IMPACTS OF FUELWOOD SCARCITY AND COPING STRATEGIES AMONG RURAL HOUSEHOLDS IN LURAMBI DISTRICT, KAKAMEGA COUNTY, KENYA

BY

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DECLARATION

Declaration by candidate

This thesis is my original work and has not been presented for a degree in any other university or any other award.

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DEDICATION

This thesis is dedicated to my parents, who have always emphasized that education is the key to a better life, for their unwavering financial and moral support

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ABBREVIATIONS AND ACRONYMS

CFA	Community Forest Association
ERC	Energy Regulatory Commission
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GHGs	Greenhouse Gases
GOK	Government of Kenya
IEA	International Energy Agency
KFS	Kenya Forest Service
KIPPRA	Kenya Institute of Public Policy Research and Analysis
NEMA	National Environment Management Authority
PEAP	Provincial Environment Action Plan
PELIS	Plantation Establishment Livelihood Improvement Scheme
RWEDP	Regional Wood Energy Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WEO	World Energy Outlook

ABSTRACT

Rural households in Kenya are highly dependent on fuelwood for their energy needs. High population growth, deforestation at 20% (4061 ha degraded out of a possible 19792 ha according to the Kakamega forest management plan) combined with agricultural expansion has served to deepen the fuelwood crisis causing a considerable gap in demand and supply of fuelwood. This study, carried out in Lurambi District, Kakamega County examined factors contributing to fuelwood scarcity, its imapcts and coping starategies among rural houesholds.The study targeted households that were adversely affected and use with the resource on a daily basis. Questionnaires were administered to 200 randomly selected households between January and March 2012. An interview schedule was used for key informants. Data was analyzed using the Statistical Package for Social Sciences (SPSS) for frequencies, percentages and cross tabulation. The findings of the study revealed that fuelwood is a dominant source of energy among 95% households in Lurambi with 84% of the households experienced fuelwood scarcity. The sources of fuelwood include the Kakamega forest and on farm sources. Deforestation, Government restriction towards accesing the Kakamega forest, restricted access to communal collection points cited by 52.5% of the households, privatization of land and reducing land sizes have contributed to fuelwood scarcity. The unavailability of fuelwood has had a negative impact on livelihoods particulary on women in terms of time and resources spent in the collection of fuelwood. Coping mechanisms include temporary switching to alternative fuels, use of energy saving stoves and minimal use of fuelwood in a bid to conserve the resource. Woodlots were observed in a few of the farms but was not considered a priority among the households as the emphasis was on agriculture. In conlcusion socio economic and environmental factors have an impact on fuelwood scarcity and that various coping strategies are employed in adopting to fuelwood scarity which are not sustainable in the long term. Recommendations inculde collaboration between the community and Government on benefit sharing within the forest, designation of communal collection points, sustained woodfuel production projects and introduction of affordable alternatives to the community.

CHAPTER ONE: INTRODUCTION

1.1 Background to the Study

Over 2.4 billion people in developing countries depend on traditional bio-energy for their cooking and heating needs, especially in Sub-Saharan Africa and South Asia (Mahiri and Howorth, 2001). Developing countries rely heavily on fuelwood as rural households in these regions are primarily based on traditional sources for cooking purposes, and use solid fuels with a high preference for fuelwood (TERI, 2007).

The demand for fuel wood is exacerbated by agricultural expansion and deforestation. In Asia, fuelwood comes from plantations. In Latin America fuelwood is no longer the primary source of energy for rural populations as it is used mostly for industrial purposes (Tobin, 2011). In the 19th Century wood was used as a principle source of energy, even in North America and Europe and has since been replaced by more efficient and convenient alternatives such as gas and oil (Arnold, 2003).

A study carried out on the wood energy situation in Bangladesh highlighted fuelwood scarcity is as a result of overuse and unsustainability of fuelwood production. Inorder to survive, households have to adopt alternative mechanisms for obtaining energy. However, this adaptation is degrading the environment thereby threatening the forest thus contributing to global climate change (Akther *et al.*, 2010).The fuelwood crisis has been documented in Africa and South Asia and is mainly due to the declining access to fuelwood

and markets. Fuelwood is a major source of deforestation in the East and Southern African highlands and the savannah zones of West Africa (Dejene, 2004). Its extraction is often done in a destructive way affecting re-growth of trees leading to accelerated rate of erosion and landscape degradation, adversely affecting ground water and causing loss of biodiversity. Fuelwood collection normally occurs in a small scale at the local level and most of the material collected is deadwood although collection rates are higher than the regeneration rates (Tobin, 2011).

In the Eastern African sub-region there is a wood fuel deficit especially in densely populated highlands in Central and Western Kenya. Kenya's population depends on woodfuel for its domestic energy needs and this has a visible impact on Kenya's dryland savannah and forests (NEMA, 2009). The scarcity of fuel-wood and the impact of its escalating prices are acute at the household level because of poverty and limited alternatives. There is a widening gap between supply and demand for woodfuel (Mahiri, 2002).

According to a comprehensive study on energy consumption patterns in Kenya conducted by the Kenya Institute of Public Policy Research and Analysis, and the Energy Regulatory Commission(KIPPRA and ERC, 2010), 70% of the consumers use biomass while 30% use other fuels. This supports well known studies by NEMA (2009) and IEA (2009) that biomass provides 70% of the energy requirements.

With population growth, demand for the fuelwood overrides supply thus creating an energy crisis. Population growth, agricultural expansion and encroachment into forests has led to forest destruction and environmental degradation in Kakamega County (GoK, 2005). High prices of wood fuel at Kshs 500 per 0.17 m^3 bale of firewood according to Ngetich *et al,* (2009) have exerted pressure on households. This translates to Kshs 2942/m^3 of fuelwood. Households have therefore resorted to various methods to cope with increasing wood fuel scarcity (Brouwer *et al.*, 1997). Currently, high fossil fuels prices at USD 80 per barrel, (Njeru, undated) have also contributed to increased demand for fuelwood.(Mahiri, 2002).

In Western Kenya, Kakamega County most firewood comes from on farm sources and some households obtain all their firewood free. It is either acquired as deadwood or collected from bushes while others regularly purchase to supplement their free firewood. 95% of rural households in Kakamega use firewood as their source of energy for cooking (NEMA, 2007).

Poverty has a key role in misuse and over exploitation of the available resources leading to resource scarcity. Due to fuelwood scarcity, households spend resources sourcing for fuelwood thereby affecting household income. Fuelwood scarcity also has a negative impact on food consumption patterns of households due to cooking less times a day and switching to less consuming

methods such as frying instead of boiling to be able to cook available food (Bensel, 1996).

The study covered fuelwood use among rural households in Lurambi and was limited to households that relied on fuelwood for energy in this area. It focussed on forest adjacent communities living within Kakamega. Therefore the study was limited as it did not take into consideration urban households in Kakamega town.

1.2 Problem Statement

Rural households rely on fuelwood for their energy needs. Currently, due to an annual population growth rate of 2.8%, available land being put to agricultural use, fuelwood sources have been on the decline (GoK, 2007). This has resulted in a situation where demand outstrips supply thereby having far reaching impacts on the environment and livelihoods of the community.

In Lurambi District, households rely on fuelwood to meet their energy demands. Previously, fuelwood was easily accessed from the forest, bushes and on farm sources but currently people are forced to purchase fuelwood. Therefore, as a result of scarcity of fuelwood, households are forced to adapt to other options in order to cope with this changing scenario. Thus, the aim of this study therefore is to identify the impacts of fuelwood scarcity on households and relevant strategies used to cope with this shortage.

1.3.Objectives

The broad objective of the study is to investigate impacts of fuelwood scarcity and coping strategies among rural households.The specific objectives are:

1. To assess factors contributing to scarcity of fuelwood in Lurambi District

2. To examine the impacts of scarcity of fuelwood on the livelihoods of the households

3. To assess coping strategies with regard to scarcity of fuelwood

1.4. Research Questions

The study sought to address the following questions.

1. What are the factors contributing to scarcity of fuelwood in Lurambi District?
2. What are the impacts of scarcity of fuelwood on the livelihoods of the local households?
3. What are the coping strategies among households towards scarcity of fuelwood?

1.5. Significance of the Study

Overreliance on fuelwood creates a situation whereby demand outstrips supply leading to the unavailability of fuelwood. The study will provide relevant information in developing policies relating to energy use and in understanding energy needs at the household level; promotion of agro-forestry practices and

afforestation efforts among farmers in the area to enhance sustained fuelwood production at the local level. The study will also address strategies with regard to effective fuelwood use among the community in Lurambi and to enhance knowledge on household responses towards the scarcity of fuelwood.

1.6. Conceptual Framework

Livelihoods are affected by the allocation of resources and depend on the interaction of the natural, social, physical, financial and human capital (Hartter and Boston, 2008). Once the food is made available energy is needed to cook and to process the food. This will inturn lead to fuelwood consumption within the household. These wood resouces are then sourced from the forest, onfarm sources and bushes. This framework, (see Fig 1.1.) is based on the model by Hartter and Boston on fuelwood consumption in a subsistence based community which relies heavily on planting of food crops as a function of fulfilling individual and household level energy requirements. This framework indicates two paths to fuelwood consumption as follows:

1. Sustainable fuelwood consumption, where wood resources are well utilized, with minimum environmental impact and trees are replanted to meet increasing wood fuel demands leading to sustainable laud use practices.

2. Unsustainable harvest levels leading to negative impacts such as loss of biodiversity, habitat fragmentation and encroachment of natural forest

resulting in deforestation. More land is thereby converted to agricultural use leading to a loss of environmental service offered by the forest.

This model is relies on a neighbouring forest resource (Kakamega forest) and therefore is not applicable to arid areas.

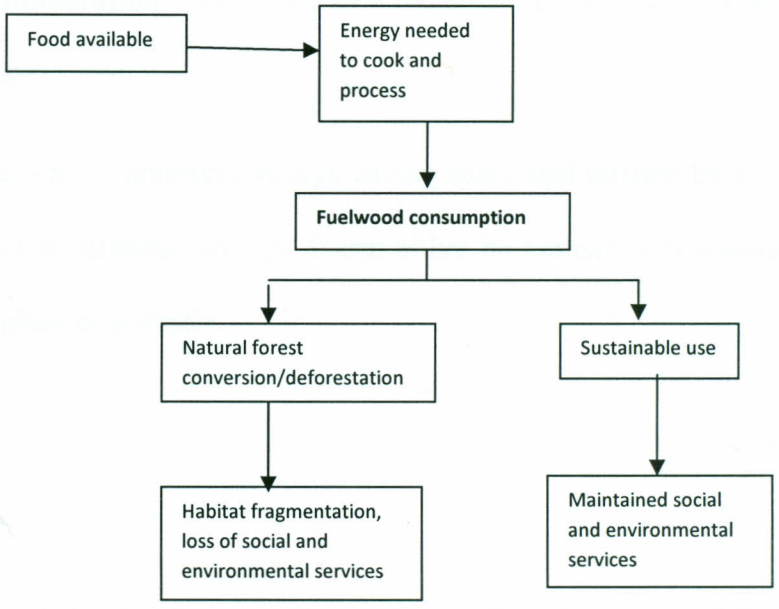

Figure1. 1: Relationship between Human Energy Requirements and Fuelwood Consumption. Source: (Hartter and Boston, 2008)

1.8. Definition of Terms

These are descriptions of various terms used in the study in line with fuelwood use and impacts in Lurambi Divison.

Coping strategies - Developing different means of dealing with decreasing fuelwood availability (Brouwer, 1997). It is a means of adaptation towards a changing scenario with regard to the unavailability of fuelwood.

