# ENVIRONMENTAL IMPLICATIONS OF HOUSEHOLD ENERGY USE:

# A CASE OF CENTRAL KAMAGAMBO LOCATION, RONGO COUNTY


**BY**

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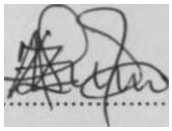
## DECLARATION

This project paper is my original work and has not been submitted for a degree in any other university.

**Nyamboki Linzy Atieno** Signature.. 

This research project has been submitted for examination with our approval as university supervisors:

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## DEDICATION

This research project is dedicated to my parents; my loving mom Phoebe Saga and my dad. the late Mr. Martine Nvambok for instilling in me the value of education. Mom. you are the best and thanks for encouraging me in all my endeavors.

To all my loving brothers and sisters - A big thank you for your support.

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## ABSTRACT

The production and consumption of any type of biomass fuel has environmental impacts and it is important to ensure that the exploitation of these fuels is sustainable. This paper investigates the environmental implications of household energy use in Central Kamagambo location of Rongo County. The specific objectives of the study were to: Examine existing energy consumption patterns by different households; Identify sources and factors that influence biomass energy consumption by households and analyze the effects of biomass consumption on the environment.

A systematic random sampling of 100 households was obtained from the study area. The paper establishes that socio economic factors influence the choice of fuel preferred by a household. Among the socio economic factors that influence the choice of fuel include education, income (nature of employment), family size and wealth status. Other important factors that determine fuel choice and consumption among households include cost (affordability) and availability of fuels. The main types of biomass fuel frequently used are firewood and charcoal. Fire wood is mostly used followed by charcoal but this varies across the socio economic status of the households. The sustained use of these fuels was attributed to the cost implications and ease of availability.

The major sources of biomass energy were found to be the community woodlot. own farm and local market. Most of these fuels were collected and in other instances bought. The preference by household/lds to source their energy from the community woodlot was because it was an open access resource. Absence of control in the use of this resource coupled with its high demand among the households renders the resource towards over exploitation and degradation. Similarly, the unsustainable harvesting, production and utilization of biomass energy has had considerable negative environmental outcomes in the study area. This is mainly attributed to the economic value attached to biomass stocking among households.

The policy implications is for the government and other stakeholders to promote strategies aimed at ensuring efficiency in the utilization of biomass energy resources by reducing the amount of fuel demanded. Secondly there is need to ensure that the amount of biomass energy resources are increasing with the increase in its demand for sustainability. This can be achieved through the promotion of afforestation, agro-forestry and tree planting programmes. There is also need for the government to promote joint management strategies that integrate rural energy programmes and promote technological initiatives to reduce dependence on biomass energy.

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background to the study

Energy is an important aspect of sustainable development and its enhanced access is essential in increasing its role in the well being and standard of living of the population; whether directly or indirectly. Traditionally, the major source of energy in developing countries is biomass whose availability continues to decline; yet it is currently widely used by a majority of the population in developing countries of the world. Today, more than 2 billion people around the world predominantly rural and the urban poor use biomass fuels to meet their dietary needs and whose use accounts for 80% of the total energy consumption in Africa (1RF. 2006). Moreover, the number of people that rely on biomass fuels is expected to increase to 2.6 billion by 2015, and 2.7 million by 2030 due to population growth (IEA, 2006).

The share of biomass in the global energy consumption based on available statistics has shown that it has more or less remained the same over the last thirty years. Currently, about 80% of the global energy supply comprises of biomass energy (IEA, 2003). However, at the regional level, total biomass energy consumption varies significantly with the developing regions recording higher levels of biomass energy consumption (Africa, Asia and Latin America) as opposed to the developed regions (Karekezi et al, 2004). The consumption in most regions will therefore increase but the total share of biomass energy in terms of supply will not increase especially with the high exponential population growth in most regions of the developing world.

Energy from biomass forms the bulk of Africa's total final energy supply. Profound reliance on biomass is majorly in sub- Saharan Africa where biomass accounts for 70-90% of energy supplies in most of these countries (UNDP, 2003; Karekezi et al, 2002). In most developing countries, domestic energy is mainly sourced from biomass (a very important source of domestic energy for cooking and heating) which is mainly fuel wood and charcoal and other bio fuels such as animal and crop production (Bajacharya, 1980; Fournier and Demurger, 2010; Hetelberg, 2003). Kerosene on the other hand is mainly

used for lighting. Any research therefore that sets out to analyze rural energy consumption patterns must focus largely on wood fuel use (Karekezi and Mackenzie, 1993).

Biomass is all renewable organic matter that can be burned and used as an energy source. The sources of biomass are diverse and this include forest resources from which we get trees (woody plants) for fuel wood and charcoal, grass crops or herbaceous plants/grasses, agriculture residues from crop residues like straw, baggase, rice husks, palm oil waste, yard and animal waste like dung and urban waste (Lai. 2004; NEED project, 2011). The study has focused mainly on trees for fuel wood, agriculture residue and animal waste at the household level. In each case biomass has to be harvested, collected transported and or stored for use (McKendry, 2001).

In Kenya the main sources of energy are wood fuel (Biomass), petroleum and electricity which respectively account for 70%. 21% and 9% of the total energy consumption. The reliance on biomass as a major source of energy by majority of the population is expected to remain the chief source of energy in the foreseeable future (Mugo and Gathui. 2010).

Empirical studies on patterns of household energy use among households in developing countries shows that the demand and supply of domestic energy utilization and consumption patterns is largely influenced by the level of disposable income among households (Barnes and Qian. 1992). In addition to income, empirical studies on energy consumption patterns found that energy demand and supply vary by region, district and village (Mugo and Gathui. 2010) and differs greatly between medium and high potential areas, between rural and urban areas (Hosier. 1985) and between different geographical and topographical distinctiveness of various regions.

In households, choice in most cases is seen through the lens of the energy ladder model and energy transition (Murphy. 2001) whose main framework is assumed to be linear where the increase in income is always associated with acceleration in the ladder from tradition to modern. However, empirical studies have shown that transition does not occur as a pattern or series (Barns et al. 2004) but tends to manifest itself in multiple fuel

use strategy which is common among rural households as evidenced by the case study done on rural households in Mexico (Masera et al, 2000). This tendency to consume a combination of fuels rather than switching to one form of fuel to another is what is known as fuel stacking (Masera et al, 2000: Hetelberg. 2005; Mekonnen, 2008 & 2009).

In rural areas, household energy consumption patterns are determined by availability and affordability of fuels, access to infrastructural services (Hetelberg, 2003)cooking and consumption habits, dependability of supply, cost, household and cultural preference and taste, convenience, uncertainty of alternative supplies, price of alternatives, household size, availability of technology, education, age. household sizes, dietary patterns of the household (Dzioubinski and Chipman. 1999; Karekezi and Mackenzie. 1993; Mekonnen and Kohlin. 2009) familiarity of working with traditional fuels, climate and resource endowments (Elias and Victor. 2005).

Albeit the various variables that determine energy consumption patterns at the household level, biomass energy is still widely used in the rural areas than in the urban areas because of its perceived widespread availability .This is because biomass sourcing is perceived to have low opportunity cost as opposed to sourcing other forms of fuel. Since it is not marketed and does not have a price, the price of biomass is determined by its availability and the opportunity cost of collection that is manifested in the labor and time taken to source for biomass fuels (Hetelberg. 2005). This explains why in the face of scarcity, most rural households opt for biomass fuels as it has low opportunity cost and collection labour time.

In developing countries, the extent to which modern displaces tradition is quite low and this transition is difficult when traditional fuels are available at zero cost, though this has environmental implication in terms of negative externalities. Like most developing countries, Kenya portrays more of fuel stacking than switching for the different energy demands. From time immemorial, biomass has been used with minimal effects but with population pressure and technological advancements, its use continue to be significantly demanded leading to unsustainable and inefficient utilization. Because of increased reliance on bio mass as a source of fuel, biomass as a renewable resource continues to

tend towards a non renewable resource because of its extraction and inefficient utilization.

In the rural areas, the existence of multiple categories of users with different and often competing interest has varied impacts on the environment with regards to their energy consumption patterns (Duraiappah. 1996).In most cases, the poor households often lack the ability to optimize consumption than wealthier households and lack alternative sources of fuels which make them rely heavily on biomass (Duraiappah, 1996; 1998).This therefore ensnares them in a cycle of poverty as they spend more time buying and collecting each amount of energy they consume than their wealthier households counterparts. IEA (2006) further observes that the great reliance on biomass by a great percentage of the rural population in the African countries will lead to greater competition to traditional energy which will continue to result to resource depletion and overexploitation, and further exacerbate poverty.

Biomass production, harvesting and conversion have environmental implications. In Africa, the high level of consumption of biomass fuels over time has contributed to deforestation, soil erosion, and desertification (IEA. 2006).The spiral effect is the impact that this has on the hydrological cycle especially in pollution of water bodies due to siltation that diminishes the quality and quantity of waters available for use and the impact that forest clearance and biomass burning has on increasing green house gases due to air pollution leading to global warming.

For instance, the energy sector is one of the main sources of green house gases and the contribution of emissions from both deforestation and forest degradation accounts for about 18 percent of global greenhouse gas (IPCC, 2007).This also has implications on the well being of women given their critical role in utilizing energy (Hosier. 1985; IRF, 2006 and Derky et al, 2011). Most of the forest resources' in Africa is lost to charcoal. In Nigeria for instance, harvesting of fuel wood contributes to deforestation to a rate of 400.000 hectares per year, while desert encroachment is estimated at 6 million hectares per annum whilst the number of people that continue to die daily due to indoor air pollution as a result of biomass use is increasing and the trend is still persistent (Oladosu.

1994). The World Health Organization estimates that 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of solid fuels (IEA, 2006).

In Kenya, the major causes of deforestation are land use and population pressure. However, the dependence on wood as fuel for heating and cooking is said to be one of the major factors contributing to the country's high rates of deforestation. In 1963 Kenya had forest cover of some 10 per cent and by 2006 1.7 per cent remained. In Addition, the use of biomass especially in charcoal and firewood is said to be one of the main causes of loss of biodiversity and wide scale deforestation in Kenya (Mugo and Gathui. 2010).This has shown to have detrimental effect on the hydrological cycle as it has reduced the role of forest and tree cover in sustaining the ecosystem.

The various sources of biomass in the rural areas are diverse. However, empirical studies on analysis of biomass sourcing among different households have shown that majority of the households in the rural areas depend on their own farm for biomass energy supplies than on forested lands as evidenced in study carried out in rural India and Nigeria (Laxmi et al. 2003 and Besnel et al. 1996). As such, most of the biomass sourcing is extracted outside the forest, non forested lands, self collected or grown in the rural areas and bought cheaply in nearest towns or villages (Hosier. 1985; Hetelberg, 2003; Mahiri and Howorth. 2001). In most cases, populations that do not reside near forest reserves or protected national parks and sanctuaries rarely depend on them for their fuel wood sourcing and as such, most opt to grow trees on their own farms.

Given the grave contribution of biomass harvesting to social and economic aspects of peoples livelihoods and its extensive usage, there is need to ensure efficient and limited use of such resources so as to reduce the adverse effects to both the environment and peoples well being. As most of the biomass for cooking among rural households is either collected or sourced from own farms, the implications of these sourcing methods has implication on the environment depending on whether household attach economic or environmental utility on the trees planted in their farms. However, the implication of biomass sourcing on the environment as influenced by energy patterns is not explicit in

rural households among the various socio economic groups. It is imperative that the present conditions give an evident outlook of these implications in the face of climate change and dwindling resources for a sustainable future.

### 1.2 Statement of the problem

Empirical studies on analysis of biomass sourcing among different households have shown that majority of the households in the rural areas depend on their own farm for biomass energy supplies than on forested lands (Laxmi et al, 2003). As such, most of the biomass sourcing is extracted outside the forest, non forested lands, self collected or grown in the rural areas and bought cheaply in nearest towns or villages (Hetelberg, 2003, Mahiri and Howorth. 2001).

Taking into account that wood is heavily relied on as the largest source of biomass today in most of the rural areas, current exploitation levels and increased demand compromises its sustainable utilization as biomass is seen to be readily available, though in the short term. The perceived availability has environmental trade off in terms of its sustainable use and this will depend on how they are grown and harvested to ensure regeneration and replenishment of existing supplies. Besides dependence, the greater competition for the dwindling biomass resources in the face of a burgeoning population renders the resource towards depletion and overexploitation.

Even in the face of technological advancements and economic growth, the existing literature has shown that the current and projected demand of biomass energy especially in developing countries is said to accelerate in the foreseeable future. Consequently, reliance on biomass fuels will persist. Current mechanisms of sourcing for biomass energy needs among different household user groups therefore, ought to be efficient to encourage the adoption of sustainable utilization. In addition, given the intricate nature of poverty -environment nexus, timely strategies need to be adopted to reduce perpetual poverty associated with environmental degradation in relation to unsustainable biomass utilization.

As the transition to higher fuels is portrayed by fuel staking in these countries, the adoption of alternatives to biomass, like kerosene and fossil fuels are unlikely to be used as long as there is a range of much lower cost options of alternatives to fuel wood (Dewes, 1998). In addition, the prices of petroleum fuels and frequent unavailability are causing institutions to switch to various forms of biomass energy (Stephen and Timothy, 2010) and this may even be the most common lower fuel alternatives (Foley, 1984). In most situations, the long term sustainability and environmental implications may be detrimental and undermined.

Given that the production and consumption of any type of biomass fuel has environmental impacts and subsequent harvesting and over utilization of biomass energy sources can have negative implications on the environment as well, it is vital to ensure sustainable utilization. In the case of niral households dependent on their own farms for biomass energy, the consumption of biomass fuels could contribute to loss of vegetation, deforestation, and soil erosion, initially in own farms. Thus the environmental consequences of energy consumption patterns at the households' level are likely to be felt in the immediate vicinity.

As energy is important in the overall quality of life, its utilization should aim at maintaining an acceptable quality of life for those enjoying and enhance opportunities for those who do not without unacceptable environmental and social outcomes. Little is however known on own farm biomass availability, patterns of consumption, effects associated with its harv esting, use and management of the resource. The study therefore aims at understanding household energy consumption patterns and harvesting rates by the different households in the study area and assesses the ecological effects that are associated with biomass harvesting on the existing if any biomass stocks at the household level.

### 1.3 Research questions

i. What are the energy uses by the different households?
ii. What influences the consumption patterns of biomass fuels among households?
iii. What are the implications of biomass harvesting on own farm biomass availability?
iv. What are the environmental effects that are associated with the rate of biomass harvesting among the households?
v. What socio economic factors among households influence environmental outcomes?

### 1.4 Research objectives

The overall objective of the study was to examine biomass energy use by households and the effect that this will have on the environment in Rongo County. Specific objectives of the study included:

- To examine existing energy consumption patterns by different households.
- To identify sources and factors that influence biomass energy consumption by households.
- To analyze the effects of biomass consumption on the environment.

### 1.5 Justification of the study

The availability and ease of access to efficient energy resources is very important in enhancing well being among households. Although none of the Millennium Development Goals are concerned with promoting better access to energy services, access to energy is a decisive factor in their achievement. In Kenya the attainment of Vision 2030 cannot be realized without adequate energy which is essential to power the economy towards becoming a middle industrialized economy.

Understanding biomass fuel consumption pattern and its effects to the environment can therefore be of use as a policy tool of the energy and global warming mitigation policy makers to mitigate global warming and to reduce the environmental and health hazards

that are associated uith its use in the country. The study will also add a new methodology to the existing literature as most literature on household fuel consumption and environmental effect in the rural areas are mainly longitudinal whilst the study is cross sectional.

The study is therefore important in addressing the implications of biomass energy sourcing on the environment and necessitates the adoption of sustainable in addition to alternative biomass sourcing strategies in view of the current and potential impacts that it will have on the environment. Clear guidelines should hence be sought to promote the efficient use of the available energy resources. This will not only promote the conservation of renewable energy sources but will also contribute to sustainable environmental protection not only at the local level but also in the regional and global level in view of thinking locally and acting globally.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

The purpose of the study was to examine the patterns of biomass energy extraction and production and the environmental effects of its usage among rural households. This chapter looks at both theoretical and empirical studies that have been done on the relationship between energy consumption patterns and the environmental effects in order to gain insight of the variables under study. The chapter will be concluded with a summary of the studies that were reviewed.

## 2.2 Household Energy consumption patterns and sources

Empirical studies on energy consumption patterns have shown that energy demand and supply vary by region, district and village (Mugo and Gathui. 2010) and differs greatly between; medium and high potential areas; rural and urban areas (Hosier. 1985) and between different geographical and topographical distinctiveness of various regions. These differences in spatial and temporal characteristics largely influence the type of fuel preferred in a specific area.

The supply and demand pattern of domestic energy utilization is primarily influenced by the level of disposable income among households. In addition to income, household energy consumption patterns in the rural areas is determined by: availability and affordability of fuels; access to infrastructural services (Hetelbe rg,2003);cooking and consumption habits; dependability of supply; cost; household and cultural preference and taste; convenience: uncertainty of alternative supplies; price of alternatives, household size; availability of technology; education: age. dietary patterns of the household (Dzioubinski and Chipman, 1999; Karekezi and Mackenzie, 1993; Alemu and Kohlin. 2009); familiarity of working with traditional fuels; climate and resource endowments (Elias and Victor. 2005).

The level of income strongly correlates to the type of energy preferred by households. Increased income influences consumption in two ways in that the rise of the level of income leads to the supplementary of food items and thus more fuel is needed to cook the additional food .Similarly, the price of fuel is less of a constraint to wealthier households as they would prefer more cleaner, convenient, higher energy and modern alternative fuels provided it is available (Pandey. 2002). Dependency on biomass energy decreases with increase in income. The dependence on biomass for the poor is therefore higher than those who are well off as the latter can easily shift from lower efficiency to modern fuels which clearly shows that "poverty' does not conserve energy.

The nature of employment which is a function of income also influences the dependence on biomass fuels especially fuel wood in that the dependence for the employed is lower than for the unemployed (Ghilardi at al, 2009). For the well off households. Charcoal functions as a transition fuel (Barnes et al, 2002).Livestock holding is also a function of wealth index and households that can afford more livestock have the incentive to plant more trees on individual forms so that they can provide enough fodder for their animals (Ghilardi et al, 2009).

