AN ASSESSMENT OF FOREST PRODUCT EXTRACTION IN KAKAMEGA RAINFOREST AND ASSOCIATED HUMAN IMPACT, KAKAMEGA COUNTY, KENYA

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2018
DECLARATION

I, Pauline Mutaki declare that this is my own work that it has not been previously submitted for assessment for any degree or diploma to any other university to the best of my knowledge and belief, it contains no material previously published or written by any other person except where due reference is made in the work itself.

Signed…………………………………….. Date…………………………

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

Signed…………………………………….. Date…………………………

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ACKNOWLEDGEMENTS

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Above all, I thank God Almighty for His grace, strength and favor that He granted me throughout the period of study.
DEDICATION

This work is dedicated to my beloved husband George Musumba and daughter Linda for their affection, encouragement and perpetual prayers during my studies. Their unconditional support and valuable sacrifice made this work possible. God Bless them.
ABSTRACT

Forest products utilization by the rural households living adjacent to forests is a common practice. Sustainable utilization of products from forests ecosystem is critical in ensuring continued availability of products for the current and the future generations. Bio economic values of rainforest and human impact were assessed in Kakamega forest. The objective was to identify the types of products that are extracted from Kakamega forest, what influences their utilization and the associated human impact on the forest ecosystem. Questionnaire survey using stratified random sampling was employed to collect data from 96 respondents from the edge of the forest within a radius of 5-10 kilometers. Data analysis was done using a combination of descriptive statistics like percentages, measures of central tendency and measures of frequency together with inferential statistics like chi square and presented using tables, graphs and pie charts. The results indicate that products extracted from Kakamega forest include fuel wood, charcoal, medicinal herbs, timber for building and making furniture, fodder and honey. Utilization is influenced by distance of the household homestead from the forest, income levels of the rural households adjacent to the forest and the family size. The study concluded that there has been an increase in exploitation of these products as a result of population increase, encroachment and weak enforcement that has decreased the forest products according to 83% of the respondents. The study recommends that utilization of products from the forest can be made sustainable through creating awareness on the benefits of products from the forest through seminars and workshops, incorporation of the communities that depend on the forest for their livelihood into forest governance and encouraging many researchers to venture in forest research and trainings to protect the forest from overexploitation.
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ACRONYMS AND ABBREVIATIONS

CBD: Convention on Biological Diversity
CFA: Community Forest Association
EIA: Environmental Impact Assessment
FAO: Food and Agriculture Organization
FRA: Forest Resources Assessment
GFW: Global Forest Watch
GHGs: Greenhouse Gases
IPCC: Intergovernmental Panel on Climate Change
ITTO: International Tropical Timber Organization
IUCN: International Union of Conservation of Nature
KCCAP: Kenya Climate Change Action Plan
KEEP: Kakamega Environmental Education Program
KFE: Kakamega Forest Ecosystem
KEFRI: Kenya Forest Research Institute
KFS: Kenya Forest Service
KWS: Kenya Wildlife Service
MDGs: Millennium Development Goals
NEMA: National Environment Management Authority
NGOs: Non-Governmental Organizations
NLBI: Non-Legally Binding Instrument on all Types of Forests
NWP: Non-Wood Forest Products
PFM: Participatory Forest Management
PES: Payment of Ecosystem Services
REDD+: Reduction in Emissions from Deforestation and Degradation
SAS: Statistical Analysis Software
SFM: Sustainable Forest Management
SBSTTA: Subsidiary Body for Scientific, Technical and Technological Advice
TIES: The International Tourism Society
UNEP: United Nation Environmental Program
UNFCCC: United Network Framework Convention on Climate Change
CHAPTER ONE: INTRODUCTION

1.1 Background Information

A forest refers to a continuous growth of trees covering an area of more than 0.5 hectares with a height of more than 5 meters and a canopy cover of above 15 percent, these trees can either be natural or planted in state or private land (GoK, 2005). They play a key role in the economic development of many countries and provide employment opportunities that are related to forest products. Besides that, they are also a key component of the environment as they offer various goods and essential services that benefit people as well as animals, this include providing goods for example food, water, fiber, fuel, and genetic resources. In addition to that they also offer regulatory services by regulating floods, drought, air quality, erosion, climate, diseases and natural hazards. Forests offer cultural services like recreational, spiritual, education, meeting areas, religious and other non-material benefits; are also a habitat to various species of wild animals, they provide supportive services that play a key role in the growth of plants like photosynthesis, help in nutrient cycling and soil formation.

These indispensable benefits of forests inform us why they are a major contributor and facilitator in the achievement of the targets of the Sustainable Development Goals. The world’s total forest areas are equivalent to 31 percent of the global land but there has been a reduction from the year 2000 at a total net rate of 5.2 million hectares every year (Food and Agriculture Organization, 2010; Global Forest Resource Assessment, 2010).

A reduction in the forests is a result of both direct and indirect causes. Direct causes include illegal logging, forest conversion into agricultural land, wood and fuel wood extraction, overgrazing, fires, mining and infrastructure development (Geist and Lambin, 2001). Indirect causes or drivers refer to a complex interplay of many economic, technological, demographic, political and cultural factors for example governance weakness and weak law enforcement capacity. Some of the notable impacts on forest ecosystem include conversion of forested areas to farming land which leads to temporary or permanent deterioration in the density or structure of vegetation cover or its species composition.
Human impact can be abrupt due to excessive logging or a slow gradual process, which can take long time due to spiraling demand for forest products. These lead to plantation agriculture, expansion of agro fuel and a rapid shift toward a bio energy economy. Besides these factors, conflicts of land tenure caused by the acquisition of community forest, loss of livelihood, destruction of community forests and pollution have contributed to the forest degradation. Development of infrastructure, human settlement, urbanization and industrialization are also among the drivers with significant impact on forests. Today there are changes in the global climate as most of the areas are experiencing rising temperatures, unpredictable rainfall and land degradation which are partly due to human impact on the environment. Forest products are made available by the presence of the forests but human activities that interfere with the forest ecosystem directly affects the products that can be extracted. The human activities can either reduce or increase the products that can be extracted.

Different measures have been put in place to counteract the proximate and underlying drivers of deforestation, these include formulation of an integrated and comprehensive land policy geared towards attaining sustainable development. Others include policy enforcement by meting out harsh penalties on those destroying the forests and promoting conservation of forests through sustainable harvesting of products and reforestation. This also includes capacity building of forest users and advocacy for sustainable forest management.

1.2 Statement of the Research Problem
Kenya’s forests are among the country’s most important natural resources for social cultural and economic development. However, increased demand for natural resources has resulted in their overexploitation thus affecting forest structure, ecology and utilization (Kareri, 1992). Some of the forest’s products with great importance especially to the community include firewood, which is the main source of energy; fodder, a source of cattle feed and other grazing animals; and fruits, a source of income and food for some of the rural households; others include herbs, used for curing various diseases and ailments; fiber, used for making ropes and fabrics; and oil, used for making soaps, cosmetics and confectioneries.
Kakamega forest in western region of Kenya is important as a source of support of local livelihood including illegal encroachment for farming activities and areas to settle (Dose, 2007). This has implication on the forest physical and biotic components, which in turn affect the availability of products. The forest lies in a densely populated area of rural settlement with livelihood dependent on agricultural activities and most of the households supplement their agricultural livelihood with income from forest products (Blackett, 1994; Wass, 1995; Lung & Schaab, 2006). To the local community, the forest has not only been an important source of firewood and building materials but also a source of medicine for curing various ailments (Mitchell, 2004; Keifer & Bussman 2008). In addition, ecotourism is one of the other main activities in the forest with various retreat sites like Rondo research site that is used by various researchers on forest ecosystem. Nature reserves such as Yala, Isecheno, Buyangu and Kisere were created to ease pressure on the forest ecosystem.

There is scanty information on the types of products that are extracted from Kakamega forest, factors that influence their exploitation and impacts of human activities on the forest ecosystem as a result of exploiting the products. The results of this study would help in policy formulation on practical environmental management and conservation strategies geared towards forest resource use sustainability.

1.3 Research Questions

The research was to answer the following questions:

i. What are the main products that are extracted from Kakamega forest?

ii. What are the factors that influence the utilization of products from Kakamega forest?

iii. What are the human impacts on the availability of Kakamega forest resources?

1.4 Overall Objective

To assess the products extracted from Kakamega forest and the impact of human activities on their availability

Specific Objectives

i. To document the products extracted from Kakamega forest.

ii. To assess the factors that influence utilization of products from Kakamega forest.
To assess the impact of utilization on the availability of forest products from Kakamega forest.

1.5 Research Hypothesis
The research was guided by the following hypothesis

H0: There is no significant relationship between forest product utilization and their availability

H1: There is a significant relationship between utilizing forest products and their availability

1.6 Justification of the Study
Kakamega forest is the only remnant of the unique Guinea-Congolian forest ecosystem that offers unique wildlife and scenic beauty harboring an immense and unique biodiversity (KIFCON, 1994; Wass, 1995). It has many attractions like bird watching, butterfly watching, massive trees and scenic spots like waterfalls, snakes and primates for watching that contributes towards the tourism sector in Kakamega County.

In 1933, Kakamega forest covered approximately 24000 Hectares (Kokwaro, 1988; Mitchelle, 2004) but it was reduced to about 15000 Hectares by the start of the 21st century which is separated into small patches (Glenday, 2006). Fragmentation has resulted into smaller forest patches that have led to reduced genetic variability that has resulted to extinctions and decreased species diversity. This in turn has affected the availability of various forest products. The forest is also embedded in a matrix of subsistence agriculture, exotic plantation and grasslands (Lung & Schaab, 2007). Availability of various forest products have been impacted by changes in land cover and ecological variability.