Free good – fuelwood perceived as a gift of nature that is readily available and does not accrue any financial cost implication

Fuelwood crisis – the use of wood, its dominance as an energy source and its associated impacts

Fuelwood substitution - switching to an alternative fuel either permanently or temporarily.

Jiko Kisasa – is an improved energy saving stove that utilizes both charcoal and firewood at different timings. It can either be permanently installed into the kitchen place or portable.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

This chapter covers factors influencing fuelwood scarcity and highlights fuelwood consumption both at the global and national level. It also discusses the impacts of fuelwood scarcity on community livelihoods and the environment. Finally, coping strategies to fuelwood scarcity are discussed.

2.2. Fuelwood Consumption Trends

2.2.1. Global Fuelwood Consumption Trends

Fuelwood plays a major role in supplying energy to rural households owing to its importance in domestic consumption. It plays a role in meeting essential needs as cooking, heating and rural industries in developing countries. It has been estimated that 2.4 billion people worldwide rely directly on traditional biomass fuels and that in poor countries biomass use presents over half of residential energy consumption (IEA, 2005). Less developed countries are not able to afford this alternative fuel therefore rely heavily on woodfuel. A projection of world energy consumption is shown in table 2.1.

Table 2 1: Projected Trends in Biomass World Energy Consumption

Primary energy consumption *(EJ)*			**Average annual change, 2007–2030 (%)**
2007	2020	2030	
49	60	67	1.4

Source: IEA, 2009

The demand for fuel wood is exacerbated by agricultural expansion leading to deforestation. Currently, high fossil fuels prices have also contributed to increased demand for fuel wood. There has been an increasing demand for wood products, especially firewood and charcoal (Mahiri, 2002). The demand for wood products and the need for land for agriculture and other purposes has an impact on forests. These forests are threatened by a range of pressures, for example, acidifictaion, fuelwood and fire. Reduced or degraded habitats threaten biodiversity at gene, species and ecosystem level, hampering the provision of key products and services (UNEP, 2002). Degradation can lead to a situation of fuelwood scarcity. Dependence on forests for energy implies that scarcity can negatively impact on household welfare.

According to an analysis carried out by the Food and Agriculture Organization on the fuelwood situation in the Eastern African sub-region using 1980 as base year and assessing developments to the year 2000, it was found that there is a woodfuel deficit especially in the densely populated highlands estimated at 53 percent of needs in the East African region. In Kenya, households especially in the rural areas rely heavily on fuelwood. Biomass provides 70% of the energy requirements for households. (KIPPRA and ERC, 2010)

2.2.2. Fuelwood Consumption Patterns Among Rural Households

According to a draft report on Kenya's Climate Change Technology Needs and Needs Assessment report (2009), about 80% of Kenya's population depends on woodfuel for its domestic energy needs and this has a visible

impact on Kenya's dryland savannah and forests. The scarcity of fuel-wood and the impact of its escalating prices are acute at the household level because of poverty and limited alternatives. There is a widening gap between supply and demand for woodfuel. According to Mugo (2010) household fuelwood wood demand in Kenya was at 4,171, 217 tonnes per year.

Most of the fuelwood resources in Kenya are declining due to overuse, increased population and the accompanying pressure of settlements and the agricultural frontier on the original natural vegetation and bushes. The combined effect of land privatization and the declining fuelwood resources led to commoditization of fuelwood and reduced access to communal collection areas (Mahiri, 2002). Currently, measures have been put in place by the Government of Kenya (GoK) to address tree planting by reducing firewood demand as sustainable exploitation of fuelwood has not received much attention (Bizzarri, 2010).

The constant growth combined with a poverty level of 58% of the total population of the Kakamega District leads to a deteriorating situation for the people (Kenea, 2007). If fuelwood consumption does not correspond to tree planting initiatives and sustainable wood production, fuelwood will continue to decline.

There are various theories relating to fuel wood demand and supply including: the fuelwood gap theory of supply and demand which is based on the

projection of fuelwood consumption in direct proportion to population growth (RWEDP, 1997). The Fuelwood orthodoxy approach associates fuelwood consumption with deforestation (Mahiri and Howorth, 2001). It states that fuelwood scarcity is related to lack of trees and that inorder for fuelwood demands to be met large areas should be cleared and massive afforestation be carried out to maintan wood fuel balance. Most woodfuel in Western Kenya comes from on farm sources. According to NEMA (2007), it was noted that a majority of households obtain all their firewood free while others regularly purchase to supplement their free firewood.

2.2.3. Livelihood Activities in the Study Area

A majority of the population live in rural areas, and generate their income from agriculture and livestock sectors (GoK, 2002). The farms are privately owned and usually quite small, ranging from 1-3 hectares. The main food crops are maize, millet, bananas and cassava. The cash crops consist of sugarcane, tea, tobacco and rice. Animal husbandry is practiced and dairy farming is increasing particularly with the assistance from National Agriculture and Livestock Extension Programme. There is widespread dependence on the forest by the local people who obtain firewood, thatch grass, medicinal plants and also graze in the Kakamega forest.

2.3. Factors Influencing Fuelwood Scarcity in Rural Households

A review of literature by Heltberg *et al.* (2002) indicates that there are various factors that contribute to increasing wood fuel scarcity and these are discussed below.

2.3.1. Land and Fuelwood Scarcity

There is declining fuelwood resources and free collection areas due to the impact of land privatization, increased demand and entitlement that have resulted in many rural households resorting to the market in order to obtain fuelwood. In a study on rural household responses in Nyando by Mahiri (2002), that used a multi method approach to collecting data among 67 households in Nyando District it was noted that land privatization has diminished all open collection sources, thus also raising the issue of distance travelled to fetch fuelwood. Land in Western Kenya is mostly freehold, subdivisionof the land into smaller units has meant maximum use of available land for agriculture thereby reducing tree cover leading to a deficit in fuelwood supply (GoK, 2007). This is as a result of imposed land and agricultural rights that inhibit control of wood fuel resources and land management by women (Brouwer, 1997).

2.3.2. Climate Change and Fuelwood Scarcity

Climate change refers to any change in climate over time either due to natural variablity or as a result of human activity(IPCC, 2007). Climate change is caused by both natural and anthropogenic causes such as encroachment, destruction of

catchments for fuelwood use. Fuelwood exploitation will lead to environmental degradation especially desertification, soil erosion and loss of biodiversity thereby inducing climate change (Gbadegesin and Olorunfemi, 2011). Deforestation enhances conditions that produce global warming such as the release of carbon dioxide into the atmosphere (Heltberg *et al.*, 2000).

Recent studies have shown remarkable changes in availability, fluctuation rates and redistribution of renewable natural resources, these changes are attributed to Climate change (Adamu and Alarina, 2013). Climate change is attributed to deforestation through tree cutting, firewood and expanding stock and burn agriculture (Pelemo and Olatuge, 2008). Deforestation and land clearing activites emit about 1.7 billion metric tonnes of carbon per year in to the atmosphere (CBD, 2007). These activities lead to increased carbon content in the atmosphere leading to climate change.

Climate change, biodiversity and forest loss are cross-cutting issues that need to be addressed simultaneously for adaptation in Africa in order to enhance the sustainability of the forest resource pools on which poor communities directly depend for their livelihoods (Nkem et al, 2008). Forest biodiversity is vulnerable to various climate change scenarios, affecting wildlife population and the livelihoods of humans. Forests contribute to climate mitigation by sequestering carbon in forest biomass (Lecocq, *et al.*2010).

Impacts of climate change include depletion of natural resource base, changes in vegetation types and changing livelihood systems thereby inluencing the supply of fuelwood(Abaye and Giwa, 2007). It affects the availability of fuels in the dry season as opposed to the rainy season, prolonged floods and rains lead to scarcity of woodfuels and also affect the drying process of wood of which use of wet fuels contributes to indoor air pollution. Temperature variations make it necessary for households to utilize significant amounts of energy for space heating. Climatic changes due to an increase in altitude also increase the need for space heating within the households. Climatic variations influence energy consumption by determining biomass production rates and therefore the availability of traditional fuels.

2.3.3. Socio- Economic Factors

These include household endowments and institutions for natural resource management (Heltberg *et al.,* 2000). According to Gbadegesin and Olurufemi (2011), frequent increase in the price of petroleum products has pushed the price of the products beyond the reach of the poor. This has led to an increased demand for fuel wood in Nigeria, and that prices of fuelwood will rise as free fuelwood is exhausted. With population growth over time and the rising cost of commercial fuels, the demand for fuelwood has increased. Fuelwood collectors are forced to travel longer distances inorder to access fuelwood.

Growing trees is least associated with need for fuelwood rather for commercial purposes. This is attributed to the fact that firewood is regarded as a 'free' gift of nature. Cultural factors in the community determine who should plant and/ or cut trees on the farm (Alumasa, 1992). According to Alumasa (1992) women in the Luhya community of Western Kenya are not allowed to plant trees unless given special permission by their husbands therefore this hampers tree planting efforts in the household. When trees are to be cut, it is the head of the household who decides what purpose this tree is to be used for and this mainly falls to commercial purposes as opposed to the sole purpose of providing for fuelwood.

With increasing houshold size, there is normally need to use more fuelwood to secure energy needs at the household level. Therefore with a large household, one is required to utilize more fuelwood inorder to sustain their needs.

Poverty has a key role in regards to impacts on fuelwood availability. Fuelwood is easily available and also perceived as free and therefore for poor households its normally seen as the best source of fuelwood. With increasing incomes one is able to afford more efficient alternatives to fuelwood.

Access to sources of fuelwood including the forest will be affected by distance. This is in terms of time taken to gather fuelwood, resulting in a lesser porton of the portion of the households relying on the forest. Location

of households interms of access to markets also influences the availability of commercial fuels or even their ability to purchase fuelwood (Sumati, 2006).

The size of the population also has an impact on fuelwood availability. A greater portion of the population is highly dependednt on forest for fuelwood this will thereby impact on the forest.

2.4. Impacts of Fuelwood Scarcity on Rural Households

2.4.1. Environmental Impacts

Activities such as deforestation, encroachment and destruction of catchment areas for fuelwood and for cultivation lead to a reduction of tree cover thereby affect fuelwood supply (Adamu and Alarina, 2013). As a result of deforestation, rare habitats are threatened thereby affecting important flora and fauna within the forest ecosystem. This leads to loss of biodiversity, loss of environmental services as harvesting levels exceed capacity of the environment to regenerate itself.

There is an increased amount of pressure on forests as a result of increased population growth, agricultural expansion, overgrazing, fires and overexploitation for timber and fuelwood. This affects the protection of the watershed and supply of water, preservation of species populations in the long run affecting the economic benefits for tourism and the loss of aesthetics. The loss of livelihood by communities that depend on the forest for food, shelter, medicine, spiritual and aesthetic is as a result of deforestation (Chambwera, 2004).

Destruction of forests results in soil erosion, increased floods, desertification and declining soil fertility thereby enhancing the community's vulnerability to external shocks (Alumasa, 1992). A loss in soil fertility will lead to decline in agricultural productivity. Fuelwood scarcity leads to greater use of agricultural residues and animal dung for fuel rather than left in the fields or ploughed back which results in reduced soil fertility and the propensity for soil erosion is increased (WEO, 2006).

Fuelwood scarcity has resulted in policies that promote the use of biofuels that include crops such as maize, sugarcane, oil palm, soy which can be used for multiple purposes. The major motivation for investing in biofuels had been the desire to reduce Greenhouse Gas emissions and research shows that the emissions balance varies widely depending on which crops grown and production methods. Biofuels have been linked to deforestation and encroachment. Due to these land use changes, the carbon balance can be negative meaning that more carbon is released in producing and using biofuels than the equivalent of using fossil fuels (UNEP, 2012).

