HUMAN USE OF FOREST TREES AND ITS IMPACT ON TREE DIVERSITY AND ABUNDANCE IN CHEMUSUSU FOREST, BARINGO COUNTY, KENYA

MOROGO HOSEA KIPKOECH, B.Ed. (Sc.)

I56/CE/28501/2013

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE (PLANT ECOLOGY) IN THE SCHOOL OF PURE AND APPLIED SCIENCES OF KENYATTA UNIVERSITY

SEPTEMBER, 2020

DECLARATION

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

Signature ______________________________ **Date**____________________

Morogo Hosea Kipkoech - I56/CE/28501/2013

Department of Plant sciences

SUPERVISORS

We confirm that the work reported in this thesis was carried out by the candidate under our supervision as university supervisors

Signature ______________________________ **Date**______________________

Dr. Paul K Muoria
Department of Plant Sciences
School of Pure and Applied Science
Kenyatta University

Signature ______________________________ **Date**______________________

Dr. Grace W Gatheri
Department of Plant Sciences
School of Pure and Applied Science
Kenyatta University

DEDICATION

This work is dedicated to my wife Gladys, my children Dorothy, Purity and Frankline, my parents Jackson and Magrina. I excelled in my academic work because of you.

ACKNOWLEDGEMENT

I would like to thank my University supervisors Dr. Paul K Muoria and Dr. Grace W Gatheri for their guidance, advice, patience, encouragement, invaluable time and their positive criticisms during the proposal writing stage and subsequent writing of thesis. My sincere appreciation goes to all my family members, my parents and special thanks to my brother Shadrack Morogo who worked tirelessly with me during data collection. Special appreciation goes to my colleagues in the place of work, Mr Joshua Kiprotich for providing printing service, my best friend Mr. John Aholi who encouraged me to undertake postgraduate studies.

I would not forget to mention Dr. Mwaniki, Dr. Muoria and Dr. Kamau for their invaluable administrative and academic guidance. My special thanks also goes to various personalities and institutions that contributed to the successful achievement of this work. First, I thank all the Lectures from the Department of Plant Sciences, Kenyatta University who took me, through the course work, expanding my knowledge and academic skills. Secondly, The Director Kenya Forest Service, the Assistant County Commissioner Koibatek and Mr Ireri Chemususu forest officer, thanks for your willingness to provide information related to my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

ABREVIATIONS AND ACRONYMS

ANOVA:	Analysis of Variance
BCGADP:	Baringo County Government Annual Development Plan
CFA:	Community Forest Associations
DBH:	Diameter at breast height
FAO:	Food and Agricultural Organization
GDC	Geothermal Development Company
GTP	Geothermal Training Programme
GPS:	Global Positioning Systems
ICRAF:	International Centre for Research in Agro-forestry
IUCN:	International Union for Conservation of Nature
KFS:	Kenya Forest Service
KLR:	Kenya Law Report
LCE:	Lembus Council of Elders
LF:	Lembus Forests
MEF	Ministry of Environment and Forestry
MENR:	Ministry of Environment and Natural resources
NEMA:	National Environment Management Authority
PFM:	Participatory Forest Management
RoK:	Republic of Kenya
SARPO:	Southern Africa Regional Programme Office
SPSS:	Statistical Package for Social Sciences
UNU:	United Nations University