1.7 Scope of the Study
This study sought to assess the bio economic values of Kakamega forest and establish the impact utilizing the forest products by the local community. The assessment focused on the use of the forest products by the adjacent community who were perceived to have the likelihood of largest impact on the availability of these products. Impacts were measured through the perceived availability of the forest products but on the changes on land cover
or ecological change. Products inventory was done using socio-economic tools and not on forest inventory.

1.8 Definition of Terms and Concepts

**Deforestation:** Is the process by which forests are natural or planted forests are cleared either for utilizing the timber and other products from the forest or for alternative uses of the forest land like agriculture, industries and settlement

**Driver:** Any factor that causes a change or alterations in an ecosystem either directly or indirectly and it can either be natural or artificial

**Ecotourism:** Responsible travel to natural areas that conserve the environment, sustains the wellbeing of the local people and involves interpretation and education

**Ecosystem:** A self-sustaining unit of a community of plants and animals interacting with each other in a given area, and also with their non-living environments

**Empty Forest:** A forest whose ecosystems have been deteriorated.

**Conservation:** Practice of planning and maintaining forested areas for the benefit and sustainability of the future generations.

**Degradation:** The reduction of the capacity of a forest to provide goods and services

**Fragmentation:** Subdivision of a habitat or land covers type either by natural disturbance like fire or human activities like road and agriculture

**Non-Wood Forest Products:** Goods of biological origin other than wood, as well as services, derived from forests other than wooded land and trees outside forests

**Protected Areas:** An area that is clearly defined either on land or in the sea and is dedicated towards protection, maintenance and conservation of biodiversity, ecosystem services and cultural values managed either by legal or other effective means

**Sericulture:** Production of silk by rearing silkworms.

**Watershed:** An area that drains or supplies water either by surface or sub surface flow to a given drainage system or body of water, be it a stream, river, wetland, lake or ocean.
CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Forest resources form the bulk of resources that are significant to many economies of the world in terms of meeting their development goals. Forest ecosystem has the potential towards improvement of human welfare (Angelsen & Wunder, 2003). Forests improve the human welfare through provision of a wide range of resources which include timber, non-timber products and offer beautiful sites for recreational activities among other uses. However, the poor tend to destroy the environment by cutting down the trees in the forests, overgrazing and cultivating marginal lands (World Development Centre, 1992).

Human activities affect soil nutrient content which in turn affects growth of trees, forest cover and to some extend they can cause the destruction of the habitats of birds and invertebrates’ (Peh et al., 2005). The nutrient dynamics of the forest is altered by the removal of dead tree branches from the forest and dry leaves as well as overgrazing and erosion of the top soil is triggered by the constant movement of animals and humans (Belsky & Blumenthal, 2002). FAO (2005) estimated the rate of forest destruction at 13 million hectares per year.

2.2 Global Forest Status

The area that is covered by forests does not; to a larger extent tell us how healthy or productive a forest is. For example, the forest assessment that was done in 2010 by the Forest Resource Assessment used several variables to show the extent of the forests' health which included characteristics of forests, standing volume of forest and forest biomass. Among the Millennium Development Goals, forests form a major indicator of the targets in achieving of the goal on environmental sustainability (United Nations, 2005).

The total area under forests in the whole world is estimated to be about four billion hectares which is almost equal to 31% of the total world (Forest Resources Assessment, 2010). The forests are unevenly distributed with some of the developed countries like Russia, United States of America, Canada, Brazil and China accounting for 53 percent and above of the world’s total area under forest cover.
2.3 Status of Forests in Africa

Forests and woodlands are estimated to cover 650 million hectares of land in Africa which is 21.8 percent of the total land area though they are unevenly distributed but form 16.8 percent of the global forests (FAO, 2005). The density of forests in Africa vary with the countries that lie within the Congo Rainforest having the densest forests because Congo Rainforest has the largest rainforest cover after the Amazon but northern Africa has the lowest forest cover (FAO, 2003). These forests are divided into nine main groups namely equatorial rainforest, tropical moist forest, tropical dry forest, tropical shrubs, subtropical dry forests, subtropical mountain forests and plantations (FAO, 2003).

Forests are a key component to the environment as they help in reducing land degradation and climate regulation besides the other benefits of forests. However, forest resources have been declining due to increased demand forest products like wood fuel, need for more land for agriculture has led to clearing of the forests, poor implementation of polices on extraction of forest products and (FAO, 2002). Central Africa has the largest portion of the land covered by forests because of the Congo Basin. The ecosystem forms about 18% of the world tropical forests hosting over 10000 plant species and over 400 million mammalian species (Maathai, 2005). Forests in this region have been diminishing mainly because of bush fires, agriculture and overgrazing. Most of the countries in this region have given out forest concessions like Gabon has 221 concessions over 11.9 million hectares (Global Forest Watch, 2002), 81 percent of the forests in Cameroon have been allocated to concessions (White and Martin, 2001). The concessions take advantage of the weak monitoring and regulation enforcement resulting to overusing of the forest resources that were permitted.

In eastern Africa some of the forests are important source of livelihood including grazing, fuel wood, fruits and fiber. However, change of management from government command and control to participatory approach has not translated to more effective management and forest destruction is still common (Thenya et al, 2007). Inadequate resources in these areas have contributed to low investment in a forestation and reforestation activities (FAO, 2005). Mismanagement and ineffective monitoring have hindered sustainable use of the forest resources too. Most parts of the northern Africa lie in the Sahara Desert with
a very low percent of the land under forests. Most of the forests in this region are on the coastal regions and have been subjected to various pressures by human activities (Thirgood, 1981; Gilani, 1997) which has led to their forest degradation.

In South Africa there has been a rapid increase in population that has led to an increase in demand for food (UNEP, 2002). This has accelerated the opening up of forest areas for agricultural production. There was a reduction in the land under forest cover in West Africa from 13 million hectares to 11.9 million hectares in 2002 as a result of frequent cyclones and droughts.

### 2.4 Status of Forests in Kenya

Kenyan forests are classified into five distinct categories namely indigenous closed canopy trees, indigenous mangroves, open woodlands, public plantations forests and private plantation forests. Deforestation and forest degradation have been highlighted by the Kenya’s Climate Change Action Plan (KCCAP) as major present challenges to Kenyan livelihoods as they reduce biomass energy, reduce water infiltration in the soil and cause changes in precipitation. At independence it is estimated that Kenya’s forest cover was 11% but despite the attempts of the government to conserve the forests, its cover has reduced to 7.5% with the country losing about 12000 hectares of land with forest cover every year (KFS, 2009). Table 2.1 shows the forest cover change between 1990 and 2010 in thousands of hectares

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<td>Indigenous closed canopy</td>
<td>1240 Ha</td>
<td>1190 Ha</td>
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<td>Indigenous mangrove</td>
<td>80 Ha</td>
<td>80 Ha</td>
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<tr>
<td>Open woodlands</td>
<td>2150 Ha</td>
<td>2100 Ha</td>
<td>2075 Ha</td>
<td>2050 Ha</td>
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<tr>
<td>Public plantation forests</td>
<td>170 Ha</td>
<td>134 Ha</td>
<td>119 Ha</td>
<td>107 Ha</td>
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<tr>
<td>Private plantations forests</td>
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<td>78 Ha</td>
<td>83 Ha</td>
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<tr>
<td>Subtotal (forests)</td>
<td>3708 Ha</td>
<td>3582 Ha</td>
<td>3522 Ha</td>
<td>3467 Ha</td>
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(Source: FAO Report, 2010 pg. 9)

### 2.5 Global Socio Economic Benefits of Forests

According to FRA, (2005) there are four measures of socio-economic functions of forests which can be measured either in the value of the products that are extracted from the
forest, the employment opportunities created by the forests, type of ownership or forests areas that are designated for social functions. The economic benefits of the forests are measured in monetary terms towards the general economy of a country through utilization of forest products. The recreational values are measured in monetary terms which may include income from employment sector and the value of the goods and services from the forests. Forests have varied social functions from one country to another which depends on the state of development of a country that is developed or developing and their traditional beliefs of a country. Developed countries value the forests for their recreational activities, amenity and in the maintaining of the rural area but developing countries value the availability of the forest land for their economic activities like agriculture more important than the social functions.

Provisioning services provided by forests can either be renewable resources or cultural services like spiritual, aesthetic and inspirational services. Some of the local communities adjacent to the forests have taken an opportunity of preserving these forested areas for the passive services and they earn an income. Forests contribute directly and indirectly towards the economy of Kenya, they offer regulatory services on the local climate, hydrological cycle, soil erosion, purification of water act as a sink to water pollution and diseases (UNEP, 2012). All these services work towards the environmental balance of all the ecosystems by ensuring that the conducive environment is created for all living organisms. These services promote indirectly to the various sectors of the economy shown in Table 2.2.

Table 2.2: Indirect Promotion of Economy by Regulatory Services

<table>
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<tr>
<th>Regulatory Services of Kenya’s Water Towers</th>
<th>Economic Sectors that benefit indirectly</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Climate Regulation</td>
<td>Agriculture</td>
</tr>
<tr>
<td>Water Regulation</td>
<td>Forestry</td>
</tr>
<tr>
<td>Erosion Regulation</td>
<td>Fishing</td>
</tr>
<tr>
<td>Water Purification</td>
<td>Water Services</td>
</tr>
<tr>
<td>Natural Hazard Regulation</td>
<td>Public administration and defense</td>
</tr>
<tr>
<td>Disease Regulation</td>
<td>Households</td>
</tr>
</tbody>
</table>

(Source: UNEP 2012)
Another driver to deforestation is economic poverty with no other alternative source of income yet the families have to support themselves, this is bound together with unemployment due to lack of education in some communities who turn to the forests to get a livelihood.

