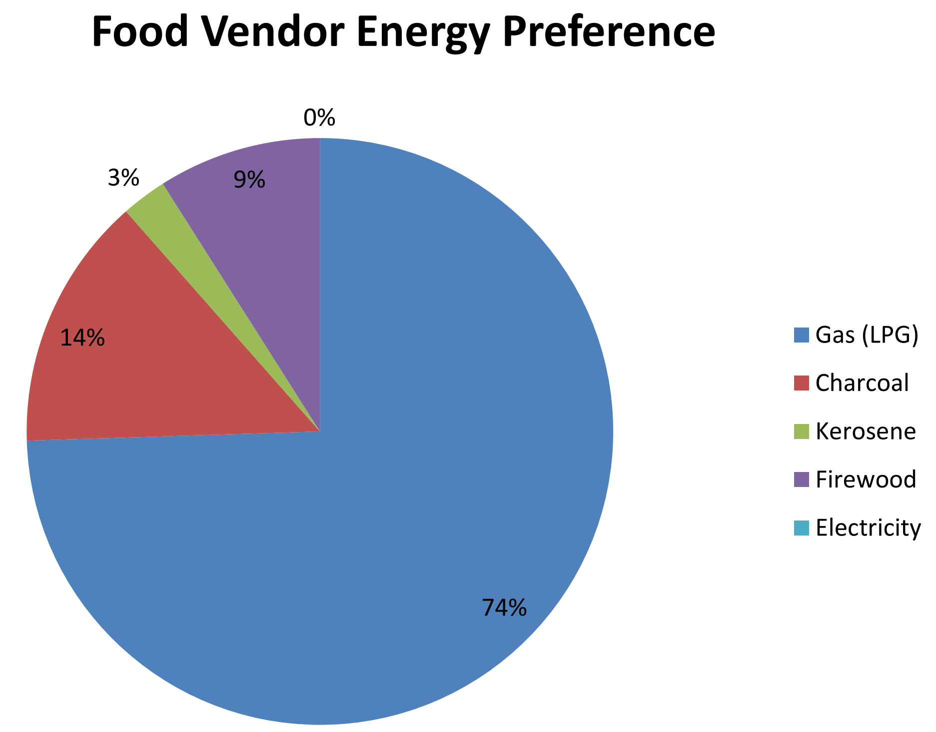


Figure 5.10: Sampled Fuel Preference of Food Vendors in Ibadan metropolis.

5.3 Objective Five

This was to find out if user characteristics (vendor sex, age, marital status, level of education, number of years in business, number of workers) do significantly influence vendor consumption therefore a multiple regression analysis was performed. This was to show if consumption levels of fuelwood could be predicted by socio-economic characteristics (vendor sex, age, marital status, level of education, number of years in business, number of workers). The multiple R was 0.64 which indicated a positive relationship between the independent variables and consumption. All the socio-economic variables were first of all used for the analysis to assess their contribution and most of the variables selected gave p-values bigger than 0.05. Some variables were removed (marital status, level of education) and the analysis run again. Results showed the multiple R as 0.67 indicating a positive relationship between the independent variables and consumption (R^2=.42, F(2,113)=6.34E-14, p-value >0.05. The main variable from the analysis that had significance for how much fuelwood a vendor consumed was the number of years a vendor had spent in the business (p>0.01) The result was statistically significant at 0.05 significance level. Thus the main variable found to significantly explain variation was the number of years a food vendor had invested into her business impacted greatly on her fuelwood needs.

Table 5.20: Multiple Regression Analysis between Number of years, Number of workers and Vendor Fuelwood Consumption in Ibadan metropolis.

Regression Statistics		F	Significance F	df
Multiple R	0.649849	40.57117	6.34E-14	2
R Square	0.422303			111
Adjusted R Square	0.40809			113
Standard Error	101.7637			
Observations	113			

Table 5.21. Regression model coefficient of socio-economic variables of food vendors predicting consumption levels.

	Coefficients	***Standard Error***	***t Stat***	***P-value***	***Lower 95%***	***Upper 95%***	***Lower 95.0%***	***Upper 95.0%***
Intercept	0	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
Vendor Sex	-2.03562	24.57939	-0.08282	0.934148	-50.7512	46.67993	-50.7512	46.67993
No of Workers	12.54174	11.49843	1.090735	0.277795	-10.2478	35.33126	-10.2478	35.33126
No of years in business	26.02616	8.321546	3.127563	0.002261	9.533126	42.51919	9.533126	42.51919
Age	-0.25042	0.824394	-0.30376	0.761891	-1.88434	1.383504	-1.88434	1.383504

5.4 Conclusion

Summarily from the empirical evidence given, the distinctiveness of household fuelwood utilization pattern as against that of food vendors in Ibadan metropolis is undoubtedly clear. There was a significant difference in the weekly fuelwood consumption as households consumption was lower than food vendor consumption (t_{69}=5.38). The most commonly used cooking fuel by food vendors is fuelwood while kerosene was the most commonly used fuel by households. Main fuel preferred by both groups was gas. Although consumption pattern of vendor group bears little responsiveness to socio-economic characteristics, business demographics (particularly for older businesses) play a notable role in shaping pattern.

CHAPTER SIX

SUMMARY, RECOMMENDATIONS AND CONCLUSION

6.1 Introduction

This chapter synthesizes the empirical findings that have emerged from this study about the role fuelwood demand plays in environmental change in SouthWest Nigeria. It is a timely contribution to literature in Environmental geography, Energy geography and Human geography. Below are the summary and the implications it has for policymakers. Further recommendations and final conclusions are also highlighted.

6.2 Summary and Conclusions on Research Objectives.

This study was conducted in Oyo State due to its unique state of two contrasting ecosystems (forest and savanna) within a single bounded area. It was designed to investigate the effects of fuelwood extraction on vegetation characteristics, associated soil properties, and fuelwood consumption differentials between households and food vendors. In order to achieve the aim of the study, a mixed method design was adopted and five research objectives were outlined as discussed in chapters four and five. The summary of the research findings is presented below.

The study sought to characterize and compare effects of fuelwood extraction on vegetation (tree density, diversity, species composition and tree structure at savanna and forest extraction sites in Oyo State. The tabulated results of the diversity analysis (chapter four) showed lowered number of species, tree density, tree count of both forest and savanna extraction sites but at varying intensities. It is clear that fuelwood extraction does effect important changes on the vegetal component of an ecosystem but these changes vary across space (ecosystem). Additionally, the research sought if there are significant differences in soil properties between wood fuel extraction sites and unexploited sites within and between forest and savanna areas. As seen from the results of the soil analysis (chapter four) exploited forest soils tended to be less resilient to nutrient losses than savanna soils (Tredennick, 2014). Moreover, the study sought to characterize the relationship between structural characteristics of trees and soil properties of wood fuel extraction sites at forest and savanna sites.

Results of the Detrended correlation analysis on the Paleontological Statistics (PAST) software (Hammer *et. al.,* 2001) showed a significant relationship between soil properties and the structural characteristics of trees in fuelwood exploited areas. This is similar to other findings showing the strong interrelationship in soil-vegetation relations. A further exploration on the urban dimensions of fuelwood use was the determination of variation and preference amidst households and vendors in the Ibadan metropolis. From the results, it was apparent that food vendors used more and therefore spent more on fuelwood than the average household. There was a significant increase in household use of modern fuels for cooking more than before (similar to Ogwumike, 2012) and a slight reduction in use of woodfuels compared to previous reports (Adelekan, 2006).

Finally, the influence of user characteristics (vendor sex, age, marital status, level of education, number of years in business, number of workers) on vendor consumption was explored using a multiple regression analysis. Results have shown the impacts of fuelwood extraction to be primarily a simplification of forest structure and diversity, while denuding soils of important nutrients. The study has also revealed the near total reliance of food vendors in urban Ibadan on fuelwood as a primary cooking fuel due to a lack of affordable alternatives.

6.3 Critical Reflection on Research problem and Implications

The growing nexus between environmental change and demand for fuelwood can therefore not be said to be tenuous but has sufficient merit to warrant further explorations. It can be said that increased fuelwood consumption impinge on the environment in ways more far reaching than previously known. Theoretically both the Energy ladder hypothesis and the Multiple stack concept as constructs to understand drivers of fuelwood consumption, are applicable in the Ibadan experience with distinct relevance for households and food vendors. The problem of exclusive dependence on fuelwood by vendors is exacerbated by the increasing number of food vendors participating in the informal economy (Tedd *et. al,* 2001) which in turn can be attributed to the rapid urbanization of the city which necessitates a high number of working class people feeding away from home in the different restaurants (Tinker, 1997). It is estimated that up to 30% of domestic food expenses are made on buying meals cooked outside the home (FAO, 1997). The import of this is that increased commercial fuelwood consumption by these vendors may trigger the beginning of hitherto unknown wood fuel scarcities in the south west since these users have few acceptable fuel alternatives apart from fuelwood. Although this finding is slightly different from previous studies that emphasize the predominance of domestic users as most significant in fuelwood consumption (Ayoub, 1988; Adelekan and Jerome, 1996; Kersten *et. al,* 1998), others such as Ogwumike (2012) and Siong (2011) corroborate this finding and suggest modern fuels are more in use for cooking in urban Ibadan households.

6.4 Recommendations

Even though findings suggest a shift towards more domestic use of fossil fuels in Ibadan, there is still a need for policymakers to engage more advocacy and enlightenment of food vendors on the need for fuel switching. There is also the need to reframe demand interventions to make modern fuels more attractive, affordable and available as alternatives to fuelwood. An increased understanding by research on how current fuelwood use efficiencies may be increased will also be of help to subsequently reduce volume being consumed. Given the changes that extraction of wood brings to forests and woodlands, there is a need for more research into increasing potential fuelwood supplies through a resuscitation of previous established plantations and increased woodlot interventions developed within Oyo State.

Based on available funds and limited time for the research, the work was limited to a comparative analysis of only two user groups. To further elaborate on the present findings, future research may find more opportunities in exploring a wider scope of users to achieve a more generalisable result on urban fuelwood consumption. Furthermore on environmental change, more assessments on the influence of seasonality and harvesting practices in determining extraction impact on soils properties should be investigated. Effective solutions cutting across various political, legislative, social issues will be required to reduce the ecological footprints of fuelwood demand before it assumes a more challenging dimension in the not too distant future.

REFERENCES

Aabeyir.R., Jonathan .A., Quaye-ballard. Van leeuwen,M. L. & William.O. 2011. Analysis of factors affecting sustainable commercial fuelwood collection in Dawadawa and Kunsu in Kintampo north district of Ghana.*IIOAB-India journal*; Volume. 2; Issue 2; 2011: pp 44- 51.

Aatyi, R. Eba'a, Ngouhouo Poufoun J., Mvondo Awono,J.P., Ngoungoure Manjeli.A & Sufo kankeu. R. 2016. Economic and social importance of fuelwood in Cameroon.*International Forestry Review*Volume.18(2), 2016.

Adegbulugbe, & Akinbami, J-F.K. 1995. Urban Household Energy Use Patterns in Nigeria.*Natural Resources Forum,*Volume. 19, No. 2. pp 125-133

Adelekan.O.I & Jerome.A.T .2006. Dynamics of household energy consumption in a traditional African city, Ibadan *The Environmentalist*, Springer Netherlands Volume 26, Number 2 / June, 2006 : pp 99-110

Adejuwon, J.O and Adesina, F.A .1988. Vegetation patterns along a forest savanna boundary in Nigeria. *Singapore journal of Tropical Geography*, Vol 9, no1

Adewole, O.O, Desalu.O.O, Nwogu, K.C, Adewole, T.O. Erhabor, G.E. 2013. Respiratory symptoms and lung function pattern in workers exposed to woodsmoke and cooking fumes (Mai Suya) in Nigeria. *Ann.Med health, Sci. Res* 2013 3: 38- 42.

Aina O. I. & Odebiyi A. I. 1998. Domestic Energy Crisis in Nigeria: Impact on Women and Family Welfare. *African Economic History*, No. 26 (1998), pp. 1-14 Publisher: African Studies Program at the University of Wisconsin--Madison Stable URL: http://www.jstor.org/stable/3601688 Accessed: 22/02/2010 12:54

Aiyeloja, A. A., 2009. Potentials of small-scale Forest based enterprises in poverty reduction in Southwestern Nigeria. PhD.Thesis. Department of Agric Extension University Of Ibadan, Nigeria.

Akintola.F.O., Aweto, A.O, Gbadegesin, A.S, Daura, M.M .1996. Rural energy consumption patterns and deforestation in Nigeria. Working paper 9, *Niser / SSCN national research network on Liberalization policies in Nigeria.*

Akut, Y. B. 2008. Some Determinants of HouseHold Energy Consumption in Jimeta. In Mammam, A.B; Chup, C.D; & Mashi, S.A. (eds). *Urbanization, Resource Exploitation and Environmental Stability in Nigeria.* Book of Proceedings of the 49th Annual Conference of the Association of Nigerian Geographers (ANG). Joyce Graphics Printers & Publishers. Pg. 535 & 537.

Alabe,M.,1996. Household Energy Consumption Patterns in Nigeria. *Energy for Sustainable Development Volume. 2(5), 42-45*

Alamu, L. O. and Agbeja B. O. 2011. Deforestation and endangered indigenous tree species in South-West Nigeria. *International Journal of Biodiversity and Conservation* Vol. 3(7), pp. 291-297, July 2011 Available online http;//www.academicjournals.org/ijbc

Alan, R. 2012. Introduction to vegetation monitoring. Department of Conservation, Te papa Atawhai, New Zealand. Inventory and monitoring toolbox; vegetation DOCDM- to geria. ,N 400531

Ajadi, K. O., Alabi, F. M. and Adebisi, J.A. 2012. Subsistence Living And Global Climate Change; Implications Of Bio-charcoal Production For Farmers *In Rural Areas Of Nigeria in Ethiopian Journal of Environmental Studies and Management* Vol. 5 No.1 2012.