The number of people in a household influences the dependence and amount of fuel consumed where bigger families consume slightly higher amounts than smaller sized families .Large families require more fuel wood and also have increased labour for collection hence increased consumption. Cooke (1998) and Fox (1984) affirm that large families consume more fuel than smaller families but they burn less per capita than households of smaller family size. The diminishing per capita energy requirement associated with larger family size is a common finding for most studies as it is the result of the coefficient of cooking and water heating that result from increasing their scales (Brown et al. 1985) in contrast to small sized families.

The availability and cost of obtaining a particular fuel also influences the rate of its consumption. For fuels that are collected, the cost implies the time taken to collect the fuel as is the case of most fuels in the rural areas. Related to this is the distance of the fuel

source from the household. For instance, in areas where households live near forest the rate of consumption would be higher than for those households far from the forests (Pandey, 2002). Similarly, the distant that a household covers to collect the fuel influences the consumption where nearby households use more than those from distant sources (Adhikari et al. 2004). In addition, areas with no available forests tend to compensate their fuel needs by use of other sources of biomass such as cow dung and agricultural residues.

Ghilardi et al (2009) found out that the number of trees planted in a farm to the land holding size is not significant to the rate of fuel wood collection. They affirm that it may imply that households with large si/.es of land may use fewer amounts of fuel as they are likely to grow their trees on their private land. Conversely, another interpretation may be that larger families may opt to grow trees on their farm for commercial timber hence private trees may account for relatively small proportion of household's fuel proportion of fuel consumption.

There are various sources of biomass energy in the rural areas. Literature on household fuel consumption has shown that most households' energy needs are still supported by fuel wood to a very large extent while being supplemented by small amounts of charcoal, kerosene and Liquified Petroleum Gas (LPG) (Pandey, 2002; Ghilardi et al. 2009). However, the dependence on a particular fuel is largely influenced by its affordability and ease of access, dependability of supply and familiarity of working with the fuel.

The various sources of fuel in most rural areas range from natural forests plantation, wooded lands and private sources (individual trees planted on own farms). From time immemorial, the dependence on free access forest as major sources of household fuel has been very high but changes in the management and sustainability of these resources has led to a considerable shift to other alternative sources (Mike and Persson, 2003; CIFOR. 2003). This has substantially increased the importance of non forest resources and private trees on individual farms (trees outside the forest) as vital sources of fuel, which have over the years provided a large amount of overall wood fuel output.

In studies conducted in rural India and Nigeria on biomass sourcing among households, Besnel et al (1996) and Laxmi et al(2003) found that majority of the households in the rural areas depend on their own farm for biomass energy supplies than on forested lands. Furthermore, majority of the rural population particularly those who do not reside near forest reserves, protected national parks or sanctuaries rarely depend on them for their fuel wood sourcing and as such, most opt to grow trees on their own farms.

### 2.3 Environmental impacts of biomass energy consumption

The utilization and extraction of any form of fuel has impacts on the environment. Biomass production, harvesting and conversion has environmental implications and its sustainability is determined by the rate of harvesting, production and use (McKendry, 2001) .Global concern over the years has been rampant in developing countries especially due to the environmental effects of overreliance of biomass fuels. However, the environmental impacts are site specific and depend on the method of harvesting (Karekezi etal, 1992).

Biomass production has impact on hydrology, soils, wildlife and species habitat whilst its conversion (from biomass to energy) has air emissions and its related impacts on quality. Its use over time has contributed to forest degradation, soil erosion, desertification, loss of biodiversity due to preference to particular wood types and adverse health effects as a result of indoor air pollution that is generated by burning wood, animal dung, or agricultural residues (Bruce et al. 2000: Mugo and Gathui, T,2010; IRF, 2006).

For instance, the loss of forest cover in Malawi is attributed to agriculture expansion, biomass use for fuel wood and charcoal production and as such the high demand for biomass fuels has been seen to be a threat to forests (World Bank. 2006). With regard to loss of biodiversity, the preference of particular types of tree species for energy renders them endangered and threatened species. The former species being those species in danger of becoming extinct throughout all or a portion of their range and the latter implying those species most likely most likely to become endangered (Karekezi et al,I992).

The spiral effect is the impact that loss of tree cover has on the hydrological cycle especially in pollution of water bodies due to siltation that diminishes the quality and quantity of waters available for use (Cheboiwo et al, 2010), and the impact that forest clearance and biomass burning has on increasing green house gases due to air pollution leading to global warming. As such, the energy sector is one of the main sources of green house gases and the contribution of emissions from both deforestation and forest degradation (IPCC, 2007).

Biomass use also competes with other land uses and competing interest and the choice of use has environmental implications. For instance, the use of dung by households for domestic fuels instead of manure has implications on available soil and land resources and improper removal of agricultural residues has potential to degrade natural resources (William et al, 2004: Lai, 2004). In Ethiopia for instance the dependence on dung and woody biomass is said to contribute to forest degradation, deforestation and land degradation (Mekonnen and Kohlin. 2008).

Burning dung as fuel and other crop residues from the farm in essence makes it unavailable as manure to increase soil productivity exacerbating soil nutrient depletion, quality and land degradation over time. In the case of burning animal waste (dung) which has very high nitrogen and sulfur causes excess $NO_x$ and $SO_x$ emissions which has impact on the air quality and health implications for its users due to indoor air pollution (Mekonnen and Kohlin. 2008).

The major causes of forest degradation, deforestation and land degradation are said to result from commercial logging for timber and charcoal production. However, the impact of firewood collection and harvesting on forest degradation has been largely contested over time (Kohlin et al, 2003; 2006) with regards to the relationship between the two. Therefore, in evaluating the environmental impact of fuel wood collection, forest degradation rather than deforestation is emphasized (Demurger et al. 2010).

The former has little to do with fuel wood consumption as much of fuel wood sources are extracted from outside the forest (l)erkvl et al, 2011). However, forest or tree cover

degradation is deeply linked to the behavior of the local people including the rate of firewood collection and resource management that have been put in place to replenish the existing stock of biomass available. It is widely acknowledged that local communities may threaten natural environment and forest regeneration by taking a lot out of the existing resources (Demurger et al. 2010).

Literature on dependence on natural resources has shown that dependence tends to decline with increase in incomes (Narain et al, 2005). With regards to biomass. high availability also leads to high use and dependence among different groups. Leach (1992), argues that households make choices on the basis of socio economic characteristics with income being the major influence of choice. In addition, in the face of scarcity, the poor opt for alternative energy sources which are lesser forms of biomass fuels (Dewees, 1998; Hetelberg et al. 2000) and in most situations, the long term sustainability and environmental implications may be detrimental and undermined.

Rahman (2001) argues that because of the heavy dependence on the environment by the poor, environmental degradation makes the poorer households more vulnerable and because they are at the bottom of the energy ladder, environmental degradation impoverishes them into more poverty. Because of the low initial or first cost of the energy appliances, most poor people adopt the use of less efficient devices which consume more of the less efficient sources of fuel. The Exposure to environmental degradation is because of lack of a strong resource base which makes it difficult for the poor to opt out of the degraded environment and try to gain a source of livelihood sources which are less degrading. In addition, environment degradation depresses the ability of the poor to generate income by increasing their share of labour to routine household activities (Dasgupta et al, 2003).

As a result, the less affluent households have a higher discount rate (Reddy, 1994) and may therefore sacrifice long term goals at the expense of the immediate consumption. This does not however mean that the poor are not rational but implies that they are constrained in investment and consumption and as a result, have a higher trade off for survival than conservation or sustainable use of resources (Narain et al, 2005). Save for

the predominant school of thought that poverty is the major cause of environmental degradation, these linkages are also affected by various factors such as economic policies, resource prices, local institutions, property rights, entitlements to natural resources and gender relations (Duraiappah. 1996:1998). However, the effect of overreliance by the poor makes their consumption tendencies more unsustainable.

These renders the poor into a downward spiral which reduces their income and livelihoods (Jehan and Umana. 2002) where resource degradation deepens poverty, while poverty makes it difficult to care for or sustainable use of resources (WCED, 1987; World Bank. 1992).As a result people in poverty are forced to deplete resources to survive and this degraded environment further impoverishes them (Ostrom et al. 1999). In a sense the poor are therefore victims at the same time agents of environmental degradation.

**2.4 Findings from Developing countries**

Most rural domestic fuels among households in developing countries are not traded but produced and consumed by the household itself (Hetelberg et al, 2000). The most common and widely used biomass in most households is wood for fuel and its (un)sustainable sourcing and use among has either positive or negative environmental implications. Biomass is a renewable energy source as long as it is produced sustainably. This section will therefore be looking at case studies carried out in developing countries on the impact of fuel wood harvesting on the environment.

Shawkat et al (2009) carried out a study to determine the fuel consumption patterns and environmental consequences of biomass fuel usage in Bangladesh, especially in traditional and improved cooking stoves. The study employed a multistage sampling to get a total of one hundred and sixty households out of the four villages that were randomly picked from the thirty six villages. The results of the study suggest that firewood was the most frequently used biomass by the population. With regard to the patterns of consumption, these varied significantly with the wealth status, seasons, and availability of different kinds of fuels.

The rate of collection of fuels also ranged from once to twice a week. The environmental impact of these patterns showed that the harvesting of biomass fuels (firewood) from the major sources which were from forest reserv es and homesteads. In areas that were not close to forests, homesteads offered the next best alternative source of biomass sources which resulted in aggrav ated site decline through nutrient depletion, soil erosion and poor regeneration. The use of these fuels also showed to have health effects on women, who had irritated eyes, headache, lung disease, asthma and cardiovascular diseases.

The analysis to ascertain the impact of biomass fuel utilization in Rivers State Nigeria was carried out by Wachoka (2010) and employed a survey design which involved data collection from a defined population using the variable under study. The sample obtained was one hundred and fifty respondents in five communities in the local government area who were sampled randomly. The purpose of the study was to identify the variety of biomass fuels available to Niger Delta people and ascertain the environmental and health impact of utilizing biomass fuel in the region.

Results of the study showed that there were a variety of biomass energy resources in the area. Moreover, the use of biomass fuel has adverse impact on the environment in terms of decreased number of trees in woodlots and the health of the people which was accompanied by increased respiratory conditions. The major recommendations for the study were to enhance environmental awareness campaigns, aggressive renewal of woodlots by community members and that the felling of tress should be done in a sustainable manner.

A study by Sangay (2010) in alpine was carried out to understand the consumption and harvesting rates by residents' of Butan and to assess the ecological effects that are associated with wood harvesting and the impact that this will have on the wood biomass stocks. The study documented fuel wood consumption, standing biomass. annual growth and yield through a case study in Nasiphel and neighbouring areas where residents and others rely on fuel wood for one month each year while gathering a medicinal fungus (Cordyceps). Total annual fuel wood consumption was estimated using the weight-survey method .The total standing biomass was estimated by mapping and calculating the area

from which fuel wood was harvested and measuring the height and diameter of trees in randomly established transects and sample plots.

The results of the study suggested that biomass energy is the main and crucial energy source for the people in these rural areas and that the current extraction of wood for fuel is unsustainable leading to forest cover loss and tree degradation in the alpine vegetation. Further results also show that there was loss of biodiversity because of the extraction of preferred wood species. Sangay's results also showed that the only extent to which fuel harvesting leads to forest or tree loss depends on the area in question, specific rate of consumption in comparison to biomass availability and accumulation.

In Nigeria, a Study by Tee et al (2009) on the implications of fuel wood consumption patterns and implications on the environment was carried out in Makurdi area. The main purpose of the study was to determine fuel wood consumption patterns, the different wood species utilized for firewood and the implication of these in the environment among the different user groups in the area. The results on the household consumption patterns showed that biomass in the form of fuel wood was mainly used by most households.

The results further showed that the massive exploitation with little planting operations going on in the area saw the preferred fuel wood species under threat of extinction. This was explained by the limited supply of these tree species. The existing pressure on the sources, poor harvesting and exploitation and the negative attitude towards established fuel wood plantation resulted in environmental degradation. Here (Tee et al (2009) shows that massive demand with limited supply and rapid exploitation of tress without replacement is what has caused disappearance of tress within and outside its environs. The major recommendations were increased awareness on adverse effects of the unsustainable utilization and the encouragement of tree planting by providing incentives like seedlings and seed equipment among the households.

Rummer's and Bensel (1996) study in Philippines emphasizes that in relation to fuel wood consumption and deforestation, fuel wood consumption contributes to deforestation

but does not work in isolation. This is especially so as planted forests or major forests where logging and forest clearing for agriculture and increasing population remain the principal cause of deforestation. According to him, the quantitative indicators that support the negative effects of fuel wood consumption in the environment will be realized in increased removal of v\ood. decreased areas under tree cover of forests and reduce growing stock of trees in the plantation or forest areas.

Biomass energy in large has the potential to become one of the major sources of global primary energy in the next century. Its main potential to become a major source of energy is because of its impact in offsetting fossil fuel emissions which are major sources of green house gases and resultant climate change (Lai, 2004). Though the use of biomass has competing interests between biomass resources and alternative energy resources, its utilization should be sustainable with the impending threat of climate change. There is therefore a strong need for critical appraisal of good and intensive natural resources management and research and development to offset the environmental impacts of its use.

### 2.5 Summary of the reviewed literature

All the literature reviewed has shown that the consumption of biomass has negative effects on the environment if not sustainably utilized. Literature by Tee et al (2009) and Sangay (2010) has shown that fuel wood collection leads to the extinction of certain tree species due to the preferences by households for specific wood or tree types.

The study done by Wachoka (2010) affirmed the use of biomass has both environmental and health impacts on the people in the area but did not quantify consumption patterns and the impacts that the consumption patterns had on the environment. This however, is showed in part b> the recommendations given which indicated that utilization of the biomass resources was not sustainable. In addition, his use of instrument was inadequate as it was mainly a questionnaire with closed ended questions and only allowed for yes, no responses and this could not quantify the consumption rates and the effect on the environment.

Sangay (2010) addressed the same issues and variables as the study but this was done on urban areas and also on gazetted and protected plantation forest that were mainly man made. Study by Tee also addresses the study variables but did not show the consumption patterns though specified that har\ csting without regeneration contributes to loss in tree cover. In sum the existing literature on firewood consumption and forest degradation mostly focuses on Asian countries and the few in African countries have mainly been done in Nigeria. Very limited studies have been done in Kenya.

This paper therefore intends to contribute to fill the gap by examining the energy patterns on the environment in a geographically different context and specifically in woodlots or plantation forests that that arc grown by most households. Specifically, the study will focus on the areas that have been missed out in the empirical literature in developing countries and this will include concurrent concentration on the rural areas, rate and pattern of harvesting, rate of replenishing and concurrent quantification of the environmental effects of all these aspects on the environment using cross sectional information.

**2.6 Environmental implications scenario**

Environmental implications of biomass energy use and harvesting in existing literature have been studied with various scholars and three case scenarios of analysis as suggested by Andrews (2006) has emerged. These have been: prediction of future resources by measuring temporary or spatial trends; measuring production and harvesting rates, and measuring of specific biophysical factors in controlling future production like plant regeneration, soil physical and chemical conditions.

The study will use the production harvest balance which compares the rate of production with that of harvesting. The implicit model is one of a homogenous resource stock (B) to which biomass is added at a stock dependent rate (P) and from which a homogenous harvest (H) is removed. Therefore, if II exceeds P, then future product as well as productivity will decline. The usefulness of this P-H balance is that it is applied to aggregate biomass and this criterion does not require temporal data or any benchmarks (Andrews, 2006).

## 2.7 Theoretical framework

From the literature review, there are strong indications that household energy use by the various households has impacts on the environment .In trying to understand and explain this relationship: the environmental externality model will be used. Externalities occur when certain actions of producers or consumers have unintended external effects on others or land consumers .This can either be positive or negative. Positive externalities occur when social benefits are higher than private benefits while negative externality occurs when social cost is higher than the private cost (Sankar. 2000).

The degradation and depletion of natural and environmental resources occur because of market failures. Markets for environmental goods and services do not exist, and when they exist they underestimate their social scarcity values, this means that negative externalities are not always reflected in prices. Negative inter temporal externalities occur when exhaustible resources are depleted and when renewable resources are harvested at rates that are greater than the regeneration rates (Sankar.2000: Pinard and Puts .1996).

In our study, the use and production of energy has both environmental and other societal costs, however, these are not accounted for. Accounting for these externalities is also difficult as consensus on how best to measure them in monetary terms is lacking (Reddy et al. 2001). Additionally, accounting for externalities is intricate due to the issue of biomass and land tenure. In most cases as is in the study, households make own decisions on how to manage resources on their own plots. Because land is privately owned, it is exclusive and non rival and therefore the consumption(utilization) of its good or service by a household does not reduce the amount available to others and therefore the owner can use as he pleases (Mills et al. 2002).Associated with the use of land is reduced soil erosion, decreased land degradation and the effect of these in maintaining water quality in the water shed areas and the failure lor markets to realize this externalities has an implication on the conservation, management and control in use of land resources(Mills et al, 2002).

As environmental goods and services do not have observable prices and their markets do not exists, the production of negative externalities as a result of misuse of the

environment cannot be economically valued and this encourages rampant harvesting of the environment, and in our case; rampant biomass harvesting. In most cases, individual households have little incentives in the short run to adopt conservation practices which may reduce short run production and increase costs at the expense of the environment (Marshal. 198 l).Therefore. households will be forced to make tradeoffs between immediate household's energy requirements and environmental sustainability both in production and consumption (Duraiappuh. 1998).

### 2.8 Conceptual framework

The main purpose of the study was to examine the implications of energy use among households by determining the rate and pattern of harvesting, rate of replenishing and concurrent quantification of the environmental effects of all these aspects on the environment. This was conceptualized as indicated in the figure below.

**Figure 1.1 Conceptual analysis**

**Households**

**Wide choices: Distinguished by different Socio -economic factors:**

Level of education

Nature of employment (determines level of income)

Demographic characteristics

Cost and availabilitv of fuel

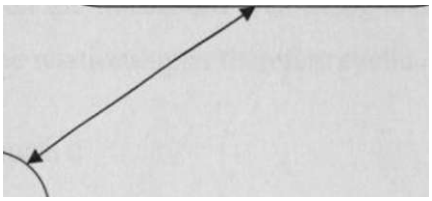
**Biomass energy Consumption:**

**Types:** Wood fuel, Charcoal, Crop residues

**Availability** (dominant fuel for cooking, frequency of harvesting)

**Production-** Availability of a tree nursery fuel, frequency of planting trees

**Patterns**-Dependency on type of fuel. Type of cook stoves. Sourcing methods, Quantity of fuel sourced



**Environmental Outcomes**

- Supply of trees in individual farms ; Available and logged
- Supply of preferred tree species for fuel; decreasing Vs Increasing supply
- Use of crop residues; Use for energy Vs use for manure

Source: Author's own 2012

The above framework shows that there is a link between households whether rich or poor and their choice of energy, though their decisions may vary due to the socio economic status of each households. The socio-economic characteristics that determine choice of fuel include: level of education, nature of employment which determines the level of income and

demographic characteristics of a household. Cost and availability of fuel also influences choice of fuel by households. These characteristics influence the type, nature and pattern of fuel consumed among households.