WWF: World Wildlife Fund or World Wide Fund for Nature

WHO: World Health Organization

NTFP: Non-Timber Forest Products

ABSTRACT

Trees provide both direct and indirect benefits to humans, who depend on them for their livelihoods. Forest ecosystems are vulnerable to over-utilization and exploitation due to the sensitivity of its complex and highly diverse ecosystem. The aim of the study was to determine the human impact on tree species diversity, abundance, plant population structure and uses of forest trees by local communities adjacent to Chemususu forest Reserve in Koibatek Sub-County, Baringo County. Questionnaires and interview schedules were used to collect data on uses of trees; the target group were households within 3km stretch from the forest edge. The data on trees species, diversity, abundance and plant population structure was collected by systematic sampling using six parallel belt transects each starting from the forest edge. Sampling was conducted in quadrats of 20m x 20m (for trees) located along the transects at 500m intervals. In each of the quadrats, all the trees species were identified, counted and diameter at breast height (DBH), measured at 1.36m outside the bark to the nearest cm. Indicators of human disturbance were assessed to determine the extent of human impact. The Statistical Package for Social Sciences (SPSS) was the main tool for quantitative data analysis from both questionnaires and interview schedules. Analysis of Variance (ANOVA) was used to test whether the mean number of cut stems and debarked trees varied with distance from forest edge. ANOVA was also used to test for variation in the mean diversity indices, tree species abundance and DBH with distance from forest edge. In both cases, tukey test was used to separate the means. Shannon-Wiener Diversity index (Magurran, 1988) was computed. Pearson's correlation was carried out to determine the relationship between abundance of cut stems and debarked trees with distance from human settlement in each study plot and to investigate the relationship between mean species abundance, diversity, and DBH with distance from human settlement. Majority of the local residents had stayed in the region for more than 15 years and perceive the forest as important for various uses, 98.4% for spiritual and cultural purposes, timber (97.52%), tourism and recreation (96.3%) and hunting (97.1%).Three trees species, *Olea europaea*, *Dombeya torrida* and *Olea capensis* were used for firewood as well as charcoal and formed a large proportion of used trees. Trees used for timber *Juniperus procera*, *Podocarpus falcatus* and the exotic *cupressus lusitanica* had been heavily extracted. There was no significant relationship between the number of charcoal kilns and distance from the forest edge ($r = -0.849$; $P=0.069$). This also applied to the number of plots with evidence of pit sawings with distance from the forest edge ($r = 0.555$; $P = 0.333$) but the number of plots with split stems decreased significantly with distance from the forest edge ($r = -0.892$; $P = 0.043$).There was no significant variation in the mean number of cut stems and mean number of debarked trees with distance from human settlement ($F_{(4, 25)} = 0.082$; $P = 0.546$) and ($F_{(4, 25)} = 1.795$; $P=0.162$), respectively. Tree diversity did not vary with distance from human settlement ($F_{(4, 25)} = 1.67$; $P=0.189$).There was a significant difference in the mean number of trees in different DBH classes ($F_{(4, 25)} = 5.181$; $P = 0.002$). The number of trees on the lower DBH classes was more than those on the higher classes at various distance intervals, but this difference was not statistically significant. The study showed that the community role in forest degradation was significant and they highly depended on it for their livelihood. Thus, it was important to understand the relationship between the community and the forest. Alternative sources of trees used for timber and charcoal should be encouraged to reduce pressure on forest trees.

CHAPTER ONE: INTRODUCTION

1.1 Background information

The importance of forest to mankind cannot be overemphasized. Agbogidi and Eshegbeyi (2008) noted that forests and forest products play vital roles in human life from the cradle to the grave. Aimufia (2002) emphasized that the cot on which the baby lies at birth, the buildings and furniture he uses, at the various levels of his education, his endeavours in industry and agriculture, the accommodation and furniture he acquires as a worker or entrepreneur, his diet and health sustaining systems, are forest dependent. Keay *et al*. (1989) and Abu and Adebisi (2002) stated that the traditional uses of forests are basically for subsistence, income, environmental and social/culture. Udo (2001) noted that forest benefits include tangible wood products, non-wood products, and environmental benefits.

Human beings impact the environment through the exploitation of natural resources (Chapin .*et al.,* 2000, Wright, 2005 and Bradshaw *et al.*, 2009). Conservation strategies must therefore anticipate the associated threats as well as address contemporary pressures in order to prove successful (Spector and Forsyth, 1998). The current anthropogenic impact on forests is a concern for conservation research due to the global importance of these forests in biodiversity, ecosystem functioning and carbon sequestration (Shearman *et al.*, 2009). The main anthropogenic drivers of forest loss are land use change, wood extraction, hunting, atmospheric change and climate change (Wright, 2005; Wright, 2010). Human activities are highly variable in their influence on biodiversity (Putz *et al*., 2000). For example, many studies have shown that logged forests retain much of their original biodiversity despite the severe damage that logging can inflict on the forest ecosystem (Whitmore and Sayer 1992, Cannon *et al*., 1998, Meijaard *et al.*, 2005).

The global loss of forest area during 1980-90 was estimated to be 163 million ha, of which 154 million ha or 94.5 per cent was in the tropics only. The per capita forest area fell globally from an average of nearly 1.2 ha in the 1960 to 0.6 ha in 1990 and it is projected to be less than 0.2 ha by the year 2020 (FAO, 1995). The consequence of rapid loss and destruction of forests is that an unknown number of species become extinct, often without ever being recognized. The total state forest area in Kenya is estimated at 2.35 million ha (about 2.7% of Kenya's land area) out of which 1.57 million ha are gazetted and 0.78 million ha ungazetted forests. In addition, there is approximately 2.1 million ha of other woodlands, 24.8 million ha of bush land and 10.7 million ha of wooded grassland. The number and volume of trees on farm are considerable in Kenya, particularly on small- and medium size farms in the highlands, but it is impossible to translate these tree resources into an area equivalent figure (Mathu *et al.*, 2011).