2.6 Forest Products and their Uses

Besides wood products from forests, there are also minor non-wood products that are beneficial to both man and animals (Clendon, 2001; Foppes and Ketphanh, 2000). These products include grasses which are used as fodder or for thatching in some of the communities; other grasses are also used for cordage, matting and as important raw material for manufacturing of paper for example Sabai (Eulaliopsis Binata) grass in India. Other grasses like Khus (Chrysopogon Zizanioides) in most of the forests in Nepal are used for making cooling screens and Munj (Saccharum Munja) which is used for making chicks, stools and chairs, leaves are twisted to form strings while bamboo provides a cheap raw material for roofing, walling, flooring, matting and basketry (Lamxay, 2001). Canes which grow in most of the moist forest are harvested for making strings, walking canes and mats.

Tannins and dyes extracted from some of the plant tissues play an important role in the economic development especially in the leather industry (Jansen and Cardon 2005); they are mainly from oak, hemlock and some mangrove trees. Some dyes are obtained from the barks of some trees like wattle; other trees contain several oils that are used in the manufacture of soaps, confectionery, cosmetics and pharmaceutical preparations. Trees provide gum which is used in textile industries and in ink making as well as resins which is distilled to get turpentine and resin. Turpentine is mainly used as a solvent for paints and varnish, synthetic camphor and pine oil while resin is an important raw material for several industries like paper, paint, adhesive tape, water proofing and rubber. Fiber obtained from the tissues of some trees are used for rope making while others like the AK (Calotropis Spp) is used for making fishing nets because it is fine, strong and silky. Flosses are obtained from some of the fruits and used for stuffing mattresses and pillows. Leaves obtained from different trees are used as plate and leaf cups in some of the countries in the world and others also use leaves as wrappers by vendors of sweets.
Thousands of drugs are obtained from fruits, flowers, roots, stems and leaves of different trees, plants and herbs found in the forests like Quinine is obtained from the Cinchona tree, Aspirin from Willow bark and Penicillin from Penicillin mold from the forests. Spices used to add aroma and flavor certain dishes are from forests for example Cinnamon, Lesser Cardamom and greater Cardamom. Some of the Indian forests produce poisonous substances which can act as medicine when taken in small regular doses (Sayer and Maginnis 2005; Patosaari, 2007) Fruits, flowers and roots of various tree species found in the forests are edible such as Allspice berry, Almonds, Grape Fruit, Apricots, Avocados, Chest nuts and Hazel nuts just to mention a few. Forests act as a habitat for some of the wild animals, they also provide animal and animal products, some of the animals mainly vertebrates like mammals, birds and reptiles are bought and kept as pets by some of the people in the society, honey and beeswax is provided by the bees, game meat is provided by vertebrates like antelopes and buffalo which forms a source of protein especially for the poorest segments of the population (Demmer and Overman, 2001). Other edible animal products include eggs from some of the animals like the ostrich, hides and skins from the forest animals are used for various purposes too.

Drugs beneficial to humans are obtained from some parts of animals such as various organs from water buffalo which is believed to treat fever and convulsions and the Grevys Zebra that is used by traditional healers to treat diseases like tuberculosis, bones which are not edible are used as tools by some of the traditional communities. Forests provide various services to the ecosystem which ensure that there is stability. According to Sousson, Shrestha and Uprety (1995), forests offer ecological services, economic and social cultural services to the communities around them.

2.7 Factors Influencing Forest Use, Conservation and Management

The utilization of forest products and the dependence on the forest for livelihood vary from one region to another in the whole world depending on the level of development of the region. Past studies (Wells and Shane, 2000; Wambua, 2008) pointed out that forest utilization is affected by factors which like economic endowment of the household, the demographic characteristics of the household and other external factors like the
availability of market for the forest products, the prices of the forest products and the level of technology in the country or region.

Sumati (2006) examined the socioeconomic drivers of the use of fuel wood in India and found that wage labor, land size, household size and proximity to the forest from the village affect the use of the forest resources. People who own large tracts of land are able to substitute most of the forest products with the agricultural products from their farms unlike those who are landless. On the other hand, small landholders are able to substitute part of their forest products with what they have from agriculture. However, human dependency on forest wood and non-wood products has led to negative effect on the forest ecosystem and overutilization has resulted to environmental degradation in the long run (FAO, 1999). Consequently, these have impacted negatively globally on climate change, desertification and forest degradation.

The distance between the forest and the village also affect the access to the forest resources (Hedge and Enters, 2000; Karanth et al., 2006; Guthiga, 2008; Wambua, 2008). These studies found that as the distance to the forest edge increases the rate of extraction decreases and education influences dependency on forests. They indicate that education increases income earning opportunities that in turn lead to asset accumulation and improved welfare and as income increases reliance on forests as a source of income declines. Other studies (Cavendish, 2000; Sanders and Zellar, 2004) found out that the poorest households suffer most from strict conservation while the rich benefit more due to improved provision of indirect benefits. Higher level of education of family members makes fuel wood collection unprofitable due to higher opportunity cost of time in collection and gathering of firewood. Better education facilitates intelligent farm management that widens a household’s scope of coping strategies other than forest extraction, as income increases reliance on forest as a source of income declines.

Sumati (2006) argues that location determines access to markets and hence influences the availability of commercial fuels. Villages close to the market but far from the forests tend to use commercial fuel as compared to villages which are close to the forests and markets as they concentrate on the extraction of forest fuels because they have a ready market for them. Households close to the markets and forest tend to have greater incentives to
exploit that income generating option. Sunderlin *et al.* (2005) found out that studies that had been done indicated that the poor people in the rural areas are proportionately dependent on forest products for their livelihood from the sale of the forest products which forms a larger percentage of their income (Reddy and Chakravarty, 1999). Odihi (2003) noted that lack of alternative sources of energy among the households adjacent to the forests and the high profits accrued when forest products are sold formed part the major causes of deforestation. Though, they are promoted and conserved for improving the wellbeing of local communities adjacent to them (Elands *et al.*, 2004) most of the expansive forests’ in the tropical regions are surrounded by communities that depend on them for their livelihood (Wunder, 2001).

### 2.8 Impacts of Utilization of Forest Products on Forest Ecosystem

Poor planning and implementation of extraction regulations of wood and non-wood forest resources cause result to a negative impact on the forest ecosystem. Other impacts emanate from construction of transport networks like roads or recreation activities in the forest and waste dumping (Lawes *et al.*, 2004). Utilization of forest products vary from one community to another around the forest areas and the impacts vary in intensity and importance of the forest products depending on the specific form of forest resource utilization.

Logging of Non-Timber Forest products (NTFPs) has impacts which can either be positive or negative classified into four main groups. For instance, some of the forest tree species may have more than one value when extracted which makes them to be overexploited (Laird, 1999). Counsell *et al.* (2007) refers to them as disputed species as they also have specific cultural and social importance for example Moabi (Baillonella toxisperma) and Sapelli (Entandrophragma cylindricum). These trees are endangered because they have multiple uses as listed by the Red List (IUCN, 2010). They are exploited because of their high value resulting to their decline and inability to regenerate again after logging has been done (Schulze *et al.*, 2008).

Utilizing some of the forest resources that are found on the slopes of mountains especially logging makes the slopes to become unstable, prone to sipping, sliding or even earth flows and to be easily affected by earthquakes (Olschewski R. *et al.*, 2012). The
river banks and shores may become unstable, prone to undercutting, long ocean shore erosion as well as deposition. Rill, gulley and sheet erosion may result to loss of nutrients and organic matter from the soil as it will be prone to leaching. Destabilization of the soil may lead to the exposure of the microorganisms to the sun, this changes the life of the microorganisms that are responsible for transferring nutrients and decomposition which in turn alters all the processes that are responsible for the formation of fertile soils.

When there is a Non-Timber Forest Product that is of great value, the operators may carry out logging to exploit the product though the exploitation may not include the local communities or they may compete with them in exploitation. For example, Okuome (Aucoumea klaineana) tree in Gabon was on demand when it was discovered that its resin can be used as an anti-inflammatory (Praxede-Mapangou, 2003). The resin was exported by some of the companies that were involved in logging illegally excluding the local people from benefiting from the Okuome as their new source of income in improving their livelihood (Robinet, 2003). This led to removal of the resources from the communities around the forest (Dove, 1993). Utilization of Non-Timber Forest Products may be facilitated by logging for example bush meat trading can be facilitated by making the forests accessible through construction of roads and bridges that enable the hunters to get their way to the forests easily and transport the bush meat to urban areas for sale (Robinson et al., 1999; East et al., 2005). When there is a discovery of any forest resource the demand raises which leads to it being overexploited (Sunderland et al., 2004).

In arid areas, over utilization of forest resources lead to dust in the air and bare soils that are prone to wind deflation. Cutting down of trees and use of equipment may lead to pollution; saw milling, burning of charcoal and other uses of wood may increase the concentration of wood particles in the air and emissions to the local environment. Clear cutting of trees in moist tropical high forests may lead to total destruction of some of the plant species or part of them, as well as loss of biodiversity and genetic resources (Mahapatra and Kant, 2003). Decrease in the supply of fuel wood locally as a result of deforestation makes the communities adjacent to the forest to seek alternative sources of energy. Deforestation may increase the rate of incidences of some of diseases and birth
new diseases for example malaria may be introduced when the stagnant water that was under the forest is exposed and also eliminate some of the traditional foods from the ecosystem.

Logging changes the general structure, composition as well as the functioning of the forest (Hall et al., 2003; Foley et al., 2007). Cutting trees selectively may have biophysical influences like the availability of particular herbs and vines (Costa and Senna, 2002) as these Non-Timber Forest Products are able to get sunlight through the gaps that are left after the cutting of the canopies (Guariguata et al., 2010) though some of the species respond negatively. Uncontrolled cutting of trees facilitates soil erosion that contribute to pollution and siltation when the eroded materials are deposited in the rivers (Douglas et al., 1993) which affects fish stocks, loss of animal species as some of their habitats are destroyed while some totally depend on the trees that are targeted for logging (Shanley and Rosa, 2004).