The second link shows that these energy consumption patterns are influenced by the environment within which they are sourced especially with regards to availability of the biomass energy resource and its use which has an effect on the environment. Efficient use of biomass by households ensures its sustainability while inefficient use promote the degradation of the resource. On the other hand the implications of the use of the resource whether sustainable or unsustainable may lead to availability or lack of the resource and this may also influence the household decisions on their energy patterns.

The third link is the link between households and the environmental outcomes. Certain activities on the one hand like farming, agro forestry, and agriculture may have either positive or negative environmental outcomes whereas environmental outcomes such as depletion or decreased resources will have an impact on the household well being and this in turn will influence their consumption patterns. The relationship is therefore cyclic.

From the conceptual framework, we will want to distinguish if

1. Socio economic factors of the different households influence the environmental outcomes and from the literature, we have seen that income is a major determinant of household fuel choice which determines dependence on biomass energy.
2. Less affluent households will therefore have a more nuanced effect on the environment due to their heavy reliance and dependability on biomass energy. Poor households may not have access to alternative energy resources and increases reliance on biomass energy. As we have seen from the literature the limited access to disposable incomes makes them rely heavily on biomass energy and thus have limited alternative options and in most cases have negative outcomes on the environment. Because of low income and higher discount rate, they opt for consumption than conservation activities.

3. More affluent households rely less on biomass energy for their energy needs and therefore have less minimal effects on the environment. Affluent houses use more fuels than the poorer households but since they have disposable income they can opt for cleaner and more efficient alternatives. In most cases they will tend to buy rather than collect their own fuel

In the study area, we will expect to find less affluent households relying more on biomass energy than the more affluent households and hence increased dependence on this source of fuel. Being a rural area, where a large percentage of households are mainly agrarian the utilization of biomass energy will be v\ idespread as the productivity of the agriculture sector generally is said to decline and this also relates to decline in incomes by the households. Therefore, a greater number of households will be relying on biomass energy.

However, uncontrolled variables in the study area may affect the relationship of the conceptual framework. The availability of briquettes in the study area which are said to be a cheaper and an alternative source of fuel may have an effect on the utilization of biomass energy in the study area. This will therefore imply that the patterns of biomass energy consumption patterns by the households may be manipulated by the existence of briquettes.[1]

**' Briquettes are made from the conversion of loose biomass residues such as saw dust, straw or rice husks into high density solid blocks that can be used as fuel. The type of briquette in the study area are made from charcoal dust which is mixed with clay and rolled into balls then left to dry after which it is used by households. The use of briquettes is said to be a sustainable way of making use of biomass residues that would otherwise go to waste.**

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

This chapter begins with an overview of the research design used in the study. The main focus of the study was to examine the environmental implications of energy use by different households in Central Kamagambo Location. The study was primarily analytical and of cross sectional nature. The study used both quantitative and qualitative research methods and triangulation in terms of data collection was used to collect information on variables under study. Mixed orientation of methods was employed to ensure that both qualitative and quantitative aspects of the study were captured.

The research design consisted of a household survey of 100 households. This was complemented by two focus group discussions and five key informant interviews. Observation was also used as a complimentary method of data collection. The design was preceded by a pilot study which involved a pre-test of the survey questionnaire. The key informant interviews were the first to be carried out and this was followed by the survey of 100 households. Observation was also employed during the survey. Focus group discussions were the last to be carried out. This chapter also discusses the study site and criterion for the site selection, sampling procedure used in the study, data collection methods, data analysis as used in the study and lastly the challenges experienced by the researcher.

## 3.2 Description of study site and site selection

Rongo district is one of the districts which was curved out of Migori District in 2007. It borders Homabay and Kisii south districts to the north. Migori and Transmara Districts to the east and Gucha district to the south. The total area of the district is 848.7km $^2$ The district is divided into 4 administrative divisions, 17 locations and 54 sub locations (GOK. 2009). The two parliamentary electoral constituencies in the district are Rongo and Uriri. Rongo County covers Rongo and Awendo division.

Rongo division, which is the study area, covers an area of 212.1 knr with 5 locations and 17 sub locations. The study area is in Nyarach Village of Karabuor Sub-Location. Central Kamagambo location of Rongo Division. Rongo division is the third most populous division after Suba Last and Awendo Divisions with the latter being overcrowded due to the presence of the Sony sugar factory which attracts population to these areas. The average household size and farm size is 4.5 people and 3 acres respectively.

The district has 3 gazetted forests of 136.7 Ha in size with an average number of 120 trees per farm. Destruction of forests is among the forms of environmental hazards experienced in the area. Rural households using solar power is 1%, kerosene, gas or biogas is 19% and households using firewood and charcoal account for 69.9% and 10.1% respectively. The major developmental challenges are high population growth, high dependency ratio, poverty and HIV/Aids. Agriculture is the main contributor of household income in the area (GOK. 2009).

Rongo division was purposively picked because it is in a district that has high poverty levels and whose households rely on charcoal and fuel wood for their energy use. The main source of income is from agriculture. Subsequently Rongo Division is among the most populous divisions in the district. These characteristics are relevant to the study because energy consumption is a function of household size, level of income and as seen from the literature majority of the poor households tend to heavily rely on biomass as a source of their cooking fuel. The reliance on agriculture for their income whose productivity is decreasing also depicts the high level of poverty.

### 3.3 Sampling Procedure

The study employed the use of both probability and non probability sampling. The target group for the study was households, extension officers, and village elders. The unit of analysis for the study was a household in Nyarach village and a systematic sample of 100 households was obtained. The sampling procedure began at the village level. Nyarach village was purposively picked because most of its population was mainly rural and the area also has a diversity of fuel sources from which households can choose from.

Nyarach area is in Kabuoro sub Location of Central Kamagambo Location. These characteristics were purposed to be relevant to the study.

Data from the 2009 Kenya household census shows that Kabuoro sub location is estimated to have 3195 households and a targeted sample of 100 households was drawn from the area. The sample of 100 households was assumed to be manageable, time cognizant and sufficient for statistical inference using the central limit theorem for representative large population sizes where (n > 30). The sample size also allowed the researcher to get diverse information on different households' energy use and their environmental implications.

To obtain the sample of 100 households from the village, systematic random sampling was used where every 5"' household was sampled. Nyarach Secondary school was used as the main landmark feature where the sampling started. From there every $5^{.h}$ household was sampled. A semi structured questionnaire was administered to the 100 households where the household heads (man) or a representative (mainly the spouse) and guardians formed the main respondents in the household study.

To obtain baseline information of the area under study, 2 village elders from Nyarach village were purposively picked to give background information of the study area. Every village in the study area has two village elders who act as representatives in formal functions. The researcher picked the two village elders from Nyarach village who would help in mapping the area under the study.

To augment the information obtained from the households, 5 key informants were purposively interviewed and this included the District Home Economics Officer under the Ministry of Agriculture. District Forestry Officer. District I nvironment Officer, District Development Officer and the District Energy officer. The key informants were selected for their expert knowledge, experience and involvement in energy and environmental issues in the area. The interviews were guided by checklist prepared for each of the key informant interviews. Prior visits enabled the researcher to schedule the dates and timings of the interviews

Triangulation which entailed a combination of various methods of data collection was used as this enabled the researcher to collect both qualitative and quantitative data pertaining to the study variables. As such, two focus group discussions were carried out to authenticate the information obtained from the households.

### 3.4 Data collection

The study relied on the use of both primary and secondary methods of data collection. Primary data collection methods used in the study included; a household survey, key informant interviews, focus group discussions and observation. Secondary data was generated from documented literature such as books, journal articles, bulletins, newsletters and reports relating to biomass and its implications on the environment. The secondary data sources provided background information and empirical literature for the study.

#### 3.4.1 Key informant Interviews

In order to be acquainted with the **area** under study and to enable planning for data collection, the researcher interviewed two village elders while going round the area. This was mainly done to get some baseline information on the study area. During this time the researcher carried out a pilot survey of 10 households to test the instrument and also to prepare for data collection. The village elders in the area were interviewed so as to give the general overview of the area with regard to the variables under study and to ascertain the history of the site in relation to the study.

Key informant interviews with the extension officers were scheduled to take place before administering the household questionnaires. As most of the key informants had busy schedules, some were interviewed before while others were interviewed after administering the survey questionnair -s. Two key informants; District Home Economics Officer and District Forestry Officer were interviewed before administering the questionnaires while the District Development Officer, District Energy Officer and District Environment Officer were i cr vie wed after administering the questionnaires because of their busy schedules in i! J field. An interview schedule was employed to

gather in-depth information from the extension officers. The interview schedule had open ended questions that allowed further exploration and flexibility.

### 3.4.2 Questionnaires

Information on study variables which include biomass availability, production and environmental effects was collected using structured questionnaires consisting of both open and closed ended questions. The Held survey started on the 3rd of May 2012 and ended on the 18"' of May 2012. Throughout the field days respondents were sampled and interviewed. The questionnaires were administered personally through face to face interviews with the household heads in each household. This was done to ensure that the questions were well understood by ihc respondents. This contributed to greater data accuracy and reliability.

The household head in this case were either or both men and women in the households. This is because the decision making i executed by men and the task of cutting trees and firewood collection is performed by both men and women respectively. There were very few child headed households and in these households, the guardians and elder children were interviewed as household heads to obtain the information on the study variables. In all the households visited, the researcher walked with an interpreter in order to minimize on any communication barrier in the part of the respondent or the researcher. This was done to ensure that the questions were well understood.

### 3.4.3 Observation

Observation was used as a complimentary method of data collection. Direct observation of homesteads and tree cover especially at the household level was used so as to verify the responses by the respondents and : > evaluate the current outlook of the area in terms of fuel availability. In most of the households sampled, respondents would negate the availability of trees in their farms yet they had trees planted in their farms, or would acknowledge the existence of tree n r.scries yet they had none. Observation was therefore

a very important data collection technique as it encouraged the researcher to probe further and to verify the information given by the respondents.

### 3.4.4 Focus group Discussions

Besides the household survey. 2 focus group discussions were held to augment the study findings. One group was for men and the other for women. The focus group discussions were conducted to generate detai' .1 information that was used to explore the issue of environmental implications at Ian e in the study area. These discussions were meant to complement findings from the households.

The total number of people or households in each group discussion was ten households and spatial considerations were factored in to get divergent views. Participants of the focus group discussion were purposively selected following interviews and discussions subsequently held with household heads. The objectives were explained to the participants and all were allowed to give their opinion after self introduction. The discussion started with the assistance of an interpreter and was guided by the interview guide. The information was gathered and recorded by the researcher. For both FGD's (focus group discussions) similar topics were discussed.

## 3.5 Data Analysis

The purpose of this section is to describe the procedure for the analysis of data collected. Data analysis was done using both quantitative and qualitative methods. Quantitative data from the questionnaires and the interview checklist was checked for data integrity, completeness and consistency before entry and subsequent analysis. The data was later coded and entered in SPSS (Statistical package for Social Sciences) for analysis.

The first stage of analysis involved generating of descriptive statistics. These were frequency tables and charts to review general findings on the specific research questions. Measures of central tendency w ere also used on quantitative variables such as household size, distance, time, and quantity of fuel obtained. The second stage of analysis involved both bivariate and multivariate analysis. Chi-Square tests and cross tabulations were

carried out to ascertain the relationship between variables. Generalizations and inferences were then made for the population pertaining to the variables under study.

Qualitative data from the focus group discussions. Key informants interviews and household questionnaires were analyzed qualitatively. The qualitative data was coded, organized and summarized into narratives. The data was later analyzed thematically as per the research questions. From these, the emerging concepts were understood and used to help in expounding some of the quantitative aspects of the study.

### 3.6 Challenges encountered in the Held

#### 3.6.1 Weather conditions

The study took place during the rainy season and most of the respondents were out weeding on their farms. Getting the household heads was therefore problematic as most would not be available until midday. The rains were also heavy in the afternoon and this meant that the data collection process and time of the interviews was prolonged. In most cases data collection would extend till evening.

However, the researcher managed to work well within the available time and in most cases had to interview the respondents in their farms to obtain the necessary information. The heavy rains also posed a challenge as most feeder roads to households could not be accessed. This did not disrupt the sampling procedure as the researcher had to use alternative feeder roads that were longer and the researcher managed to reach the sampled households.

#### 3.6.2 Respondents expectation

Most of the respondents expected to be given tokens or aid for participating in the study. However, the researcher, village elder or the interpreter would explain that the researcher was a student and that she had no money to give as the study was purely academic.

# CHAPTER FOUR

# HOUSEHOLD EN1RC.Y CONSUMPTION PATTERNS

## 4.1 Introduction

This chapter presents findings of the research based on the data collectcd from the field study. In this chapter, issues related to energy consumption patterns among households are presented ?nd discussed in lour main sections. The first section provides information on the type of energy used by households and the sources of these energy types. Section two discusses the patterns of household energy consumption in the study area. This is explored in terms of: cooking devices used in the household, rate and quantity of fuel obtained, individual collecting fuel in the household and the time and distance taken to obtain fuel by households.

The third section looks at the socio-cconomic factors determining energy consumption patterns by the households. Establishing this linkage is important is assessing how socio-economic factors inform energy consumption patterns at the household level. Section four further illustrates other factors that determine energy consumption patterns by households. These findings have been presented using tables and charts.

## 4.2. Types and Sources of energy used by households

### 4.2.1 Types of energy used by households

The utilization of energy is not only one of the most important environmental issues facing society today, but also a very crucial factor in the livelihood of many people. This is because it provides comfort, enables a desired lifestyle and increases productivity. The study established that there were two sources of energy mainly used by households for cooking. Firewood was the most (83.S" >) used source of energy for cooking followed at a distant second (16.2%) by charcoal. (This is shown in table 4.1 below).

On the type of lighting, it emerged that households used different types of energy for lighting although the use of kerosene was used by a significant proportion (83.8%) of households. The number was follow ed bv the use of electricity which constituted 9.1% of

the households surveyed and the use of solar energy which accounted for 7.1 % of the households sampled.

**Table 4.1: Type of energy/fuel used by households**

| Cooking | Percent | Lighting | Percent |
|---|---|---|---|
| Firewood | 84.85 | Kerosene | 83.8 |
| Charcoal | 15.15 | Solar energy | 7.1 |
| | | Electricity | 9.1 |
| Total | 100 | Total | 100 |

Source: Field data 2012

It is interesting to note that kerosene was mainly used in the traditional lamps ('*nyangile')* which uses a relatively small amount of kerosene and burns longer that the tin lamp. This may be interpreted to mean that the preference to use traditional lamp over tin lamp was attributed to the cost implication by households. Similarly, households that were near the major town (Rongo Town) and the main highway were also more likely to use electricity than houses that were in the periphery showing that the more urbanized households were better served with electricity as opposed to those further away from the major towns (mainly rural households).

The predominant use of firewood by households in the study area affirm the findings of Sangay (2010). Tee et al (2009) and Shawkat et al (2009) which shows that that there is dependence on fuel wood as the main source of fuel for populations in the rural areas. This dependence on fuel wood in the rural areas is attributed to the type of fuel sourcing in the rural area, where the majority of the fuel used in the households for cooking is mainly collected. This shall be elaborated further in the succeeding section.

### 4.2.2 Fuel stacking among households

In the energy ladder model and energy transition, increase in income is always assumed to be associated with acceleration in the ladder from tradition to modern. However, this is not the case as evidenced by empirical literature which affirms that households' tends to exhibit more of fuel stacking than transition to more modern fuels (Mascra et al, 2000). The literature emphasizes that multiple fuel use strategy also known as fuel stacking is common among rural households. This is the tendency by households to consume a

combination of fuels rather than switching to one form of fuel to another with the increase in income.

The study area was a rural area and as such it was expected on average that the survey findings should exhibit varying levels of fuel stacking among the households. Data collection for the study coincided with the planting season which was also the rainy season. Respondents using fire wood ; s their main source of fuel reported that they were obligated to use charcoal in many instances especially in the preparation of morning and evening meals. However, the respondents asserted that they would always revert back to using firewood when il was dry enough for use. The transition to charcoal by most of the respondents was expected as literature stipulates that charcoal serves as a transition fuel in the intermediate consumption stage among most households (Barnes ct al, 2004).

Similarly, households that were using lire wood were also more likely to use agriculture waste as an additional/alternative source of fuel. This varied with the plnnting seasons as the availability of agricultural waste was more pronounced after the Ivirvesting season. From the literature, the extent to which modern replaces tradition is quite low and the transition to higher fuels is low when lower cost options and alternatives to major sources of fuel exists (Stephen &Timothy, *10*10; Foley, 1994). This may explain the respondents' choice in the study area to use agiiculture residues as it presents a lower cost option to fire wood.

Respondents also reported to using briquettes and paraffin stoves in addition to their main types of fuel. However, the use of briquettes was minimal as respondents argued that it took a long time to ignite. One of the respondents reported that she had been using paraffin in addition to charcoal. The respondent affirmed that she preferred using paraffin to prepare breakfast in the morning for her husband and children and would use charcoal to prepare other meals during the day. This she explained was becausc using paraffin stove in the morning was faster than u ing charcoal. It therefore appears that fuel stacking was a common occurrence among the ampled houses in the study area.

### 4.2.3 Sources of energy used by households

The study sought to find out the sources of fuel in the study area. From the literature, it can be observed that most of the biomass for cooking among rural households is either collected or sourced from own farms (Hetelberg. 2000: Pandey 2002). The study had listed various sources of energy: The local market, neighbours, own farm and community woodlot. Table 4.2 below shows the sources of fuel in the study area.

**Table 4.2: Sources of Fuel**

| Source of fuel | Always | Sometimes | Never |
|---|---|---|---|
| Buy from local market | 32.3 | 33.3 | 34.3 |
| Buy from neighbour | 1 | 21.2 | 77.8 |
| Own farm | 31.3 | 30.3 | 38.4 |
| Community woodlots | 41.4 | 22.2 | 36.4 |
| Collect from the neighbour | 1 | 5.1 | 93.9 |

Source: Field data 2012

The major source of energy for use by households was obtained from the community woodlot (41.1%). which is an open access resource. The implication here is that exploitation of the community woodlot is unsustainable. Open access resources are resources that lack defined property rights. These are resources that are neither privately owned nor collectively managed in the common interest (Perman et al, 1996) and belong to no one in particular where each person has the right to use the resources as they wish.