The significance of the Mau complex in Kenya is viewed within the context of the enormous diversity of flora and fauna. A study was conducted in Mau complex evaluating the land cover for a period of about 37 years from 1973 to the year 2010 (Ongong'a and Sweta, 2014). Post classification of both visual and area comparisons were done to get information on the trends, rates and magnitude of land cover and land use changes in the Mau forest complex over time. The results of the study showed that changes in land use and land cover had occurred in all the 22 blocks of Mau forest complex. This has resulted in reduction of forest cover, loss of biodiversity and reduction in rainfall and subsequent decrease in river discharge.

Forests resources are shared by local community and managed by the government through the Kenya Forest Service. However, local communities strive to use the greatest share of the forest resources like firewood, charcoal, timber, poles and herbs (Ronoh, 2016). A forest health survey conducted in 2016 across the entire Mau Forest Complex showed a high level of illegal logging of indigenous trees of which 79% were cedar (*Juniperus procera*). Logging was by far most intense in Maasai Mau forest followed by Ol Pusimoru, and Lembus Forest Reserve (MEF, 2018).

There was an increase in the percentage of forest decline in the Chemususu Forest Block resulting from the clearance of forest-cover to pave the way for dam construction. Illegal logging may have also contributed to the decline (Kimutai and Watanabe, 2016). The Lembus Forests in Baringo County are among the few remaining indigenous forests in Kenya, comprising of gazetted forest blocks and covers an area of 16,875.90 hectares. It covers eight blocks, Chemususu forest being one of the blocks where livelihood activities have compromised the integrity of its ecosystems and the services it provides.

1.2 Statement of the problem

Tropical regions have continued to experience rapid changes in forest-cover, with most regions recording high forest-cover loss compared to total forest gain (Hansen *et al.*, 2013). East African rainforests suffer large over-exploitation by humans and belong to the most threatened and least explored ecosystems on Earth (Köhler 2004). Forests cover only about three per cent of Kenya's land area, yet they provide crucial direct and indirect goods and services to its people and make a significant contribution to the national economy (MENR, 1994).

Kenya's forest cover was estimated to be about 7.4% of the total land area, which was below the recommended global minimum of 10%. On the other hand, Kenya's closed canopy forest cover currently stands at about 2% of the total land area compared to the African average of 9.3% and a world average of 21.4 per cent. In recent years, Kenya's forests have been depleted at an alarming rate of about 5,000 hectares per annum (MEF, 2018). A study by Ongong'a and Sweta (2014) in Mau forest complex showed that it had undergone many changes in its land cover and land use over time due to different anthropogenic factors. Reduction in forest cover in Kenya has contributed to diminishing livelihoods and reduced land productivity, famine and drought for many Kenyans.

Although forests play important roles in the life of mankind, man continues to destroy them through various activities such as fires (Veblen and Lorenz, 1987), animal grazing (Carabelli *et al*., 2006), logging for timber, collection of fuel wood (Terborgh, 1992), farming and small scale mining. Disturbance created by these activities influences tree density and forest dynamics (Hubbell *et al*., 1999). Forest resources are the main source of livelihood of the people living in forest communities .This coupled with the increasing population trend over the past few years, has led to the massive exploitation of natural forests (Todaria *et al.,* 2010). In Kenya, forests are estimated to cover about 6% of the total land-cover, which is below the 10% threshold recommended by the United Nations (FAO, 2010).

According to Nyariki *et al.* (2007), as cited in Matiru *et al.* (2008) 87% of the households in the Lembus Forest use herbal medicine, a slightly higher percentage than the national average of 75%. Greater commercialization of herbal remedies often leads to more people harvesting them in the wild, sometimes without the requisite knowledge of proper harvesting methods (Matiru *et al.*, 2008).

1.3 Justification of the study

The diversity of trees is fundamental to total forest biodiversity, because trees provide resources and habitat for other flora and fauna (Huang *et al.*, 2003). Currently more and more species are threatened due to land-cover and land-use changes all over the world understanding the impact of disturbance on vegetation and the resilience of plant communities to disturbance is imperative to environmental management (Speed, 2010).

Despite Lembus Council of Elders raising an alarm on wanton destruction of the 152,000-acre Lembus forest in Koibatek Sub-County very little has been done. The destruction of indigenous *Podocarpus falcatus* and *Juniperus procera* trees was horrifying; especially in Chemususu Forest Station where a multi-billion shilling dam was constructed (KFS, 2010).

Baringo County Government Annual Development Plan 2015-2016 indicates that felling of Cedar, Podo for timber and *Osyris lanceolata* as well as sandal wood harvesting and charcoal burning were a threat to the forest cover in the county and contributes to deforestation and destruction of water catchment (BCGADP, 2014).There are many reports of threats and continued destruction of trees in Chemususu forest, but little information exists on the extent to which the human activities have contributed. Additionally, the exact effects of the disturbances have not been investigated.