Land on which the tree cover has been drastically reduced becomes susceptible to soil erosion, both by wind and by heavy seasonal rainfall. This, in turn, encourages desertification and flooding (RWEDP, 1997). As a result of this, soil productivity becomes low thereby affecting agricultural yields on which activity the community is highly dependent on, thereby increasing vulnerability to the ravages of climate change.

Demand for biofuels as a result of dwindling fuelwood supply has risen sharply driven by increased population, greater consumption and biofuel friendly policies causing land conversion, land degradation and pressure on protected areas.

2.4.2 Health Hazards and Indoor Air Pollution

Air pollution and health problems are associated with the use of firewood among the households. According to the WHO, (2002) cooking and heating with solid fuels on open fires or traditional stoves results in high levels of indoor air pollution. This smoke contains various pollutants such as small particles, nitrous oxides, sulphur oxides, carcinogens and carbon monoxide which are highly harmful to human health. Women and children are mostly exposed to this as they spend most of their time searching for wood resources and also use the fire.

Indoor cooking with biomass produces high levels of indoor smoke. Effects of indoor air pollution include acute infection of lower respiratory tract (pneumonia) in young children, tuberculosis, cataracts, and low birth weight in babies of exposed expectant mothers (WHO, 2002). Some of the interventions to avoid indoor air pollution include use of energy saving stoves, use of smoke hoods to trap the smoke and also the incorporation of eaves spaces. Use of properly cut and dried fuelwood reduces kitchen pollution sustainably.

2.4.3. Socio- Economic Impacts

These impacts occur with regards to time spent gathering fuelwood due to effort a household invests in acquiring the resource. Due to scarcity, households increased collection frequency to ensure sustainable supply of fuelwood, prompting fuelwood collection on a daily basis (Sikei, 2009). This is because collectors could hardly gather enough fuelwood to last a long time. Fuelwood collection is mostly undertaken by adult females in the household.

Since sources of fuelwood in Kakamega include forest, distances to and from the forest will be affected in terms time taken to gather fuelwood. With increasing distances to collection sites, households tend to re-focus their attention to other nearby sources of fuelwood.

The type of energy used depends largely on the income levels of the households (GoK, 2007) and to some extent to its accessibility. This means that with economic status households become less reliant on forests therefore they are able to explore other more effective sources of energy. Due to scarcity, households are forced to divert some resources to purchase fuelwood. Resource scarcity is indicated by a sharp rise in the prices of the resource whereby an increase in the unit price of fuelwood increases the expenditure on fuelwood (KIPPRA and ERC, 2010). Fuelwood scarcity will also impact on the demand and supply aspects among households in the area.

As a result of fuelwood scarcity, households are limited to less cooking times to save on fuels and also have to switch to different cooking styles thereby reducing nutritional benefits of the available foods (Brouwer, *et al.* 1997).

2.5. Fuelwood Scarcity Coping Strategies among Rural Households

Rural households have evolved diverse ways of responding to fuelwood scarcity some of which include: purchasing, whereby households spend some of their income buying fuelwood. This is highly dependent on the availablility of the fuel as prices increase with decreased supply. According to an analysis of biofuel consumption patterns in four rural villages in the Northwestern highlands of Ethiopia by Bewket (2005) as the availability of fuelwood decreases, households resort to using more animal dung and crop residues as fuel.

Tree planting through the establishment of woodlots among households, either separate from other activities or as an agroforestry project. Reafforestation efforts and the establishment of fuelwood plantations are some of the strategies in promoting sustainable fuelwood production. Improved production of woodfuel from existing wood resources can be achieved through better management of the resource.The adaption of less economically valuable trees/ bushes such as *Thevetia peruviana* and *Lantana camara* both of which are exotic species for fuelwood are also other alternatives (Mahiri, 2002).

The use of fuel-saving or demand-reducing technologies are some of the strategies households adopted to cope with or sustainably use a diminishing resource such as fuelwood. Among poor households, the main focus has been on improved stoves (Kammen, 1995). Another coping strategy among households is switching to alternative energy sources such as kerosene which is the most common fuel for cooking(Johnsen, 1999). Other sources include electricity generated from windmills, solar cookers and ovens although these are deemed expensive and also inconvenient as cooking has to be done during the day especially with regards to solar. Other sources of enregy include biogas a result of methane from dung extracted from livestock and natural gas in the form of Liquified Petroleum Gas(LPG) which can be harnessed. Substitution from fuelwood to alternative sources of energy such as crop residues or animal dung, in addition to more widespread use of improved end-use technologies, e.g. stoves, can reduce pressure on forests (Hejlsberg *et. al.,* 2000).

According to a study carried out in Nyando district by Mahiri (2002), some of the response mechanisms to lack of fuelwood at the household include adaptation of different modes of cooking to save fuel wood use such as frying instead of boiling certain foods, use of fuel wood and cowdung to cook, soaking foods in water such that they are able to take less time to cook and retrieving of half burned firewood such that it can later be used for cooking. In

rural areas households faced with scarcity may also reduce their consumption of fuel, or use lower quality fuelwood (Brouwer *et al.*, 1997).

Increased efficiency is achieved through more careful use of fires, more controlled use of cooking vessels, sharing cooking amongst two or more households, incoorporating a greater use of foods and dishes requiring less cooking. Other forms of adaptation include having fewer cooked meals, shifting to foods that take less time to cook, changing cooking methods, substituting home cooking with purchased food, reducing space and water heating and reducing fires for the protection of livestock (Arnold *et al*,2003).

As fuel supply dwindles, the source of woodfuel extends progessively from collecting deadwood to the lopping of live trees, the felling of trees, the uprooting of stumps and removal of shrubs, thereby leading to clearing of vegetation unsustainably. When deadwood is not available, people result to the felling of trees in extreme cases of scarcity as a means of coping. Once trees are cut and stumps uprooted, there remains little else due to the extensive clearing thereby leading to desertification.

2.5. Knowledge Gaps

Fuelwood crisis has been documented in Africa and South Asia and this is mainly due to declining access to fuelwood and markets (Akther, 2010). Household responses to fuelwood scarcity in Kakamega have been documented, outlining response mechanisms among households unique to certain environment unique to their specific locales (Mahiri, 2002). This study

addresses factors influencing fuelwood scarcity, the resultant impacts and sustainability of adaptive responses employed by the households to meet fuel wood demand.

CHAPTER THREE: METHODOLOGY

3.1. Introduction

This chapter describes the procedures used in carrying out the study. It gives a description of the study area, research design, and sample size, sampling procedures and data collection procedures and analysis that are discussed in detail as follows.

3.2 Study Area

The study was carried out in Kakamega County which is located in Western Kenya bordering Bungoma to the North, Trans Nzoia to the North East, Uasin Gishu and Nandi Counties to the East, Vihiga to the South, Siaya to the South West and Busia to the West. It comprises of 9 constituencies and six districts. It lies between longitudes 34^{0} 32"E and 35^{0} 30" east of the prime meridian and latitudes 0^{0} 30" North and 0^{0} 15" North of the equator (Fig 3.1.). There are seven administrative Districts comprising twenty seven locations and ninety seven sub-locations covering a total area of 3051km^{2} (GoK, 2005).

3.2.1. Climate

The climate of the area is tropical. Rainfall in the province is relatively high with mean annual rainfall varying from 1000mm in the eastern part to about 2000mm around Kakamega. The driest months are December-February while heaviest rainfall occurs in April and May (GoK, 2007). Temperatures in the

region are fairly constant throughout the year, with a mean daily minimum of about 11°C and mean daily maximums of about 26°C.

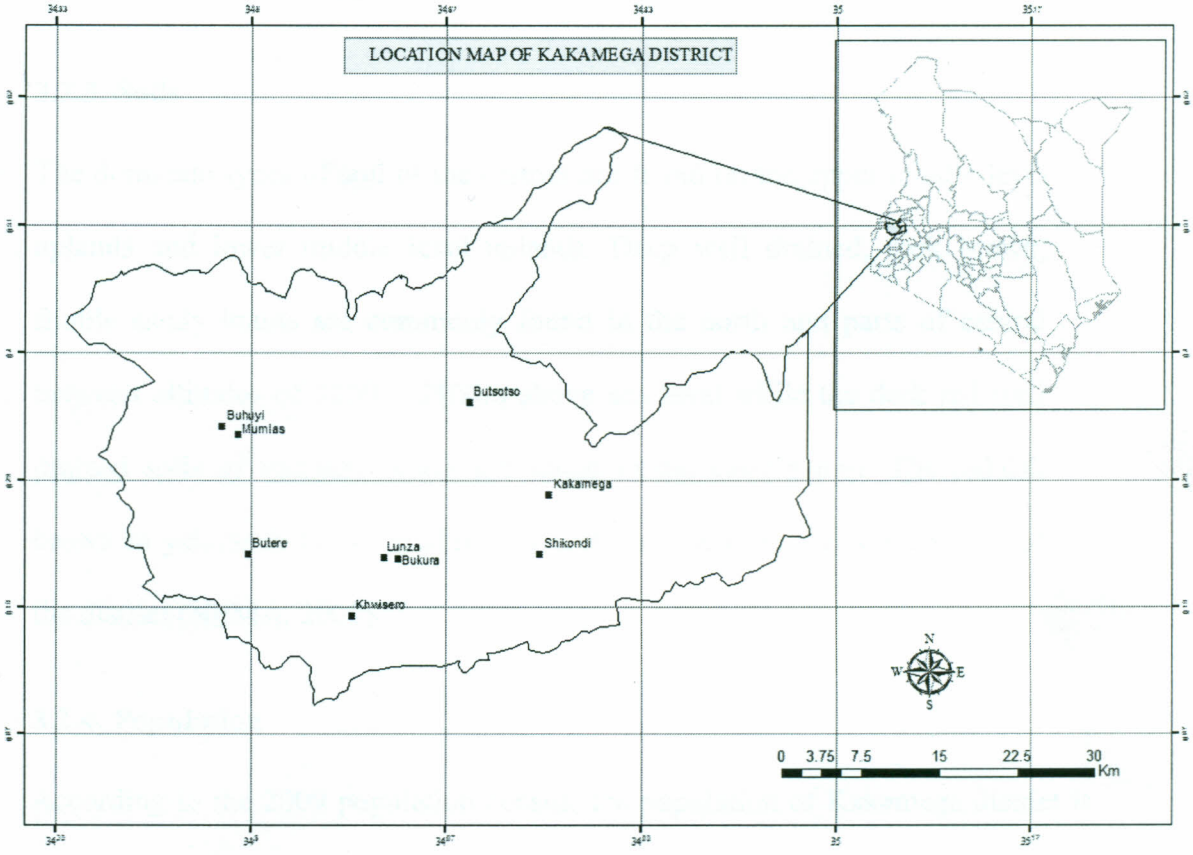

Figure 3. 1: Map of Kakamega District

Source: Surveys of Kenya, 1963

3.2.2. Geology

The main rock type of the area is granite, which is intrusive to Kavirondian and Nyanzian system rocks. Other main geological structures consist of Nyanzian volcanics, the Kavirondian sediments, tertiary volcanics, the basement system and pleitocene and recent deposits (NEMA, 2007).Kakamega has a general elevation of 1200-1700m and its characteristic

topographical feature is the small- scale undulating landscape with hills, valley and rivers with the major river in the area being the Nzoia river which drains into Lake Victoria.

