SOCIO-ECONOMIC DETERMINANTS OF WOODFUEL EXTRACTION AND ITS EFFECTS ON VEGETATION COVER OF GAZETTED FORESTS WITHIN KOIBATEK FORESTS ZONE, KENYA

BY

RONO KIPNG'ETICH KEITH

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DECLARATION

Declaration by Student

I certify that this Thesis has not been presented for Award of a degree in Maseno University or in any other University. The work reported herein has been carried out by me and all sources of information have been acknowledged by means of references.

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RONO KIPNG'ETICH KEITH DATE

PG/PHD/00092/2012

Approval by Supervisors

This Thesis has been submitted for examination with our approval as University Supervisors

_____ _____

Prof. Raphael Achola Kapiyo Date

Department of Environmental Science

School of Environment and Earth Sciences

Maseno University

_____ _____

Dr. Esnah Kerubo Bosire Date

Department of Environmental Science

School of Environment and Earth Sciences

Maseno University

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ABSTRACT

Globally, about 2 billion people extract and use woodfuel in the form of firewood and charcoal. Africa's per capita woodfuel consumption is 0.89 m^3 per year accounting for 67% of the total energy while Kenya's woodfuel consumption accounts for 68% of the total energy. Despite the importance of woodfuel in Kenya's economy, information on socio-economic determinants of woodfuel extraction and its effects on vegetation cover of gazetted forests is scarce. Therefore, the study purposed to assess the socio-economic determinants of woodfuel extraction and its effects on vegetation cover of gazetted forests within Koibatek Zone, Kenya. The specific objectives were to: establish the influence of socio-economic determinants on woodfuel extraction within gazetted forests, assess the relationship between income earned from sale of woodfuel on the volume extracted; analyze the influence proximity of extractors to forests on the number of firewood headloads extracted; determine the relationship between volume of woodfuel extracted and percent gazetted-forest cover change and evaluate the influence of mechanisms for enforcing existing legislations on woodfuel extraction within gazetted forests from 2006 to 2014. A cross-sectional descriptive research design was adopted. Purposive sampling was used to select all 8 gazetted forests blocks and the 8 forest officers while stratified random sampling was used to select 384 woodfuel extractors within the Zone. Primary sources of data included: scrutiny of registers for licenses of woodfuel extraction; administration of questionnaires to 384 woodfuel extractors, key informant interviews with Ecosystem Conservator and 8 forests officers; 8 Focused Group Discussions and Classification and Interpretation of satellite images. Secondary data was collected by review of policy documents, office files and journals. Data analysis utilized Pearson Chi-Square tests, Simple Linear Regression and descriptive statistics such as percentages and crosstabs. Qualitative data were arranged, coded and discussed. The study established that gender was a significant socio-economic determinants of woodfuel extraction from gazetted forests ($X^2(2) = 33.113$, $p<0.005$). Age ($X^2(10) = 15.759$, $p>0.005$), level of education ($X^2(10)$ 8.439, $p>0.005$) and livelihood support when unemployed $X^2(10) = 11.207$, $p>0.005$) were not significant socio-economic determinants of woodfuel extraction within gazetted forests. Income earned from sale of woodfuel had significant ($p<0.05$) relationship with volume of woodfuel extracted within gazetted forests since about 53.1% variation in volume of woodfuel extracted can be explained by income from sales ($R^2=0.531$). Proximity to forests had positive but not significant influence on the number of firewood headloads extracted within gazetted forests ($R^2=0.002$, $P>0.05$). Thus, 0.2% variation in firewood headloads can be attributed to proximity to gazetted forests. The volume of woodfuel extracted within gazetted forests had significant negative relationship with percentage forest cover change ($R^2=0.001$, b= -0.023, t=- 0.04, $p<0.05$). The estimated 260,745.59m^3 of woodfuel extracted within gazetted forests from 2006-2014 equated to 8.24% (3,902.5 hectares) loss in forest cover. The study also established that enforcement of existing legislations had significant ($p<0.05$) influence on woodfuel extraction within gazetted forests. It can be concluded that volume of woodfuel extracted was determined by gender and sale of woodfuel extracted. The woodfuel extracted within gazetted forests leads to significant change in cover of these forests. It is recommended that woodfuel extractors be sensitized on woodfuel extraction legislations and empowered with knowledge of sustainable forest management and agro-forestry. In addition, surveillance of gazetted forests be enhanced to curb illegal activities such as charcoal burning. The results are useful to energy and forest policy makers in developing policy strategies for sustainable extraction of woodfuel.

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ACRONYMNS AND ABBREVIATIONS

ADAS	Agricultural and Development Advisory Services
ANOVA	ANalysis Of Variance
C.S.O.	Community Service Order
CFA	Community Forest Association
CPAs	Charcoal Producers Associations
ENSDA	Ewaso Ngiro South Development Authority
ESDA	Education for Sustainable Development Africa
ESMAP	Energy Sector Management Assistance Program
FAO	Food and Agriculture Organisation
FCC	Forest Conservation Committee
FGDs	Focused Group Discussions
FSC	Forest Stewardship Council
GDP	Gross Domestic Product
GOF	Global Objectives on Forests
GoK	Government of Kenya
GTZ	*Gesellschaft für Technische Zusammenarbeit* (German Agency for Technical Cooperation)
IEA	International Energy Agency
IUCN	International Union for Conservation of Nature
KEFRI	Kenya Forestry Research Institute
KFWG	Kenya Forests Working Group
Ksh	Kenya shilling
LFICDP	Lembus Forest Integrated Conservation and Development Project
MEWNR	Ministry of Environment, Water and Natural Resources

MFL	Monthly Fuel License
MoE	Ministry of Energy
MPND	Ministry of Planning and National Development
NEMA	National Environment Management Authority
OECD	Organisation for Economic Co-operation and Development
P.B.C.	Pending Before Court
PELIS	Plantation Establishment and Livelihood Improvement Scheme
PFM	Participatory Forest Management
REA	Rural Electrification Authority
REDD	Reducing Emissions from Deforestation and forest Degradation
SFM	Sustainable Forest Management
TOE	Tonnes of Oil Equivalent
UBET	Unified Bio-Energy Terminology
UCS	Union of Concerned Scientists
UN ECOSOC	United Nations Economic and Social Council
UNEP	United Nations Environment Programme
UNFF	United Nations Forum on Forests
USA	United States of America
USD	United States Dollar
USDA	United States Department of Agriculture
WEC	World Energy Council
WETT	Wood Energy Today for Tomorrow
WGS	World Geodetic System

OPERATIONAL DEFINITION OF TERMS

Effects on vegetation gazetted forests cover: The consequences of woodfuel extraction on the closed canopy of the gazetted forests. In this study, the effects refer to changes in forest cover and area in hectares. Effects on forest cover were measured using percentage change equivalent to the volume (in m^3) of woodfuel extracted within the gazetted forests.

Enforcement mechanisms: This refers to the methods put in place to ensure compliance of existing laws. In this study, enforcement mechanisms refer to institutions for enforcing legislations and officers responsible for the specific activities of enforcing the legislations. The enforcement mechanisms were measured by percentage of responses on the number of institutions and the specific officers enforcing legislations.

Firewood Headload: Headload refers to a pile of firewood enough to be carried by one person on the head or back.In this study firewood heads were extracted by adjacent forest community registered as Community Forest Association members and with Monthly Fuel License. The average weight of firewood headload in Kenya is about 25kg (Ndegwa, 2010).

Firewood stack: Refers to a cuboid pile of firewood of dimension of 3m length by 1m width and 1m Height. Firewood stack is therefore a pile equivalent to a volume of $3m^3$

Forests Zone: Is an area whose administrative boundaries are equivalent to former Administrative Districts. Koibatek Forests Zone refers to area of 2,306 km² covered by Eldama Ravine and Mogotio sub-counties (formerly Koibatek District)

Gazetted Forests: Gazetted forests are land areas of forests that have been surveyed, demarcated and published by the government in the Kenya Gazette and management is bestowed on Kenya Forest Service (KFS). In the study, gazetted forests referred to gazetted forest area of

51,007.7hectares (510.08 km^2) within Koibatek Forests Zone covered by closed canopy forests, agriculture, grasslands and water.

Livelihood support: Refers to activities that provided basic needs for human survival. In this study livelihood support refers to financial aid and other material support from parents, spouse, children, well-wishers and government. It was measured by frequency of the support stated by respondents not employed.

Sack of charcoal: This refers to charcoal packed in a gunny bag with capacity to carry 90kgs grains such as maize or beans. The average weight of a sack of charcoal produced from the most preferred trees species in Kenya is 40kg (Ndegwa, 2010)

Socio-Economic Determinants: These are social and economic factors that influence woodfuel extraction. In this study social determinants include: gender, level of education, and proximity to forests. The economic determinants include: income earned from sale of woodfuel, accessibility and mechanisms for enforcing existing legislations. The socio-economic determinants were measured quantitatively using descriptive statistics.

Woodfuel Extraction: Refers to harvesting of biofuel directly or indirectly from trees, and shrubs grown on gazetted forests and non-forests lands. In this study woodfuel extraction refers to collection of dead wood, harvesting of standing trees or branches for firewood and charcoal burning. Woodfuel extracted was measured by volume (in m^3) of firewood headloads, firewood stacks and charcoal.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

According to Oregon State University (2006), there are three types of biofuels namely: first generation biofuels such as bio-ethanol and biodiesel; second generation biofuels such as wood, organic waste, food waste and specific biomass crops and; third generation biofuels that are produced from engineered algae. FAO (2009) and FAO (2010a) further reported three categories of biofuels based on the sites of extraction namely: woodfuel (from forests and woodlands), agro-fuel and municipal by-products. UCS (2011) stated that woodfuel include a range of fuels such as fuelwood (or firewood), charcoal, industrial fuelwood, wood pellets, biogas, cellulosic ethanol, and other advanced forms of bio-energy. IEA (2013) and FAO (2015) indicated that the most commonly used woodfuel in both developing and developed countries globally is firewood and charcoal. From the categories of biofuels, woodfuel has greatest implications on the economies of both developing and developing countries. Therefore, a study that focuses on woodfuel extraction and its effects on vegetation cover of forests is crucial. Hence, the study focused on assessing socio-economic determinants of woodfuel extraction and its effects on vegetation cover of gazetted forests.

Globally, about two (2) billion people extract woodfuel for use in domestic cooking and heating (Webi, 2000). UNDP (2000) and IEA (2006) also stated that the survival and lives of most people globally depends on biomass resource base particularly woodfuel rather than on oil, coal, or nuclear energy. Many ecological and socio-economic aspects accelerate the volume of woodfuel consumed in the world (Kairiukotis et al, 2004). However, Kairiukotis et al, 2004) neither listed the main socio-economic determinants of woodfuel extraction nor the effects of

woodfuel consumption on global forests. Woodfuel provide 10-15% of the world total annual primary energy converted to thermal energy in both developed and developing countries (Hillring and Trossero, 2006). ESMAP (2012) indicated that woodfuel (firewood and charcoal) are the dominant energy source for most developing countries while Abdi'razak (2013)stated woodfuel use has increased in recent years in the developed world. Stecker *et al* (2013) also reported that the global population relying on woodfuel reached 2.7 billion (or 38%) in 2015.According to FAO (2016), the volume of global woodfuel produced reached 1,863 million m^3 in 2016 whereby Asia-Pacific region was leading with 39% (733 million m^3) followed by Africa with 36% (673 million m^3) of the total consumption. FAO (2016) stated that commercialization of woodfuel has increased its extraction. However, ESMAP (2012) has stated that woodfuel is underpriced relative to its production costs and volume extracted. The studies did not establish the relationship between income earned from trade in woodfuel and the volume extracted. Therefore, the study focused on assessing the relationship between income earned from sale of woodfuel and volume extracted between 2006 and 2014 from gazetted forests.

Forestry Administration (2002) argued that woodfuel extraction is a forest 'cleaning up'/tidying activity and good forest management. However, FAO (2006) reported that unsustainable woodfuel extraction has consumed over a half of the global temperate broadleaf and mixed forest biome and nearly a quarter of the tropical rainforest biome. Thus, according to FAO (2006) woodfuel extraction is a major cause of global forests degradation. Consequently, IEA (2006) indicated that forest degradation has contributed to increased distances that must be travelled and time spent to obtain sufficient supply of woodfuel in many regions of the world. Biran *et al* (2004) established that the mean distance travelled to obtain a viable firewood resource was 2.1 km and the average trip time was 241 minutes. Despite the availability of information on

effects of woodfuel extraction on forests, the effect of forest proximity to woodfuel extractors on volume of woodfuel extracted is unknown. This necessitates a study to establish the effect of forest proximity of extractors from adjacent community to forest on the volume of woodfuel extracted. Thus, the study analyzed the influence of forest proximity on the number of firewood headloads extracted from 2006 to 2014 within gazetted forests.

According to UNFF (2008), Global Objectives on Forests (GOF) were agreed upon in 2006 by member states of United Nations Forum on Forests to cure deforestation and its consequences globally. Forest Stewardship Council (2009) also proposed a voluntary forest management certification for sustainable extraction of forests products including woodfuel. According to Lattimore *et al* (2009), SFM certification schemes are mechanisms that apply standards and monitoring regimes to ensure ecological sustainability of forests. Despite the availability of policy and legislative guides on SFM, the influence of their enforcement on forest resource utilization is still scarcely studied. In effect, the study evaluated the influence of mechanisms for enforcing existing legislations on woodfuel extraction within gazetted forests from 2006 to 2014.

According WETT (2000) and WEC (2007), Africa heavily depends on woodfuel for her energy needs and her consumption level, which is the highest globally, stands at $0.89m^3$annually. IEA (2010) also reported that the share of woodfuel consumption in Africa ranges from 61% to 86% of primary energy out of which 74% to 97% was consumed by rural households. Wicke *et al* (2011) further highlighted that woodfuel accounts for nearly 90% of total energy supply in Sub-Saharan Africa while Dasappa, (2011) stated that consumption of woodfuel is greater than 90% of primary energy in African countries such as Burundi, Rwanda and the Central African Republic. Ndegwa *et al* (2011) further established the annual income value of the charcoal alone in is USD 60 million in Rwanda (equivalent to 2% of GDP) and USD 450 million in Kenya.

ESMAP (2012) also stated that commercial woodfuel value chains are significantly increasing in scale and provide a source of income for many urban and rural households in Africa. In fact, based on commercialization of woodfuel, IEA estimated that the share of woodfuel and municipal wastes will increase to between 51% and 57% in Africa's total energy consumption by 2035 (Bildirici, and Ozaksoy, 2015). Commercial significance of woodfuel to economies of countries and household has been widely reported, however, information the relationship between the incomes earned and the volume of woodfuel extracted remain scarce. Further to that, the studies presented percentage share of woodfuel consumed to total primary energy but did not provide data on the volume of the woodfuel consumed.

The demand of woodfuel in Kenya is estimated at 40.5 million tonnes against a sustainable supply of 16 million tonnes (MOE, 2002). GoK (2006a) and Ndegwa (2010) indicated that 68% of Kenya's primary energy is from woodfuel. Nellie and Githiomi (2009), Ochieng (2009) and Githiomi and Oduor (2012) also indicated that woodfuel is an important energy source in Kenya as it relates to rural development, employment creation and incomes from foreign exchange. Njogu and Kungu (2013) stated that demand for firewood and charcoal in Kenya has continued to rise due to the population growth. Mbugua (2013) also indicated that income levels and population growth are the major basic determinants for demand for woodfuel in Kenyan forests. According to the studies, there exist various socio-economic determinants of woodfuel demand and utilization. However, there exists little information on the socio-economic determinants on extraction of woodfuel from gazetted forests. Nellie and Githiomi (2009) established that woodfuel extraction results into ecological effects on forests such as decreased forest cover and loss of biodiversity. FOSA (2013) indicated that the share of woodfuel consumption increased to between 70 and 80% of primary energy by 2014. However, MEWNR (2013) reported that the

demand for woodfuel was approximately 35,028,558m^3 (18,702,748 m^3firewood and 16,325,810 m^3charcoal) which was a decrease from the 40.5 million tonnes reported by MoE (2002).MEWNR (2013) reported that there exist firewood and charcoal deficits of 18% and 19.1% respectively. Therefore, woodfuel extraction is unsustainable and will lead to deforestation and disappearance of the remaining forests in Kenya (Ndegwa, 2011).Despite the availability of information on effects of woodfuel extraction on forests, relationships between the volume of woodfuel extracted and the percent forest cover changes during the process of woodfuel extraction remain unstudied. Therefore, a study is necessary on the relationship between volume of woodfuel extracted and the percentage of forest cover change.

According to Filmer and Pritchett (2001) resource scarcity especially firewood collection is measured by time taken per trip. McPeak (2002) on a study focusing on three villages of Kargi, North Horr and Logologo in Northern Kenya established the distance to firewood resources has increased and time spent for collection has reached an average of 70 minutes per day. IEA (2006) concurred that the distance and time spent to obtain sufficient supply of woodfuel has increased due to deforestation. Wagura and Nyagena (2008) also pointed out that deforestation in rural Kenya has burdened women and children during woodfuel extraction by increasing time spent. Wagura and Nyagena (2008) also established that time spent in firewood collection depends on the source of firewood and distance to that source. The studies, however, focused on the effects of distance on time spent but did not establish the relationship between distance and quantity of firewood collected. This study was necessary so as to establish the influence of forest proximity to extractors on the number of firewood headloads extracted by forest adjacent community within gazetted forests.

According to Mbugua (2013), the government of Kenya has put in place restrictions and measures to manage extractions of firewood and charcoal in order to control deforestation. This is evidenced by the enacted legislations that include Forest Act (GoK, 2005), Energy Act 2006 (GoK, 2006a), Forest Policy 2014 (Republic of Kenya, 2014) and Forest Management and Conservation Act, 2016 (GoK, 2016) which addresses forest conservation and energy management. However, influence of mechanisms for enforcing the legislations on woodfuel extraction from gazetted forests is still unknown in Kenya. FAO (2000a) stated that analysis of policy frameworks and implementation of legislations on global forests resources including woodfuel are conducted between five (5) years and ten (10) years. Therefore, it is necessary to conduct a study focusing on mechanisms for enforcing existing legislations on woodfuel extraction from gazetted forests for a period between 5 and 10 years. The study adopted a nine (9) year period between the year 2006, when Kenya started implementing key legislations enacted Forest Act, 2005 and Energy Act 2006 and,2014 when Kenya's Forest Policy, 2014was launched.

The study was conducted within the gazetted forests of Koibatek Forests Zone located within Mau Forest Complex. ENSDA (2005) reported that Mau Forests Complex has been the most degraded amongst Kenyan forests and its cover has receded drastically over time. In addition, GoK (2006b) indicated that Mau Forests Complex, which covers an area of 400,000 ha, is a major water tower and the largest single block of closed-canopy forest in East Africa. IUCN (2008) described the gazetted forests of Koibatek Forests Zone to cover an area of 510.08 km^2 (51,007.7ha) on the Eastern part Mau Forests Complex. Therefore, the gazetted forests of Koibatek Forests Zone cover 12.75% of Mau Forest Complex (IUCN, 2008). KFS (2009) further stated that gazetted forests of Koibatek Forests Zone comprises of 27,996.5 ha of natural forests

and 19,416.3 ha of forest plantations. According to KFS-Koibatek (2011), the gazetted forests within Koibatek Forests Zone have experienced increased pressure from logging, woodfuel extraction, grazing and sourcing of other forest products. GoK (2016) further reported that the gazetted forests of Koibatek Forests Zone are the most vulnerable to degradation within Mau Forest Complex due to high demand for woodfuel and other forest products such as timber and grass. However, little has been done to establish the socio-economic determinants of the increased pressures and the consequent effects on the vegetation cover of gazetted forests. Therefore, the study focused on assessing socio-economic determinants of woodfuel extraction and its effects on vegetation cover of gazetted forests within Koibatek Forests Zone, Kenya.

1.2 Statement of the Problem

Despite the importance of woodfuel in Kenya's economic development especially of rural areas and by creation of employment, the information on the socio-economic determinants of woodfuel extraction within gazetted forests in Kenya is scarce. Previous studies have not clearly focused on the relationship between income earned from sale of woodfuel and the volume of woodfuel extracted. Furthermore, the influence of proximity to gazetted forests on firewood collected (in headloads) by forest adjacent communities remain unknown. Studies also contradicts each other on the effects of the woodfuel extraction activity on forests cover with some indicating that woodfuel causes forest degradation and loss of biodiversity while other studies have indicated that woodfuel extraction is a forest cleaning activity and a part of good forest management. However, such studies did not established the relationship between volume of woodfuel and the percentage cover change of gazetted forests due to woodfuel extraction. In 2006, Kenya enacted key legislations that established mechanisms for managing all forests as well as harvesting of forest products that includes woodfuel in Kenya. However, the influence of mechanisms put forth for enforcing the existing legislations on woodfuel extraction within

gazetted forests in Kenya still unknown. Therefore, the purpose of the study was to assess the socio-economic determinants of woodfuel extraction and its effects on vegetation cover of gazetted forests within Koibatek Forests Zone from 2006 to 2014.

1.3 Objective of the Study

The overall objective of this study was to assess the socio-economic determinants of woodfuel extraction and its effects on vegetation cover of gazette forests within Koibatek Forests Zone, Kenya.

The specific objectives of the study were:

(i). To establish the influence of socio-economic determinants (gender, age, level of education and livelihood support) on woodfuel extraction within gazetted forests of Koibatek Forests Zone.

(ii). To assess the relationship between income earned from sale of woodfuel and volume extracted between 2006 and 2014 from gazetted forests of Koibatek Forests Zone.

(iii). To analyze the influence of forest proximity to extractors with Monthly Fuel Licence on the number of firewood headloads extracted from 2006 to 2014 within gazetted forests of Koibatek Forests Zone.

(iv). To determine the relationship between volume of woodfuel extracted and percent gazetted forest cover change between 2006 and 2014 in Koibatek Forests Zone.

(v). To evaluate the influence of mechanisms for enforcing existing legislations on woodfuel extraction within Koibatek Forests Zone from 2006 to 2014.

1.4 Research Questions

The following research questions were answered by the study:

(i). How do socio-economic determinants (gender, age, level of education and livelihood support) influence woodfuel extraction within gazetted forests of Koibatek Forests Zone?

(ii). What relationship exists between income earned from sale of woodfuel and volume of woodfuel extracted from 2006 to 2014 within gazetted forests of Koibatek Forests Zone?

(iii). What is the influence of proximity of extractors with Monthly Fuel Licence to gazetted forests on the number of firewood headloads extracted between 2006 and 2014 within Koibatek Forests Zone?

(iv). What is the relationship between volume of woodfuel extracted and percent gazetted forest cover change between 2006 and 2014 in Koibatek Forests Zone?

(v). What influence do mechanisms for enforcing existing legislations have on woodfuel extraction within Koibatek Forests Zone from 2006 to 2014?

1.5 Justification/Significance of the Study

The study identified information gaps on the socio-economic determinants of woodfuel extraction and its effects on gazetted forests cover. The main focus of socio-economic determinants were gender, age, level of education and livelihood supports. Income earned from sale of woodfuel and proximity of forest to woodfuel extractors were other socio-economic determinants studied. The information on socio-economic determinants enables forest managers and energy to develop strategies for sustainable woodfuel extraction within the gazette forests in Kenya. In addition, the study established the relationship between volume of woodfuel extracted and percentage forest cover change and documented the influence of mechanisms for enforcing

existing legislations on woodfuel extraction within gazetted forests. The resultsof the study will guide further research on the same or related fields of energy. Therefore, the study isuseful to policy makers and researchers in both forests and energy sectors during development of policy strategies and legislations for better management of forests and sustainable woodfuel extraction from gazetted forests.

1.6 Scope and Limitations of the Study

The study focused on woodfuel extraction on the eight (8) gazetted forest blocks within Koibatek Forests Zone managed by the KFS, an institution mandated by law to manage the forests within Kenya. The study was limited to studying the socio-economic determinants such as gender, age, level of education, livelihood support, income earned from sales and proximity to the forests on woodfuel extraction. In addition, the study focused on the relationship between volume of woodfuel extracted and the percentage change in forest cover between 2006 and 2014 and; mechanisms for enforcing existing legislations on woodfuel extraction from gazetted forests.

The study encountered the following limitations:

i. There was improper filing of recordson firewood and charcoal extraction within the forest stations' offices within Koibatek Forests Zone. This forced the researcher to make several visits to the forest stations and Ecosystem Conservator's offices in search of files containing the information thus taking longer time in data collection.

ii. Some respondents could not honour appointments as scheduled. This led to long waiting or rescheduling of appointments, thus delaying the data collection period.

iii. Difficulty in accessing some forest station offices such as Esageri, Kiptuget and Chemorgok Forest Stations especially during rainy days because of earthen roads which were slippery and could not be used by most 2-wheel vehicles or motorcycles. This forced

the researcher to walk at times to the stations or wait till the roads were dry hence delaying the process of data collection.

iv. Respondents who were involved in an illegality within the gazetted forests such as charcoal burners or unlicenced firewood collectors were hesitant to give any information for fear of arrests. The researcher took more time to convince the respondents by explaining the intentions data collection process.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter examines studies related to the topic of research. It highlights researched and published information relating to woodfuel extraction issues and the lessons that have been or can be learnt. The chapter also identifies critical gaps of knowledge on the research area based on past researches. This chapter has been divided into sections which rein line with the specific objectives of the study namely: Socio-economic determinants of woodfuel extraction, relationship between income earned on volume of woodfuel extracted; influence of proximity to forests on firewood headloads; relationship between volume of woodfuel and forest cover change; mechanisms for enforcing existing legislations; theoretical framework and; conceptual framework for the study.

2.2 The Socio-Economic Determinants of Woodfuel Extraction

Woodfuel plays a major socio-economic role in many countries of the world (FAO, 2000b). WETT (2000) indicated that woodfuel provide primary energy to over 2 billion people globally while Hillring (2006) indicated that majority of the people who rely on woodfuel live in the developing countries. These studies (FAO, 2000a, FAO, 2000b, WETT, 2000 and Hillring, 2006) focused on socio-economic importance of woodfuel but did little on the underlying socio-economic determinants of woodfuel as the dominant source of fuel globally. UNDP (2000) explained that socio-economic determinants of woodfuel extraction globally include: poverty, demography, gender in which women dominates in most communities and lifestyles. WEC (2001) stated that there was nexus between poverty and woodfuel use as people who live below poverty lineuse proportionately more woodfuel compared to other types of energy such as electricity and Liquefied Petroleum Gas (LPG). Economy Watch (2000) and Forestry

Administration (2002) added that use of woodfuel is common among the poor rural communities within developing countries. ADAS (2006) also stated that labour conditions where women and children are the dominant group is a major social factor determining woodfuel extraction. The study (ADAS, 2006) further stated that most cultures of African countries do not permit men to undertake firewood extraction/collection. ESMAP (2012) and WEC (2013) further indicated that as economies of countries rise, energy consumption shifts from traditional fuels such as woodfuel to electricity and other types of modern energy. The studies reported the socio-economic determinants of woodfuel extraction globally. However, information on the significance of each of the socio-economic determinants reported on woodfuel extraction from gazetted forests remains scarce.

The total consumption of woodfuel in Africa amounted to 630 million m^3 in 1994; 172 million m^3(28%) consumed by West Moist region, Tropical Southern (19%) and East Sahelian regions (19%) and Central Africa (16%) (FAO, 2000b). WETT (2000) stated that the major socio-economic determinants of woodfuel consumption in Africa were: location of the country, gender where women and girls are generally the most concerned by fuelwood while charcoal production and marketing tends to be male-specific and economics associated with the commodity. Delali *et al* (2004) listed diet (type of food cooked), types of fires/stove technology, population growth, availability of substitutes as socio-economic determinants of Africa's woodfuel consumption. IEA (2006) statistics showed that share of woodfuel in total primary energy was lower in North Africa (5.8%) and Southern Africa (10.3%) compared East Africa (81.7%) and Central Africa (80.5%). ADAS (2006) also highlighted that women dominates the labour of woodfuel extraction in most African countries.FAO (2009) reported that, woodfuel in Africa helps to provide jobs and substantial income for rural and urban people. Ndegwa *et al* (2011) also underscored the

importance of woodfuel in providing employment and income to many rural residents of Africa. According to Sola *et al* (2007) production and use of woodfuel remains an important socio-economic activity in Sub-Saharan Africa (SSA) where more than 70% of the population relies on it**.** Therefore, though socio-economic determinants of woodfuel consumption in Africa exist, the specific socio-economic determinants for extracting woodfuel from gazetted forests remains largely unknown. Furthermore, the links between the socio-economic determinants and volume of woodfuel extracted from gazetted forests remain unstudied.

Kenya's demand for woodfuel (charcoal and firewood) stands at 68% of the total energy supply (Kituyi *et al,* 2000, MoE, 2000). Kituyi *et al* (2001) indicated that the socio-economic determinants of woodfuel use in Kenya included: sources and distance of woodfuel, type of meal, cooking duration and demographic factors such as gender, age and income levels associated with rural and urban residents. Expounding on the source of woodfuel, FAO (2009) and UCS (2011) indicated that any type forests and woodlands were the main sources of woodfuel. However, there exist categories of forests in Kenya such as private and public forests or gazetted forests (Republic of Kenya, 2010). Therefore, there is need to focus on one type of forest in establishing the socio-economic determinants of woodfuel extraction in Kenya. Republic of Kenya (2014) stated that, forests covered 6.99% of the total land area of Kenya by 2014. Given that the land area of Kenya is 582,644 km² (58.2644 million ha) (Trading Economics, 2011), the total forest cover of Kenya in 2014 was 40,726.86 km^2 (4,072,686 ha).However, Trading Economics (2011) and Republic of Kenya (2014) did not provide the details of the Kenya's percentage cover of gazetted forests or other types of forests in the country. According to Matiru (2000), the area of gazetted forests in Kenya was 1,687,390 ha (1,359,254 ha in government land and 328,136 ha on trust lands). Most of the area (64.63%) of

gazetted forests in Kenya is covered by indigenous forests, 25% is covered by non-forest vegetation while 9.76% is plantation forests (Matiru, 2000). According to Ndiritu (2009), about 530,000 households in Kenya depend on gazetted forests mainly for woodfuel and other benefits such as cultivation, grazing. However, the socio-economic determinants of the woodfuel extracted by the household reported by Ndiritu (2009) are unclear.

In summary, it is evidenced from the studies (WETT, 2000, UNDP, 2000, Kituyi et al, 2000, Ndegwa et al 2011, ADAS, 2006, Ndiritu, 2009) that socio-economic determinants of woodfuel extraction vary depending on the area, country or region where extraction of woodfuel occurred. Therefore, this study focused on the Kituyi et al (2000) and Ndiritu (2009) socio-economic determinants of woodfuel extraction in Kenya which included: gender, age, level of education and income levels specifically on gazetted forests.

2.3 The Income Earned versus Volume of Woodfuel Extracted

According to Kairiukstis (2004) the global use of woodfuel is both economically reasonable and improves the livelihood of rural population compared to oil. Hillring and Trossero (2006) reported that woodfuel together with bagasse provide 10-15% of the world's total annual primary energy consumption. They further indicated that there was a growing interest in the international trade of woodfuel with the trade in Europe estimated at a level of 50Peta Joules per annum. The study however did not establish the monetary value of the woodfuel traded globally. Thus, a study is necessary to establish the income earned from trade of woodfuel. IEA (2010) stated that an estimated 2 billion people globally rely on traditional biomass such as firewood and charcoal for their energy needs. However, it did not indicate whether the commodity was traded either locally or internationally. Krajnc and Cebal (2011) on the first report on woodfuel prices within nine (9) EU countries established that woodfuel prices were highest in Greece and Germany

followed by Ireland, Spain, Catalonia, Italy and Austria but were lowest in Croatia, Romania and Slovenia. Prislan *at al* (2014) in the 6threport on woodfuel prices within the eight (8) EU countries indicated that the prices of woodfuel increased in all the 8 EU countries between 2011 and 2014. Despite the comparisons by Prislan *at al* (2014), the actual prices of woodfuel were not provided. Krajnc and Cebal (2011) admitted that it was hard to get data on rising trends in prices of woodfuel within the EU countries. In addition, it is not clear whether the prices were on the supply-side or demand-side. Therefore, it is important to establish the prices of woodfuel in specific units which translate to the income earned from the sales of woodfuel.

According to Arnold *et al* (2006) and Kambewa *et al* (2007), the growing urban demand and markets for woodfuel provide opportunities for income generation from sales in the urban areas in Africa. MARGE (2009) on its part found that woodfuel contributed directly in employing between 120,000 and140,000 people in2008 in Sub-Saharan Africa. Charcoal sector alone was estimated to contribute $650million to Tanzania's economy which was 5.8 times the combined value of coffee and tea production. The sector provided income to thousands of households in both urban and rural areas (WorldBank, 2009). The value of woodfuel was equivalent to 3.5% of Malawi's GDP (Zulu, 2010). According to Hiemstra-Vander Horst and Hovorka (2009), collection and trade in firewood in most parts of Sub-Saharan Africa is from dead plant material The charcoal sector in Africa has been growing by around 3% annually since the turn of the 21st century(FAO, 2009). UCS (2011) reported that charcoal production and trade has been increasing due to increased urbanization. ESMAP (2012) stated that charcoal business employs about 200 to 300 transporters and 2,000 charcoal vendors living chiefly in the urban areas. The income earned within the charcoal sector in turn supports approximately 300,000 other people. Zulu and Richardson (2013) reported that charcoal is a major source of income for Africa’s rural

households in areas with access to urban markets. Ouya (2013) further stated that in 2007 charcoal sector alone was a US$8-billion industry employing more than 7 million people in the Sub-Saharan Africa. Therefore charcoal is a source of energy, critical in commerce and employment that makes it an important socio-economic asset to the African continent. Nelleman *et al* (2014) on their part indicated that the charcoal market in Africa has been estimated to be worth between USD 9.2 and 24.5 billion per year.

In Kenya, the value of woodfuel sourced from gazetted forests in addition to 24 million m^3 that is sourced from farmlands is estimated at Ksh. 4.8 billion based on 2009 rates (Ndiritu, 2009) and Mugo (2010). Ndegwa (2010) also indicated that the annual value of the charcoal traded alone in Kenya is USD 450 million. Unpublished report from Business Daily (23rd June 2011), Kenya has a Ksh.30 billion charcoal industry that employs more than 200,000 people in production alone, contributes more than Ksh.5 billion in taxes, and meets the energy needs of 80% of urban households and 34% of rural households. Nellie and Githiomi (2009) found that firewood and charcoal are forest products which support livelihoods on many rural communities. Ndegwa *et al* (2011) also reported that woodfuel sector was a source of employment to about 18,000 people who include: 7,000 loggers engaged in felling, sizing and stacking the wood and about 8,000 charcoal producers, most of them in impoverished rural areas of Kenya. Ndiritu (2009) and Ndegwa *et al* (2011) further pointed to the fact that the value of woodfuel extracted is significant to economic development of rural areas of Kenya. Olunga (2013) identified income as a determining factor for utilization of forest resources in Tana Delta, Kenya. However, the studies neither provided the value of firewood collected in Kenya nor the effects of the income earned on the volume of firewood extracted. Thus, it was important for the study to establish the

relationship between income earned from sale of woodfuel and the volume of woodfuel extracted.

According to ESDA (2005), government of Kenya loose about Ksh. 5.1 billion in form of evaded tax by charcoal producers due to lack of legal and policy framework on charcoal production. This implies that a lot of income is earned by charcoal producers since, Ksh. 5.1 billion accounts for 16% statutory tax (Institute of Economic Affairs, 2011) of the income earned. In rural areas of Kitui, Narok and Kajiado, it was found that charcoal sub-sector alone employs about 200,000 charcoal producers, 2700 transporters and 500,000 ventors (Ndegwa *et al,* 2011).The employees then support about 2.5 million people in terms of basic commodities such as food, clothing and education showing that woodfuel trade has a huge impact on the economies of the rural areas of Kenya and Rwanda. According to Netherlands Enterprise Agency (2010), the situation in charcoal production is unsustainable, and if allowed to continue may lead to complete destruction of Kenya's already depleted forests and woodlands. According to MEWNR (2013), the charcoal industry is part of the informal sector and is by far the largest contributor to job creation, employing approximately 700,000 people, who in turn are believed to be supporting 2.3–2.5 million dependents. Therefore, woodfuel trade and the income earned have significant economic effects of both rural and urban communities. However, little information is available on the relationships between income earned from sale of woodfuel and volume of woodfuel extracted from forests.

2.4 Forest Proximity to extractors and Firewood Headloads Extracted

According to FAO (2000b) most public forests in proximity of human habitats have been degraded due to pressure from resource exploitation. Kairiukotis *et al* (2004) identified proximity to forest together with road infrastructure as key determinants to extraction and use of

woodfuel in Lithuania within Europe. The infrastructure defined by Kairiukotis *et al* (2004) include machinery such as drum chipper and forwarders, market intelligence, information systems, woodfuel production related legislation, and a change in traditional thinking. FAO (2005) while acknowledging that urban areas depends heavily on its hinterlands to meet the woodfuel requirements of the residential, commercial (hotels and restaurants) and industrial (bakeries) sectors, stated that a well-developed road network from the sources of woodfuel to the urban areas has enhanced easy and bulk transportation of the commodity. However, Kairiukotis *et al* (2004) and FAO (2005) did not take into account the small-scale woodfuel extraction and transportation in public forests and farmlands that is done manually without requirement of well-developed road networks.

According to FAO (2005) and IEA (2006), degradation of public forests has made extraction of firewood increasingly difficult due to increased distance that must be travelled. OECD (2006) further stated that proximity to a forest and any other woodfuel resource affects the amount of firewood collected. Chakravorty *et al* (2014) in a study in India established that reduced forest cover directly affected the time allocation by households to firewood collection due to distance travelled to the forest and time spent to collect the scarce resource in the degraded forests. Proximity to a forest also affects the quality of firewood and fodder collected by individuals in Nepal (Mani, Karki and Berrrens, 2017). The studies though indicated that proximity to forests affected firewood extraction, information on the relationship between proximity to forests and quantity of firewood remain scarce.