Open access resources are characterized by free access where anybody can extract the resources as much as they want. The likelihood of the resource being harvested to the point of exhaustion i higher in situa'ions where private property rights are established and access to harvesting restricted (Perman et al. 1996; Adikari, 2001). Adhikari (2001) further argues that free entry to these resources encourage overconsumption, overuse of the resource ind inefficient methods o! harvesting the resource. Open accss resources are also exploited under conditions of individualistic competition Perman et al. 1996) and

there is potential of conflict as some people may misuse the resource hence others may lack enough. Increase in population also increases the total demand on the resource which eventually exceeds its rate of regeneration. This is because there is no method of excluding in-comers from the resource and as a result, competition encourage over harvesting.

In most cases, individual households fail to notice that there is decline in the resource (Adhikari, 2001). Moreover, the cost of the resource use to individual is less than the cost to the society and therefore households ignore the effects of their consumption cost faced by others using the same resource. Adhikari (2001) further argues that individuals cannot capture the benefits of the investment in these resources and are therefore not likely to invest in the resource due to lack of incentives. There is also under investment in information by individuals about resources since they have no incentives to acquire knowledge on sustainable utilization. The study therefore established that in addition to high dependence, increased population, competition and inefficient methods of harvesting encourage over consumption leading to degradation of the community woodlot.

Similarly, the local market (32.3%), own farms (31.3%) and neighbours (1.0%) offered the next best alternative sources of energy for the households. This means that most domestic fuels in the study area are collected, produced informally or bought from the local market. The findings also reveal that the proportion of households that collect their fuel to those that buy is higher which implies that most of the households in the area are largely rural. This may also be attributed to the high level of poverty in the study area. This was anticipated as the research was carried out in a rural area.

Table 4.2 also shows that households sometimes buy their fuel from the local market (33.3%) and obtain it from their own farms 30.3%, while 22.2% and 21.2% of the households sometimes obtain their fuel from the community woodlot and buy from their neighbours. Another implication here is that the alternative sources of fuel may be costly or not easily available hence the preference by households to collect rather than buy the fuel used.

Akin to studies by Shawkat et al (2009) and Tee et al (2009) is the fact that people in most rural areas have a propensity to use free access area or community woodlots as their main sources of fuel. However in all the studies, homesteads provided the next best alternative source of fuel but in the study area nearby markets offered the next best alternative followed by the own farms though with a very negligible difference.

The increasing role of individual farms as an important source of household fuel is observed from the study findings. This presents an opportunity for increased level of knowledge and awareness on the importance of farm forestry in the study area to promote availability and sustainability of biomass fuel sources.

### 4.3 Energy consumption patterns

fhis subsection looks at the energy consumption patterns in relation to the cooking devices used in the households, rate and quantity of fuels obtained, individual fetching fuel in the household and time and distance taken to collect fuel by the households. The researcher proposed these as parameters that would influence energy consumption patterns among households.

#### 4.3.1 Cooking devices used in the households

The type of cooking devices used in the household determines the type of fuel mostly used in the household and the pattern of energy consumption .With regards to cooking devices used in the households, the traditional stove (three stones) and the Kenya ceramic jiko registered the highest number of users among the respondents though the use of the ceramic jiko (89.9%) was higher than that of the traditional stove (76.8%). The findings as shown in Table 4.3 affirm that firewood is the main source of fuel for the sampled population followed by the use of charcoal.

**Table 4.3: Proportion of cooking devices used per household**

| Cooking Devices | Yes | No | Total |
|---|---|---|---|
| Improved Fire Place | 15.2 | 84.8 | 100.0 |
| Three stones | 89.9 | 10.1 | 100.0 |
| Kenya Ceramic Jiko | 76.8 | 23.2 | 100.0 |
| Paraffin Stove | 22.2 | 77.8 | 100.0 |
| Biogas | 0.0 | 100.0 | 100.0 |
| LPG Cooker | 2.0 | 98.0 | 100.0 |

Source: Field data 2012

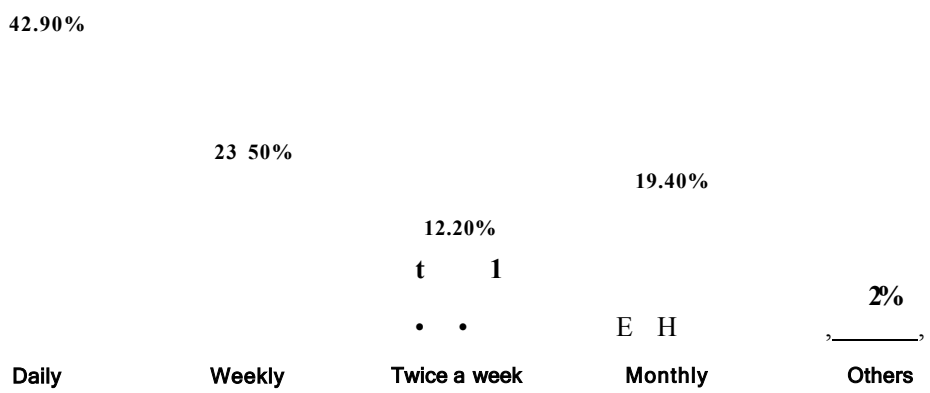
Approximately one fifth of the households used the paraffin stove while a quarter of the households sampled used the improved fire place. Remarkably, households that acknowledged having paraffin stoves asserted to rarely using them. This suggests that the use of kerosene for cooking by the respondents is very minimal. Only 2.0% Percent of the respondents used LPG (Liquified Petroleum Gas) while biogas was not utilized at all. Based on the results of the study, it appears that the use of biogas and LPG as alternative fuels has also not been adequately exploited in the study area. This may imply that LPG is either not affordable or not easily accessible to the respondents.

Table 4.3 also shows that the use of three stones by the households interviewed is more prevalent than the use of improved fire place. It is from these responses that the researcher made inferences on efficiency of the energy consumption patterns among households. This is because the use of improved fire place minimizes the amount of fuel wood used by households and thus minimizes both the environmental and heath related effects of using fire wood as a source of energy (Shawkat, I et. al, 2009). It is apparent in the study area that energy saving technologies is minimal and that the use of fire wood is inefficient as the use of improved fire place is less than the use of traditional stove for the sampled households. Similarly, the findings reveal that available alternative energy options which are environmental friendly have not been adequately harnessed in the area.

### 4.3.2. Rate and quantity of fuel obtained by households

The rate and quantity of collecting fuels influences households' energy consumption patterns. This has environmental impacts as the frequency of obtaining fuels reduces the availability of the fuel source in the long term when measures are not put in place to replenish the available sources. Figure 4.1 below shows the rate of collecting fuel by households in the study area.

**Figure 4.1: Frequency of obtaining fuel by households**




Source: Field data 2012

The question assessing the frequency of collecting fuels by respondents shows that fuel collection was mostly a daily activity for about two fifths of the respondents. The study further revealed that households near the community woodlot were more likely to collect their firewood daily as opposed to households that were far off. Similarly,' households that were in close proximity to the rivers were also most likely to collect their fuels daily due to the nearness of the community woodlots in relation to the river. The implication here is that availability of a particular source of fuel determines the frequency of its collection.

Other frequencies for obtaining fuel by households were weekly (23.5%), monthly (19.4%), tw ice a week (12.2%) and thrice (2%) a week. Majority of the households that obtained their fuels on a monthly basis were those that used charcoal as their main source of fuel. Further probing by the researcher revealed that the preference by households to

obtain their fuels monthly was because it was cheaper to buy charcoal in bulk (1 sack/ *gunia)* as opposed to buying in smaller quantities. Weather conditions and availability of the person fetching fuel for the households also influenced the weekly collection of firewood. Being a rainy season, households preferred collecting large sums of fuel wood and storing them for use in the week. Households with older children also preferred collecting their fuels on a weekly basis as the quantity collected would be sufficient enough to be used in the household for a week.

The tendency by households in the study area to obtain their fuel on a daily basis is contrary to the findings by Shawkat et al (2009) which shows that most households preferred to collect their fuel on a weekly basis and not on a daily basis. Strikingly, the disparity in the two studies is for the reason that in the study by Shawkat. the use of improved cooking stoves was more prevalent than in the study area. This explains further the predominant collection of fuel wood by households on a daily basis as the use of traditional stoves is inefficient which necessitates the use of more fuel by households.

Respondents were also asked about the quantity of fuel consumed daily in the household. With the information on frequency and quantity of fuel obtained, the researcher would be able to deduce the environmental implication of these consumption patterns on the environment. On average, the quantity of fuel consumed daily in a household was 21.76 Kilograms of charcoal for households who rely on charcoal and 5 bundles of collected fuel wood for households that use fuel wood as their main source of fuel. These amounts suggest that the quantity of fuel used per households is reasonably high. The implication here is that the quantity of fuel consumed per household will possibly have negative implications on the environment if the rate of replenishing the existing supplies is not put in place. In addition, the inefficiencies of cooking devices used in the households results in inefficient consumption of fuel.

From the preceding findings the study indicates that fuel wood was mainly used while the use of improved cooking devices was minimal. Additionally, apart from the community woodlot, individual farms formed a major part of household fuel. Coupled with the current rate of extraction in the study area (daily collection of fuel) and the quantity of

fuel obtained, the implications of these in the study area is that the sustainability of the available fuel sources is at stake.

### 4.3.3 Individual fetching fuel in the household

The study sought to find out the person fetching fuel in the household. Persons fetching fuel in the households included wife (mother), children, both children and mother, husband (father) and domestic worker (Table 4.4).

**Table 4.4: Individual fetching fuel in the household**

| Person fetching fuel in the household | Frequency | Percent |
|---|---|---|
| Children | 21 | 21.2 |
| Domestic worker | 5 | 5.1 |
| Wife (mother) | 37 | 37.4 |
| Husband( father) | 11 | 11.1 |
| Both children and mother | 23 | 23.2 |
| Others | 2 | 2 |
| Total | 99 | 100 |

Source: Field data 2012

Most of the fuel in the sampled population was fetched by the mother and this accounts for 37.4% of the respondents. The proportion of women collecting /fetching fuel was expected given their societal role in the domestic affairs of a household. The proportion of both children and mother and children fetching firewood was 23.3% and 21.2% respectively. Other individuals fetching firewood in the households were the husband (father) (11.1%), domestic worker (5.1%) and both children and domestic worker. The acquisition of fuel by the husband (father) was expected to be negligible. However, instances when the husband fetched fuel for the households was when fuel would be obtained in bulk or over long distances and in such cases they would use faster means of transport to obtain the fuel other than walking.

Table 4.4 shows that women and children in the study area spend most of their time in collecting fuel as opposed to engaging in other activities. Men on the other hand spend

little of their time in fetching fuel for their households. The findings attest that women and children continue to carry the burden of collecting fuel and are therefore prone to any negative implications, which may be brought about by the unsustainable utilization and consumption of the various sources of fuel in the study area.

### 4.3.4 Time taken and distance covered to obtain fuel for the household

Survey respondents were asked about the time taken to collect firewood for the household. Through this, the researcher would be able to determine the availability of fuel sources in the area. The amount of time households take to collect fuel shows the availability of a particular fuel source and also influences the rate of consumption. Table 4.5 shows the time taken by respondents to obtain fuel.

**Table 4.5: Time taken by households to collect fuel**

| Time | frequency | Percent |
|---|---|---|
| 0-30 minutes | 49 | 50 |
| 31-60 minutes | 23 | 23.5 |
| 61-90 minutes | 6 | 6.1 |
| 91-120 minutes | 9 | 9.2 |
| 121 minutes and abo\e | 11 | 11.2 |
| Total | 98 | 100 |

Source: Field data 2012

The results shows that half of the respondents interviewed took around half an hour to obtain their fuel. This was mostly prevalent for households that were near the community woodlot or for households that bought their fuel from their neighbours. The number was followed by 23.5% of the respondents who reported that they take around 31-60 minutes to obtain their fuel and 6.1% of the respondents who take 61-90 minutes to obtain their fuels.

Similarly, about one fifth of the respondents take over 90 minutes to obtain their fuels. It was further found out that respondents who took more than 90 minutes to obtain their fuels obtained their fuels in bulk. One of the respondent affirmed that they lt;id been using

LPG as their main source of energy but had stopped using it due to the time taken to cover the distance to obtain this fuel .The respondent affirmed that he bought **LPG** gas in Kisii town which was more than 30 km from where the household resided and in most cases would find that the price had increased. This he argues made him switch to buying other sources of energy that were available to the household.

Further analysis was done in an attempt to understand the influence of time on type of fuel collected. The analysis showed that on average, households which obtain firewood used more time in contrast to households which used charcoal. This means that the availability and ease of access to obtaining charcoal is higher than obtaining fuel wood in the study area. From the analysis, it can be argued that the cost implication is what might have hindered households to use charcoal hence preference for fuel wood. It may also suggest that the availability of fuel wood in the area is decreasing and therefore households are obliged to use more time to travel and obtain fuel wood for use in the household.

Respondents were also asked about the distance covered to obtain their sources of fuel. Through this, the researcher would establish if the distance covered determined the rate of collection of fuels by households. This is illustrated in table 4.6 below.

**Table 4.6: Distances covered in Km**

| Distance covered in Km | Frequency | Percent |
|---|---|---|
| 0-1 km | 68 | 68.7 |
| 1.2-2 km | 21 | 21.2 |
| 2.1-3 km | 7 | 7.1 |
| 3.1-4 km | 1 | 1.0 |
| 4.1 and above | 2 | 2.0 |
| Total | 99 | 100 |

Source: Field data 2012

The findings established that there were variations based on the distance covered by the respondents. The mean distance covered by the respondent was **1**.3km and the highest frequency of distance recorded was between 0-1 km. From previous findings, (Figure 4.1) the study indicated that most of the fuel was obtained on a daily basis from the

community woodloi and own farms. This might explain why most of the respondents covered a distance of less than one kilometer to obtain their fuel for use in the household as the fuel sources were in close proximity to the households. This therefore means that distance travelled determines the rate of fuel collection by households.

### 4.4 Socio-economic factors determining energy consumption patterns

Households have diverse characteristics which in turn influence the patterns and type of energy consumed. This mainly depends on the socio-economic status of the household. This subsection looks at the households characteristics and analyzes how these characteristics inform energy consumption patterns. These include: education, occupation, family size and wealth status of the households.

#### 4.4.1 Level of education

Education level of the household head is important in establishing knowledge level of the study population. It is a decisive factor in determining the type of fuel that a household consumes. Table 4.7 presents the education level of the study population.

**Table 4.7: Education level of respondents**

| Level of education | Frequency | Percentage |
|---|---|---|
| No education | 9 | 9.2 |
| Primary | 43 | 43.4 |
| Secondary | 24 | 24.2 |
| Post secondary | 23 | 23.2 |
| Total | 99 | 100 |

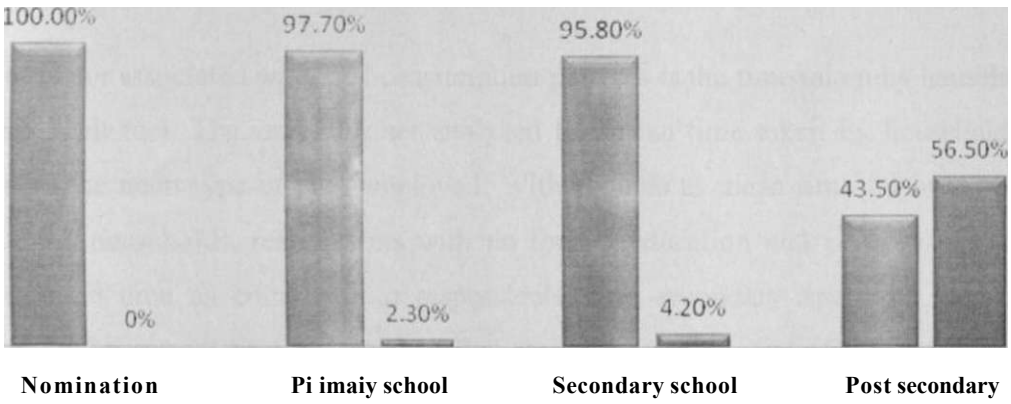
Source: Field data 2012

From the study, household heads were interviewed to ascertain their level of education. Majority of the respondents (43.4%) had primary education. These results were expected as the stud> sought to interview household heads. Being largely rural most of the respondents were elderly. About a quarter of the respondents had secondary and post secondary education while only a few of the respondents had no formal education. The

study established that primary education was the highest level of education for majority of the respondents.

Literature has shown that the level of education is an important factor in determining the type of fuel used. As such, the higher the education levels the less reliance on biomass as a major source of fuel. The dependence on biomass thus decreases with increase in the level of education (D/.ioubinski and Chipman. 1999; Mekonnen and Kohlin 2009). Figure 4.2 below shows the relationship between education and type of fuel used by respondents.

**Figure 4.2: Relationship between level of education and main type of fuel used by households**




Source: Field data 2012

Further analysis through cross tabulation was done to determine the relationship between level of education and type of fuel used by households. The cross tabulated results indicate that having a higher education increased the likelihood of using charcoal among households. For example, all respondents with no formal education relied on firewood as their main source of fuel and did not use charcoal. A majority of those with both primary and secondary school (97.7% and 98.5%) also relied on fire wood as the main source of fuel. For respondents with post secondary education, charcoal formed their main source

of fuel. It can be observed that the use of charcoal increases with the increase in education level. The findings therefore suggest that level of education is a decisive factor in influencing the type of fuel consumed.

The study also sought to test the null hypothesis that there was no relationship between the level of education and frequency of obtaining fuels. The null hypothesis was rejected as the results show that there was a strong relationship between education and frequency of obtaining fuels (C'hi-Square=32.597, df=12. P<0.05). The survey findings showed that increase in education level reduced the frequency of collecting fuel by households. For instance, the collection of fuel was a daih activity for majority of the respondents with primary education while the collection of luel by a majority of the respondents with post primary education was a monthly activity. This analysis implied that the level of education is a significant factor influencing the frequency of obtaining fuels by households. This was perhaps because of the preference by the educated population to buy in bulk which in the long run was cheaper and efficient.