3.2.3. Soils

The dominant types of soil of the district are found on the upper middle level uplands and lower middle level uplands. Deep well drained, dark brown, friable sandy loams are commonly found in the north and parts of central between altitudes of 1200 – 2100m above sea level while the dark red well drained soils of volcanic origin are found in the eastern part. The reddish brown to yellowish brown friable clay soils are found in the western part of the district (NEMA, 2007).

3.2.4. Population

According to the 2009 population census, the population of Kakamega district is 1,660,651 this shows a gradual increase in population as compared to the population in 1999. The population of Lurambi District is approximately 85,863(GoK, 2005). Population growth is indicated in the graph below:

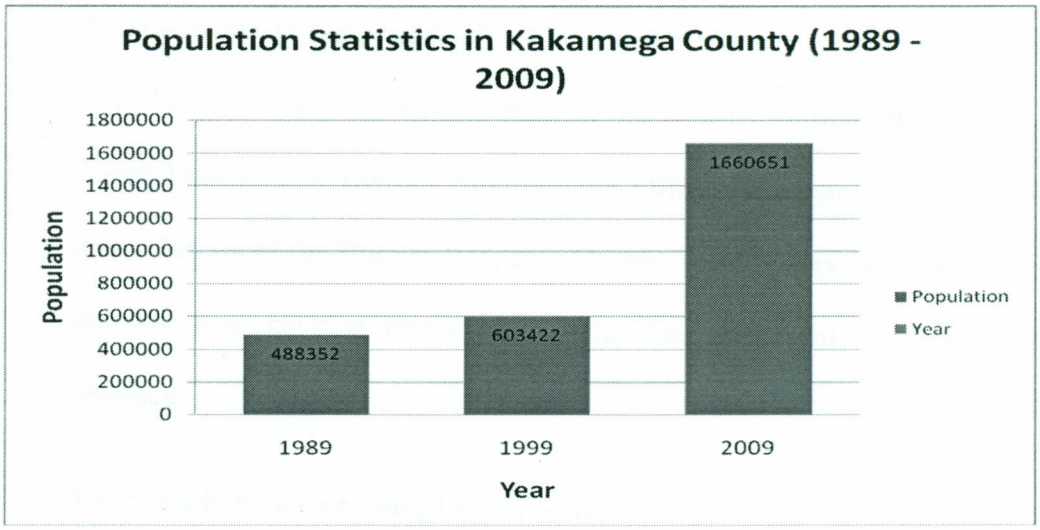

Figure 3. 2: Graph showing population statistics in Kakamega County

3.3. Research Design

This research design is a cross sectional survey carried out among households in Lurambi to dermine the facors influencing fulwood scarcity, impacts of this scarcity on households and coping mechanisms used. The questionnaire was the main tool of data collection where the primary source of data was the household. Questionaires were used to collect data on households determine relationships between various variables.Interviews were used to get information on fuelwood use among key informants. The study involved sampling households, interviewing key informants in Lurambi, Kakamega county.

Secondary sources of data involved documentary analysis regarding fuelwood use, information that was derived from relevant agencies in the area incluing the Kenya Forest Service records, the National Environment Management

Authority, the Ministry of Agriculture and the Ministry of Energy. Interviews were held with key informants such as the District Agricultural Officer, the Zonal Manager,the District Environment Officer, the Public Health Officer and Officials of the Bukura Resource Centre. Field observations were carried out where a checklist was used to determine availability of the fuelwood resource.

3.4. Sample Size and Sampling Procedure

The community in Lurambi District was the target population with an emphasis on the household as a unit. A random sampling technique was used for the villages and systematic sampling carried out among households to be included in the study, with households of villages as the ultimate sampling unit. The researcher was assisted by the area Chief with the assistance of village elders as guides in identifying the household heads. Four villages were sampled as shown in Table 3.1 below. The researcher carried out Systematic sampling was carried within four villages to obtain 200 households. In this method, total households in the villages was divided by the sample size in each of the households selected. This is what was included in the sample.

Table 3. 1:Villages sampled in Lurambi District

Village	Sichirayi	Bukhungu	Shimala Vandu	Lubao
No. of Households	50	50	50	50

3.5. Sample Size Determination

Sample size was calculated below, since population in the District is over 10,000, the formula by (Daniels, 1999) was used. Average fuelwood use prevalence among households is 70% at 95% confidence level was calculated.

$$N = \frac{Z^2 P(1-P)}{d^2}$$

Where,

N = desired sample if size is greater than 10,000

Z = critical value of confidence interval for standard deviation

d = estimated percentage points from the value of the desired level of precision

P = estimate of the expected prevalence (derived as 1-0.7 = 0.3/2 = 0.15)

$$N = \frac{1.96^2 0.15(1-0.15)}{0.5^2}$$

N = 196

For ease of analysis and the inclusion of a response error, a total of 200 households were determined as the sample size.

3.6. Data Collection

Data collection involved the use of questionnaires that were administered to the households. The questionnaires were divided into various sections including: socio- economic data, factors influencing fuelwood scarcity, impacts of fuelwood scarcity and coping strategies employed by the

households in periods of scarcity. An interview schedule was used for collection of data among key informants such as the Zonal Manager, Kenya Forest Service, Kakamega and the District Environment Officer, Kakamega. Documentary analysis was carried out to supplement primary data. A checklist was designed that focussed on observation in terms of the storage of wood fuel, what type of fuel was being utilised and woodlots observed.

3.7. Data Management and Analysis

Data were organised in such a way that they were clustered according to the objectives of the study and inferences and conclusions were then drawn from the findings. Data entry was carried out in an excel sheet, where it was cleaned which means addressing irregularities as data was being entered and coding where numerical values were assigned to each of the options offered. Analysis of the data was carried out using the SPSS version 12 statistical package for presentation whereby cross tabulation and graphs were used. Descriptive statistics were used as they allow for meaningful description of a distribution of scores or measurement using a few indices or statistics (Mugenda and Mugenda, 1999).

To analyse fuel wood scarcity at the household level, frequency of this scarcity was confirmed and cross tabulated with socio- economic factors such as family size, income, gender, literacy and land owned. Frequencies, tables and graphs were used to present results on data such as land size, factors influencing scarcity and alternatives used in case of the unavailability of

fuelwood. Correlations were carried out to determine significant relationships between variables.

3.8. Pre-testing the Questionnaire

The questionnaire was pre-tested in Sirambi village in Lurambi on ten households with similar characteristics for example proximity to forest, socio – economic traits identified for convenience that were not included in the study. Pre-testing was done to check the reliability and validity of the instruments. In case of any bias and flaw, the interview schedule and observation guide were modified for more clarity and accuracy.

3.9. Ethical Approval for the Research

Ethical approval is necessary to protect the rights and safety of research participants in the research. In line with conforming to the research clearance and authorization process that research work in the country be conducted only on issuance of a research permit from the National Council of Science and Technology. The researcher, on approval of the proposal through Graduate school and the Directorate of Research, applied for a research permit. A research license was issued (see appendix) for a period of three months. This was used while carrying out interviews with relevant government officials and for collecting data among the households in the District.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

4.1. Introduction

This chapter carries out an analysis of factors influencing fuelwood scarcity, impacts of fuelwood scarcity and coping mechanisms among households in Lurambi District. Results for this study will be reported under the following sub-topics: socio-economic characteristics, fuelwood consumption trends among the households and factors influencing fuelwood scarcity. The socio-economic and environmental impacts of fuelwood scarcity on livelihoods of local households are discussed. The final section discusses coping mechanisms employed by the households as a response to fuelwood scarcity. Cross tabulations were carried out with regard to socio economic variables affecting fuelwood scarcity and analysis of relationships of various variables influencing fuelwood scarcity.

4. 2. Social Economic Characteristics of Households in Lurambi District

The section covers the socio- economic characteristics of households in Lurambi District namely age, gender, education and income status.

4.2.1 Age of respondents

Age was one of the socio-economic characteristics surveyed to determine relationship between age and fuelwood use within the household. According to the findings, 35% were aged 19-30 years. Whereas 20.5% were aged between of 31- 40 years and 17% between the ages of 41-50 years. Those above the age of 60 were 12% (Table 4.1). There is no correlation between the ages of the respondents in regards to fuelwood scarcity in the households therefore age is not a factor to

consider with regards to fuelwood scarcity among households in Lurambi. Co-relations (p value at 0.01) between household size and fuelwood scarcity indicated that there exists a positive relationship between household size and fuelwood scarcity such that the larger the household are more likely to experience scarcity than smaller households.

4.2.2. Family Size and Education levels

With regard to family size, average number of children per household is three and average family size is six persons per household. In terms of literacy levels, 50% of the population had primary school level of education, 27.5% of the households had reached the level of secondary school level while 19.5% of the population had not received any formal education (Table 4.1). Participants (50%) in the study cited lack of resources to enable them continue with schooling.

Table 4. 1: Socio-economic Characteristics of Households in Lurambi District

Characteristic	Type	Frequency	Percent(%)
Age	<18	9	4.5
	19-30	70	35.0
	31-40	41	20.5
	41-50	34	17.0
	51-60	22	11.0
	>60	24	12.0
Education	Non	39	19.5
	Primary	99	50.0
	Secondary	55	27.5
	Tertiary	6	3.0
Source of income	Farming	92	46.5
	Officialemployment	13	6.5
	Self employment	20	10.0
	Business	50	25.0
	manual labour	20	10.0

	hand outs	2	1.0
	None	2	1.0
Gender	Male	12.5	25
	Female	87.5	175

From the table below there is a positive corelation between fuelwood scarcity experiences among those in the no education level and the primary education level bracket that shows that with lower education level one is bound to be affected by fuelwood scarcity. This is shown by a marked difference in percentage among those that did and those who did not experience fuelwood scarcity among those with no education and those that had attained primary level education.

Table 4. 2: Cross tabulations between 2 variables: Fuelwood scarcity and Education levels

Education Level	**Fuel shortage**		**Total**
	Yes	**No**	
Non	37 22%	2 6.7%	19
Primary	80 47.6%	19 63.3%	99
Secondary	48 28.6%	6 20%	55
Tertiary	3 1.8%	2 6.7%	5
Total	168	32	200

4.2.3. Poverty

According to the Kenya Integrated Household Baseline Survey District poverty estimates of 2005/2006 the county poverty rate is 53% compared to the national average of 47.2%. Kakamega county is thereby ranked 29th among the counties

with highest poverty rates. Due to this situation, most households that lack adequate income have very few options and thereby mostly rely on fuelwood thus contributing overdependence on the resource. These households hardly have enough resources to spend their income on fuelwood, therefore in times of scarcity are forced to develop strategies in order to address their needs.

Among the factors influencing fuelwood it was found that the relationship between overuse/overexploitation of fuelwood and cost of fuelwood is statistically significant with p at 0.01. This therefore shows that with continued overuse of fuelwood there are increasing costs thereby enhancing fuelwood scarcity.

Table 4. 3: Cross tabulation between Fuelwood scarcity and income sourced

Income sources	**Fuelwood scarcity**		**Total**
	Yes	**No**	
Farming	82 49.1	10 33.3	92
Employment	7 4.2%	6 20	13
Self	19 11.4%	1 3.3	20
Business	40 24%	8 20.7	49
Manual labour	16 9.6%	4 13.3	20
Handouts	1 0.6%	1 3.3	2
None	2 1.2	0	2

Table 4.3 above shows the status between fuelwood scarcity and income statues among households in Lurambi. It shows that those that rely on manual labour as a source of income are most affected by fuelwood shortage. This is particularly the

case among those that fell in the low income bracket that are increasingly dependent on the resource. It can be concluded that there is a positive relationship between fuelwood scarcity and income sources thereby poverty contributes to fuelwood scarcity.