Proximity to a forest affects prices of firewood in most African Counties (WETT, 2000, FAO, 2005 and WEC, 2006). IEA (2006) stated that firewood collection in remote and unstable areas

deep inside forests in Africa poses significant safety risks to women and children. OECD/IEA (2006) reported that the average distance travelled for firewood collection in the rural areas of Tanzania ranged from 1.5km per day in Kilimanjaro region to 10.4km per day in the central region of Singida. Wagura and Nyangena (2008) found that the average distance travelled by firewood collectors within Lari Division, Kiambu County was 3km. The studies evidently indicate that distance travelled varies depending on a region or place. Furthermore, the increase in distance travelled to get sufficient firewood also increase the time used to cover the distance. However, the relationship between quantity of firewood and the distance travelled was not studied. OECD/IEA (2006) further asserted that, increased woodfuel collection time has a significant opportunity cost, i.e. it limits the opportunity for women and children to improve their education and engage in other income-generating activities. This is because, many children, especially girls, are withdrawn from school to attend to domestic chores related to woodfuel extraction hence reducing their literacy and restricting their economic opportunities FAO (2005) and (OECD/IEA, 2006).However, the studies did not establish the effects of long distance travelled to the forests on the quantity of firewood collected.

According to McPeak (2002), average time spent in firewood collection in Northen Kenya is 70 minutes per trip. Wagura and Nyangena (2008) found out that the average distance from households to forests where firewood collection occur within Lari Division Kenya is approximately 3km and the average collection and travel time two way to collect firewood in the forests is 257.85 minutes. Kituyi (2008) indicated that proximity to firewood resource determines the amount of firewood collected. Olunga (2013) also indicated that distance from households to forest edges greatly affected extraction of woodfuel and other forest products. These studies (McPeak, 2002, Wagura and Nyangena, 2008, Kituyi, 2008 and Olunga (2013) did not report the

nexus between distance covered from households to the forests and the quantity of firewood collected. Thus, this study sought to establish the influence of proximity of extractors to gazetted forests on the amount of firewood headloads extracted.

2.5 Volume of Woodfuel Extracted and Forest Cover Change

Openshaw (1978) put forth two methods of measuring firewood collected: by volume and by weight. If volume method is used, a conversion factor from the bundle of headload to solid measure may be between 0.35 and 0.40. For instance, with an average conversion factor measured by water displacement method of 0.38, the average volume of firewood headload in Machakos County-Kenya has been established to be 0.087 m^3(Openshaw, 1978). In some countries, a *stere* or stacked cubic metre is the standard measure (i.e. 4 feet × 4 feet × 8 feet = 128 stacked cubic feet or the metric cord 1m × 1 m × 3m). One advantage of volume measure over weight measure is that the volume of 'wet' wood does not differ greatly from air-dry wood (Openshaw, 1978). Ndegwa (2010) observed that a standard bag of charcoal in most parts of Kenya weighs an average of 40kg

According to Hillring (2006), there is no single source for woodfuel statistics available at the global level. However, there is a possibility to estimate volumes and trade patterns by use of connections to trades on forest products. In that sector of trade on forest products, international statistics are established covering both volumes and trade patterns (Hillring, 2006). Ojo *et al* (2012) also reported that statistics on energy production from wood are difficult to obtain because the two main agencies that collect the statistics i.e. FAO and IEA present different figures because of different definitions and primary data sources. IEA (2006) presents biofuel production figures that include other types of biomass besides wood such as agricultural residues and dung. Its statistics also include heat and power generation in the forest industry and by

commercial energy producers, which are not fully captured in FAO (2005) statistics. Thus, the studies are a pointer that only estimates of woodfuel extracted and consumed can be made but it is difficult to get real time statistics.

Hillring (2006) estimated that traditional use of woodfuel and other bioenergy has a share of 10–15% of total energy supply globally and is used mainly within households. The study by Hillring (2006) further provided statistics of aggregate world's extraction of firewood and charcoal for three consecutive years from 2000 to 2002. The statistics indicated that the world's aggregate firewood extraction was 1790.7 million m^3 in 2000, 1789.5 million m^3 in 2001 and 1801.3 million m^3 in 2002. Asia had the biggest extraction share of approximately 44%, followed by Africa at 30% and South America at 10.5%Charcoal production increased marginally from 39.2 million metric tonnes in 2000 to 40.8 million metric tonnes in 2001 to 42.8 million metric tonnes in 2002. Africa had the greatest production share of approximately 51% followed by South America 34.7% share and Asia at 10.5% share (Hillring, 2006). According to Ndegwa (2010), 1.6 million tonnes of charcoal are consumed in Kenya each year with a turnover of about USD 419 million which at 16% value added tax charged by the Kenyan Government, can contribute USD 67 million in taxes every year. Despite the availability of the statistics on woodfuel consumption, Ojo *et al* (2012) stated that there was difficulty in obtaining statistics on woodfuel.IEA (2013) documented that, the total world energy consumption in the year 2011 was 13,113 million TOE out of which 10.0% (i.e. 1,311.3 million TOE) was derived from biofuels. However, Hillring (2006) choice of period of three (3) years for the study was not consistent with FAO (2000a) which recommends a period of between five (5) years and ten (10) years on conducting studies for the global forests resources. In addition, the separate statistics provided by Hillring (2006) for firewood (in million m^3) and charcoal (in million Tonnes) to per regions

could have also been combined to provide an aggregate global woodfuel production between year 2000 and 2002. This leaves firewood and charcoal production to be treated as separate types of energy yet together are categorized as woodfuel.

Mbugua (2013) established that most rural communities highly depend on woodfuel as their primary source of energy. Osei (1993) also observed that the percentage consumption of energy from woodfuel in Burkina-Faso, Ethiopia, Mali, Tanzania and Zambia is over of 90% of the total energy supply but did not provide volumes of the woodfuel consumed and the duration referred. UCS (2011) established that 1.4 billion m^3 of firewood and about 40 million metric tonnes of charcoal is used annually across the tropical areas of Africa and in other regions such as Asia and Latin America. According to FAO (2010c), much of the woodfuel in Asia come from plantations. Of the roughly 8 million hectares of woodfuel plantations in the world, 6.7 million are located in Asia (FAO, 2010c). Africa has the highest per capita annual woodfuel consumption in the world (0.89m^3 per year). An estimated 623 million m^3 woodfuel is extracted annually from forest and tree resources in African continent (UCS, 2011). FAO (2010a) reported that woodfuel production in Africa is on small scale. Therefore, contribution of forest and tree resources to household energy supply in Africa is essential and will remain so for the foreseeable future. The information on woodfuel consumption in Africa is a pointer that forest resources require proper management; otherwise, it faces real threats of over-exploitation and depletion. In spite of this, changes in forest cover resulting from volume of woodfuel extracted have not been well studied.

Mugo (2010) made emphasis that most of the wood harvested from Kenyan forests is used for woodfuel (94%) followed by poles (4%) and timber (2%). With a continually increasing population, the energy needs together with increasing demand for timber continues to exert great

pressure on the country's gazetted forests (GoK,, 2011). The KFS Strategic Plan of 2014-2017 stated that 80% of Kenyans rely on wood and wood products from forests as their primary source of energy either in the form of charcoal or firewood (KFS, 2015). The gap between supply and demand of woodfuel continues to grow with an increasing population, viewed against minimal growth in forests available for harvesting (Republic of Kenya, 2014). The Strategic Plan 2014-2017 (KFS, 2015) neither provided the estimated amounts of woodfuel extracted from Kenya forests nor percentage share of the total energy consumption commanded by woodfuel in Kenya. The Strategic Plan 2014-2017 also did not put into considerations likelihood of importation of woodfuel particularly charcoal from other countries to bridge the demand gaps in Kenya.

The total annual amount of woodfuel extracted from Kenyan forests is 31,617,678 tonnes annually (MoE, 2002). Charcoal production stood at 16,506,498 tonnes which was more than firewood whose volumes were 15,111,180 tonnes. Hillring (2006) justifies the statistics stating that most of the wood extracted for woodfuel is processed to charcoal so as to make transportation more efficient and increase the energy value. The rural households extracts and uses a total of 21,826,398 tonnes of woodfuel, urban households 6,463,235 tonnes and cottage industry 3,328,045 tonnes (MoE, 2002). Ndiritu (2009) estimated the value of the woodfuel sourced from Kenyan gazetted forests at Ksh. 4.8 billion annually. According to Netherlands Enterprise Agency (2010), charcoal logistics and trade can be divided into a 'formal' and an 'informal' commercialization chains. The 'formal' commercialization chain begins with the harvesting of wood to produce charcoal. The product is transported and traded by officially licensed transporters and traders, who pay the necessary duties and taxes. On the other hand, the 'informal', usually much larger, commercialization chain is undertaken without official

licensing. Charcoal produced through the informal chain is transported and traded clandestinely in an attempt to avoid authorities, taxation, and penalties (Netherlands Enterprise Agency, 2010).

Kenya's State of Environment report of 2004 (NEMA, 2004) reported that the principal sources of firewood were agro-forestry (84%), biomass in trust lands (8%) and gazetted forests (8%). However, the report did not mention the sources of charcoal whose supply exceeds that of firewood in Kenya as per the MoE (2002). Mead (2005) also provided additional information on main sources of woodfuel (firewood and charcoal). It stated that woody biomass energy in a variety of forms such as twigs, stems, branches and leaves come from a range of sources namely: natural and planted forests, trees outside forests, and shrub lands. Therefore, sustainable management of forests is key to ensuring continuity is supply of firewood and charcoal to most household in both rural and urban areas of Kenya.

Martinez-Alier (2002) stated that the demand for woodfuel destroys forests located near villages and towns in many countries of the world. It reported that in the arid regions of Asia, Africa and Latin America (i.e. the Sertôes in Brazil, the coast of Peru, the highlands of the Andes or Central America), the reason for deforestation is the use of firewood or charcoal as fuel by the poor. On the contrary, Soussan (1998) stated that, whereas forest depletion has often been attributed to over reliance on woodfuel, other factors such as local proximity and access, land tenure, and local management regimes determine the levels of exploitation and sustainability. However, Agarwala (2006) stated that increased woodfuel usage is one of the biggest threats to health of a forest. Therefore, there is need to establish the relationship between the volume of woodfuel and the percentage changes in forest cover.

Abd'razack (2013) stated that the effects associated with firewood and charcoal extraction and use in Africa are enormous and include: loss of indigenous biodiversity, depletion of ecosystems and desertification of some regions. FAO (2000a) also indicated that the annual rate of deforestation in Africa ranges between 0.75% in Angola and 2.2% in Malawi. However, according to Abd'razack (2013), woodfuel extraction alone cannot be blamed for the deforestation in developing countries of Africa; there are other factors such as lumbering, and export of wood products to other nations particularly developed nations. This is in agreement with Leach and Mears (1998) which had suggested that deforestation cannot be stopped even if the use of woodfuel is completely stopped. This is because according to UN ECOSOC (2017), there exist other causes of deforestation that include: illegal or unsustainable logging, unmanaged fires, pollution, dust-storms, sandstorms and windstorms, disease, pests, invasive alien species, fragmentation and the impact of climate change, including severe weather events. FAO (2006) established that over-reliance of woodfuel in rural areas has caused changes in forest ecosystems in various ways such as changes in distribution of animal and plant species, tree physiology and stability. This manifests itself in stand-level effects, as well as in major disruptions or disasters caused by more dramatic weather events (FAO, 2006). Therefore, forest protection and management should ensure that these effects can be foreseen, managed and reduced to the greatest possible extent, particularly due to the very long production and ecological cycle of forests. Nellie and Githiomi (2009) established that continued loss of forests and associated resources have had far reaching negative effects on the country's economy and welfare of Kenyans. According to Forest Society of Kenya (2010), woodfuel extraction in fragile areas of Kenya has caused severe deforestation, biodiversity loss and reduction of food opportunities from natural vegetation. This means that the supply of wood to meet household

energy needs should be properly taken into account in forest planning and policy formulation. Furthermore, there is need to isolate the percentage change in forest cover caused by woodfuel extraction from changes due to the other causes of deforestation listed by UN ECOSOC (2017)

Arnold *et al* (2003) indicated that there exists some localized deforestation in most countries of the world, but depletion of forest cover on a large scale has not been found to be attributable to demand for firewood. This is because firewood is more often gathered from the roadside and trees outside forests, rather than from natural forests. This argument has been supported, in part, by ESMAP (2012) which stated that woodfuel harvesting is no longer considered the primary source of global deforestation, as it was in the 1970s.According to ESMAP (2012), most deforestations currently results from clearing of land for farming to meet the food requirements of the rising population. In addition, a great portion of rural woodfuel supply comes from trees outside forests, dead branches and logs, and agricultural residues. Therefore, woodfuel supply to the dispersed rural populations is rarely an environmental threat nor is it globally unsustainable. Du Plessis (1994) had however reported that firewood harvesters generally first collect all available dry wood on forest floor, and then proceed to break dead branches off live trees. When all available dead wood has been collected, the harvesters turn to cutting down live trees and/ or branches. ESMAP (2012) contradicts itself by also pointing out that urban demand for woodfuel in a situation of weak regulations can contribute to degradation of forests located around major centers of consumption. This arise because small rural industries (such as brick makers), urban businesses (such as bakeries and restaurants), and traders of woodfuel for the urban household market are largely unregulated. Such consumers tend to source wood at the lowest possible price, with little concern for supply-side sustainability. Therefore, woodfuel extraction eventually leads to a decrease in forest cover if sustainability mechanisms are not put in place from the onset.

To isolate changes due woodfuel extraction from other causes of deforestation, Patmos (2005) provided conversions of commercial timber or firewood to the number of standing trees in a forest. For instance, one cord of firewood is made from one tree with a diameter of 22 inches (at the height of 4.5 feet) or 50 trees each having a diameter of 5 inches. The conversions can be used to keep a running tally of the number of many trees to cut for the required number of wood stacks rather than waiting until the wood is all stacked. However, Patmos (2005) did not provide the average Diameter at Breast Height (DBH) of trees either within a natural forest or forest plantations making it difficult to be applied on forests whose information on the average DBH of its trees is unknown.

World Bank (2009) on a policy note for transforming charcoal sector in Tanzania stated that, the daily charcoal consumption in Tanzania is estimated at 2650 tonnes. Although World Bank (2009) did not provide formulae for converting the amounts of charcoal (in tonnes) consumed in Tanzania into area of forest cover required for the process of charcoal production, it is worth noting that the statistics provided implied that 82,192 m^3 of wood extracted equivalent to that contained in 342.5 hectares of closed canopy forest. Therefore, the volume of woodfuel extracted within forests is statistically convertible to the resultant decrease in forest cover without carrying out experiments to establish the changes.

2.6 Mechanisms for Enforcing Existing Legislation on Woodfuel Extraction

According to UNFF (2008) four shared Global Objectives on Forests (GOF) with a series of 25 policies and measures were agreed upon in 2006 providing clear guidance on the future work of the international arrangement on forests These GOF were: (i) Reverse the loss of forest cover through Sustainable Forest Management (SFM); (ii) Enhance forest-based economic, social and environmental benefits; (iii) Increase significantly the area of protected forests worldwide and

sustainably managed forests; (iv) Reverse the decline in official development assistance for SFM and mobilize additional financial resources (UNFF, 2008). Despite the global policy frameworks, FAO (2015a) reported that the world loses a net of 3.3 million ha (8.1 million acres) of forests every year-an area the size of Taiwan. The Global Objectives on Forests were revised to 6 by a special session of the 197 member States and with the launch of UN Strategic Plans for Forests (Forest Management Bureau, 2017 and UNFF, 2017).However, Global Witness (2017) further stated that 66 acres of forests equivalent to 50 football pitches is lost every minute globally. This means that 95,040 acres of global forests is lost per day (this is equivalent to 72,000 football pitches). In spite of this, FAO (2010c) indicated that 143 countries worldwide have forest policy statements to guide forest management.

FAO (2000a) reported that the rate of deforestation in Africa ranges between 0.75% and 2.2% per year while in Kenya, WWF (2016) reported that the observed decline in 824,115 hectares of forest cover in the country was lost between 1990 and 2015. The rate of decline was 33,000 hectares forest loss per year**.** Put in context, this is the same as losing forest cover equaling the size of 100football pitches or over 200,000 tree stamps daily (WWF, 2016).This indicates that the GOF have not been realized and that implementation of the 25 policies and measures among member countries of Africa is not clearly known. However, according to FAO (2010b), international forest-related conventions, agreements and initiatives have affected the way forests are governed, ranging from globalization, decentralization and privatization to changing demand for forest products and services from a growing and often more urbanized population.

ESMAP (2012) stated that, in most African countries, forest administrations traditionally had the exclusive right to assign permits for commercial harvesting of forest products. The permits were typically awarded to a small number of urban-based woodfuel traders, resulting in an

oligopolistic woodfuel industry based on inequitable forest exploitation, in which communities living close to the forests did not benefit at all. Consequently, local populations tend to become uninterested in forest management activities. According to Ndegwa (2010), biomass energy for a long time in the past was viewed as a poor man's fuel leading to governments' negligence. Therefore, policies of most governments are bent towards 'modern fuels' such as electricity and petroleum. The new perspective of biomass energy points to a competitive and clean environmentally friendly energy resource. UNEP and IEA (2007) stated that this is especially the case in developed countries, where biomass use has seen continuous growth over the years yet little legislative interventions on sustainable management has been undertaken.

According to Ndegwa (2010), there are still no proper policies to support the development of biomass energy and specifically woodfuel despite the international promotion and acceptance of the energy as a clean fuel. In some countries, the policies dealing with woodfuel lack coherence and the management of the sector falls under the authority and jurisdiction of several ministries (Mugo, and Ong, 2006). Ndegwa (2010) gave example of some African countries such as Angola, Senegal and Madagascar where the supply and demand side of woodfuel and other types of energy is handled by different ministries. ESDA, (2005) on a survey of charcoal production in Africa, established that Kenya has had adhoc policies and presidential decrees banning the production and distribution of charcoal while trade and consumption has been accepted. This is in contrast with the status in developing countries such as Austria and Germany which gives long term support to their biomass sector thus attracting more private investment to ensure sustained growth (IEA, 2007).

Article 69 (1) and of the Constitution of Kenya (2010) provides for the State to perform various duties to ensure sustainable exploitation of natural resources. Article 69 (1)(i) states that the State

shall ensure sustainable exploitation, utilisation, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits and work to achieve and maintain a tree cover of at least ten per cent of the land area of Kenya.

Article 69 (1) therefore calls on the State to develop strategies that not only regulates sustainable extraction of forest products for the benefits of its people but also empowers citizens to fully participate in ensuring that forests within their surroundings are conserved. The strategies are geared towards ensuring that a 10% forests cover in Kenya is achieved.

Article 69 (2) of the Constitution of Kenya (2010) further states that, every person has a duty to cooperate with State organs and other persons to protect and conserve the environment and ensure ecologically sustainable development and use of natural resources. This Article (69 (2))therefore provides for mandatory participation by all persons in Kenya either individually or in cooperation state organs or other persons in decision making regarding sustainable use of natural resources.

According to GoK (2006a) a major development in the energy sector had been the Energy Act of 2006. Mugo and Ong (2006), however, indicated that the Energy Act 2006 has strong bias towards electric energy and the petroleum sector, with only a token mention of biomass energy particularly woodfuel. This neglect of woodfuel energy by government in the national energy polices has led to the sector operating informally, and many people looking down upon woodfuel as a poor man's fuel despite its importance in the energy sector of the country. Consequently, forests within both government and private lands continue to experience enormous pressures from the woodfuel with little regulations from both national and county governments.

The Energy Act, 2006 (GoK, 2006b) addresses the development and use of biomass energy in only three sections i.e. Sections 6, 67 and 103. Section 6 of the Act states that the Commission (ERC) shall have the power to: - (i) issue, renew, modify, suspend or revoke licences and permits for all undertakings and activities in the energy sector and, (ii) grant licences, in coordination with other statutory authorities, for sustainable charcoal production upon submission of satisfactory development plans. However, ERC has been active in regulating the prices of petroleum products and electricity in Kenya but has done little on other types of energy particularly woodfuel extraction and consumption. Section 6 of the Act has left out licencing or permits for extraction of firewood. Section 67 of the Act further mandates the Rural Electrification Authority (REA) to promote use of renewable energy sources including, but not limited to, small hydropower stations, wind, solar, biomass, geothermal, hybrid systems and oil fired components (GoK, 2006b). However, REA is more involved in rural electrification programmes taping from the national electricity grid and there exist scarce information on their involvement in promoting biomass energy.

Part V Section 103 (1) of the Energy Act, 2006 allows for promotion, development and use of renewable energy technologies, which, among others, includes biomass, charcoal and firewood (GoK, 2006b). In addition, Section 103 (2)(b) of the Act allows for provision of an enabling framework for the efficient and sustainable production, distribution and marketing of biomass and charcoal. Section103 (2) (c) on its part allows for promotion of the use of fast-maturing trees for energy production and the establishment of commercial woodlots including peri-urban plantations (GoK, 2006b). The Energy Act, 2006 though has provisions for both firewood and charcoal, there is no clear provision under the Act of sustainable management of the forests and woodlands from where the commodities are sourced.

Section 40 subsection (1) of the Forest Act 2005 (GoK, 2005) stated that 'all indigenous forests and woodlands shall be managed on a sustainable basis for purposes that includes {in section 40(1) (e)} sustainable production of wood and non-wood products. In the pursuit to enforce its provisions under Section 40 (1), the Forest Act, 2005 in section 52 gave a list of prohibited forest activities unless a person has licence or permit or management agreement to undertake the activities. For instance, Section 52 (1) (a) of the Act states that no person shall fell, cut, take, burn, injure or remove any forest produce and that such activity requires a license or a permit without which will constitute offense that is punishable in accordance to Section 49 of the Act.

Part IV Sections 45 to 47 of Forest Act, 2005 (GoK, 2005) provided for community participation in the conservation and management of government forests. Specifically, section 45 of the Act provides the guidelines of registration of a community forest group i.e. Community Forest Association. Any registered CFA may apply to the Director of KFS for permission to participate in the conservation and management of a state forest or local authority forest in accordance with the provisions of the Forest Act, 2005. CFA is required to provide among other things, the area of forest for which the association proposes to undertake conservation and management and, the association's proposals concerning: (i) use of forest resources, (ii) methods of conservation of biodiversity; (iii) methods of monitoring and protecting wildlife and plant populations and enforcing such protection (GoK, 2005).However, the provision of Act does not address participation of community members as single individuals in forest management and or conservation yet in most instances single individuals enter forest to exploit resources such as building poles, grass or fodder for their livestock and woodfuel.

With a focus on charcoal, PISCES (2011) reported that apart from Forest Act 2005 Local Government Act Cap 265 empowers local authorities and administration to control destruction of trees, transportation of charcoal and other forest produce. Charcoal traders and vendors are also required to apply for a single business permit tolocal authority for engaging in the charcoal trade. However, charcoal movement permits are issued by KFS subject to Section 7(1) of The Forest (Charcoal) Regulations, 2009 (Revised 2012) (KFS, 2012).It prohibits any person engaged in any activity relating to commercial charcoal production and transportation without a valid licence, issued by the KFS under the regulations.' Traffic Act CAP 403 consolidates the laws relating to traffic on public roads, and requires traffic police at the check points to verify the validity of all charcoal movement permits. It is therefore difficult to coordinate the enforcement of the provisions since each of the three offices mandate by law for licensing and permits of charcoal i.e. County governments, KFS and National Police Service operates independent of the each other in executing their mandates.

Regulation 5 (1) of The Forest (Charcoal) Regulations, 2009 (Revised 2012), requires that all commercial charcoal producers shall organize themselves into charcoal producer associations (CPAs) which should be registered by KFS (GoK, 2012). Regulations 5 (3) (a), states that the registered CPA shall, among others other functions, facilitate sustainable production of charcoal by its members. Regulation 9 (2) further states that a person who wishes to produce charcoal for commercial purposes on his own land, shall be required to obtain a licence (KFS, 2012). However, the Forest (Charcoal) Regulations, 2009 (Revised 2012) does not mentioned or provide for charcoal production within gazetted forests. EMCA, 1999 (Revised in 2012) mandates NEMA to coordinate all matters related to environment (GoK, 2012). But with regards to woodfuel energy, EMCA, 1999 (Revised 2012) has no clear provision on extraction of

woodfuel from forests in Kenya. Only Section 49 of EMCA, 1999 provided for promotion of the use of renewable sources of energy by, among others, promoting measures for the conservation of renewable sources of energy and taking measures to encourage the planting of trees and woodlots by individual land users, institutions and community groups (GoK, 2012). However, the EMCA has not provided for sustainable management and extraction of forest products such as woodfuel from gazetted forests of Kenya.

2.7 Theoretical Framework of the Study

UNDP (2000) stated that the socio-economic determinants of woodfuel extraction globally include: poverty, demography, cultural lifestyles and gender in which women dominate in most communities. Shackleton *et al* (2011) also indicated that sharing of responsibilities between men and women based on historical and cultural backgrounds explains why women in most African communities are the dominant group in woodfuel extraction activity. According to Sola *et al* (2017) the socio-economic determinants of woodfuel extraction also include changes in income levels of households, employment status, assets ownership such as land, costs of extraction and profits made after sale of the commodity.

According to Gadow (2001), Normal Forest Model is applicable in establishing the number of acres of forest required to secure a continuous harvest of timber and or firewood. Fuwape (2003) further stated that the effects of woodfuel extraction on forests included: loss of biodiversity, disruption of hydrological cycle, soil erosion and hastened desertification. Thus, the socio-economic determinants and its effects of woodfuel extraction on gazetted forests were adopted from UNDP (2000), Gadow (2001), Fuwape (2003), Shackleton *et al* (2011) and Sola *et al* (2017).The tenets of the theory are: (i) woodfuel extraction is a function of socio-economic determinants such as income earned, gender of extractors and accessibility to the forest

resources; (ii) forest cover change is a product of yields of forest products harvested from the forest and the frequency of harvesting and; (iii) forest-specific indicators for predicting forest cover change include: trade statistics of forest products, policy frameworks and forest governance structure.

World Bank (2009) put forth the tenets of Normal Forest Model into practice by stating that 82,192m^3 of woodfuel is equivalent to all the trees contained in 342.5 hectares of forests. Thus, the study adopted the tenets of Gadow (2001) theory contained in World Bank (2009) conversions to establish relationship between volume of woodfuel extracted and the percentage change in cover of gazetted forests.

2.8 Conceptual Framework of the Study

The conceptual framework of the study is shown by Figure 1. The income from sales of woodfuel and proximity are viewed as the major socio-economic determinants of the volume of woodfuel extracted and the number of firewood headloads extracted from gazetted forests. The volume of woodfuel extracted consequently have effects on gazetted forests indicated by changes in percentage of cover of the forests. Mechanisms for enforcing exisiting intervenes between major socio-ecomomic determants and volume of woodfuel extracted from gazetted forests.

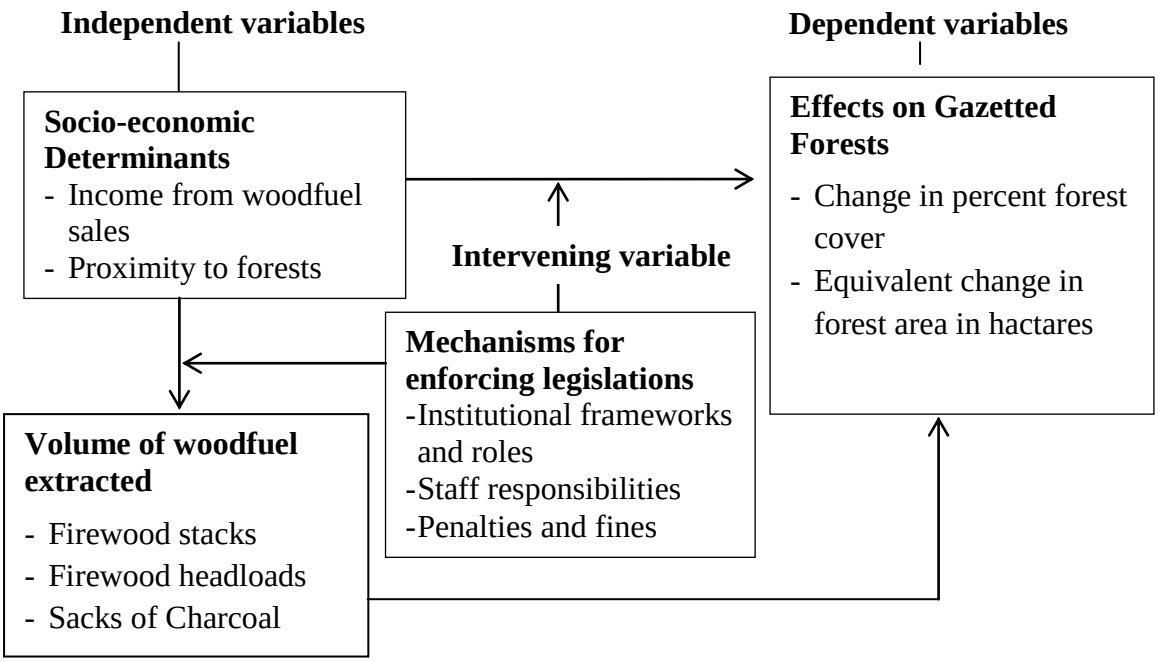

Figure 1: Conceptual framework of the study

Source: Researcher, 2015

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The chapter describes methodology under the following topics: the study area, research design, population and sampling, data collection procedures, data analysis and presentations, data reliability and validity and research ethics.

3.2 Description of Study Area

The study area was the gazetted forests within Koibatek Forests Zone, Mau Forests Complex, Kenya.

3.2.1 Geographic Location and Size

Koibatek Forests Zoneis located between longitude 35'35", and 35'15" and between Latitude 0'11" south and 0' 15" North. The Zone borders Kericho and Uasin Gishu Zones to the West, Keiyo to the North, Baringo to the South, Laikipia to the South East and Nakuru to the South. The Zone is located on Eastern part of the 2,535 km^2 (253,500 ha) Mau Forests Complex. The total area of the gazetted forests of Koibatek Forests Zone is 510.08 km^2 (51,007.7 ha)(IUCN, 2008).

Mau Forests Complex is the largest forest block in Kenya and is made up of 22 forests blocks namely: Transmara, Ol Posimoru, Maasai Mau, Eastern Mau, Mau Narok, South West Mau, Western Mau, Mt. Londiani, Eburru, Molo, South Molo, Tinderet, Northern Tinderet, Timboroa, Nabkoi, Kilombe Hill, Metkei and Koibatek forests (ENSDA, 2005).Koibatek forests comprises of the eight (8) gazetted forests blocks which lie within Koibatek Forests Zone in Baringo County. Figure 2 is a map showing part of Mau Forests Complex within which the eight blocks Koibatek Forests Zone lie.

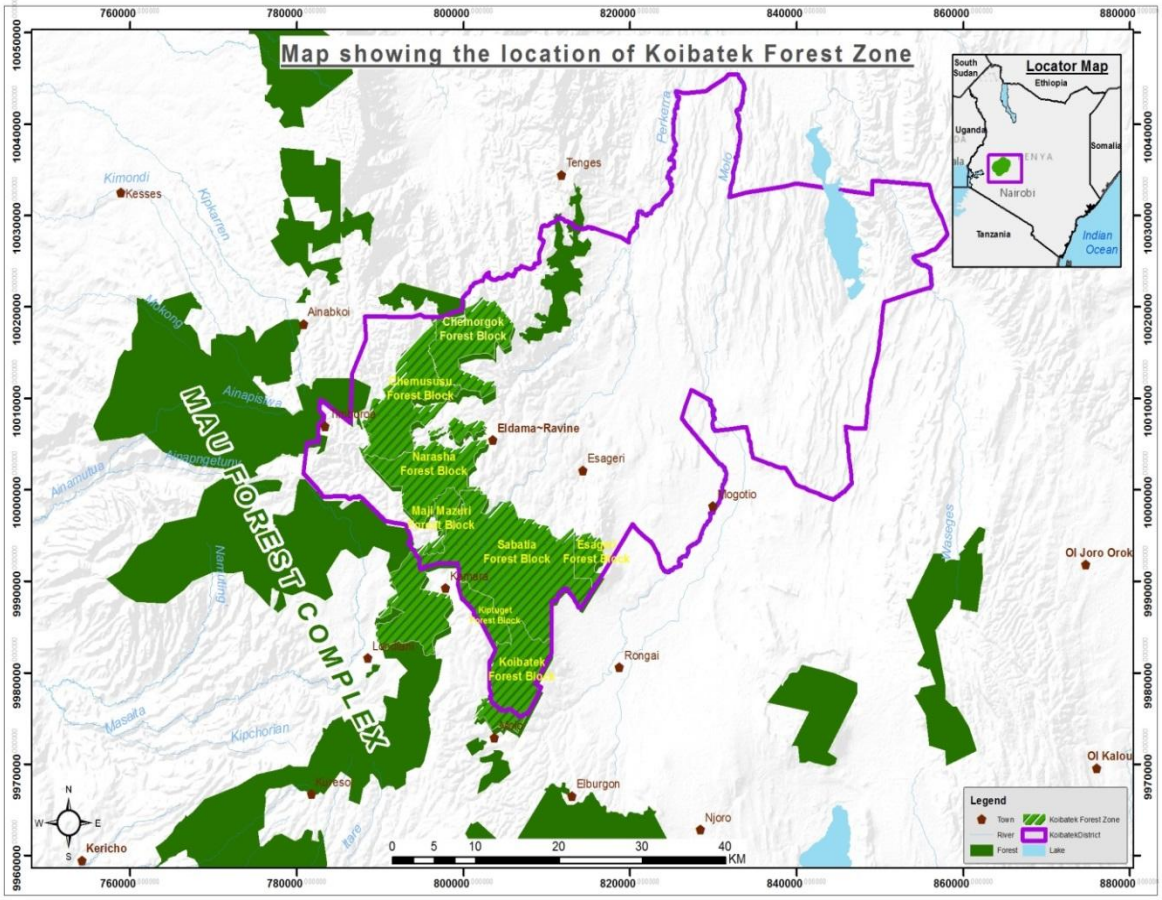

Figure 2: Map showing the Location of Koibatek Forests Zone within Mau Forests Complex

Source: Kenya Forest Service (KFS), 2015

3.2.2 Gazetted Forests Blocks of Koibatek Forests Zone

According to KFS-Koibatek Forests Zone (2011), Koibatek Forests Zone is composed of eight (8) gazetted forests blocks namely: Chemorgok, Narasha, Chemususu, Sabatia, Esageri, Maji Mazuri, Kiptuget and Koibatek Forests. The main vegetation of the gazetted forest blocks constitutes natural forest, grassland vegetation, and industrial plantation. In addition to the gazetted forests, there exist forests on trust lands within the jurisdiction of Koibatek and Mogotio Sub-Counties of Baringo County. Figure 3 shows the location of Koibatek Forests Zone in Map of Kenya and also indicates the boundaries of the eight gazetted forests blocks within the Zone.

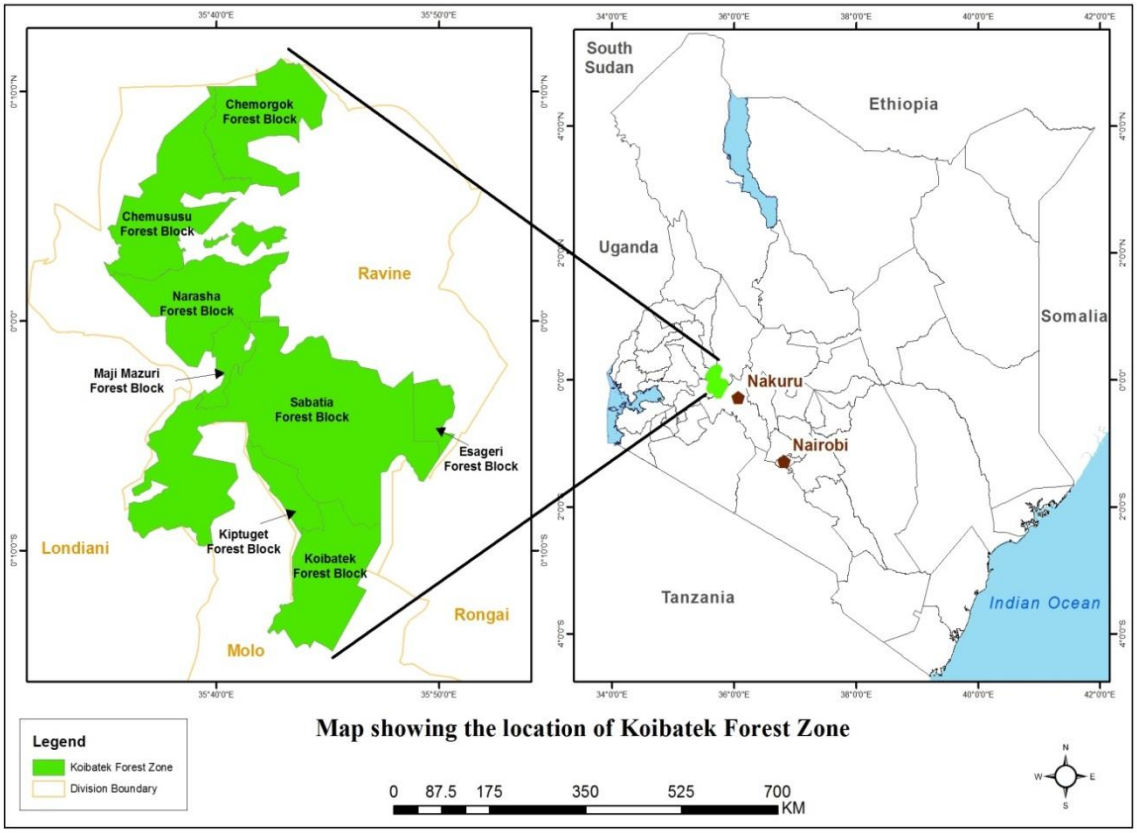

Figure 3: The eight gazetted forest blocks within Koibatek Forests Zone

Source: Kenya Forest Service (KFS), 2015

The total area covered by the eight (8) gazetted forests blocks is 51,007.7 hectares (KFS-Koibatek, 2011). Table 1 shows the total area of the eight gazetted forest blocks with in Koibatek Forests Zone was 51, 007.7ha out of which plantations forests occupied 19,416.3 ha, indigenous forests (27,996.5 ha) and grasslands (3,594.9 ha).