Ajah, Julius. 2013. Households' access and preference to cooking fuels in Abuja, Nigeria. *Journal of Environmental Science and Technology*

Amoah, M., Oduro. M., and Ohene. M. 2015. Assessment of household energy utilized for cooking in Ikeja, lagos State, Nigeria. *Nigerian Journal of Technology* vol35, no 4, pp 796- 804, 2016

Angelsen, A, and Wunder, S. 2003. Exploring the forest- poverty link; Key concepts, Issues and research implications. A paper available at www.cifor.org/pdf/occpapers

Anderson, D.1986. Declining tree stocks in African countries. *World Development,* vol14, no 7, pp 853- 863 *Pergamon Journals* ltd.

Anderson, J.M., Spencer.T. 1991. Carbon, nutrient and water balances of tropical rain forest ecosystems subject to disturbance; management implications and research proposals. *MAB digest 7*, UNESCO, Paris.

Antii, W. 2006. Effect of biomass removal on soil fertility. Report of Metla/Kannus Research unit on soil fertility and soil productivity, *Finnish Forest Research Institute*. Available at www.metla.fi

Appiah, D.O., and Boateng .A.I 2011. Woodfuel Extraction and Utilization; A Carbon Emission Conduit In Ejura-Sekyedumase District Ghana. Department of Geography and Rural development, Kwame Nkrumah University of Science and Technology, Kumasi presented at the Ghana Geographical Association Conference 2011. University for Development studies, wa campus 3rd to 6th august, 2011

Arnold,J.E.M and Bird, P.1999. Forests and poverty nexus. Profor paper prepared for the UNDP/EC expert workshop on poverty and the environment, Brussels, Belgium. Program on forests Washington DC, USA.

Arnold, M., Kohlin G, Persson R, Shepherd G.2003. Fuelwood revisited; what has changed in the last decade? Occasional paper no. 39. BogorBarat, Indonesia; Center for International Forestry Research (CIFOR);2003.Available[last visited on November 2009]http;// www.cifor.cgiar.org/publications/pdf_files/OccPapers/OP-39.pdf;

Arnold, M., Köhlin, G., Persson, R. 2005. Woodfuels, livelihoods and policy interventions; changing perspectives. *World Development* 34 (No 3); 596-611

Arshad, M.A., B. Lowery, and B. Grossman. 1996. Physical tests for monitoring soil quality. p.123- 142. In: J.W. Doran and A.J. Jones (eds.) *Methods for assessing soil quality. Soil Sci. Soc. Am. Spec. Publ. 49*. SSSA, Madison, WI.

Asadu, C.L.A., Chibuike, G.U. 2015. Contributions of organic matter,clay and silt to the effective CEC of soils of different landuse history. *Advances in Natural and Applied Sciences* 9(8), July 2015, pp 110-115.

Asner, P.G., Rudel, T.K., Aide.M., DeFries.R., Emerson. R. 2009. A Contemporary assessment of change in Humid Tropical Forests. *Conservation Biology*, Vol 23; No 6, 1386 – 1395. Special section.

Atyi, R. Eba'a, Ngouhouo Poufoun J., Mvondo Awono,J.P., Ngoungoure Manjeli.A, Sufo kankeu. R. 2016.*Economic and social importance of fuelwood in Cameroon in International Forestry Review* Vol.18(2), 2016.

Aweto, A.W. 1995. A spatio-temporal analysis of fuelwood production in West Africa. *OPEC Winter Review*;4;333–47

Aweto, A. O. 1981a; "Secondary Succession and Soil Fertility Restoration in South-western Nigeria", *Journal of Ecology*, Vol. 69, pp. 601-607.

Aweto, A.O. 1981b; Organic matter build-up in fallow soil in a part of South-western Nigeria and its effects on soil properties. *Journal of Biogeography*, 8, 67-74.

Aweto, A.O., Dikinya. O. 2003. The beneficial effects of two tree species on soil properties in a semi-arid savanna rangeland in Botswana, *Land Contam.Reclam.*, 11(3); 1-6.

Ayres, E., Steltzer. H., Berg.S., Wallenstein. M.D., Simmons. B.L. and Wall.D.H. 2009. Tree Species traits influence soil physical, chemical and biological properties in high elevation forests. *PLoS ONE* 4(6); e5964 doi;10.1371/journal.pone.0005964. accessed online Aug 2 2017

Ayorinde, M. 2012. Characteristics and reactivity of humic acids extracted from forest and savanna soils of Nigeria. PhD dissertation. Department of Soil Science, Faculty of Agriculture, Ahmadu Bello University, Zaria Nigeria

Ayoub, J. 1988. Patterns of rural household energy consumption and fuel preferences; a case study in Oyo State, South-western Nigeria. Masters Thesis. Department of Geography, McGi11 University,Montreal, Québec

Azeez, F. A., Ajayi C.A., Olarewaju T.O., Nosiru M.O., Farinola L.A. 2014. The Utilisation pattern and Economic Evaluation of Fuelwood Enterprise ; A case study of some areas in Ibadan metropolis, Oyo State. *International Journal of Agriculture*, *Forestry and Fisheries*. Vol. 2, No 6, 2014, pp 91-95.

Bailis, R. 2005. Fuel from the Savanna: the Social and Environmental Implications of the Charcoal Trade in Sub-Saharan Africa. A doctoral dissertation, University Of California, Berkeley. Available at http: rael.berkeley.edu/sites/default/files/old-site-files/diss/Robert_Bailis_2005.pdf

Barbour, M.G., Burk, .J.H., Pitts.D.W. 1942. Terrestrial Plant Ecology. Second ed. The Benjamin Cummings Publishing Co.

Baroody, .J. 2013. Firewood Extraction as a Catalyst of Pine-Oak Forest Degradation in the Highlands of Chiapas, Mexico M.Sc. thesis, *School of Environmental and Forest Sciences*, University of Washington.

Beak International Inc. and Geomatics International Inc. 1999. Report on Oyo State Forest resource study. Unpublished. Pp 38, 44-45, 49, 56, 122-123.

Bembridge, T. J. 1990. Woodlots, woodfuel and energy strategies for Ciskei. *South African Forestry Journal* 155: 42-50.

Bensel. T. 2008. Fuelwood, deforestation, and land degradation: 10 years of evidence from Cebu province, the Philippines. *Land Degrad. Develop.* 19: 587–605 .2008.

Bohlin, F. & Roos.A. 2002. Wood fuel supply as a function of forest owner preferences and management styles. *Biomass and Bioenergy* 2002; 22:237-49

Bouyoucus, C.J. 1951. A recalibration of the hydrometer method of making mechanical analysis of soil. *Agronomy Journal* 43: 434-438

Brady, N.C. and Weil, R.R. 1999. The Nature and properties of soil (12th Edition) Prentice Hall, New Jersey.

Broadbent, F. E. 1986. Effects of organic matter on nitrogen and phosphorus supply to plants. The role of Organic matter in modern Agriculture pp13- 27.

Brown, G., Tolsma .A., Murphy.S., Miehs. A., McNabb .E. & York.A. 2009.*Ecological impacts of firewood collection — a literature review to inform firewood management on public land in Victoria.* Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment In partnership with Department of Forest and Ecosystem Science,The University of Melbourne.

Brites, A.D., Morsello.C. 2012. The Ecological Effects of Harvesting Non-Timber Forest Products from Natural Forests: a Review of the Evidence. VI Encontro Nacional da Anppas Bel ém, Brasil.

Cardelús, C.L, Mack, M.C., Woods, C., DeMarco, J., Treseder, K.K. 2009. The influence of tree species on canopy soil nutrient status in a tropical lowland wet forest in Costa Rica. *Plant Soil*: pp.318;47–61.

Chapman, H.D. 1965. Cation exchange capacity. In; Black C.A. (ed). Methods of soil analysis-chemical and microbiological properties. *Agronomy,* 9; 891-901

Chandra, M. S, Sumeet, G., Sunil, K.G, & Sarvesh. S. 2009. Forest Resource Use Patterns in Relation to Socio-economic Status.*Mountain Research and Development*, 29(4):308-319. 2009.

Chettri, N, Sharma, E, Deb, D.C, and Sundriyal, R.C.2002. Impact of firewood extraction on tree structure, regeneration and woody biomass productivity in a trekking corridor of the Sikkim Himalaya. *Mountain Research and Development,* 22(2);150-158. URL;http;//www.bioone.org/doi/full/10.1659/02764741%282002%29022%5B0150%3AIOFEOT%5D2.0.CO%3B2

Chidumayo, E.N., and D.J. Gumbo. 2013. The environmental impacts of charcoal production in tropical ecosystems of the world; A synthesis. *Energy for Sustainable Development* 17 (2);86-94

Chowdhury,N.A., Chowdhury.M.H. 2001. Energy issues in the street food sector, findings from the baseline survey and in depth study ITDG document. A DFID funded study.

Cline-Cole, R.A. 1987 summary of Ph.D. thesis published under a collection of papers found at www.odifpeg.org.uk/publications/grey literature.

Cline-Cole, R.A., Falola J.E and O’Reilly, F.D. 1990. Wood fuel in Kano. United Nations press, Tokyo.

Córdoba-Aguilar, H. 1992. "Firewood use and the effect on the ecosystem — a case study of the Sierra of Piura, Northwestern Peru." *GeoJournal 26* (3), 297–309.

Cole, D.N. 2004. Impacts of hiking and camping on soils and vegetation; a review. *Environmental impacts of Ecotourism* 41,60.

Daioglou, V., B.J. Van Ruijven, and Van Vuuren D.P. 2012. Model projections for household energy use in developing countries. *Energy* 37 (1): 601-615.

Dattalo, P. 2014. A demonstration of canonical correlation analysis with orthogonal rotation to facilitate interpretation.Unpublished manuscript, School of Social Work, Virginia Commonwealth University, Richmond, Virginia.

DFID. 2002. Energy and street food. DFID KaR Project ITDG (Intermediate Technology Development Group) R7663 publication

Dhanai. R., Negi R.S., Singh.S., and Parmar. M.K.2015. Fuelwood Consumption by Villagers in Different Altitudinal Gradient; A Case of Takoligad Watershed of Garhwal Himalaya, India.*International Journal of Current Engineering and Technology*. Vol.5, No.1 (Feb 2015)

Dzioubinski, O and Chipman, R. 1999 Trends in consumption and production; Household energy consumption. ST / ESA / 1999 DP 6. *A Discussion Paper of the United Nations Department of Economic and Social Affairs DESA.*

Du plessis M. A. 1995. The effects of fuelwood removal on the diversity of some cavity-using birds and mammals in South Africa. *Biological Conservation* 74 (1995) 77-82

Eckholm, E.1975. The Other Energy Crisis; Firewood. *Worldwatch* Paper 1, Worldwatch Institute, Washington.

Egbinola.N. 2016. The impacts of human activities on tree species composition along the forest savanna boundary. *Indonesian Journal of Geography*. Vol47, no 2

Eni D. D., Iwara A. I., and Offiong R. A. 2012. Analysis of Soil-Vegetation Interrelationships in a South-Southern Secondary Forest of Nigeria *International Journal of Forestry Research* Volume 2012

Ektveldt, T.M., 2011. Firewood consumption amongst poor inhabitants in a semi-arid tropical forest; a case study from Piura, northern Peru. *Norwegian Journal of Geography* 65, 28–41.

Emagbetere, E., Odia.J., Oreko.B.U. 2016. Assessment of household energy utilised for cooking in ikeja, Lagos State, Nigeria *Nigerian journal of Technology(NIJOTECH)* vol 35, no 4, 2016 pp796- 804

Emuh, C.N and Gbadegesin, A.S. 2009. Specie diversity patterns along a forest-savanna boundary in Nigeria. *Journal of Management of Environmental quality* Vol 20, No 1

European Commision. 1986. Energy in the cities of the third world, Unpublished report

ESMAP.2001Energy Sector Management Assistance Program (ESMAP) *Indonesia: Urban Household Energy Strategy.* ESMAP Report No. 107A/90. Washington, D.C.: World Bank.

Ezebilo, E.E., 2004. Threats to Sustainable forestry Development in Oyo State, Nigeria. Unpublished M.sc Thesis no.54.Swedish University of Agricultural Sciences. Accessed on line October 3 2010 http;//exepsilon.slu.se;8080/archive /00001073/ 01/Ezebilo_threats.pdf

FAO, 1997. Report of an FAO Technical Meeting on Street Foods, Calcutta, India, (FAO/Rome)

FAO, 2004. Unified Bioenergy Terminology. Rome, Food and Agriculture Organization of the United Nations

F.A.O,2005. Global forest resources assessment summary; facts on Forests and forestry available at www.forestfacts.org/l_3/forests_5.htm

FAO, 2015. Woodfuels handbook Food and Agriculture Organization of the United Nations

Feka, N., Manzano, G. & Dahdouh-Guebas, F. 2011.The effects of different gender harvesting practices on mangrove ecology and conservation in Cameroon. *International Journal of Biodiversity Science, Ecosystem Services &Management*, Online article .http://dx.doi.org/10.1080/21513732.2011.606429

Foley, G. 1985. Wood Fuel and Conventional Fuel Demands in the Developing World *Ambio*, Vol. 14, No. 4/5, Energy in Developing Countries 1985, pp. 253-258 Published by; Allen Press on behalf of Royal Swedish Academy of Sciences http;//www.jstor.org/stable/4313159

Foley, G., Kerkhof. P.,Madougou. D. 2002 A Review of the Rural Firewood Market Strategy in West Africa, Africa Region Working Paper Series No. 35 August 2002 available at http;//www.worldbank.org/afr/wps/index.htm.