Forest utilization may lead to sedimentation in streams which may lead to channel instability, challenge in the movement vessels on the streams and the reduction in light penetration for the aquatic life of the organisms that live on the bottom of the streams like the benthos (Goode et al. 2012). Increased sedimentation on the sloping grounds from the logged areas may reduce the lifespan of useful reservoirs and in some cases may bury the vegetation adjacent to the forest and the nearby places. The ground temperature may be increased but the humidity reduced which interferes with the growth of plants, microorganisms and the local convectional patterns.

2.9 Theoretical Framework

Trade theory (Heckscher-Ohlin, 1991) states that the magnitude and direction of the flow of forest products is determined by the geographical distance to the source of the forest product, demand for the forest product, the availability of the forest product at the source and the government policies in place that govern the extraction of the products. It further states that a country can increase the availability of forest products by planting trees that mature faster, having an efficient transport network that lowers the cost of movement of the products so as to reinvest in tree planting and acquiring of new technology through training for efficient use of raw materials from the forest. This theory acknowledges that
communities around the forest utilize the forest products because of their proximity to the forest from household’s homestead, the size of their families form the demand and the way the products are utilized determine their availability from the forests (their supply). Extraction of timber and Non-Timber products from the forest can either be for commercial or subsistence purposes which react differently to the forest Munanira et al (2014). Household near the forest have a greater impact on the forest ecosystem as they utilize the products more than the households that are far from the forest.

2.10 Conceptual Framework
The Kakamega forest products extraction is perceived in four main components namely i) Kakamega forest products and services. ii) Products and Services' values to people and environment. iii) Human activities in and around the forest. iv) Human activity impact on the forest ecosystem. v) Interventions if needed to improve the health of the forest and in policy formulation Figure 2.1.

Understanding the linkage between those products and the benefit they generate to the people and the environment is important. Different people protect the forests for different reasons whereas the policy makers focus on protecting forests to reduce greenhouse gas (GHG) emissions the local people see the forest as a resting place for their ancestors and being essential for their dietary requirements and their health.
To determine the forest product extraction and associated human impact on Kakamega forest, there was need to first identify the forest products and services together with the human activities that are carried out in and around the forest. After identifying the forest products and services the value of these products and services to the people and the environment were determined and the impact of the human activities on the forest ecosystem from the activities carried out. The forest products value, the value of the services provided by the forests and the associated human impact on the forest ecosystem were used to propose the possible interventions that could be applied in improving the forest health. These interventions could lead to forest policy formulation that would in turn influence extraction of products from the forest and the associated human impact on the forest ecosystem.

Figure 2.1: Conceptual Framework (Researcher, 2017)
CHAPTER THREE: STUDY AREA

3.1 Study Area and Characteristics

3.1.1 Size and Location

Kakamega forest is located in western part of Kenya in Kakamega County Figure 2 lying along the North Eastern border of the Lake Victoria Basin with the Nandi escarpment rising on the eastern edge running to the western edge of the Rift Valley (Mitchell, 2004). The forest is on an elevation of between 1500-1700 meters above the sea level (Musila, 2007) and on latitude 00° 08’30.5” North and 00 22’12.5” North and longitude 34 46’08.0” East and 34 57’26.5” East. Kakamega forest reserve is in Kakamega County Figure 3. It is bordered by Busia district to the west, Bungoma, Nandi, Uasin Gishu, Vihiga and Siaya Counties. Figure 3 shows the main block of Kakamega forest and the fragments.
Figure 3.1: Location of Kakamega County in Kenya (Researcher, 2017)
Figure 2.2: Location of Kakamega Forest in Kakamega County (Researcher, 2017)
Figure 3.3: Kakamega Forest and its Fragments (Researcher, 2017)
3.1.2 Forest Ecosystem

It is suggested that Kakamega forest covered most of the parts in the western region from historical and biological evidence and forms part of the Congolean forest that was in equatorial forest in Africa (Kendall, 1969; Kokwaro, 1988; Mitchelle, 2004). Kakamega forest covers a total area of 240 km square which is 7.9 percent of the total area of Kakamega County that has an area of 3034 km square. It is divided into five management sectors by the Kenya Forest Ecosystems namely

i. Kakamega Forest Zone that comprises of Kakamega Forests Reserve, Isecheno and Yala under KFS

ii. Main block in Kakamega district comprising of Kakamega National Reserve and Kisere under KWS.

iii. Kibiri and Yala under KFS in Vihiga Zone.

iv. Malava under KFS in Malava Station.

v. Bunyala under KFS in Bunyala Station

3.1.3 Geology and Soils

Kakamega forest is characterized by a Precambrian rock which is the underlying bedrock in Lake Victoria Basin (Lovett and Waser, 1993). Over the underlying rock there are low fertile, well drained, deep and heavily leached soils mainly clay-loams that are acidic (Blackett, 1994) though some areas of the forest have humic soils (Tattersfield et al., 2001; Glenday, 2006) and some have fertile soils called nitosols (Blackett, 1994). There are four classes of sols that have been identified to dominate the forest namely ferrasols, cambisols, phaeozems and lixisols in the campsites (Musila, 2007).

3.1.4 Drainage

The study area falls within the tropical climate which receives an average annual rainfall of between 1200-2100 mm per year due to its proximity to the Lake Victoria and position near the equator (Musila, 2007). The forest has a double maximum of rainfall from April to November with a short dry season from December to March (Mitchelle and Schaab, 2008). The temperatures are fairly constant throughout the year ranging between 15 -28 degrees Celsius.
3.1.5 Economic Activities
Kakamega forest is situated in the Lake Victoria Basin, about 50 km north of Kisumu town. The park offers a unique wildlife and scenic beauty for tourist activities. There are various tourist sites like the former Crying Stone and Caves besides the forest itself which attracts tourist who bring income to the local communities.

The forest lies in a rich arable land that is used for large scale sugarcane farming, mixed farming, commercial businesses and transport business. The main agricultural products are maize, millet, beans, tea, dairy products, and sunflower and soya beans. All these economic activities especially agricultural depend on the availability of rainfall which is greatly influenced by the Kakamega forest.

3.1.6 Biodiversity
Kakamega forest is dominated by different species of plants and animals which are found in both lowland and highland areas and harbors a variety and unique biodiversity. It has various species of fauna and flora though it lies in Kenya its diverse biodiversity is more than what is found in any other Central, East and West African forests (Wagner et al., 2008). It has more than 380 plant species that have been put into record with 150 species representing trees (KIFCON, 1994) which include the African mahogany (Khaya Anthotheca), Antiaris Toxicaria (fig family tree) and Aningeria Altissima among other trees. Others species of plants are the vines, shrubs and herbs of which some of them are only found in Kakamega forest.

It is estimated that this forest has 40-50 species of butterflies with at least 72 species of dragonflies of which 19 recognized nationally to be occurring only in Kakamega forest (Claunitzer, 2005). The forest has one of the world’s largest beetles (Huge Goliath) with at least 36 species of snakes’ e.g. the Green Mamba, Forest Cobra and the Kaimosi Blind Snake.

This forest is a habitat for over 350 species of birds (Brooks et al., 1999) which include the Great Blue Turaco, Black billed Turaco, Jamesons Wattle eyed and Blue headed Bee eater, with two endemic bird species that are restricted to Kakamega forest like Ansorges
Greenbul and Grey chested Illadopsis. The forest has some of the most conspicuous species of primates like the Debrazzas Monkey, the wild pig, tree pangolin and mongoose.

3.1.7 Management Status
Kakamega forest boundary was established between 1908-1910 but later on modified between 1929-1932, the management during this period was by the village elders until the time when the Forests Department took over (Mitchell, 2004), it was later gazette in 1933 and declared a Central Forest in 1964 (Blackett, 1994). Some parts of the forest were established and gazette in 1967 that is Isecheno, Kisere and Yala reserves, Buyangu was gazette in 1986 when the forest went under the management of Wildlife Reserve.

3.1.8 Population and Human Impact
Kakamega forest is in Kakamega County which is one of the densely populated counties (Blackett, 1994). The population was widely spread in the forest up to the time when the it was gazette though it has still in the long term it has been affected by human activities (Wass, 1995). Communities adjacent to the forest extract various products from the forest like gold, honey, medicinal plants and charcoal as well as using the forest land for farming and grazing of animals (Kokwaro, 1988; Mitchell, 2004). The main crops that are grown include maize which forms a staple meal for most parts of the western region, tea and sugarcane.

Fragmentation has disturbed and selective cutting of trees in Kakamega forest led to the modification of the ecosystem processes and interfered with the density and availability of the plants and animal diversity (Tsingalia, 1990; Bleher et al.; 2006; Farwig et al., 2007). In 1930 there was a gold rush that facilitated commercial logging for the pit props required logs and fuel wood requirements were also high (Mitchell, 2004). Timber extraction was done by sawmills after they were given licenses in 1933, both clear cutting and selective cutting was carried out. Clear cutting was to create more space for the fast-growing exotic trees, settlement as well for tea farming that was carried out by the colonial government (Bleher et al., 2006). Selective cutting went on till mid 1980s when there was a presidential Decree that banned the exploitation of indigenous trees but clear cutting was stopped in 1975 (Mitchell, 2004). The size of Kakamega forest in hectares for the period between 1933 and 2001 is shown in Table 3.1.
Table 3.1: Kakamega Forest main Block and Fragments in 1933 and 2001

<table>
<thead>
<tr>
<th>Main Forest Block</th>
<th>Area in (Ha) in 1933</th>
<th>Area in (Ha) in 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malava block</td>
<td>703</td>
<td>190</td>
</tr>
<tr>
<td>Kisereblock</td>
<td>458</td>
<td>420</td>
</tr>
<tr>
<td>Kakamega Main Forest Block</td>
<td>26632</td>
<td>8537</td>
</tr>
<tr>
<td>Ikuywa block</td>
<td></td>
<td>1370</td>
</tr>
<tr>
<td>Yala block</td>
<td></td>
<td>1199</td>
</tr>
<tr>
<td>Kaimosi block</td>
<td></td>
<td>132</td>
</tr>
</tbody>
</table>

(Source: Biota East-Phase 1 Final Report, 2004)
CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction
The research methodology provides details on the area of study, the target population, sampling method, the tools of data collection that were used and how the data was analyzed. Participatory approach known as Participatory Rural Approach (PRA) was used in this study because it is widely used and advocated as a strategy for development in the rural areas and in management of natural resources (Chambers and Guijt, 1995). Participatory approach recognizes that it is critical when a research is conducted a local context where differences in land, labor and market are in constant change as the technological solutions to the problems in the forest may also be affected. It involved the forest support groups adjacent to the forest, households engaged in activities in and around the forest, the local government officials and researchers.