Table 1*: The Area Covered by Gazetted Forests within Koibatek Forests Zone*

Forest Blocks	***Area of Plantation(Ha)***	***Natural Forest (Ha)***	***Grasslands (Ha)***	***Total Gazetted Forest(Ha)***
Chemorgok	164.5	5,647.0	40.0	5,851.5
Chemususu	891.0	10,391.8	22.0	11,304.8
Narasha	4,208.4	724.0	1,227.0	6,159.4
Maji Mazuri	3,994.0	1,940.0	131.0	6,065.0
Sabatia	3,826.8	281.2	0.0	4,108.0
Esageri	1,611.7	4,469.9	1,715.9	7,797.5
Kiptuget	319.0	480.0	51.0	850.0
Koibatek	4,400.9	4,062.6	408.0	8,871.5
Total Area	**19,416.3**	**27,996.5**	**3,594.9**	**51,007.7**

Source: KFS-Koibatek, 2011

3.2.3 Administrative Structure of the Forests

The gazetted forests within Koibatek Forests Zonein Baringo County were under the management of the Koibatek District's Forest Department until year 2006 when the Forest Act, 2005 came into force. The former Districts of Koibatek and Mogotio became one Forest Zone known as Koibatek Forests Zone. The Zone is currently under the management of Kenya Forests Service (KFS)-Koibatek Forests Zone with an Ecosystem Conservation (EC) stationed at Eldama Ravine town. In addition, each of the eight (8) gazetted forests blocks within the Zone has an administrative forest station managed by a forester. There are also forest extension services that are undertaken in both Mogotio and Koibatek (KFS-Koibatek Forests Zone, 2011).The Zone also has eight Community Forest Associations (CFAs) as provided for in the Forest Act, 2005.Table 2shows the names of the registered CFAs operating within each forest block and their members by the end of December 2014.

Table 2: Registered CFAs within the Gazetted Forests and total Membership by December 2014

Gazetted Forest Blocks	*Name of the Registered Community Forest Association (CFA)*	*Total membership by Dec., 2014*
Chemorgok	Tulwob Lembus Community Forest Association	372
Chemususu	Lembus Chemususu Forest Association	893
Narasha	Lembus Narasha Community Forest Association	900
Maji Mazuri	Maji Mazuri Station Community Forest Association	1,005
Sabatia	Sabatia Community Forest Association	298
Esageri	Esageri Community Forest Station	1,229
Kiptuget	Kiptuget Community Forest Station	707
Koibatek	Koibatek Community Forest Association	1,750
	Total	**7,154**

Source: KFS-Koibatek, 2015

3.2.4 Forest Management Plans

According to KFS-Koibatek Forests Zone (2011), Koibatek Forests Zone does not have a management plan for the eight forests stations within its territory. However, the zone is empowering the Community Forest Associations in all the eight stations to come up with participatory management plans. A felling plan for the entire zone had been drawn to guide harvesting operations for three years i.e. 2011 to 2013. However, there has not been any specific plan for woodfuel harvesting for the zone.

3.2.5 Topography

Koibatek Forests Zone is well endowed with unique topographical features including undulating river valley and plains, the Londiani Hill, Rock outcrops and incised Valley which form seasonal streams and rivers that flow to Lake Bogoria and Lake Baringo within Baringo Forests Zone (MPND, 2002).

3.2.6 Climatic Conditions

The mean annual rainfall of Koibatek Forests Zone range from 800mm to 1800mm, with long rain occurring between March and July and short rain from September to November. High rainfall is experienced along the Koibatek hills and Londiani hills. Rainfall in the Zone is fairy reliable with 50% reliability. The mean annual temperatures are 30^0C in the highlands. The climate conditions support growth of natural and plantation forests within the Zone. In addition, weather conditions determine entry into forests since during rainy seasons, the soils become sticky and slippery making accessibility difficult (MPND, 2002).

3.2.7 Socio-economic Activities

The main socio-economic activities within former Koibatek District (now Eldama Ravine and Mogotio Sub-counties) is crop farming, livestock keeping, charcoal burning, and quarrying, sawmilling and sand harvesting. Most of the activities directly affect gazetted forests as follows: forests have been cleared to create more land for crop production, livestock grazed within forests particularly during droughts destroys young growing trees, quarries located within the gazetted forests have caused land dereliction, saw-milling, firewood collection and charcoal burning contributes also to overall removal of vegetation leading to deforestation (KFS-Koibatek Forests Zone, 2011).

3.2.8 Road Networks

Republic of Kenya (2013) categorized the main access roads in Koibatek Sub-county where Koibatek Forests Zone is located into bitumen, murram and earth roads where earthen roads were the dominant access. Appendix VI is a map of showing the major road networks within and along the edges of gazetted forests blocks of Koibatek Forests Zone. Nakuru-Eldoret Highway passes the edge of Koibatek forest block while Maji Mazuri block had Eldama Ravine-Makutano

tarmac road passing through the block. Narasha block had Eldama Ravine-Kamwosor-Eldoret tarmac road passing through edges the blocks (Appendix VI). The tarmac access to the forests made it easy for vehicles particularly lorries and pick-ups to transport forest products that includes firewood and charcoal to markets and other end-user destinations.

3.2.9 Poverty Level

The poverty level of Baringo County in 2010 was 58.5%. Based on the poverty index, Baringo County was ranked number 32 out of 47 counties in Kenya in terms of riches/wealth (Republic of Kenya, 2013). Since Forestry Administration (2002) and Ndegwa (2010) stated that woodfuel is common among poor rural communities, majority of residents of Baringo County rely on woodfuel for their energy needs.

3.3 Research Design

A cross-sectional descriptive research design was adopted for the study. The design was relevant in understanding how a random sample of woodfuel extractors across gazetted forest blocks participates in real-time extraction activity. Firstly, a representative sample of gazetted forests blocks within Koibatek Forests Zone was purposely selected. A random sample of woodfuel extractors and purposely selected forests officers were interviewed so as to establish the socio-economic determinants of woodfuel extraction within the gazetted forests. Secondly, secondary data on permits/licenses for woodfuel extracted from the gazetted forests for the period between January 2006 and December 2014 were obtained and used to estimate the volume of woodfuel extracted. In addition, the volume of woodfuel extracted between 2006 and 2014 was then converted into area of closed forest cover required to supply the wood, which consequently indicated the relationship between volume of woodfuel extracted and the percentage change in cover of gazetted forests.

3.4 Population and Sampling

Koibatek Forests Zone has eight (8) gazetted forests blocks. Purposive sampling was used to select: all the eight (8) gazetted forest blocks were selected in consistent with Morris, (2009) who stated that, for very small populations (50 or less), the entire population is selected in order to achieve high level of accuracy. The unit of analysis for the study was woodfuel extractors registered as CFA members. From the 7,154 registered CFA members, the following formula given by Kothari (2004) was used to determine the representative sample of woodfuel extractors within gazetted forests:

$$n = \frac{Z^2.p.q.N}{e^2(N-1) + Z.p.q}$$

Where*: n* = size of sample.

Z= the value of the standard variate at a given confidence level and to be worked out from table showing area under Normal Curve;

e = acceptable error (the precision)

p = sample proportion,

q = 1 – *p*;

Kothari (2004) indicated that, for the most conservative sample size, the value of p = 0.5; therefore q=0.5. At confidence level of 95.5% (Z=2.005) and within ±5% of the true value, the sample size (n) of the study is calculated as follows:

$$n = \frac{2.005^2 \times 0.5 \times 0.5 \times 7154}{0.05^2(7154-1) + 2.005^2 \times 0.5 \times 0.5} = 384$$

The resultant sample of 384 woodfuel extractors was then distributed proportionately across the adjacent community of each of the eight (8) gazetted forests blocks based on the total number of registered CFA members. Simple random sampling was then utilized in identifying the woodfuel

extractors to be interviewed within each of the gazetted forests blocks. Purposive sampling was also used to select the following: 1 Ecosystem Conservator, 8Forest Officers, 8 Forest Rangers and 10members to represent each of the 8 CFAs within Koibatek Forests Zone.

3.5 Data Collection Procedures

The study relied on both primary and secondary data.

3.5.1 Primary Sources of Data

Primary data was collected by use of the following methods:

3.5.1.1 Examining licensing and permits profile

The registers of licences and permits issued to persons to gain entry into gazetted forests and undertake activities relating to woodfuel extraction for period between January 2006 and December 2014 were examined. Therefore Monthly Fuel Licences (MFLs) and firewood stacks licenses was counted for the entire period of study.

3.5.1.2 Volume estimation of Woodfuel

(a) Volume of Firewood

The volume of firewood extracted from the forest was estimated by use of two methods: stack measurements and headloads counts.

(i) Firewood stacks measurements

According to FAO (2006), a stack is the amount of wood in a neat pile of 3 m^3(i.e. 1mwidth by 1m height by 3mlength). It is the most common measurement of firewood in most parts of the world (Oester and Bowers,2003). The amount of actual wood depends on the size and shape of pieces. Therefore, the number of firewood stacks sold and recorded by KFS was multiplied by 3 m^3 to get the approximate volume of the firewood extracted. The volume of firewood arrived at under this method is abbreviated as V_{stacks} by the study.

(ii) Firewood Head load counts

According to Openshaw (1978), a headload of firewood refers to a pile of firewood enough to be carried by one person on the head or back**.** From surveys, the average firewood headload weighed about 26 kg in Gambia and Tanzania whereas in Kenya it weighs 25 kg and 20kg in Sri Lanka. Volume estimation through this method took the following simple steps:

(i) Total number of MFLs recorded by KFS for every month in each of the eight forest blocks for the period between January 2006 and December 2014 was obtained.

(ii) The average number of times a MFL's holder extract firewood from the forest per month was sought.

(iii) The product of the MFLs and monthly number of times of woodfuel extraction was established. The result was then multiplied by 25kg (in consistent with Open shaw, 1978) to obtain the total weight of firewood collected.

(iv) Thereafter, the weights (in kgs) were further converted to volume (in cubic metres) using $0.087m^3$ per 25kgs.

(b) Charcoal

Charcoal produced is packed in sacks each weighing of 40kg (Ndegwa (2010). The total volume of charcoal produced from gazetted forests was estimated stepwise as follows:

(i) An estimate of the total number of sacks of charcoal produced was established.

(ii) The total weight in kilograms charcoal produced was calculated by multiplying the number of sacks by 40kgs-weight of each sack filled with charcoal.

(iii) The weights of charcoal was then converted to cubic metres using the figure of 180kg/m^3 for charcoal produced with preferred tropical hardwood charcoal species provided in Table 3.

Table 3: Weight of charcoal per m^3 for specified tree species

Tree Species	***Weight of Charcoal (in Kg) Per M^3***
Pines	115
Average Tropical hardwoods	170
Preferred tropical hardwoods charcoal species	180
Rhizophora	285

Source: Open shaw (1978)

3.5.1.3 Use of Questionnaires

Questionnaires were administered to 384 woodfuel extractors who were registered members of CFA within each of the eight forest blocks. The number of respondents was proportionately distributed to the gazetted forest blocks in accordance with registered members of the CFA within each forest block by December, 2014(as was shown in Table 2).Table 4shows the number percentage of respondents selected in every gazetted forest block.

Table 4: Number of Respondents selected within the Gazetted Forests Blocks

Forest Block	**Name of the CFA**	**Population**	**Sample size**	**% of the total**
Chemorgok	Tulwob Lembus	372	20	5.2
Chemususu	Lembus Chemususu	893	48	12.5
Narasha	Lembus Narasha	900	48	12.5
Maji Mazuri	Maji Mazuri	1005	54	14.1
Sabatia	Sabatia	298	16	4.2
Esageri	Esageri	1,229	66	17.2
Kiptuget	Kiptuget	707	38	9.9
Koibatek	Koibatek	1,750	94	24.5
Total		**7,154**	**384**	**100.0**

Source: Field Survey, 2015

The questionnaires administered contained both closed and open ended questions (Appendix 1). All the questionnaires were either self-administered or through research assistants to allow respondents get clarification on questions that they did not understand.

3.5.1.4 Key Informant Interviews

The Key informants for the study were drawn from forest officers, forest rangers, firewood and charcoal business men and women within Koibatek Forests Zone. Therefore, key informants who wereinterviewed during the study included:1 ecosystem conservator, 1 deputy ecosystem conservator, the eight (8) forest Officers within Koibatek forests Zone i.e. one forest officer from each of the 8 gazetted forest blocks and eight (8) forest rangers and 2 firewood yard attendants.

3.5.1.5 Focused Group Discussions (FGDs)

One (1) FGD was done for each of the identified eight (8) CFAs within the gazetted forest blocks of the study. Each FGD comprised of 10 participants in accordance with Escalada and Heong (2010) that stated that the optimum number of participants in a FGD should be 8 to 10. Of the participants in each FGD, 6 were men and 4 were women of which at least two were youth.

3.5.1.6 Observations and Photography

The researcher visited the gazetted forests to establish the existing situations concerning woodfuel extraction and transportation activities. During the visits, woodfuel extractors and transporters were directly observedand photographs of them taken. Observational checklists were used to record features directly observed by the researcher. The photographs taken enhanced the quality of data as they represented the significant physical attributes relevant to the study. The method wasalso used to cross-check the respondents' answers in the questionnaires and interview schedules.

3.5.1.7 Remote Sensing Data Acquisition

Forest cover change over the study period of between 2006 and 2014 was examined by acquiring and analyzing satellite images. Satellite image data was acquired from the United States Geological Survey (USGS) Global Visualization viewer website (www.glovis.usgs.gov). The satellite images acquired were for the years 2006, 2010 and 2014. These three years were purposely selected as follows: the year 2006 due to commencements of implementation of both Forest Act, 2005 and Energy Act, 2006; year 2010 due to the promulgation of Constitution of Kenya (2010) and, the year 2014 because of establishment of Kenya's Forest Policy, 2014. In order to obtain high quality satellite data, cloud free images were selected. In addition, shape files containing forest blocks demarcation data were acquired from Kenya Forest Service (KFS).Table 5 indicates the path, row, acquisition date and the source of satellite images/shape file used.

Table 5: Summary of information of Satellite images and shape files used

Satellite Image/Shape file	Path	Row	Acquisition Date	Source
Landsat 8 OLI*	169	060	25/10/2014	USGS*
Landsat 5 TM	169	060	30/10/2010	USGS
Landsat 7 ETM+	169	060	07/01/2006	USGS
Forest Blocks Shapefile			2010	KFS

USGS*-United States Geological Survey **OLI*-**Operational Land Imager

Source: Field Survey, 2015

The spectral bands selected from Landsat 5 Thematic Mapper (TM) and Landsat 7 Enhanced Thematic Mapper+ (ETM+) satellite images were bands 1, 2, 3, 4, 5 and 7 while for Landsat 8 Operational Land Imager (OLI), band 2-7 were selected then imported to ArcGIS 10.3 software for processing. The satellite images were then projected to Universal Transverse Mercator World Geodetic System 1984 (WGS84) Zone 36N as relates to the location of the study area. Image

pre-processing such as cloud removal and mosaicking was done in order to fill the scan lines especially for Landsat 7 ETM+ image which had scan line errors from the satellite sensor. For Landsat 8 OLI atmospheric correction for earth-sun geometry was done by converting Digital Numbers (DN) to surface reflectance.

The Forest blocks shape file was used to extract the study area from the satellite images. Unsupervised classification was done in ArcGIS software. Normalized Difference Vegetation Index (NDVI) was performed by combinations of the pixel values from two or more spectral bands in a multispectral image. It highlighted pixels showing the relative abundance or lack of a forest cover type of interest the image.As a result, five classes of land cover types of the gazetted forest areas were developed namely: Closed forests, Open forests, Grasslands, Water and Agriculture from each of the 3 satellite images: 2006, 2010 and 2014 as shown in Table 6.

Table 6: Land Cover Classification Schemefor Gazetted Forests with Koibatek Forests Zone

ForestLand Cover	**Description**
Closed canopy forests	Forest land covered by trees with overlapping canopies
Open forests	Sparsely vegetated forest land areas dominated by shrubs and scattered trees
Grasslands	Areas covered mainly by grass
Agriculture	Areas covered with agricultural fields for various types crops
Water	Open water body

Source: Field Survey, 2015

High resolution Google Earth images were used to access the accuracy of the classification. From the resulting unsupervised classification, Maximum Likelihood Classifier (MLC) algorithm from ArcGIS software was used to calculate the probability that a pixel belongs to a specific class. This generated forest cover for the entire study areas and consequently developsforest cover data maps.

3.5.1.8 Equivalent forest area of the volume of woodfuel

The study adopted World Bank (2009) conversions of woodfuel extracted to the equivalent area of closed canopy forest cover whereby, 82,192$m^3$of woodfuelis equivalent to that contained in 342.5 hectares of forest. Therefore, the total volume of firewood extracted from gazetted forests within Koibatek Forests Zone was converted directly into area (in hectares) of closed forests. The volume of charcoal produced was first treated to be equal to20% volume of wood used to produce the charcoal in accordance to World Bank(2009) and KFS (2009) which stated that the efficiency of tradition kilns used for charcoal production in Tanzania and Kenya is 20%. Then the resultant volume of wood established for charcoal production was converted to the area (in hectares) of closed canopy forests cover using World Bank (2009).

3.5.2 Secondary Sources of Data

Secondary data was obtained through reviews of relevant information on energy and specifically on woodfuel extraction. Firstly, licensing and permits data on woodfuel for the period between 2006 and 2014 recorded in KFS files were obtained so as to gather for the longitudinal aspects of the study. In addition, registers of CFA members up to the end year 2014 was also sought from KFS reports. Furthermore, a review of national energy policy papers, journals, conference proceedings, newspapers, magazines, dissertations and theses on related topics and; any other relevant published and unpublished literature were reviewed. The main sources of the fore-mentioned materials included: various websites and libraries of Maseno University, University of Eldoret, University of Kabianga and Londiani Forest Training College. Secondary data gave insight into the research topic and enabled comparisons of a variety of researches on biofuels or woodfuel extraction, trade and consumption. The data assisted in the identification of existing knowledge gaps and the best practices adopted or recommended for adoption.

3.6 Data Analysis and Presentations

The questionnaires, interview schedules, GIS and Remote Sensing data, field notes and photographs we rearranged and authenticated. The unit of analysis for the study was woodfuel extractors while the units of observation were gazetted forest blocks of Koibatek Forests Zone. Filled questionnaires by woodfuel extractors were also coded for analysis. Both qualitative and quantitative techniques were utilized in the analysis of collected data. Quantitative data were analysed in SPSS software using (i) descriptive statistics which included: frequencies, Cross tabulations (ii) Chi-square and (iii) Simple linear regression. Some data were imported and analyzed in Microsoft Excel. In addition, supervised classification of Remote Sensing data was done in ArcGIS software.Photo Express software was used for digital photographs production. Microsoft Word was used for processing text. The processed data was presented in the form tables, figures, plates (photos) with discussions.

3.7 Data Reliability and Validity

The study pre-tested the data collection instruments during reconnaissance surveys to ensure that the data needed by the study would be sufficiently collected. Content validity was achieved by subjecting the pool of questions in the research instrument to academic expert's panel in the field of forestry and energy who expressed their level of agreement/disagreement on use of various items in the questionnaire. The questionnaires were administered to ten 10 people (2.6%) of the targeted woodfuel extractors within the study area. This was in line with *tools4dev* (2014) that stated that once design of a survey questionnaire is completed, 5-10 people from target group should be selected to pretest it. Once the data had been collected, analysis was done to establish omission or commissions in the instruments which then was corrected for the actual field data

collection exercise. The respondents who were sampled during reconnaissance were noted so that they were not repeated again during actual data collection.

3.8 Research Ethics

The researcher first sought informed consent from KFS on the intention to conduct the research within the gazetted forests. In effect, a research permit was issued by KFS to gain entry into the gazetted forests to collect data (Appendix IV). Furthermore, the researcher assured and respected confidentiality or anonymity of respondents by giving them an option not to write their names in the research questionnaires and, assuring them that the information was to be used only for the purposes of the study. The respondents were given a chance also to participate voluntarily in the study. Consents were also sought by the researcher from managers, respondents and members of public before taking photographs in addition to explaining the photographs were to be used for the purposes of the study.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1Introduction

The chapter contains results and discussions on:(i) the socio-economic determinants of woodfuel extraction within gazetted forests; (ii) the relationship between income earned from sale of woodfuel and volumes extracted; (iii) the influence of proximity to forests on the number of firewood headloads extracted from 2006-2014; (iv) the relationship between volume of woodfuel extracted and percent gazetted forest cover change and;(v) the influence of mechanisms for enforcing existing legislations on woodfuel extraction from gazetted forests within Koibatek Forests Zone from 2006 to 2014.

4.2 The Socio-Economic Determinants of Woodfuel Extraction within Gazetted Forests

4.2.1 Effects of Gender on Woodfuel Extraction

Table 7 shows that majority of woodfuel extractors within gazetted forests were female accounting for 79.2% of the total extractors while male woodfuel extractors were 20.8%. There existed three categories of woodfuel extractors: (i) those who extracted firewood only accounting for 87.5% of which 73.2% were female and 14.3% male, (ii) charcoal producers only were 2.1% whereby 0.8% were female and 1.3% were male and, (iii) 10.4% (5.2% male and 5.2% female) extracted both firewood and charcoal from gazetted forests.

Table 7: Gender of Woodfuel Extractors in Gazetted Forests, Koibatek Forests Zone

	% of Total Extractors Per Type of Woodfuel			
Gender	***Firewood only***	***Charcoal only***	***Firewood & charcoal***	***Total***
Female	73.2	0.8	5.2	79.2
Male	14.3	1.3	5.2	20.8
Total	**87.5**	**2.1**	**10.4**	**100.0**

Source: Field Survey, 2015

Table 8: Chi-Square Tests of Gender and woodfuel extraction

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	33.113[a]	2	.000
Likelihood Ratio	27.443	2	.000
Linear-by-Linear Association	29.089	1	.000
N of Valid Cases	384		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 1.67.

Source: Field Survey data, 2015

Pearson's Chi-square $X^2(2) = 33.113$, $P<0.05$ as shown in Table 8indicates that gender of woodfuel extractors had strong association with woodfuel extraction within gazetted forests. Thus, gender was significant determinant on woodfuel extraction within gazetted forests of Koibatek Zone. The results of the study agree with WETT (2000) and FAO (2000a) which reported that women generally devote a lot of their time and dominates in firewood gathering within household level. The findings also conform to ADAS (2006),Wagura and Nyagena (2008), ESMAP (2012) and WEC (2013) which stated that the main socio-economic factor related to the extraction of woodfuel is labour conditions where women are the dominant group. However, the results contradicts the findings of Bechtel (2010) and Sunderland et al (2010) that both men and women jointly undertook harvesting of forest products in Central Africa. Sunderland et al (2014) also established that men participate more than women in extraction of

forest products such as firewood for domestic consumption in rural area. Table 9 indicates the distribution of woodfuel extractors by gender within each of the eight gazetted forests blocks within Koibatek Forests Zone.

Table 9: Gender Distribution of Woodfuel Extractors within Gazetted Forest Blocks

	% of Extractors by Gender within Forest blocks	
Forest Block	**Male**	**Female**
Chemorgok	20.0	80.0
Chemususu	10.4	89.6
Narasha	27.1	72.9
Maji Mazuri	24.1	75.9
Sabatia	25.0	75.0
Esageri	13.6	86.4
Kiptuget	28.9	71.1
Koibatek block	22.3	77.7
Mean	**20.8**	**79.2**

Source: Field Survey, 2015

Table 9 shows that the percentage of female woodfuel extractors was highest within Chemususu block at 89.6%, followed by Esageri block at 86.4% then Chemorgok block at 80.0% and Koibatek block at 77.7%. On the other hand, Kiptuget block recorded the highest percentage of male (men) woodfuel extractors at 28.9% followed by Narasha at 27.1%, then Sabatia block at 25.0% and Maji Mazuri block at 24.1%. Generally, women dominated woodfuel extraction activity at 79.2% compared to men who accounted for 20.8%(Table 9). The results were consistent with Khare et al (2000) and Dovie (2003) that women and particularly those in female-headed households, are more directly reliant on consumption and sale of forest resources than men. The results of the study were however contrary to Sunderland et al (2014) where men dominated harvesting of forest products such as bush mangos and woodfuel at 61% compared to 25% women.

Table 10: Chi Square Tests of Gender Distribution within Gazetted Forests

	Value	***Df***	***Asymp. Sig. (2-sided)***
Pearson Chi-Square	8.535[a]	7	0.288
Likelihood Ratio	9.080	7	0.247
Linear-by-Linear Association	0.007	1	0.934
N of Valid Cases	**384**		

a. 2 cells (12.5%) have expected count less than 5. The minimum expected count is 3.33.

Source: Field Survey, 2015

Table 10 shows Pearson Chi-Square tests of gender distribution of woodfuel extractors within gazetted forest blocks. $X^2(7)= 8.535$, $P>0.05$ indicates that there is no association between gender of woodfuel extractors and the gazetted forests blocks from which they extract woodfuel within Koibatek Forest Zone. Therefore, gender distribution was random factor which was independent of the gazetted forest block within Koibatek Forests Zone. The findings agree with FAO (2005) that gender of woodfuel extraction was a product of geographical location of the community. On the contrary WETT (2000), ADAS (2006), Wagura and Nyagena (2008) and Shackleton *et al* (2011) stated that gender distribution was dependent on cultural background and not geographical locations.

Table 11shows the reasons why the various groups of woodfuel extractors were involved in woodfuel extraction activities within gazetted forests of Koibatek Forests Zone.

Table 11: Reasons why Groups of Extractors were involved in Woodfuel Extraction

Group of extractors	***% responses on Reasons for involvement in woodfuel extraction***				
	Cultures	***Poverty***	***Business***	***Unknown***	***Total***
Women	64.8	15.4	7.6	1.8	89.6
Men	0.3	0.5	1.0	-	1.8
Children	2.6	4.7	-	1.3	8.6
Total	**67.7**	**20.6**	**8.6**	**3.1**	**100.0**

Source: Field Survey, 2015

Table 11 indicates that women were the dominant group involved in woodfuel extraction at 89.6% followed by children at 8.6% and men at 1.8% of the respondents. The main reasons cited for such involvement were: cultures (67.7%), poverty (20.6%) and business (8.6%).The findings agrees with FAO (2005), ESMAP (2012) and WEC (2013) that factors that affects woodfuel extraction included poverty and cultural practices of people.

Table 12: Chi-Square Tests of group of extractors and reasons for involvement in woodfuel extractions

	Value	***df***	***Asymp. Sig. (2-sided)***
Pearson Chi-Square	70.415[a]	6	.000
Likelihood Ratio	52.835	6	.000
Linear-by-Linear Association	22.659	1	.000
N of Valid Cases	**384**		

a. 6 cells (50.0%) have expected count less than 5. The minimum expected count is .22.

Source: Field Survey Data, 2015

Table 12 ($X^2(6)= 52.835$, $P<0.05$) showsthat there was strong association between group of woodfuel extractors and the reasons for involving in woodfuel extraction. Thus, the involvement of the groups in woodfuel extraction activity within gazetted forests was greatly influenced by cultures and poverty. The findings also agree with ADAS (2006), IEA (2006) and Shackleton *et al* (2011) which reported that most cultures of African countries do not permit men to undertake

firewood extraction. Further to that Personal communication from forest rangers within the forest Zone (2015) reported that women and children extractors were preferred to men in the gazetted forests because they were less likely to perform illegal activity aside from firewood extraction once permitted into the forests. Men were accused of likelihood of undertaking illegal activities such as cutting standing trees for building poles and making clubs (*rungus*), chopping of cedar poles and burning charcoal. However, according to Sunderland *et al* (2014), more men than women participate in harvesting of forest products for income and domestic consumption.

4.2.2 Effects of Age of Extractors on Woodfuel Extraction

Table 13: Age Intervals of Woodfuel Extractors within Gazetted Forests

	% of Total Extractors per type of Woodfuel			
Age intervals in years	***Firewood only***	***Charcoal only***	***Firewood & charcoal***	***Total***
Below 18	1.0	0.0	0.0	**1.0**
18-29	10.4	0.0	2.3	**12.8**
30-39	46.9	0.8	3.9	**51.6**
40-49	24.7	1.3	3.9	**29.9**
50-59	3.6	0.0	0.0	**3.6**
60 and above	1.0	0.0	0.0	**1.0**
Total	**87.5**	**2.1**	**10.4**	**100.0**

Field Survey, 2015

Table 13 shows that the age group that dominated woodfuel extraction within gazetted forests was 30-39 years at 51.6% followed by 40-49 years at 29.9% and 18-29 years accounting for 12.8% of total woodfuel extractors. The study also noted that children (below 18 years) and elderly with 60 years and above were the minority each accounting to 1.0% of the total woodfuel extractors while age group of 50-59 years accounted for 3.6%.Table 13furthershows that extraction of firewood only was done by all age groups as follows: below 18 years (1.0%), 18-29 years (10.4%), 30-39 years (46.9%), 40-49 years (24.7%), 50-59 years (3.6%) and 60 years and

above (1.0%).The results indicate that children below 18 years and elderly 50 years and above extracted firewood only from the forests. The other three age groups namely 18-29 years, 30-39 years and 40-49 years extracted both firewood and charcoal from the forests.

Table 14: Chi-Square Testson Age Interval and Woodfuel Extraction

	Value	***df***	***Asymp. Sig. (2-sided)***
Pearson Chi-Square	13.741[a]	10	0.185
Likelihood Ratio	15.759	10	0.107
Linear-by-Linear Association	.938	1	0.333
N of Valid Cases	**384**		

a. 11 cells (61.1%) have expected count less than 5. The minimum expected count is .08.

Source: Field Survey Data, 2015

Table 14 shows that there was no association between age of woodfuel extractors and the type of woodfuel extracted type of woodfuel extracted within gazetted forests as indicated by $X^2(10)=15.759, P>0.05$ (since 61.1% of the cells have expected counts less than 5).Therefore, the volumes of woodfuel extracted within gazetted forests of Koibatek Forests Zone were independent of the ages of extractors. The findings of the study contradicts Kituyi *et al* (2001) and Sola *et al* (2017) where age was listed as one of the demographic factors that influence the use of woodfuel. However, the results agree with studies that include WETT (2000), UNDP (2000) and Delali *et al* (2004) which did not find any correlation between age of extractor and woodfuel extraction and use.

4.2.3 Level of Education of woodfuel extractors

Table 15: Level of Education versus Type of Woodfuel Extracted within Gazetted Forests

	% of Total extractors type of woodfuel			
Level of Education	*Firewood only*	*Charcoal only*	*Firewood & charcoal*	*Total*
Primary	25.5	1.0	3.6	**30.1**
Secondary	52.3	0.8	4.8	**57.9**
Tertiary certificate	4.7	0	1.0	**5.7**
Diploma	2.9	0.3	0.5	**3.7**
Undergraduate	1.8	0	0.5	**2.3**
Master	0.3	0	0	**0.3**
Total	**87.5**	**2.1**	**10.4**	**100.0**

Source: Field Survey, 2015

Table 15 shows that majority (57.9%) of woodfuel extractors had attained secondary level of education while 30.1% had attained primary level of education. This implies that most of those residents who did not proceed to tertiary levels education were undertaking woodfuel extraction within gazetted forests. The remaining few extractors had attained tertiary certificates (5.7%), Diploma (3.7%), Undergraduate degrees (2.3%) and master degrees (0.3%). Therefore, based on the percentages of woodfuel extractors, the study notes that as the level of education increase, the number of woodfuel extractors within gazetted forests decreases. The results were consistent with Shackleton *et al* (2011) that individuals who have attained higher levels of education use other cleaner fuels such as electricity.

Table 16: Chi-Square Tests of Level of Education on Categories Woodfuel Extraction

	Value	*Df*	*Asymp. Sig. (2-sided)*
Pearson Chi-Square	8.897[a]	10	.542
Likelihood Ratio	8.439	10	.586
Linear-by-Linear Association	.326	1	.568
N of Valid Cases	384		

a. 11 cells (61.1%) have expected count less than 5. The minimum expected count is .02.

Source: Field Survey Data, 2015

Table 16 indicates that Likelihood Ratio $X^2(10)$ =8.439, P> 0.05 depicting that there was no association between level of education and woodfuel extracted within gazetted forests of Koibatek Forests Zone. Therefore, though majority of woodfuel extractors had primary and secondary level of education, there were also woodfuel extractors who had attained higher levels of education such as diploma, undergraduate degrees and master degrees within the categories of woodfuel extracted. The results are supported by UNDP (2000), Hillring (2006), ESMAP (2012), WEC (2013) and Sunderland et al (2014) where level of education was not associated with woodfuel extraction.

4.2.4 Employment Status of Woodfuel Extractors within Gazetted Forests

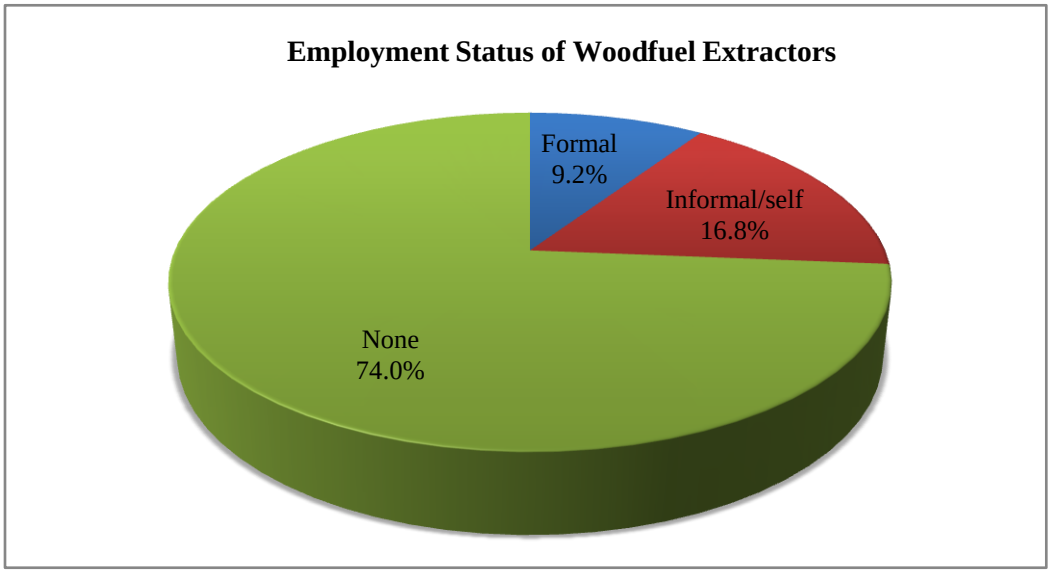

Figure 4: Employment Status of Woodfuel Extractors

Source: Field Survey, 2015

Figure 4shows that 74.0% of woodfuel extractors were unemployed while 16.8% were informally or self-employed undertaking activities such as businesses and farming and 9.2% of woodfuel extractors were in formal employments such as public service, private companies and

community organizations. Therefore, majority (74%) of woodfuel extractors was unemployed and undertook woodfuel extraction not only as source of energy to their homes but also as a source of income. According to Ndegwa *et al* (2011) charcoal value chains in Rwanda supports livelihood of over 300,000 people and over one (1) million in Kenya. Ouya (2013) also reported that in 2007 charcoal sector alone was a US$8-billion industry employing more than 7 million people in the Sub-saharan Africa.

Table 17 indicates the relationship between levels of employment of woodfuel extractors and their monthly incomes.

Table 17: Monthly Incomes of Woodfuel Extractors under each of the Economic Activity

Income Levels per month		***% of Total on Employment Status***			***Total %***
Level	***Amount (Kshs)***	***Formal***	***Informal/self***	***None***	
Low	1-1000	0.0	0.0	12.0	**12.0**
	1001-5000	0.0	1.0	35.4	**36.4**
	5001-10000	0.5	0.5	23.2	**24.2**
Medium	10001-20000	2.6	4.9	3.1	**10.7**
	20001-50000	4.7	7.8	0.3	**12.8**
High	50001-100000	1.3	2.1	0.0	**3.4**
	Above 100000	0.0	0.5	0.0	**0.5**
	Total	**9.2**	**16.8**	**74.0**	**100**

Source: Field Survey, 2015

Table 17 shows that extractors in formal employment had their monthly incomes from Ksh.5,001 to Ksh.100,000, those in informal/self-employment had monthly incomes starting from kshs 1,001 to above 100,000. The monthly income of extractors with no other activity concentrated between Ksh 1.00 and ksh. 10,000 with a few earning over Ksh.10,001. On average majority of woodfuel extractors were low income earners: 36.5% earned Kshs. 1001- 5000; 24.2% (Kshs. 5001-10,000) and 12.0% (Ksh.1-1000). Those who fall on middle income were 10.7% (10001-

20000) and 12.8% (Kshs. 20,001- 50,000). High income earners were 3.4% earning Ksh. 50001-100000 and 0.5% (above Ksh. 100000). Therefore, most woodfuel extractors had lower levels of income compared to extractors with higher levels of income. The findings agrees with the results of UNDP (2000) that increasing income levels tend to lead to a higher use of energy by citizens of modern society. Delali *et al* (2004) and Hillring (2006) also indicated that woodfuel extraction attributable to poverty where the energy source was in household with low income levels. However, the increase in energy demands is met by shifting from traditional energy types such as firewood and charcoal to modern energy types that include electricity, natural gas and petroleum products (Wagura and Nyagena, 2008).