Another factor associated with fuel consumption patterns is the time taken by households to obtain their fuel. The study further analyzed the mean time taken by households in relation to the main type of fuel employed. With regards to mean time taken to obtain fuel for the households, respondents with no formal education and primary education utilized more time as compared to respondents with secondary and post secondary education. The survey findings suggest that the collection of fuel (firewood which is mostly used by respondents with primary and no formal education) is more time tasking for those with minimal education as opposed to those with higher levels of education(who mainh use charcoal), from the analysis, it can be argued that increase up the education ladder is a significant factor in reducing time taken to collect or obtain fuels by households.

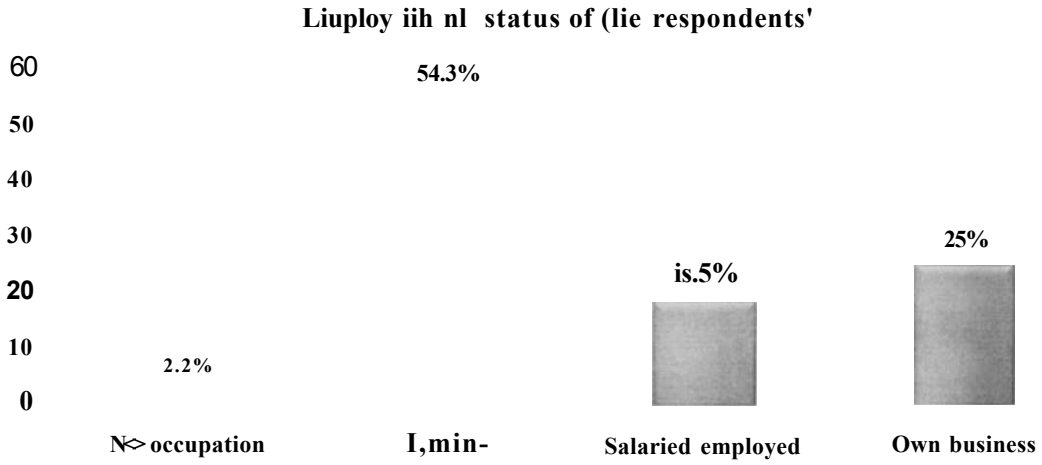
### 4.4.2 Employment status

Information on the type of occupation of the respondents was collected. Figure 4.3 shows that farming stands out as the major form of occupation in the study area which accounts for over half of the study population. 'I he major categories of farming included

subsistence farming, peasant farming and commercial fanning, however, the major type of farming for the study population was peasant fanning while none of the respondents were engaged in commercial farming. This may be attributed to the low level of education among the household heads and the high poverty levels in the study area.

Engagement in own business was practiced by a third of the respondents as their main occupation while the proportion of salaried employed accounted for a fifth of the respondents. The main types of business were small businesses of less than ten employees and in most cases sole proprietorship or family businesses. A few of the respondents interviewed had no occupation.

**Figure 4.3: Occupation of the respondents**




Source: Field data 2012

The type of occupation is a crucial factor in determining the level of income that a household earns. Literature indier s that an individual's occupation is closely related to the amount of income that one earns and this determines the households' wellbeing (CBS and MPND. 2003). This is becai **J** income is among the most significant factor that largely determines fuel consumption patterns at the household level.

Further analysis was done to dclerninc the level of association between the types of fuel preferred and occupation levels of the respondents. More often than not. the type of

occupation is strongly linked to the level of income that a household gets. Similarly Income strongly correlates to the type of energy that is chosen by a household. More affluent households can shift from lower efficiency to higher or more modern energy types in contrast to less well off families, making the latter more dependent on lower efficiency fuels.

Further analysis through cross tabulation illustrates that there is a significant relationship between occupation and the type of fuel used by the households. The analysis shows that all respondents with no occupation mainly use firewood as their main fuel while 96% of households engaged in fanning as an occupation used firewood as the main source of fuel. Equally (82.6%) of household heads with own business and (52.9%) of households heads who are salaried employed use firewood as the main fuel source.

**Table 4.8: Relationship between occupation and main type of fuel used by households**

| Occupation | | Firewood | Charcoal | Total |
|---|---|---|---|---|
| No occupation | Count | 2 | 0 | 2 |
| | Expected Count | 1.7 | 0.3 | 2.0 |
| | % within occupation | 100.0 | 0.0 | 100.0 |
| Farming | Count | 48 | 2 | 50 |
| | Expected Count | 42.4 | 7.6 | 50.0 |
| | % within occupation | 96.0 | 4.0 | 100.0 |
| Salaried employed | Count | 9 | 8 | 17 |
| | Expected Count | 14.4 | 2.6 | 17.0 |
| | % within occupation | 53.0 | 47.1 | 100.0 |
| Own business | Count | 19 | 4 | 23 |
| | Expected Count | 19.5 | 3.5 | 23.0 |
| | % within occupation | 82.6 | 17.4 | 100 |
| Total | Count | 78 | 14 | 92 |
| | Expected Count | 78.0 | 14.0 | 92.0 |
| | % within occupation | 84.8 | 15.2 | 100 |

Source: Field data 2012

From the analysis it can be argued that the type of employment which is closely related to the amount of income earned influences energy consumption patterns. Households that own businesses or are salaried employed are more likely to have significant amount of income as opposed to households with no occupation and farming where income is fluctuating or seasonal. This helps illustrate why utilization of charcoal as the main

source of fuel is higher in households with own business and salaried employed and why fire wood is higher among those households with no occupation or engaged in farming.

These findings suggest that one of the key instruments to energy transition is education and incomes which tend to influence lifestyles, thereby leading to shifts in energy sourcing and preferences among households. In terms of preference, the price of fuel is less of a constraint to wealthier households as they would prefer more convenient, higher energy and alternative fuels provided it is available. Similarly, wealthier households would rather buy than collect their household fuel.

### 4.4.3 Type of dwelling

Housing is an important basic need as proper and adequate housing contribute significantly to better living standards and household welfare .Table 4.9 below shows the type of housing for the study population.

**Table 4.9: Type of dwelling for the study population**

| Roof type | Percent | Floor type | Percent | Wall tvpe | Percent |
|---|---|---|---|---|---|
| Corrugated iron sheets (Mabati) | 100 | Dung | 14.1 | Mud and wattle | 60.6 |
| | | Earth/sand/mud | 39.4 | Clay bricks | 31.3 |
| | | Cemented | 46.5 | Cement blocks | 6.1 |
| | | | | Corrugated iron sheets | 2 |

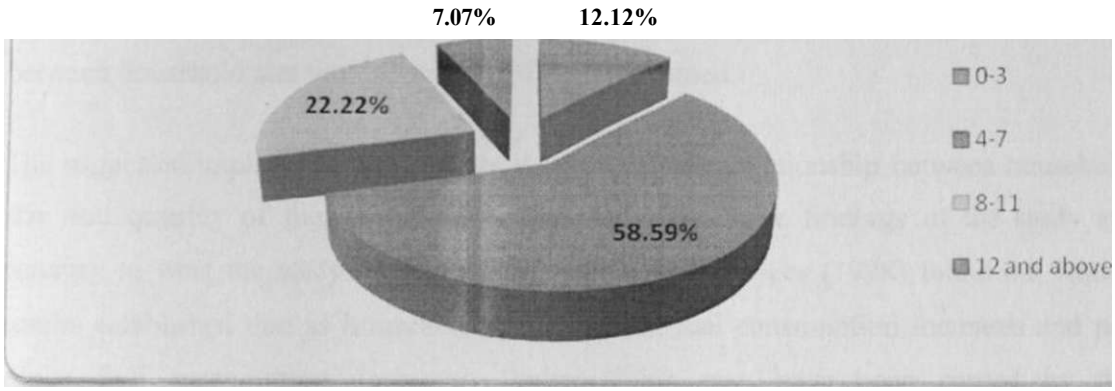
Source: Field data 2012

The type of material used in construction determines the quality and durability of the houses. In the study area, most of the households interviewed had corrugated iron sheets for the roof type. This showed that most of the people in the area are fairly better off as most houses had corrugated iron sheets for their roofing material .The main floor type of the households interviewed was cemented, earth and dung which accounts for 46.5%, 39.4% and 14.1% respectively. Equally, the main wall type was mud and wattle, clay bricks, cement blocks and corrugated iron sheets.

### 4.4.4 Family size

Demographic characteristics of a household influence the energy consumption patterns. The study sought to find out the influence of number of members in a household (house hold size) and the resultant patterns on energy consumption. Figure **4.4** shows the distribution of family size of the interviewed population in the study area.

**Figure 4.4: Family size of the study population**




Source: Field data 2012

Households covered by the study had a minimum of 1 member and a maximum of 15 members. The mean and the median value were 6. In addition, over half of the respondents had a family size of between 4-7 household members. This data corresponds with the 2009 census results on the study area. This number was followed by almost a fifth of the respondents who had a family size of between 8-11 members and less than a tenth of the respondents who had a family size of more than twelve members. The study established that the average household size of the surveyed population had a family size of between 4- 7 members.

Family size does not influence the type of fuel consumed but determines the quantity of fuel consumed by a household, regardless of the type. Literature on the relationship between family size and amount of fuel consumed indicate that households' demographic characteristics influences energy consumption where larger family size tend to consume

more fuel in contrast to smaller families (Ghilardi et al.2002).However. the per capita consumption of larger families is lower than per capita consumption for smaller sized families.

In order to establish the relationship between the family size and amount of fuel consumed, Pearson correlation co-efficient was employed by the researcher. The analysis showed that there was a negative correlation between family size and amount of charcoal consumed and a positive one for fuel wood consumed. The degree of correlation for the consumption for both fuels was negligible and quite low in relation to the amount of fuel consumed (r=0.076). The analysis established a generally weak relationship between household size and the amount of fuel consumed.

The suggested implication is that there is no significant relationship between household size and quantity of fuel consumed in the study area. The findings of the study are contrary to what the study by Sangay, W (2010) and Dewees (1998) found out whose results established that as household size increases fuel consumption increases and per capita fuel consumption decreases. Perhaps, this may have been caused by the manipulation of consumption patterns among households due to fuel stacking tendencies.

### 4.4.5 Wealth status

To determine the wealth grouping of the study population, a wealth index was computed and a mean derived from the wealth index to give a wealth grouping of the respondents. Respondents were asked if over the past year they had gone without: enough food to eat, enough clean water for home use, medicines or medical treatment, enough gas/kerosene to cook food, a cash income and money for school expenses. The wealth grouping of the respondents is shown in Table 4.10 below.

**Table 4.10: Wealth grouping of the respondents**

| Wealth grouping | Frequency | Percentage |
|---|---|---|
| Severe | 31 | 37.3 |
| Moderate | 52 | 62.7 |
| Better- Off | 0 | 0 |
| Total | 83 | 100 |

Source: Field data 2012

Of the respondents interviewed 37.3% of the population fell under severe. This connoted that respondents had always or in many occasions gone without the fore mentioned basic necessities. Respondents who had gone just once or twice or several times without the basic needs were in the moderate category and this was represented by around 63% of the respondents. None of the respondents were in the better off category which depicts that none had ever gone without accessing the basic necessities. These results were not expected as in any population, a certain proportion must fall in all the three categories mentioned. This means that the study population therefore comprises of population that is both severely and moderately poor (poor and middle class).Perhaps. this may be attributed to the high poverty levels in the study area.

The proportion of cooking devices used in the household determines the type and efficiency of fuel used by households. Further analysis was done to establish the relationship between the wealth grouping and proportion of cooking devices used in the households. This is illustrated in the succeeding table.

**Table 4.11: Wealth grouping by cooking devices used in the household**

| **Wealth grouping** | | **Cooking devices used in the household** | | | |
|---|---|---|---|---|---|
| **Categories** | Improved fire place | Traditional stove | Kenya ceramic jiko | Paraffin stove | LPG cooker |
| Severe | 2(13.3%) | 30(40.5%) | 23(34.8%) | 4(21.1%) | 0(0.0%) |
| Moderate | 13(86.7%) | 44(59.5%) | 44(65.78) | 15(78.9% | 2(100.0%) |
| Total | 15(100.0%) | 74(100.0%) | 67(100.0%) | 19(100.0%) | 2(100.0% |

Source: Fie d data 2012

The study found that most of the respondents in the moderate category employed the use of an improved fire place in relation to the respondents in the severe category. This means that the very poor are less likely to use improved fire place than those who are moderately poor. Similarly, the Kenya ceramic jiko is used by less of the respondents in the severe category. The implication here is that the use of charcoal is less of a transition fuel for the poor than for the respondents in the moderately poor category. From the analysis, it can be argued that the wealth status influences the type of cooking devices used in the households which in turn determines the type of energy used.

### 4.5 Other factors determining energy consumption patterns

Besides socio economic factors, energy consumption patterns in rural areas is determined by availability and affordability of fuels, dependability of supply, cost, convenience, household size, dieterary patterns of the households and familiarity of working with traditional fuels (Dzioubinski and Chipman.l999;Alemu and Kohlin,2009;Elias and Victor,2005). Respondents gave a wide range of reasons for their preference for using the main source of fuel. This included cost, availability and affordability. burns more than other fuel, and familiarity of working with the fuel. Table 4.12 illustrates reasons for preference by respondents to use the main type of fuel.

**Table 4.12: Reason for using main type of fuel**

| Reason for using main source of fuel | Yes | No | Total |
|---|---|---|---|
| Cheap | 72.7 | 27.3 | 100.0 |
| Readily available | 79.8 | 20.2 | 100.0 |
| Burns more than other fuel | 24.2 | 75.8 | 100.0 |
| Have been using it for a long time | 12.1 | 87.9 | 100.0 |

Source: Field data 2012

When asked why they prefer using the particular source of fuel, around four fifths of the households (79.8%) affirmed that they use the main source of fuel because it was easily available. This response was mainly for respondents who relied on fire wood as their main source of fuel. Respondents reported to obtain these fuel sources from the community woodlot and own farms where it was readily available and convenient to

obtain. Perhaps, the perceived long term availability of fuel wood in the study by respondents influenced their consumption patterns in terms of frequency of obtaining fuel for their households as collection of fuel was a daily activity for most of the respondents.

The cost of the main source of fuel was also a consideration by respondents to use the main source of fuel. The study findings show that 72.7% of the households used the main source of fuel because it was cheap. Respondents did not have to pay for collecting their fuel as most respondents who used fuel wood mainly obtained it from the community woodlot which was a free access area. The findings suggest that the cost implication for using the main fuel was mainly measured in monetary terms by the respondents. Respondents did not therefore factor in the time taken to obtain this fuel as a cost implication as long as it was available at zero cost in monetary value.

Another factor influencing preference by respondents to use firewood as the main source of fuel was because it burned longer than other fuels. Further probing by researcher revealed that this was associated with the dietary patterns/tastes of the household. Respondents affirmed to using fire wood to cook certain types of food which required a lot of heat and took a long time to cook. The consumption of boiled maize and beans *nyoyo '* which is a delicacy among the respondents in the study area is one of the types of foods that require a lot of heat and time to cook. One of the respondents further reported that *'nyoyo'* cooked by firewood tastes better than when cooked with other types of fuel. This finding demonstrates that the length of time that a fuel burns in relation to the food cooked is a factor that is considered when using a particular source of fuel.

Familiarity of working with the main source of fuel is another factor that determines the preference by respondents to use a particular source of fuel. Respondents reported to using fuel wood as they have simply been using it since time immemorial. This means that respondents are more inclined to use a well-known type of fuel that one in which they are not acquainted to. This may explain the minimal use of briquettes in the study area.

Respondents who used charcoal as their main source of fuel reported that they preferred to use it as it had less health risks. Respondents reported that the use of charcoal was healthier than the use of fuel wood as it was less smoky thus presenting less health related risks to the respondents. One of the respondents argued that she had been suffering from chest pains and frequent coughing and these incidences reduced once she resorted to using charcoal for cooking. This finding clearly demonstrate that the associated health risks for using a particular fuel is among the factors considered in the utilization of fuels by households.

The preference by respondents to use charcoal was also attributed to the scarcity of fire wood in the area. The respondents reported that the quantity of firewood in one of the community woodlots had decreased significantly making the task of collecting fire wood demanding. They argued that they were forced to use charcoal as it was the next available option. The researcher established from key informants that the reduced **availability** of fuel wood from the community woodlot saw one of the community woodlot turned into government property.

These results substantiate the choice of preference of the various sources of fuel in the study area by respondents. The factors behind preference of particular source of fuel especially fuel wood is similar to findings in the study by Tee et al (2009) who established that the preference by the population to use fuel wood was due to familiarity with working with the fuels, cost and affordability. However the use of fuel wood was preferred as it provided an additional source of income for the population in the study by Tee et al (2009).

# CHAPTER FIVE

# ENVIRONMENTAL EFFECTS ASSOCIATED WITH HOUSEHOLD ENERGY CONSUMPTION

## 5.1 Introduction

This chapter presents findings on the linkages between household energy consumption and the environment. These findings are presented in six sections. The first section explores the linkages between the types of biomass used and the environment. This is in light of the fact that the utilization and extraction of any form of fuel has impacts on the environment. The second section discuses the type of cook stoves used by the households in relation to the environment. Section three provides information on the sources of biomass in particular sourcing from community woodlots and individual farms.

The fourth section looks at on-farm biomass production by households. The study focused on the rate of biomass harvesting, production and use in relation to its continued sustainability among the households. Section five looks at the motivation behind biomass production among households. In particular, economic and environmental value attached to biomass production among households. The last section provides discussions by key informants regarding strategies put in place to enhance own farm biomass production by households.

## 5.2 Types of biomass used in the households

This section presents findings on the impact of type of biomass use on the environment. Particularly it looks at the impact of firewood, charcoal, crop residue and dung.

### 5.2.1 Firewood and charcoal

The study established that there were two sources of energy used by households for cooking and heating in the study area (Table 4.1).These included firewood and charcoal. The results further indicated that the use of firewood was more extensive in the study population than the use of charcoal. However, both firewood and charcoal are forms of biomass energy. Literature on biomass utilization on the environment emphasizes that the

burning of biomass fuels has an impact on the quality of air. This is because it increases green house gases due to air pollution leading to global warming (IEA, 2006).

The dependence on both forms of biomass energy in the study population has dual effects. This means that the increased burning of fuel wood and charcoal by the study population is continually leading to the degradation of air quality given their dependence on biomass for their cooking and heating needs.