Fontodji, K., Atsri, H., Adjonou,K., Radji,A., Kokutse,A., Nuto, Y. and Kokou,K. 2011. Impact of Charcoal Production on Biodiversity in Togo (West Africa), The Importance of Biological Interactions in the Study of Biodiversity, Dr. Jordi L.Pujol (Ed.), ISBN; 978-953- 307-751-2, InTech, Available from;http;//www.intechopen.com/books/the-importance-of-biological-interactions-in-the-study-of-biodiversity/impact-of-charcoal-production-on-biodiversity-in-togo-west-africa-

Fouchard, L., 2003. The case of Ibadan, Nigeria. In *Understanding Slums*; Case Studies for the Global Report on Human Settlements.

Fox. J., 1984. Firewood consumption in a Nepali village. *Environmental Management* Volume 8, No 3,pp 243 – 250.

Gao, Y., Skutsch.M., Drigo, R., Pacheco,P., amd Masera, O., 2011 Assessing deforestation from biofuels; Methodological challenges. *Applied Geography* 31(2011): pp 508 – 518.

Gbadegesin, A.S.and Olorunfemi, F., 2011. Socio-Economic Aspects of Fuelwood Business in the Forest and Savanna Zones of Nigeria; Implications for Forest Sustainability and Adaptation to Climate Change. *Global Journal of Human Social Science* Volume 11 Issue 1

Gbile,Z.O., 1998. Vernacular names of Nigerian plants, Yoruba. Forestry Research Institute of Nigeria, Ibadan.

Gebhardt, A., 2007. Impact of charcoal production activities on soil profiles; the micromorphological point of view », *ArchéoSciences* [Online], 31 | 2007, Online since 31 December 2009, connection on 05 April 2013. URL; http;//archeosciences.revues.org/833

Girard, P., 2002. Charcoal production and use in Africa; What future? *Unasylva* 211; 30-34.

Gregoire, T. 1999. Statistical methodology in forestry. *Biometrics* Vol2, Encyclopedia of life support systems EOLSS available at http;//www.eolss.net/Eolss-sampleAllChapter.aspx

Geist, H.J., Lambin E.L. 2002. Proximate causes and underlying driving forces of tropical deforestation. *BioScience* 52(2);143–50.

Gumartini, T. 2009. Biomass Energy In The Asia-Pacific Region; Current Status, Trends And Future Setting, Asia-pacific Forestry sector Outlook study ii working paper series of the FAO Asia office. No. APFSOS II/WP/2009/26

Hammer,O., Harper, D.A.T and Ryan, P.D. 2001. PAST; Paleontological Statistics software package for education and data analysis. *Palaeontologia Electronica* 4(1);pp 145- 152.

Hair, J. F., Anderson, R.A., Tatham, R. L. and Black, W. C. 1998. Multivariate Data Analysis, 5th edition. New York; Prentice Hall, Inc.

Higgins, S.I., Shackleton, C.M. and Robinson, E.R.,1999. Changes in woody community structure and composition under contrasting landuse systems in a semi-arid savanna, South Africa.*J. Biogeogr*. 26, pp 619-627.

Hiemstra-van der Horst, G., Hovorka, J.A. 2009. Fuelwood; The ‘‘Other’’ Renewable energy source for Africa? *Biomass and Bioenergy* 33, pp 1605 – 1616.

Hennenberg, K., Goetze, D., Minden,V., Traor´. D., and Porembski. S. 2005. Size-class distribution of Anogeissus leiocarpus (Combretaceae) along forest–savanna ecotones in northern Ivory Coast. *Journal of Tropical Ecology* (2005) 21;273–281. Cambridge University Press doi;10.1017/S0266467404002160

Heltberg, R.. 2005. Factors determining household fuel choice in Guatamala, *Enviromental and Development Economics.*10:337-361, Cambridge University press.

Hosier, R., & Kipondya .W. 1993. Urban Household Energy Use in Tanzania: Prices, Substitutes and Poverty. *Energy Policy*, Volume. 21, No. 5, 453-473.

I.I.T.A, 1979. Selected methods for soil and plant analysis. I.I.T.A manual series No 1, IITA Ibadan

International Energy Agency 2006. Energy for cooking in developing countries.World Energy outlook 2006. Paris; *International Energy Agency*, pp 420-445.

Ikurekong, E. E., Esin, J. O. & Mba, C. C. 2009. Rural Fuelwood Exploitation in Mbo Local Government Area: *Ethiopian Journal of Environmental Studies and Management* Volume. 2 No. 3, 2009. Department of Geography, University of Uyo, Nigeria.

Ji, She. 2014. Woodfuel use and its influence on people's livelihood in Ethiopia-Comparison among three peasant associations in Wondo Genet. Thesis submitted for a M.Sc degree in Faculty of Agriculture and Forestry, Univ of Helsinki.

Jones, A., 1973. The Organic matter content of the Savanna soils of West Africa. *European Journal of soil science*. Vol 24, pp 42-53.

Jones, B., 2015. The Social and environmental impacts of charcoal production in Liberia. An M.Sc thesis (Natural Resources and Environment) at the University of Michigan

Joubert, D.F. and Zimmermann, I. 2002. The potential impacts of wood harvesting of bush thickening species on biodiversity and ecological processes. Proceedings of the First National Forestry Research Workshop held on 12 and 13 March 2002 in Windhoek, Namibia, Ministry of Environment and Tourism, Forestry Publication 9;67-78.

Keay, R.W., 1953, An outline of Nigerian Vegetation, 2nd Edition, Government Printed, Lagos.

Kebede, A., Chimdi, A., and Nair,A., 2015. Effect of firewood energy Consumption of Households on Status of Soil Fertility in Debis Watershed, Ambo District, Oromia Regional State, Ethiopia. *Science, Technology and Arts Research Journal Sci. Technol. Arts Res. J.*, Jan-March 2015, 4(1), pp154- 159

Kersten, I., Baumbach, G., Oluwole, A.F., Obioh, I.B., Ogunsola, O.J., 1998. Urban and rural fuelwood situation in the tropical rainforest area of south-west Nigeria. *Energy* 23, 887–898.

Khundi, F., Jagger, P, Shively, G., & Sserunkuuma, D., 2010.*Income, poverty and charcoal production in western Uganda. Basis Brief, CRSP.* Available at http://www.basis.wisc.edu

Kituyi, E., Marufa, L., Huber, B., Wandiga, S.O., Jumba, O.I., Andreae. M.O. &Helas, G., (2001) Biofuels consumption rates in Kenya. *Biomass and Bioenergy* 20: 83-99.

Koami, K.,Yaovi, N.and Atsri, H..2009. Impact of charcoal production on woody plant speciesin West Africa; A case study in Togo. *Scientific Research and Essay* Vol.4 (9),pp.881-893, Available online at http;//www.academicjournals.org/SRE

Kowsari.R. 2013. Twisted energy ladder; Complexities and unintended consequences in the transition to modern energy services. A P.hD dissertation in the faculty of graduate studies, University of British Columbia.

Kristensen, P., 2004. The DPSIR Framework. Paper presented at the 2004 workshop on a comprehensive / detailed assessment of the vulnerability of water resources to environmental change in Africa using river basin approach. UNEP Headquarters, Nairobi, Kenya. Available online

Kumar, S., Kumar, M.. 2015. Fuelwood Consumption in Takoli Gad Watershed of TehriGarhwal in Garhwal Himalaya, India. *Forest Res 4:* 138. doi;10.4172/2168-9776.1000138

Lal, R. 2015. Restoring Soil Quality to mitigate Soil degradation. *Sustainability,*7, 5875 - 5895

Leach, G., and Gowen, M., 1987. Household energy handbook, *World Bank technical paper* 67

Linderman,M., Li an, Bearer. S., Guangming. H., Zhiyun. O., Jianguo.L. 2006. Interactive effects of natural and human disturbances on vegetation dynamics across landscapes. *EcologicalApplications*, 16(2), 2006, pp. 452–463

Liu, J., G. Daily, P. Erlich, and G. Luck. 2003. Effects of household dynamics on resource consumption and biodiversity.*Nature* 421;530-533.

Lurimuah, S., 2011. The economic and environmental effects of Commercial Charcoal production in the upper west region of Ghana. An unpublished M.sc Thesis Submitted to the School of Graduate Studies Kwame Nkrumah University of Science and Technology Kumasi.

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

Maconachie, R., Tanko, A. and Zakariya, M. 2009. Descending the energy ladder? Oil price shocks and domestic fuel choices in Kano, Nigeria. *Land Use Policy*, 26 (4); 1090-1099.

Madukwe, C.E., 2014. Domestic energy usuage pattern of households in selected urban and rural communities of Enugu State. An unpublished M.Sc dissertation in the Institute of Development Studies at the University of Nigeria, Nsukka.

Magurran, A.F., 1988. Ecological Diversity and its Measurement. Princeton University Press, Princeton, New Jersey, pp. 145–146

Malla, S., and Timilsina, G. 2014. Household Cooking Fuel Choice and Adoption of Improved Cookstoves in Developing Countries, A Review *World Bank Policy Research Working Paper* 6903.

May-Tobin,C., 2012. Wood for fuel ; the Root of the problem. A Tropical forest and Climate Initiative Report on What's driving deforestation today? Chapter 8 Union of Concerned Scientists. Available at www.ucsusa.org/whatsdrivingdeforestation.

Marshall, V.G., 2000. Impacts of forest harvesting on biological processes in northern forest soils. *For Ecol Manage* 133; 43-60.

Miah. D., Al-Rashid. H., & YongShina, M., 2009. Woodfuel use in the traditional cooking stoves in the rural floodplain areas of Bangladesh: A socio-environmental perspective. *Biomass and Bioenergy* 33(2009)70–78

Modi, V., McDade, S., Lallement, D., Saghir, J. 2006. Energy and the Millennium Development Goals.Energy Sector Management Assistant Programme, United Nations Development Programmer, UN Millennium Project and World Bank, New York. [Online] Available from: http://www.unmillenniumproject.org/documents/MP_Energy_Low_Res.pdf

Mekonnen, A., Gebreegziabher, Z., Kassie, M.,&Kölin. G., 2009. Income alone doesn't determine adoption and choice of fuel types: Evidence from households in Tigrai and major cities in Ethiopia .*The Environment for Development Policy Brief*, downloaded March 2010, available at www.efdinitiative.org

Melin. M., Heiskanen, J., Packalen, P., and Valbuena, R. 2016. Inventory of biomass and forest resources. Book chapter in Mononen. K. and Pitkanen.S. eds. 2016 .*Sustainable fuelwood management in West Africa*.available online at http//www.researchgate.net/publication/311614491.

Mola-Yudego, B., Yanez, O.D., Haapala, A., 2016. Wood energy on a global scale.Book chapter in Mononen.K. and Pitkanen.S. eds. *Sustainable fuelwood management inWestAfrica*.available online athttp//www.researchgate.net/publication/311614491.

Morgan, B., 1983. Urban demand: studying the commercial organization of woodfuel supplies. In: FAO Forestry Department, Wood fuel surveys. Rome: FAO; pp18–24.

Morley, J., Hazas. M., 2011. The significance of difference : understanding variation in household energy consumption. Panel 8 presentation at the Energy Efficiency first: The Foundation of a low carbon society, ECEEE 2011 Summer study. Pp 2037 – 2046.

Mueller-Dombois, D and Ellenberg, H. 1974.Aims and methods of vegetation ecology.John Wiley and Sons Inc.New York.547p.

Morley, J, Hazas, M. 2011. The significance of difference ; understanding variation in household energy consumption. Panel 8 presentation at the Energy Efficiency first; The Foundation of a low carbon society, ECEEE 2011 Summer study. Pp 2037 – 2046.

Mwampamba, T.H, Ghilardi. A., Sander. K., Jean Chaix, K., 2013. Dispelling common misconceptions to improve attitudes and policy outlook on charcoal in developing countries. *Energy for Sustainable Development* April, 2013.Vol 17(2); pp 75 – 85.

Nadoma, M.M., 1988.Fuelwood Energy Development in Plateau state, Nigeria.PhD dissertation, University Of Ibadan, Nigeria.

Naibbi. A.I., 2013.Fuelwood and Vegetation Change in Northern Nigeria: An Exploration Using Remote Sensing (RS), Geographical Information Systems (GIS) and Field Reports.A Ph.D thesis, University of Portsmouth, UK.

Nash, R., and Lutteral, C., 2006.Crisis to context: The fuel wood debate *Forest policy and Environment programme (Grey Literature)* available online at www.odi.org

Naughton-Treves, L., Kammen, D., Chapman, C., 2007. Burning biodiversity; Woody biomass use by commercial and subsistence groups in western Uganda's forests.*BiologicalConservation* 134 (2007) 232 –241

Ndagalansi, H. J., Bitarho, R., Dovie, D. B. K., 2007. Harvesting of non timber forest products and implications for conservation in two montane forests of East Africa. Biological conservation 134 (2007) 242– 250

Ndah, N., Andrew,E., and Bechem, E., 2013. Species composition, diversity and distribution in a disturbed Takamanda Rainforest,South West, Cameroon. *African Journal of Plant Science* Vol. 7(12), pp. 577-585, December 2013

Njiti, Clement, Kemcha, M., 2003. Survey of fuelwood and service wood production and consumption in Sudano-Sahelian region of CentralAfrica; the case of Garoua,Cameroon and its rural environs. Jean-Yves Jamin, Lamine Seiny Boukar, Christian Floret, 2003. Cirad- Prasac, 15 p., 2003. Available at www.hal.archives-ouvertes.fr/hal-00135780.

Nizam, M.S., Jeffri, A.R., Latiff, A. 2013. Structure of tree communities and their association with soil properties in two fan palm dominated forests of east coast Peninsular Malaysia. *TropicalEcology* 54(2); 213-226.

Noble, A. D., Randall, P. J., 1998. How Trees Affect Soils. A report for the Rural Industries Research and Development Corporation RIRDC Publication No 98/16 RIRDC Project No CSL-3A . Accessed online July 2017.

Nyem, P.H., 1961. Organic matter and nutrient cycles under moist tropical forest. *Plant and Soil* 13; 330-346.