4.2.5 Livelihood support for unemployed wodfuel extractors

Table 18: Main Livelihood Support for Unemployment Woodfuel Extractors

Source of livelihood support	***% of Total Extractors per Category of Woodfuel extraction***			
	Firewood only	***Charcoal only***	***Firewood & charcoal***	***Total***
Parents	35.6	0.4	4.2	**40.2**
Spouses	32.8	1.4	4.2	**38.4**
Children	14.4	0	1.4	**15.8**
Well-wishers	3.5	0.7	0.4	**4.6**
Government	1.0	0	0	**1.0**
Total	**87.3**	**2.5**	**10.2**	**100**

Source: Field Survey, 2015

Table 18 shows that 40.2% of woodfuel extractors who were unemployed depended on their parents for livelihood support while 38.4% depended on their spouses, 15.8% depended on the children (whohad been employment), 4.6% depended on well-wishers and 1.1% depended on government for livelihood.The results in Table 23 indicated most of the woodfuel extractors who were unemployed dependent on their parents for livelihood support. Thus, they were involved in woodfuel extraction within gazetted forests to supplement the support. The results agree with

World Bank (2009) where charcoal extraction was done to supplement incomes from other sources.

Table 19 shows Chi-Square Tests on independence between livelihood support and type of woodfuel extracted within gazetted forests of Koibatek Forests Zone.

Table 19: Chi-square Tests Between Livelihood support and Type of Woodfuel Extracted

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16.229[a]	10	.093
Likelihood Ratio	11.207	10	.342
Linear-by-Linear Association	.246	1	.620
N of Valid Cases	384		

a. 10 cells (55.6%) have expected count less than 5. The minimum expected count is .06.

Source: Field Survey Data, 2015

According to results in Table 19 no association was found between livelihood support and type of woodfuel extracted(X^2 (10) =11.207, p>0.05) which implies that livelihood support was not significant (p>0.05) in woodfuel extraction within gazetted forests. The findings of the study agree with Kituyi et al (2001), Ndegwa et al (2011) and ESMAP (2012) which did not find any association between woodfuel and sources of livelihood support. On the reasons why extractors over 70 years depended on government for livelihood support, National Social Protection Secretariat, (2017) reported the existence of Old Persons Cash Transfer (OPCT) programmes run by national government to support elderly residents.

4.3 Relationship between Income Earned and Volume of Woodfuel Extracted from Gazetted Forests

4.3.1 Relationship between Revenue from Licensing and Woodfuel Extraction

According to GoK (2015) there are three categories of woodfuel extraction licenses namely: Monthly Fuel License which costs Kshs 100, commercial clear felling or salvaging costing Kshs 2, 000 per cubic metre and annual charcoal production licenses which ranged between Kshs.50,000 (for 10,000 bags), Kshs, 200,000 (for 10,001 to 20,000 bags) and Kshs 500,000 (for 20,001 to 50, 000 bags). However, Republic of Kenya (2018) indicated that charcoal production within gazetted forests in Kenya was banned and therefore illegal. Therefore, the revenue collected from woodfuel extraction within gazetted forests is only from licensing of firewood collection.Table 20 indicates the two types of licenses namely Monthly Fuel Licenses (MFLs) and Stacks Licenses were issued for firewood collection within gazetted forests of Koibatek Forests Zone.

Table 20: Revenue from Licensing of Firewood Collection from Gazetted Forests within Koibatek Forests Zone between 2006 and 2014

Forest Blocks	***License***	***Annual Revenue (Kshs) raised from Licensing of firewood collection from 2006-2014***									***Total***
		2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
Chemorgok	Stacks	0	1700	0	0	0	0	0	0	0	1,700
	MFLs	13275	14120	13200	9300	14600	16100	15500	10700	17500	124,295
	Total	**13275**	**15820**	**13200**	**9300**	**14600**	**16100**	**15500**	**10700**	**17500**	**125,995**
Chemususu	Stacks	500	2450	4000	600	0	0	15000	0	0	22,550
	MFLs	4455	8800	6100	4600	14800	69100	96300	85700	85200	375,055
	Total	**4955**	**11250**	**10100**	**5200**	**14800**	**69100**	**111300**	**85700**	**85200**	**397,605**
Narasha	Stacks	174500	128535	67000	469200	238800	56400	276300	85800	15900	1,512,435
	MFLs	36855	28800	11400	8900	12800	24200	18200	20700	25800	187,655
	Total	**211355**	**157335**	**78400**	**478100**	**251600**	**80600**	**294500**	**106500**	**41700**	**1,700,090**
Maji Mazuri	Stacks	394000	432500	438000	378000	83600	32400	521600	131400	20400	2,431,900
	MFLs	10980	25120	18500	23700	25100	27200	68400	109000	70000	378,000
	Total	**404980**	**457620**	**456500**	**401700**	**108700**	**59600**	**590000**	**240400**	**90400**	**2,809,900**
Sabatia	Stacks	102140	65000	45500	0	24000	15000	157800	3000	0	412,440
	MFLs	1755	1530	7000	15100	5600	3100	2600	3300	13000	52,985
	Total	**103895**	**66530**	**52500**	**15100**	**29600**	**18100**	**160400**	**6300**	**13000**	**465,425**
Esageri	Stacks	0	0	5000	9600	0	0	6000	21600	0	42,200
	MFLs	49320	63560	51000	36100	53800	61600	100300	29400	64500	509,580
	Total	**49320**	**63560**	**56000**	**45700**	**53800**	**61600**	**106300**	**51000**	**64500**	**551,780**
Kituget	Stacks	4500	73000	43000	25200	0	14400	62400	25200	0	247,700
	MFLs	18495	21345	6200	11500	10700	20100	51400	30200	37600	207,540
	Total	**22995**	**94345**	**49200**	**36700**	**10700**	**34500**	**113800**	**55400**	**37600**	**455,240**
Koibatek block	Stacks	10000	117500	228500	38400	1000	46400	283200	25800	10800	761,600
	MFLs	23445	51170	32600	66900	196400	47900	271400	138000	98300	926,115
	Total	**33445**	**168670**	**261100**	**105300**	**197400**	**94300**	**554600**	**163800**	**109,100**	**1,687,715**
Koibatek Forests Zone	**Stacks**	**685,640**	**820,685**	**831,000**	**921,000**	**347,400**	**164,600**	**1,322,300**	**292,800**	**47,100**	**5,432,525**
	MFLs	**158,580**	**214,445**	**146,000**	**176,100**	**333,800**	**269,300**	**624,100**	**427,000**	**411,900**	**2,761,225**
	Total	**844,220**	**1,035,130**	**977,000**	**1,097,100**	**681,200**	**433,900**	**1,946,400**	**719,800**	**459,000**	**8,193,750**

Source: KFS-Koibatek, 2015 (1USD=Ksh.74 in 2006, 1USD=Ksh.82 in 2010 and 1USD=Ksh.88 in 2014 (Pele, 2015).

Table 20 shows that the total revenue collected for the two licenses between 2006 and 2014 was Kshs 8,193,750 out of which Kshs 5,432,525 was collected from licensing of firewood stacks and Kshs. 2,761,225 from MFLs. Therefore, more revenue was collected from licensing of firewood stacks compared to revenue from MFLs. However, within the gazetted forests blocks, there was less revenue from firewood stacks compared to that of MFLs four stations namely: Chemorgok, Chemususu, Esageri and Koibatek blocks. Table 24 further indicates that highest revenue within the gazetted forests blocks between 2006 and 2014 was collected at Maji Mazuri (Kshs 2,809,900) while the lowest revenue was Kshs 125,995 collected at Chemorgok forests block. Across the period between 2006 and 2014, the high annual revenue within all the gazetted forests of Koibatek Forests was in 2012 (Kshs 1,946,400) and the lowest was in 2011 (Kshs 433,900).

The results of the study are in line with Ndiritu (2009) which stated that the value of revenue the woodfuel sourced from Kenyan gazetted forests at Ksh. 4.8 billion annually. The study established through Personal communication from Forest Officer of Narasha Forest Station (2015) that the revenue from an MFL was Kshs. 100 and that of a firewood stacks ($3m^3$) from salvaging costs was Kshs 1,200.However, GoK (2015) indicated that license for $1m^3$ of firewood from salvaging costs Kshs 2,000. Therefore, the provisions for firewood salvaging had not been applied fully within Koibatek Forests Zone. Furthermore, the study established that there was zero (0) revenue collected from licensing charcoal production within gazetted forests This was in agreement with Republic of Kenya (2018) which stated that charcoal production activity within gazetted forests was illegal.

Table 21: *Summary of Linear Regression of Revenue collected on Volume of woodfuel Extracted within Gazetted Forests*

	B	SE_b	β	
Constants	2.077	0.758	--	
Main Effects				
Revenue collected	0.640	0.877	0.544	
R				.544
R Square				0.296
Adjusted R Square				0.294
R Square Change				0.315
Model F Change				158.239
Model Summary df				1,376
Sig. F Change				0.000
T Values				12.579
Note: Dependent variable, Volume of woodfuel N=377				
The significance levels p<0.05				

Source: Field Survey data, 2015

Table 21 shows a summary of linear regression results of revenue collected as an independent variable and quantity of woodfuel collected as a predictor. The linear regression model can be expressed as Volume of woodfuel = 2.077+0.758×Revenue collected). R^2=0.296 indicates that 29.6% of the variation in volume of woodfuel extracted can be attributed to the revenue collected within gazetted forests of Koibatek Zone. R^2=0.296 and the adjusted R^2=0.294 also indicates that the regression model lost predictive power by only 0.002. Thus, the model was very good in generalization since Field (2000) gave a shrinkage of less than 0.075 for a good model. There was positive and significant relationship between revenue collection and volume of woodfuel collected (β= 0.544, $p < 0.05$).

The B=0.544 and SE_b=0.877 at 95% confidence interval reveals that an increase in volume of woodfuel collected between from 0.544 m^3 and0.877 m^3 can be explained by revenue collected. The t-values (T=12.579) for these coefficients were significant at p<0.05) and it can therefore be

concluded that revenue collected made a significant contribution to predicting the volume of woodfuel extracted within gazetted forests.

4.3.2 Relationship between Income Earned from Sale of Woodfuel and Volume Extracted of 2006 and 2014

Table 22: Summary of Linear Regression of Income Earned from daily Sale of Woodfuel and Volume of woodfuel Extracted

	B	SE_b	**β**	
Constants	.982	1.031	--	
Main Effects				
Income from Sale		.868	1.194	
R				.729
R Square (R^2)				0.531
Adjusted R Square (R^2)				0.528
R Square Change				0.315
Model F Change				158.239
Model Summary df				1,139
Sig. F Change				0.000
T Values				12.503

Note: Dependent variable, Volume of woodfuel N=140
The significance levels p<0.05

Source: Field Survey data, 2015

Table 22 shows a regression model: Volume of Woodfuel = 0.982+ (1.031×Income Earned) to explain the relationship between income earned and volume of woodfuel extracted per day. According to the results R^2=0.531 and adjusted R^2=528 (F=158.239, P<0.05, df=1,139) indicates a loss of only 0.003 in predictive power of the model. Therefore, since the loss of predictive power was less than 0.075 (Field, 2000) the regression model was very good in generalization of the entire population. The results R^2=0.531 also indicates that 53.1% change in volume of woodfuel extracted from gazetted forests can be explained by the income earned for sale. There was positive and significant relationship between revenue collection and volume of woodfuel collected (β= 1.194, p <0.05).At 95% confidence interval, the model indicates that volume of

woodfuel extracted increased by between 0.868m^3 and 1.194m^3 due to income earned for the sale of the commodity. The t-values (T=12.503) were significant at $p<0.05$) and it can therefore be concluded that income earned was a significant determinant of the volume of woodfuel extracted within gazetted forests of Koibatek Forest Zone.

The results of the study concur with studies such as WETT (2000), UNDP (2000) Kituyi *et al* (2001), Kairiukstis (2004), Hillring and Trossero (2006), Shackleton *et al* (2011) and Sola *et al* (2017) which stated that income generated from sales of woodfuel was a key determinant to increasing extraction of woodfuel in African countries. Arnoldetal (2006), Ndegwa (2010), Ndegwa et al (2011) and Prislan *at al* (2014) however did not report income earned from sales of woodfuel as a determinant to woodfuel extraction and use.

4.3.2.1 The Estimated Volume of Woodfuel Extracted within Gazetted Forests between 2006 and 2014

The study estimated the volume of woodfuel extracted from gazetted forests by first obtaining the licensing profiles of woodfuel extractors between 2006 and 2014. The volume of firewood stacks and the volume of firewood headloads for the period between 2006 and 2014 were then established as follows:

(i). Volume of Firewood Stacks Extracted between 2006 and 2014

Table 23shows the number of firewood stacks while Table 24 shows the estimated volume of firewood stacks extracted gazetted forests between 2006 and 2014.

Table 23: Firewood Stacks Extracted from the Gazetted Forest Blocks in Koibatek Forests Zone between 2006 and 2014

GAZETTED FOREST	***ANNUAL FIREWOOD STACKS BETWEEN 2006 AND 2014***									
	2006	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***Total***
Chemorkok	0	2.5	0	0	0	0	0	0	0	**2.5**
Chemususu	1	4.3	4	6.5	0	20	12.5	0	0	**48.3**
Narasha	349.5	277	67	794.2	470	515	230.25	71.5	13.3	**2,787.8**
Maji Mazuri	787	807	438	659	304	188	435	189	17	**3,824.0**
Sabatia	204.5	101	45.5	255.5	104	30.5	131.5	2.5	0	**875.0**
Esageri	0	0	5	52	24	20	5	18	0	**124.0**
Kituget	9	80	43	112	85	22	52	21	0	**424.0**
Koibatek	20	235	228.5	256	256.5	316.05	261	21.5	9	**1,603.6**
Total	**1,371**	**1,506.8**	**831**	**2,135.2**	**1,243.5**	**1,111.55**	**1,127.25**	**323.5**	**39.3**	**9,689.2**

Source: Kenya Forest Service-Koibatek, 2015

Table 24: Volume of Firewood Stacks (V_{stacks}) Extracted fromGazetted Forest Blocks of Koibatek Forests Zone from 2006 to 2014

GAZETTED FOREST	***ANNUAL V_{STACKS} EXTRACTED IN M^3 BETWEEN 2006 AND 2014***									
	2006	***2007***	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***TOTAL***
Chemorkok	0	7.5	0	0	0	0	0	0	0	**7.5**
Chemususu	3	12.9	12	19.5	0	60	37.5	0	0	**144.9**
Narasha	1048.5	831	201	2382.6	1410	1545	690.8	214.5	39.9	**8,363.3**
Maji Mazuri	2361	2421	1314	1977	912	564	1305	567	51	**11,472.0**
Sabatia	613.5	303	136.5	766.5	312	91.5	394.5	7.5	0	**2,625.0**
Esageri	0	0	15	156	72	60	15	54	0	**372.0**
Kituget	27	240	129	336	255	66	156	63	0	**1,272.0**
Koibatek	60	705	685.5	768	769.5	948.1	783	64.5	27	**4,810.7**
Total V_{stacks}	**4113.0**	**4520.4**	**2493.0**	**6405.6**	**3730.5**	**3334.6**	**3381.8**	**970.5**	**117.9**	**29,067.4**

Volume of firewood stacks =Number of Stacks × $3m^3$

Source: Field Survey, 2015

Table 23shows that 9,689.2 firewood stacks were extracted within the eight gazetted forest blocks of Koibatek Forests Zone between 2006 and 2014. Of the total extraction, Maji Mazuri block recorded the highest with 3,824stacks, followed by Narasha Forest block (2,787.8 stacks) and Koibatek block (1,603.6stacks). Firewood stacks recorded in other forest blocks were: 875 in Sabatia, 424 in Kiptuget, 124 in Esageri, 48.3 Chemususu and the least was 2.5 recorded in Chemorgok.

The highest annual firewood stacks extraction within Koibatek Forests Zone was 2,135.2 in 2009 while the least annual stack license was 39.3 issued in 2014 (Table 23). In 2014, firewood stacks were extracted only in three forest blocks namely: Maji Mazuri (17 licenses), Narasha (13.3 stacks) and Koibatek (9 stacks).

Table 24 indicates the estimated volume of firewood stacks extracted calculated by applying the following simple formula:

Equation 1: Conversion formula for Number of Firewood Stacks to Volume in m^3

$$\mathbf{V_{stacks} = Number\ of\ Stacks \times 3m^3}$$

Where : V_{stacks} refers to the estimate of Volume of the total firewood stacks;

: Number of stacks provided in Table 23;

: $3m^3$ is the standard volume of a pile of firewood making a stack.

The study therefore established that the volume of firewood stacks extracted from Koibatek Forests Zone between 2006 and 2014 was $29,067.4m^3$ (Table 24). Maji Mazuri forests block recorded the highest volumes of $11,472.0m^3$ followed by Narasha forests block with $8,363.3m^3$ while the lowest volume of $7.5m^3$ in firewood stacks extracted was recorded in Chemorgok

forest block (Table 24). The results reflect on KFS-Koibatek (2011) which stated that firewood stacks are mainly collected from plantations forests. This was because Narasha forests blocks had the highest percent cover of forest plantations (68.3%) with the Zone recorded the second highest amounts of firewood stacks while Maji Mazuri forests block comprising of 65.8% of forest plantations recorded the highest amounts of firewood stacks. On the other hand, Chemorgok forests block which recorded the lowest amount of firewood stacks had 2.8% cover of forest plantations which is the lowest in Koibatek forests Zone.

The study however, established that number of registered CFAs members within the forest blocks greatly influenced the amount of stacks collected. This explains why the volume of firewood stacks extracted within Maji Mazuri, whose CFA membership was 1,005, was greater than the volume extracted in Narasha with a CFA of 900 members.

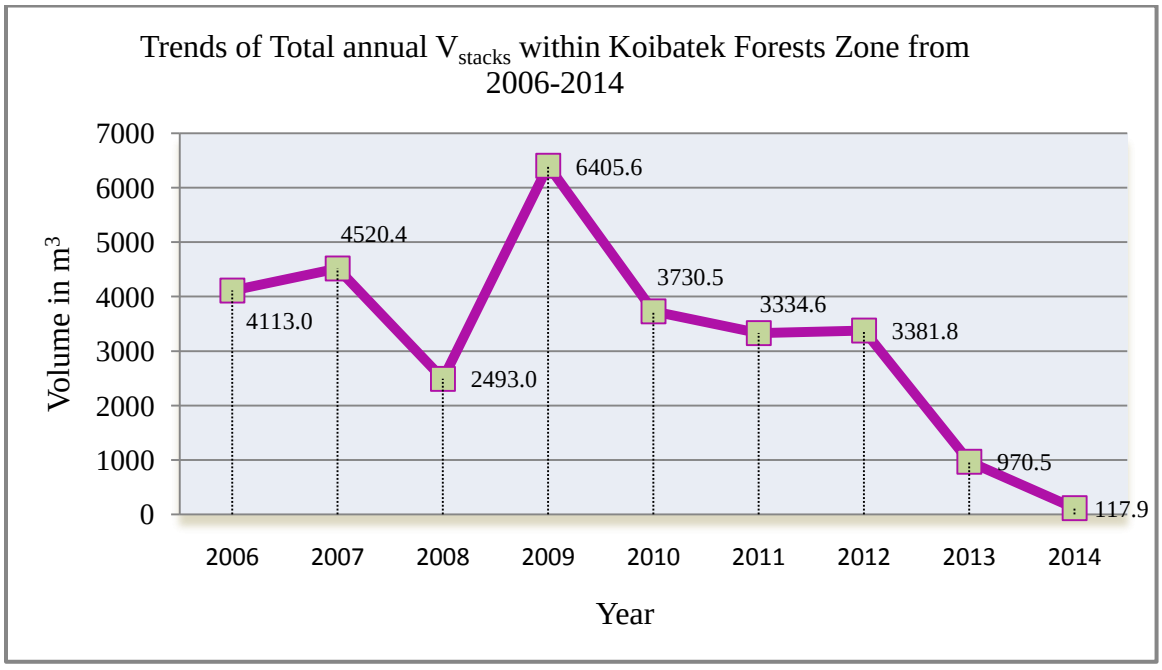

Figure 5: Trends of Total Annual Volume of firewood stacks (V_{stacks}) within Koibatek Forests Zone from 2006-2014

Source: Field data, 2015

Figure 5 indicate trends on the annual total volume of firewood stacks extracted within Koibatek Forests Zone. The volume of stacks of firewood increased from 4113m^3 in 2006 to 4520.4m^{3}in 2007. Thereafter, in 2008 there was a significant decrease to 2493m^3 and, in 2009 there was sharp increase to 6405.6m^3 where extraction reached the peak volume in the 9 year period. In 2010 and 2011, there was a decrease in which extraction stood at 3730.5m^3 and 3334.65m^3 respectively. In 2012, there was a marginal rise in volume to 3381.75m^3 before it drops to 970.5m^3 in 2013 and to 117.9m^3 in 2014 which was the lowest in the 9 year period (Figure 5). The fluctuations in the amounts of firewood stacks were controlled mainly by regional weather patterns (KFS-Koibatek, 2011). Seasons characterized by rainfall renders earthen roads within forests impassable by vehicles such as lorries and pick-ups consequently reducing the amounts of firewood stacks extracted. Dry seasons are therefore characterized by higher amounts of firewood stacks

Figure 6 shows the trends of volume of stacks of firewood extracted within each of the eight gazetted forest blocks of Koibatek Forests Zone from 2006 to 2014.

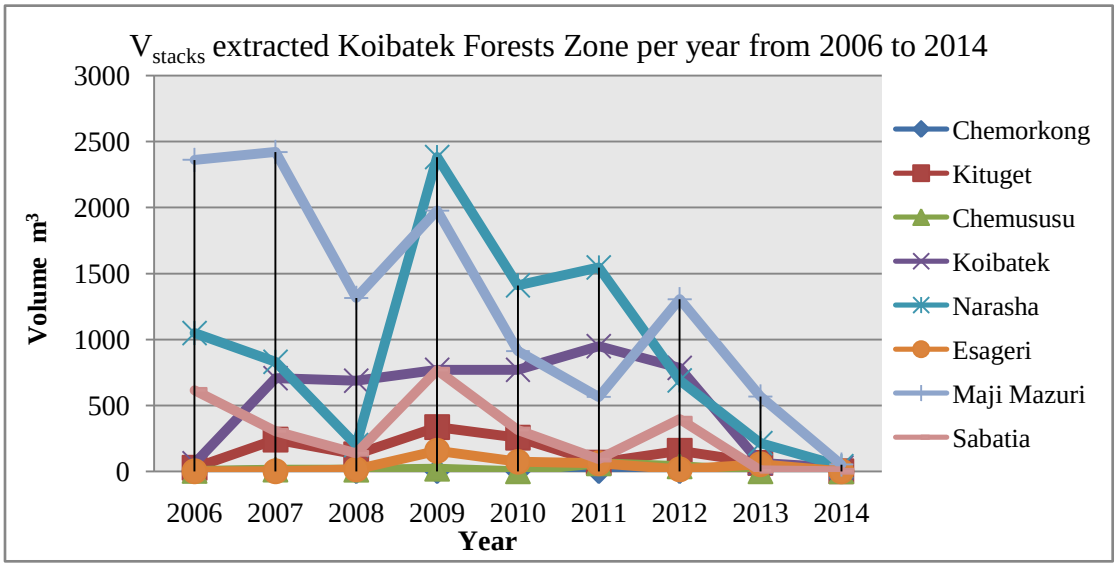

Figure 6: Trends of V_{stacks} of firewood extracted from 2006-2014 in Koibatek Forests Zone

According to Figure 6, Maji Mazuri, Narasha and Sabatia forests blocks recorded the most unstable trends with sharp increases and decreases in volume of firewood stacks extraction in the 9 years as indicated by sharp edges of curves. However, the annual extraction trends for Maji Mazuri was higher in all years compared to that of Narasha. The trend curve for Sabatia oscillated at a lower level compared to that of Koibatek. Extraction trend curve for Koibatek block was near normal curve beginning from $60m^3$ in 2006, then, a steady rise to a peak of 948.15 m^3 in 2011 thereafter there was a steady drop to $27m^3$ in 2014.

The trends of Esageri, Chemususu and Chemorgok forest blocks were near constant for the 9 year period. However, the annual volumes were either low or none at all in some years. For Chemorgok block, there was zero in all years except 2007 ($7.5m^3$). There was no firewood stacks extracted within Esageri block from 2006 and 2007 and in 2014 where Chemususu did recorded zero firewood stacks 2010, 2013 and 2014 (Figure 6). Forest rangers of these forest blocks which recorded zero extraction of firewood stacks in some years were unanimous that such occurrences were due to temporal closures of forest blocks due to potential threats to natural vegetation posed by human activities such as firewood collection, charcoal burning and illegal logging.

(ii). Volume of the Firewood Headloads ($V_{headloads}$) between 2006 and 2014

A headload of firewood refers to a pile of firewood of approximately about25kg in weight enough to be carried by one person on the head or back (Ndegwa, 2010). The study established through FGDs and confirmed by Forests Officers and forest rangers that firewood head loads extraction within gazetted forests was done under the Monthly Fuel Licences (MFLs) upon payment of prescribed fee. According to KFS-Koibatek (2011), the MFLs were issued with conditions that included: License holder was not allowed to carry any cutting tool such as panga, axe or power saws to the forest for extracting the firewood; only collection with bare hands was

accepted; Only dry and decomposing tree trunks, branches, backs, twigs and roots were allowed for firewood collection; and the license holders of the license were allowed to enter into the forest only once per day to collect only 1 back or head load for a period of one month when the license expires.

Table 25 illustrates the estimated volume of firewood headloads extracted within each of the eight gazetted forests blocks within Koibatek Forests Zone between 2006 and 2014.

Table 25: Volumes of Annual Firewood Headloads Extracted within Gazetted Forests in Koibatek Forests Zone from 2006-2014

	VOLUMES (M^3) OF ANNUAL FIREWOOD HEADLOADS FROM 2006 TO 2014										
Forests Block	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**TOTAL**	**%**
Chemorkok	813.57	656.59	365.75	255.56	405.83	442.56	426.69	323.21	484.37	**4,174.13**	5.0
Chemususu	273.70	508.49	168.77	127.96	400.30	1912.08	2666.25	2363.26	2245.00	**10,665.81**	12.6
Narasha	2259.42	1301.20	316.23	244.86	352.96	664.66	505.41	573.88	671.19	**6,889.81**	8.2
Maji mazuri	700.21	1204.44	514.12	654.86	690.23	751.08	1895.94	2993.00	1848.51	**11,252.39**	13.4
Sabatia	107.92	63.30	196.16	424.06	153.54	85.97	72.10	91.67	329.20	**1,523.92**	1.8
Esageri	2970.69	3277.22	1414.02	448.46	1483.12	1697.88	2787.59	812.48	1623.24	**16,514.70**	19.6
Koibatek block	1433.61	2183.88	902.53	1845.70	5416.57	1329.32	7574.33	3750.16	2260.33	**26,696.43**	31.7
Kituget	1132.34	1123.73	171.58	317.86	293.65	556.92	1423.45	839.23	646.34	**6,505.10**	7.7
$V_{headloads}$	**9,691.46**	**10,318.85**	**4,049.16**	**4,319.32**	**9,196.20**	**7,440.47**	**17,351.76**	**11,746.89**	**10,108.18**	**84,222.29**	**100**

Source: Field Survey, 2015

Table 25 indicates that the estimated total volume of head loads of firewood collected from Koibatek Forests Zone from 2006 to 2014 was 84,222.29 m^3. Out of these volumes, approximately 31.7% (26,696.43 m^3) of firewood headloads was extracted from Koibatek block, 19.6% (16,514.70 m^3) from Esageri block, 13.4% (11,252.39 m^3) from Maji Mazuri block and 12.6% (10,665.81 m^3) from Chemususu block. The percentage of total volume for headloads extracted in other blocks were: 8.2% (6,889.81m^3) from Narasha block, 7.7% (6,505.10 m^3) from Kiptuget block, 5.0% (4,174.13 m^3) from Chemorgok block and, 1.8% (1,523.92 m^3) from Sabatia block (Table 25).

The results indicates that the volume of firewood headloads collected from the gazetted forests was mainly determined number of registered CFA members which reflects on the population. In effect, extraction within Koibatek block was the highest, followed by Esageri and Maji Mazuri blocks and the least volume of firewood headloads was recorded within Sabatia block (Table 25). Table 2 indicated that the total registered CFA members in Koibatek block was the highest (1750), followed by Esageri block (1229) and Maji Mazuri block (1005) while the least number of CFA members were in Sabatia block at 298. The results of the study agrees with KFS (2015) which stated that, continuous population increases have exerted great pressure on the country's gazetted forests due to increased demand for woodfuel.

(iii). Total Volume of Firewood Extracted between 2006 and 2014

Results in Table 24 and Table 25 were combined to get estimated volume of firewood extracted within gazetted forests in Koibatek Forests Zone between 2006 and 2014 shown in Table 26.

Table 26: Estimated Volume of Firewood Extracted from the Gazetted forest Blocks within Koibatek Forests Zone from 2006 to 2014

Gazetted Forest Blocks	Annual Volume of Firewood (M^3) between 2006 and 2014									
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Chemorkok	813.57	664.09	365.75	255.56	405.83	442.56	426.69	323.21	484.37	**4,181.63**
Chemususu	276.7	521.39	180.77	147.46	400.3	1972.08	2703.75	2363.26	2245	**10,810.71**
Narasha	3307.92	2132.2	517.23	2627.46	1762.96	2209.66	1196.21	788.38	711.09	**15,253.11**
Maji Mazuri	3061.21	3625.44	1828.12	2631.86	1602.23	1315.08	3200.94	3560	1899.51	**22,724.39**
Sabatia	721.42	366.3	332.66	1190.56	465.54	177.47	466.6	99.17	329.2	**4,148.92**
Esageri	2970.69	3277.22	1429.02	604.46	1555.12	1757.88	2802.59	866.48	1623.24	**16,886.7**
Koibatek block	1493.61	2888.88	1588.03	2613.7	6186.07	2277.42	8357.33	3814.66	2287.33	**31,507.13**
Kituget	1159.34	1363.73	300.58	653.86	548.65	622.92	1579.45	902.23	646.34	**7,777.1**
Total	**13,804.46**	**14,839.25**	**6,542.16**	**10,724.92**	**12,926.7**	**10,775.07**	**20,733.56**	**12,717.39**	**10,226.08**	**113,289.59**

Source: Field Survey, 2015

Table 26 indicated the total volume of firewood extracted from gazetted forests within Koibatek Forests Zone between 2006 and 2014 was 113,289.59m^3. The total volume of firewood extraction within each of the gazetted forests blocks were: Koibatek block (31,507.13 m^3), Maji Mazuri (22,724.39 m^3), Esageri (16,886.7m^3), Narasha (15,253.11m^3), Chemususu (10,810.71m^3), Kiptuget (7,777.1m^3), Chemorgok (4,181.63 m^3) and Sabatia (4,148.92m^3) (Table 26). The results of the study indicates that the volume of firewood collected from the gazetted forests of Koibatek Forests Zone is mainly determined the population of forest adjacent communities as reflected by registered members of CFAs operating within the gazetted forests. According to Table 2, the CFA members within Koibatek block (which had the highest volume of firewood collected) were the majority (1750) while CFA members within Sabatia which had the least volume of firewood collected were also the least (298). The results of the study agrees with KFS (2015) which stated that demand for woodfuel continues to grow with an increasing population.

Table 26further indicates that the estimated total volume of firewood extracted from gazetted forests of Koibatek Forests Zone between 2006 and 2014 was found to be 113,289.59m^3. The highest volume of firewood extracted of 20,733.56$m^3$was recorded in 2012 within the 9 year study period. According to FGDs (2015), the high records of firewood extraction 2012 were occasioned due to availability of money given by politicians during campaigns towards party nominations and general elections in Kenya which occurred in in 2012 and March 2013. The money enabled most residents adjacent to the forests to afford MFLs for entering into gazetted forests for firewood extraction. The results of the study therefore show that increase levels of income leads to an increase in extraction of firewood from gazetted forests of Kenya. The income would enable residents to obtain adequate purchasing power for required licenses for

firewood extraction. The results contrasts FAO (2010a) and UNDP et al (2000) that stated that woodfuel in the form of firewood and charcoal is the most common biofuel utilized by low income earners rural and urban households in developing countries and when income increases people tend to use other alternative sources of energy such as electricity and Liquefied Petroleum Gas (LPG).

4.3.2.2 Estimated Volume of Charcoal Produced between 2006 and 2014

The volume of charcoal produced within gazetted forests of Koibatek was estimated by first establishing the number of producers within gazetted forests. This was followed by determination of the number of sack produced by one producer per event. Thereafter, the number of events were per month were estimated. Thus, the total number of sacks of charcoal produced between 2006 and 2014 was then established by the following steps:

(i) Number of Charcoal Producers within Gazetted Forests

Table 7 indicated that 10.4% of respondents extracted both firewood and charcoal and another 2.1% extracted charcoal only from gazetted forests of Koibatek Forests Zone. Therefore, 12.5% of total respondents were charcoal producers within gazetted forests of Koibatek Forests Zone. From the total registered CFA members of 7,154within Koibatek Forests Zone (Table 2), charcoal producers were 895 of the registered members (12.5%). The findings of the study were contrary to KFS (2012) which only addressed charcoal production for commercial purposes in private lands and not within gazetted or government forests. The study also established that records for charcoal producers within gazetted forests blocks of Koibatek Forests Zone were unavailable in KFS offices. Personal communications of Forest Officers (2016) indicated that

charcoal production within gazetted forests was illegal and any person found undertaking the activity within the area commits an offense punishable by law.

(ii) Estimated Number of Sacks and Weight of Charcoal between 2006 and 2014

The study established that charcoal produced was packed in sacks for ease in transportation and as a standard measure for bulk sales. The size of the sacks used had a capacity of 90kgs when used to carry cereals such as maize and beans as reported by 100% of the charcoal producers and the average weights of charcoal packed in the sacks is 40kg (Ndegwa, 2010).

Table 27: Number of Sacks of Charcoal per a Production Event within Gazetted Forests

	% of the Number of sacks produced per event				
Extraction Activity	**0-1**	**1-5**	**6-10**	**11-15**	**Total**
Firewood and Charcoal	6.3	72.9	4.2	0.0	83.3
Charcoal only	0.0	2.1	12.5	2.1	16.7
Total	**6.3**	**75.0**	**16.7**	**2.1**	**100**

Source: Field Survey, 2015

The study established in Table 27 that 75.0% of charcoal producers produced 1-5 bags of charcoal per event while 16.7% produced 6-10 bags of charcoal. Charcoal producers who produced less than 1 sack of charcoal per event were 6.3% and those who produced 11-15 sacks were 2%. Table 27 also reveals that majority of charcoal producers (83.3%) did the production together with firewood collection while the remaining 16.7% were purely charcoal producers.

Table 28: Number of Sacks of Charcoal Produced at a Time within Gazetted Forests

Number of Sacks at a time			
Interval	*Mid-Points (x)*	***Frequency (f)***	***fx***
0-1	0.5	3	1.5
1-5	3	36	108
6-10	8	8	64
11-15	13	1	13
		∑f=48	**∑fx=186.5**

Source: Field Survey, 2015

Equation 2: Average Number of Sacks of Charcoal produced at a time

$$\text{Aaverage number of sacks at a time} = \frac{\sum \text{fx}}{\sum \text{f}} = \frac{186.5}{48} = \mathbf{3.9\ sacks\ of\ charcoal}$$

The study established in Table 28 that the amount of charcoal produced at any one time by the 48 charcoal producers interviewed was found to be approximately 186.5 sacks. Equation 2 shows that the average number of sacks of charcoal produced at a time by individual was derived by dividing total number of sacks produced (∑fx) by frequency or total number of charcoal producers (∑f). Therefore, the averagenumber of charcoal sacks produced at any one time by one person is about 3.9 (Equation 2). Given that there were895 charcoal producers who undertook the activity within gazetted forests of Koibatek Forests Zone,3,480 sacks of charcoal was produced at a time as shown in Table 29.

Table 29: Number of Sacks of Charcoal Produced within Koibatek Forests Zone

No. of sacks per event		***Charcoal Producers***		***Total No. of Sacks of Charcoal***
Range	***Average***	***% of 895***	***No. of producers***	
0-1	0.5	6.3	56	28
1-5	3	75	671	2,013
6-10	8	16.7	149	1,192
11-15	13	2	19	247
Total	**-**	**100**	**895**	**3,480**

Source: Field Survey, 2015

Table 30: Percentage of Charcoal Producers on the Times of Charcoal Production per Month

Sacks Charcoal Per Event	***% of Producers within the Times per month***			
	1	**2**	**3**	**4**
0-0.99	-	33.3	33.3	33.3
1-5	38.9	47.2	11.1	2.8
6-10	25.0	62.5	12.5	-
11-15	100.0	-	-	-
Total	**35.4**	**47.9**	**12.5**	**4.2**

Source: Field Survey, 2015

Table 30 shows that the proportion of charcoal producers who did the activity once a month were 35.4%; 2 times were 47.9%; 3 times were 12.5% and 4 times were 4.2%. Within the cohorts of producing less than 1 sack of charcoal at a time; 33.3% did production twice a month, 33.3% (3 times) and another 33.3% (4 times). Of those who produced 1-5 sacks of charcoal; 25% did the activity once a month, 62.5% (2 times) and 12.5% (3 times) while 100% of producers who produced between 11-15 sacks did the activity only once per month (Table 30). Therefore, majority of the producers did charcoal production either twice a month (47.9%) or once a month (35.4%) within gazetted forests of Koibatek Forest Zone.