The harvesting of timber for charcoal and fire wood also leads to loss of tree cover. The harvesting of timber for commercial and fuel needs was observed in the study area. However, the researcher observed that only one household was harvesting timber for charcoal production. The harvesting of timber for varied reasons reduces the role of tree cover in sustaining the ecosystem. Moreover, empirical literature has shown that the loss of tree cover leads to soil erosion. The spiral effect is the impact that the loss of tree cover has on the hydrological cycle especially on pollution of water bodies due to siltation which diminishes the quality and quantity of waters available for use (Mugo & Gathui. 2010: IEA, 2006).

An interaction with one of the key informants revealed that the quality of water had indeed declined. Further observation of the water bodies in the study area by the researcher corroborated the same. This was attributed to the pigmentation of the water in the streams and rivers in the study area. This observation enabled the researcher to make an inference on the impact of tree harvesting on the water quality in the study area which established that the loss of tree cover in the study area had led to the decline in the quality and quantity of water in the water bodies.

### 5.2.2 **Crop residues and cow dung**

The study sought to find out the type of crops grown by households in the study area and the utilization of residues from these crops. The varied types of crops grown in the study area were maize, beans, groundnuts, cassava, sweet potatoes, sorghum/millet and bananas respectively. The use of biomass competes with other land uses whose choice of use has implications on the environment. Literature stipulates that the use of dung and other crop

residues for domestic fuels instead of manure has implications on available soil and land resources and the improper removal of agricultural residues has the potential to degrade natural resources (William et al, 2004 and Lai. 2004).

This is because the burning of dung and other crop residues from the farm makes it unavailable as manure to increase soil productivity exacerbating soil nutrient depletion, quality and land degradation over time. In the case of burning animal waste(Dung) which has very high nitrogen and sulfur causes excess $NO_x$ and $SO_x$ emissions which has impact on the air quality and health implications for its users due to indoor air pollution (Mekonnen and Kohlin, 2008).

Respondents were asked about how they utilize crop residues from their farm. Through this the researcher would be able to establish if the crop residues were used for domestic fuel or was left on the farm. This would then inform the kind of effects on the environment depending on the choice of use of crop residue by the respondents. Most of the respondents (56.4%) reported to using waste from crop residues as fuel. This was mainly waste from maize and cassava. The respondents reported that the waste from maize and cassava provided good sources of fuel. The respondents also reported that the availability of these crop residues varied with different seasons where availability increased during and immediately after the harvesting seasons. This further demonstrates that the availability of a fuel determine its utilization.

The use of crop residue was followed by a distant second by households who spread most of their wastes in the farm (20.2%).A few households used waste from the farm as fodder (14.9%) while a negligible percentage (8.5%) either sold or gave it to their neighbours. It is interesting to note that households only spread crop residues on their farm when it could not be used as source of energy. This findings suggest that meeting fuel needs for the household is important than maintaining the quality of the soil. This therefore means that the use of crop residues as fuel robs the environment the necessary nutrients required to maintain the quality of soil thus advancing soil degradation in the study area.

In terms of utilization of cow dung from their farm animals, most of the households interviewed (98.4%) reported to using dung largely for manure while a negligible percentage (1.6%) used dung as both manure and fuel. Equally, other households used dung for building purposes. The findings reveal that the use of cow dung by most households in the study area was mainly for manure and this has shown to enhance the quality of soil. The implication here is that the utilization of cow dung by most households is environmentally benign.

### 5.3 Type of cook stoves

The type of cooking devices used in the household determines the type of fuel mostly used in the household and the pattern of energy consumption .With regards to cooking devices used in the households, the traditional stove (three stones) and the Kenya ceramic jiko registered the highest number of users in the sampled population while only a quarter of the households sampled used the improved fire place (Table 4.3).

Fuel use efficiency is dependent on the design of the cook stove and fuel used by households which in turn is related to the emission of green house gases. Literature by Smith et al (2000); Akter and Hossain (2001) demonstrate that the traditional cooking stoves are low efficient due to the incomplete combustion of the fuel wood. Due to the incomplete and inefficient combustion, such stoves produce significant quantities of 'products of incomplete combustion' (PlC).These products of incomplete combustion emit pollutants such as carbon monoxide, methane, nitrogen oxides benzene among other pollutants which have significant implication for climate change due to their considerably high global warming potential. In addition, the low efficiency results to high consumption of fuel wood leading to the collection of more fuel wood from the varied sources.

The utilization of improved cooking stoves on the other hand minimizes the amount of fuel wood required to meet household needs and reduces the consequences associated with the use of traditional stoves. From the study findings, the use of three stones by the households interviewed was more prevalent than the use of improved fire place. It is from these responses that the researcher made inferences on efficiency of the energy consumption patterns by the households.

It is apparent in the study area that energy saving technologies is minimal and that the use of fire wood is inefficient. This is because the use of improved fire place is not as much as that of the traditional stoves for the respondents. This has implications on the long term availability of fuel sources in the study area. Similarly, the incomplete combustion associated with the traditional cooking stoves is leading to increased global wanning.

### 5.4 Sources of hiomass

Generally, most of the biomass for cooking among rural households is either collected or sourced from own farms. The use of biomass is preferred as it is perceived to have low opportunity cost as opposed to sourcing from other fuels. As such most people in most rural areas have a propensity to use free access area or community woodlots as their main sources of fuel .These sources are preferred as they are assumed to be 'free' and readily available by those harvesting them.

The community woodlot. local market and own farms formed the major sources of energy for the respondents (Table 4.2) where the community woodlot recorded the highest number of frequency among the respondents .The results of the study also established that most of the domestic fuels was collected as opposed to being bought. This may be attributed to the availability of the community woodlot where fuel for use in the household would be sourced without charge. The study also showed that majority of the respondents obtained their fuel on a daily basis.

Being an open access resource, the limited restrictions in utilizing the community woodlot leads to over consumption by households. Overharvesting of the resource also mean that the biomass stocks are being depleted and that the rate of replenishing is damaged leading to the collapse of the resources ecological functions. It can be argued that perceived availability of biomass has trade-offs in terms of sustainability as the resources are always assumed to be in constant supply. The dependence on the community woodlot coupled with the frequency of obtaining fuels from the community woodlot suggests that the sustainability of biomass resources is at stake in the study area. Increased availability has also been attributed to enhanced frequency of obtaining fuels by the population.

Besides dependence, the greater competition among dwindling biomass resources in the face of a burgeoning population renders the resource towards depletion and overexploitation. The perceived constant availability of the biomass resource especially fuel wood is causing the population to overexploit the available biomass resources. This has implication on the future availability and sustainability of biomass resource in the study area as the resource is rapidly shrinking.

## 5.5 On-farm biomass production by households

The increasing importance of individual farms as a significant source of household fuel was observed from the study findings. The study established that apart from collecting and buying fuel, a good number of the domestic fuels was produced and consumed by the household itself. In this section, on farm biomass production by households has been looked at in terms of tree availability and restocking rates, length of time that households have been planting trees, preferred tree species by households, rate of biomass harvesting and production by households.

### 5.5.1 Availability of trees in the farm and re-stocking rates

#### 5.5.1.1 Size of land

Land is an important resource. The size of land in this study refers to the amount of land resource exploited by the respondents for farming activities. Almost all the households in the study area had land for farming which was majorly owned by the household. Data on farm size was also collected and defined in terms of acres. This was because most of the respondents were more conversant with the measurements on acreage. The minimum land size was 0.1 Acres and the maximum land size was 7 Acres. It was found that the mean size of land in the study area was 1.5 Acres.

Further analysis on the association between the size of land in acres and the number of trees showed a very weak relationship (r=-0.046). Furthermore the relationship was negative connoting that as the size of land increased the number of trees planted by respondents decreased. This implied that the availability of land for farming did not affect the number of trees planted by households in their farms.

It is interesting to note that households with large tracts of land preferred growing of crops over planting trees. This may be attributed to the economic value of crops as tree planting realizes economic value only in the long term. Similarly, households who reported to having 'small' pieces of land preferred to have kitchen gardens in the remaining pieces of land as captured by one of the respondents: *7 had a very big piece of land but as my 5 sons aged 1 had to divide the land so that each son could set up his homestead The remaining portion is for my wife's kitchen garden. If 1 resort to planting trees in the remaining small piece of land, what will my family eat'?*

Based on the findings, it appears that size of land does not influence the number of trees planted by households. This finding suggests that farm forestry should be encouraged and the level of awareness enhanced so that more households in the study area can engage in massive restocking of existing biomass.

#### 5.5.1.2 Av ailability of trees in the farm

Information on availability of a tree nursery among the households was ohtained. Through this information, the researcher would be able to determine the scope of strategies put in place by households to ensure own farm biomass stocks. In the study, the availability of a tree nursery would demonstrate that households have put in place strategies to replenish the quantity of trees harvested for firewood. In households that use firewood as their main source of fuel, the availability of a tree nursery would depict that the rate of planting is partly in tandem with the rate of harvesting. Therefore minimal environmental implications in the long run would be realized due to loss of tree cover.

Respondents were asked whether they had a tree nursery. Almost three quarters of the households interviewed (74.7%) did not have a tree nursery while a quarter of the households had a tree nursery. This was unexpected as confirmed by one key respondent who established that most of the households put up tree nurseries during the rainy season. Being a rainy season, the researcher expected that majority of the households would have established a tree nursery. The analysis implies that existing strategies by households to replenishing existing biomass stock is comparatively low.

Respondents were also asked about the availability of trees on their farms and most (91.9%) of the respondents reported to having trees on their farms. Of the trees available in the individual farms the study established that more than half of the trees (53.3%) on the farms were planted by the owners while 28.3% of the trees on the farms were planted by other household members. The researcher observed that most female respondents mentioned sons and male relatives as other household members who planted the existing trees on the farms. Further probing by the researcher revealed that tree planting in the study area was mainly a male affair. This might explain in part the low levels of tree planting in the study area as the input of women is not factored in. The respondents further reported that 18.5% of the trees planted on the farms existed before.

Similarly, information on the length of time that households had been planting trees was also obtained. This is represented in Table 5.1 below.

**I able 5.1: Length of time households have been planting trees**

| Length of time | Frequency | Percent |
|---|---|---|
| 0-5 years | 14 | 20.3 |
| 5-10 years | 23 | 33.3 |
| 10 years and above | 32 | 46.4 |
| Total | 69 | 100 |

Source: Field data 2012

Approximately 46.4% of the households started planting trees more than 10 years ago while about 33.3% of the households have been planting trees for around five to ten years. Only 20.3% of the households have been planting trees for five years. The findings also revealed that respondents who started planting trees for the past 10 years and above have not been planting trees as regularly as those that started in the past 0-5 years. In this context, the length of time that households have been planting trees does not necessarily show the current restocking rates. This information therefore could not be used by the researcher to determine the extent of biomass restocking rates among households.

When asked about where they acquired the idea or knowledge of planting trees. 43.0% of the respondents were of the view that the idea was out of their own initiative. Other sources of knowledge on tree planting by the respondents were other farmers (32.6%), extension officers (14.0 %) and village meetings (10.5%). Knowledge of tree planting in the study area was also acquired in women groups, youth groups, other household members and Non Governmental organizations.

Focus group discussions and Key informant interviews affirmed that most of the respondents were aware of the benefits of tree planting but very few households planted trees on their farms. This finding implies that a large amount of trees are used with little effort being made in afforestation. Similarly the findings suggest that the impact of the extension workers is very minimal in the area as very few respondents acquired the knowledge from extension officers in the area. Key informant interviews also revealed that extension workers serve a very large area and therefore lack the capacity to adequately impart a significant number of the population (K13). I his may explain in part why the services of most extension officers are not received in the study area. On the other hand ignorance and the general attitude of the population in the study area may also be a contributing factor.

#### 5.5.1.3 Preferred tree species

Respondents in the study area exploited a variety of tree species for differing purposes. Blue gum (eucalyptus) and gravellia were the most preferred trees species for cooking (fuel wood) while Blue gum. Gravellia and Cyprus were the most preferred tree species for timber products respectively. Similarly, the use of Blue gum, Gravellia and Cyprus was mainly chosen for preventing soil erosion while Caliandra and Jacaranda tree species were mostly preferred for use as fodder for livestock.

Key informant interviews further established that indigenous trees species are preferred for fuel (fire wood and charcoal) in the study area. The preferred use of Blue gum (Eucalyptus) for fuel wood is mainly because of its enhanced availability. The Blue gum and White gum species are also preferred because they have low water content and

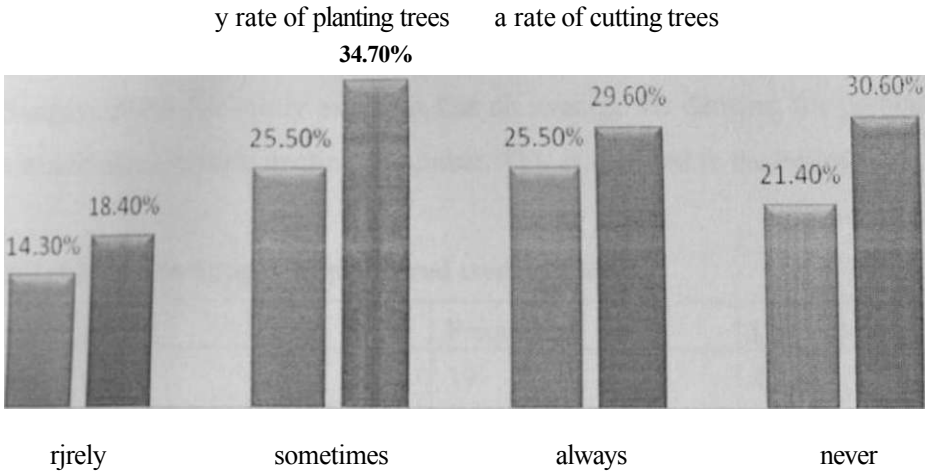
therefore burn quickly. The use of gravellia is mostly preferred for indoor furniture. Similarly, the preference for Caliandra and Jacaranda tree species is because of their suitability for forage.

The main agro-forestry tree species that are currently being promoted in the study area are *Caliandra. Lukina. Sesbunai sesban.* and *Makamia* tree species also known as *siala* which takes the longest time to mature (KI2).However study findings showed minimal adoption of the main agro- forestry trees in the study area apart from the use of *Caliandra.* This findings advocate for the need to enhance level of awareness among study population on available agro forestry tree species. The means that the level of knowledge should therefore be enhanced to encourage the restocking rate of biomass resources given that the agro forestry tree species promoted in the take a shorter time to mature.

#### 5.5.1.4 Rate of planting and harvesting trees by households

Massive exploitation of tree cover with little planting operations has negative environmental implications. When the use of trees for fuels is unsustainably and inefficiently utilized, biomass, a renewable source of fuel tends towards a non renewable resource. The production harvest balance compares the rate of production with that of harvesting. When the rate of harvesting exceeds the rate of production, the future product as well the productivity of biomass will decline and this will have negative environmental repercussions associated with loss of tree cover. The study sought to establish the product harvest balance of the respondents as illustrated in the succeeding figure (Figure 5.1).

**Figure 5.1: Frequency of cutting and planting trees by households**




Source: Field data 2012

When asked about the frequency of planting trees, an equal number of respondents (25.5%) were of the view that they sometimes and always plant trees in their farms while 34.7% and 29.6% of the respondents were of the view that they sometimes and always cut trees on their farms respectively. The researcher aggregated and compared the statistics on the rate of planting and harvesting and the results revealed that the rate of harvesting among the respondents was higher than the rate of planting (production). It therefore appears that the rate of biomass harvesting has exceeded the rate of biomass production in the study area. This may be attributed to the low level of awareness by respondents on the importance of tree planting which is further aggravated by the minimal reach of extension officers to the respondents.

The results of the study are comparable to the study by Sangay, (2010) and Tee et al (2009) who establishes that when the rate of replenishing is slower than the supply of fuels in an area, the future supply and availability will be wanting. The increased reliance and rate of harvesting which exceeds biomass production (growth and yield) reduces future harvesting potentials.

#### 5.5.1.5 C hange in supply of preferred tree species

The preference for particular types of tree species for energy leads to the loss of biodiversity which renders some preferred tree species threatened and extinct (Tee at al. 2009; Sangay. 2010).The study expected that on average the demand for particular tree species would result to their decline in number. This is depicted in the below table.

**Table 5.2: Change in Supply of preferred tree species**

| Change | Frequency | Percent |
|---|---|---|
| Decreased | 39 | 45.8 |
| Remained the same | 16 | 18.9 |
| Increased | 30 | 35.3 |
| Total | 85 | 100 |

Source: Field data 2012

When asked if the supply of the preferred trees species had changed, most of the respondents reported that the supply of the preferred tree species had changed. Of these, almost half of the respondents interviewed (45.8%) reported that the supply of the preferred tree species had decreased while 35.3% of the respondents interviewed are of the view that the supply has increased. This may be attributed to the low levels of afforestation in the area. Only 18.9% of the respondents were of the view that the supplv of the preferred tree species has remained the same.

The researcher observed that respondents who reported that the supply of tree species had remained the same were those who had started planting trees for around zero to five years. In most cases these trees were still young and therefore could not be harvested. The findings of the study resonate with the study by Sangay (2010). However, in the study by Tee et al. (2009) this was captured in terms of quantity. The findings showed that massive exploitation of the 37 wood species in the study area had led to the threat of extinction of 5 tree species.

### 5.6 Motivation for on-farm biomass production

Trees are very important in maintaining the ecological value of land. Households plant trees depending on the economic and environmental values that they attach to the trees planted on their farms. This in turn has environmental implication depending on the value attached to them as this influences the rate of utilization by households. Table 5.4 shows the motivation by households to plant trees on their farms. When trees are grown for economic gains, the economic value they fetch is always considered contrary to the sustainability of their harvesting.

**Table 5.3: .Motivation for planting trees by households**

| Reason | Yes | No |
|---|---|---|
| Fodder for livestock | 12.7 | 87.3 |
| Fuel wood | 69.6 | 30.4 |
| Timber products | 58.2 | 41.8 |
| Prevent soil erosion | 43 | 57 |
| Fruits/food | 53.2 | 46.8 |

Source: Field data 2012

Most of the respondents (69.6%) reported planting trees in their farms for fuel wood while 58.2% of the households reported to plant trees in their farm for timber products. Other reasons for planting trees by respondents were for source of fruit/food (53.2%), prevent soil erosion (43%) and fodder for livestock (12.7 %). These findings established that the motivation of tree planting by farmers is insignificantly environmentally oriented. The implication here is that the harvesting of trees is mainly driven by economic gains and therefore the sustainability of harvesting is minimally considered.