Ogundele,A.T., Oladapo, O.S, Aweto,A.O. 2012. Effects of Charcoal Production on Soil in Kiln Sites in Ibarapa Area, South Western Nigeria. Ethiopian *Journal of Environmental Studies*Vol 5, No 3 (2012)

Ogunkunle, A.T.J., Oladele,F.A. 2004. Ethnobotanical study of Fuelwood and Timberwood consumption and replenishment in Ogbomosho, Oyo State, Nigeria. *Environmental Monitoring and Assessment* 91; 223-236.

Ogunkunle,O., 2013. A Comparative Study of the Physical and Chemical Properties of Soils underDifferent Vegetation Types *Journal of Environment and Earth Science*www.iiste.org ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol. 3, No.1, 2013.

Ogunleye, A.J., Adeola, A.O., Ojo, A.O. and Aduradola, A.M. 2004. Impact of farming activities on vegetation in Olokemeji Forest Reserve, Nigeria. *Global Nest; The Int. J. Vol*. 6 No.2 pp 131-140

Oguntoyinbo, J.S. 1985. Climatic Characteristic of Ibadan in Ibadan Region First Edition. Department of Geography, University of Ibadan; Ibadan, Nigeria.

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

Ogwumike,F.O.,Ozughalu,U.M and Abiona, G.A. 2012. Household Energy Use and Determinants; Evidence from Nigeria *International Journal of Energy Economics and Policy* Vol. 4, No. 2, 2014, pp.248-262

Omoro, L. 2012. Impacts of indigenous and exotic tree species on ecosystem services; Case study on the mountain cloud forests of Taita Hills, Kenya. A Dissertation in the Faculty of Agriculture and Forestry of the University of Helsinki, Finland.

Oriola, E. and Omofoyewa, O. 2013. Impact of Charcoal Production on Nutrients of Soils under Woodland Savanna Part of Oyo State, *Nigeria. Journal of Environment and Earth Science* ISSN 2224-3216 (Paper) ISSN 2225-0948 (Online) Vol. 3, No.3, 2013 available at www.iiste.org

Orimoogunje. O., Asifat,J. 2015.FuelwoodConsumption And Species Degradation In South-Western Nigeria; The Ecological Relevance. *Journal of Landscape Ecology (2015)*, Vol;8/ No.1. Downloadedfrom http:scholar.oauife.edu.ng/ooorimoogunje/files/fuelwood_consumption_and_species_degradation_in_sw_nigeria.pdf

Otypková. Z. & Chytry. M. 2006.Effects of plot size on the ordination of vegetation samples. *Journal of Vegetation Science 17: 465-472, 2006 .IAVS; Opulus Press Uppsala. Pp465-472.*

Oyekale, A.S., Dare, A.M., and Olugbire, O.O.. 2012. Assessment of rural households‘cooking energy choice during kerosene subsidy in Nigeria; A case study of Oluyole Local Government Area of Oyo State. *African Journal of Agricultural Research* Vol. 7(39), pp. 5405-5411. Available online http;//www.academicjournals. org/AJAR

Oyerinde, O.O. 2010. Comparative Analysis of Household energy consumption in Ibadan Region. Unpublished Msc Thesis Dept of Geography, University Of Ibadan

Peet, R.K. and Christensen, N.L., 1988. Changes in species diversity during secondary forest succession on the North Carolina Piedmont. In: During, H.J., Werger, M.J.A. & Willems J.H. (eds.) Diversity and pattern in plant communities, pp. 233-245. SPB Academic Publishing. The Hague

Pennock.D., Yates. T. and Braiedk. J. 2008. Soil sampling designs. Chapter 1 in *Soil sampling and methods of analysis* / edited by M.R. Carter and E.G. Gregorich. -- 2nd ed.

Phil-Eze, P., 2010. Variability of soil properties related to vegetation cover in a tropical rainforest landscape *Journal of Geography and Regional Planning Vol. 3(7*), pp.177-184, July 2010.

Pitman, N., Terborgh,J., Silman,M., Nunez.P, Neill,D., Ceron, C., Palacios,W., and Aulestia, M. 2002. A Comparison Of Tree Species Diversity In Two Upper Amazonian Forests.*Ecology,* 83(11), 2002, pp. 3210–3224 , the Ecological Society of America.

Puri, G.S., 1961. Role of Trace elements in Soils of Humid Tropical Regions.Report of the UNESCO Humid Tropics Research programme. Available online at unesco.org.

Rajmohan, K.,and Weerahewa, J.. 2010. Househols Energy Consumption patterns in Sri-Lanka.*Sri LankanJournal of Agricultural Economics*. 9, pp. 55-77.

Ratnam, J., Bond. W., Fensham, R., Hoffmann, W., Archibald, S., Lehmann, C., Anderson, M., Higgins,S., and Sankaran, M. 2011. When is a ‘forest’ a savanna, and why does it matter?geb_634 1..8 *Global Ecology and Biogeography*, Blackwell Publishing Ltd

Remedio, E.M., 2002. Wood energy and livelihood patterns; a case study from the Philippines *Unasylva,* Vol. 211.

Ribot, J., 1998. Theorizing access: forest profits along Senegal’s charcoal commodity chain. *Development and Change* 29, 307–341.

Robertson,A.L., Kilgore, M.A., and Ek, A.R. 2008. Tools to Minimize the Impacts of Energy Wood Harvesting on the Environment and Soil Productivity in Minnesota Staff Paper Series No. 200 Department of Forest Resources, University of Minnesota available at http;//www.forestry.umn.edu/publications/staffpapers/index.html

Ruger,N., Williams-Linera, G., Kissling, W. 2008. Long term impacts of fuelwood extraction on a tropical montane cloud forest. Ecosystems (2008)11.868

Ruuska. E.M.2012. The significance and sustainability of charcoal production in the changing landscape of Dakatcha woodland, SE Kenya. Master's Thesis in Geography, University Of Helsinki.

Sahoo,S. and Davidar, P. 2013. Effect of harvesting pressure on plant diversity and vegetation structure of Sal forests of Similipal Tiger Reserve, Odisha. *TropicalEcology* 54(1); 97-107, 2013.

Salami, K.K. and Brieger, W.R..2011. Commercial Charcoal Production in the Ibarapa District of Southwestern Nigeria; Forestry Dividends and Welfare Implications*International Quarterlyof Community HealthEducation* Issue; Volume 31, Number 4

Salami, K.D., Akinyele, A.O., Adekola. P.J. and Odewale, M.A., 2016. Tree species composition and regeneration potential of Onigambari Forest Reserve, Oyo State*Direct Research Journalof Agriculture and Food Science*. http;//directresearchpublisher.org/journal/drjafs Vol.4 (3), pp. 39-47, March 2016.

Saxena, N.C. 1997.The woodfuel scenario and policy issues in India, *Food and Agriculture Organization of the United Nations—Regional Wood Energy Development Programme in Asia*, Bangkok, Thailand; Field Document No. 49

Sassen, M., Sheil, D., Giller,K. 2015. Fuelwood collection and its impacts on a protected tropical mountain forest in Uganda. *Forest Ecol. Manage*. (2015), http;//dx.doi.org/10.1016/j.foreco.2015.06.037

Sathaye,J., and Meyers, S., 1990. Urban energy use in developing countries, in Desai, A. V., Patterns of energy use in developing countries, *International Development Research Center and United Nations University.*

Scholes, R.J., 1987. Response of 3 semi-arid savannas on contrasting soils to the removal of the woody component. PhD thesis, University of Witwatersrand, Johannesburg.

Scherr.S.J., 2000. A downward spiral? Research evidence on the relationship between poverty and natural resource degradation. *Food policy* 25(479-498) Elsevier Science Ltd.

Schleuning, M.,N. Farwig, A. Althof, D. Berens, T. Bergsdorf, B. Bleher, A. Brenner, H. Dalitz, E. Fischer, G. Fischer, W. Freund, M.W. Gikungu, R. Gliniars, M. Hagen, F.H. Garcia, M. Kaib, J.M. Kirika, M. Kraemer, T. Kraus, L. Kühne, T. Lung, I. Malombe, N. Mitchell, W. Musila, M.K. Peters, G. Schaab, I. Theisen, H. Todt, D. Uster, J.W. Wägele, K. Yeshitela, K. Böhning-Gaese. 2008. Effects of forest fragmentation and disturbance on biodiversity and ecosystem functions in an African rainforest. Paper Presentation at the Biodiversity of Africa -Observation and Sustainable Management for our Future! International Congress, 29 September –3 October2008, at Spier, RSA.

Shackleton, C.M., Gambiza, .J., and Jones, R., 2007. Household fuelwood use in small electrified towns of the Makana District, Eastern Cape, South Africa. *Journal of Energy in Southern Africa.*Volume 18 No 3 , August 2007

Shackleton, C.M., Griffen, N.J., Banks, D.I., Mayrandonis, J.M. and Shackleton, S.E., 1994. Community structure and species composition along a disturbance gradient in a communally managed South African savanna.*Vegetatio* 115, pp. 157-167, 1994

Shackleton, C.M.,2000. Comparison of plant diversity in protected and communal lands in the Bushbuckridge Lowveld savanna, South Africa. *Biol. Conserv.* 94, pp. 273-285, 2000

Shackleton,C.M., Griffin.N.J., Banks. D.I., Mavrandonis. J.M., Shackleton.S.E. 1994. Community structure and specie composition along a disturbance gradient in a communally managed South African Savanna. *Vegetatio* 115: 157- 167

Shahabuddin. G., Kumar.R. 2006. Influence of anthropogenic disturbance on bird communities in a tropical dry forest: role of vegetation structure *AnimalConservation.* Print ISSN 1367-9430

Sherry, A. and Henson, R. K. 2005. Conducting and Interpreting Canonical Correlation Analysis in Personality Research: A User-Friendly Primer. *Journal of Personality Assessment.* 84(1), 37–48.

Simpson, E.H., 1949: Measurement of diversity. *Nature*. 163: 688

Siong, H..2011. Energy Consumption Pattern of Food Vendors in an Indigenous African City, Ibadan, Nigeria. *Interdisciplinary Journal of Contemporary Research In Business* › Volume. 3 Nbr. 7, November 2011

Singh, S.P., 1998. Chronic disturbance, a principal cause of environmental degradation in developing countries. (editorial). *Environmental Conservation 25*: 1-2.

Sorensen, T.A., 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of the vegetation on Danish commons. *Kgl Danske Vidensk. Selsk. Biol. Skr., 5: 1-34*.

Spetch, M.J., Felipe, P.L., Melo, C. 2015. Burning biodiversity: Fuelwood harvesting causes forest degradation in human- dominated tropical landscapes. *Global Ecology and Conservation, Volume 3, Jan 2015, pp 200-209 http//doi.org/10.1016/j*

Sturtevant, B., R. Bissonette, J. Long, and D.W. Roberts 2007.Coarse woody debris as a function of age, stand structure and disturbance in boreal Newfoundland.*Applied Ecology 7:702-712.*

Svarstad. H., Petersen.L.K., Rothman. D., Siepel. H., Watzold. F. 2007. Discursive biasesof the Environmental research framework DPSIR. *LandUse Policy.*doi:10.1016/ j.landusepol.2007.03.005

Tedd, L., Choudbury, N., Liyanarachchi, S., 2001. Energy and Street Foodvendors . DFID KaR Project R7663. *Boiling point* 47. A publication of the Intermediate Technology Development Group (ITDG), UK.

Teketay, D., Geeves, G., Kopong,I., Mojeremane,W., Sethebe, B., and Smith, S.2016. Diversity, stand structure and regeneration status of woody species, and spatial cover of herbaceous species in Mokolodi Nature Reserve, Southeastern Botswana. *International Journal of Biodiversity and Conservation Vol. 8(8), pp. 180-195,* August 2016.

Tinker, I. 1997. Street foods ; Urban food and employment in developing countries, Oxford University Press, New York.

Tomori. M.A., 2008. Ibadan Metropolitan area and the challenges to sustainable development. MACOS Urban Management Consultancy Available online at http://macosconsultancy.com/ibadan%20metropolitan.html Accessed April 2018

Top.N., Mizoue, N., Kai, S., Nakao, T., 2004. Variation in woodfuel consumption patterns in response to forest availability in Kampong Thom Province, Cambodia. *Biomass and Bioenergy* 27 (2004) 57 – 68).

Tredennick, T., 2014. Africa's fuelwood footprint and the biome level impacts of tree harvest. A dissertation submitted to the Graduate Degree Program in Ecology, Colorado State University, Colorado.

Tsheboeng,G., and Murray-Hudson, M. 2013. Spatial variation of population size structure of selected riparian tree species in the Okavango Delta, Botswana. in Oldeland, J., Erb, C., Finckh, M. and Jürgens, N. 2013 [Eds.];*Environmental Assessments in the Okavango Region. – Biodiversity and Ecology* 5; 341–350. DOI; 10.7809/b-e.00287

UNDP, 2005. Energising the Millennium Development Goals; A guide to Energy's role in reducing poverty. New York, United Nations Development Programme.

UNCHR. 1997. Social and economic impact of large refugee populations on host developing countries. EC/47/SC/CRP.7 Report of the Executive committee of the high commissioner's programme.

United States Forest Service, 1997. Environmental consequences, chapter iv. Ashley National forest(N.F), Wasatch-Cache National Forest(N.F), management of the High Uintas Wilderness; Environmental Impact Statement. 1997 Available online 2013 jan

US Bureau of Land Management.(USBLM)1999. Sampling vegetation attributes. Tech. Ref. 1734-4. BLM, Denver, Colo. 164p.http;//www.blm.gov/nstc/library/pdf/samplveg.pdf

USDA, 1972.Soil Survey laboratory methods.Soil survey investigations report No 1.

Vermeulen, S. 2001. Woodfuel in Africa; Crisis or adaptation? Literature review.ODI. In G. Kohlin(Ed.), Fuelwood—crisis or balance; Workshop proceedings,Marstrand, June 6–9, 2001 (pp. 208–231).Goteborg University for CIFOR.