Table 31: Approximate Number of Sacks of Charcoal Produced per Month within Gazetted Forests

Cohorts of Sacks of Charcoal	***Sacks of Charcoal per Month***				***Total***
	1	**2**	**3**	**4**	
0.1-0.99	0	18.5	27.7	37.0	**83**
1-5	783	1900.3	670.3	225.5	**3,579**
6-10	298	1490.0	447.0	0	**2,235**
11-15	247	0	0	0	**247**
Total	**1,328**	**3,408.8**	**1,145**	**262.5**	**6,144**

Source: Field Survey, 2015

Table 31 indicates that most of the charcoal (3408.8 sacks) was produced by producers who undertook the activity twice a month. Production events of between 1-5 sacks per event

cumulatively accounted for 3,579 sacks of charcoal per month while events that produced 6-10 sacks accounted for 2, 235 sacks per month. Therefore, approximately 6,144 sacks of charcoal were produced within the gazetted forests of Koibatek Forests Zone per month.

According to Ndegwa (2010), the average weights of charcoal packed in the sacks is 40kg. Therefore, the estimated weight of the 6,144 sacks of charcoal produced within the gazetted forest blocks per month within Koibatek Forests Zone is 245,760 kg. For the entire period of 108 months (January 2006 to December, 2014); the total weight of charcoal produced within gazetted forests was approximately 26,542,080 Kgs or 26,542.08 tonnes. The study converted the weights (kg) into volume (m^3) by utilizing Openshaw (1978) which stated that $1m^3$ of charcoal from preferred tropical hardwoods weighs 180kg. Therefore, the estimated volume of 26,542,080 kgs (or 26,542.08 tonnes) of charcoal was 147,456 m^3.

The study therefore established that the 147,456 m^3 of charcoal produced within gazetted forests Koibatek Forests Zone from 2006 to 2014 was more than the volume of firewood (113,289.59m^3) which was extracted within the forests in the period. The results conforms to the findings of MoE (2002) that reported that charcoal production from Kenyan forests stood at 16,506,498 tonnes which was more than firewood whose volumes were 15,111,180 tonnes. Hillring (2006) in justifying why charcoal was more than firewood stated that most of the wood extracted for woodfuel is processed to charcoal so as to make transportation more efficient and increase the energy value. Given that personal communication of forests officers (2016) were unanimous that charcoal production within gazetted forests was illegal, the volume of charcoal produced illegally was significant. This is therefore a pointer that enforcement of rules and regulations governing extraction of forest products within gazetted forests was weak.

(iii) Charcoal business within Gazetted Forests

Table 32: Purpose for Producing Charcoal in Gazetted Forests of Koibatek Forests Zone

Category of Woodfuel extraction	*Users (% of Total)*		
	Self/domestic	*Sale*	*Total*
Charcoal only	2.1	14.6	16.7
Firewood & Charcoal	4.1	79.2	83.3
Total	6.2	93.8	100.0

Source: Field Survey, 2015

Table 32 shows that 93.8% of charcoal producers within Koibatek Forests Zone produced charcoal for sale while 6.6% produced charcoal for domestic consumption. The charcoal production activity within gazetted forests was illegal as per GoK (2006a) and the personal communications from the 8 Forest Officers (2016) of Koibatek Forests Zone. However, charcoal production continues to occur within the gazetted forests following the findings of the study whereby approximately 6,144 bags of charcoal (translating 26,542.08 tonnes or 147,456 m^3) was produced within Koibatek Forests Zone between 2006 and 2014.

The charcoal produced was packed in sacks which carry an average of 40kg weight of charcoal (Ndegwa, 2010). The study established through FGDs (2015) the prices of sacks of charcoal produced ranged from an average Ksh. 400 in Chemorgok, Chemususu and Sabatia blocks to an average Kshs 500 in Kiptuget and Esageri to Kshs 600 in Narasha, Maji-Mazuri and Koibatek Blocks. The main markets centres for charcoal were urban areas nearer to the gazetted forests blocks of Koibatek such as Eldama Ravine, Molo, Kampi-ya-Moto, Rongai and Nakuru. According to Netherlands Enterprise Agency (2010) charcoal producers generally brings the sacks of charcoal from forests or farms to the roadside from where it is transported by trucks and other motorised vehicles or by motorbike to the urban centres. World Bank (2009) indicated that

majority of charcoal is sold along the roadsides to large-or small-scale transporters who then pass the charcoal on to smaller-scale retailers and consumers in urban areas.

According to Business Daily of 23rd June 2011, Kenya has a Ksh.30 billion charcoal industry that employs more than 200,000 people in production alone, contributes more than Sh5 billion in taxes, and meets the energy needs of 80 per cent of urban households and 34 per cent of rural households. Charcoal also saves the country billions in foreign exchange which would have otherwise been used to import fuel to meet domestic needs (Business Daily, 23rd June 2011). Plate 1 shows a group of entrepreneurs in charcoal industry transporting the commodity to the markets. Each bicycle in Plate 1 is carrying charcoal equivalent to 5 sacks but shared to 6 sacks-one full sack and 5 others sacks.

Plate 1: A group of entrepreneurs transporting charcoal to the market using bicycles
Source: Business Daily, Thursday 23rdJune 2011

The national study on charcoal in Kenya by Energy for Sustainable Development Africa (2005) estimated that annual production was 1.6 million tonnes. Thus, the results of the study that 26,542.08 tonnes of charcoal produced within a period of 9 years translated to 2,949,120 kgs or

2,949.12 tonnes per annum accounting for 1.68% of the national charcoal production. NL Agnecy (2010) on his part stated that the current situation in charcoal production is unsustainable, and if allowed to continue may lead to complete destruction of Kenya's already depleted forests and woodlands. There has been no deliberate investment made in growing trees to meet rising demand for charcoal production. Instead gazetted forests have borne the brunt of unsustainable charcoal burning leading to severe deforestation. According to MEWNR (2013), the charcoal industry is part of the informal sector and is by far the largest contributor to job creation, employing approximately 700,000 people, who in turn are believed to be supporting 2.3–2.5 million dependents.

The study found out that the firewood business was a profitable enterprise within Koibatek Forests Zone. For instance, the MFL cost Kshs. 100 per month (GoK, 2015) and out of it, an extractor was capable of earning an approximately Ksh. 3,750 per month from sales of the approximate 30 headloads of firewood collected at Ksh. 125 per headload. The yard operators sold the same quantity of firewood with 100% profits earning about ksh 7,500 per month.

4.3.2.3 Estimated Income earned from Sale of Woodfuel Extracted within Gazetted Forests of Koibatek Forests Zone between 2006 and 2014

The incomes earned from sale of woodfuel was derived using the following steps: the purposes for which woodfuel was extracted within gazetted forests, the units for measuring woodfuel for sale and, the cost of each of the units of measure. Table 33shows that woodfuel extracted from gazetted forests within gazetted forests were either for domestic use with a mean of 64.8% respondents and/or commercial with 35.2% of the total respondents.

Table 33*: Woodfuel Extraction within Gazetted Forests of Koibatek Zone*

	% of Total respondents on purpose for woodfuel extraction		
Category of Woodfuel	***Domestic***	***Commercial***	***Total***
Firewood only	71.1	28.9	100.0
Charcoal only	62.5	37.5	100.0
Firewood & Charcoal	12.5	87.5	100.0
Mean Total	**64.8**	**35.2**	**100.0**

Source: Field Survey, 2015

Within the firewood only category, 71.1% was for domestic purpose while 28.9% was commercial purpose while on the category of charcoal only; 62.5% was produced for domestic purpose while 37.5% was commercially traded. Within the combination of firewood and charcoal 87.5% was done for commercial purpose leaving 12.5% for domestic consumption (Table 33). Therefore, the study noted that the combined firewood and charcoal extraction activity was for commercial purposes while each of the activity in isolation was for the domestic purposes. The results conforms with GoK (2016a) report that MFLs were issued to registered CFA members within gazetted forests so as to obtain firewood for their domestic needs. However, there is no requirement that restricts a licensee from selling the commodity provided that they visit the forest only once per day to obtain firewood. Kenya Forest Service (2015) in explaining why a combination of firewood and charcoal was for commercial purposes indicated that licensed firewood extractors did charcoal extraction illegally for commercial purposes.

Table 34: Chi-Square Tests Statistics for Category of Woodfuel and Purpose for Extraction

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	53.920[a]	2	.000
Likelihood Ratio	53.396	2	.000
Linear-by-Linear Association	52.362	1	.000
N of Valid Cases	384		

a. 1 cells (16.7%) have expected count less than 5. The minimum expected count is 2.81.

Source: Field Survey Data, 2015

Table 34 shows Pearson Chi-Square X^2=53.920, P<0.05 indicating that there was an association between the category of woodfuel extracted and the purpose for their extraction within gazetted forests of Koibatek Zone. Therefore, both domestic and commercial purposes were the main drivers for woodfuel extraction in which the main purpose for firewood extraction and charcoal production was domestic consumption. However, combined firewood and charcoal extraction was mainly for commercial purposes in which charcoal sales dominates the business. The results supports MoE (2002) that the total annual woodfuel extracted for domestic and commercial purposes from Kenyan forests is 31,617,678. Hillring (2006) reported that the woodfuel extracted is processed to charcoal so as to make transportation more efficient and increase the energy value. Ndiritu (2009) on his part stated that the value of the woodfuel sourced from Kenyan gazetted forests at Ksh. 4.8 billion annually.

Table 35 shows that measuring units and the approximated costs of each unit of firewood and charcoal was extracted within gazetted forests of Koibatek Forests Zone for commercial purposes.

Table 35: Measuring Units and Costs for the Units of Woodfuel within Gazetted Forest Blocks

Type of Woodfuel	***Measuring Unit***	***Approximate Cost (Kshs) per Unit***	***Gazetted Forest Block***
Firewood	Split or round 1m long Piece	10	Koibatek, Maji Mazuri, Kiptuget, Narasha
	Back/Headload	250	Koibatek, Maji Mazuri, Kiptuget, Narasha Chemususu, Chemorgok, Sabatia, Esageri
	Donkey load	500	Koibatek, Maji Mazuri
Charcoal	90kgs Sack	400	Chemorgok, Chemususu, Sabatia
		500	Kiptuget, Esageri
		600	Narasha, Maji-Mazuri, Koibatek

1 USD = Ksh. 89 in 2015 (Pele, 2015)

Source: Field Survey/FGD, 2015

Table 35 shows that measuring units for firewood were: split/round piece 1m long each costing Kshs 10 within Koibatek, Maji Mazuri, Kiptuget and Narasha blocks; back/headload costing Kshs 250 within all the gazetted forests blocks. In addition, a donkey load of firewood costs Khs 500 within Koibatek and Maji Mazuri blocks. Therefore, the most common measure for sale of firewood was back/headload which was used across all the eight gazetted forests blocks. This agrees with GoK (2016a) which stated that Monthly Fuel Licenses yields 1 headload of firewood within gazetted forests per day. Table 35 further shows that charcoal produced within the gazetted forests was measured using 90kg sacks. According the Ndegwa (2010) the average weight of the sack of charcoal in Kenya is 40kg. The cost of each sack of charcoal varied from Kshs 400 within Chemorgok, Chemususu and Sabatia blocks to Kshs 500 within Kiptuget and Esageri blocks to Kshs 600 within Narasha, Maji-Mazuri and Koibatek blocks.

The yard attendants within Kamara Shopping Centre (2015) reported that a head/back load of 1m long firewood comprises of 25 pieces, a donkey load comprised of 50 pieces, a bicycle load contains 150 pieces of firewood, a pick-up had a capacity of 500 pieces, a Canter lorry carries 3000 pieces and a FH lorry had a capacity of 4300 pieces (Personal Communications from Kamara Yard Attendant, 2015). Plate 2 shows one of the firewood yards where firewood business occurred located at Kamara area along the Nakuru-Eldoret Highway at the edges of Maji Mazuri forest block.

Plate 2: A pile of firewood in a yard located at Kamara along Eldoret-Nakuru Highway

Source: Researcher, July 2015

Plate 2 shows piles of firewood pieces either in round or split each measuring approximately 1m long. According to firewood yard attendants of Kamara, the firewood yards were collection points for extractors who were willing to sell the whole or part their firewood headloads collected using MFLs. Plate 3 shows a donkey loaded with an firewood estimated to contain 50 pieces of firewood. Donkeys were used for ferrying firewood for two MFL holders equivalent to two headloads per day from the gazetted forests. However according to GoK (2016a) there was no licensing provision for donkey-load of firewood within gazetted forests. Plate 4 shows a longitudinal view of the trailer for a FH lorry with a capacity of estimated 4300 pieces of firewood. FGDs (2015) indicated that lorries collected firewood either from yards at a cost of Ksh 10 per piece or could obtain license of Kshs 1200 to collect firewood stacks from salvaging within gazetted forests. However, firewood stack extraction faced myriad of challenges including

poorly maintained roads within the forests, high labour costs and longer time required to salvage lorry load of firewood.

Plate 3: A donkey load of firewood being off-loaded at a firewood yard

Source: Researcher, July 2015

Plate 4: View of FH lorry whose capacity was estimated to be 4300 pieces of firewood

Source: Researcher, July 2015

Plate 5 shows a bicycle carrying the estimated 150 pieces of split/round firewood load along Maji Mazuri-Eldama Ravine tarmac road. According to the rider of the bicycle, the firewood was sourced from Maji Mazuri block which is at the far background of Plate 5 and was being ferried to Eldama Ravine town for sale. Plate 5 also shows that the bicycle rider carries a panga (between the pedals), an axe and a sack (in the front carrier of the bicycle) for cutting and splitting large tree trunks and branches into small pieces of approximately 1m long for easy transportation. The study observed that some of the pieces of firewood on the bicycle were green (wet), a strong indication that standing trees or branches were exploited for firewood.

Plate 5: A bicycle transporting firewood from Maji-Mazuri Block along Eldama Ravine-Makutano Road

Source: Researcher, July, 2015

Table 36: Regression Model Coefficients for Income Earned and Volume of Woodfuel Extracted Within Gazetted Forests

Model	Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B	
	B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound
1 (Constant)	.982	.248		3.963	.000	.492	1.472
M^3	1.031	.082	.729	12.503	.000	.868	1.194

Dependent Variable: Income Earned in Kshs.

Source: Field Survey Data, 2015

The results in Table 36 shows the unstandardized coefficients (B) = 0.982, 1.031, $p<0.05$. Therefore the resultant predictive regression model from the unstandardized coefficients is indicated by Equation 3.

Equation 3: Regression Model for Predicting Income from Volume

Income earned (Kshs)=0.982+ (1.031× (Volume of woodfuel extracted)

The estimated volume of firewood collected was 113,289.59 m^3 (Section 4.3.3.1) and volume of charcoal was 147,456 m^3 (section 4.3.3.2) between 2006 and 2014. Therefore an estimated 260,745.59m^3 of woodfuel was extracted from gazetted forests of Koibatek Forests Zone between 2006 and 2014.

The results are supported by FGD (2015) that average selling prices for a split 1m long piece of firewood was Kshs 10 (Kshs 250 per headload) and a bag of charcoal was sold between Ksh. 400 and 600.The results income earned from sale of woodfuel extracted from gazetted forests was significant and contributed immensely to improvement of livelihoods of forest adjacent communities. The results of the study adds to the statistics by Ndiritu (2009) stated that the value

of the woodfuel sourced from Kenyan gazetted forests at Ksh. 4.8 billion annually. Business Daily (23rd June 2011) also stated that Kenya has a Ksh.30 billion charcoal industry and contributes more than Sh5 billion in taxes. In addition, Shackleton *et al* (2011) and Sola *et al* (2017) had indicated that income earned and profits from trading in woodfuel were key determinants of the volume of woodfuel extracted. However, the studies did not indicate the amount of income earned in trading in woodfuel.

4.4 Influence of Proximity to the ForestsonNumber of firewood Headloads

4.4.1 Introduction

This section present results and discussions of the influence of proximity to forests on the number of firewood headloads extracted within gazetted forests of Koibatek Forests Zone. Firstly, the relationship between the distance from the forests and number of trips made daily by firewood collectors toundertake firewood collection. Secondly, the study sought to number of MFLs issued by KFS for firewood collection within the gazetted forests. Furthermore, the study compared the quantity of firewood for collection using MFL and the actual quantity collected within gazetted forests between 2006 and 2014.

4.4.2 Relationship between Distance to Forests and Number of Trips per Day

Table 37: Distance from Home to Forests and the Percentage Responses on the Trips per Day

Distance from home to forests	*% on Trips per day*			
	1 trip	*2 trips*	*3 trips*	*Total*
0.1-1km	14.4	1.0	0.3	15.7
1km-3km	45.6	2.4	-	48.0
3.1km-5km	23.0	0.3	-	23.3
5.1km-7km	7.2	-	-	7.2
7.1km- 9km	5.8	-	-	5.8
Total	**96.0**	**3.7**	**0.3**	**100.0**

Source: Field Survey, 2015

Table 37 shows that 96% of extractors made 1 trip per day to the gazetted forests for firewood collection,3.7% made 2 trips and 0.3% made 3 trips daily. The results in Table 41 also indicates that majority (45.6%) of firewood extractors who made 1 trip per day lived between 1-3km from gazetted forests, followed by 23.0% who lived 3.1km-5km away from gazetted forests and 14.4% lived between 0-1km from forests. Those who made 2 trips per day lived at 0.1-1km (1%), 1.1-3km (2.4%) and 3.1-5km (0.3%). Only 0.3% of firewood extractors made 3 trips per day and lived within 0-1km from the gazetted forests.

Table 38 shows summary linear regression results of proximity to forests and number of daily trips made during firewood collection within gazette forests.

Table 38: Summary of Linear Regression of Proximity to forests and Number of Trips for Firewood Extraction within Gazetted Forests

	B	***SE*$_b$**	**β**	
Constants	1.064	-0.009	--	
Main Effects				
Proximity to forests	-.030	.012	0.044	
R				.044
R Square (R^2)				0.002
Adjusted R Square (R^2)				-0.001
R Square (R^2) Change				-0.003
Model F Change				0.723
Model Summary df				1,375
Sig. F Change				0.396
T Values				-0.85

Note: Dependent variable, Number of daily trips; N =377
The significance levels p>0.05

Source: Field Survey data, 2015

Table 38 shows that predictive model is expressed as: Number of trips = 1.064 – (0.009)× (distance to the forests in km). R^2=0.002, Adjusted R^2= -.001, p>0.05 shows that 0.2% of change

in number of daily trips were influenced by proximity to the forests and therefore was not significant in explaining the number of trips. The change in R^2 was 0.003 implying that the model was good in predicting the relationship between proximity to forests and number of daily trips made for firewood collection within gazetted forests. There was positive but insignificant relationship between proximity to forests and number of trips made for firewood collection (β= 0.044, $p>0.05$). At 95% confidence interval, the predictive model indicates that the average number of trips increased between - 0.030 and 0.012. The t-values ($T=-0.85$, $p>0.05$) were not significant and it can therefore be concluded that proximity to forests was not a significantly socio-economic determinant of the number of trips made by woodfuel extractor to gazetted forests. The findings agree with GoK (2015) that irrespective of proximity, every CFA member is expected to enter the forest once a day to collect firewood.

4.4.3 Effects of Proximity to Forests on the Number of Firewood Headloads

Table 39 indicates the linear regression model summary results for proximity to forests and firewood headloads collected by woodfuel extractor within gazetted forests.

Table 39: Percentage Responses on the Number of Firewood Headloads per Distance in Kilometers from Home of Extractors to Gazetted Forests

Distance to Gazetted forests	% Responses on daily Number of Firewood Headloads			
	1	2	3	Total
0.1- 1km	12.2	1.2	1.2	14.6
1.1 km-3km	36.0	7.8	4.6	48.4
3.1km-5km	20.4	1.8	1.2	23.4
5.1km-7km	6.3	0.5	0.9	7.7
7.1km- 9km	4.0	1.2	0.7	5.9
Total	**78.9**	**12.5**	**8.6**	**100.0**

Source: Field Survey, 2015

Table 39 shows that 78.9% of firewood extractors collected 1 headload of firewood per day while 12.5% collected 2 firewood headloads and 8.6% collected 3 firewood headloads of firewood daily from gazetted forests. According to KFS-Koibatek (2011) and GoK (2015), MFL demands that 1 headload of dry and decomposing firewood was collected daily within gazetted forests. Therefore, about 22.1% firewood collectors flouted the conditions since 12.5% of the extractors extraction 2 headloads of firewood per day and another 8.6% of firewood extractors collected 3 firewood headloads daily. On the effects of proximity to gazetted forests on number of firewood headloads, majority of firewood extractors lived between 0-1km (14.6%), 1.1-3km (48.4%) and 3.1-5km (23.4%). Few firewood extractors lived between 5.1-7km (7.7%) and 7.1-9.0 (5.9%). Therefore, the study notes that most firewood extractors within gazetted forests of Koibatek Zone were drawn from forest adjacent communities within a radius of 5km. The results conform to the results of Wagura and Nyangena (2008) that the average distance travelled by firewood collectors with Lari Division, Kiambu County was 3km. Republic of Kenya (2014) and KEFRI (2014) agrees with the results and indicated that forest adjacent communities (within a radius of 5km) benefit directly from gazetted forests by subsistence utilization of forest resources such as firewood and farming under PELIS.

Table 40: *Linear Regression Model Summary for Proximity to Gazetted Forests and Daily Number of Firewood Headloads Collected*

	B	SE_b	β	
Constants	1.365	0.065	--	
Main Effects				
Proximity to forests	1.09	-.037	0.207	
R				.065
R Square (R^2)				0.004
Adjusted R Square (R^2)				0.002
R Square (R^2) Change				0.002
Model F Change				0.723
Model Summary df				1,375
Sig. F Change				0.000
T Values				1.264
Note: Dependent variable, Number of firewood headloads; N =377				
The significance levels p<0.05				

Source: Field Survey data, 2015

Table 40 shows the results for regression model summary between proximity to the forests and the daily number of headloads collected within gazetted forests of Koibatek Zone. The results in Table 40that R=0.065, R^2=0.004, Adjusted R^2=0.002 shows that the model lost only 0.002 in predictive power and thus was good in predicting the relationships between proximity to gazetted forests and the number of firewood headloads collected from gazetted forests. However, R^2=004 indicates that there was 0.4% positive variations in number of firewood headloads which could be explained by proximity to gazetted forests. Thus, proximity to forests has no significant influence on the number of firewood headloads collected within gazetted forests. Table 40 also indicates the coefficients constants for the predictive regression model as B=1.365, 0.065. Therefore, Number of Firewood headloads = 1.365 + (0.065) (Distance to the forests). There was also positive but not significant relationship between proximity to forests and number of headloads of firewood extracted within gazetted forests (β= 0.065, p>0.05). Thus, the results also

shows at 95% confidence level, that the regression line of proximity to forests (x- axis) and number of firewood headloads (y-axis) lies between -0.037 and 0.168. The t-values (T= 1.264, p>0.05) were not significant and it can therefore be concluded that proximity to gazetted forests was not significant in predicting the number of firewood headloads extracted within gazetted forests. The results of the study agree with Republic of Kenya (2014), that irrespective of the distance, it was mandatory for MFL holders to extract only 1 firewood headload of firewood daily. However, the results contradicts the findings of Kituyi et al (2001) and Wagura and Nyangena (2008) that distance to the forest was a determinant of quantity of forest products extracted. The results also contradict the findings of Chakravorty et al (2014) that long distance travelled from households to forests for firewood collection increase time spent in firewood collection and quantity extracted. Unlike many studies (Kituyi et al,2001, Wagura and Nyangena, 2008, Chakravorty et al, 2014) that did not specify the type of forests from which findings were based, the findings of this study were specifically based on the gazetted forests.

4.4.4 Estimated Number of Firewood Headloads Extracted within Gazetted Forests of Koibatek Forest Zone between 2006 and 2014

The number of firewood headloads collected within the gazetted forests of Koibatek Forests Zone between 2006 and 2014 was established by the following 3 steps: (i) seeking MFLs data for each month between January 2006 and December 2014 (ii) determining the average monthly number of trips made to the forests by extractors, and (iii) finding the product of monthly number of MFLs and average number of trips within the month.

Step 1: The total number of MFLs between January 2006 and December 2014

In this first step, the study sought thenumber of MFLs recorded within the eight gazetted forests blocksfor the 108 months between January 2006 and December 2014. Summation of the annual MFLs within the eight forests blocks were done as shown by Table 47.

Table 41: Total Number of MFLsfor the Gazetted Forests Blocks within Koibatek Forests Zone between 2006 and 2014

Gazetted Forest Blocks	Number of MFL Per Year from 2006 to 2014									
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Chemorkok	295	238	132	93	146	161	155	117	175	**1,512**
Chemususu	99	185	61	46	148	691	963	857	852	**3,902**
Narasha	819	473	114	89	128	242	182	207	258	**2,512**
Maji Mazuri	253	434	185	237	251	272	684	1090	768	**4,174**
Sabatia	39	23	70	7	56	31	26	33	130	**415**
Esageri	1074	1184	510	161	538	616	1003	294	645	**6,025**
Kiptuget	411	406	62	115	107	201	514	302	376	**2,494**
Koibatek Block	521	791	326	669	1964	479	2714	1380	983	**9,827**
Total	**3,511**	**3,734**	**1,460**	**1,417**	**3,338**	**2,693**	**6,241**	**4,280**	**4,187**	**30,861**

Source: KFS-Koibatek, 2015

Table 41 shows the MFLs issued per gazetted forest block (from the highest to the lowest) between 2006 and 2014 were: 9,827 in Koibatek block, 6,025 in Esageri, 4,174in Maji Mazuri, 3,902in Chemususu, 2,512in Narasha, 2,494 in Kiptuget, 1,512 in Chemorgok and 415 in Sabatia. Therefore, the total number of MFLs issued by KFS for firewood extraction within gazetted forests between 2006 and 2014 was 30,861. The number of MFLs was directly proportional to the number of registered CFA members as of December 2014 within each of the eight gazetted forests blocks. According to KFS-Koibatek (2011), CFA membership within a forest station (or gazetted forest block) reflects the population of forest adjacent communities within each of the forests block. Therefore, Koibatek forests block which had highest number of MFLs (9,827) also had the highest registered members of its CFA (1750) while Sabatia forests block which had the lowest number of registered CFA members at 298 recorded 415 MFLs which was the lowest in Koibatek Forests Zone as indicated by Table 2.

Table 41 further indicates that the annual total MFLs for the gazetted forests of Koibatek Forests Zone were: 3,511 (2006); 3,734 (2007); 1,460 (2008); 1,417 (2009); 3,338 (2010); 2,693 (2011); 6,241 (2012); 4,280 (2013); and 4,187 (2014). The highest number of MFLs was recorded in the year 2012 while the lowest MFLs number of MFLs was recorded in year 2009. The fluctuations in MFLs issued was explained by UNDP *et al* (2000) which stated that apart from firewood from forests and woodlands, most people depend on biomass sources including crop residues such as maize stacks, maize cops, and animal dung. Thus, it was difficult to get a constant or near constant trends in annual MFLs because of availability of alternative sources of biomass energy such as maize cops, maize stacks, and firewood from trees within farmlands (the farms are normally closed when crops are on the farms) around the gazetted forests.

Figure 7 indicates the fluctuations in the annual number of MFLs for gazetted forests of Koibatek Forests Zone between 2006 and 2014

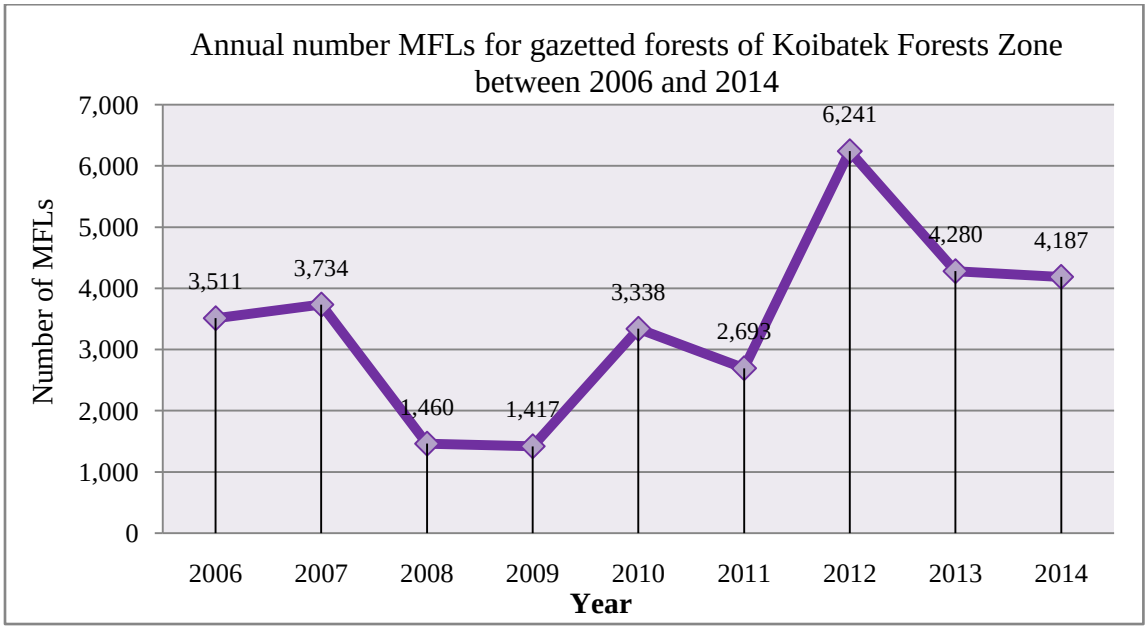

Figure 7: Annual Number of MFLs for Koibatek Forests Zone from 2006 to 2014

Source: Field Survey, 2015

Figure 7 shows that the highest number of MFLs was 6,241 in 2012while the lowest was 1,417 MFLs recorded in 2009. The total MFLs differed marginally 2008 and 2009 and between 2013 and 2014 shown by the near horizontal trend-line during the two periods. The trend-line is bi-modal with two peaks one in 2007 and another in 2012. The peaks coincided with the Kenya's periods for general elections as per ECK (2007) and IEBC (2012-2013). FGDs (2015) reported that during electioneering periods, large amounts of money was dished by politicians at campaign rallies to woo voters the high records of MFLs in 2012 (6,241) and 2013 (4,280) were occasioned by the large amounts of money given by politicians to voters during campaigns rallies towards party nominations and general elections in Kenya which occurred in late 2012 and March 2013 respectively.

Step II: Number of trips made by firewood extractors into the forest per day

Table 42: Daily Number of Trips by Firewood Extractors into the Gazetted Forests

		Number of trips per day			
	Number of Respondents (N)	Minimum	Maximum	Mean	Std. Deviation
Trips per day	377	1.00	3.00	1.0424	0.21463
Valid N (Listwise)	377				

Source: Field Survey, 2015

Table 42 show that the mean daily number of trips made into gazetted forests by firewood collectors was calculated to be 1.0424 (with standard deviation of 0.21462). The results of contrasts the Personal communications of Koibatek Forests Zone Deputy Ecosystem Conservation (2016)that, *'the main condition for issuance of MFL was that each individual holder of the Licence was allowed to make 1 trip only into the forests per day for collection of only 1 headload of firewood for a period of one month'*. GoK (2015) also indicated that MFL cost Ksh 100 applicable for 1 headload per day for a period of one month. Forest rangers in all the gazetted forests blocks were assigned daily duty to ensure that each individual complies with the conditions of MFLs (KFS-Koibatek, 2012). However, the study established in Table 42that holders of the license made between 1 (minimum) trip and a maximum of 3 trips a day to the forest to collect firewood. This implies that some holders of the license had flouted the conditions for MFL during firewood collection within gazetted forests. The monthly number of trips was a product of number of days for the specific month and the average number of daily trips to the forests for firewood collection.

Step III: Total Number of Firewood headloads collected

From the results of Table 41 and Table 42, the study estimated the number of firewood headloads extracted within the gazetted forests blocks as shown in Table 43. Table 43 shows that between 2006 and 2014, 968,072.72 firewood headloads were extracted within gazetted forests of Koibatek Zone. The highest number of firewood headloads (306,855.44) was recorded within Koibatek block, followed by Esageri forests block with 189,824.17 firewood headloads and Maji Mazuri forests block with 129,337.87 firewood headloads between 2006 and 2014. The least number of firewood headloads of 17,516.5 was extracted within Sabatia forests block. The results in Table 49 also show that highest number of firewood headloads was recorded in 2012 (199,445.52) followed by 135,022.07 firewood headloads in 2013 while the least (46,542.12) firewood headloads was recorded in 2008.

Table 43: Number of Firewood Headloads Extracted from Gazetted Forest Blocks of Koibatek Forests Zone from 2006-2014

	Annual Number of Firewood Headloads between 2006 and 2014									
Forests Block	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**Total**
Chemorkok	9351.37	7546.98	4204	2937.48	4664.74	5086.91	4904.49	3715.11	5567.46	**47,978.54**
Chemususu	3145.96	5844.74	1939.91	1470.83	4601.15	21977.96	30646.56	27163.9	25804.61	**122,595.62**
Narasha	25970.35	14956.36	3634.85	2814.48	4057.02	7639.75	5809.3	6596.31	7714.8	**79,193.22**
Maji Mazuri	8048.37	13844.11	5909.37	7527.17	7933.71	8633.16	21792.41	34402.33	21247.24	**129,337.87**
Sabatia	1240.46	727.60	2254.71	4874.26	1764.78	988.20	828.71	1053.87	3783.91	**17,516.5**
Esageri	34145.9	37669.21	16253.1	5154.67	17047.41	19515.81	32041.29	9338.86	18657.92	**189,824.17**
Koibatek Block	16478.26	25102.03	10373.96	21214.92	62259.42	15279.5	87061.25	43105.32	25980.78	**306,855.44**
Kituget	13015.41	12916.38	1972.22	3653.61	3375.29	6401.38	16361.51	9646.37	7429.19	**74,771.36**
Zone's Total	**111,396.08**	**118,607.41**	**46,542.12**	**49,647.42**	**105,703.52**	**85,522.67**	**199,445.52**	**135,022.07**	**116,185.91**	**968,072.72**

Source: Field Survey, 2015

According to KFS-Koibatek (2011) and Personal Communications of Ecosystem Conservator (2016), the conditions for MFL within gazetted forests was a major determinant on the number of firewood headloads collected within gazetted forests. GoK (2015) indicated that MFL requires that 1 headload of firewood to be collected by an individual licenses holder per day However; the study noted that compliance to MFL conditions by holders was not 100%.The study established that 12.5% of firewood extractors collected 2 firewood headloads and 8.6% extracted 3 firewood headloads per day.

4.5 Relationship between Volume of Woodfuel Extracted and Changes in Cover of Gazetted Forests

4.5.1Introduction

The section contains results and discussions of the following: analysis of the relationships between woodfuel extraction and changes in woodfuel based on respondents answers and the estimated volume of woodfuel extracted within gazetted forests of Koibatek Forests Zone between 2006 and 2014. Additionally, the equivalent percentage forest cover change due to the woodfuel extracted was determined by converting the volume of woodfuel extracted into equivalent area of closed canopy forests. Furthermore, satellite images of the gazetted forests between 2006 and 2014 were analyzed to obtain the actual change in forest cover.

4.5.2 Relationship between Woodfuel Extraction and Forest Cover Changes

Table 44 shows the percentage forest cover changes and the percentage responses on whether the forests cover increased or decreased between 2006 and 2014.

Table 44: Percentage Changes in Forests Cover and Responses on either Increased or Decreased Forest Cover 2006 and 2014

% Change in forests cover from 2006-2014	% of total responses on Forest Cover change		
	Decreased	*Increased*	*No Change*
0	0.0	0.0	1.6
1-2	41.7	1.6	-
3-4	41.1	3.6	-
5-6	3.9	0.3	-
7-8	5.2	0.0	-
9-10	1.0	0.0	-
Total	**92.9**	**5.5**	**1.6**

Source: Field Survey, 2015

Table 44 indicates that majority (92.9%) of woodfuel extractors reported that the gazetted forest cover between 2006 and 2014 had decreased while 5.5% of the extractors reported that forest cover had increased and 1.6% indicated that there was no change in gazetted forest cover. Of those who reported a decrease in gazetted forest cover, 41.7% indicated that the cover had decreased by 1-2%, while 41.1% indicated a decrease by 3-4%. 3.9% of extractors reported a decrease of 5-6% in forest cover while 5.2% indicated a decrease of 7-8%. The percentage increase in gazetted forest cover reported was between 1-2% (reported by 1.6% of woodfuel extractors), 3-4% (3.6%) and 5-6% (0.3%). Therefore, the results indicates that gazetted forests cover within Koibatek Forests Zone had decreased by 1-4% between 2006 and 2014. The results are in line with the findings of FAO (2000a) also indicated that the annual rate of deforestation in Africa ranges between 0.75% in Angola and 2.2% in Malawi. In addition, Global Witness (2017) stated that 66 acres of forests is lost every minute or 95,040 acres per day globally. However, FAO (2000a) and Global Witness (2017) did not attribute the loss of forest to woodfuel extraction and use. Thus, there is need to establish the relationships between the volumes of woodfuel extracted and the changes in forest cover.

Table 45 shows a summary of the regression analysis results on the relationships between volume of woodfuel extracted and the percentage changes in forest cover in gazetted forests. According to the results, the regression model that explains the relationship between volume of woodfuel extracted and the percentage change in forest cover is expressed as: Change in Forest Cover = 1.847 – (0.021) (Volume of woodfuel in M^3). The regression model summary R=0.023, R^2=0.001 and adjusted R^2= - 0.002 shows that only 0.1% change in forest cover can be explained by volume of woodfuel extracted within gazetted forests. Since the Model lost only 0.003 in its predictive power, then it was good in predicting the relationships. **β** = - 0.023, p>0.05 indicates that there exist negative but not significant relationship between volume of woodfuel extracted and forest cover change.