**Tabic 5.4: Other reasons for planting trees**

| Reason | Frequency | Percent |
|---|---|---|
| Cash | 12.00 | 60.00 |
| Construction | 3.00 | 15.00 |
| Beauty | 2.00 | 10.00 |
| Shade | **1.00** | 5.00 |
| Fencing | **1.00** | 5.00 |
| Medicine | **1.00** | 5.00 |
| Total | 20.0 | 100.0 |

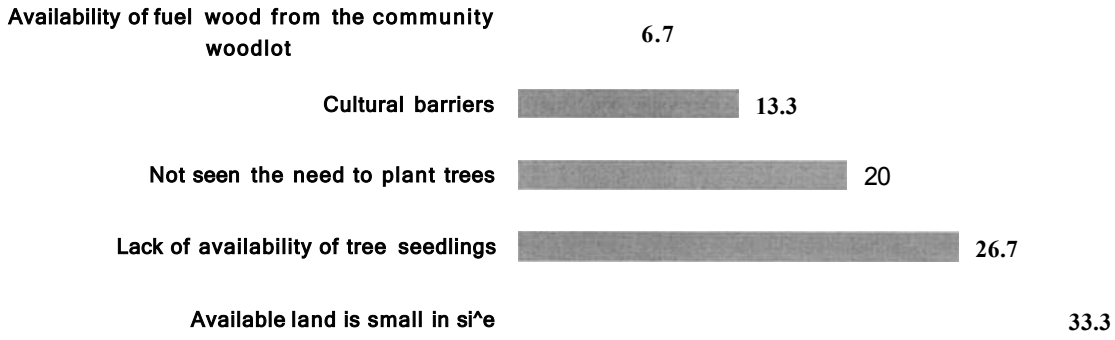
Source: Field data 2012

Respondents also gave other reasons behind tree production in the farms. Planting trees for cash registered the highest number of frequency (12.0%). Respondents also cited that they planted trees in the farm for construction, beauty, medicine, shade and fencing. The researcher observed that use of trees for fencing was pronounced in the area.

These findings established that the main motivation for planting trees amongst households in the study area is largely for fuel wood, for timber products and for cash respectively. The results of the study indicate that the main motivation for planting trees is largely economic and minimally environmental oriented. This means that households attach more economic value than environmental value to planting trees and therefore the sustainability of their utilization is minimized. This has negative environmental connotations as the stock of existing trees will decrease with extensive harvesting.

Respondents who did not plant trees in their farms gave varied reasons for not doing planting trees in their farms. The major reasons are shown in figure 5.2.

**Figure 5.2: Reason for not planting trees**




Source: Field data 2012

When asked why they do not plant trees in the farms, 33.3% of the households were of the opinion that the available land that they own is small while 26.7% of the households were of the view that they lacked tree seedlings. Equally, 20% of the households were of the view that they have not seen the need to plant trees while 13.3% do not plant trees because of cultural barriers. Only 6.7% of the households do not plant trees because of availability of fuel wood from the community woodlot. The study established that land holding size, lack of availability of tree seedlings and lack of knowledge on importance of trees are the major reasons why respondents do not plant trees in their farms.

In addition to the fore mentioned reasons. Key informant interviews also revealed that cultural barriers hinder the planting of trees by household. This is because the task of planting trees amongst households is regarded as a man's obligation rather than a woman's task. Women are therefore not allowed to plant trees. The land holding size is attributed to the increasing fragmentation of land amongst household members such that the size of land that a household occupies is exceptionally small which does not allow for planting of trees. The lack of knowledge among respondents suggests that they may not be aware ot the consequences of unsustainable utilization of tree resources in the study area.

pests thus reducing their life span. This may explain the low number of tree nurseries among respondents.

Respondents were also of the view that people should be sensitized on the importance of trees. One of the respondent reported that he had planted trees on his farm only for them to be uprooted by his neighbours. The respondent further explained that even after the neighbour uprooted the tree seedlings, he did not plant the trees in his own farm. This clearly shows that sensitization on the importance of trees in the study area should be enhanced. Additionally other respondents were of the opinion that people should use energy saving Jikos and that there should be strict laws and penalties on cutting trees.

The suggested solutions by respondents indicates the need for increased awareness and incentives to households in the study area to encourage tree planting so as to ensure that biomass resources in the area are adequate both in the long and short term.

### 5.6.2 Measures put in place by households to ensure future fuel wood availability

Table 5.6 below shows measures that have been put in place by households to ensure future availability of fuel wood in their households.

**Table 5.6: Measures put in place by households**

| Measures to take to ensure the supply of preferred tree species | Frequency | Percent |
|---|---|---|
| Plant more tree in the farms | 36 | 52.3 |
| Avoid cutting trees | 13 | 15.1 |
| Introduce more tree seedlings species that are pest/diseases resistant | 13 | 15.1 |
| Sensitization on importance of trees | 6 | 7.0 |
| Provision of alternative sources of fuel | 5 | 5.8 |
| Use energy saving Jikos | 3 | 3.5 |
| Strict laws and penalties on cutting trees | 1 | 1.2 |
| Total | 77 | 100 |

Source: Field data 2012

Respondents were asked about the measures they had put in place to ensure future availability of fuel wood. Approximately 26 % of the responses reported that respondents had not put in place any measures to ensure future availability of fuel wood. This may be attributed to the lack of knowledge among respondents on the impacts of unsustainable utilization of biomass resources.

An equal number of responses (13.0%) established that respondents bought fuel in bulk from other people while using it well while as other respondents avoided cutting trees. Other households fetch firewood in time, budget for their fuel properly .use other types of fuel than firewood, collect from the woodlot and others prune trees instead of cutting them down in a order to ensure that there is availability of fuel wood for future use.

### 5.7 Findings from key Informant Interviews

Key informants were interviewed to augment the study findings from the household's survey. Key informants were selected and interviewed based on their expert knowledge, experience and involvement in energy and environmental issues in the study area. The five key informants interviewed included: District Forestry officer (KI1), District Home Economics officer (KI2). District Environment officer (KI3), District Development officer (KI4) and District Energy officer (KI5).

Responses obtained from key informants were grouped into four thematic areas: Strategies in place to ensure own farm tree availability. Rate of adoption and reasons for adoption /rejection of the strategies, and recommendations by key informants.

#### 5.7.1 Strategies in place to ensure own farm tree availability

Key informants reported various types of fuel in the District. These included firewood, paraffin, charcoal, LPG, saw dust, briquettes and crop residues. However, the most commonly used fuels are charcoal and firewood for most of the rural population. The use of LPG is more pronounced among the population living in Rongo Township.

Generally, most of the strategies to ensure own farm tree availability in the study area are ongoing and have been promoted for the last two to four years. The existing strategies

differ with the various departments but are all aimed at towards the same purpose: promotion of own farm tree availability. Some of the strategies include; Farm forestry which requires that at least 10% of the farm land should be under tree cover(KIl.KI2); Law enforcement to reduce destruction of tree resources and under the forestry extension services.

In addition to law enforcement, strategies have also been put in place to intensify awareness creation on agro forestry; Creation of simple market for local produce (promote markets for produce) (KI1); Promotion, formation and support of local NGO's dealing with tree nurseries that produce tree seedlings (KI3. KI5); and Kazi kwa Vijana initiative which target the planting of 5000 trees in the area (KI4). The main objective of these initiatives is to increase tree cover.

The current strategies can be grouped into two: demand oriented and supply oriented. The demand oriented programs and projects are aimed at reducing the amount of fuel demanded while the supply oriented programs and projects are aimed at increasing the amount of wood fuel sources(KI5).Thc demand oriented strategies include promotion of the use of improved cooking stoves like the Kenya Ceramic Jikos and maendeleo portables (kuni mbili Jikos), promotion of briquette industry, promotion of bio gas digesters / solar systems in institutions and homes and the introduction of wind power. The promotion of demand oriented initiatives has seen the disbursement and establishment of up to 3.700 improved cooking stoves to households in the District (Rongo District). This number is projected to increase in the recent future (KI2).

Supply oriented approaches include the promotion in the establishment of own farm tree nursery and farm forestry by the community at large. The major types of trees for agro-forestry promoted in the area include: *Caliandra. Lucina and Makamia (Siala).* Of the trees promoted siala takes the longest time to mature while the rest take around two years to mature (K12).

The main target group of these initiatives is the community at large but these initiatives are promoted through youth groups, women and male groups, institutions (schools) and

environmental groups. These strategies are also implemented with the support and collaboration of various line ministries in the government which include the Ministry of Environment and Natural resources, Energy ministry. Ministry of Agriculture through the Home Economics department. Forestry Ministry and Ministry of Planning through the District Development Office. Community based organizations, private institutions and non Governmental Organizations are also involved in the promotion of tree planting strategies in the study area.

### 5.7.2 Rate of adoption and reasons for adoption and rejection of the strategies

Key informant interviews established that the community members are generally well receptive of the strategies introduced to ensure own farm tree availability in the study area. One of the key informants argued that the rate of adoption can be estimated to be over fifty percent in terms of receptivity and implementation by households (KI1). The key informants also acknowledged that the strategies have not been rejected but the rate of adoption of the strategies by the community members is slow. While the information dissemination is to the group or the community, the actual implementation is by individuals thus various factors come into play which inhibits or promotes actual implementation by households.

Some of the reasons behind the slow adoption of these strategies include negative attitude of the people towards tree planting and cultural barriers which prohibit women from planting trees. The slow rate of adoption is also attributed to the perceived fuel wood availability by the community members. In comparing the rate of adoption of the study district to the one that he previously worked in. one of the key informants argued that the perceived constant availability of fuel wood (KI1) in the study area had contributed to the slow adoption. He reported that there was scarcity of fuel in the area that he previously worked in and this saw the massive adoption of tree planting among households.

Adoption of the strategies was also enhanced by the level of awareness among the population where the more enlightened individuals adopted faster than those not enlightened. Consequently, the key informants argued that the success of these strategies

by fast adopter's aids in influencing slow adopters in the community to gradually take up the strategies that are in place to ensure tree availability.

### 5.7.3 Constraints faced in the promotion of these strategies in the area

Some of the challenges faced in the promotion of tree planting strategies in the study area as reported by key informants include;

Cultural barriers which task the duty of planting trees to men thereby excluding women from planting trees a tradition that has been exceptionally problematic to break; The increased fragmentation of existing farms due to the increasing population rendering available land too small and households have to compete between crop production and growing of trees; Related to land is the issue of tenure and farm forestry where the jurisdiction of the extension officers is to create awareness and not force individual households to plant trees in their farms; Ignorance and general attitude by the people towards adoption of strategies; Rural urban migration by the youth which has also led to decline in labour especially for the men and young boys who are the only ones allowed to plant trees among others.

On the part of implementation, inadequate government support has hampered the facilitation of these strategies and this has incapacitated the role of extension officers despite relevant policies being in place. The key respondents reported that the area served by an extension officer is fairly large compared to the population of the people to be served and this has hampered adequate information dissemination (inadequate personnel). There are also few NGO's in the study area to augment the government's effort.

### 5.7.4 Recommendations by key informants

Some of the suggested solutions by key informants towards the successful implementation of existing strategies in the study area include:

- General involvement and participation of the community members with all the major stakeholders involved in implementing the strategies.

Awareness intensification through the Community Based Organizations and line ministries which involve constant capacity building and lobbying for all the stakeholders involved.

Need for male sensitization to facilitate more tree planting by women.

Provision of incentives to the community members to encourage tree planting such as the provision of cheap tree seedlings to the community.

Creation of local markets for forest programs so as to ensure sustainable utilization of own farm tree resources.

Organization of exchange visits across geographic divide so that the community can learn from other communities in diverse localities.

# CHAPTER SIX

# SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 6.1 Introduction

The main objective of the study was to examine the environmental implications of energy use by different households in Central Kamagambo Location .The research focused on rural households in Karabuor Sub-Location. This chapter presents a summary of the study findings in light of the research questions. It provides conclusions drawn from the study findings and finally gives the recommendations for policy and further research.

## 6.2 Summary of findings

The study set out to examine the existing energy consumption patterns by different households and to establish the effects of the consumption patterns on the environment. The study was guided by the following research questions:

- What are the energy uses by the different households?
- What influences the consumption patterns of biomass fuels among households?
- What are the implications of biomass harvesting on own farm biomass availability?
- What are the environmental effects that are associated with the rate of biomass harvesting among the households?
- What socio economic factors among households influence environmental outcomes?

Both quantitative and qualitative data for the study was collected and analyzed. Data collection began by a pre-test of ten households. The pre-test was followed by the actual survey of 100 households. Focus group discussions and key informant interviews were also carried out to augment the information obtained from the households. This was followed by data analysis. Descriptive statistics for the quantitative data was generated and the findings presented using tables and charts. Cross tabulations and Chi Square tests

were also carried out to further investigate the relationship between household characteristics and energy consumption patterns. Qualitative data for the study was reviewed and analyzed thematically.

### 6.2.1 Types and sources of energy used by households

The major uses of energy among households were for cooking and lighting. The study shows that kerosene was used by a majority of the population for lighting. In terms of cooking, the main types of fuels used were charcoal and firewood (biomass energy). However, the use of firewood was more pronounced than the use of charcoal as its use accounted for over four fifths of the households surveyed. The study also established that fuel stacking was a common occurrence among the households. This was attributed to multiple fuel usage for cooking among households.

Most of the biomass for cooking among the households was sourced from the community wood lot. local market and own farms respectively. This shows that most of the domestic fuels for the households were collected, produced informally or bought from the local market. The preference by households to source their energy from the community woodlot was because it was an open access resource. The limited restriction in utilizing the community woodlot leads to over consumption by households. This subsequently leads to the depletion of biomass stocks. The study also found out that the proportion of fuel collected to fuel bought was generally high showing the increasing role of individual farms in household fuel sourcing.

### 6.2.2 Energy consumption patterns

The study established that the energy consumption patterns among households in the study area are inefficient. Out of the 100 households, less than a quarter of the households surveyed used improved cooking stoves while around 90.0% of the households used traditional stoves. The use of improved cooking stoves is more efficient as it minimizes the amount of fuel used and minimizes the environmental and health related effects of using firewood as a source of energy. The prevalent use of traditional

stoves over the improved fire place demonstrates that fuel wood consumption patterns among households are inefficient.

The study also found out that fuel wood collection was a daily activity for most of the households. This was mostly carried out by women and children. Men were only incorporated in obtaining fuel when it involved buying in bulk or travelling over long distances. The mean distance covered by households to obtain domestic fuel was 1.3 Km while the mean time taken by households to obtain their fuel was around 62 minutes. Distance covered and time taken to obtain fuels also determined the energy consumption patterns among households.

### 6.2.3 Socio economic factors influencing energy consumption patterns

As indicated by the conceptual framework for this study, energy consumption patterns in rural areas are influenced by socio — economic characteristics of the household. Socio-economic characteristics studied included education, occupation, family size and wealth status. All these influenced energy consumption patterns among households.

Most of the respondents had primary education. The study shows that the utilization and consumption of biomass was largely influenced by education level and the level of income among households. Thus, the dependence on biomass fuel decreased with the increase in education level and income. The study established that the higher the education levels among the respondents the less reliance on biomass energy. The level of education also influenced the frequency of obtaining fuels by households.

Majority of the respondents with primary education had higher tendencies of obtaining their fuel on a daily basis in relation to those with higher levels of education. For most of the respondents with post primary education, fuel collection was a monthly activity. With regards to mean time taken, respondents with lower levels of education (no formal education and primary education) utilized more time compared to respondents with higher levels of education (secondary and post secondary education).

The main types of occupation among the respondents were farming, salaried employed and own businesses. Farming stands out as the major form of occupation among households in the study area. The type of occupation is a critical factor in determining the level of income that a household earns. The study shows that most of the respondents who were engaged in farming used firewood as their main fuel for cooking. The proportion of respondents using firewood decreased significantly among the population engaged in own business and salaried employed.

In terms of demographic characteristic, the average household in the study area had a family size of between 4-7 household members. Family size determines the quantity of fuel obtained where larger families have shown to consume more fuel than smaller sized families. However results of this study established a weak relationship between household size and amount of fuel consumed.

Wealth status was operationalized under three categories: severe, moderate and better off. The study shows that no respondent fell under the better - off category. Around 63.0% of the respondents were moderately poor while 37.0% of the respondents fell under severe. The study shows that the use of improved cook stoves was negligible for most of the respondents under the severe category. The use of ceramic jiko was also less among the severe population.

The study also established that availability and affordability of fuels, familiarity of working with traditional fuels and dietary patterns of the households were among other factors that influenced energy consumption patterns among the households.

### 6.2.4 Environmental implications of household energy consumption patterns

The dependence on biomass fuels among the households has shown to have negative environmental effects. The study found that the harvesting of timber for charcoal and firewood has led to the loss of tree cover. This is attributed to sourcing of household fuel in the open access resource (community woodlot) which is characterized by high dependence, over harvesting and consequent degradation of the resource. Loss of tree cover in the study area has also been associated with decline in quality of the water

bodies in the study area. Similarly, the burning of biomass fuels has had an impact on the quality of air as it increases the amount of harmful gases in the atmosphere leading to air pollution.

The use of crop residues as fuel by most households instead of its application on the farm robs the necessary nutrients required to maintain the quality of soil thus advancing soil degradation in the study area. This is evidenced by the large number of households using crop residues as fuel who account for over half of the households surveyed.

The study also established that the utilization of energy in the study area is inefficient as more people depend on firewood with a negligible percentage of the total population using improved fire place (jiko). Lack of use of improved Jikos promotes the consumption of large quantities of fuel among households which is unsustainable. This is further aggravated by the relatively low afforestation practices among households.

The rate of biomass production is not in tandem with the rate of exploitation in the study area. This is because the harvesting rates have far exceeded the production rates of biomass fuels. In addition, the motivation behind planting trees in the area is mainly economic oriented with little regard to environmental ramifications. The utilization of biomass resources is therefore unsustainable as the environmental implications of using these resources are not factored in during their utilization. Similarly, the study found that the rate of production in Rongo area has exceeded the harvesting rates and this is seen in the decrease in number of preferred tree species for households use. This therefore compromises the future supply and availability of biomass in the study area.

The major constrains prohibiting households from planting trees in the study area are: inadequate land for planting due to fragmentation of farm land, lack of access to tree seedlings, ignorance, cultural barriers and perceived fuel wood availability. This has affected the rate with which households replenish biomass (tree) stocks in the area.