Walkey,A. and Black, I.A. 1934. An examination of the Djetgareff method determining organic matter and proposed modification of the chromic acid titration method. *Soil Science* 37, 29-38

Wangchuk, S. 2011. Fuelwood Consumption and Production in Alpine Bhutan; A Case Study of Resource Use and Implications for Conservation and Management in Wangchuck Centennial Park. M.Sc. Spring 2011 Resource Conservation, University of Montana.

WCED(World Commission on Environment and Development). 1987. Our common future; the report of the world commission on environment and development, Oxford; Oxford University Press.

Wessels, .K.J., Matheiu, R., Erasmus,.B.F.N., Asner, G.P., Smit, I.P.J., Van aardt.J.A.N.,Main.R., Fisher.J., Marais.W., Kennedy-Bowdoin.T., Knapp.D.E., Emerson.R., Jacobson.J. 2011. Impact of communal use and conservation on woody vegetation structure in the lowveld savannas of South Africa. *Forest Ecology and management* ,261 (2011) pp19 – 29.

Westhoff, V., Van der Maarel, E. 1978. The Braun- Blanquet approach. Whittaker, R .H. (eds) Classification of plant communities.*W. Junk. Den. Haag.* Pp 287-399.

Zhou, Ping, Olavi Luukkanen, Timo Tokola and Minna Hares .2009.Comparison of forest stand characteristics and species diversity indices under different human impacts along an altitudinal gradient. *Fennia* 187; 1, pp. 17–30. Helsinki. ISSN 0015-0010.

Zulu,L.C., .2010. The forbidden fuel; Charcoal, urban woodfuel demand and supply dynamics, community forest management and woodfuel policy in Malawi *Energy Policy* 38 (2010) 3717–3730.

APPENDICES
SUPPORTING DOCUMENTS FOR CHAPTER FOUR
APPENDIX I

List of Forest and SavannaTree species encountered

Oyo ile	*Alaja*	*Onigambari*	*Serafu*
Acacia hockii	*Albizia ferruginea*	*Afzelia africana*	*Afromosia laxiflora*
Afzelia africana	*Albizia zygia*	*Albizia ferruginea*	*Afzelia africana*
Ancistrophyllum secundiflorum	*Alchornea cordifolia*	*Albizia zygia*	*Ajadin,ajade*
Anogeissus leiocarpus	*Alcornia laxiflora*	*Alcornia cordifolia*	*Anacardium occidentale*
Bridellia ferruginea	*Alophylus africana*	*Alstonia boonei*	*Anogeissus leiocarpus*
Burkea africana	*Anthocleista djalonensis*	*Amuranju*	*Anona senegalensis*
Byrsocarpus coccineus	*Antiaris toxicaris*	*Antiaris toxicaria*	*Anthocleista nobilis*
Cussonia arborea	*Asa funfun*	*Baphia spp*	*Anthocleista djalonensis*
Daniellia oliveri	*Blighia sapida*	*Blighia sapida*	*Azadirachta indica*
Detarium microcarpum	*Blighia unijugata*	*Bombax buonopozense*	*Blighia unijugata*
Dichrostachys Cinerea	*Bosqueia angonensis*	*Bosqueia angonensis*	*Bridellia ferrugina*
Disthemonantus benthamianus	*Bridellia micrantha*	*Bridellia ferrugina*	*Burkea africana*
Ficus Mucuso	*Byrsocarpus coccineus*	*C. junearum*	*Cussonia arborea*
Gardenia ternifolia	*Carpolubea lutea*	*Capolubea lutea*	*Daniella oleiveri*
Hymenocardia Acida	*Cassia cameroonia*	*Cassalia kolly*	*Entada abyssinica*
Isoberlinia doka	*Ceiba pentandra*	*Cedrela odorata*	*Euphorbia convolvuloides*
Lecaniodiscus cupanioides	*Chrysophyllum albidum*	*Ceiba pentandra*	*Ficus capensis*
Lonchocarpus sericeus	*Citrus medica*	*Celtis mildbraedii*	*Ficus exasperata*
Lophira lanceolata	*Claucezena anisata*	*Celtis sp*	*Hymenocardia acida*
Maranthes polyandra	*Cnetis ferrugina*	*Chordea allodora*	*Lonchocarpus sericeus*
Monodora myristica	*Cola millenii*	*Chrysophullum albidum*	*Lophira lanceolata*
Parkia biglobosa	*Cola nitida*	*Cletofonix partensis*	*Manilkara obovata*
Phyllanthus discoideus	*Combretum*	*Cola gigantea*	*Monodora myristica*
Piliostygma	*Dalbergia lactea*	*Cola millenii*	*Nauclea latifolia*

thonningii			
Prosopis africana	*Dallium guinesis*	*Cola nitida*	*Parkia biglobosa*
Pseudocedrela kotschyi	*Diosparous mobitensis*	*Cordia millenii*	*Phyllanthus discoideus*
Pterocarpus	*Dracaena arborea*	*Daniella ojea*	*Piliostigma thonningii*
Spondias mombin	*Ficus carpensis*	*Deibola pinnata*	*Rothmannia whitfieldii*
Strychnos spinosa	*Ficus exasperate*	*Detrarium microcarpum*	*Securidaca longipedunculata*
Terminalia avicennoides	*Ficus mucuso*	*Dialium guineense*	*Senna siamea*
Urena lobata	*Funtumia elastic*	*Diosparos Montbuttensis*	*Spondias audti*
Vitellaria paradoxa	*Gliricidia sepium*	*Dracanea manni*	*Sterculia tragacantha*
Vitex doniana	*Holarrhena floribunda*	*Elaeis guineensis*	*Terminalia avicennioides*
Vitex ferruginea	*Lecaniodiscus cupanioides*	*Entandrophragma sp*	*Terminalia ivorensis*
Total 115	*Lonchocarpus cyanescens*	*Ewe ape*	*Tetracera pototoria*
	Longocarpus cerecius	*Ficus exasperate*	*Vitellaria paradoxa*
	Malacanta alnifolia	*Funtumia elastic*	*Vitex doniana*
	Malacanta ternifolia	*Graywei mullis*	*Vitex ferruginea*
	Milletia thonningii	*Huitera obelata*	*Total 101*
	Millicia excels	*Iyere papan*	
	Miriantum	*Kleptofoli*	
	Monodora myristica	*Lantaria camara*	
	Monodora tenifolia	*Landa osan*	
	Monterea alnifolia	*Lecaniodiscus cupanioides*	
	Morinda lucida	*Macaranga heudelolli*	
	Morus mesozygia	*Malacanta alnifolia*	
	Newbouldia laevis	*Mallotus oppositifolius*	
	Olax subscorpioidea	*Massularia acuminata*	
	Parkia biglobosa	*Napoleona fuggeli*	
	Phyllanthus discoideus	*Newbouldia laevis*	
	Psidium guajava	*Olax subscorpioidea*	
	Hura crepitans	*Olooragbo*	
	Pycnanthus angolensis	*Omolagbao*	
	Rauvolfia vomitoria	*Piptadeniastrum africanum*	
	Senna siamea	*Pseudocedrela kotschyi*	
	Spathodea campanulata	*Pterocarpus Santalinioides*	
	Spondias mombin	*Pterygota*	

		macrocarpa	
	Tabernaemontanan pachysiphon	*Pycnanthus angolensis*	
	Tetrapleura tetraptera	*Rauvolfia vomiforia*	
	Treculia africana	*Ricinodendron heudelotii*	
	Treculia chodifollia		
	Treculia monadelfia	*Senna alata*	
	Triplochiton scleroxylon	*Sphenocentrum jollyanum*	
	Zeltis mildbraedii	*Sterculia tragacantha*	
	Zeltis zenkeri	*Tabernaemontanan pachysiphon*	
	Total 171	*Terminalia superba*	
		Tetrapleura tetraptera	
		Treculia monadefia	
		Triplochiton scleroxylon	
		Umbellatum piper	
		Vitellaria	
		Vitex doniana	
		Zanthoxylum xanthoxyloides	
		Zeltis zenkeri	
		Total 167	

APPENDIX II

List of species encountered with local names.

Acacia hockii	*Ede*	*Mimosaceae*
Afromosia laxiflora	*sedun*	*Leguminosae*
Afzelia africana	*Apa*	*Caesalpinioideae*
Ajadin,ajade	*Ajadin,ajade, Ayunre Weere,*	
Albizia ferruginea	*Banabana*	*Mimoasceae*
Albizia zygia	*Ayunre*	*Mimoasceae*
Alchornea cordifolia	*Ijan*	*Euphorbiaceae*
Alcornia laxiflora	*Pepe*	*Euphorbiaceae*
Alophylus africana	*Ekan ahoro*	*Sapindaceae*
Alstonia boonei	*Ahun*	*Apocynaceae*
Anacardium occidentale	*Kaju*	*Anacardiaceae*
Ancistrophyllum secundiflorum	*Okuku*	*Arecaceae*
Anogeissus leiocarpus	*Ayin*	*Combretaceae*
Anthocleista nobilis	*Sapo*	*Loganiaceae*
Anthocleista djalonensis	*saapo*	*Gentianaceae*
Antiaris toxicariavar africana	*ooro*	*Moraceae*
Asa funfun	*Asa funfun*	
Azadirachta indica	*Dongoyaro*	*Meliaceae*
Baphia nitida	*iyere osun*	
Blighia sapida	*Isin igbo*	*Sapindaceae*
Blighia unijugata	*Isin oko*	*Sapindaceae*
Bombax buonopozense	*eso olu kondo*	*Bombacaceae*
Bosqueia angolensis(Trilepisium.m)	*lahoro*	*Moraceae*
Bridellia micrantha	*Ira*	*Euphorbiaceae*
Bridellia ferruginea	*Ira odan*	*Euphorbiaceae*
Burkea africana	*Asapa*	*Caesalpiniaceae*
buse	*buse*	
Byrsocarpus coccineus	*Amuje-wewe*	*Connaraceae*
C. sunearum		
Carpolubea lutea	*osunsun*	
Cassalia kolly	*isape agbe*	
Cassia cameroonia		
Cedrela odorata		*Meliaceae*
Ceiba pentandra	*Araba*	*Bombacaceae*
Celtis mildbraedii		*Sterculiaceae*
Celtis wightii		*Ulmaceae*
Chordea alliodora		
Chrysophyllum albidum	*agbalumo*	*Sapotaceae*
Citrus medica	*goingoin*	*Rutaceae*
Clausena anisata	*atapari obuko*	*Rutaceae*
Cleistopholis patens	*Apako*	*Annonacaceae*
Cnetis ferrugina	*Akara Aje,Oyan aje*	*Connaraceae*
Cola gigantea	*Obi agbaya*	*Sterculiaceae*

Cola millenii	*Obi edun*	*Sterculiaceae*
Cola nitida	*obi*	*Sterculiaceae*
Combretum smethmannii	*agbon igbo*	*Combretaceae*
Cordia millenii	*Omo*	*Boragineaceae*
Cussonia arborea	*Sigo, siga*	*Araliaceae*
Dalbergia lactea	*Igi ojiji*	*Laguminosae*
Dallium guinesis	*aaran*	*Fabaceae*
Daniella ojea	*asunwole*	*Caesalpiniaceae*
Daniellia oliveri	*iya*	*Caesalpiniaceae*
Deinbollia pinnata	*lagbao,ogiri egba*	*Sapindaceae*
Detarium microcarpum	*Aluki, Arira*	*Ceasalpiniaceae*
Dialium guineense	*Awin*	*Meliaceae*
Dichrostachys cinerea	*Ajagboluuti*	*Mimosaceae*
Diospyros monbuttensis	*Oganapa*	*Ebenaceae*
Disthemonantus benthamianus	*Aayan*	*Ceasalpiniaceae*
Dracaena arborea	*peregun*	*Dracaenaceae*
Elaeis guineensis	*Ope*	*Arecaceae*
Entada abyssinica	*gbengbe*	
Entandrophragma sp	*Ako ijebu*	*Meliaceae*
Euphorbia convolvuloides	*buje*	*Euphorbiaceae*
Ficus arperacter		
Ficus capensis	*opoto*	*Moraceae*
Ficus exasperata	*ipin*	*Moraceae*
Ficus mucuso	*Obobo*	*Moraceae*
Funtumia elastica	*Ire*	*Apocynaceae*
Gardenia ternifolia	*Oruwan*	*Rubiaceae*
Gliricidia sepium	*Agunmaniye*	*Papilionaceae*
Graywei mullis	*itakun okere*	
Holarrhena floribunda		*Apocynaceae*
Hymenocardia acida	*Orupa*	*Hymenocardiaceae*
Isoberlinia doka	*baabo*	
Kleptofoli	*Igi efo*	
Landa osan	*Landa osan*	
Lecaniodiscus cupanioides	*Aaka*	*Sapindaceae*
Lonchocarpus cyanescens	*elu*	*Papilionaceae*
Lonchocarpus sericeus	*Ipapo, Paapo*	*Papilionaceae*
Lophira lanceolata	*Pahan, Pehen*	*Ochnaceae*
Macaranga barteri	*Asasa*	*Euphorbiceae*
Malacanta alnifolia	*ilaka ile*	
Malacanta ternifolia		
Malanthera scandens	*abo*	*Asteraceae*
Mallotus oppositifolius	*Eja, orokoro*	*Euphorbiaceae*
Manilkara obovata		*Sapotaceae*
Maranthes polyandra	*Idofun*	*Chrysobalanaceaes*
Massularia acuminata	*Pako ijebu*	*Rutaceae*
Milicia excelsa	*Iroko*	*Moraceae*
Milletia thonningii	*Ito*	*Papilionaceae*
Myrianthus arboreus	*ewe ade*	*Cecroplaceae*
Monodora myristica	*Abo odan*	*Annonaceae*