Table 45: Summary of Linear Regression of Volume of Woodfuel Extracted and the Percentage change in cover of gazetted forests

	B	***SE*$_b$**	**β**	
Constants	1.847	-.021	--	
Main Effects				
Volume of woodfuel (m^3)	-0.111	.069	-0.23	
R				.023
R Square (R^2)				0.001
Adjusted R Square (R^2)				-0.002
R Square (R^2) Change				0.003
Model F Change				0.203
Model Summary df				1,376
T Values				-.45
Note: Dependent variable: Percentage change in forest cover; N =377				
The significance levels p>0.05,				

Source: Field Survey data, 2015

Table 45 also shows that (F=0.203, p>0.05), T= -0.45, p>0.05 indicates that volume of woodfuel extracted was not significant in predicting the changes in forest cover. Regression model also

reveals that, at 95% confidence level, the regression line of proximity to forests (x- axis) and volume of woodfuel (y-axis) lies between -0.111 and 0.069.Thus, the results imply that there was a decrease in percentage cover of gazetted forests due to the volume of woodfuel extracted between 2006 and 2014.The results of the study agree with the findings of Webi (2000), Ochieng' (2009) and Nellemann (2014) that there exists crisis of deforestation due to increase demand for woodfuel. Republic of Kenya (2018) on its part indicated that degradation of Mau Forest Complex was attributed to illegal activities such as charcoal burning. However, unlike other studies such as Webi (2000) and Nellemann (2014) that did not explain significance of woodfuel extracted in predicting forest cover loss, the study established the relationship between volume of woodfuel extracted and change in percentage forest cover. In addition, the studies generalized all forests as homogenous in reporting their findings but this study focused only on the gazetted forests.

The results of the study contradict Forestry Administration (2002) that woodfuel extraction activity is forest tidying activity and good forest management. However, it further agrees with Abd'razack (2013) that though woodfuel extraction contributes to deforestation, it cannot be sole blame for the deforestation in developing countries of Africa; there are other factors such as lumbering, and export of wood products to other nations particularly developed nations. While agreeing with Abd'razack (2013) the study sought to establish the main causes of deforestation of gazetted forests within Koibatek Forests Zone as shown in Figure 8.

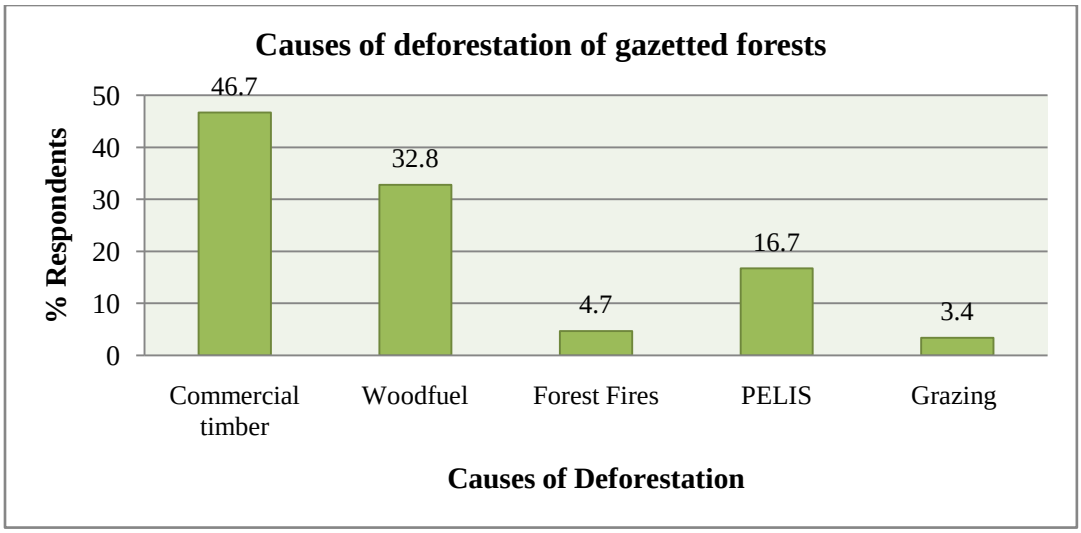

Figure 8: Causes of Deforestation of gazetted forests within Koibatek Forests Zone

Source: Field Survey, 2015

Figure 8 indicates that commercial timber and woodfuel were the main causes of deforestation of gazetted forests at 46.7% and 32.8% respondents respectively. Other causes of deforestation were PELIS reported by 16.7% of the respondents, forest fires (4.7%) and animal grazing (3.4%). Commercial timber was cited because in most cases clear felling of standing trees was done during their extraction. The study further observed that woodfuel was not only extracted from remnants of commercial logging and other decomposing wood materials, but also from standing trees felled for charcoal burning or split into small pieces for firewood. The results of the study are supported by Ministry of Forestry and Wildlife (2013) as it listed the direct drivers of deforestation of Mau Forests Complex (gazetted forests of Koibatek forests Zone forms part of it) to include: agricultural expansion (i.e. permanent subsistence and commercial agriculture); wood extraction; domestic fuelwood and charcoal, commercial timber (poles and timber), forest fires and animal grazing.

4.5.2.1 Types of Cover of Gazetted Forests between 2006 to 2014

The study sought to establish the forest cover types within the gazetted forests blocks within Koibatek Forests Zone for the years 2006, 2010 and 2014. Koibatek Forest Landsat 7 ETM+ 2006 (Figure 9) shows the gazetted forest-land cover types in 2006 while Koibatek Forest Landsat 5 TM 2010 (Figure 10) shows the gazetted forest-land cover types in 2010. Koibatek Forest Landsat 8 OLI 2014 (Figure 11) shows the gazetted forest-land cover types in 2014.

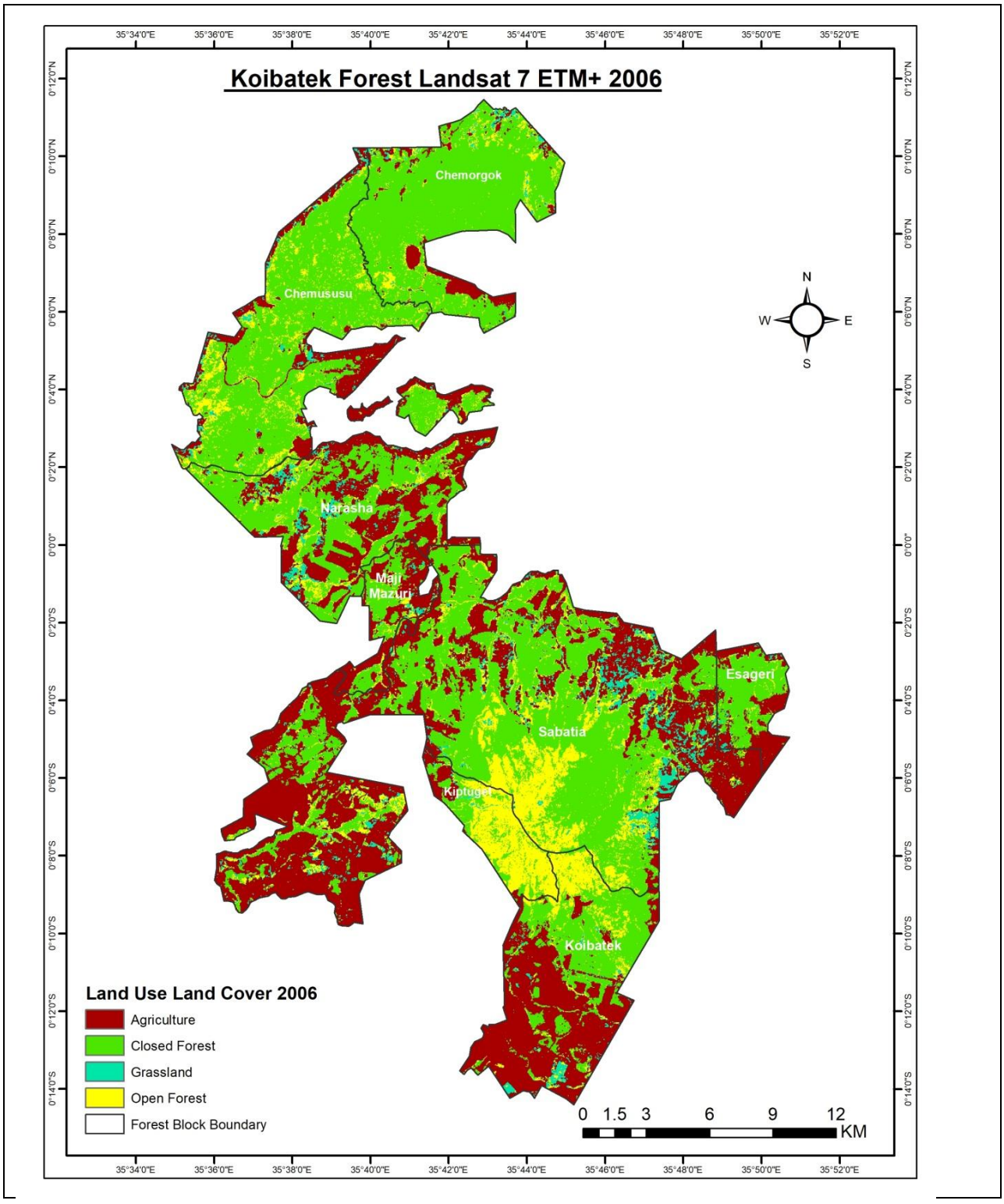

Figure 9: Land cover types of gazetted forests in Koibatek Forests Zone in 2016

Source: Researcher, 2015

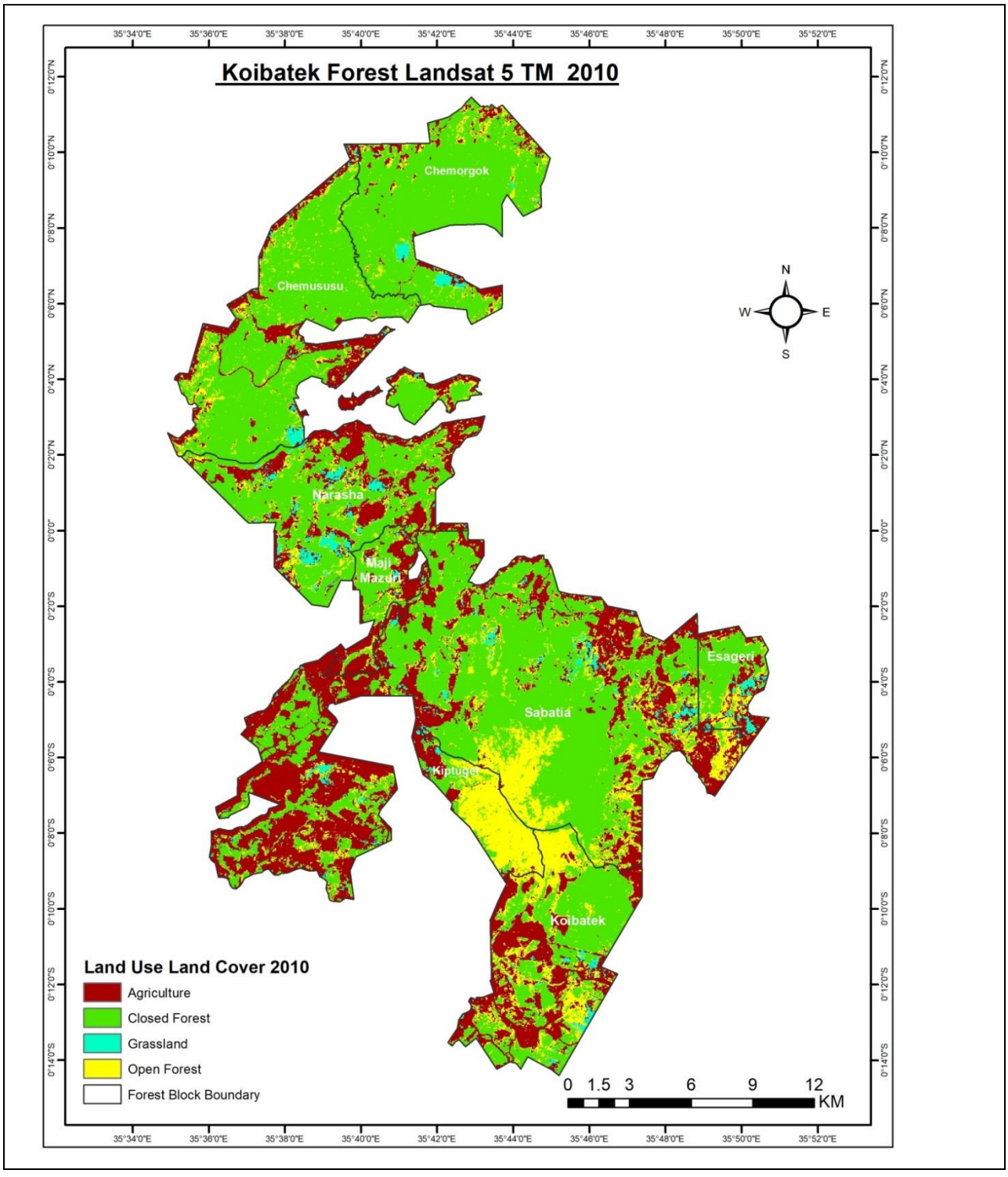

Figure 10: Land cover types of gazetted forests within Koibatek Forests Zone by 2010

Source: Researcher, 2015

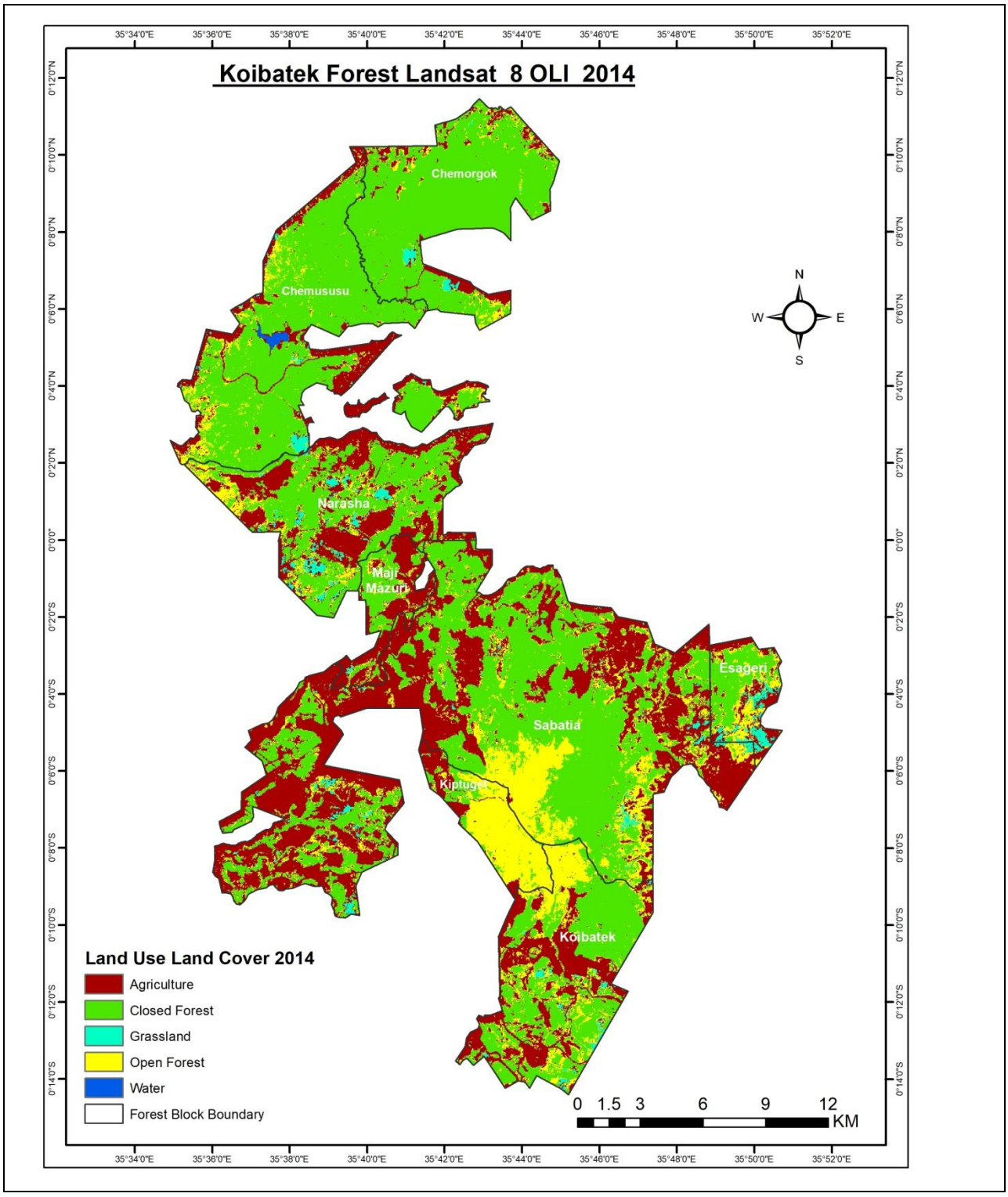

Figure 11: Land cover within gazetted forests within Koibatek Forests Zone by 2014

Source: Researcher, 2015

Figure 9 and Figure 10 indicates that gazetted forest land area within Koibatek Forests Zone had four (4) forests cover types in 2006 and 2010 respectively namely; closed forest, open forest, agriculture and grasslands. Figure 11 indicates that in 2014, the forest land cover types were five (5) namely: closed forest, open forest, agriculture, grasslands and water. The water cover occurred only within Chemususu forest block in 2014 (Figure 11). The study found out that the water was due to Chemususu Dam which according to RVWSB (2015) its construction began in 2009 with water holding capacity of 11 billion cubic meters and covering a total area of 95 hectares of Chemususu forests. That explains why water cover only occurs in 2014 map and not in 2006 and 2010.

Table 46 shows the area (in hectares) and percentage coverage of land cover types within gazetted forest land of Koibatek Forests Zone from 2006 to 2014.

Table 46: Percentage Cover of Land Use Types within Gazetted Forests in 2006, 2010 and 2014

Types of Land	**% Cover within the gazetted forest land**		
Uses	**2006**	**2010**	**2014**
Closed Forest	50.63	55.64	52.57
Open Forest	12.35	14.89	14.90
Agriculture	32.59	26.60	30.37
Grassland	4.43	2.87	2.04
Water	0.00	0.00	0.12
Total	**100**	**100**	**100**

Source: GIS Map, 2015

Table 46 shows that the percentage of gazetted forests covered by closed forests was the dominant land cover type accounting for 50.63% in 2006, 55.64% in 2010 and 52.52% in 2014. Agriculture was the second dominant land cover type with 32.59% in 2006, 26.6% in 2010) and

30.37% in 2014. The study also unraveled that agriculture in the gazetted forest blocks was as a result of PELIS programme implemented by KFS. This was in agreement with KEFRI (2014) which stated that area of forest plantation under PELIS within Baringo County was 3,816.2 ha in 2014 (KEFRI, 2014). However, the study found out that agriculture covered 16216.29 ha of Koibatek Forests Zone alone in 2014 and indication that most of the agricultural activities occur within the Forests Zone unpermitted or without proper records kept.

The percentage of open land cover or bare lands within gazetted forests increased from 12.35% in 2006 to 14.89% in 2010 and 14.9% in 2014 indicating that forests are continuously degraded with time. This was in agreement with Njoroge (2011) statement that the sections of Mau Forests Complex South of Londiani (bordering Koibatek Forests Zone) decreased from 226,064 hectares in 2000 to 178,974 hectares by 2009. Therefore, 53,376 hectares of open lands resulted due to deforestation between 2000 and 2009 within these sections of Mau Forest Complex. The study further established that grasslands covered 4.43% in 2006, 2.87% in 2010 and 2.04% in 2014 while water covered 0.12% in only 2014 but had 0% cover in 2006 and 2010.

The study further derived forest land cover changes for two periods: first period of 2006-2010 and second period of 2010-2014. The cover change of 2006-2010 period was derived from analyzing the cover differences of 2010 map from the 2006 map. Cover change of 2010-2014 period was derived from finding the difference in changes in 2014 map from the 20010 map (Table 47).

Table 47: ForestLand Cover Changes within Gazetted Forests of Koibatek Forests Zone in 2006-2010 and 2010-2014 periods

	1st Period (2006-2010)		2nd Period (2010-2014)	
Land Cover	**Area (ha)**	**%**	**Area(ha)**	**%**
Closed Forest	2677.23	**4.72**	-1643.49	**-2.84**
Open Forest	1355.40	**9.32**	8.46	**0.05**
Agriculture	-3198.06	**-10.12**	2013.57	**6.62**
Grassland	-834.57	**-21.4**	-442.53	**-16.87**
Water	0	**0.0**	63.99	**100.00**

Source: Field Survey, 2015

Table 47 shows that, in the 2006-2010 period, gazetted forests of Koibatek Forest Zone experienced an increase of 2677.23 ha (4.72%) in closed forest cover while in the second period (2010 -2014), closed forests dwindle by 1643.49 ha (-2.84%). Open forest gained a total of 9.32% (1355.40 ha) area coverage in the 2006-2010 period while the 2010-2014 period saw a slight increase of 0.05ha (8.46ha) in area coverage. Agriculture significantly declined in the first period at by 3198 ha (-10.12%) while in the second period there was a significant increase of 6.62% (2013.57 ha). Grasslands experienced a significant decline in both periods with first period loss of 21.4% (834.57ha) and in second period there was loss of 16.87% (442.53ha). Water cover was 0 ha (0%) in the first period and in the second period it increased by 63.99 ha (100%).

The positive changes in cover of either of open forests; grasslands or water was an indicator of deforestation and consequent reduction in cover of closed canopy forests. On the other hand, positive change in cover of closed forest was an indication of afforestation due to plantations or natural regeneration of forests from either open forests or grasslands. This was in line with FAO (2015b) which indicated a general increase in cover of both naturally regenerated and plantation

forests in Kenya. The cover of naturally regenerated forests in Kenya increased from 3881,000 ha in 2005 to 4037,000 ha in 2010 to 4193,000 ha in 2015. In addition, forests plantations also increased from 166,000 ha in 2005 to 193,000 ha in 2010 to 220,000 ha in 2015 (FAO, 2015b).

Forest cover change detection for Koibatek Forests Zone was done by first reclassifying the land use types into two main classes namely: forest to refer to closed canopy forest areas and non-forest to refer to open fields including shrub lands, agricultural lands, grasslands and water bodies. Figures 12-14 shows the maps of land use types of gazetted forest blocks within Koibatek Forests Zone in 2006 (Landsat 7 ETM+), in 2010 (Landsat 5 TM) and in 2014 (Landsat 8 OLI). The maps indicate the location and proportion of area covered by forest and non-forest in 2006, 2010 and 2014.

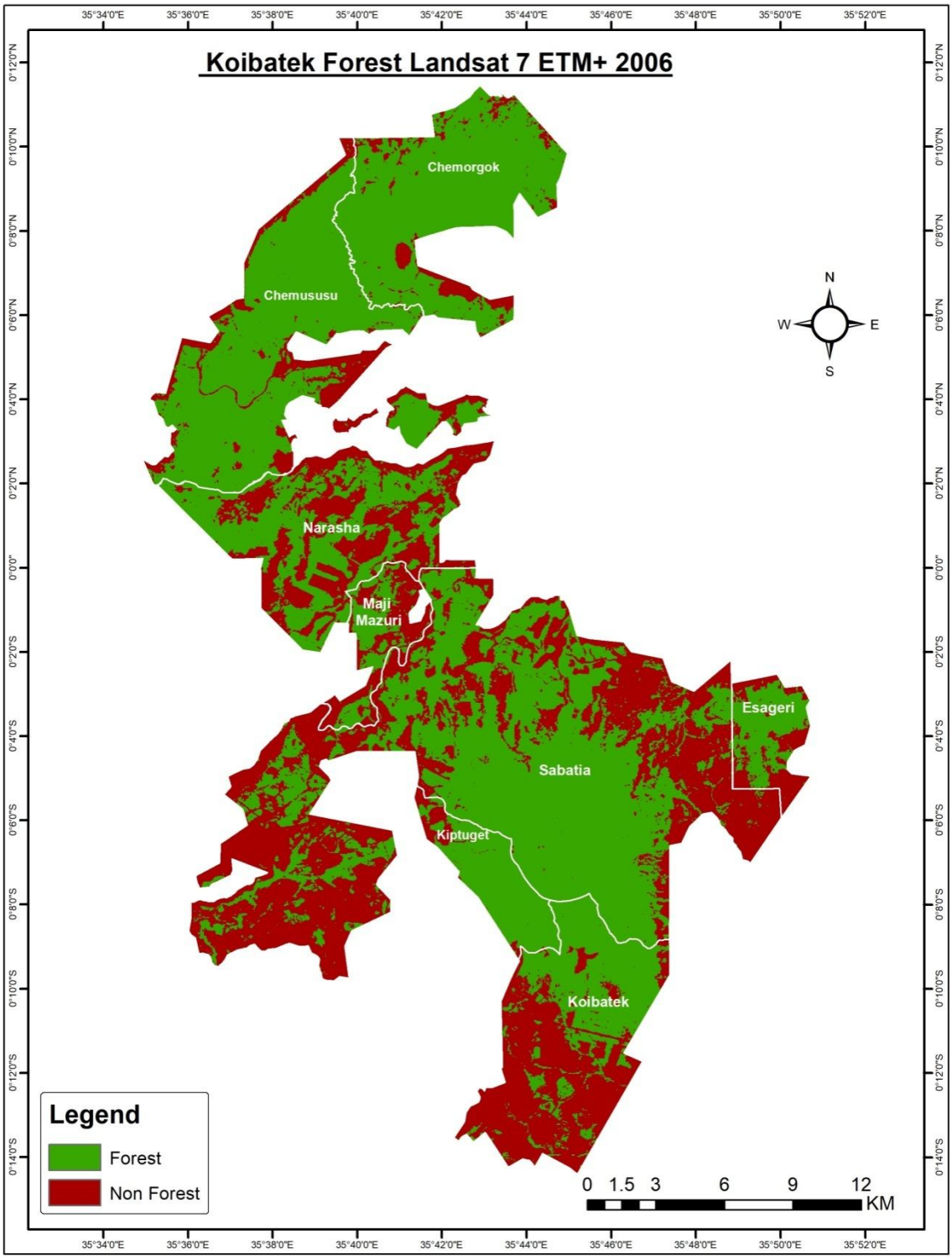

Figure 12: Land cover types within gazetted forests of Koibatek Forests Zone in 2006

Source: Researcher, 2015

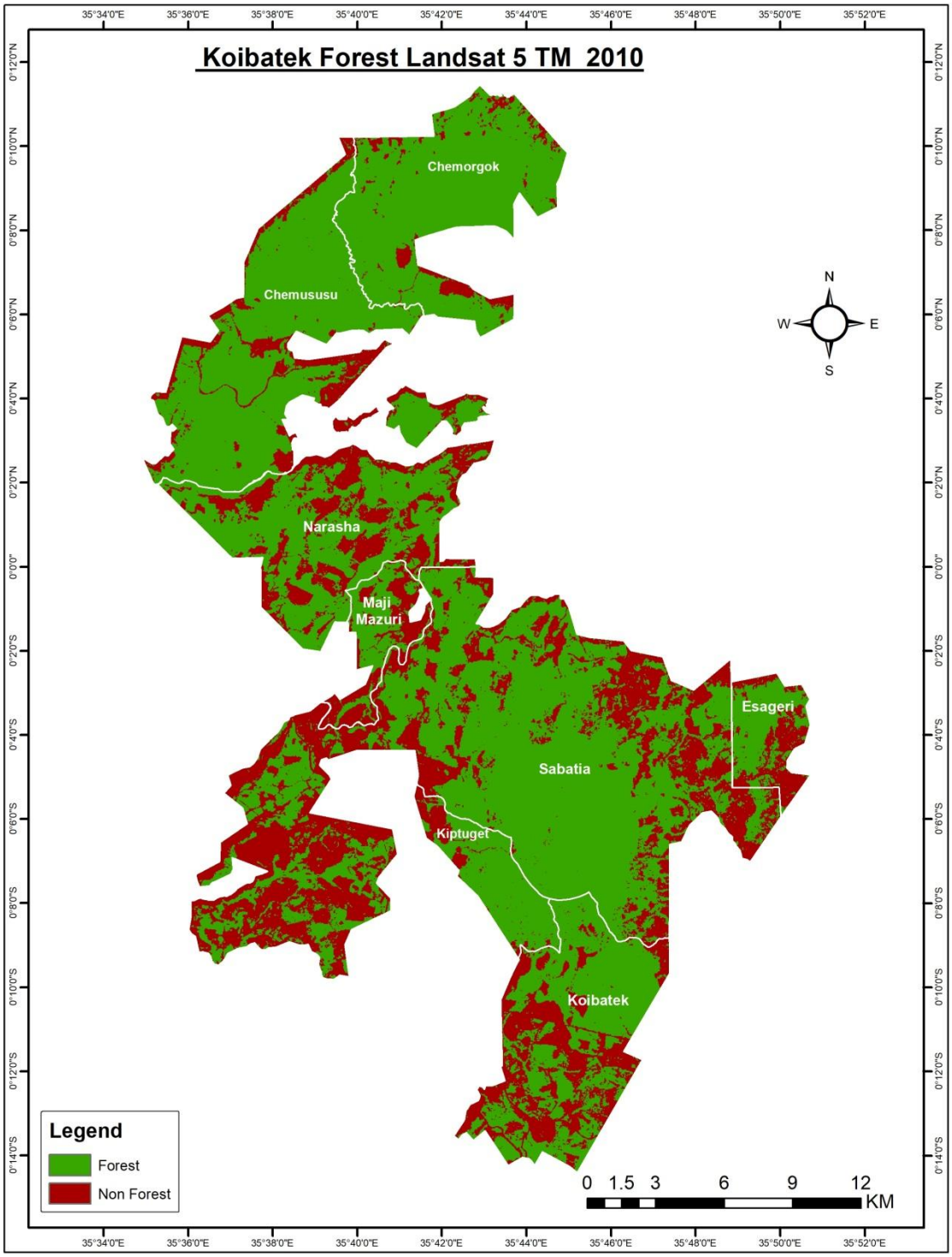

Figure 13: Land cover types within gazetted forests of Koibatek Forests Zone in 2010

Source: Researcher, 2015

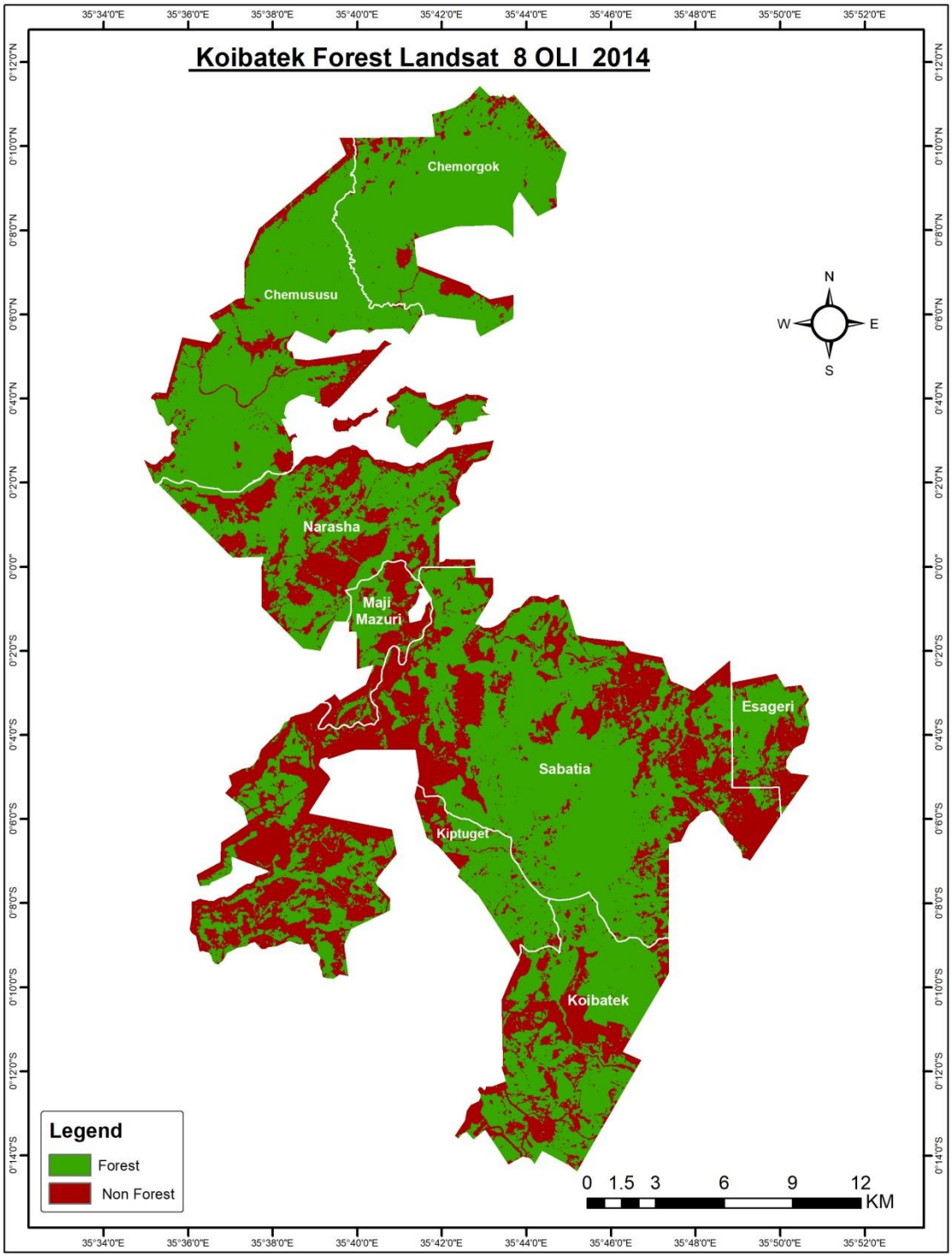

Figure 14: Land cover types within gazetted forests of Koibatek Forests Zone in 2014

Source: Researcher, 2015

The area and percentage cover of forest and non-forest land cover within the gazetted blocks of Koibatek Forests Zone is shown in Table 48.

Table 48: Area and Percentage of Land Cover Types within Gazetted Forests of Koibatek Zone

	2006		2010		2014	
Land Cover	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**
Forest	32124.65	**62.98**	35975.73	**70.53**	34414.90	**67.47**
Non Forest	18883.05	**37.02**	15031.97	**29.47**	16592.80	**32.53**
Total	**51,007.70**	**100.00**	**51,007.70**	**100.00**	**51,007.70**	**100.00**

Source: GIS, 2015

Table 48 indicates that in 2006 the forest area was 62.98% (32,124.65 ha) of the total gazetted forest land while non-forest area was 37.02% (18,883.05 ha). By 2010, forest area had increased to 70.53% (35,975.73 ha) as non-forest decreased 29.47% (15,031.97 ha) of the total gazetted forest land. By 2014, the proportion of forest cover decreased to 67.47% (34,414.90 ha) while non-forest increased 32.53% (16,592.80 ha) of the total gazetted forest land (Table 48). The changes in forest and non-forest land cover within the gazetted forests of Koibatek Forests Zone detected within the two periods of 2006-2010 and 2010-2014 are indicated in Table 49.

Table 49: Forest Cover Change of Gazetted Forests in 2006-2010 and 2010-2014

	Change in 1st Period (2006-2010)		Change in 2nd Period (2010-2014)	
Land Cover	**Area (ha)**	**%**	**Area(ha)**	**%**
Forest	3851.08	**10.70**	-1560.2	**4.50**
Non Forest	-3851.08	**25.62**	1560.2	**9.40**

Source: Field Survey, 2015

Table 49 indicates that there was a significant increase of 10.7% (3851.08 ha) in cover of forest between 2006 and 2010. This meant that 25.62% of non-forest decreased that period. However, in the period between 2010 and 2014, there was a decrease of the forest cover by 4.5% (1560.2ha) indicating an increase of 9.4% in the total area of non-forest. Therefore, in the period between 2006 and 2010, there was an increase in closed canopy forest cover by 10.7% signifying afforestation and in the period between 2010 and 2014 there was a decline in close canopy forest cover by 4.5% signifying deforestation.

4.5.3The Volume of Woodfuel Extracted and Equivalent Percent Loss in Cover of Gazetted Forests between 2006 and 2014

The estimated volume of woodfuel extracted from gazetted forests of Koibatek Forests Zone between 2006 and 2014 was 260,745.59m^3. Volume of firewood accounted for 113,289.59 m^3 (Section 4.3.4.1) and volume of charcoal was 147,456 m^3 (section 4.3.4.2) between 2006 and 2014. The volume of charcoal produced was greater than the volume of firewood collected within the gazetted forests blocks of Koibatek Forest Zone. The findings conform to MoE (2002) report that out of the 31,617,678 tonnes of woodfuel extracted from Kenyan forests annually, charcoal production accounted for 16,506,498 tonnes which was more than firewood whose volumes was 15,111,180 tonnes.

The equivalent loss in gazetted forest cover due to woodfuel extraction between 2006 and 2014 was calculated by applying World Bank (2009) formula which states that 82,192 m^3 of wood extracted (for charcoal, firewood or timber) is equivalent to that contained in 342.5 hectares of a closed canopy forest cover. Therefore, the 113,289.59 $m^3$of firewood was extracted from gazetted forests of Koibatek Zone between 2006 and 2014 translates to a loss of approximately472.1 hectares in cover of the gazetted forests. According to KFS-Koibatek (2011), the total area of the closed canopy cover of gazetted forests within Koibatek Zone was

47,412.8 hectares(Table 50), the 472.1 hectares of equivalent volume of firewood extracted between 2006 and 2014 was 1.0% of the forest cover. Table 50 shows that area of closed canopy forests and the equivalent loss in forest cover in hectares and percent due to the volume of firewood extracted within gazetted forests.