## 6.3 Conclusion

Socio economic factors have a strong influence on the type of energy utilized among households in the rural areas. These factors influence the type, nature and pattern of fuel consumed among households. Households with higher levels of education and income are less likely to depend on biomass as their major source of fuel. Similarly, the availability and affordability of biomass fuels enhances its dependence by households.

Biomass energy still remains a critical resource in the rural areas and its dependence is unlikely to change very soon as it is widely demanded. The dependence on biomass energy among a majority of the rural population is because of its perceived widespread availability. Further, the production-harvest balance of biomass energy is such that the production level has exceeded the production level and therefore the future as well as the productivity of the resource is declining leading to environmental degradation. This is further aggravated by poverty which undermines the long term sustainability of biomass resources.

The current biomass harvesting and exploitation is unsustainable and this has resulted to environmental degradation and the disappearance of biomass stock (tree cover). Unless sustainable measures are put in place to curb this trend, future supply and availability of biomass energy will be wanting both in the short term and long term with adverse effects on the environment and people utilizing this resource.

## 6.4 Recommendations

The study has shown that the dependence on biomass energy is still high in the rural areas. As it remains highly demanded, there is need to promote the use of efficient cooking devices so as to decrease the quantity of fuel demanded as well as minimize environmental effects associated with biomass utilization. These improved devices should be easily available and accessible to the local population.

The study recommends that the various stakeholders and institutions in the study area need to be strengthened so as to disseminate information and promote the sustainable

utilization of biomass resources. There should also be intensified education and massive awareness initiatives on environmental consequences of over exploitation and poor management practice of biomass consumption.

Efforts to deliberately curtail the present level of tree harvesting in the area should be encouraged by the various stakeholders through providing incentives like tree seedlings to meet the demand and reduce implications on the environment.

The government should also check the increase in prices of alternative fuels so as to shift the attention from sole dependence on biomass.

Finally, the strategies put in place should be geared towards upholding and management of biomass resource and this should be given a community participatory approach for sustainability.

Policy responses in this regard include promotion of agro forestry, afforestation and tree planting programmes, promotion of technological initiatives to reduce dependence on biomass and Joint management strategies that integrate rural energy programmes

**6.5 Suggestion for further research**

The utilization of biomass energy in the rural areas is determined by various socio economic factors like education, age, level of education, affordability, availability among others. All these factors work in isolation or mutually in trying to explain the preference for using a particular source of fuel hence varied environmental implications. However, the attitude and level of knowledge about the environmental effects of using a particular source of fuel will also determine the kind of implications on the environment. Apart from small land size, some of the reasons why households did not plant trees were due to cultural barriers and ignorance by people on importance of tree planting and careful management of the environment.

A qualitative study on the influence of culture and attitude in relation to biomass utilization and conservation of the environment warrants further research. This is because different cultures have different attitudes towards the environment and this

therefore affects the way they relate to the environment and its resources. Similarly, the level of knowledge that one has on the environment and its resources determines the attitudes towards such resources which consequently determines nature of utilization.

Such a study is useful for it would provide the much needed information to policy makers and programme implementers which could help increase environmental awareness in Kenya and hence facilitate the reduction of inefficient utilization of biomass energy.

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# APPENDICES

## Appendix 1: Household Questionnaire

QUESTIONNAIRE FOR HOUSEHOLDS

My name is **Linzy A. Nyamboki,** a Masters' student at the institute for Development studies, University of Nairobi. I am conducting a research on the environmental implications of household energy use in central Kamagambo location, Rongo County.

You are among the households that have been randomly sampled for the study. I will be glad if you could spare some of your time to respond to a number of questions that I will ask you. I wish to assure you that the information gathered is for academic purposes only and will be treated with utmost confidentiality. Your time and cooperation will be highly appreciated.

**DATE:** QUESTIONNAIRE NO:

**QUESTIONNAIRE FOR HOUSEHOLDS**

**HOUSEHOLD DEMOGRAPHICS**

| **1. What is the highest level of formal education that you have attained?** | |
|---|---|
| **0 No formal schooling** | **6 Some university, college or polytechnic** |
| **1 Some primary schooling** | **7 University, college or polytechnic completed** |
| **2 Primary completed** | **8 Post-graduate** |
| **3 Some secondary school** | **77 Refused to answer** |
| **4 Secondary completed** | |
| **5 Post-secondary qualifications, other than university** | |

| **2. How many years of formal education do you have?** | **years** |
|---|---|

| **3a. Are you currently working?**<br>**1- Yes 2.No**<br>**b. If Yes, what is your main occupation? If the respondent is unemployed, retired or disabled, then ask: what was your last main occupation?] 3) After recording the occupation, indicate whether that occupation is respondent's CURRENT JOB or LAST JOB.** | **Current or last job?** | | |
|---|---|---|---|
| | **Current job** | | **Last job** |
| **Never had a job** | **1** | | |
| **I Subsistence farmer (produces only for home consumption)** | **2** | **1** | **2** |
| **Peasant Farmer (produces both for own consumption and some surplus produce for sale)** | **3** | **1** | **2** |
| **Commercial Farmer (produces mainly for sale)** | **4** | **1** | **2** |
| **Farm worker/labourer** | **5** | **1** | **2** |
| **Trader / Hawker / Vendor** | **7** | **1** | **2** |
| **Businessperson (Owns small business of less than 10 employees)** | **8** | **1** | **2** |
| **Miner /Artisan / skilled manual worker** | **9** | **1** | **2** |
| **Domestic Worker / Maid /Househelp /labourer** | **10** | **1** | **2** |
| **Professional Worker (e.g., lawyer, accountant, nurse, engineer, Clerical Worker,teacher,government worker , etc** | **11** | **1** | **2** |
| **Housewife / Works In the Household** | **12** | **1** | **2** |
| **Other, specify below:**<br>**I** | **13** | **1** | **2** |

**X l n total, how many people (including the respondent) live in this house?**

**HOUSEHOLD CHARACTERISTICS**

**5. What is the main type of dwelling of the respondent?**

| Roof type | Floor type | Wall type |
|---|---|---|
| 1 Comigated iron sheets(mabati)<br>2. Makuti/Grass/thatch<br>3. Other natural or traditional materials<br>4.Other | 1.Dung<br>2. Earth/sand/Mud<br>3. Cemented<br>4.Other | 1 .Mud and wattle<br>2.Corrugated iron sheets<br>3. Clay bricks<br>4. cement blocks<br>5.other |

| | 6.0ver the past year, how often, if ever, have you or anyone in your family gone without: | Never | Just once or twice | Several times | Many times | Always | No children | Dont Know | Refused to answer |
|---|---|---|---|---|---|---|---|---|---|
| A | Enough food to eat? | 0 | 1 | 2 | 3 | 4 | | 99 | 77 |
| B | Enough clean water for home use? | 0 | 1 | 2 | 3 | 4 | | 99 | 77 |
| C | Medicines or medical treatment? | 0 | 1 | 2 | 3 | 4 | | 99 | 77 |
| D | Enough gas/kerosene to cook your food? | 0 | 1 | 2 | 3 | 4 | | 99 | 77 |
| ; E | A cash income? | 0 | 1 | 2 | 3 | 4 | | 99 | 77 |
| F | Money for school expenses for your children (like fees, uniforms or books)? | 0 | 1 | 2 | 3 | 4 | 7 | 99 | 77 |

**ENERGY CONSUMPTION**

| | | |
|---|---|---|
| 7.1What type of fuel does your household mainlv use for cooking? | 1 .Firewood /straw<br>2.Charcoal<br>3. Kerosene<br>4. LPG/natural Gas<br>5.Bio gas<br>6.Agriculture waste e.g maize cobs<br>7.Briquettes<br>8. Others (specify) | |
| 7.2 If the main type of fuel mentioned above is not available, which other fuel do you use for cooking?(the above options apply- multiple responses apply) | | |

| | |
|---|---|
| **7.3 What type of fuel does your household use for lighting?**<br>**1. Kerosene**<br>**2.Solar energy**<br>**3.Electricity**<br>**4.0ther (Specify)** | |
| **8. Which of the following cooking devices does your household use? Indicate 1 for yes and 2 for No. Read out the names of the devices and probe if household has other devices** | |
| **1. Improved fire place** | |
| **2.3 stones** | |
| **3.Kenya ceramic jiko** | |
| **4.paraffjn stove** | |
| **S.biogas** | |
| **6.LPG cooker** | |
| **7.0ther(specify)** | |

| **9. Where do you usually obtain the main fuel mentioned in 7.1 above** | **Always** | **Sometimes** | **Never** |
|---|---|---|---|
| **Buy from the local market** | **1** | **2** | **3** |
| **Buy from the Neighbor** | **1** | **2** | **3** |
| **Own farm** | **1** | **2** | **3** |
| **Community woodlot** | **1** | **2** | **3** |
| **Collect from the neighbor** | **1** | **2** | **3** |
| **Others (specify)** | **1** | **2** | **3** |
| **10. What is the distance of the fuel source from the household?** | **(Specify distance in kilometers )** | | |
| **11. How much time does it take to obtain the fuel?(to and fro)** | **(Time in minutes)** | | |
| **12. For the main source of cooking fuel mentioned in 7.1, how frequently do you obtain it? Tick the option that applies** | | | |
| **1.Daily** | | | |
| **2.Weekly** | | | |
| **3.Twice a week** | | | |
| **4.Monthly** | | | |
| **5. Other** | | | |
| | | | |

| 13. What is the quantity obtained per WEEK? | Quantity | Unit | Price per unit | Unit code<br>1-kilogram<br>2-gororgoro<br>3-debe<br>4-gunia<br>5-number<br>6-litres<br>7-other |
|---|---|---|---|---|
| .harcoal | | | | |
| nrewood | | | | |
| kerosene | | | | |
| IPG | | | | |
| Agriculture waste | | | | |
| Cow dung | | | | |

| 14. Who regularly fetches the fuel for the household? l-Children 2-Domestic worker 3-Wife (mother) 4-Husband (father)<br>5.Both children and mother 6.0ther (Specify) | |
|---|---|
| 15. Why do you prefer using the fuel named in 7.1 above? l=yes,2=no | |
| a) Cheap | |
| b) Readily available | |
| c) Burns more than other fuel | |
| d) Have been using it for a long time | |
| e) Others (Specify) | |

ENVIRONMENTAL IMPLICATIONS

| 16A. Presently, do you have land for farming? | l.Yes 2.No | |
|---|---|---|
| 16B. If YES, what is the ownership status of the farmland | | |
| | 1 .owned by household | |
| | 2.Leased | |
| | 3.Family land | |
| | 4.0ther(specify) | |
| 17.What is the total size of the farm (in acres)?specify the number of acres | | |
| 18A. DO you grow crops in your farm? | 1- Yes 2-No | |
| B. If yes specify crops grown in the last season | | |

| 19. How do you dispose off or use your agriculture waste (crop residues e.g maize cobs, wheat and maize stems) after harvesting season? | | |
|---|---|---|
| Type of waste | Method of utilization | 1-use it as fuel |
| | | |

| | | |
|---|---|---|
| | | 4- Sell it to Neigbours<br>5- Other, specify |
| | | |
| | | |

**20A.Do you have livestock on your farm? 1- Yes 2-No**

**(IF NO SKIP TO QUESTION 22 IF YES PROCEED TO 20B)**

**20B. What type of livestock do you have on your farm?**

| Type of animal | Owned (l=yes, 2=N0) | Number |
|---|---|---|
| a) Dairy cattle | | |
| b) Beef cattle | | |
| c) Goats | | |
| d) Chicken | | |
| e) Others(specify) | | |

**If household does not have cows skip to question 22**

**21. If household has cattle (cows) how does the household use dung obtained from the cattle?**

**1 Use as manure**

**2 Use as fuel**

**3 Use as both manure and fuel**

**4 Others, specify**

**BIOMASS AVAILABILITY**

| | |
|---|---|
| **22. At present do you have a tree nursery?** | **I-Yes 2-No** |
| **23.1.Do you have trees on your farm?** | **1- Yes 2-No** |
| **II. Who planted the trees on your farm?**<br>**1 .Self**<br>**2. Other household member**<br>**2.Existed before**<br>**3. Other (please specify)** | **III. Where did you get the idea of planting trees on your farm?**<br>**1 .From extension officers**<br>**2.From village meetings**<br>**3.From other farmers**<br>**4.0thers, please specify** |
| **IV. When did you start planting trees in your farm?** | **0-5 years**<br>**5-10 years**<br>**10 years and above** |

| | | |
|---|---|---|
| | | 4- Sell it to Neigbours |
| | | 5- Other, specify |
| | | |

**20A.Do you have livestock on your farm? 1- Yes 2-No**

**IF NO SKIP TO QUESTION 22 IF YES PROCEED TO 20B)**

**20B. What type of livestock do you have on your farm?**

| Type of animal | Owned (l=yes, 2=N0) | Number |
|---|---|---|
| a) Dairy cattle | | |
| b) Beef cattle | | |
| c) Goats | | |
| d) Chicken | | |
| e) Others(specify) | | |

**If household does not have cows skip to question 22**

**21. If household has cattle (cows) how does the household use dung obtained from the cattle?**

**1 Use as manure**

**2 Use as fuel**

**3 Use as both manure and fuel**

**4 Others, specify**

**BIOMASS AVAILABILITY**

| | |
|---|---|
| **22. At present do you have a tree nursery?** | **1- Yes 2-No** |
| **23.1.Do you have trees on your farm?** | **1- Yes 2-No** |
| **II. Who planted the trees on your farm?** | **III. Where did you get the idea of planting trees on your farm?** |
| **l.Self** | |
| **2. Other household member** | **l.From extension officers** |
| **2.Existed before** | **2.From village meetings** |
| **3. Other (please specify)** | **3.From other farmers** |
| | **4.0thers, please specify** |
| **IV. When did you start planting trees in your farm?** | **0-5 years** |
| | **5-10 years** |
| | **10 years and above** |
| | |

| | |
|---|---|
| If household does not have trees on the farm, what are the reasons behind not having trees in the farm? Then proceed to Question 30 | |
| 24. What is the size of land under tree cover? If respondent does not know question 25 applies | Acres |
| 25. How many trees do you have on the farm?(if not known, physical counting of the trees with the respondent)approximation | Trees |

| 26. How frequently do you plant trees in your farm? Choose only one option | | | |
|---|---|---|---|
| Rarely | Sometimes | Always | Never |
| 1 | 2 | 3 | 4 |

| 27. How frequently do you cut trees in your farm? Choose only one option | | | |
|---|---|---|---|
| Rarely | Sometimes | Always | Never |
| 1 | 2 | 3 | 4 |

28. why do you plant trees in your farm as specified abovc(Indicate 1 for yes and 2 for No for each response )

| | |
|---|---|
| 1 .Fodder for livestock | |
| 2.Fuel wood | |
| 3.Timber products | |
| 4.Prevent soil erosion | |
| 5.Fruits/food | |
| 6.0thers | |
| 29. If household uses trees other than for fruit/food, which tree species do you prefer for( write the native name, English name may not be known) | |
| a) Cooking(fiiel wood) | |
| b) Timber products | |
| c) Prevent soil erosion | |
| d) Fodder for livestock | |
| 30. Compared to five years ago has the supply of the preferred tree species changed for the above uses? l-yes,2-No | |
| If Yes, how has the supply of the preferred tree species changed? | |

l=Decreased 2=Remained the same 3=Increased

4=N/A

31. Can anything be done to ensure that the supply of the above, especially source of fuel is available for use in your household? 1. Yes 2.No

32. What can be done to ensure that the supply of the above tree species is available for future uses?

33. What do you personally do to ensure that the supply of the above source of fuel is available for use in your household?

THANK. YOU FOR YOUR COOPERATION

## Appendix 2: Interview Checklist for Extension Officers

My name is **Linzy A.Nyamboki,** a Masters' student at the institute for Development studies, University of Nairobi. I am conducting a research on the environmental implications of household energy use in central Kamagambo location, Rongo County. I will be glad if you could spare some of your time to respond to a number of questions that I will ask you. I wish to assure you that the information gathered is for academic purposes only and will be treated with utmost confidentiality. Your time and cooperation will be highly appreciated.

Occupation:.....Officer

1. How long have you been working/living in the area under study?
2. What are some of the sources of energy in the study area? Which is the main source of energy?
3. What are some of the strategies (program/project) in your department that have been put in place to ensure own farm tree availability?
4. For how long has these been promoted in the study area?
5. Who was the target group in these projects?
6. How has it been adopted by the community members?
7. What are the reasons behind the adoption and rejection by the community members of these strategies?
8. What tree species are preferred by the community and for what reasons?
9. Why do some farmers fail to adopt the strategies in question?
10. What are the constrains faced in the promotion of these strategies in the area?
11. In your opinion, what can be done to ensure that the strategies are well implemented?

## Appendix 3: Interview Checklist for Village Elders

My name is Linzy A.Nyainboki, a Masters' student at the institute for Development studies, University of Nairobi. I am conducting a research on the environmental implications of household energy use in central Kamagambo location, Rongo County. I will be glad if you could spare some of your time to respond to a number of questions that I will ask you. I wish to assure you that the information gathered is for academic purposes only and will be treated with utmost confidentiality. Your time and cooperation will be highly appreciated.

1. Is there any extension work in your area by agriculture, forestry or environment officer?
2. What activities do they promote with regards to ensuring own farm biomass availability? (tree planting of agro-forestry, re-afforestation)
3. Has there been any involvement by the government in afforestation activities?
4. If yes what type of involvement?
5. Who has been the target group in the promotion of agro forestry/afforestation in these areas?
6. In your opinion, has it been widely adopted by the community?
7. What are the main reasons for the current rates of adoption?
8. Is there any group that is concerned with the afforestation or agro forestry?
9. What are some of the benefits of these practices to the community?
10. What are some of the constraints that the community faces in adopting these practices in this area?

## Appendix 4: Focus Group Discussion Guide

My name is **Linzy A.Nyamboki,** a Masters' student at the institute for Development studies, University of Nairobi. I am conducting a research on the environmental implications of household energy use in central Kamagambo location, Rongo County. I will be glad if you could spare some of your time to respond to a number of questions that I will ask you. I wish to assure you that the information gathered is for academic purposes only and will be treated with utmost confidentiality. Your time and cooperation will be highly appreciated.

1. What are the main sources of fuel in this area?
2. Where did you get the idea of planting trees in your farm? For those who do not have trees on their farm, what is the reason for this?
3. Over the past five years ago, how has the supply of preferred tree species changed for the various uses of trees in this area? (Increased, decreased, remained the same- discussant to ask respondent which tree species and for which particular use).Why do you think this is so?