4.2 Research Design
Research design is an outline for conducting a study with maximum control over factors that may interfere with the credibility of the results (Burns and Grove, 2003). This study adopted descriptive research which gives a picture of a situation as it occurs without any interference. It targeted the local households adjacent to the forest that extract products from the forest, factors that influence the extraction and the effect of extracting these products on the forest ecosystem. The data was collected by interviews using structured questionnaires, key informant discussions and focus group discussions, analysis was done using descriptive and inferential statistics.

4.3 Target Population
The target population were the households adjacent to the forest from the edge to a radius of 10 kilometers away from the forest. The unit of analysis was the household. The target for the interview as the household heads where the father was present but in the absence of the household head the mother was interviewed using a structured questionnaire. 96 households were selected and interviewed, focus group discussions were also carried out with some of the leaders from the Community Forest Associations since they have decentralized their functions to the different forest fragments. Key informant people who
were officers from the forest departments that is KFS and KWS provided information also as they are the one in charge of the management of the forest.

4.4 Sources of Data
The study was to assess the bio economic values of the rainforest in Kenya and the associated human impacts using information collected from primary and secondary. Secondary sources included existing reports, official records, working papers from conferences, books and research papers by scholars on the study topic that have been documented. Primary data was collected through household questionnaire surveys, focus group discussions and key informant interviews.

4.5 Sampling Techniques and Sample Size

4.5.1 Sampling
This study used data that was collected from households around Kakamega forest which has five management sectors namely the main Block in Kakamega Zone under KFS; Buyangu in Kakamega District under KWS; Kibiri and Yala under under KFS; Malava Reserve under KFS and Bunyala Forest Reserve under KFS. Each sector has several households of varying household populations.

Multistage sampling technique was used to select a representative sample from the population for interviews as the five sectors were selected purposively depending on the management regime of the forest. A list of all villages was obtained with the help of the local administrators that is location heads, village heads and forest extension officers. There was a total of 17 villages Kakamega Zone had five villages, Buyangu three villages, Kibiri and Yala four villages, Malava three villages and Bunyala two villages. The villages were clustered in two categories based on the proximity to the forest; five villages one from each forest zone close to the forest was selected randomly (distance of 0-5 kilometers) while the other five one selected from each forest zone were far from the forest (distance of 6-10 kilometers). A total of ten villages were drawn with the help of the prospective village leaders who work closely with the forest conservation groups, their names were availed to me from the forester office in each respective forest fragment. The names availed from the forester’s office for the selected villages were selected randomly to arrive at the samples size of 96 households. In Kakamega zone 30
respondents were interviewed since it had the highest number of villages, Buyangu 18
respondents, Kibiri and Yala, Malava and Bunyala each provided a sample of 16
respondents.

4.6 Data Collection

4.6.1 Questionnaires
Data collection was done using structured questionnaires which were administered by the
researcher with assistance of few trained enumerators. The researcher targeted the
household head, village leaders and some of the forest department officers from Kenya
Wildlife Service and Kenya Forest Service. Training was done to some of the village
leaders so that they could assist in collecting data.

4.6.2 Focus Group Discussions
This comprised 18 village members in two groups of nine members who were active
members in the Community Forest Associations who had an interactive session with the
researcher and indicated good knowledge of the forest ecosystem utilization. They
participated in various activities attached to the forest and they had rich knowledge on
most of the forest products that were extracted from the forest, factors that influenced the
extraction and the effects on the forest ecosystem.

4.6.3 Key Informant Interviews
This comprised of chiefs, village leaders and some of the forest officers from KWS and
KFS. They were involved in gathering information because they are well versed with
knowledge on the forest and forest products

4.7 Data Analysis
Data from the 96 questionnaires that were administered, key informant interviews and
focus group discussions collected from the field was coded and entered into SPSS. The
data was analyzed using descriptive statistics like percentages to show the number of
respondents that extract products from the forest, the demographic characteristics and the
level of education of the respondents. Data means, cross tabulation and frequencies were
used to show the distribution of the respondents in the various occupations. The
relationship between human activities and their impact on the forest ecosystem was tested
using Chi square, the analyzed data was presented using pie charts, tables and bar graphs.
CHAPTER FIVE: RESULTS AND DISCUSSIONS

5.0 Results

5.1 Introduction
Forests play a key role in human welfare as they benefit the country at large as well as the adjacent communities which in most cases depend on the forest for their livelihood. This chapter provides a summary of the results and discussions on the findings on the products that are extracted from Kakamega forest, the factors that influence their exploitation and the human impact of extracting the forest products on the forest ecosystem.

5.1.1 Gender of the Respondents
A total of 96 respondents were interviewed from the total population who were distributed in terms of gender, 56% were female and 44% were male (Figure 5.1).

![Gender of Respondents](image)

**Figure 3.1: Gender of Respondents**  
(Source: Researcher, 2017)

5.1.2 Age of the Respondents
With regards to age, the largest population of individuals who extracted products from the forest was in the category of 21-50 years. Those that are less than 21 years were not involved much in extraction of forest products because they do not have time as they are still in school though a few of them who have dropped out of school also participate in the extraction of forest products for their livelihood (Figure 5.2).
5.1.3 Education Level

In terms of education almost all the respondents interviewed had some formal education. Of the respondents interviewed 38% had attained primary education, 45% secondary education, 13% had attained tertiary education and 5% did not have any formal education. However, it was noted that a majority of the community members had not attain tertiary education while others who had gone up to secondary level had not finished but dropped out so as to get involved in activities that generate income for their livelihood Table 5.1.

Table 5.1: Level of Education

<table>
<thead>
<tr>
<th>Level of education</th>
<th>Frequency</th>
<th>Percentage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>5</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Primary school</td>
<td>36</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Secondary school</td>
<td>43</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Tertiary institutions</td>
<td>12</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>96</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Researcher, 2017)
5.1.4 Mode of Acquisition of the Land by the Respondents

Most of the respondents were living on ancestral land because it was inherited with most of them about 72% having title deeds to the land, 95% of those that had bought land had acquired title deeds. It is clear from the data collected that most of the respondents are living on inherited land as compared to those that have bought land with a few carrying out their agricultural activities on rented land (Table 5.2). The land available will not be enough with time for the residents as the population increases, which may lead to the encroachment into the forest land.

Table 5.2: Mode of Acquisition of the Land by the Respondents

<table>
<thead>
<tr>
<th>What is the tenure status of your land?</th>
<th>Mode of acquisition of land.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>With title</td>
<td>Bought</td>
<td>Gift</td>
</tr>
<tr>
<td>23</td>
<td>0</td>
<td>50</td>
</tr>
<tr>
<td>95.8%</td>
<td>0.0%</td>
<td>72.5%</td>
</tr>
<tr>
<td>Without title</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>0.0%</td>
<td>100.0%</td>
<td>24.6%</td>
</tr>
<tr>
<td>Rented</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4.2%</td>
<td>0.0%</td>
<td>2.9%</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

(Source: Researcher, 2017)

5.2 Products Extracted from Kakamega Forest

Findings from the field indicated that most of the households adjacent to the forest benefited from it. They utilized a variety of products from the forest which included both timber and non-timber products (Figure 5.3).

Other forest products that are utilized from the forest include fuel wood, herbal medicine, charcoal timber for building and making furniture, poles and fodder. These forest products are mainly for home use though some households use them as a source of livelihood income sources.
5.2.1 Source of Household Energy

Fuel wood is used as the main source of energy by most of the households. Other sources of energy include charcoal, kerosene, biogas and gas. Extraction of fuel wood and charcoal are the main contributors of deforestation because they form the main source of energy for the adjacent communities to the forest which interferes with the forest ecosystem (Figure 5.4).

![Bar chart showing source of household energy](source: Researcher, 2017)
The devices used for cooking indicate that majority of the community members use traditional three stones with fuel wood being the main source of energy. This is followed by traditional charcoal cooking stove (jikos) and then energy saving jiko that are used by some households. The least used cooking device is the gas cooker, electric cooker and biogas digester which were only found in a few of the households. Some households combine either wood fuel with charcoal or charcoal with gas for cooking.

5.2.2 Measures on the Extraction of the Forest Products
There are existing formal measures on the extraction of the forest products. Some of the formal measures include government restriction at 52% and community restriction at 35% Table 5.3. Some of the existing informal measures include community restriction at 26%, government restriction at 9%, cutting trees require permission/permit at 12% and trees along the river bed are government property they should not be cut at 7%. Some of the penalties/punishment for violation of these rules include, payment of fine, planting a given number of trees and ex-communication.