Table 50: Area and Percent Cover of Forests Equivalent to Firewood Extracted from 2006 to2014

Gazetted Forest Block	Closed Forest cover (Ha)	Forest cover loss equivalent to volume of firewood	
		Area in Ha	% loss in forest cover
Chemorgok	5,811.5	17.4	0.30
Chemususu	11,282.8	45.0	0.40
Narasha	4,932.4	63.6	1.30
Maji Mazuri	5,934.0	94.7	1.60
Sabatia	4,108.0	17.3	0.42
Esageri	6,081.6	70.4	1.16
Kiptuget	799.0	32.4	4.06
Koibatek block	8,463.5	131.3	1.55
Total	**47,412.8**	**472.1**	**1.00**

Source: Modified from KFS-Koibatek (2011)

Table 50 indicates that Kiptuget lost 4.06% (32.4 ha) of forest cover to firewood extraction. The percentage loss in forest cover in other gazetted forests were: 1.60% (94.7ha) in Maji Mazuri, 1.55% (131.3ha) in Koibatek block, 1.30% (63.6ha) in Narasha, 1.16% (70.4ha) in Esageri 0.42% (17.3ha) in Sabatia, 0.40% in Chemususu (45.0ha) and 0.3% (17.4ha) in Chemorgok. The results indicates that Kiptuget forests was the most affected by firewood extraction while Chemorgok block forest cover was the least affected block by firewood extracted between 2006 and 2014.

Since World Bank (2009) and KFS (2009) stated that the efficiency of tradition kilns used for charcoal production Kenya is 20%, 147,456 m^3 of charcoal produced between 2006 and 2014 (section 4.3.4.2) was 20% the volume of wood used in production. Therefore, approximately 823,247m^3 of wood was used in charcoal production within gazetted forests within gazetted forests of Koibatek Forests Zone. The volume of wood, according to World Banks (2009), was equivalent to that contained in 3,430.5 hectares of closed canopy forest cover. This translated to 7.24% of the 47,412.8hectares of closed canopy cover of gazetted forests within Koibatek Zone.

In general, the study established that the equivalent percentage loss in cover of closed canopy forest cover due to woodfuel between 2006 and 2014 was 8.24% (3,902.5 hectares). However, according to the results in Table 44, majority of woodfuel extractors reported a decrease in forest cover of between 1-2% (41.7%) and 3-4% (41.7%). FAO (2015b),in justifying why there was a difference between the equivalent percentage loss in forest cover and the reported percentage loss in forest cover, indicated that loss of cover due to extraction of products is difficult to be accounted due to natural regenerations and plantation establishment. The results also agree partly with Forestry Administration (2002) that woodfuel extraction is a forest clean up activity and part of good forest management. However, the study noted that the volume of woodfuel extracted within gazetted forests of Koibatek Forest Zone was significant and contributed to degradation of gazetted forests. This was in agreement with WETT (2000) and Fuwape (2003) that extraction of woodfuel and other forest products leads to destruction of forest cover and ecological imbalance.

4.5.4 Volume of Woodfuel Extracted and the Equivalent Forest Cover Changes

According to Figure 8, 32.8% of the respondents indicated that woodfuel extraction cause loss of forest cover and deforestation of gazetted forests. An analysis of volume of firewood extracted

between two periods i.e. 2006-2010 and 2010-2014 reveals that, woodfuel extraction played a role in the decline in cover of gazetted forests of Koibatek Forests Zone. This is because, in the period between 2006 and 2010, where there was significant increase of 10.7% in forest cover(Table 49), the volume of firewood extracted within the period dropped significantly from 14,839.25m^3 in 2007 to 6,542.16m^3 in 2008(Table 50). Generally, the total volume (58,837.5m^3)of firewood extracted in 2006-2010 was lower compared to 67,378.8$m^3$of firewood extracted in 2010-2014 (Table 51). A decrease in forest cover of 4.5% was detected between 2010 and 2014. This was also the period where firewood extraction increased to 67,378.8m^3 (Table 52).The volume of firewood extracted in 2010-2014 period was more by 8,541.3m^3compared to that extracted 2006-2010. The study noted that forest cover changed by -4.5% in the 2010-2014 period.

Table 51: Volume of Firewood Extracted from Gazetted Forests between 2006 and 2010

Gazetted Forest Block	***Volume of Firewood (M^3) from 2006- 2010***					
	2006	**2007**	**2008**	**2009**	**2010**	**TOTAL**
Chemorkok	813.57	664.09	365.75	255.56	405.83	**2.504.8**
Chemususu	276.7	521.39	180.77	147.46	400.3	**1,526.62**
Narasha	3307.92	2132.2	517.23	2627.46	1762.96	**10,347.8**
Maji Mazuri	3061.21	3625.44	1828.12	2631.86	1602.23	**12,748.9**
Sabatia	721.42	366.3	332.66	1190.56	465.54	**3,076.48**
Esageri	2970.69	3277.22	1429.02	604.46	1555.12	**9,836.51**
Koibatek block	1493.61	2888.88	1588.03	2613.7	6186.07	**14,770.3**
Kituget	1159.34	1363.73	300.58	653.86	548.65	**4,026.16**
Total	**13,804.46**	**14,839.25**	**6,542.16**	**10,724.92**	**12,926.70**	**58,837.5**

Source: KFS-Koibatek, 2015

Table 52: Volume of Firewood Extracted from Gazetted Forests between 2010 and 2014

Gazetted Forest Block	***Volume of Firewood (M^3) from 2010-2014***					
	2010	**2011**	**2012**	**2013**	**2014**	**TOTAL**
Chemorkok	405.83	442.56	426.69	323.21	484.37	**2,082.66**
Chemususu	400.3	1972.08	2703.75	2363.26	2245	**9,684.39**
Narasha	1762.96	2209.66	1196.21	788.38	711.09	**6,668.30**
Maji Mazuri	1602.23	1315.08	3200.94	3560	1899.51	**11,577.8**
Sabatia	465.54	177.47	466.6	99.17	329.2	**1,537.98**
Esageri	1555.12	1757.88	2802.59	866.48	1623.24	**8,605.31**
Koibatek block	6186.07	2277.42	8357.33	3814.66	2287.33	**22,922.8**
Kituget	548.65	622.92	1579.45	902.23	646.34	**4,299.59**
Total	**12,926.7**	**10,775.07**	**20,733.56**	**12,717.39**	10,226.08	**67,378.8**

Source: KFS-Koibatek, 2015

The results indicate that there exist a nexus between firewood extraction and decrease in percentage forest cover of gazetted forests detected within Koibatek Forests Zone. This also agrees with findings at section 4.5.3 that woodfuel extracted within gazetted forests was equivalent to 3,902.6 hectares (8.24%) of closed canopy cover of gazetted forests. However, FAO (2000a) indicated that forests are capable of regenerating naturally or through intervention by man in establishing forests plantation. Thus, the 8.24% loss due to woodfuel extraction within gazetted forests cover over a period of 9 years was difficult to be detected using satellite images. The findings also contrast with Leach and Mears (1998) and Abd'razack (2013) that firewood and charcoal was not solely to blame for deforestation and if its extraction is completely stopped, deforestation will continue. However, the results support Martinez-Alier (2002), IEA (2006), FAO (2006), Netherlands Enterprise Agency (2010), Mbugua (2013) that woodfuel extraction causes deforestation.

In summary, majority (92.9%) of woodfuel extractors reported a decrease in cover of gazetted forests by 1-4%. R^2=0.001 shows that 0.1% of gazetted forest cover change was due to woodfuel

extraction. However, the volume of woodfuel was not significant in predicting the changes in forest cover as indicated by $F=0.203$, $p>0.05$) and $T= -0.45$, $p>0.05$. In addition, 32.8% of woodfuel extractors cited woodfuel extraction as a cause of deforestation of gazetted forests. Furthermore, the volume of woodfuel extracted within the gazetted forests between 2006 and 2014 was equivalent to wood contained in 3,902.5 hectares (8.24%) of closed canopy forests. The volume of charcoal and firewood extracted was equivalent to 7.24% and 1.0% of closed canopy gazetted forests respectively. The detected forest cover changes were increase of 10.7% between 2006 and 2010 and a decrease of 4.5% between 2010 and 2014. Therefore, using the volume of woodfuel extracted within a forest over a period of time, it is possible to predict the equivalent loss in percentage forest cover of that forest within the period.

4.6 The Enforcement Mechanisms for Existing Legislations on Woodfuel Extraction within Gazetted Forests from 2006 to 2014

4.6.1Introduction

The section assesses the enforcement mechanisms to existing legislations on woodfuel extraction within gazetted forests. Firstly, it evaluated awareness of existing legislations by woodfuel extractors and secondly identifies the existing legislations on woodfuel extraction within gazetted forests. Thirdly, the study assessed the institutional frameworks for enforcing the existing legislations. Fourthly, the officers responsible for the enforcement activities of the legislations within gazetted forests of Koibatek Forests Zone were identified.

4.6.2 Awareness of Existence of Legislations on Woodfuel Extraction

Table 53: *Awareness of Existence of Legislations within Gazetted Forest Blocks*

Gazetted Forest Block	% Awareness by Woodfuel Extractors on Whether Legislations on Woodfuel Extraction existed	
	Yes	**No**
Chemorgok	100.0	0.0
Narasha	100.0	0.0
Chemususu	97.9	2.1
Kiptuget	97.4	2.6
Maji Mazuri	98.1	1.9
Esageri	97.0	3.0
Koibatek block	96.8	3.2
Sabatia	100.0	0.0
Mean	**97.9**	**2.1**

Source: Field Survey, 2015

Table 53shows that 97.9% of woodfuel extractors were aware that there existed legislations on extraction of woodfuel within the gazetted forests of Koibatek Forests Zone while 2.1% were not aware of existence legislations. All (100%) of woodfuel extractors within Chemorgok, Narasha and Sabatia forest blocks were aware of the existenceof legislations. Awareness within other gazetted forest blocks were: 98.1% in Maji Mazuri, 97.9% in Chemususu, 97.4% in Kiptuget, 97.0% in Esageri and 96.8% in Koibatek block (Table 53). Therefore, majority of woodfuel extractors were aware of existence of legislations on woodfuel extraction. This indicates that information of existing policies and legislation had been adequately communicated. The results agree with PISCES (2011) that awareness creation by government agencies targeting farmers, charcoal producers association and CFAs had been done for policies and legislations on woodfuel. In addition, Republic of Kenya (2014) reported that the government plays critical role in creating awareness on forest policy and legislations among stakeholders. However, the level of awareness of legislations by the forest stakeholders had not been established.

Table 54: Chi-Square Tests of Awareness on Existing Legislations on Woodfuel Extraction

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.713[a]	7	.910
Likelihood Ratio	4.346	7	.739
Linear-by-Linear Association	1.192	1	.275
Symmetric Measures			
Phi	0.084		.910
Cramer's V	0.084		.910
N of Valid Cases	**384**		

a. 8 cells (50.0%) have expected count less than 5. The minimum expected count is .33.

Source: Field Survey data, 2015

Table 54 indicates the Pearson Chi-Square value of $X^2(7)=2.713$, $P>0.05$, Phi and Cramer's $V=0.084$, $P>0.05$. Therefore there was no statistical significant relationship between awareness of existing legislations and the gazetted forest blocks. Awareness by woodfuel extractors on existing legislations was not dependent on the gazetted forests where the extractors were undertaking their activities. The results of the study are in line with Republic of Kenya (2005) which stated that public awareness-creation with regard to forest conservation, management and utilization will be supported by government of Kenya. KFS (2012) indicated that over 5,022 households were sensitized on policies for sustainable woodfuel extraction and utilization in Elgeyo Marakwet, Kiambu and Meru Counties in 2012. PISCES (2011) and Republic of Kenya (2014)also stated that a robust strategy for communicating and creating awareness on forest legislations in Kenya was in place.

5.6.3 Existing Legislations on Woodfuel Extraction within Gazetted Forests

Table 55 shows the existing legislations on woodfuel extraction within gazetted forests and the percentage responses from woodfuel extractors.

Table 55: Existing Legislations on Woodfuel Extraction and Percentage of Responses

Existing Legislations on Woodfuel Extraction	***% of the Total Woodfuel Extractors***
Community Forest Association (CFA) Membership rules	83.3
Monthly Fuel License (MFL) Regulations	72.5
Charcoal Burning Regulations	53.6
Firewood stacks Regulations	48.9

Source: Field Survey, 2015

Table 55shows that woodfuel extractors mentioned five (5) legislations which existed on woodfuel extraction within gazetted forests. The legislations were: (i) CFA membership rules reported by 83.3% of the total woodfuel extractors (ii) MFL Regulations (72.5%), (iii) Charcoal burning regulations (53.6%) and (iv) Firewood Stack Regulations (48.9%). According to KFS (2014), Kenya's forests were governed by Forest Act, 2005. Mbugua (2013) also stated that government of Kenya has put in place measures and restriction on firewood and charcoal extraction. These were in the form of Forest Act (GoK, 2005), Forest Policy 2014 (Republic of Kenya, 2014) and Forest Management and Conservation Act, 2016 (GoK, 2016). Wasonga (2017) stated that forest laws in Kenya are among the most stringent in the world and that rules and regulations had been drawn to ensure their implementations. Therefore, Wasonga (2017)explains why only rules and regulations on woodfuel were highlighted by respondents.

(i) CFA Membership Rules

Table 55shows that 83.3% of the total woodfuel extractors within gazetted forests of Koibatek Forests Zone reported that there existed CFA membership rules. FGDs conducted revealed that for one to qualify to be a CFA member of a forest block, they should be residents of sub-locations adjacent to the forests and must pay registration fees. The results of the study conforms

to PFM guidelines (KFWG, 2015) which defines CFA as a group of persons who are registered as an association under the Societies Act (Cap 108) and who are resident in an area close to the specified forest. The FCD discussions (2015) further revealed that only registered members of a specific CFA for a gazetted forest block qualifies to obtain a MFL for firewood collection, monthly livestock grazing licences and annual PELIS permits within gazetted forests. However, the study established that were other licenses and permits that did not require CFA membership including: timber harvesting, sawmilling, quarrying, and firewood stack collections.

The results of the study reflect Section 46 (1) of the Forests Act 2005 which states that: "*a member of forest community may, together with other members or persons resident in the same area, register a community forest association under the Societies Ac*t"(GoK, 2005). Republic of Kenya (2005) affirmed that the Forest Act recognizes CFAs as the only legal entity through which communities enter into a management agreement with the Director of KFS. Section 46 (2) of the Forest Act, 2005 states that "*an association registered under subsection (1) may apply to the Director of Kenya Forest Service for permission to participate in the conservation and management of a state forest or local authority forest in accordance with the provisions of this Act''.* According to Republic of Kenya (2010), both the state and local authority forests in Kenya are under the management of KFS. Section 47 (2) of Forest Act, 2005 (GoK, 2005) also gave the provisions by stating that the management agreement between the Direction of KFS and CFA may confer on the CFA forest user rights that includes harvesting of timber or collection of fuelwood in gazetted forests. KFS (2014) also affirms this by stating that communities engaging in forest conservation and management are required to have a signed management agreement with the Director of KFS as stipulated in the Forest Act 2005.

Table 2 indicates that there exist eight (8) CFAs operating within the gazetted forest blocks within Koibatek Forests Zone namely: Esageri, Lembus Narasha, Tulwob Lembus, Kiptuget, Koibatek, Lembus Chemususu, Maji Mazuri Station and Sabatia (KFS, Koibatek, 2015). The total registered members in all the CFAs by December 2014 were 7,154. Koibatek CFA which operates within Koibatek Forest Block had the highest membership of 1,750 while Tulwob Lembus CFA within Chemorgok Forest Block had the lowest membership 372.Therefore, by December 2014, 7,154 members of community adjacent to gazetted forests within Koibatek Forests Zone were had complied with CFA Regulations by being registered members of CFA within Zone.

(ii) Monthly Fuel License Regulations

Table 55 shows that 72.5% of the total woodfuel extractors reported the existence of MFL rules which was applied to firewood collection within gazetted forests. According to Koibatek Forests Zone Deputy Ecosystem Conservation's Personal Communication (2016), a MFL was issued upon payment of a prescribed fee of Ksh.100 by registered CFA members within the Zone. FGDs (2015) also revealed that each individual holder of MFL was allowed to collect only one headload of firewood per day for a period of one month. In addition, no tool including hand tools was permitted to be used for firewood extraction and only dry and decomposing wood was allowed for firewood extraction under the MFL. The results of the study conform to GoK (2016c) where MFL for firewood collection was Kshs. 100 as shown in Table 56.

Table 56: Firewood Fees in the Forest (Fees and Charges), Regulations 2015

Unit of Firewood Extracted	**Cost (Ksh)**
Commercial Clear fell per cubic metre	2,000
Salvaging, per cubic metre	2,000
Monthly Fuel Licence (MFL)	100

Source: Third schedule of The Forest (Fees and Charges), Regulations 2015

The Table 62 also shows that the fees for a cubic metre of firewood from commercial clear fell was Ksh. 2,000 and a cubic metre of firewood from salvaging attracted a fee of Ksh. 2,000 (Table 56).Despite the existence of the MFL rules which stipulates one trip per day to the forest to collect firewood, the study had found out (in Table 42) that the mean number of trips per day of 1.0424.

Table 57: Percent Extractors within the Daily Number of Trips forFirewood Extraction

Daily Number of Trips	No. of Extractors	Percent
1	362	96.0
2	14	3.7
3	1	0.3
Total	**377**	**100.0**

Source: Field Survey, 2015

Table 57 indicates that 96.0% of firewood collectors undertook the recommended 1 trip per day to the forest to collect firewood. However, 3.7% of woodfuel extractors undertook 2 trips per day and 0.3% undertook 3 trips daily (Table 57). Therefore, 4% of the total firewood extractors did not adhere to the MFLs regulations within gazetted forests of Koibatek Forests Zone which meant that there was 96% compliance to the Regulation and 4% non-compliance. Ministry of Environment and Forestry (2018) in explaining the non-compliance of MFL regulations stated that KFS was understaffed of forest rangers and currently each ranger covers 972 hectares of forests often on foot which is way below the internationally recommended ratio of 1 ranger per 400 hectares (where rangers have access to a vehicle).. Consequently, the forests rangers were ineffective in undertaking inspections and verifications of the daily number of trips undertaken

by each of the 7,154 registered CFA members within Koibatek Forest Zone for a whole month. Muthui (2018) also stated that compliance of forest legislations follows deterrence theory. According to the theory if the cost of compliance is low, the cost of non-compliance is high. Therefore, extractors would likely break the law if the financial gain exceeds the potential fines.

(iii) Charcoal Burning Regulations

Table 56shows that about 53.6% of woodfuel extractors indicated that charcoal burning regulations existed within gazetted forests. FGDs (2015) supported the findings by indicating that there was a ban of charcoal production within gazetted forests and any persons found conducting the activity or in possession of charcoal within the forests was deemed to have committed an offense. Forest Act 2005 (GoK 2005) supports and states that '*any person who makes charcoal in a state, local authority or provisional forest; commits an offence and is liable on conviction to a fine not exceeding one hundred thousand shillings or to imprisonment for a term not exceeding one year, or to both such fine and imprisonment*.' In addition, charcoal production is not one of the forest user rights conferred to a registered CFA within gazetted forests in Kenya by Section 47 (2) of the forest Act 2005 (GoK, 2005). However Section 59 (2) (r) of Forest Act 2005 states that rules may be made under the section for regulating production, transportation and marketing of charcoal.

The study established that the charcoal burning regulations were titled; 'Forests (Charcoal) Regulations, 2009' (GoK, 2009). Regulation 2directly reflects Section 59 (2) (r) of Forest Act 2005 and states that the Regulations relates to forestry and sustainable charcoal production, transportation and marketing, for the time being in force. Regulation 9 of Forest (Charcoal) Regulations, 2009 provides for any person producing charcoal for commercial purposes is

required to have a production license from the KFS before engaging in any production, transportation and marketing of charcoal. However, Subject to Regulation 9, landowners producing charcoal for their own household use do not require a license.

There existed a multi-step process set out in the Forest (Charcoal) Regulations to be followed by persons obtain a charcoal production license. The steps are as follows:

(i) Obtain 'Application for Charcoal Producer Licence' form from KFS office (Second Schedule of Forest (Charcoal) Regulations, 2009-Form 2).

(ii) Fill the form, giving the required details as indicated in Appendix 4 (Second Schedule Form 2) and obtain consent from the land owner(s) of the farm where charcoal will be produced (Form 3- Appendix 5).

- Seek a recommendation from the local environment committee. This committee has to assess the environment situation in the area to avoid land degradation.
- Develop a reforestation/conservation plan: This is an outline on how the cut trees/shrubs will be replaced and managed.

(iii) Submit all the information required in Step (ii) to the Forest Conservation Committee (FCC) and pay the required fee. This fee will vary from time to time.

(iv) The licensing sub-committee will review the application and give its recommendations to the FCC.

(v) KFS will issue a license depending on the recommendations from the FCC. The conditions of the license may be varied for different circumstances.

The Forest (Charcoal) Regulations 2009 regulates charcoal production from forests and woodlots in private farms where the producer seeks consent from landowner. However, the Regulations

did not provide for charcoal production within gazetted forests. The regulations reflect the personal communications from the 8 Forest Officers (2016) of Koibatek Forests Zone that charcoal production within gazetted forests were illegal. However, charcoal production continue to occur within the gazetted forests of Koibatek Zone since the study established that 6,144 bags of charcoal was produced within Koibatek Forests Zone between 2006 and 2014. According to UN-REDD (2013) non-compliance of Regulations within the charcoal sector was due to bribery and corruption that is high and widespread. Muthui (2018) also established that a charcoal producer or transporter breaks the law if the financial gain is higher than the potential fine when convicted in a court of law. Figure 15 shows that charcoal producers have devised three (3) main strategies to avoid arrests or being spotted by forest surveillance officers during charcoal production events within gazetted forests of Koibatek Forests.

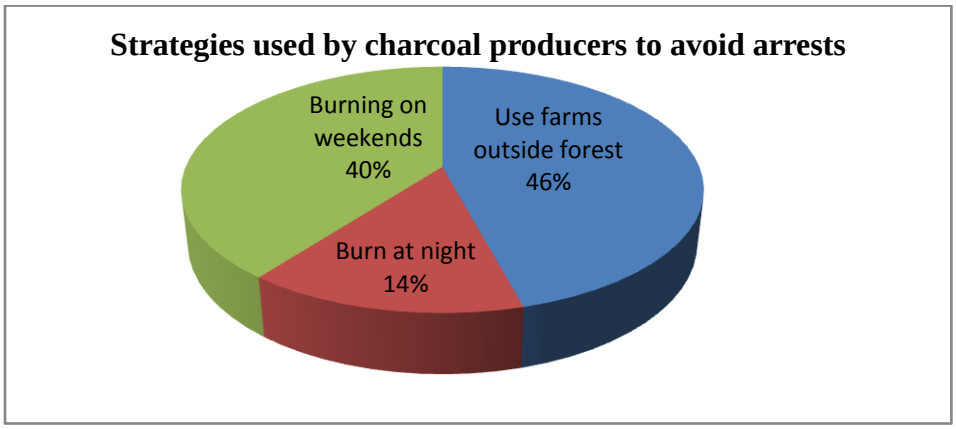

Figure 15: Strategies used by charcoal producers to avoid arrests
Source: Field Survey Data, 2015

Figure 15 shows that 46% of charcoal producers used farms outside the gazetted forests as a strategy to produce charcoal. The strategy makes it difficult for forest officials to link the activity to the forests yet the wood is sourced from the forests illegally. 40% of charcoal producers did the activity on weekends while 14% burn charcoal at night within gazetted forests. The charcoal

producers indicated that weekends and nights are very conducive since surveillance by forest rangers and officers was minimal. However, KFS-Koibatek (2015) listed court cases commenced for offences related to charcoal burning and transportation within gazetted forests of Koibatek Zone (Table 58).

Table 58: Offences related to Illegal Charcoal Burning Prosecuted in Courts of Law between 2012 and 2014

FOREST BLOCK	KFS/POLICE (SPECIFY) OB NO. AND DATE	NATURE OF THE OFFENCE	NO. OF PEOPLE ARRESTED	NATURE OF EXHIBIT	COURT STATION & COURT FILE NO	COURT OUTCOME
December 2014						
Koibatek	Molo Police Station 49/20/12/2014	Transporting charcoal illegally	1	1 bag of charcoal	Molo Law Court	Pending
November 2014						
Koibatek	Molo Police Station 2/7/11/2014	Making charcoal in a state forest	1	1 bag of charcoal	Molo Law Court	Sentenced to 6 months imprisonment
September 2014						
Maji Mazuri	Molo Police Station 34/18/8/2014	-Entering the forest - Preparing charcoal	1	10 cedar posts	E/Ravine Law Court 889/2014	Accused placed on 6 months CSO
	E/Ravine Police Station 02/21/09/2014	-Entering the forest -preparing charcoal	1	1 bag of charcoal	E/Ravine Law Court 896/2014	Accused fined Ksh.100,000 or 12 months
Koibatek	Molo Police Station 35/22/09/2014	Charcoal preparation	1	1 bag of charcoal	Molo Law Court 669/2014	P.B.C
August 2014						
Esageri	Molo Police Station 10/30/8/2014	Entering the forest preparing charcoal	2	A half a bag of Charcoal each	Molo Law Court 669/2014	P.B.C
Koibatek	Mochongoi Police Station 4/30/07/2014	Cutting trees to make charcoal	1	Charcoal remains	Molo Law Court	Accused place on 6 months imprisonment
July 2014						
Esageri	Rongai Police Station 22/09/07/2014	Entering the forest, cedar post chopping and illegal firewood collection	2	Cedar post Three donkeys	Molo Law Court	1st accused fined Ksh.100,000 or 12 months imprisonment and 2nd accused sentenced to 12 months CSO; 3 donkeys forfeited to the state
Sabatia	E/Ravine Police Station 36/16/07/2014	Entering the forest Preparing charcoal	1	2 bags of charcoal 1 spade	E/Ravine Law Court 669/2014	Accused placed on 6 months' probation
June 2014						
Koibatek	Molo Police Station	Charcoal burning	1	- Charcoal	Molo Law Court	Pending before court

FOREST BLOCK	KFS/POLICE (SPECIFY) OB NO. AND DATE	NATURE OF THE OFFENCE	NO. OF PEOPLE ARRESTED	NATURE OF EXHIBIT	COURT STATION & COURT FILE NO	COURT OUTCOME
	19/06/6/2014			remains		
Narasha	E/Ravine Police Station 17/25/06/2014	Entering the forest Charcoal burning	1	- 1 indigenous log	E/Ravine Law Courts 608/2014	Accused fined Ksh.100,000 or 12 months imprisonment
July 2013						
Chemususu		Cutting/felling Charcoal burning	1	- 3 bags of charcoal - An axe - A panga	Eldama Ravine law courts 655/2013	Placed on six months' probation
May 2013						
Maji Mazuri	Police OB NO. 36/13/05/2013	Charcoal burning Illegal entry	1	- Logs - Pangas	Eldama Ravine Law Courts	Sentenced to 6 months imprisonment or Ksh. 50,000 fine
February 2013						
Esageri	E/Ravine Police 2/16/02/2013	Charcoal burning	1	- 3 bags of charcoal	E/Ravine Law Courts	Sentenced to 6 months CSO
November 2012						
Koibatek	Police OB 42/21/11/2012	Charcoal burning chopping red cedar posts	2	- 1 cypress post - 1 bag of charcoal	Molo Law Courts	P.B.C
	Police OB 25/11/11/2012	Charcoal burning	2	- 2 bags of charcoal	Molo Law Courts	P.B.C
Esageri	Police OB 39/07/11/2012	Cutting trees to make charcoal	1	- Two indigenous logs	E/Ravine Law Courts	P.B.C
October 2012						
Koibatek	Police OB 53/18/10/2012	Charcoal burning	2	1 bag of charcoal	Molo Law Courts	P.B.C
	Police OB	Charcoal burning	1	1 bag of	Molo Law Courts	P.B.C

FOREST BLOCK	KFS/POLICE (SPECIFY) OB NO. AND DATE	NATURE OF THE OFFENCE	NO. OF PEOPLE ARRESTED	NATURE OF EXHIBIT	COURT STATION & COURT FILE NO	COURT OUTCOME
	46/24/10/2012			charcoal		
	Police OB 20/26/10/2012	Charcoal burning	1	1 bag of charcoal	Molo Law Courts	P.B.C
Esageri	Police OB 18/06/10/2012	Cutting trees to make charcoal	1	2 indigenous logs	E/Ravine Law Courts	Fine Ksh. 50,000 or 6 months imprisonment
	Police OB 37/29/10/2012	Cutting trees to make charcoal	1	4 indigenous logs	E/Ravine Law Courts	Placed on CSO for 6 months
September 2012						
Esageri	16/11/09/2012	Entering the forest Charcoal burning	1	1 log and 1 panga	E/Ravine Law Court	6 months C.S.O
	34/20/09/2012	Entering the forest Charcoal burning	1	1 log and 1 panga	E/Ravine Law Court	6 months C.S.O
	34/21/09/2012	Entering the forest Charcoal burning	1	1 log and 1 panga	E/Ravine Law Court	P.B.C
	34/20/09/2012	Entering the forest Charcoal burning	1	1 log and 1 panga	E/Ravine Law Court	P.B.C

Source: KFS-Koibatek, 2015

Table 59: Number of Court Cases and Offenders on Charcoal Production

Forest Block	Number of Court Cases	No of Offenders
Chemorkok	0	0
Chemususu	1	1
Narasha	1	1
Maji Mazuri	3	3
Sabatia	1	1
Esageri	10	12
Kituget	0	0
Koibatek block	10	13
Total	**26**	**31**

Source: KFS-Koibatek, 2015

Table 59 shows that twenty six (26) cases relating to charcoal burning were heard in either Eldama Ravine or Molo Law courts between September 2012 and December 2014. Koibatek and Esageri forests blocks were leading in the number of charcoal burning cases heard in courts of law with each block recording 10 cases. Three (3) cases were from Maji Mazuri block, one (1) case each from Chemususu, Narasha and Sabatia blocks. Chemorgok and Kiptuget blocks did not record any case within the period. The cases involved 31 individuals as follows: 13 from Koibatek block, 12 from Esageri, 3 from Maji Mazuri and one (1) each from Chemususu, Narasha and Sabatia blocks. According to KFS-Koibatek, (2015), the culprits were arrested with exhibits such as charcoal packed in bags, pangas and axes, donkeys and indigenous logs as indicated by Table 58.

The court sentences for the convicted offenders ranged from sentences of fine of Kshs. 100,000 or 12 months imprisonment to a fine of Kshs 50,000 or 6 months imprisonment to 6 and 12 months CSO. The sentences are in line with Section 54 (1) (e) of Forest Act, 2005 which stated that, charcoal making in a state, local authority or provisional forest; or in private forest or farmlands without a licence or permit of the owner as the case may be, commits an offence and

is liable on conviction to a fine not exceeding one hundred thousand shillings or to imprisonment for a term not exceeding one year, or to both such fine and imprisonment. The 3 donkeys arrested were forfeited to the state. KFS-Koibatek (2015) indicates that some cases were Pending Before Court (P.B.C) but no information was provided thereafter on how the cases were determined.

Regulation 7 of 'The Forest (Fees and Charges), Regulations 2015 (Republic of Kenya, 2016) also states that there shall be payable in respect of the activities set out in the first and second columns of the Fourth Schedule the fees respectively specified in the third column of that Schedule. Table 60 shows an extract from Fourth Schedule of the Regulations of the prices of three activities relating to charcoal: production, movement and export. Annual Charcoal production license for 10,000 bags is priced at Ksh. 50,000; 10,001-20,000 bags is Ksh. 200,000 while 20,001- 50,000 bags is Ksh 500,000. In addition, charcoal movement permit costs Ksh. 30 per bag and charcoal export permit costs Ksh.5, 000 per tonne (Table 60).

Table 60: Fees for Charcoal Production and Movement

Activity	**Quantity**	**Price (Ksh.)**
Charcoal Production License (Annual)	10,000 bags	50,000
	10,001–20,000 bags	200,000
	20,001–50,000 bags	500,000
Charcoal Movement Permit	Per bag	30
Charcoal Export Permit	Per tonne	5,000

Source: Fourth Schedule: Fees and Charges Regulations, 2015 (GoK, 2015)

(iv) Firewood Stack Regulations

Table 56 shows that 48.9% of woodfuel extractors within gazetted forests indicated that there existed Firewood Stack Regulations. Personal Communication from Forester of Narasha block (2016) also confirms the existence of firewood stack regulations where wood must be cut into pieces not more than 3 feet or 1m each before being transported from the extraction site within the forests. The study further established cost of firewood stack has been changing from Kshs. 500 (2005-August 2007) to Kshs. 1000 (September 2007 and December 2008) to Kshs. 1200 (from January 2009 to 2014) (DFO Koibatek Revenue Returns Volume VII, 1/1/17). In addition, only dry and decomposing trees or parts of trees are permitted to be collected under the firewood stack regulations. The study, in ascertaining the existence of firewood stack regulations, sought responses of extractors on the status of trees extracted for woodfuel within gazetted forests (Figure 16).

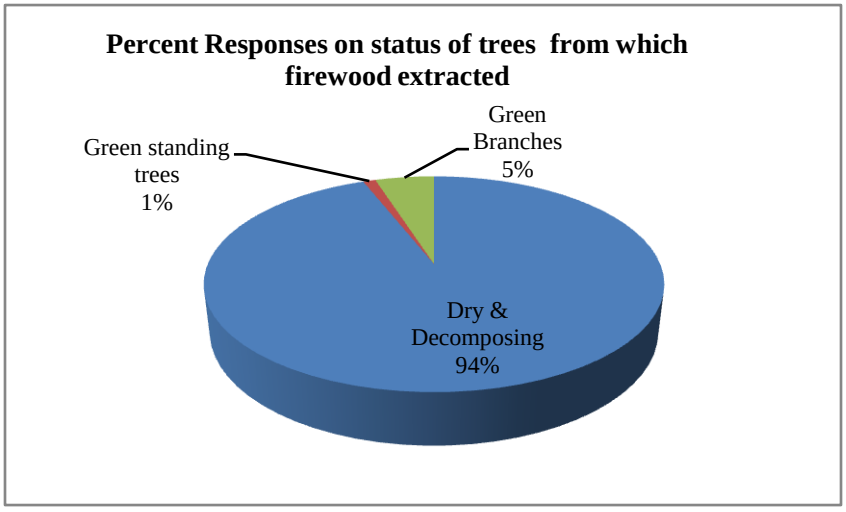

Figure 16: Status of Trees Exploited for firewood within Koibatek Forests Zone

Source: Field Survey, 2015

Figure 16 show that 94% of firewood extractors collected firewood from dry and decomposing trees. However, 5% of extractors harvested green branches for firewood and 1% extracted green standing trees for firewood. The results of the study shows that the stack regulations were in force and majority (94%) of woodfuel extractors complied with the requirements of the regulations. GoK (2005) supports the findings and stated that any person who commits a breach of, or fails to comply with any of, the terms or conditions of a licence issued to him under Forest Act (2005) commits an offence and is liable on conviction to a fine not exceeding one hundred thousand shillings or to imprisonment for a term not exceeding one year, or to both such fine and imprisonment.

4.6.4 Institutions for Enforcement of Legislations on Woodfuel Extraction

Table 61: Institutions for Enforcing Woodfuel Extraction Legislations

Institution	Frequency	% Respondents
KFS & CFAs	365	95.1
Kenya Forest Service (KFS) alone	7	1.8
County Government	7	1.8
Community Forest Associations (CFA)	3	0.8
Non-Government Organization (NGO)	2	0.5
Total	**384**	**100.0**

Source: Field Survey, 2015

Table 61 shows that 95.1% of woodfuel extractors reported that KFS and CFAs were the main institutions enforcing legislations on woodfuel extraction. In addition, 1.8% of the extractors reported that KFS alone did the enforcements while another 0.8% of extractors indicated that CFAs alone enforces the rules of woodfuel extraction. Furthermore, 1.8% of woodfuel extractors reported that County Government enforces the legislations while 0.5% stated that NGOs were tasked to enforce the legislation on woodfuel extractions within gazetted forests (Table 61). The

results reflects the provisions of Section 46 (1) (e) of Forest Act, 2005 (GoK, 2005)which stated that CFAs approved by Director of KFS shall assist Kenya Forest Service in enforcing the provisions of the Act and any rules and regulations made pursuant thereto, in particular in relation to harvesting of forest produce. On why County Government was cited by 1.8% of the extractors as one of the enforcers of existing legislations, the Fourth Schedule of the Constitution of Kenya 2010 (Republic of Kenya, 2010) stated that the 10th function of County Governments is implementation of specific national government policies on natural resources and environmental conservation, including (a) soil and water conservation; and (b) forestry.

The NGO cited by woodfuel extractors referred to IUCN which operated between within the gazetted forests of Koibatek Forests Zone 2006 and 2009 (IUCN, 2008). IUCN (2008) stated that they partnered with KFS and the County Council of Koibatek in launching the Lembus Forests Integrated Conservation and Development Project (LFICDP). The project was aimed at strengthening community management of Koibatek Forests through trainings to improve their participation in forest management so as to ensure they meet local ecological, social and economic needs. Hence, the few (1.8%) woodfuel extractors who indicated an NGO as enforcer had knowledge of the operations of IUCN in the gazetted forests.

4.6.4.1 Responsible Officers for enforcement of Legislations

Figure 17 shows the officers responsible for enforcing the existing legislations on woodfuel extraction within gazetted forests of Koibatek Forest Zone.