4.2.4. Source of Income

Farming is the major source of income, 46.5% followed by earnings from business 25% (Table 4.1). Crops grown in the district, according to the District Agriculture Officer include: maize, sugarcane, fruits, avocadoes, pawpaws, vegetables, cabbages, traditional vegetables, soya beans, tea, coffee, beans, sweet potatoes and cassava. As at June, 2013, maize stocks for Western were at 615, 260 (90 Kg) Bags, beans, 10735 bags and targeted production for cassava is 209, 298 bags according to the Ministry of Agriculture food security report for 2013.

4.3. Factors Influencing Fuelwood Scarcity

One of the objectives of the study was to analyze factors influencing fuelwood scarcity in Lurambi District. In this study, 95% of households interviewed depended on fuelwood for their household energy needs. These findings compare favourably to a study by Githiomi (2011), analysing household energy sources and utilization techniques through structured questionnaires among households in Maragua District, Kenya found out that 96% of the households relied on firewood as a source of energy. This dependence on fuelwood has a direct impact on the environment as demand outstrips supply thereby leading to the overexploitation of the available resources.

When the respondents were asked to indicate whether they had enough fuelwood, 84%, responded that they experienced fuelwood scarcity. This result favourably compares with Akther (2010) findings, in a study where an exploratory survey was carried out to analyse the reasons for fuelwood scarcity and adaptation techniques in Brahmaputra, Bangladesh found that 94% of the households had experienced fuelwood scarcity. Other factors influencing fuelwood scarcity are discussed below.

Among the households that experienced fuelwood scarcity it was found that 33.5% of the households experience fuelwood scarcity on a monthly basis, 24.5% on a weekly basis and 21.5 % on a daily basis.

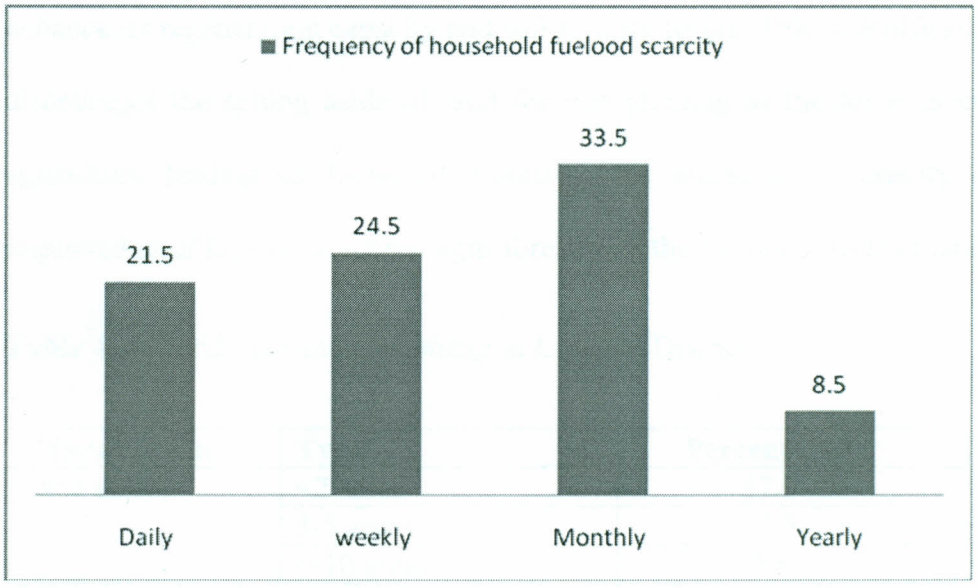

Figure 4. 1: Frequency of Household Fuelwood scarcity among Households in Lurambi District

4.3.1. Land Size and Ownership

Land size and ownership have an impact on the availability of fuelwood. Land ownership in the District is freehold (89%) and only 6% is communal land meaning much of the land is privately owned (Table 4.3). According to Beyene (2011), there is a relationship between property rights and household demand for fuelwood which is measured by the source from which fuelwood is collected. Reduced land sizes within the District have made the land prone to agricultural intensification and overexploitation thereby leading to land degradation. Land tenure is strong in Western Kenya due to its productivity and the fact that it has reliable rainfall.As observed in Table 4.4, 87% of the households owned less than two acres of land due to increased land sub-division. Small scale farms dominated the area and these enhance land intensification as land can hardly lay fallow to enhance its regeneration capacity and soil fertility levels. This intensification also discourages the setting aside of land for tree planting as the focus is more on agriculture leading to fuelwood scarcity. This situation of scarcity can be improved on if farmers practised agro-forestry on their small parcels of land.

Table 4. 4: Land Size and Ownership in Lurambi District

Characteristic	Type	Percent (%)
Land size	<2 acres	87.0
	3-5 acres	12.5
	6-10 acres	0.5
Ownership	Freehold	89.0
	Communal	6.0
	Trust land	0.5
	Rent	4.5

The relationship between land use and overuse of fuelwood is also statistically significant with p at 0.01. This indicates that with increasing changes in land use and increased fuelwood exploitation are contributing to fuelwood scarcity among households in Lurambi.

The relationship between deforestation and land use is also statistically significant with p at 0.01 indicating that land use changes over time have had an impact on local fuelwood sources including the Kakamega forest.

Climate change and overuse also share a statistically significant relationship at $p< 0.01$ indicating that variations in temperatures, rainfall combined with over exploitation of the resource have lead to a situation of fuelwood scarcity.

4.3.2. Household Fuelwood Sources

Rural households use firewood as their source of energy for cooking and heating. According to findings in the study, 66% of fuelwood is source from outside the forest (23.5% from on-farm source, 22.5% from twigs and bushes, and 20% from markets) while 34% of the households get their fuelwood from the Kakamega forest (Table 4.5). These findings are in line with an analysis of biofuel consumption patterns in the Northwestern highlands of Ethiopia where a structured household survey was carried out among 133 households; it was found 26% accessed the fuelwood from privately owned farms (Bewket, 2005). In this study, 22.5% of the households derived their fuelwood from figs and bushes and 20% purchase their fuelwood from the market indicating that

there is increasing unavailability of fuelwood in the District as households are forced to use what is easily available in order to cater for their energy needs.

Table 4. 5: Sources and Collection Practices for Fuelwood by Households in Lurambi District

Characteristic	Type	Percent(%)
Fuelwood sources	On farm	23.5
	Twigs/bushes(off farm)	22.5
	Forest	34.0
	Market	20.0
Collection of firewood	Collection of deadwood	58.0
	Lopping of live trees	20.0
	Felling of trees	7.0
	uprooting of shrubs/stumps	5.5

These results show that 34% of the household relies on the Kakamega forest for provision of fuelwood. There are restrictions in access to the forest though collection of deadwood is allowed. The Government has put in place mechanisms in Kakamega forest (Plate 4.1) to ensure that fuelwood extraction is monitored and controlled by charging fees (Kshs 100 per month in 2012) for the collection of firewood. Due to high dependence on forests and increasing unavailability of fuelwood, the source of fuelwood extends progressively from collecting deadwood and lopping of live trees and proceeds to the felling of trees thereby leading to destruction of tree cover (Arnold, 2003). The preferred means of harvesting among the households was

the collection of deadwood (58%) followed by the lopping of live trees at (20%) of the households both from on-farm and off farm sources (Table 4.3).

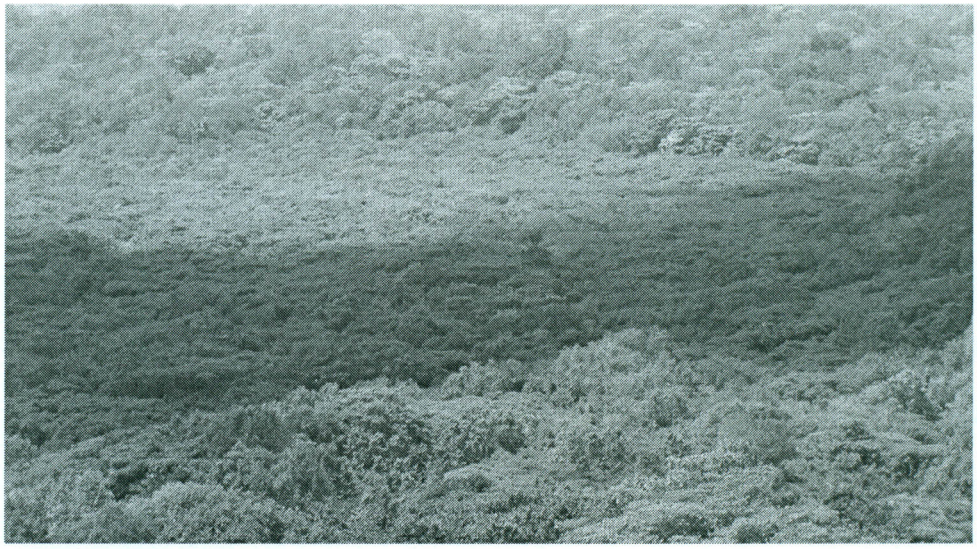

Plate 4.1: A section of the Kakamega Forest (*Source:Field Study, March,2012*)

4.3.3. Access to Communal Collection Areas

Reduced access to common collection points has contributed to fuelwood scarcity within Lurambi as 47.5% of the households had access to communal collection points, while 52.5% of the population had no access to communal collection areas due to increasing land fragmentation and privatization. In many rural areas according to Mercer, (1992) the amount of communal land is rapidly declining as woodlands are cleared and enclosed for agricultural production.

A majority of the households stated that they lacked fuelwood as there was restriction of access due to land privatization. Privatization of the available

land reduces access to communal collection points which the community previously relied on for fuelwood thereby leading to fuelwood scarcity. This will therefore put a strain on the forest. These findings compare favourably to Mahiri (2002) in a study on household responses to fuelwood scarcity in Nyando District, Kenya where he stated that land privatization has led to reduced access to communal collection areas.

4.3.4. Deforestation

Deforestation contributes to a loss of tree cover thereby necessitating a reduction in the amount of fuelwood collected. There is evidence that deforestation induces more landslides and floods according to Boahne (1998), which affects lake Victoria's water catchment river basins, and contributes to siltation and floods as far away as Budalangi. On a global scale deforestation hastens the depletion of ozone layer, inducing greater climate change (Baland, 2007). Overexploitation and over reliance on wood resources was stated by 70.5% of the households interviewed implying that the available wood supplies were dwindling due to a high demand in fuelwood. Value for wood has also increased with the entry of charcoal which is highly sought after in the urban areas thereby causing over-exploitation of the available wood resources.

4.3.5. Tree Planting

When carrying out the study in Lurambi, the researcher sought to know reasons for tree planting within the home. Various responses were given including for commercial use, building, provision of shade and fuelwood

provision. Among these, 26% of the respondents stated that they planted trees for fuelwood provision. This has therefore created a situation of fuelwood scarcity as the focus of tree planting within the households is not on fuelwood provision.

Some of the tree species used by the community in Lurambi for the provision of fuelwood are highlighted in table 4.6. The Eucalyptus tree was used by 23% of the respondents due to its availability and fast growth rate. It is largely used as charcoal which is a popular alternative to woodfuel. It is said to have good burning qualities. This is corroborated by Bewket (2005) in his study on biofuel consumptions patterns in Ethiopia where the Eucalyptus was the most dominant tree type in the area and was preferred due to its fast growth rate.

The Cypress used by 11.5% of the households, Cedar (6%), Guava (3%) as fuelwood among the households. The Guava and Mango trees have multiple benefits as they provide fuelwood if harvested properly and also supply fruits to the household. This is comparable to a study by Bensel (2007) addressing connections between woodfuel, deforestation and land degradation that saw an increase in mango trees planted in Cebu, Philippines for fuelwood. It was also observed that fruit trees are very popular for firewood, as they are easily available in the farms. The Avocado tree does not provide a good source of fuelwood and thus its use is associated with fuelwood scarcity.