Monodora tenifolia		*Saphidaceae*
Monterea	*Abo/dodo fufun*	
Morinda lucida	*oruwo*	*Rubiaceae*
Morus mesozygia	*Igi aiye*	*Moraceae*
Napoleona fuggeli		
Nauclea latifolia	*Egbesi*	*Rubiaceae*
Newbouldia laevis	*Akoko*	*Bignoniaceae*
Olax subscorpioidea	*Ifon*	*Olacaceae*
Parkia biglobosa	*Igba*	*Mimosaceae*
Phyllanthus discoideus	*Awe*	*Euphorbiaceae*
Piliostigma thonningii	*Abafe*	*Caesalpiniaceae*
Piptadeniastrum africanum	*agboyin*	*Mimosaceae*
Prosopis africana	*Ayan*	*Mimosaceae*
Pseudocedrela kotschyi	*Emigbegiri*	*Meliaceae*
Psidium guajava	*guava*	*Myrtaceae*
Pterocarpus angolensis	*Ara*	*Papilionaceae*
Pterygota macrocarpa	*poroporo*	
Hura crepitans	*Kerebuje tyre moto*	
Pycnanthus angolensis	*Akomu*	*Myristicaceae*
Rauvolfia vomitoria	*Asofeyeje*	*Apocynaceae*
Ricinodendron heudelotii	*Erinmodo, epu*	*Euphorbiaceae*
Securidaca longipedunculata	*ipeta*	*Polygalaceae*
Senna siamea		*Caesalpiniaceae*
Spathodea campanulata	*onuru*	*Bignoniaceae*
Sphenocentrum jollyanum	*Akerejupon*	*Menispermaceae*
Spondias audti		*Anacardiaceae*
Spondias mombim	*Iyeye*	*Anacardiaceae*
Sterculia tragacantha	*Koko igbo, alawefon*	*Sterculiaceae*
Strychnos spinosa	*Orombo Igbo*	*Loganaceae*
Tabernaemontanan pachysiphon	*Dodo*	*Apocynaceae*
Terminalia avicennioides	*idin*	*Combretaceae*
Terminalia ivorensis	*afara dudu*	*Combretaceae*
Terminalia superba	*afara*	*Combretaceae*
Tetracera pototoria	*Opon*	*Dillenlaceae*
Tetrapleura tetraptera	*gidan, Aidan*	*Fabaceae*
Treculia africana	*rere*	*Moraceae*
Treculia chodifollia		
Treculia monadelfia		
Triplochiton scleroxylon	*Arere*	*Sterculiaceae*
Umbellatum piper	*ewe efon*	
Urena lobata	*Akerielu*	*Malvaceae*
Vitellaria paradoxa	*Emi*	*Sapotaceae*
Vitex doniana	*Ori*	*Verbenaceae*
Vitex ferruginea	*Oriko, Orieta*	*Verbenaceae*
Zanthoxylum xanthoxyloides	*Ata pagara*	*Sterculiaceae*
Zeltis mildbraedii		*Apocynaceae*
Zeltis zenkeri	*ita*	*Ulmaceae*

APPENDIX III

Species diversity of undisturbed savanna vegetation (Oyo ile)

PLOTS	**SPECIES**	**ni**	**ni-1**	**ni(ni-1)**	**N**	**N-1**	**N(N-1)**	**ni(ni-1)/N(N-1)**			**Plot Species Diversity**
plot 1	*Acacia hockii*	1	0	0	22	21	462	0			
	Bridellia ferrugina	1	0	0	22	21	462	0			
	Burkea africana	1	0	0	22	21	462	0			
	Danielli oliveri	2	1	2	22	21	462	0.004329			
	Dichrostachys cinerea	1	0	0	22	21	462	0			
	Ficus mucuso	1	0	0	22	21	462	0			
	Gardenia ternifolia	1	0	0	22	21	462	0			
	Hymenocardia acida	4	3	12	22	21	462	0.025974			
	Prosopis africana	4	3	12	22	21	462	0.025974			
	Pseudocedrela kotschyi	2	1	2	22	21	462	0.004329			
	Terminalia avicennoides	1	0	0	22	21	462	0			
	Vitellaria paradoxa	1	0	0	22	21	462	0			
	Vitex doniana	2	1	2	22	21	462	0.004329	0.064	1- 0.064	0.936
plot 2	*Afzelia africana*	1	0	0	15	14	210	0			
	Ancistrophyllm secundiflorum	1	0	0	15	14	210	0			
	Burkea africana	3	2	6	15	14	210	0.028571			
	Gardenia ternifolia	1	0	0	15	14	210	0			
	Hymenocardia acida	4	3	12	15	14	210	0.057143			
	Maranthes polyandra	1	0	0	15	14	210	0			

	Pilliostygmia thornningii	1	0	0	15	14	210	0			
	Terminalia avicennoides	3	2	6	15	14	210	0.028571	0.114	1-0.114	0.886
plot 3	*Afzelia africana*	2	1	2	18	17	306	0.006536			
	Burkea africana	2	1	2	18	17	306	0.006536			
	Cussonia arborea	1	0	0	18	17	306	0			
	Daniellia oliveri	2	1	2	18	17	306	0.006536			
	Gardenia ternifolia	1	0	0	18	17	306	0			
	Hymenocardia acida	3	2	6	18	17	306	0.019608			
	Parkia biglobosa	1	0	0	18	17	306	0			
	Piliostigma thonningii	1	0	0	18	17	306	0			
	Terminalia avicennoides	4	3	12	18	17	306	0.039216			
	Vitellaria paradoxa	1	0	0	18	17	306	0	0.078	1-0.078	0.922
plot 4	*Acacia hockii*	1	0	0	7	6	42	0			
	Afzelia africana	1	0	0	7	6	42	0			
	Daniellia oliveri	2	1	2	7	6	42	0.047619			
	Maranthes polyandra	1	0	0	7	6	42	0			
	Spondias mombin	1	0	0	7	6	42	0			
	Strychnos spinosa	1	0	0	7	6	42	0	0.048	1-0.048	0.952
plot 5	*Anogeissus leiocarpus*	1	0	0	15	14	210	0			
	Burkea africana	1	0	0	15	14	210	0			
	Ficus mucuso	2	1	2	15	14	210	0.009524			
	Hymenocardia acida	1	0	0	15	14	210	0			

	Piliostigma thonningii	1	0	0	15	14	210	0			
	Terminalia avicennoides	4	3	12	15	14	210	0.057143			
	Vitellaria paradoxa	5	4	20	15	14	210	0.095238	0.162	1-0.162	0.838
plot 6	*Acacia hockii*	1	0	0	13	12	156	0			
	Danielli oliveri	3	2	6	13	12	156	0.038462			
	Disthemonantus benthamianus	1	0	0	13	12	156	0			
	Terminalia avicennoides	5	4	20	13	12	156	0.128205			
	Vitellaria paradoxa	3	2	6	13	12	156	0.038462	0.205	1-0.205	0.795
plot 7	*Ficus mucuso*	3	2	6	13	12	156	0.038462			
	Isoberlinia doka	2	1	2	13	12	156	0.012821			
	Parkia biglobosa	1	0	0	13	12	156	0			
	Prosopsis africana	1	0	0	13	12	156	0			
	Pterocarpus	1	0	0	13	12	156	0			
	Terminalia avicennoides	3	2	6	13	12	156	0.038462			
	Vitellaria paradoxa	2	1	2	13	12	156	0.012821	0.103	1-0.103	0.897
plot 8	*Afzelia africana*	1	0	0	8	7	56	0			
	Anogeissus leiocarpus	1	0	0	8	7	56	0			
	Danielli oleiveri	4	3	12	8	7	56	0.214286			
	Vitellaria paradoxa	2	1	2	8	7	56	0.035714	0.214	1-0.214	0.786
plot 9	*Vitellaria paradoxa*	5	4	20	11	10	110	0.181818			

	Piliostigma thonningii	1	0	0	11	10	110	0			
	Burkea africana	3	2	6	11	10	110	0.054545			
	Bridellia ferruginata	2	1	2	11	10	110	0.018182	0.254	1- 0.254	0.746
plot 10	*Vitellaria paradoxa*	2	1	2	13	12	156	0.012821			
	Burkea africana	2	1	2	13	12	156	0.012821			
	Piliostigma thonningii	1	0	0	13	12	156	0			
	Ficus mucuso	4	3	12	13	12	156	0.076923			
	Hymenocardia acida	2	1	2	13	12	156	0.012821			
	Bridellia ferruginata	1	0	0	13	12	156	0			
	Acacia hockii	1	0	0	13	12	156	0	0.115	1- 0.115	0.885
plot 11	*Strychnos spinosa*	1	0	0	10	9	90	0			
	Parkia biglobosa	1	0	0	10	9	90	0			
	Burkea africana	4	3	12	10	9	90	0.133333			
	Lophira lanceolata	3	2	6	10	9	90	0.066667			
	Lonchocarpus sericeus	1	0	0	10	9	90	0	0.133	1- 0.133	0.867
plot 12	*Vitellaria paradoxa*	4	3	12	14	13	182	0.065934			
	Bridellia ferruginata	2	1	2	14	13	182	0.010989			
	Gardenia ternifolia	1	0	0	14	13	182	0			
	Hymenocardia acida	4	3	12	14	13	182	0.065934			
	Piliostigma thonningii	1	0	0	14	13	182	0			
	Strychnos spinosa	2	1	2	14	13	182	0.010989	0.154	1- 0.154	0.846

Species diversity of disturbed savanna vegetation (Serafu)

PLOTS	SPECIES	Ni	ni-1	ni(ni-1)	N	N-1	N(N-1)	ni(ni-1)/N(N-1)		Plot Species Diversity
plot 1	*Bridellia ferrugina*	2	1	2	5	4	20	0.1		
	Burkea africana	1	0	0	5	4	20	0		
	Ficus capensis	1	0	0	5	4	20	0		
	Lophira lanceolata	1	0	0	5	4	20	0	0.1	0.9
plot 2	*Azadirachta indica*	2	1	2	8	7	56	0.035714		
	Lophira lanceolata	2	1	2	8	7	56	0.035714		
	Piliostigma thonningii	1	0	0	8	7	56	0		
	Terminalia avicennioides	2	1	2	8	7	56	0.035714		
plot 2s	*Securidaca longipedunculata*	1	0	0	8	7	56	0	0.107	0.893
plot 3s	*ABO*	2	1	2	4	3	12	0.166667		
	Parkia biglobosa	1	0	0	4	3	12	0		
	Tetracera pototoria	1	0	0	4	3	12	0	0.167	0.833
plot 4s	*Afzelia africana*	2	1	2	5	4	20	0.1		
	Anacardium occidentale	2	1	2	5	4	20	0.1		
	BUSE	1	0	0	5	4	20	0	0.2	0.8
plot 5s	*Anogeissus leiocarpus*	2	1	2	9	8	72	0.027778		
	Burkea africana	1	0	0	9	8	72	0		
	Danielli oleiveri	1	0	0	9	8	72	0		
	Entada abyssinica	1	0	0	9	8	72	0		
	Piliostigma thonningii	1	0	0	9	8	72	0		
	Securidaca longipedunculata	2	1	2	9	8	72	0.027778		

	Spondias audti	1	0	0	9	8	72	0	0.05	0.05
plot 6s	*Anogeissus leiocarpus*	1	0	0	12	11	132	0		
	Bridellia ferrugina	2	1	2	12	11	132	0.015152		
	Burkea africana	1	0	0	12	11	132	0		
	Danielli oleiveri	3	2	6	12	11	132	0.045455		
	Ficus capensis	2	1	2	12	11	132	0.015152		
	Hymenocardia acida	1	0	0	12	11	132	0		
	Parkia biglobosa	1	0	0	12	11	132	0		
	Vitex doniana	1	0	0	12	11	132	0	0.075	0.925
plot 7s	*Anogeissus leiocarpus*	2	1	2	3	2	6	0.333333		
	Ficus capensis	1	0	0	3	2	6	0	0.33	0.67
plot 8s	*Azadirachta indica*	2	1	2	5	4	20	0.1		
	Bridellia ferrugina	1	0	0	5	4	20	0		
	Phyllanthus discoideus	1	0	0	5	4	20	0		
	Vitellaria paradoxa	1	0	0	5	4	20	0	0.1	0.9
plot 9s	*Afzelia africana*	1	0	0	9	8	72	0		
	Azadirachta indica	2	1	2	9	8	72	0.027778		
	Bridellia ferrugina	1	0	0	9	8	72	0		
	Burkea africana	1	0	0	9	8	72	0		
	Lophira lanceolata	2	1	2	9	8	72	0.027778		
	Phyllanthus discoideus	2	1	2	9	8	72	0.027778	0.083	0.917
plot 10s	*Daniellia oleiveri*	1	0	0	1	0	0	0	0	1

plot 11s	*Anogeissus leiocarpus*	2	1	2	7	6	42	0.047619		
	Azadirachta indica	2	1	2	7	6	42	0.047619		
	Vitex ferruginea	*2*	1	2	7	6	42	0.047619		
	Daniellia oleiveri	1	0	0	7	6	42	0	0.142	0.858
plot 12s	*Vitellaria paradoxa*	2	1	2	5	4	20	0.1		
	Burkea africana	2	1	2	5	4	20	0.1		
	Daniellia oleiveri	1	0	0	5	4	20	0	0.2	0.8

Source; Researcher’s Fieldwork, 2015

Species diversity of disturbed forest vegetation (Alaja).