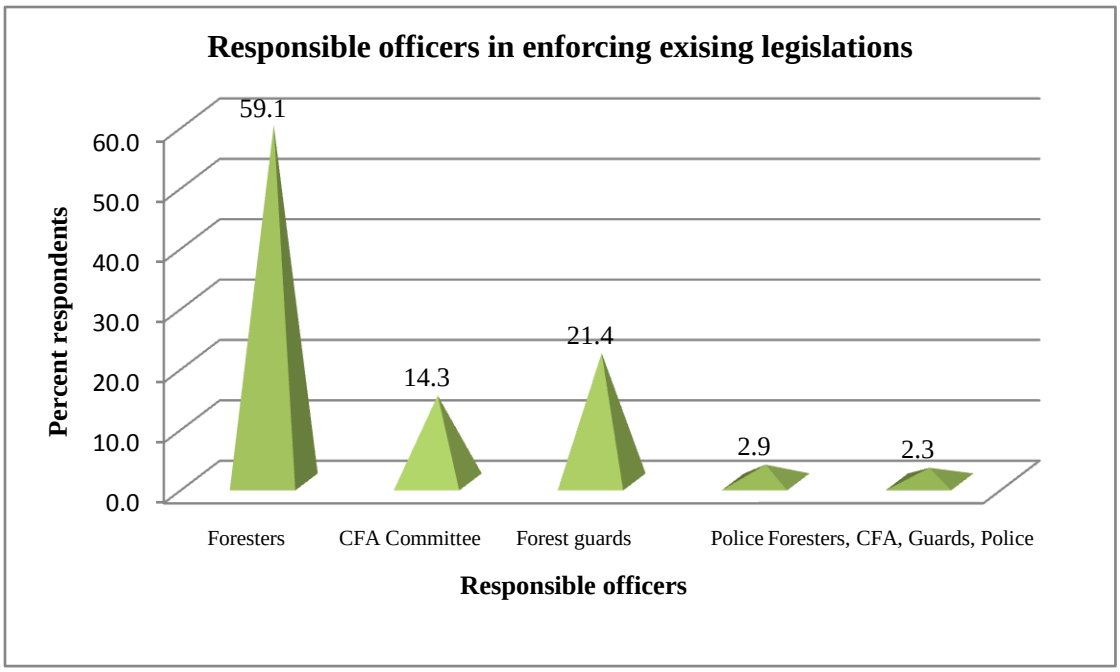

Figure 17: Responsible officers for enforcing of rules within institutions

Figure 17 indicates that 59.1% of woodfuel extractors reported that the foresters were responsible for enforcement of woodfuel extractions legislations. Other responsible officers were forest guards (rangers)(21.4%) and CFA committee at 14.3%. Kenya Police Service officers were also reported by 2.9% of the respondents as enforcers of legislations. The study also noted that 2.3% of the respondents indicated that enforcement of legislations a combined function of: Foresters, Forests Rangers, CFA and Police officers from Kenya Police Service. The results agree with GoK (2005) and PISCES (2011) which provide for KFS to work with CFA in management of forests. According to Kimani (2012) and KFS (2012) forest rangers now known forest rangers fall under the enforcement and Compliance division as per the Forest Act 2005. Therefore, they are mandated to implement legislations on forest management and products. In addition, Onyango (2013), Personal communications of Ecosystem Conservator of Baringo County (2016) affirmed that each forest station had one forest officers (forester) who was in-

charge of all the activities including firewood extraction within the station's boundaries. In addition there were forest rangers who assisted the foresters in enforcing the rules and programmes of KFS within gazetted forests and have mandates to arrests perpetrators within the forests areas before handing them to Kenya police. However handing over arrested culprits to police was a futile activity as per the World Bank (2007) assertion that weak enforcement of Forest Act, 2005 resulted from unsympathetic response from local police who may also be in the pay of offenders.

Section 49of Forest Act (2005) enlisted the roles and responsibilities of forest officers (foresters) to include: (a)demand from any person the production of an authority or licence for any act done or committed by that person in a state, local authority or provisional forest, or in relation to any forest produce for which a licence is required under this Act orunder any rules made there under; and (b) require any person found within or without a state, local authority or provisional forest who has in his possession any forest produce, to give an account of the manner in which he became possessed thereof, and, where the account given is not satisfactory, arrest and take such person before a magistrate (GoK, 2005). The study established that enforcing the rules in the gazetted forests meant that forest officers and rangers search for the approximately 7,154 registered CFA members in the forests to ascertain their authorization documents. In addition, the authorized woodfuel extractors were not obligated by law to carry with them the documents into the forests. However, Ministry of Environment and Forestry (2018), stated that KFS is understaffed of forest rangers and currently each ranger at KFS covers 972 hectares of forests often on foot which is way below the internationally recommended ratio of 1 ranger per 400 hectares (where rangers have access to a vehicle). Thus, the enforcement of the provisions of

Forest Act 2005 was difficult leading to flourishing of illegal activities such as charcoal production within gazetted forests

Furthermore, Subject to Section 46 (1) (e) of Forest Act, 2005 (GoK, 2005) CFAs should assist the Kenya Forest Service in enforcing the provisions of the Act and any rules and regulations made pursuant thereto, in particular in relation to illegal harvesting of forest produce. The study also revealed that each CFA is managed by a committee elected by members whose membership included: a Chairman, Vice Chairman, Secretary, Deputy Secretary and a Treasurer (FGDs, 2015). However, the study established that it was difficult for CFA committee to know who among its members was authorized or unauthorized members to enter forests or extraction forest products because authorization is done at the KFS station's offices. In effect, CFAs roles in assisting forest officers was not defined or not clear.

4.6.4.2 Indicators of enforcements gaps of woodfuel extraction legislations

The findings of the study points to the existence of gaps in the enforcement of the rules and regulations of woodfuel extraction within gazetted forests. The indicators established by the study include the following:

i. Presence of charcoal production activity within all the gazetted forests blocks with the Zone contrary to provisions of Forests Act, 2005 and Forests (Charcoal) Regulations 2009 that makes the activity illegal within these gazetted forest areas as per the findings in Section 4.2.3
ii. Extraction of green trees and branches for woodfuel against the regulations of KFS for issuance of MFLs and permits for stacks collection.

iii. Reported more than 1 trip per day (between 2 and 3 trips) of firewood headloads collected form the gazetted forests by MFL holders yet the terms of MFLs is 1 trip per day of head load for a month.

iv. Use of hand tools such as pangas and axes by some MFL holders to extract firewood yet it is against the rules of KFS.

v. Non-payments by some extractors to extract and transport charcoal and firewood from the gazetted forest zone.

KFS-Koibatek (2015) reported the court cases which were either on-going or had been concluded on various offenses related to charcoal burning and illegal logging. The findings agrees with Ochieng (2010) who stated that weak institutional capacity and poor enforcement of forest laws have also been identified as major drivers of forest cover change in Kenya. As a result, GOF as spelled out by UNFF (2008) to include reversing the loss of forest cover through Sustainable Forest Management (SFM) and enhancing forest-based economic, social and environmental benefits will not be achieved.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings

This section summarizes the findings of the study in line with specific objectives of the study.

The study established that of the socio-economic determinants of woodfuel extraction (gender, age, level of education, employment status and source of livelihood support), only gender was significant in woodfuel extraction within gazetted forests. Pearson's Chi-square $X^2(2) = 33.113$, $P < 0.05$ indicates that gender of woodfuel extractors had strong association with woodfuel extraction within gazetted forests. The remaining socio-economic determinants (age, level of education and livelihood support) were not significant in woodfuel extraction within gazetted forests as indicated: age ($X^2(10) = 15.759$, $p>0.005$), level of education ($X^2(10)$ 8.439, $p>0.005$) and livelihood support ($X^2(10) = 11.207$, $p>0.005$).

The study established that the relationship between income earned from sale of woodfuel and volume extracted is explained by a regression model: Volume of Woodfuel = 0.982+ (1.031×Income Earned). The results $R^2=0.531$ also indicates that 53.1% change in volume of woodfuel extracted from gazetted forests can be explained by the income earned for sale. There was positive and significant relationship between revenue collection and volume of woodfuel collected ($\beta= 1.194$, $p < 0.05$). At 95% confidence interval, the model indicates that volume of woodfuel extracted increased by between $0.868m^3$ and $1.194m^3$ due to income earned for the sale of the commodity. The t-values ($T=12.503$) were significant at $p<0.05$) and it can therefore be concluded that income earned was a significantly determinant of the volume of woodfuel extracted within gazetted forests of Koibatek Forest Zone.

The study further established that the linear regression model that explains the influence of proximity to forests and number of firewood headloads: Number of Firewood headloads = 1.365 + (0.065) (Distance to the forests). According to the model R^2=0.004, β= 0.065, p>0.05 and the t-values (T=1.264, p>0.05), 0.4% of variations in number of firewood headloads can be explained by proximity. P>0.05 indicates that proximity to gazetted forests was not significant in predicting the number of firewood headloads extracted within gazetted forests. The results also shows at 95% confidence level, that the regression line of proximity to forests (x- axis) and number of firewood headloads (y-axis) lies between -0.037 and 0.168.

The study established that majority (92.9%) of woodfuel extractors within gazetted forests of Koibatek Zone reported a decrease in cover of 1% and 4%. R^2=0.001 shows that 0.1% of gazetted forest cover change was due to volume of woodfuel extracted. However, p> 0.05 indicates that volume of woodfuel extracted was not significant in predicting the changes in forest cover since other factors such as lumbering and agriculture plays a role in forest cover loss. The study established that woodfuel extraction was the second main cause of deforestation of gazetted forests after commercial timber as reported by 32.8% and 46.7% of the respondents respectively. Other causes were Plantation Establishment and Livelihood Improvement Scheme (PELIS) (16.7%), forest fires (4.7%) and animal grazing (3.4%). The estimated 260,745.59m^3 of woodfuel extracted within gazetted forests from 2006-2014 was equivalent to 8.24% (3,902.5 hectares) loss in forest cover within the period. The volume of charcoal produced (147,456m^3) between 2006 and 2014 was equivalent to 7.24% cover of gazetted forests. On the other hand, the volume of firewood (113, 289.59m^3) extracted between 2006 and 2014 was equivalent to 1.0% cover of the gazetted forests. The detected forest cover changes were increase in forest cover of 10.7% between 2006 and 2010 and a decrease in forest cover of 4.5% between 2010 and

2014. In general, changes in percent forest cover can be accurately predicted by the total volume of woodfuel extracted which is a product of number of woodfuel extractors, per capita volumes of woodfuel extracted and the frequency of extractions.

The study further established that 98% of woodfuel extractors were aware of the existence of rules and regulations governing woodfuel extractions within gazetted forests. The level of awareness to the existing legislations was not statistically significant ($X^2(7)=2.713$, P>0.05, Phi and Cramer's V=0.084, P>0.05) to woodfuel extraction within the gazetted forest blocks. The study established that the main legislations for woodfuel extraction within gazetted forest were: Community Forest Association (CFA) Membership rules as reported by 83.3% of woodfuel extractors; Monthly Fuel License (MFL) Regulations (72.5%); Charcoal Burning Regulations (53.6%) and; Firewood stacks Regulations (48.9%). The study also established that Kenya Forest Service, in consultation with Community Forests Associations was responsible for enforcement of legislations on woodfuel as indicated by 95.1% respondents. The implementation of the legislations was mainly vested on forest officers (59.1%) and forest rangers (21.4%) and CFA committees (14.3%). Kenya Police Service also participated to a very small extent in implementation of the legislations as was reported by 2.9% of woodfuel extractors.

5.2 Conclusions

It can be concluded that the socio-economic determinant significant in woodfuel extraction within gazetted forests was mainly gender where women are the dominant gender. People's cultures and poverty mainly influences the involvement of women in woodfuel extraction activity within gazetted forests. Age, level of education and livelihood support when unemployed are not significant determinants of woodfuel extraction within gazetted forests.

It can also be concluded that income earned from sale of woodfuel greatly affected the volume of woodfuel extracted from gazetted forests. Firstly, Kenya Forest Service collects significant revenue by issuing licenses and permits for firewood collection within gazetted forests. This permits issued triggers trading chains in woodfuel around the gazetted forests blocks whereby woodfuel extractors sell all or a proportion of firewood collected to traders operating yards or to individual households. These woodfuel extractors therefore earn income from the sales of woodfuel extracted. In addition, there exists illegal charcoal extraction within gazetted forests of Koibatek Forests. The charcoal produced from gazetted forests is transported to nearby urban areas where demand is high. Therefore, producers, transporters and retailers in towns also earn income from the charcoal activity. The trade involving charcoal and firewood sourced from gazetted forests was profitable venture thus leading to more wood requirement.

The study also concludes that proximity to gazetted forests does not influence the number of firewood headloads collected within these forests. Though most adjacent forest community within a radius of 5km depends on gazetted forests for their energy needs, the key factors that determine extractions are membership to CFA and valid MFL from KFS. Firewood headload collection within gazetted forests demands that an extractor must be registered member of a CFA and must pay for the monthly fuel license. Thus irrespectively of one's proximity to forests, MFL are issued with rules that restricts collection of firewood from gazetted forests to 1 headload per day. Therefore, the number of licensed woodfuel extractors influences the number of firewood headloads collected within the gazetted forests.

Furthermore, it can be concluded that that volume of woodfuel extracted contributed to only0.1% loss in forest cover. The volume of woodfuel extracted within the gazetted forests of Koibatek

Zone between 2006 and 2014 was equivalent to trees contained in 3,902.5 hectares or 8.24% of gazetted forests cover. The volume of charcoal accounted for 7.24% while firewood extracted was equivalent to 1.0% of gazetted forests cover respectively. The equivalent forest cover loss due to woodfuel extraction was not entirely detected for the 2006-2014 period as explained by natural regeneration and plantations establishment. Thus, based on the volume of woodfuel extracted at specific time period, the equivalent forest cover changes from where the woodfuel was extracted can be predicted.

The study further concluded that there existed clear legislations on woodfuel extraction within gazetted forests in Kenya and that most forest users particularly woodfuel extractors were aware of these legislations. The key institution tasked to enforce the legislations on woodfuel extraction within gazetted forests isKFS assisted by registered CFAs. Kenya Police Service supports KFS and CFAs in inspections of vehicles while County Governments also participates in enforcing the legislations to a small extend. The personnel responsible for enforcing the legislations are Forest Officers, Forest Rangers and CFAs Executive committees. The legislations had significant influence on volume of woodfuel extracted within gazetted forests. There exist gaps in implementation of the existing forest legislations on woodfuel extraction as evidenced illegal activities such as charcoal burning within gazetted forests. The main reason for the existing gap in implementation inadequate enforcement staff particularly forest rangers within KFS. Therefore, SFM has not been realized for gazetted forests as evidenced by 4.5% deforestation recorded between 2010 and 2014.

5.3 Recommendations

Recommendations were made according to the specific objectives of the study.

It is recommended that woodfuel extractors should be sensitized on the existing rules of woodfuel extraction within gazetted forests and their responsibilities during the extraction activity. The sensitization programmes should mainly target women groups and organizations since they are the dominant gender in woodfuel extraction activities within gazetted forests. Sensitization will also encompass promoting and recommending for alternative and cheap sources of energy such as solar and biogas in order to reduce pressure on woodfuel use.

It is also recommends that KFS and County Governments to synchronize their licensing regulations to curb illegal trade on woodfuel. In addition, licensing of woodfuel extractors should be in two categories, that is, domestic and commercial. The business owners should also innovate modern methods of adding value to woodfuel to increase income earned while reducing the volume extracted. In addition, surveillance of gazetted forests by forest rangers to be enhanced to include nights and weekends so as to curb illegal charcoal production as well as unlicensed firewood extraction activity within the forests. Furthermore, extraction and transportation of firewood by licensed extractors should be closely monitored to ensure that accepted dry wood and licensed volumes of firewood are extracted. The adjacent forest community should be sensitized on sustainable woodfuel extraction and empowered with knowledge of agro-forestry and land management in order for them to develop on-farm forestry.

It is also recommended that all households of communities adjacent to gazetted forests within Koibatek Forests Zone be encouraged to join Community Forest Association within their locality. When all households have been enrolled as CFA members, then the number of firewood

headloads extracted every month will be easily accounted for since CFA membership is a key determinant to number of firewood headloads collected.

Furthermore, it is recommended that for efficient measuring technology for the volume of woodfuel extracted is innovated together with establishment of toll stations where measurement are taken. In addition, surveillance of the entry to the forests should be enhanced so as to account for all the firewood collected and curb charcoal burning. Private land owners surrounding gazetted forests should also be encouraged and trained on on-farm forestry and agro-forestry so as to alleviate scarcity of woodfuel and increase forests cover.

In addition, it is recommended that, enforcements of existing laws and regulations on woodfuel should be enhanced through collaborations and consultations between KFS, Kenya Police Service and CFAs. More forest staff particularly forest rangers to be employed to enhance surveillance of forests In addition, penalties imposed on law breakers such as charcoal burners and un-licensed firewood extractors within gazetted forests should be reviewed to be more punitive so as to make them effective in curbing the illegal activities.

5.4 Areas for Further Research

The study lists the following topics for further research:

(i). The average Diameter at Breast Height for Tree Species preferred for Woodfuel Extraction within Gazetted Forests in Kenya

(ii). The effectiveness of surveillance activities during exploitation of major forest products within gazetted forests in Kenya.

(iii). The effects of UN Forest Instruments on Sustainable Forest Management in Kenya

(iv). The Potential of On-farm Forestry and Agro-forestry Practices in Alleviating woodfuel supply deficit among Adjacent Community within Mau Forest Complex.

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APPENDICES

Appendix I: Questionnaire for Woodfuel Extractors within Gazetted Forests

Section A: PERSONAL INFORMATION

1. Gender [ ] Male [ ] Female
2. Age in years [ ] Below 18 [ ] 18 – 29 [ ] 30 – 39 [ ] 40 – 49 [ ] 50 and above
3. Level of Education [ ] Primary [ ] Secondary [ ] Tertiary certificate
   [ ] Diploma [ ] Undergraduate degree [ ] Masters [ ] PhD
4. What is nature of other economic activity undertaken with woodfuel extraction?
   [ ] Formally employed [ ] Informally/self-employed [ ] None
   If none, what is the source of your livelihood support?
   [ ] Parents [ ] Children [ ] Well-wishers [ ] Government [ ] NGO
5. What is your monthly income in Ksh?
   [ ] 1000 & Below [ ] 1,001-5,000 [ ] 5,001-10,000
   [ ] 10,001 -20,000 [ ] Above 20,000

SECTION B: INCOME AND VOLUME OF WOODFUEL

6. What type of woodfuel do you extract from gazetted forests within Koibatek?
   [ ] Firewood only
   [ ] Charcoal only
   [ ] Both firewood and Charcoal
7. What is the main reason for your woodfuel extraction activity?
   [ ] Domestic purposes [ ] My business [ ] Employed by dealers

   Firewood collection section
8. Do you pay any money to enter into gazetted forests to collect firewood?
   [ ] Yes [ ] No
   If yes,
   (i). What is the payment for a headload of firewood (in Kshs)……..
   (ii).What is the cost for collecting firewood stacks (Kshs)…….
9. How long does it take for you to pay again for firewood headloads collection?
   [ ] Day [ ] Week [ ] Month [ ] 3 months [ ] 6 months [ ] 1 year
10. Do you sell the firewood collected from gazetted forests?

[ ] Yes [ ] No

11. Who are the main customers for firewood collected from gazetteed forests of Koibatek?

[ ] Plot dwellers [ ] Yards [ ] Hotels/Butcheries [ ] Schools [ ] Hospitals

12. How much money do you get from the sales of firewood headloads collected from gazetted forests per day?

[ ] 1- 200 [ ] 201-400 [ ] 401 – 600 [ ] 601-800

[ ] 801-1000 [ ] 1000-2000 [ ] 2001-3000

13. What are the influence of income earned on the volume of firewood extracted

[ ] Increases [ ] Decreases [ ] Remains constant

Charcoal burning

14. How many sacks of charcoal do you produce in one charcoal event?

[ ] 0-0.99 [ ] 1-5 [ ] 6- 10 [ ] 11- 15 [ ] 16- 20 [ ] Above 20

15. What is the size of the sack?

[ ] 20 kg [ ] 50 kg [ ] 90 kg [ ] 100 kg

16. How many times do you burn charcoal in one month?

[ ] Once [ ] 2 times [ ] 3 times [ ] 4 times [ ] 5 times [ ] 6 times

17. Do you get permit to burn charcoal within gazetted forests?

[ ] Yes [ ] No

(a) If yes, how much do you pay (in Kshs)…….

(b) If No, how do you manage to produce charcoal without being noticed or arrested by forests management?…….

18. After what duration are you required to pay again?

[ ] Day [ ] Week [ ] Month [ ] 3 months [ ] 6 months [ ] 1 year

19. Whom do you produce charcoal for?

[ ] Self /domestic use [ ] Sale to dealers

if you sell what is what changes in charcoal production due to income?

[ ] increase [ ] decrease [ ] No change

SECTION B: FOREST PROXIMITY AND FIREWOOD HEADLOADS COLLECTED

20. What is your area of residence?

[ ] Town [ ] Rural

21. What is the approximate distance between your home and the nearest gazetted forests

[ ] 0.1km -1km [ ] 1.1km-3km [ ] 3.1km-5km [ ] 5.1-7km

[ ] 7.1 km -9 km [ ] 9.1km and above

22. How many trips do you make into the forests per day for the firewood?

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ] other (specify) …….…….

23. What is the approximate time taken to collect firewood in a single trip to and from forests

[ ] less than 1 hour [ ] 1-2 hours [ ] 2- 4 hours [ ] 4-6 hours

24. In your estimation, how much firewood do you collect per trip to the forests?

[ ] 20 kg and below [ ] 21-60kg [ ] 61 – 100kg [ ] 1-5 stacks [ ] 6-10 stacks

25. What is the amount of firewood permitted for you to collect from the gazetted forests?

[ ] 1 headload [ ] 1 bicycle [ ] Donkey [ ] 1Trailer [ ] No of

SECTION D: EFFECTS OF WOODFUEL ON FORET COVER CHANGE

26. How much of the following do you extract from gazetted forests per month?

(i) Firewood (in stacks) …… ….(in headloads)……

(ii) Charcoal……sacks

27. Has the cover of gazetted forests changed between 2006 to 2014

[ ] Yes [ ] No

28. How has the forest cover changed in the last 10 years?

[ ] Increased [ ] Decreased

29. What is main cause of the change in the gazetted forest cover?

[ ] Lumbering [ ] Woodfuel [ ] Forest fires [ ] Livestock feeding [ ] Agriculture

30. What percentage of forest change do you attribute to woodfuel?

[ ]1-2% [ ] 3%-4% [ ] 5-6% [ ] 7- 8% [ ] 9-10%

31. What is condition of wood you prefer to collect for firewood or burn as charcoal?

[ ] Dry and Decomposing [ ] Whole green trees [ ] Prunings

32. Name the species of trees that you commonly cut for firewood and charcoal from the forest?

(i) ……. (iv) ……

(ii) ……..….. (v) …….....

(iii) …… (vi) …….....

33. Are the species you listed above the dominant in the forest?

[ ] Yes [ ] No

34. What can you say of the distribution of the tree species that you prefer to extract for wood fuel in the last 10 years?[ ] No Change [ ] Decreased [ ] Increased

SECTION E: LEGISLATIVE FRAMEWORKS

35. Are some of the rules and laws applied to manage woodfuel extraction in the forests?

    [ ] Yes [ ] No

36. Name the rules and regulations that exists

    1……..2…….3……

    4…… 5……6…….

37. Which institution enforces rules for woodfuel extraction from the gazetted forests?

    [ ] KFS [ ] CFA [ ] KFS & CFA [ ] County Government [ ] NGOs

38. Who is tasked to ensure enforcement of the rules for woodfuel harvesting within the forests?

    [ ] Foresters[ ] Forest Rangers [ ] CFA committee [ ] Kenya Police [ ] All

39. Do you think there is illegal woodfuel extraction within the forests?

    [ ] Yes [ ] No

40. How is illegal woodfuel extraction being controlled?.....

    ……

41. Have you been involved in any way in enforcing the rules of woodfuel forests?

    [ ] Yes [ ] No

Appendix II: Interview Schedule for Ecosystem Conservator/Forest Officers

1. How much of woodfuel are produced annually from Gazetted forests within your jurisdiction? ……..…....

2. How many of the following woodfuel extractors operate within your forest station?

   (a) Firewood collectors …….

   (b) Charcoal burners …….……..

3. Does office have a registers(e.g. monthly or annual) for the woodfuel extractors in Question 2?

   [ ] Yes [ ] No

   If yes, please provide copies of register from 2006 to 2014

   ……..

4. What are the criteria or steps followed by any person to be allowed enter into gazetted forests to extract woodfuel?

   ……..**.....**

   ……..

   ……...……

5. Once permission is granted into the forest under criteria or steps in question 4 above, what monitoring measures do you undertake on the operations of such a person?

   ……..…...

   ……..**.....**

   ……...……

6. Is there a fee paid by woodfuel extractors to KFS in order to carry out their activities?

   [ ] Yes [ ] No

   If Yes, how much per existing categories of woodfuel extractors?

   ……...…….

   ……

7. What are the main socio-economic activities that make people to seek permission to extract woodfuel from gazetted forests?.....

   ……..

……..**.....**

8. What type of woodfuel is preferred for each of the socio-economic activities stated Question 8above? ….……

   ……..

   ……

9. What are the specific tree species in the gazetted forests that is preferred for woodfuel for the socio-economic activities? *(Give both the local and scientific names of the trees)*

   ……

   ……

   ……

10. Which sections of gazetted forests are affected more by woodfuel extraction?

    [ ] Natural forests [ ] Plantation forests

11. What are the ecological effects of woodfuel extraction on gazetted forests known to you?

    (a) Effects on Natural forests

    ……

    ……

    ……

    ……

    (b) Effects on Plantation forests

    ……

    ……

    ……

    What strategies have you or KFS put in place to reduce the negative effects listed in Question 12 above?**.....**

    ……..**.....**

    ……..**.....**

12. Are there Regulations that have been enacted by Kenya Forests Service (KFS) on woodfuel extraction from the gazetted forests?

    [ ] Yes [ ] No

    If Yes, list them: ……..……

    ……...……

13. How do you ensure that the Regulations have been communicated to all stakeholders of the forests?.....
    ……..
    .....
14. What are the challenges faced in the implementation of the Regulations in gazette forests under your management?.....
    ……
    ……
    …….
15. What are the roles played by community members regarding to woodfuel extraction from gazetted forests?.....
    ……
    ……
16. How many registered Community Forests Associations (CFAs) are in your territory?
    ……...
17. What are the roles of CFAs in administration of woodfuel extraction within Gazetted forests?
    …….
    …….
    ……...……
18. What opportunities exist amongst forest stakeholders in sustainable management of woodfuel within the gazetted forests?
    ……
    ……..…

Thank you for your time

Appendix III: Focused Group Discussions (FGDs) Guidelines

1. Rank the main woodfuel extractors from gazetted forests of Koibatek Forests Zone
   [1]……. [2]..…… [3]…….. [4]…..…….…… [5]…….…..**.....**
2. How do KFS give permission to extractors of woodfuel in the gazetted forests? (*give the steps)*
3. What are the conditions (issued either by KFS or any other body) that accompany permission to enter into gazetted forests to extract woodfuel?
4. How do KFS do the monitoring of actual woodfuel extraction processes and activities within forests?
5. What are the contributions of CFAs in monitoring of woodfuel extraction within gazetted forests
6. What are the disciplinary measures taken to woodfuel extractors found within the forests without permission from the forests?
7. Which gender is dominant in the extraction of each type of woodfuel from the forests
   (a) charcoal burning [ ] Men [ ] Women
   (b) Firewood collection [ ] Men [ ] Women
   Give reasons for the above answers? ……..
   ……...
8. What are the reasons that make local residents to leave the private farms and seek woodfuel from gazetted forests?
9. (i) What are the cultural events that make people to seek permission into gazetted forests in search of woodfuel?
   (ii). How are the cultural events conducted in the locality?
10. Which types of trees are preferred as woodfuel for the socio-economic events in the area?
11. On which type or section of forests do woodfuel extraction activities mainly occur?
    [ ] Natural [ ] Plantations
12. Compare the effects of woodfuel extraction on natural and plantations forests
13. What are the policy areas that need to be improved for sustainable management of woodfuel extraction

Appendix III: Permit for Data Collection in Forests within Koibatek Forests Zone

KENYA
Forest Service

Kenya Forest Service Hqs
Karura, Off Kiambu Rd
P.O Box 30513 - 00100
Nairobi, Kenya.

Ref: No. RESEA/1/KFS/VOL. II (241)

Date: 8TH February 2017

Keith Kipngetich Rono
School of Environment and Earth Sciences
Maseno University
Private Bag
Maseno

RE: PERMISSION FOR DATA COLLECTION IN FORESTS WITHIN KOIBATEK SUB-COUNTY

Reference is made to your letter dated 24th February 2016 seeking permission to collect data for your PHD studies in gazette forest in koibatek.

Permission is herby granted for you to access the forest resources in Koibatek for February to June 2017. As part of the requirements of this permit, you are required to provide a copy of your findings to the Director.

By a copy of this letter, the Ecosystem Conservator Baringo is hereby instructed to facilitate access.

Emilio N. Mugo
Director

Copy to: Ecosystem Conservator – Baringo

JMM/sa

Trees for better lives

Tel:(254) 020-3754904/5/6, (254) 020-2014663, (254)020-2020285, Fax: (254)020-2385374
Email:info@kenyaforestservice.org, Website:www.kenyaforestservice.org

Appendix IV: Form 2-Application for charcoal Producer Licence Form

FORM 2 **(r. 7(2))**

APPLICATION FOR CHARCOAL PRODUCER LICENCE

Application Reference No. .....

PART A – DETAILS OF APPLICANT

A1. Name of Licensee (Association or Firm) ..... Reg. Cert No. .....

A2. PIN No. .....

A3. Full Address .....

PART B – DETAILS OF CURRENT CHARCOAL LICENCE

B1: Name of the current charcoal licence .....

B2: Locality and Date of issue the current charcoal licence .....

PART C – MATERIAL CONSIDERATIONS

C1: Place or places where charcoal is to be produced .....

C2: Designated charcoal collection point(s) .....

C3: Consent from land owner as prescribed in Form 3 .....

C4: Tree species to be used for charcoal production .....

C5: Type of technology to be used .....

C6: A recommendation from the local environment committee .....

C7: Reforestation/conservation plan for the area .....

PART D – DECLARATION BY APPLICANT

I hereby certify that the particulars given above are correct and true to the best of my knowledge and belief. I understand the that the charcoal licence may be suspended, varied, revoked or cancelled if any information given above is false, misleading, wrong or incomplete.

....

Name *Position* *Signature*

On behalf of ....

Association/Company name and seal *Date*

PART E – FOR OFFICIAL USE ONLY

Approved/Not Approved .....

Comments .....

Officer ..... signature ..... Date .....

Fees paid in words ..... In figures ..... Date of issue .....

.....

Director,
Kenya Forest Service

Source: GoK (2009)

Appendix V: Form 3-Consent from Land Owner of the Source of Charcoal

FORM 3 **(r. 7(4))**

FORESTS ACT, 2005

CONSENT FROM THE LAND OWNER

PART A – CONSENT HOLDER

A1. Consent holders' Name (Association or Firm) ..... Reg. Cert. No. .....

A2. PIN No. .....

A3. Full Address .....

PART B – CONSENT GRANTOR

B1: Name of the land owner or authorized person .....

B2: Locality (LR. No.) .....

B3: PIN No. .....

B4: Full Address .....

PART C – DECLARATION BY LAND OWNER/AUTHORIZED PERSON

I hereby give the association/firm named above consent to produce charcoal on my parcel of land using indigenous/farm forestry wood resources in accordance with the provisions of the Forests Act, 2005, the Forests (charcoal) Regulations made thereunder and the following conditions:

.....

.....

Given under my hand

....

Name *Land Owner/Authorized Person* *Signature*

On behalf of firm ....

Association/Company name and seal *Date*

PART D – FOR OFFICIAL USE ONLY

Approved/Not Approved .....

Comments .....

Officer ..... Signature ..... Date .....

.....

Director
Kenya Forest Service

Source: GoK (2009)

Appendix VI: Road Networks within the Gazetted Forests of Koibatek Forests Zone

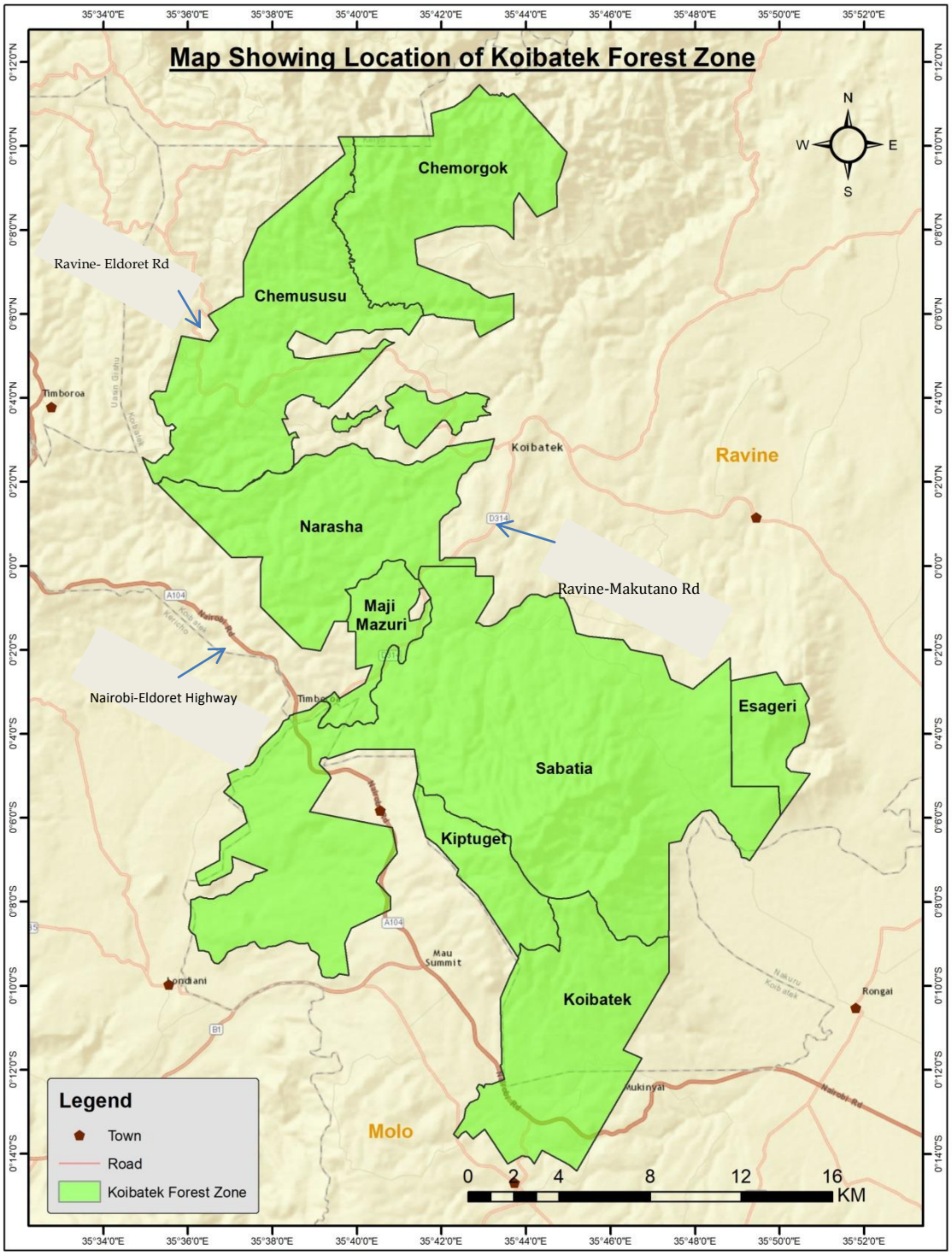

Figure 18: Map of Koibatek Forests Zone showing major roads networks

Source: Researcher, 2015

Appendix VII: Volume of Firewood in m^3 Extracted within the Gazetted Forests of Koibatek Forests Zone

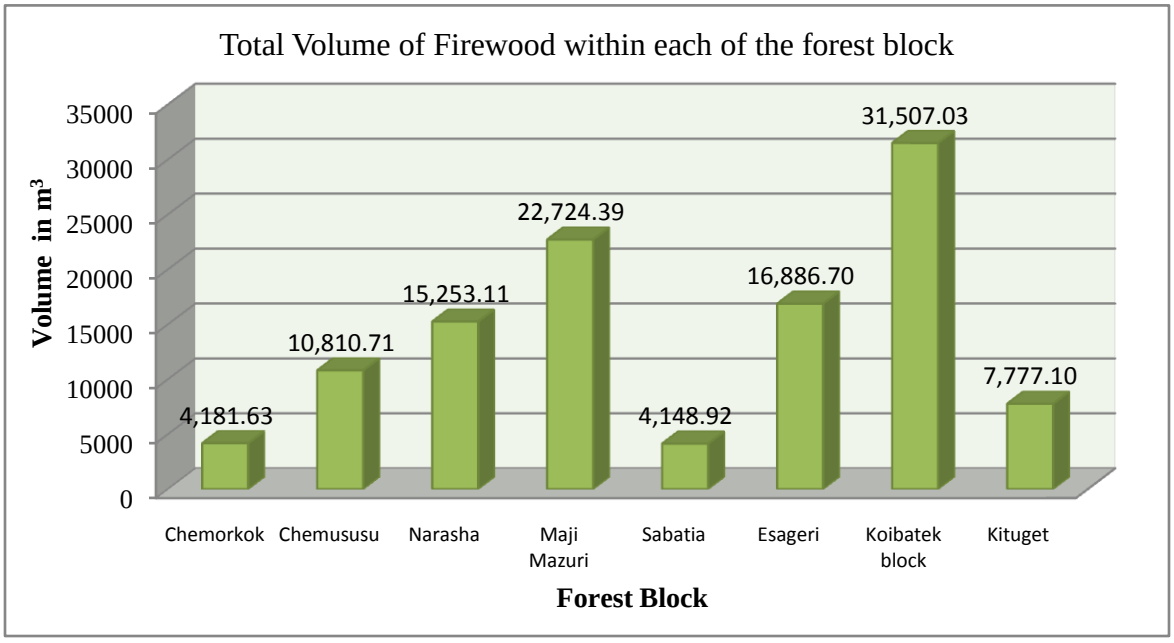

Figure 19: Estimated Total Volume of Firewood from Koibatek Zone from 2006 to 2014

Source: Field Survey, 2015