Table 4. 6: Tree Species used for Fuelwood by Households in Lurambi

Tree Species	**Frequency**	**Percentage %**
Any type	115	57
Cyprus *Cupressus lusitanica*	23	11.5
Eucalyptus *Eucalyptus grandis*	45	22.5
Cedar *Juniperus procera*	5	2.5
Guava tree *Psidium guajava*	6	3
Avocado *Persea Americana*	1	0.5
Butterfly bush *Clerodendrum myricodes*	2	1.0
Broad Leafed Croton *Croton macrostatychyus*	1	0.5
Lantana Camara	2	1
Total	**200**	**100**

Other plant species used for fuel include *Lantana camara*, a shrub that is easily available and is widely used when households are not able to access firewood and when deadwood is not easily available. These findings are similar to Mahiri (2002) in his study on household responses to fuelwood scarcity where it is stated that households are adopting less economically valuable trees for example *Lantana camara* for fuelwood in times of scarcity.

Table 4. 7: Cross tabulation of two variables: Tree planting against sources of fuelwood.

Sources	Tree planting		Total
	Yes	No	
Onfarm	46	1	47
Twigs/bushes	38	7	45
Forest	61	7	68
Market	29	11	41
Total	174	26	200

There is a positive correlation between trees planted and the sources of fuelwood, as indicated in Table 4.7 above. Majority of those that collected fuelwood from onfarm sources did plant trees within their farms and also those that accessed trees within the forest also planted trees to supplement what was being gathered in the forest (Table 4.7).

Table 4. 8. Cross Tabulation of Two Variables: Tree Planting and Land Sizes

Land size	Tree planting		Total
	Yes	No	
<2 acres	148	25	175
3-5 acres	25	0	25
6-10 acres	1	0	
Total	175	25	200

(p=0.14, df= 6)

There exists a positive relationship between tree planting and land sizes within households in Lurambi District in that those that have smaller land parcels of less

than two acres invested in tree planting the same also applies to those that had larger land parcels.

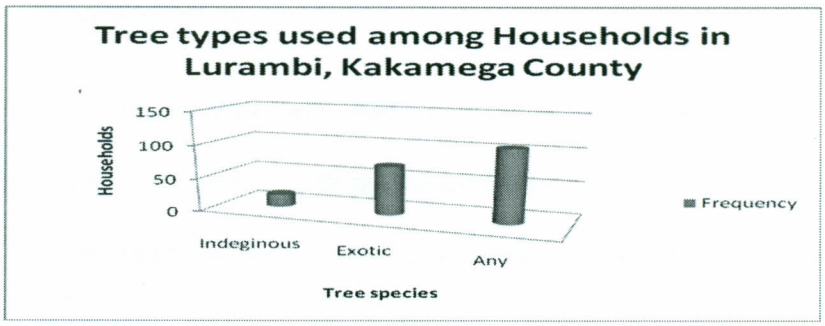

Figure 4. 2: Tree Species Used For Fuelwood by Households in Lurambi District

Participants in the study did not have a preference to any particular tree species as they used what was easily available (59.5%) and due to their good burning qualities among (29.5%) of the households, see Table 4.9.

Table 4.9: Preference of Tree Species for use as Fuelwood.

Preference for Tree species	**Frequency**	**Percent(%)**
Cheaper	7	3.5
Easily available	119	59.5
Good burning qualities	59	29.5
Convenient	4	2
Dries Easily	8	4
Fast growing	1	0.5
Culture	2	1
Total	200	100

4.4. Impacts of Fuelwood Scarcity on Livelihoods

The unavailability of fuelwood has an impact on livelihoods as it is a primary source of fuel within the home, especially on those tasked with the collection of firewood. Over reliance and the overexploitation of firewood negatively impacts

on the environment. These among other impacts of fuelwood scarcity are discussed below.

4.4.1. Impacts of Fuelwood Scarcity on Collectors

Women are tasked with the collection of firewood from the forest and are the prime users of fuelwood within the household (Plate 2.). Therefore, they are adversely affected by fuelwood scarcity. Responsibility for fuelwood collection lies with the women who represented 87% of those interviewed.

Plate 4.2: Women carrying firewood from the forest *(Source: Field study, 2012)*

In periods of scarcity, long hours are spent searching for firewood thereby reducing time for other productive activities. Transportation of firewood to the households is difficult as women are not able to afford the use of donkeys, a wheel barrow or bicycle that is normally used by men. Thus, unable to stock up on the available firewood, a woman is forced to make several trips in search of firewood. Carrying of the heavy loads on their heads or backs over time has a significant impact on their bodies and is likely to affect the spine.

Majority of the households were ignorant of the health consequences of carrying heavy loads of firewood. Collection of firewood in the Kakamega forest, which is known for its varied biodiversity, can expose them to danger such as snake bites as they go about the collection of wood and this may eventually lead to fatalities.

Table 4.10 below shows that 40% of household took a period of 30 minutes to access the resource followed by 23.5% who took an hour, 18% took 2 hours while 18% took more than two hours to access the resource. This is due to the close proximity to the markets and the Kakamega forest especially when fuelwood is available. In times of scarcity one could spend upto 2 hours searching leading to a loss in human hours.

Table 4. 10: Distribution of Time Taken Versus Sources of Firewood among Households (%) in Lurambi District

Sources	**30 mins**	**1 hour**	**2 hours**	**>2 hours**
Onfarm	19 23.8%	12 25.5%	8 22.2%	8 22.2%
Twigs/ bushes	18 22.5%	11 23.4%	11 30.6%	5 13.9%
Forest	21 26.3%	17 36.2%	14 38.9%	16 44.4%
Market	23 27.5%	7 14.9%	3 8.3%	7 19.4%
Total	80 100%	47 100%	36 100%	36 100%

4.4.2. Environmental Impacts of Fuelwood Use

The use of fuelwood within the household is bound to have some environmental impacts. Among the households that were sampled, it was found that 65.5% agreed that there were environmental problems accruing from fuelwood use among the households. Correlations between these factors was carried out and it was found that there was a significant correlation p at 0.01 for the following factors: There was also a significant relationship between air pollution and the environmental impacts relating to fuelwood use. This is a result of burning of fuels in poor conditions leading to emissions of Greenhouse gases into the atmosphere.

There was a significant relationship between deforestation and global warming such that with reducing tree cover indicates an increase in Greenhouse gases such as Carbon dioxide thereby leading to global warming.

The relationship between land degradation and soil erosion is also significant(p is 0.01) in that with continued unsustainable land utilization through poor agricultural and fuelwood collection practices will lead to soil erosion and therefore undermining land productivity. The same can also be attributed to the relationship between soil fertility and soil erosion.

There is also a significant correlation between deforestation and soil erosion, in that with reducing tree cover the land is left bare and is exposed thereby increasing its vulnerability to soil erosion. Kakamega forest has had a long history of logging and other anthropogenic disturbances including fuelwood collection

(GoK, 2012).The main signs of disturbance include footpaths and tree stumps which were observed in the study area due to unsustainable fuelwood exploitation. These disturbances have significantly altered the character of *flora* and *fauna* or depleted it from its original state. Degradation covers such parameters as composition, soil terrain and soil structure.

Destruction of wildlife habitats has a significant correlation to deforestation. This is the case as the wildlife habitat happens to be the Kakamega forest. With increased overexploitation of firewood within the forest this leads to the destruction of wildlife habitats and also contributes to deforestation.

4.4.3. Health Impacts of Fuelwood Use

In the study 67% of the participants cited health hazards accruing from the use of fuelwood. This included coughing as a result of exposure to indoor pollution and watering of the eyes as a result of the smoke. The continued use of poorly dried wood gathered enhances the risk of exposure to pollutants and to high indoor concentrations of biomass smoke (Alumasa, 1992). Incomplete combustion leads to the release of small particles and other constituents that are damaging to human health. Woodfuel that is not properly burned to carbon dioxide is diverted into products of incomplete combustion, primarily carbon monoxide, benzene, butadiene, formaldehyde and polyaromatic hydrocarbons (Smith, 2006). This is what contributes to smoke emissions due to the burning of wood. These emissions also contribute to greenhouse gases in the atmosphere leading to climate change.

According to the study, it was reported that hardwood species have good burning qualities and are said to have lower emissions than softwood species for combustion in fire places. Parameters affecting human exposure include fuel moisture, burning rate, ventilation and cooking behavior (Pandey, 2012). Cooking among households in Lurambi was carried out in a separate structure from the house that did not have adequate ventilation thus increasing exposure to indoor air pollution. Most of these structures lacked hoods, chimneys that reduce the effects of indoor pollution by venting the smoke outdoors. Most of the wood fuel stoves that were observed lacked working chimneys or hoods for venting smoke outdoors.

4.4.3. Impact of Fuelwood Scarcity on Cooking Patterns

Fuelwood scarcity has an impact on the cooking patterns of households within Lurambi District as 64.3% of the households had 3 meals a day, while 28% had two meals a day, indicating that the unavailability of fuelwood puts a strain on cooking patterns among the households. 5% of the families cooked a single meal a day instead of two simply because they lacked fuel (Fig 4.2). They claimed that they did not have adequate resources to either purchase the firewood or use alternative sources of energy as these were deemed expensive. These findings support the fact that fuelwood is increasingly becoming scarce in the District.

The community in Lurambi District relies mostly on the use of maize meal and traditional vegetables as their staple meals. Cooking of these traditional

vegetables for example cowpeas(*Vigna unguiculata)*, pumpkin leaves(*Cucurbita maschata*) and African nightshade (*Solanum scabium*)is known to take a longer time thereby the need for more fuel. Further, people are not able to cook essential meals because they lack firewood or because the money meant for food is directed to purchase domestic fuel. Lack of fuelwood induces a change in dietary patterns, for example the cooking of less nutritious foods leading to malnutrition, increased vulnerability to disease and reduction of people's productive capacity. This shows that fuelwood scarcity has an impact on household food consumption.

According to Dembner (1990), difficulties in accessing fuelwood leads to hygiene and nutrition problems as most food crops are palatable only when cooked and due to lack of fuel, food that is not well cooked could lead to a low protein intake. According to a key informant, the Public Health Officer, Kakamega foods that are nutritious generally take longer to cook and thus most households are abandoning this and shifting to foods that take less time to cook for example maize meal. These trends tend to have a negative impact on the nutrition status of community members leading to extremes such as malnutrition or lack of relevant nutrients that are vital to growth and sustenance of the body. In line with this, the Public Health department in Kakamega has embarked on a project on use of water filters for drinking water so as to discourage boiling of water which additionally leads to reduced consumption of fuelwood. In Vihiga for example, households are saving 30%

of firewood by using these filters. This strategy can be adapted in Lurambi District to reduce on fuelwood consumption.

4.5. Fuelwood Scarcity Coping Strategies

One of the objectives of this study was to assess the strategies employed by households in Lurambi District to deal with the reduced availability of fuelwood. In the study, it was found that 78.5% of the households switched temporarily to other fuels which implies that most households use alternative fuels in times of fuelwood scarcity (Table 4.11.). This is in line with studies carried out by Bewket, 2005 who stated that the pressure on the supply trend has affected the consumption of biofuels and this has necessitated improvisation on the part of the users (Bewket, 2005). Improvisation in this case means the switch to alternative sources of fuel.