PLOTS	SPECIES	ni	ni-1	ni(ni-1)	N	N-1	N(N-1)	ni(ni-1)/N(N-1)			Plot Species Diversity
plot 1a	*Albizia zygia*	2	1	2	18	17	306	0.006536			
	Antiaris toxicaria	3	2	6	18	17	306	0.019608			
	Blighia sapida	2	1	2	18	17	306	0.006536			
	Ficus exasperate	1	0	0	18	17	306	0			
	Longocarpus cerecius	5	4	20	18	17	306	0.065359			
	Parkia biglobosa	1	0	0	18	17	306	0			
	Pycnanthus angolensis	1	0	0	18	17	306	0			
	Rauvolfia vomitoria	1	0	0	18	17	306	0			
	Spondias mombin	1	0	0	18	17	306	0			
	Treculia monadelfia	1	0	0	18	17	306	0	0.98	1 - 0.98	0.02
plot 2a	*Albizia zygia*	1	0	0	12	11	132	0			
	Antiaris toxicaria	1	0	0	12	11	132	0			
	Blighia unijugata	1	0	0	12	11	132	0			
	Cola nitida	1	0	0	12	11	132	0			
	Ficus exasperate	2	1	2	12	11	132	0.015152			
	Gliricidia sepium	1	0	0	12	11	132	0			
	Morinda lucida	1	0	0	12	11	132	0			
	Newbouldia laevis	1	0	0	12	11	132	0			

	Spondias mombin	1	0	0	12	11	132	0			
	Tabernaemontanan pachysiphon	1	0	0	12	11	132	0			
	Treculia monadelfia	1	0	0	12	11	132	0	0.015	1-0.015	0.985
plot 3a	*Alchornea cordifolia*	1	0	0	5	4	20	0			
	Antiaris toxicaria	1	0	0	5	4	20	0			
	Zeltis zenkeri	2	1	2	5	4	20	0.1			
	Newbouldia laevis	1	0	0	5	4	20	0	0.1	*1 - 0.1*	0.9
plot 4a	*Albizia zygia*	1	0	0	9	8	72	0			
	Alophyllus africanus	2	1	2	9	8	72	0.027778			
	Bosqua angonensis	2	1	2	9	8	72	0.027778			
	Bridellia micrantha	1	0	0	9	8	72	0			
	Ficus mucuso	1	0	0	9	8	72	0			
	Treculia africana	1	0	0	9	8	72	0			
	Zeltis zenkeri	1	0	0	9	8	72	0	0.056	*1 - 0.056*	0.944
plot 5a	*Albizia zygia*	1	0	0	11	10	110	0			
	Bosqua angonensis	2	1	2	11	10	110	0.018182			
	Ficus mucuso	2	1	2	11	10	110	0.018182			
	Funtumia elastica	2	1	2	11	10	110	0.018182			
	Lecaniodiscus cupanioides	1	0	0	11	10	110	0			
	Milletia thonningii	1	0	0	11	10	110	0			

	Senna siamea	2	1	2	11	10	110	0.018182	0.072	*1-0.072*	0.928
plot 6a	*Albizia ferruginea*	1	0	0	9	8	72	0			
	Blighia unijugata	1	0	0	9	8	72	0			
	Gliricidia sepium	1	0	0	9	8	72	0			
	Morus mesozygia	1	0	0	9	8	72	0			
	Pura reptens	2	1	2	9	8	72	0.027778			
	Senna siamea	1	0	0	9	8	72	0			
	Triplochiton scleroxylon	2	1	2	9	8	72	0.027778	0.056	*1-0.056*	0.944
plot 7a	*Albizia zygia*	2	1	2	17	16	272	0.007353			
	Allophylus africanus	1	0	0	17	16	272	0			
	Antiaris toxicaria	1	0	0	17	16	272	0			
	Bosqua angonensis	1	0	0	17	16	272	0			
	Cola millenii	1	0	0	17	16	272	0			
	Cola nitida	1	0	0	17	16	272	0			
	Funtumia elastica	1	0	0	17	16	272	0			
	Lecaniodiscus cupanioides	1	0	0	17	16	272	0			
	Longocarpus cerecius	3	2	6	17	16	272	0.022059			
	Morinda lucida	1	0	0	17	16	272	0			
	Newbouldia laevis	1	0	0	17	16	272	0			
	Spondias mombin	1	0	0	17	16	272	0			
	Tabernaemontanan pachysiphon	1	0	0	17	16	272	0			

	Treculia monadelfia	1	0	0	17	16	272	0	0.029	*1-0.029*	0.971
plot 8a	*Albizia zygia*	1	0	0	9	8	72	0			
	Chrysophyllum albidum	1	0	0	9	8	72	0			
	Cola nitida	1	0	0	9	8	72	0			
	Milicia excels	1	0	0	9	8	72	0			
	Milletia thonningii	1	0	0	9	8	72	0			
	Pycnanthus angolensis	2	1	2	9	8	72	0.027778			
	Spondias mombin	1	0	0	9	8	72	0			
	Tabernaemontanan pachysiphon	1	0	0	9	8	72	0	0.028	*1-0.28*	0.72
plot 9a	*Albizia zygia*	1	0	0	11	10	110	0			
	Antiaris toxicaria	2	1	2	11	10	110	0.018182			
	Blighia unijugata	1	0	0	11	10	110	0			
	Funtumia elastica	1	0	0	11	10	110	0			
	Lecaniodiscus cupanioides	1	0	0	11	10	110	0			
	Milletia thonningii	2	1	2	11	10	110	0.018182			
	Morinda lucida	1	0	0	11	10	110	0			
	Newbouldia laevis	1	0	0	11	10	110	0			
	Phyllanthus discoideus	1	0	0	11	10	110	0	0.036	*1-0.036*	0.964
plot 10	*Albizia zygia*	1	0	0	13	12	156	0			
	Allophylus africanus	1	0	0	13	12	156	0			

	Anthocleista djalonensis	1	0	0	13	12	156	0			
	Antiaris toxicaria	1	0	0	13	12	156	0			
	Asa Funfun	1	0	0	13	12	156	0			
	Blighia unijugata	2	1	2	13	12	156	0.012821			
	Bridellia micrantha	1	0	0	13	12	156	0			
	Gliricidia sepium	1	0	0	13	12	156	0			
	Lecaniodiscus cupanioides	1	0	0	13	12	156	0			
	Milletia thonningii	1	0	0	13	12	156	0			
	Psidium guajava	1	0	0	13	12	156	0			
	Tetrapleura tetraptera	1	0	0	13	12	156	0	0.013	*1-0.013*	0.987
plot 11	*Albizia zygia*	1	0	0	13	12	156	0			
	Antiaris toxicaria	1	0	0	13	12	156	0			
	Blighia unijugata	1	0	0	13	12	156	0			
	Citrus medica	1	0	0	13	12	156	0			
	Cola nitida	2	1	2	13	12	156	0.012821			
	Dalbergia lacteal	1	0	0	13	12	156	0			
	Funtumia elastica	2	1	2	13	12	156	0.012821			
	Rauvolfia vomitoria	1	0	0	13	12	156	0			
	Tabernaemontanan pachysiphon	2	1	2	13	12	156	0.012821			
	Treculia africana	1	0	0	13	12	156	0	0.038	*1-0.038*	0.962

plot 12	*Alchornea laxithora*	1	0	0	13	12	156	0			
	Blighia unijugata	2	1	2	13	12	156	0.012821			
	Ceiba pentandra	1	0	0	13	12	156	0			
	Dalbergia lacteal	1	0	0	13	12	156	0			
	Ficus exasperate	1	0	0	13	12	156	0			
	Ficus mucuso	1	0	0	13	12	156	0			
	Funtumia elastica	2	1	2	13	12	156	0.012821			
	Gliricidia sepium	1	0	0	13	12	156	0			
	Miriantum	1	0	0	13	12	156	0			
	Monterea	1	0	0	13	12	156	0			
	Zeltis zenkeri	1	0	0	13	12	156	0	0.026	*1-0.026*	0.974

Source; Researcher’s Fieldwork, 2015

Species diversity of undisturbed forest vegetation (Onigambari).

PLOTS	**SPECIES**	**ni**	**ni-1**	**ni(ni-1)**	**N**	**N-1**	**N(N-1)**	**ni(ni-1)/N(N-1)**			**Plot Species Diversity**
plot 1G	*Alstonia boonei*	2	1	2	17	16	272	0.007353			
	Blighia sapida	2	1	2	17	16	272	0.007353			
	Entandrophragma sp	2	1	2	17	16	272	0.007353			
	Funtumia elastic	2	1	2	17	16	272	0.007353			
	Olax subscorpioidea	1	0	0	17	16	272	0			
	Ricinodendron heudelotii	1	0	0	17	16	272	0			
	Sterculia tragacantha	1	0	0	17	16	272	0			
	Terminallia superba	1	0	0	17	16	272	0			
	Triplochiton scleroxylon	3	2	6	17	16	272	0.022059			
	Zeltis zenkeri	2	1	2	17	16	272	0.007353	0.059	1-0.059	0.941
plot 2G	*Albizia ferruginea*	2	1	2	8	7	56	0.035714			
	Cola millenii	1	0	0	8	7	56	0			
	Funtumia elastica	1	0	0	8	7	56	0			
	Newbouldia laevis	1	0	0	8	7	56	0			
	Pseudocedrela kotschyi	1	0	0	8	7	56	0			
	Pycnanthus angolensis	2	1	2	8	7	56	0.035714			
	Sterculia tragacantha	1	0	0	8	7	56	0			
	Tabernaemontanan	1	0	0	8	7	56	0	0.071		0.929

	pachysiphon									
plot 3G	*Alstonia boonei*	1	0	0	18	17	306	0		
	Bosqua angonensis	2	1	2	18	17	306	0.006536		
	Bridellia ferrugina bridellia	1	0	0	18	17	306	0		
	Celtis mildbraedii	1	0	0	18	17	306	0		
	Cola millenii	1	0	0	18	17	306	0		
	Dialium guineense	1	0	0	18	17	306	0		
	Entandrophragma sp	1	0	0	18	17	306	0		
	Massularia acuminata	1	0	0	18	17	306	0		
	Pycnanthus angolensis	1	0	0	18	17	306	0		
	Ricinodenodrom heudelotic	1	0	0	18	17	306	0		
	Sterculia tragacantha	1	0	0	18	17	306	0		
	Triplochiton scleroxylon	3	2	6	18	17	306	0.019608		
	Zanthoxylum xanthoxyloides	1	0	0	18	17	306	0		
	Zeltis zenkeri	2	1	2	18	17	306	0.006536	0.033	0.967

plot 4G	*Albizia ferruginea*	1	0	0	17	16	272	0		
	Antiaris toxicaria	1	0	0	17	16	272	0		
	ASASA	1	0	0	17	16	272	0		
	Ceiba pentandra	1	0	0	17	16	272	0		
	Celtis sp	1	0	0	17	16	272	0		
	Chrysophullum albidum	1	0	0	17	16	272	0		
	Cola millenii	2	1	2	17	16	272	0.007353		
	Daniellia ogea	1	0	0	17	16	272	0		
	Entandrophragma sp	1	0	0	17	16	272	0		
	Funtumia elastica	2	1	2	17	16	272	0.007353		
	Malacanta alnifolia	1	0	0	17	16	272	0		
	Pseudocedrela kostchyii	1	0	0	17	16	272	0		
	Tetrapleura tetraptera	1	0	0	17	16	272	0		
	Zanthoxylum xanthoxyloides	1	0	0	17	16	272	0		
	Zeltis zenkeri	1	0	0	17	16	272	0	0.015	0.985
plot 5G	*Cola gigantea*	1	0	0	8	7	56	0		
	Daniella ojea	1	0	0	8	7	56	0		
	Funtumia elastica	1	0	0	8	7	56	0		
	Massularia acuminata	1	0	0	8	7	56	0		
	Pterygota macrocarpa	1	0	0	8	7	56	0		
	Stercullа trangacantha	1	0	0	8	7	56	0		
	Tabernaemontanan pachysiphon	1	0	0	8	7	56	0		
	Triplochiton	1	0	0	8	7	56	0	0	1

	scleroxylon								
plot 6G	*Afzelia africana*	1	0	0	20	19	380	0		
	Albizia zygia	1	0	0	20	19	380	0		
	Alstonia boonei	1	0	0	20	19	380	0		
	Ceiba pentandra	1	0	0	20	19	380	0		
	Cola gigantea	1	0	0	20	19	380	0		
	Deibola	1	0	0	20	19	380	0		
	Detrarium microcarpum	1	0	0	20	19	380	0		
	Entandrophragma sp	2	1	2	20	19	380	0.005263		
	Landa osan	1	0	0	20	19	380	0		
	Pseudocedrela kotschyi	1	0	0	20	19	380	0		
	Pterygota macrocarpa	1	0	0	20	19	380	0		
	Ricinodendron heudelotii	2	1	2	20	19	380	0.005263		
	Sterculla tragacantha	1	0	0	20	19	380	0		
	Tabernaemontanan pachysiphon	1	0	0	20	19	380	0		
	Terminalia superba	1	0	0	20	19	380	0		
	Treculi monodefia	1	0	0	20	19	380	0		
	Triplochiton scleroxylon	1	0	0	20	19	380	0		
	Zeltis zenkeri	1	0	0	20	19	380	0	0.01	0.99
plot 7g	*Albizia zygia*	1	0	0	12	11	132	0		
	Bosqua angonensis	1	0	0	12	11	132	0		
	Chrysophullum	1	0	0	12	11	132	0		

	albidum								
	Cola gigantea	1	0	0	12	11	132	0		
	Entandrophragma sp	1	0	0	12	11	132	0		
	Funtumia elastica	1	0	0	12	11	132	0		
	Malacanta alnifolia	1	0	0						
	Pipta deniastrum	1	0	0	12	11	132	0		
	Pseudocedrela kotschyi	1	0	0	12	11	132	0		
	Pterygota macrocarpa	1	0	0	12	11	132	0		
	Triplochiton scleroxylon	2	1	2	12	11	132	0.015152		
	Zeltis zenkeri	1	0	0	12	11	132	0	0.015	0.985
plot 8g	*Ceiba pentandra*	1	0	0	10	9	90	0		
	Cola nitida	1	0	0	10	9	90	0		
	Pseudocedrela kotschyi	1	0	0	10	9	90	0		
	Pterygota macrocarpa	1	0	0	10	9	90	0		
	Ricinodendron heudelotii	1	0	0	10	9	90	0		
	Stercullа tragaccantha	1	0	0	10	9	90	0		
	Triplochiton scleroxylon	1	0	0	10	9	90	0		
	Zanthoxylum xanthoxyloides	1	0	0	10	9	90	0		
	Zeltis zenkeri	2	1	2	10	9	90	0.022222	0.02	0.98
plot 9g	*Bombax buonopozense*	1	0	0	14	13	182	0		
	Bosqua angonensis	1	0	0	14	13	182	0		