Table 5.3: Existing Formal Measures on Forest Utilization

<table>
<thead>
<tr>
<th>Existing formal measures on forest utilization</th>
<th>%</th>
<th>Responsibility of formulation</th>
<th>%</th>
<th>Penalties</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government restriction</td>
<td>52</td>
<td>Government</td>
<td>59</td>
<td>Pay fine</td>
<td>90</td>
</tr>
<tr>
<td>Community restriction</td>
<td>35</td>
<td>Community</td>
<td>30</td>
<td>Excommunications</td>
<td>6</td>
</tr>
<tr>
<td>Cutting trees require permission/permit</td>
<td>11</td>
<td>Tradition/Culture</td>
<td>11</td>
<td>Plant a given number of trees</td>
<td>4</td>
</tr>
<tr>
<td>Trees along the river bed are government property they should not be cut</td>
<td>2</td>
<td>Jail</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source: Researcher, 2017)

5.2.3 Forest Cover Change
Majority of the respondents at 83% agreed that forest cover is decreasing, 8% were for the opinion that the forest cover has increased while 9% said the forest cover had not changed at all. Some of the factors that were cited for the decrease/no change include population change, education and training by organizations, inadequate land for cultivation, traditional norms and poor management while education and training by organizations was cited for increased forest cover. All these factors have either increased
or decreased the harvesting of forest products. The ones that have increased the forest cover include education and training, awareness campaigns, behavioral change among others as shown in Figure 5.5.

![Figure 5.5: Factors that have Contributed to Increased Forest Cover](Source: Researcher, 2017)

### 5.2.4 Community Role in Forest Use

According to 94% of the respondents the community has played a key role in the management and conservation of forest. Some of the roles that the community has played include tree nursery management at 33%, reforestation at 24% and control charcoal burning at 14% among others as shown in Figure 5.6.

![Figure 5.6: Community Roles in Forest Management and Conservation](Source: Researcher, 2017)
5.2.5 Management and Conservation of Forest Resources

Respondents had different opinions on the participation of the organizations, Kenya Wildlife Service and Kenya Forest Service in the management and conservation of the forest. There are different organizations /departments that are involved in the management and conservation of the forest with KWS and KFS forming the major two organizations each managing a different block of the Kakamega forest. Other organizations like NGOs, NEMA, and CFAs also play a key role in the management and conservation of the forest as shown in Figure 5.7. According to the respondents each organization has a specific role that it plays in the management of the forests. According to the respondents, NGOs participate in capacity building, KWS in monitoring and protecting of wildlife and their habitats, KFS in conservation; CFAs participate in tree planting while the local authority participates in lobbying.
Figure 5.7: Respondents Opinion on the Organization/Department Participation in Forest Conservation and Management

(Source: Researcher, 2017)

Majority of the respondents rated the organizations role in forest management and conservation to be just satisfactory apart from the NGOs which were said to be working well. KFS was the leading with 68%, NEMA 63%, KWS and local authority having 54%, CFAs 52% and NGOs had 47% (Figure 5.7).

The respondents’ rating on whether the organizations were working well are as follows: NGOs at 49% followed by CFAs and KWS at 33%, Local authority at 28%, NEMA at 21% and KFS at 16%. Some of the respondents rated the organizations and the forest departments to be totally ineffective, 10% for the KFS followed by CFAs at 8% and
Local authorities forming 2%, NEMA, KWS and NGOs were rated to be totally ineffective by any of the respondents. One percent of the sample population rated KFS to be working very well followed by local authority in charge of the private forests and NGOs 2%, CFAs 3%, NEMA 5% and KWS 8%. Finally, 14% of the total respondents rated the role of the local authority as not satisfactory followed by NEMA 12%, KFS 5%, KWS 4%, CFAs 3% and NGOs 2%.

**Figure 5.8: Respondents Rating on Organization/Department Role in Forest Conservation and Management**

(Source: Researcher, 2017)

5.3 Factors that Influence the Utilization of Products from Kakamega Forest

5.3.1 Resource Endowment of the Household and Level of Education

Education level plays a key role in the utilization of products from the forest. The community members who have attained higher education use gas cooker for cooking and heating and electricity for lighting. The less educated and those that have no formal
education utilized most of the forest products to earn their livelihood. Wood fuels being their main source of energy for most of the households for cooking, the enlightened people in the society have enough resources that they can use in acquiring other alternative sources of energy as well as income for their livelihood as compared to the people with no formal education.

![Education Level of the Household Respondents and Utilization of Forest Products](image)

**Figure 5.9: Education Level of the Household Respondents and Utilization of Forest Products**

(Source: Researcher, 2017)

5.3.2 Demographic and Economical Characteristics

Approximately 47 percent of the households that filled questionnaires had families with less than five household members, 46 percent with less than ten family members but more than six. Only 6 percent of the respondents had a family household of between 11-15 members and 1% of the respondents had a household of more than 15 household members. The social and economic characteristics of the respondents that were interviewed were different as it was observed that households many family members utilized more products than families that had less family members.
Farmers formed 54 % of the total respondents while 24% were business people in different business activities ranging from agro business, shop keeping, carpentry work and masonry. There were students who were respondents and they form 6% of the total population while 14% were employed either by the government or in the private sector like teachers and civil servants. The farmers formed a larger population of the community’s main beneficiaries of products from the forest followed by the businessmen like carpenters who get their raw materials from the forest. Some of the farmers get fodder from the forest and others take in their livestock for grazing. Population increase in the adjacent areas has made some farmers to encroach onto the forest so as to produce enough food for the growing population as evidenced in some parts of the Kibiri block of the Kakamega forest where food crops have been planted in the forest Table 5.10.

![Forest product utilization by various occupations](image)

**Figure 5.10: Forest Product Utilization by Various Occupation**

(Source: Researcher, 2017)

5.3.3 Proximity to the Forest

The distance from the forest determined the frequency of collecting forest products from the forest. Households that are within a radius of 5km from the forest collected more timber, wood fuel, charcoal burning and medicinal herbs. This is attributed to the short distance that is covered by these households to the forest as compared to the households that are far away from the forest that is 6km and more. In the findings the nearer the household to the forest the more products are utilized, the further a household is from the
forest the less products are utilized because of the time that is to be used and the long distance that is to be covered.

Figure 5.11: Distance from the Forest and Utilization of Products
(Source: Researcher, 2017)

5.4 Impact of Human Activities on the Availability of the Forest Products from Kakamega Forest

According to the respondents that live adjacent to the forest, 83% noted that there has been reduction in the availability of forest products, 22% said that the forest cover has increased with 1% having the opinion that there has not been any change in forest cover in Kakamega forest. The decline in availability was noted as having been occasioned by population increase which has led to encroachment into forest land, inadequate land for cultivation and laxity by the forest departments on enforcement of laws that govern the forest. Twenty-two percent linked the forest cover increase to community protection, government protection, individual resolutions to abide by rules, education and training by different organizations on forest management and conservation. Figure 5.12 shows the impacts on utilization of products from Kakamega forest.
Figure 5.12: Impacts of Utilizing Products from the Forests on the Forest Ecosystem
(Source: Researcher, 2017)

5.5 Hypothesis Testing

H3: There was no significant relationship between extraction of forest products and the change on the Kakamega forest ecosystem

Human activities influence the availability of forest products, extraction of the forest products while conserving the forest ensures there is continuity of the products but overexploitation reduces the availability of the products from the forest as the ecosystem is disturbed. Evaluation was done on the responses from the respondents on how human activities influence the availability of products from the forest using Chi square test with a significant level of 0.005. The P value was less than the significant level $X_1 (1) = 85.016^a$, $P=0.000$ which indicate that there is a relationship between human activities and the availability of forest products. Table 5.4 shows the Chi square calculation on the relationship between human activities and the availability of forest products, a reduction in the trees through logging directly reduces the products available for utilization.
Table 5.4: Chi Square test on Human Activities and Availability of Forest Products

<table>
<thead>
<tr>
<th>Chi-Square Tests</th>
<th>Value</th>
<th>df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>85.016</td>
<td>8</td>
<td>.000</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>69.135</td>
<td>8</td>
<td>.000</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>7.830</td>
<td>1</td>
<td>.005</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>96</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. 12 cells (80.0%) have expected count less than 5. The minimum expected count is .08.

5.6 Discussions

Most of the rural households that live within or adjacent to the forest entirely depend on the forest to meet their daily needs. Over 90% of the households depend on the forest for their energy requirements because of their high poverty levels (Jumbe et al., 2008). According to Nambiro (2000) most of the households adjacent to Kakamega forest rely on the forest for their livelihood because of the high poverty levels. The products extracted from the forest are diversified varying from fuel wood, charcoal, medicinal herbs, timber, fodder, poles, and building and furniture materials. Building materials like timber, thatching grass and bamboo are collected and used for the floor and roofs. Most of the communities adjacent to the forest are poor and they depend on the medicinal herbs they collect from the forest for curing and prevention of diseases as they lack access to adequate healthcare facilities (Yusuf et al. 2010). The medicinal plants include (Mellia Azedarach L) muarubaini (Searsia natalensis) Busangula, and mirembe (Erythrina abyssinica DC) which are believed to cure many diseases (Maroyi, 2013). Some of the households also collect food from the forest like edible leaves, mushrooms, honey, fodder, game meat and seasonal wild fruits that they consume. Increase in population has led to the diversification of products that are extracted from the forest as noted by Mogaka et al (2001). The main products found to be utilized by the local communities adjacent to the forest are fuel wood, charcoal, medicinal herbs, timber, fodder, poles, and furniture and building materials.
Most of the households adjacent and within Kakamega forest own very small farm plots which are either inherited or bought on which they grow staple food crops like maize, beans and cassava. They have their own designated boundaries that have been discussed amongst themselves though they are not official, the community members do not collect products from where they have been restricted; they respect their neighbors. Some of the households have kept domestic animals like cattle for milk and oxen which is used for ploughing. The high population around Kakamega forest has led to the encroachment to the forest land to create more room for settlement and agricultural land so as to sustain the ballooning population (Mars Group Kenya, 2010).