Table 4. 11: Coping Strategies among Households in Lurambi

Characteristic	Type	Percent (%)
Coping mechanisms	Temporary switch	78.5
	Permanent switch	2.0
	Stop activities that use fuelwood	4.5
	Reduce number of meals	1.5
	Borrow	0.5
	No option/stick to using fuelwood	9.5
	Enhance search	2.0
	Other sources are not available	0.5
Those that use other sources of energy	Yes	77.5
	No	21.0

Households responded to fuelwood scarcity by improving the search for wood leading to more time and resources being spent in search of firewood. Coping mechanisms adopted by the households in Lurambi included stopping activities such as space and water heating, reducing the number of cooked meals to minimize use of the fire, or cooking large quantities of the food that can last two meal times to drastically reduce the amount of woodfuel utilized. In the study 4% permanently switched to other fuels when fuelwood was in short supply, meaning that the community was willing to embrace alternatives to woodfuel which in the long run will reduce dependence on wood resources. There are those that relied solely on fuelwood and did not use any alternative whatsoever (21%) mainly because other sources were not affordable. According to Mercer (1992), the poor often have few alternatives to fuelwood to meet their basic subsistence needs and problems associated with access to fuelwood contributed to the wider rural development crisis.

Various cooking practices were employed to reduce use of fuelwood consumption at the household level. These include the change of cooking methods (36.5%) by cooking meals that required less time to cook for example cooking of *ugali* (maize meal) as opposed to cooking *Githeri* (a mixture of maize and beans). This therefore affects the nutritive value of the foods such that essential nutrients are lost as the focus is on particular foods that can be quickly prepared. The adoption of quicker cooking foods relates to

a means of adaptation to a changing scenario (Mercer and Sousssen, 1992). In this case it's a means of adapting to the fuelwood shortage.

Measures put in place to enhance efficiency in fuelwood use included cooking exact portions in order to minimize on wastage, drying of food was carried out such that the food could cook faster, more careful use of fire (63.5%) and the use of fuel saving technologies at 16% (Fig 4.3.). The storage of firewood in advance was carried out to ensure that fuelwood lasts longer to save on frequent trips in search of the firewood. The splitting of firewood into several pieces to increase surface area was done such that firewood may be used in the fire for a longer period of time. During the rainy seasons when firewood is scarce, households store wet wood in the kitchen just above the cooking area to hasten drying.

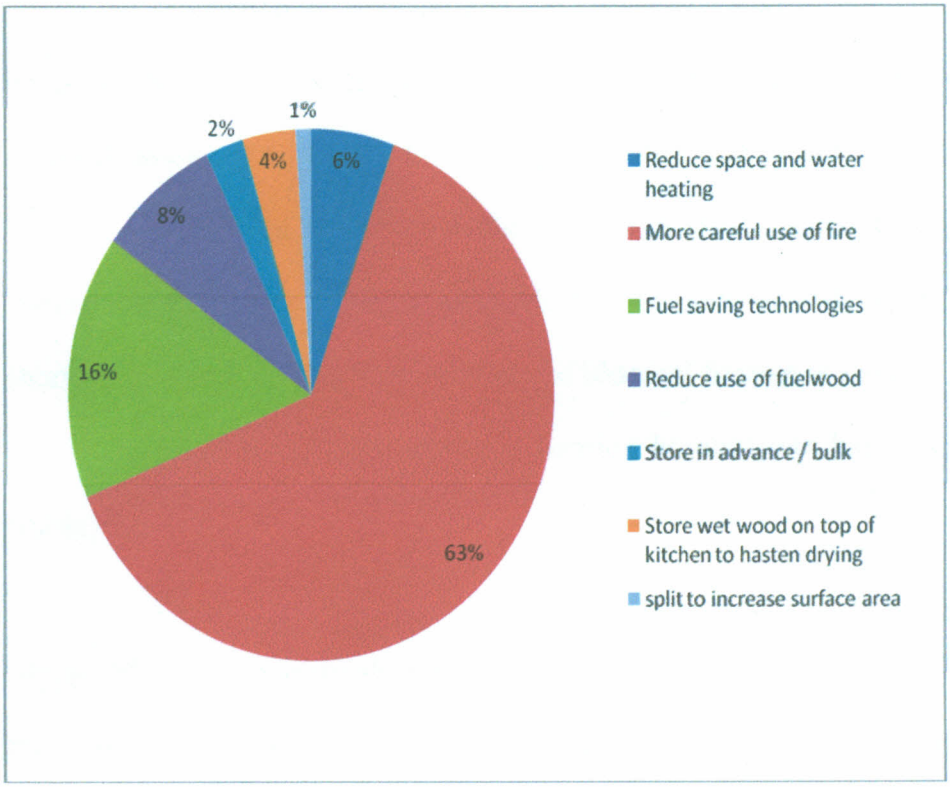

Figure 4. 3: Efficiency in Fuelwood Use among Households in Lurambi

The results of this study support the hypothesis that households have adopted various coping strategies to deal with increasing unavailability of fuelwood and that these coping strategies are short term as observed by households switching temporarily to alternative fuels in times of scarcity and not investing in long term options such as sustained tree planting.

4.5. 1. Alternatives Sources of Fuelwood

Among the households that participated in the study, 60% used charcoal in the event that they lacked fuelwood (Fig 4.4.). In Kenya, charcoal is produced in an earth kiln that typically yields only 1 kilogram of charcoal for every 6 Kg of wood handled (Kammen, 2006). Despite the inefficiency in its production

charcoal remains an affordable fuel for its consumers. The cost of damage caused by production of charcoal and the subsequent loss of tree cover are borne by the rural population where these trees are harvested. The use of charcoal among 60% of the households indicated that charcoal is in high demand especially in rapidly growing Kakamega town. These findings are comparable to Johnsen (1999) in an article discussing the severity of fuelwood shortage in Tanzania, that the production of charcoal for sale is a severe cause for deforestation because for charcoal burning because one has to cut the whole tree.

About 13% of the households in the study used kerosene as an alternate fuel in times of scarcity. Kerosene is extensively used for cooking, heating and lighting in the developing world (Chilcott, 2007). Literature on the economics of deforestation suggests that economic growth which raises the income level of the population will induce a switch from fuelwood to kerosene or other higher forms of energy and thus reduce deforestation associated with fuelwood demand (Gbadesin, 2011) as shown by increasing dependence of households on kerosene.

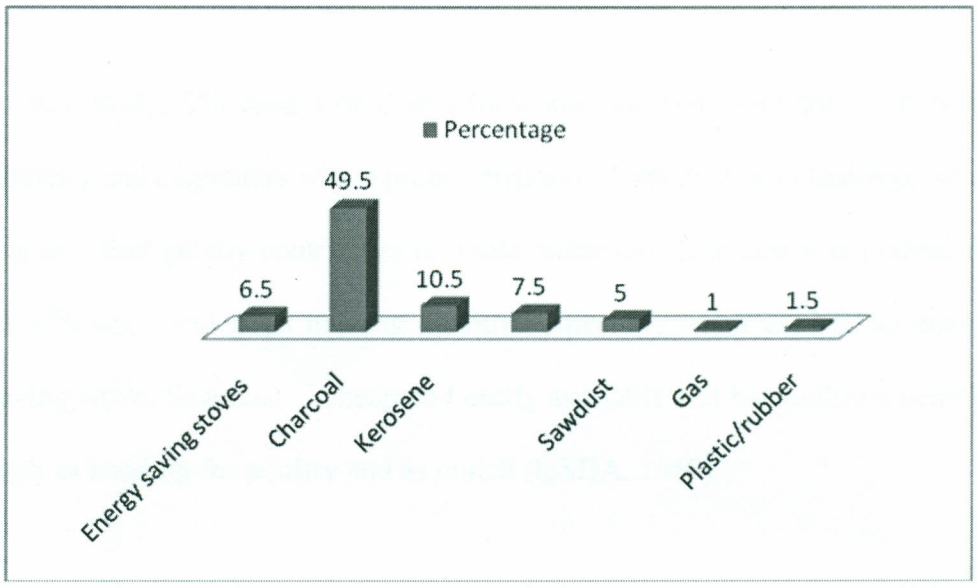

Figure 4. 4: Percentage Distribution of Common Type of Fuel used among Households in Lurambi District

According to Glassner, (1999) concerns about the security and sustainability of fossil fuels coupled with advancements in biomass conversion technology have renewed interests in crop residue as a biofuel to partially meet energy need particularly maize as it can produce 1.7 times more residue than other cereals. In Lurambi District, crop residues provide an effective source of fuelwood in times of fuelwood scarcity. Among the households (10%) that used crop residues, most cited the use of twigs, maize stalks and sugarcane for fuel. This is comparable to Akther, 2010 in a study on household adaptation to Fuelwood shortage among 60 households in Bangladesh found that 23% of the households adapted to fuelwood scarcity by use of leaves and twigs. As fuelwood becomes scarce, substitutes are eagerly sought. In a rural society, agricultural residues are virtually the only alternative to be used as a source of fuel.

In this study, 5% used saw dust which was sourced from the local wood industry and carpenters where proper disposal of sawdust is a challenge, so its use as a fuel greatly contributes to waste reduction. Saw dust was praised for its efficiency and good burning qualities especially when used in an energy saving stove. Saw dust is cheap and easily available and has multiple benefits such as bedding for poultry and as mulch (USDA, 1969).

The 'energy ladder' model reflects the poverty environment hypothesis in the context of forest degradation and firewood use. It predicts that higher incomes induce households to switch away from traditional fuels, such as cowdung and firewood, to higher quality but more expensive substitutes (Arnold *et al* , 2003). Under the energy ladder model it is percieved that low living standards induce greater dependence on forest firewood. Poor households rely more on forest firewood *vis-a-vis* modern fuel substitutes purchased from the market as observed in the high dependence on fuelwood which is affordable, accessible and did not require high initial capital cost. Gas and biogas which were least popular among the partcipants in the study were deemed expensive and that initial capital costs are restrictive.

Plate 4.3: Energy Saving Stoves (source: Field study, January, 2012)

Energy saving stoves (Plate 4.3) are used to save on fuelwood consumption and also to reduce pressure on the forest (Foley, 1984). They are known to reduce indoor air pollution. These stoves also create income generating opportunities for those involved in their production. In Bukhungu area, a local women's group with the assistance of a donor have innovated a briquette making technology and have also been taught on construction of energy efficient stoves. These briquettes made from maize stalks, flour and water are ground then dried before being used as cooking fuel. These briquettes are said to burn twice as fast as compared to firewood. According to the District Agriculture officer, fuelwood consumption trends have been changing because of the introduction of new fuel saving technologies such as *jiko kisasa*, rocket, most of which have been adopted by institutions such as schools and hospitals that use large amounts of fuelwood to cater to their needs.

CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Introduction

This study focussed on the impacts of fuelwood scarcity, coping strategies among rural households in Lurambi District and targeted a total of 200 households. A questionnaire was administered to the households and interviews were held with key informants. Data was collected and analysed using SPSS where descriptive statistics were used to analyse the data.

5.2. Summary

Fuelwood is a dominant source of energy among 95% of households in Lurambi District used mainly for cooking and heating purposes within the home. Sources of fuelwood are the Kakamega forest, on-farm sources, twigs, bushes and crop residues. This high dependence on fuelwood requires sustained production of fuelwood in order to meet increasing fuelwood demands in the District. Trees were planted for provision of shade, fuelwood, commercial and building purposes. Among farmers sustained production of fuelwood is not a key concern as it is seen as a secondary need in comparison to other benefits of tree planting. Indigenous tree species and exotic species were used as fuelwood within the households. Fruit trees are very popular for firewood among the households. The community in Lurambi can adequately invest in planting trees and also safeguard their forests in order to enable them earn the carbon credits.