Cedrela odorata	2	1	2	14	13	182	0.010989		
Chordea allodora	1	0	0	14	13	182	0		
Cola millenii	2	1	2	14	13	182	0.010989		
Funtumia elastica	1	0	0	14	13	182	0		
Newbouldia laevis	1	0	0	14	13	182	0		
Pterygota macrocarpa	1	0	0	14	13	182	0		
Ricindenodron heudelotii	1	0	0	14	13	182	0		
Sterculia tragacantha	2	1	2	14	13	182	0.010989		
Triplochiton scleroxylon	1	0	0	14	13	182	0	0.032	0.968

plot 10g	*Bosqua angonensis*	2	1	2	7	6	42	0.047619		
	Cola gigantea	1	0	0	7	6	42	0		
	Entandrophragma sp	1	0	0	7	6	42	0		
	Funtumia elastica	1	0	0	7	6	42	0		
	Ricinodendron heudelotii	1	0	0	7	6	42	0		
	Treculia monadefia	1	0	0	7	6	42	0	0.05	0.95
plot 11g	*Bosqua angonensis*	1	0	0	7	6	42	0		
	Cola gigantea	1	0	0	7	6	42	0		
	Cola millenii	1	0	0	7	6	42	0		
	Funtumia elastica	2	1	2	7	6	42	0.047619		
	Kleptofoli	1	0	0	7	6	42	0		
	Cordia millenii	1	0	0	7	6	42	0	0.05	0.95
plot 12g	*Bosqua angonensis*	1	0	0	7	6	42	0		
	Cederela odorata	1	0	0	7	6	42	0		
	Cola millenii	1	0	0	7	6	42	0		
	Funtumia elastica	1	0	0	7	6	42	0		
	SASA	1	0	0	7	6	42	0		
	Tabernaemontanan pachysiphon	1	0	0	7	6	42	0		
	Treculia monadefia	1	0	0	7	6	42	0	0	1

Source; Researcher’s Fieldwork, 2015

APPENDIX IV
SURVEY INSTRUMENT FOR FOOD VENDORS.

IBADAN FOOD VENDOR ENERGY USE SURVEY

Date of Survey_________ GPS________________
Ref. No. ______(Nr. Enumerator).
Eatery/ Head vendor F ( ) M ( )
Zone; ________________ Area _________________LGA _____________
Dear Respondent
My name is Tinu Ekanade and I am a Postgraduate student of the University of Ibadan currently working on her thesis titled Wood fuel consumption in Ibadan. In order to complete my thesis successfully, I kindly request that you correctly and honestly complete the following questionnaire; I assure you that you will remain anonymous and your response will be treated with absolute confidentiality.
Thank you for your time and assistance.
Energy Consumption, Demographics and Green Awareness.

1. How long have you been in the food business? (a)less 5yrs (b) 6 -10yrs (c) 11-15yrs (d) Over16 yrs
2. Have you done any other kind of business before entering this business? If Yes, What ______________________________.
3. Do you have more than one restaurant Y/N. If Yes, How many and Where ___________________
4. Which days are your business opening days Mon – Saturday___ Every day___
5. How many workers do you have in your business?_____________________
6. What kind of menu do you serve? Swallow_______ Non swallow____ Both______
7. When is your peak food selling period in the year__________________
8. What kind of energy source do you use mainly for cooking?
   (a) Firewood ____ (b) Gas ____ (c) Kerosene____ (d) Charcoal____
9. Why do you prefer it?_______________________________________
10. Do you combine other fuels in use or as a backup?Y/N how? ___________ ____
11. How often do you use the fuel?_________ Specify number of times per day______________________________
12. If wood/ charcoal, how many bundles/bags do you use per day (kg)? ____
13. Have you encountered problems in cooking with the fuel you use before? Y/N What kind?____
14. Have you ever changed the cooking fuel you use before? Y/N Why? ____
15. If you use firewood/ charcoal, do you plan to continue using it for the next two to five years to come? Y/N Why?__________________________
16. Without taking cost and availability into consideration, which fuel do you think is best for cooking and why?______________________________
17. How much do you spend on your main cooking fuel per week/Month? ______
18. What is the current fuel price for a bundle/bag? How many pieces? _______
19. Have you noticed any changes or fluctuations in the price of wood fuels during the past year? Y/N ____
20. How do you get your fuel supply? _____________________________________

21. How often do you restock your supply(a) every week__ (b) every 2weeks___(c) every Month____

22. If you have ever experienced late supply, how did you handle it?_ ___________________________

23. Do you think wood (for firewood) is scarce? Y/N. If Yes, what do you think is the cause?____

24. Do you store wood? Y /N

(a)If Yes, how?____

(b)If Yes, for how long? ____

(c) If Yes, why? ____

25. Do you think cutting down a lot of trees for firewood can cause problems? Yes/No.

26. If Yes, what do you think are the most severe effects of cutting trees? ____

27. If you had the opportunity to plant trees, why will you do so? ____

28. Which tribe/ area are you from?_______Age_____ Marital Status_______

29. What level of education do you have? No formal___ Primary School____ Secondary school_______ Tertiary______

Signature of Participant______________________ Date_______________
(Verifying consent after being duly informed of the full details/nature of the research)

APPENDIX V
SURVEY INSTRUMENT FOR HOUSEHOLDS
IBADAN HOUSEHOLD ENERGY USE SURVEY

Date of Survey_________ GPS________________

Ref. No. ______(Nr. Enumerator).

Head of Household F ( ) M ( )

Zone; ________________ Area _________________LGA _____________

Dear Respondent

My name is Tinu Ekanade and I am a Postgraduate student of the University of Ibadan currently working on her thesis titled Wood fuel consumption in Ibadan. In order to complete my thesis successfully, I kindly request that you correctly and honestly complete the following questionnaire; I assure you that you will remain anonymous and your response will be treated with absolute confidentiality.

Thank you for your time and assistance.

Energy Consumption, Demographics and Green Awareness.

1. What kind of energy source do you use mainly for cooking?
(a) Firewood ____ (b) Gas ____ (c) Kerosene____ (d) Charcoal____
2. Why do you prefer it?____
3. Do you combine other fuels in use or as a backup?Y/N how? ___________
____
4. How often do you use the fuel?_________ Specify number of times per day________________________________
5. If wood/ charcoal , how many bundles/bags do you use per day (kg)?_______________
____
6. Have you encountered problems in cooking with the fuel you use before? Y/N What kind?____
7. Have you ever changed the cooking fuel you use before? Y/N Why? ____
8. If you use firewood/ charcoal, Do you plan to continue using it for the next two to five years to come? Y/N Why?______________________________
9. Without taking cost and availability into consideration, which fuel do you think is best for cooking and why?________________________
10. How many people reside in your house (How many people are serviced with the fuel)? ____
11. How much do you spend on your main cooking fuel per week/Month? ___
12. What is the current fuel price for a bundle/ bag? How many pieces?________
13. Have you noticed any changes or fluctuations in the price of wood fuels during the past year? Y/N
14. How do you get your fuel supply? __________________________________
15. How often do you restock your supply(a) every week_______ (b) every 2weeks________(c) every Month________
16. If you experience extreme cooking fuel shortage or late supply what do you do?______________

17. Do you think wood (for firewood) is scarce? Y/N. If Yes, what do you think is the cause?____

18. Do you store wood? Y /N
If Yes, how?____
If Yes, for how long? ____
If Yes, why? ____

19. Do you think cutting down a lot of trees for firewood can cause problems? Yes/No.

20. If Yes, what do you think are the most severe effects of cutting trees? ____

21. If you had the opportunity to plant trees, why will you do so? ____

22. Which tribe/ area are you from?_______ Age_____ Marital Status_________

23. What level of education do you have? No formal___ Primary School____ Secondary school____ Tertiary_______

____

Signature of Participant **Date**
(Verifying consent after being duly informed
of the full details/nature of the research)

APPENDIX VI
ASSOCIATION'S LIST OF FOOD VENDORS FOR SAMPLING FRAMEWORK

S/No	LOCAL GOVERNMENT	ZONE/AREA	NUMBER
1.	NORTH WEST	ELEYELE 2	20
		ADAMASINGBA	20
		ABEBI	40
		IFELEYE/OGUNPA	40
		IDIKAN	25
		ORI-ERU	25
		OLOPOMEWA	15
		IDI-OPE	15
		ELEYELE 1	25
		AYEYE 1	35
		AYEYE 2	26
		BERE/IDI AGBA	20
		AGBENI OLOGEDE	21
		TIDIBOLE	15
		OLUKOJO OKEPADE	25
		DUGBE	28
2	IBADAN NORTH	ALAWADA	54
		ADEOYO 1	30
		ADEOYO 2	35
		OJE II	25
		ONIYANRIN	20
		BODIJA (KARA)	23
		BODIJA (ISOPAKO)	61
		BODIJA (HONEY)	60

		SECRETARIAT	20
		OKE-ARE/GALAXY	15
		MOKOLA	65
		NTA	25
		AGBOWO1/AKINGBOLA	35
		AGBOWO EXPRESS	30
		ALIWO	20
		SANGO OJA	15
		SANGO GARAGE	20
		SAMONDA	20
		SANGO TIPPER	20
		IJOKODO/OJA	35
		BOLA/AYEYE	15
		SANGO/ISOPAKO	40
		INALENDE	15
		OJUIRIN	20
3	IBADAN SOUTH WEST	OJA’BA	
		BORN FOTO	40
		ISALE JEBU	
		FOKO 1	35
		FOKO 2	40
		BOODE 1	30
		AJANGBOJU	50
		AGBENI	
		OKE-ADO	
		OKE-BOLA	
		ALESINLOYE	
		AGBOKOJO	

		ADE OJO TUNTUN	
		APATA ABUSI	40
		APATA SOUTH WEST	83
		POUCE POST	
		AKURO ASAKA	
		BCJ	
		POPO YEMOJA	
		CHALLENGE	
		LIBERTY	30
		LABA OWO	10
4	IBADAN NORTH EAST	GATE GARAGE	34
		AREMO	31
		KOSODO	25
		BASORUN	31
		ORANYAN	27
		GATE/ISO ERAN	45
		OGUNDIPE/GATE	20
		AGUGU	40
		OLUYORO	25
		GBENLA/ITUTABA	21
		ATIPE	20
		IWO ROAD MANMA	33
		IDI-APE	28
		GATE ABUSI/ISO PART	38
		ORITA APERIN	55
		ALAFARA 1	30
		ALAFARA 2	30
		AJE TOKODE	50

		BEYERUNKA	22
		OJA GBO/ MESIOGO	20
		KOLOKO 1	29
		KOLOKO II	25
		ODE-AJE	26
		OKE ADU	30
		OKE IBADAN	25
		IDI IROKO	23
		BEERE	28
		FANAWOLE /LAGOS GARAGE	20
		IYA AJADI / IWO ROAD	30
		IREFIN	25
		AARIN OKUTA	20
		ONIPEPEYE	26
		ARMY BARRACKS	25
		ORITA-NEW GARAGE	45
		BOODE	42
		MODINAT	55
		LABO/KABIOWU	58
		ASHANKE	72
		ILE TUNTUN	45
		OKE ODO	85
		OWODE 1	60
		OWODE II	52
		ORITA APERIN	72
		MUSUM	82
		BOLUWAJI	68

		ODUNJO	50
		ODO OBA	75
		EYIN GRAMMAR	38
		FELELE	85
		OSUNGBADE	38
		MOLETE	55
		ISALE JEBU	42
		BEERE	40

APPENDIX VII

FUELWOOD EXTRACTION AND CONSUMPTION STUDY IN PICTURES.

Plate 11: The boundary of the Northern-most range in Old Oyo National park, Oyo Ile range.Fieldwork,
Source:February 2015

Plate 12. Researcher and team with Old Oyo National Park rangers at Oyo ile. Source: Fieldwork, February 2015

Plate 13: Onigambari Forest Reserve entry point.
Source: Fieldwork, February 2015

APPENDIX VIII
DOCUMENT GRANTING ACCESS TO OONP

NATIONAL PARK SERVICE

Nnamdi Azikiwe International Airport Expressway, P.M.B. 0258, Garki - Abuja.
Tel: 09-6714926. E-mail: consgenparks@hotmail.com

Our Ref: **NPH/GEN/121/XIV/843** Date: **20th January, 2015**

Conservator of Parks,
Old Oyo National Park,
P.M.B. 1033,
Oyo,
Oyo State.

RE: FORWARDING OF APPLICATION FOR THE USE OF THE NATIONAL PARK (OYO) FOR Ph. D RESEARCH PURPOSE EKANADE, C. T.

Your letter dated 1st December, 2014 with ref. number OONP.112/S.3/Vol.XIV/1932 on the above subject matter refers please.

2. I am directed to convey approval for the above named student to carry out her Ph.D research titled; **"Environmental Impact of Wood Removals for Fuel from Unmanaged Forest"** in Old Oyo National Park.

3. As a policy of the National Park Service, the researcher is expected to submit two copies of her findings to the National Park Service Headquarters.

4. Attached are applications for research and declaration of compliance forms to be filled and submitted to the Conservator of Parks, Old Oyo National Park.

5. Thank you.

Yohanna Saidu
For: Conservator-General

CC: Ekanade C. T.
Dept. of Geograhy
University of Ibadan
Ibadan

All Correspondence to the Conservator-General