In households around Kakamega forest fuel wood forms the main source of energy to the households which has made its extraction to be extremely high. Studies in other rural set ups in Kenya have recorded similar utilization of fuel wood exerting high demand on the forest ecosystem (Jarstorf, 2004; Githiomi, 2010). All the respondents interviewed around Kakamega forest use fuel wood for cooking and lighting and the collection is set to increase with an increase in population. Fuel wood forms an important non-commercial source of energy to the adjacent /local communities to the forests which makes it to be extracted more (Kiplagat, 2007). The reasons for using fuel wood rather than alternative sources of energy were lack of access to alternative sources of energy, smoke from fuel wood is used for heating, lighting, drying cereals they keep as their seedlings and nearness of the forest from their homes

Existing formal measures on the conservation of the forest tend to be ineffective in ensuring the continuity in the availability of products from the forest. The Kenya Forest Service allows the offenders who overexploit the forest to pay fines thus encouraging the local communities to extract the products so long as they can pay the penalty which has led to overexploitation. The results indicate that there has been a reduction in the forest cover with time as was noted from the sample population; majority of the respondents at 83% agreed that the forest cover has reduced which is a confirmation to the thoughts of alarm on the over extraction of products from Kakamega forest through human activities some of which are done illegally (Fashing et al 2004). The forest is currently exposed to threats of overexploitation due to uncontrolled charcoal burning, collection of medicinal
plants, hunting, illegal pit sawing, collection of fuel wood and fodder for domestic animals (Mitchelle, 2004). The results agree with the findings in the study as there are many activities that take place within the forest in the process of extracting the products that lead to overexploitation. This is in line with findings by Anon, (2006) who found out that tropical forests are reducing at the rate of 5% every ten years as they are cleared and logged to supply wood and non-wood products as well as cattle agricultural produce to the local, regional and global markets.

The community plays a key role in the utilization of products from the forest. As noted from the findings the community participates in public awareness, tree planting and reforestation, tree nursery management and monitoring and reporting of illegal activities. Their main objective of these activities is to create employment, reduce poverty and improve the livelihoods of the communities around the forest to ensure sustainable use of the products from the forest. This has been done through Participatory Forest Management which has been used widely by most of the developing countries in managing forest resources (Willy and Mbaya 2001; Agrawal et al, 2008; Koech et al, 2009; Mbuvi et al, 2009). Participatory Forest Management has been adopted by the communities around Kakamega forest that has assisted to some extend on the forest conservation though their main aim is to improve their livelihoods.

Most natural forests in many countries are predominantly administered or owned by the state (Katsigiris et al., 2004) although some of them may be owned by the clans. In Kakamega forest management is done by different organizations/departments with NGOs and KWS emerging to be working well towards the conservation of the forest as compared to KFS. The areas managed by KWS tend to have a dense forest cover and more protected as compared to the areas that are under KFS. There is no human activity that is allowed in areas under KWS unlike areas under KFS where the local households are allowed to access the forest products so long as they have a permit. KWS has a framework that does not allow extraction of products from the forest while KFS allows extraction of products from the forest.

Springate-Bainski et al (2012) maintains that there is a relationship between education and the use of various sources of energy in that when a person is educated, he has
information on different alternative sources of energy than a person who is not educated. The results in Table 4 indicate that though most of the respondents have formal education majority did not further their studies to tertiary level. The dropout rate at secondary level is high which makes most of them to turn to the forest as a source of their livelihood. Tortop (2012) found that education creates awareness to people on the importance of using other alternative sources for cooking and heating rather than using wood energy all the time.

Variations were noted in the economic and demographic characteristics of the respondents that were interviewed. These variations would have a great influence on the utilization of products from the forest (Koenig et al, 2011; Rodriguez et al, 2011). Results indicated that the extraction of forest products was also influenced by the type of occupation of the household members that live adjacent to the forest. Farmers formed the highest number of households that are adjacent to the forest thus they extracted more products from the forest than those that carry out other economic activities or are in formal employment.

A higher income leads to a positive effect on the forest as fewer products will be extracted but in Kakamega forest most of low education level has led to low incomes thus more products are extracted from the forest. This contrast with the findings of Hedge and Enters (2000) that the higher income households use more forest resources as compared to the low-income households where there are restrictions but it agrees with the studies by (Wambua, 2008; Shakleton and Shakleton, 2006; Sanders and Zellar, 2004) which suggest that as the income increase the dependence on forest products reduces. The families with few members also tend to extract fewer products from the forest unlike the large families. It was noted that the distance between the forest and market to the households’ homes also influenced the exploitation of the resources from the forest. Households within a short distance to the forest and far away from the market preferred using fuel wood rather than going for the kerosene or other sources of energy from the market. On the other hand, families that are far away from the forest and near the market prefer to use alternative sources of energy from the market.
There is close relationship between the human activities in the forest with the availability of products that are extracted from the forest. This is in line with Sala *et al*, (2000) who noted that deforestation has a great impact on the forest biodiversity especially in the tropical forests which tend to have a unique diversity. Charcoal burning has interfered with the tree species in a given part of the forest. Logging has led to the exposure of the land adjacent to the forest as well as within the forest to agents of erosion which has resulted to flooding on the lower courses of the rivers and streams that pass through the forests because the water sheds can no longer sustain and regulate water flows. This is in agreement with Chomitz *et al* (2007) findings that logging causes a faster response of stream flows to rainfall and thus potential flash flooding.

Respondents noted that the reduction in forest cover due to logging had increased with an increase in population. The trees play a key role because they are form the forests and all the benefits and products from the forest are attached to the trees. Reduction in forest cover in some of the place around the forest blocks has led to reduction in the fire wood by 83 percent that used to be available for collection by the households, herbs have reduced as some of the herbal plants are cut, lack of poles and timber, declining water sources and destruction of wild animals habitats which has resulted to their migration to other areas that they can survive. Upward population growth has increased harvesting of the forest products like firewood, logs and electric poles just to mention a few that reduce the forest cover thus affecting the water tower for most of the residents in Kakamega.
CHAPTER SIX: SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary of findings

Most of the households adjacent to the forest benefit from it and the number decrease with an increase in distance away from the forest. The products extracted are of a wide range from wood fuel, charcoal, timber, cattle fodder, wild fruits, medicinal plants and honey. Some of these products are the main source of income to the households that were interviewed besides small-scale farming that is practiced by some of the households. The benefits from the forest have made the Community Based Organizations (CBO) to come up with various programs to ensure that extraction of forest products is made sustainable for example by raising and selling of tree seedlings to ensure that the trees that are cut are replaced, bee keeping, community surveillance of forest threats, selling medicinal plants, environmental education programs and reforestation together with agro forestry in the surrounding areas.

In some blocks of the forest like Isecheno the forest department is supporting the activities of the CBOs by providing land on which the activities are carried out. However, these activities have not been economically viable thus there is continued overexploitation of the products from the forest. Crop cultivation is carried out by most of the households adjacent to the forest as it forms the main human economic activity to the households. The main crops grown include beans, potatoes and maize though some of the farmers practice mixed farming as well. The land owned by most of these households is small which has made them to encroach into the forest land thus reducing forest cover which has reduced the forest products that the communities adjacent to the forest used to utilize.

Most of the respondents between ages 31-40 are involved in the collection of products from Kakamega forest. The occupation of the respondents determines the intensity of utilizing products from the forest, respondents who are in formal employment use less forest products as compared to the respondents who are involved in informal employment. The distance from the market to a lesser extent also influences the collection of products from the forest.
6.2 Conclusion

There are numerous products that are extracted from the forests as indicated in this study, it is also clear that forests support the rural households living adjacent or within the forest by providing various products like fuel wood, charcoal, timber fodder and medicinal herbs. Among other products. The income earned from the sale of forest products supplements the households’ income from agriculture. Among the various human activities logging has had a greater impact on the forests as it directly reduces the forest cover which in turn reduces the availability of products from the forest. The extraction of the products is due to the short distance between the forest and the households homestead, low income levels due to poverty as well as low level of education among other factors. There has been a reduction in the availability of products from the forest which in turn has affected the surrounding communities that depend on the forest. Measures have been put in place so as to ensure that there is sustainable utilization of products from Kakamega forest. It is recommended that stakeholders should come up with programs that promote agricultural produce together with education to help reduce overreliance by the households on forest products.

6.3 Recommendations

1. Setting up programs that support agricultural production to increase the quantity of food for the growing population by improving the quality of the already available farms

2. Forest management programs aiming at harvesting of forest products so as to increase productivity of the forest products and minimize the damages to the forest resources through activities like a forestation

3. Intensive research to be done on how the forest can be used sustainably which can be done by encouraging many researchers to venture in forest research and trainings to protect the forests from overexploitation

4. Inclusive dialogue with the local stakeholders i.e. the communities that depend on the forest for their livelihood should be incorporated into forest governance structures
5. Increase understanding on the importance of forest products and biodiversity through seminars and trainings

6. Training, publications, conducting workshops and providing experts and technical officers to help the local communities as well as the country to maximize the positive contributions of forest products and reinforce their capacity to assess and mitigate negative environmental impacts of the forest activities and policies.
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APPENDICES

Appendix 1: Household Questionnaire

An assessment of the benefits of Kakamega Rainforest and the associated human impact on the forest ecosystem.

Dear Sir/Madam,

This questionnaire has been designed as part of an academic study to assess the extraction of products from Kakamega forest and the associated human impact on the forest ecosystem. The questionnaire attempts to gather information on the extraction of products from Kakamega forest and the human impact on the availability of forest resources.

You have been selected to participate in this study and your contribution is important. Kindly answer each of the questions to the best of your ability. You are assured that the information provided will be treated with confidentiality and be applied for academic purposes only. Be assured as well that any images or photographs captured and obtained during this fieldwork are only to serve none other than academic purposes.

The term forest product for the purpose of this study is explained as any material derived from a forest for direct or indirect consumption or commercial use such as lumber, paper and forage for livestock.