Factors that are attributed to fuelwood scarcity in Lurambi included: increased land fragmentation as evidenced by reducing land sizes and agricultural intensification; reduced access to communal collection areas due to privatization; Government restrictions with regard to fuelwood harvesting in the Kakamega forest; high rates deforestation without re-planting; over reliance and the overexploitation of the firewood; climate change that manifests through unreliable rainfall has an impact on regeneration of forest.

The impacts of fuelwood scarcity include more time spent in search of fuelwood and health impacts leading to respiratory problems as a result of indoor air pollution. Fuelwood scarcity has an impact on nutrition as households are forced to cut on meals in order to minimise on fuelwood use thereby missing out on essential nutrients that are key to growth and development. Environmental impacts related to fuelwood scarcity include the reduction of tree cover due to over exploitation of fuelwood that contributes to soil erosion thereby encouraging desertification.

Coping strategies employed by households to cope with fuelwood scarcity include: switching temporarily to alternative sources of fuel; enhancing the search of fuelwood; the use of energy saving *jikos*; change in cooking patterns and methods and enhancing efficiency in the utilization of fuelwood.

Households therefore, have adopted short term coping strategies to cope with fuelwood scarcity.

5.3. Conclusions

This study has shown that there is a high dependence on fuelwood use among rural households in Lurambi, with households relying both on forest and Onfarm sources to collect fuelwood. Socio economic factors were seen to have an impact on fuelwood scarcity especially with regard to poverty. Various factors contributed to the fuelwood scarcity situation in Lurambi key among them being the land sizes in the District and access to communal collection points.

It was also found that fuelwood scarcity had an impact on the collectors of fuelwood majority of whom comprised of women thereby impacting on their livelihood as resources and time are spent in search of fuelwood. Households do have knowledge of the decreasing unavailability of fuelwood and have since developed coping strategies to be able to adequately deal with the problems. Most of these are temporary solutions to address a these needs.

5.3. Recommendations

From this study there is evidence of high dependence on use of fuelwood by households. The Ministry of Energy and Petroleum should encourage the switch to alternative sources of energy through the introduction of subsidies, price controls on oil products such as kerosene and gas.

One of the factors leading to fuelwood scarcity includes the reduced access to communal collection areas. These areas should be set aside for use by the community. Therefore, the protection and preservation of communal collection areas is key to ensure that households are able to adequately access fuelwood. These communal areas should be protected and held in Trust under the County Council of Kakamega.

There is need to enhance tree planting initiatives by encouraging agro-forestry practices to enhance provision of fuelwood from on-farm sources through enhanced extension services by the Ministry of Agriculture Fisheries and Livestock production on woodlot management. The planting of multi – purpose trees should be encouraged which can eventually be used for fuelwood.

The Ministry of Environment, Water and Natural Resources should put in place incentives to grow trees through afforestation programmes in order to reduce pressure on the forest. The Kenya Forest Service in conjunction with the local community may carry out re-afforestation in areas that are degraded within the forest and to allocate specific areas for plantation farming to enhance sustainable provision of fuelwood. Early maturing tree seedlings such as Gravelia should be planted to improve on fuelwood production. With regard to deforestation, KFS and CFAs should partner in patrols to curb illegal

logging within the forest and strict controls should be put in place to ensure that no illegal forest products leave the forest.

There is need to increase community awareness not only on tree planting, but growing and nurturing trees in order to increase its chances of growing to full term. The civil society, Non Government Organizations should be active in distribution of tree seedlings at low or no costs to participants in projects while carrying out their programmes in the District. This will encourage tree planting among farmers. The community, through forest conservation initiatives could gain carbon credits thereby contributing to reduction of accumulation of Greenhouse Gases (GHGs) in the atmosphere and reducing the effects of climate change.

The Ministry of Health in conjunction with the Ministry of Environment, Water and Natural Resources need to create awareness on the health impacts of fuelwood use and the need for the adoption of properly ventilated cooking spaces so as to reduce indoor air pollution.

5.4. Areas for Further Research

Looking at the fuelwood scarcity situation in Lurambi, there is a need for sustained production of fuelwood within the households that on average own less than 2 acres land, most of which they rely upon for their sustenance. Therefore there is need to carry out studies on attitudes and sustainable fuelwood production options among households in Lurambi District, Kakamega County.

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APPENDICES

Appendix 1: Questionnaire

HOUSEHOLD SURVEY QUESTIONAIRE

This survey is being carried out to determine fuelwood scarcity and coping mechanisms among households in Lurambi District as part of a Masters Degree research programme. Your household has been selected in a purely random process to participate in this survey. You are kindly requested to participate in this interview. All information in this survey is confidential and will not be disclosed to anyone.

Date of Interview _____

SECTION A: Background/ socio- economic data

1. Location _____
2. Respondent's Age

    1. ≤18 2. 19 – 30 3. 31 – 40

    4. 41 – 50 5. 51 – 60 6. ≥60

3. Gender of respondent

    1. Male 2. Female

4. Size of household (Adults are individuals aged 18 years and above)

    1. Adults _____
    2. Children _____
    3. Total _____

5. Land size ___

1. ≤2 acres
2. 3- 5 acres
3. 6- 10 acres

6. Land ownership system

1. Freehold 2. Communal
3. Trust land 4.Government land
5. Other

7. Highest level of Education attained

1. Non 2.Primary
3. Secondary 4.University

SECTION B: Factors Influencing Fuelwood Scarcity

1. What are your sources of fuelwood?

1. On farm 2. Twigs/ Bushes
3. Forest 4. Market
5. Other_____

2. How do you harvest/ collect fuelwood?

1. Collection of deadwood 2. Lopping of live trees
3. Felling of trees 4. Uprooting of stumps
5. Removal of shrubs

3. (a)Do you have access to communal collection points?

1. Yes
2. No

(b) If no why?_____

4. What is the **main** purpose of fuelwood in the house?

   1. Lighting

   2. Cooking

   3. Heating of open spaces

   4. Protection of livestock (to prevent animal attacks especially when there is light in the animal shelter)

5. Have you ever experienced any fuelwood shortage?

   1) Yes

   2) No

6. If yes for question 5 above, during which season?

   1) Rainy Season

   2) Dry season

7. If yes for question 5 above, how frequent has this scarcity occurred?

   1) Daily

   2) Weekly

   3) Monthly

8. In your opinion what are the reasons for this shortage?

   1. Distances 2.Cost 3.Government restriction

   4. Drought 5.Climate change 4.Land –Use patterns

   5. Overuse/unsustainable wood production 6.Deforestation

9. What types/ species of trees do you prefer for firewood? _____

(b) What is **the main** reason for preferring such species?

1) Easily available 2.It is convenient

3. Cheaper 4.Good burning qualities

Other reason

(Specify) _____

10. Have you planted trees within your farm?

1. Yes

2. No

b) If yes for question 10 above, for what purpose

1. Shade 2. Firewood

3. Fruits 4. Medicinal value

5. Other_ _____

SECTION C: Impacts of Fuelwood Scarcity

1. In this household, who is responsible for fuelwood collection?

1. Adult Male 2. Adult female

3. Male minor (Aged below 18 years)4. Female minor

2. How long do you take to collect firewood?

Distance (approx. Km) ☐

Time taken (Approx. Minutes)

1. 30 minutes 2. hour

2.2 hours 4. More than 2 hours

3. What is the family's **main** source of income?

1. Self employment

i. Farming

ii. Business

2. Official employment

3. Other (Specify)_____

4. How many meals do you prepare in a day?

1) One 2.Two

3. Three 4.> 3

5. Does the use of firewood have any environmental problems?

a) Yes

b) No

6. If yes to question 5 above, what are the environmental problems related to using firewood?

1. Noise pollution 2. Health hazards

3. Contribution to global warming 4.Soil erosion

5. Deforestation 6.Loss of biodiversity

7. Destruction of wildlife Habitat 8.Loss of aesthetic value

9. Land degradation 10.Reduced soil fertility

SECTION D: Fuelwood Scarcity Coping Strategies

1. How do you cope in periods of fuelwood scarcity?

a. Switch temporarily to another fuel (specify fuel)

b. Switch permanently to another fuel (Specify fuel)

c. Stop activities that use fuel in shortage

d. Reduce the number of meals

e. Borrow from neighbours

2. Do you use other sources of energy in place of firewood?

a) Yes

b) No

b) If no to question 2 above, why don't you use other sources of energy?

Possible reasons

a) other sources are not affordable

b) Firewood is convenient

c) We are used to firewood use

d) Other tasks need use of firewood only

e) Other sources are not available

3. In case of fuelwood shortage, what other alternatives are used?

a) Energy saving stoves b. Charcoal

c. Kerosene c. Animal Dung/ crop residues

d. Solar cooker e.Biogas

4. What cooking practices are employed to save on fuel?

a) Change of cooking methods

b) Communal cooking between households

c) Soaking of food

d) Shift to foods that require less cooking

e) Purchasing food

5. How do you increase efficiency in fuelwood consumption within the household?

a) Reduce space and water heating

b) More careful use of fire

c) Fuel saving technologies

d) Reduce the use of fuelwood

6. What can you do to ensure sustainable production of fuelwood?

Thank you for your participation. The information you have provided will greatly assist in the study.

Appendix 2: Interview Schedule for Key Informants

Impacts of Fuelwood Scarcity and Coping Strategies among Rural Households in Lurambi District, Kakamega County, Kenya

My Name is Stacey Waudo. I am a postgraduate student at Kenyatta University in the School of Environmental Studies. I am carrying out a study of factors influencing fuelwood scarcity in Lurambi District. The purpose of this study is to determine factors influencing fuelwood scarcity and household's responses to this scarcity. Your response will be treated with the utmost confidentiality and will be used for the sole purpose of making recommendations on fuelwood scarcity. Results of the study will be made available to any interested respondent. Thank you for your cooperation.

1. What are the sources of fuelwood in the Luambi Divison, Kakamega district?

2. What are the Fuelwood consumption trends within the district

3. How has land use tenure affected provision of fuelwood in the district?
4. What are the causes of fuelwood scarcity?
5. What are the impacts of fuelwood scarcity on:
    i. Nutrition
    ii. Livelihood
    iii. Environment
6. What are the environmental problems related to fuelwood production and use

7. What in your view, are the solutions to these environmental problems
8. What are the coping strategies utilised among household to deal with fuelwood scarcity
9. Are these mechanisms sustainable?
10. What are the alternative sources of energy available to local people
11. What can be done to improve fuelwood production in the region?
12. What are the manifestations of Climate change, and does it have an impact on local fuelwood production?

Appendix 3: Observations Checklist

Impacts of Fuelwood Scarcity and Coping Strategies among Rural Households in Lurambi District, Kakamega County, Kenya

1. Storage of fuel

a) Yes ☐

b) No ☐

2. Type of fuel used

   a) Wood

   b) Charcoal

   c) Cowdung/ crop residues

   d) Kerosene

3. Woodlots observed

   a. Yes

   b. No

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Website: www.ncst.go.ke

Our Ref: **NCST/RCD/17/012/11**

Date: **3rd May 2012**

Stacey Waudo
Kenyatta University
P.O.Box 43844-00100
Nairobi.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on "***Fuelwood scarcity impacts and coping strategies among rural households in Lurambi Division, Kakamega County, Kenya,***" I am pleased to inform you that you have been authorized to undertake research in **Kakamega County** for a period ending **30th September, *2012.***

You are advised to report to **the District Commissioners and the District Education Officers, Kakamega County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our office.

SAID HUSSEIN
FOR: SECRETARY/CEO

Copy to:

The District Commissioners
The District Education Officers
Kakamega County.

"The National Council for Science and Technology is Committed to the Promotion of Science and Technology for National Development."