Thank you

Pauline Mutaki
Department of Geography and Environmental Studies
College of Humanities and Social Sciences
University of Nairobi
Research Student
pnafula@gmail.com
Section 1: Household Demographic and socioeconomic information

Kindly tick as appropriate in the boxes and write where you have been asked to

Date __/__/2016

1. Gender of the respondent
   Female □□□□ □□ Male □□□□

2. Age of the Respondent
   Less than 20 yrs. □□□□ □□□□ □□ 21-30 yrs □□□□ □□ 31-40yrs □□□□ □□
   41-50yrs □□□□ □□ 51-60yrs □□□□ □□ above 60 yrs. □□□□ □□

3. Educational level of the household respondent
   None □□□□ □□ Primary □□□□ □□□□ Secondary □□□□ □□□□ Tertiary □□□□ □□

4. Area of Permanent Residence
   District___________________
   Division___________________
   Location___________________
   Sub location/Village__________

5. Occupation of the Respondent
   Employed □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□
   Business □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□
   Others □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□□□ □□
   If others specify_____________________________________________________

   What is your main source of income? _________________________________

6. Number of household members_______________________________________

Section B: Forest Product Use

<table>
<thead>
<tr>
<th>Does your household use the following forest products?</th>
<th>What is the main source of the product? Select types of sources from option (a) below this table</th>
<th>If source of product is forest, approximately how far in KM is it from homestead?</th>
<th>What is the purpose of the product? Select types of products from option (b) below this table</th>
<th>What is the means of transport for the product from the source to your home/sale point? Select types of transport from option (c) below this table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel wood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charcoal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicinal herbs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timber</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Option (a): Source 1= Own land/farmland 2= Government forest 3=Market 4=Private lands 5=Community Forest

Option (b): Purpose 1=Home use 2=Sale 3=both

Option (c): Means of Transport 1= Walking 2=Bicycle 3=Cart 4=Motorbike 5=Vehicle

Indicate your source of energy for cooking.

<table>
<thead>
<tr>
<th>Fuel wood</th>
<th>Liquid Gas</th>
<th>Kerosene</th>
<th>Biogas</th>
<th>Others specify</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Which cooking device do you use in the house?

<table>
<thead>
<tr>
<th>Traditional three stone</th>
<th>Traditional Jiko</th>
<th>Gas cooker</th>
<th>Energy saving Jiko</th>
<th>Electric Cooker</th>
<th>Bio gas digester</th>
<th>Any other Specify</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please indicate your schedule of collecting forest products from Kakamega forest.

<table>
<thead>
<tr>
<th>Forest product</th>
<th>Trips per month</th>
<th>Time spent per trip in hours</th>
<th>Household member involved. Select numerical according to the code below this table</th>
<th>For how many months were the forest products collected for the last six months?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poles</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timber</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boat material</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicinal plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

|                         | 1 2 3 4         |                              |                                                                                  |                                                                                  |
|                         |                 |                              |                                                                                  |                                                                                  |
### Section 3: Measures on the utilization of the forest products

<table>
<thead>
<tr>
<th>What are the existing formal measures? Select numerical according to option (a) below this table</th>
<th>Who is responsible for the formulation of the rules? Select numerical according to option (b) below this table</th>
<th>What are the punishment/penalties for violation of the rules? Select numerical according to option (c) below this table</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
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<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Option (a): Rules 1= Government restriction 2= Community restriction 3= Cutting trees requires permission/permit 4= Trees along the river bed are government property they should not be cut 5= other (specify)

Option (b): Responsibility for formulation of the rules 1= Government 2= Community 3= Tradition/culture 4= other (specify)

Option (c): Penalties 1= Pay fine 2= Ex-communication 3= Plant a given number of trees 4= Jail 5= other (specify)

### 2. Informal Rules

<table>
<thead>
<tr>
<th>What are the existing informal measures? Select numerical according to option (a) below this table</th>
<th>Who is responsible for the formulation of the measures? Select numerical according to option (b) below this table</th>
<th>What is the punishment/penalties for violation of the rules? Select numerical according to option (c) below this table</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
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<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Codes for household members 1= Head 2= Spouse 3= Sons / Daughters 4= Hired Worker
Option (a): Rules

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

1. Rules 1= Government restriction  2=Community restriction  3=Cutting trees requires permission/permit  4=Trees along the river bed are government property they should not be cut  5=other (specify)

Option (b): Responsibility for formulation of the rules

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
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<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

1. Responsibility for formulation of the rules 1=Government  2=Community  3=Tradition/culture  4=other (specify)

Option (c): Penalties

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
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</tr>
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<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

1. Penalties 1=Pay fine  2=Ex-communication  3=Plant a given number of trees  4=Jail  5=other (specify)

3. Have there been challenges with obedience to these measures?  Yes   No

4. What challenges does your household face?  ________________________________
   ____________________________________________________________

Section 4: Forest products availability

1. What has been the general trend in forest products on the forestland in this area?
   Increased _____  Declined __________  No change__________

2. What factors in your view have contributed to the mentioned above? Select from the options given below by giving a tick.
   a. Education and training by organizations
   b. Population change
   c. Inadequate land for cultivation
   d. Traditional norms
e. Community protection
f. Individual resolutions to abide by rules
g. Government protection

3. If your option for question one is declined, has it affected your livelihood?
   Yes No

4. How has this impacted your livelihood? Select an option from the ones given below.
   a. Lack of firewood
   b. Lack of herbs
   c. Lack of poles and timber
   d. Declining water sources
   e. Other (specify)

5. Have any plans been developed to reverse the effect?
   Yes No

6. If yes, select from the options given below on what has been done?
   a. Education and training
   b. Awareness campaigns
   c. Behavioral change
   d. Micro credit loan
   e. Organization campaigns for collective action
   f. Other (specify)

7. Have these plans in question (6) above been implemented?
   Yes No

8. If yes, have they made changes in the forest products?
   Yes No

Section 5: Community role in forest use

1. Has the community played any role in forest trends described in part (4) above?
   Yes No

2. If yes, choose one of the main roles played by the community.
   a. Control logging
   b. Control charcoal burning
c. Report fire outbreaks
d. Reforestation
e. Tree nursery management
f. Monitoring and reporting illegal activities
g. Other (specify)

Section 6: management and conservation of forest resources

1. What is your opinion about the following organizations /departments participating in the management of forests?

<table>
<thead>
<tr>
<th>Type of organization</th>
<th>Role in forest management. Select one of the following with their meaning as shown below this table</th>
<th>What is your opinion about their role in the management of forests? Select one of the following with their meaning as shown below this table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest Department/KFS</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>NEMA</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>KWS</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Local Authority</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>NGOs</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Community Forest Associations</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Other (specify)</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Role 1= Lobbying 2= Conservation 3= Capacity building 4= Monitoring 5= Tree planting 6= Awareness campaigns 7= other (specify)

Opinion 1= Working very well 2= Working well 3= Just satisfactory 4= Not satisfactory 5= totally ineffective

Section 7: Land use and food security

1. How many acres of total land holding do your household own under
   a. Crops ______________
   b. Grazing ______________
   c. Trees ______________
   d. Idle /unused __________
   e. What is the tenure status of your land? Select an option from the given below.
f. Give the mode of acquisition of your land. Select from the options given below

1= Bought 2= Gift 3= Inherited 4= Rented in 5= other (specify)
Appendix II: NACOSTI Research Authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471, 2241349, 3310571, 2219420
Fax: +254-20-318245, 318249
Email: dg@nacosti.go.ke
Website: www.nacosti.go.ke
When replying please quote

Ref: No. NACOSTI/P/18/74637/24631

Date 11th September, 2018

Pauline Nafula Mutuki
University of Nairobi
P.O. Box 30197-00100
NAIROBI

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on “An assessment of bio economic values of Kakamega Rain-Forest and associated human impact, Kakamega County, Kenya” I am pleased to inform you that you have been authorized to undertake research in Kakamega County for the period ending 11th September, 2019.

You are advised to report to the County Commissioner and the County Director of Education, Kakamega County before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit a copy of the final research report to the Commission within one year of completion. The soft copy of the same should be submitted through the Online Research Information System.

DR. STEPHEN K. KIBIRU, PhD.
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kakamega County.

The County Director of Education
Kakamega County.
Appendix III: NACOSTI Research Clearance Permit

THIS IS TO CERTIFY THAT:

Ms. Pauline Nafula Mutaki of University of Nairobi, 0-221 Matathia, has been permitted to conduct research in Kakamega County on the topic: An Assessment of Bioeconomic Values of Kakamega Rainforest and Associated Human Impact, Kakamega County, Kenya

for the period ending: 11th September, 2019

Applicant:

Signature

Permit No: NACOSTI/P/18/74637/24631
Date of Issue: 11th September, 2018
Fee Received: Ksh 1000

Director General

National Commission for Science, Technology & Innovation

CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the License and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research. Collection, taking, and collection of specimens are subject to further permissions from relevant Government agencies.
5. This License does not give authority to transfer research materials.
6. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
7. The Commission reserves the right to modify the conditions of this License including its cancellation without prior notice.

Republic of Kenya

National Commission for Science, Technology and Innovation

Research Clearance Permit

Serial No. A 20494

CONDITIONS: see back page
Appendix IV: Turnitin Originality Report
Appendix V: Declaration of Originality Form

UNIVERSITY OF NAIROBI

Declaration of Originality Form

This form must be completed and signed for all works submitted to the University for examination.

Name of Student: Paoline Mutaiki
Registration Number: C501717312018
College: CHSS
Faculty/School/Institute: CHSS
Department: Geography and Environmental Studies
Course Name: Environmental Planning and Management
Title of the work: An Assessment of Forest Product Extraction in Kakamega Rainforest and Associated Human Impact, Kakamega County.

DECLARATION

1. I understand what Plagiarism is and I am aware of the University's policy in this regard.
2. I declare that this Project (Thesis, project, essay, assignment, paper, report, etc) is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work, or my own work has been used, this has properly been acknowledged and referenced in accordance with the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work.
4. I have not allowed, and shall not allow anyone to copy my work with the intention of passing it off as his/her own work.
5. I understand that any false claim in respect of this work shall result in disciplinary action, in accordance with University Plagiarism Policy.

Signature: Paoline

Date: 30/11/2018