This study aimed at generating information that will create awareness on ethnobotanical uses of trees, human impact on tree species abundance, diversity, and ecosystem services provided by the forest. The outcomes of this study would be important to the management of Chemususu Forest and for making informed decisions on the sustainable utilization of the forest resources.

1.4 Research questions

i. What are the uses of tree species to the local community in Chemususu Forest?
ii. What are the human impact on tree species diversity and abundance?
iii. What is the relationship between diversity, abundance and population structure of tree species with distance from the human settlement in Chemususu Forest.

1.5 Hypotheses

i. The local community does not use forest trees species in Chemususu Forest.
ii. There are no significant human impact on tree species in Chemususu Forest.
iii. There is no relationship between diversity, abundance and population structure of trees with distance from human settlement.

1.6 Objectives

1.6.1 General objective

To assess the importance of forest trees to the local community and to assess human impact on tree species diversity, abundance and plant population structure in Chemususu forest.

1.6.2 Specific objectives

i. To assess the uses of forest trees by the local community.
ii. To investigate human impact on tree species diversity and abundance in Chemususu Forest.
iii. To investigate the relationship between diversity, abundance and population structure of tree species with distance from the human settlement.

1.7 Significance of the study

The findings of this study can provide Kenya Forest Service, Baringo County government, research institutions, forest conservation agencies and the community living around the forest with information on human impacts on tree species, diversity and abundance, in the forest. This will be important in creating awareness on conserving the forest and developing sustainable management programs. The Lembus forest holds a great diversity of plant and animal species, and are essential for maintaining clean water. The Kenya's Forest Act of 2005 gave provision for Participatory Forest Management to protect local livelihoods dependent on grazing, cultivation and non-timber forest products and mitigate negative human impact on the forest. The outcome of this study will play a key role in enhancing participation and the involvement of local communities, which may improve their livelihood, reduce forest related conflicts and reduce poverty.

CHAPTER TWO: LITERATURE REVIEW

2.1 Ethnobotanical uses of forest trees to the local community

Ethnobotany is the study of the interaction between plants and people with a particular emphasis on traditional tribal cultures (Awoyemi *et al.,* 2012).Ethnobotany is a very important area of study all over the world (Singh and Singh, 2009). It is the study of how the people of a particular region and culture make use of indigenous plants. Ethnobotanists explore how plants might be used in medicine, food, fodder, timber, shelter and religious ceremonies (Badshah *et al.*, 2012).

Ethnobotany is emerging as a subject of great practical value. Its application can lead to a strengthening of cultural diversity and conservation, greater sustainability in the exploitation of plant resources, and the development of new plant products. Plants have always been centrally important for the wellbeing of human beings and will always remain so. Plants are primary producers, forming the base of food webs and support almost all other forms of life. Information, foresight and practices of local people can play their role through applied ethnobotany to identify and find solutions to the problems of sustainable development and conservation of plants (Hamilton *et al*., 2003).

Trees are a valuable gift of nature and represent one of the important components of every forest ecosystem (Seth, 2004). They play an important role in conservation of ecosystem, in maintaining quality of water, in preventing or reducing the severity of floods, avalanches, erosion and drought, removing harmful air borne particles and sequestering carbon (Nowak and Crane, 2002; Nowak *et al*.,2007). Forests play an important role in the livelihoods of local people, in most developing countries, forests supply people with various products such as firewood, construction materials, medicine and fibre (Langat *et al.*, 2015).

The number of products provided by trees worldwide is extensive. The wood, bark, leaves, fruits, seeds and roots of trees yield food, fodder, shelter, medicine, fibre, resin, oils and numerous other products used for subsistence by people living in rural and tribal areas (Swain and Mohapatra, 2013). Virtually all tree species can be used for more than one purpose. It has never been more urgent than now to realize the full potential of forest trees for sustainable development, both to meet the immediate and future needs of increasing populations and to provide the continuity of the natural resource base (Sah and Dutta, 1996).

During recent decades, side effects from the use of chemicals have been identified, with measures being taken to overcome this problem. Thus, people turned to natural products, especially in pharmaceutical and food industry (Mozaffari, 2010). The World Health Organization (WHO) reports that as many as 80% of the world's people depend on traditional medicine for their primary health care needs (Joudi and Habibi, 2010). However, traditional medicines are a wealthy source of metabolites that are potential sources of drugs and essential oils (Unni *et al.*, 2009).

Ethnobotanical awareness among people will reinforce the use of local remedies, measuring the sustainability of local remedies and devise methods of transferring knowledge from generation to generation (Martin, 1995).The extraction and utilization of forest trees by the local community around Chemususu forest has always taken place (KF S, (2010a). Based on studies from other areas this will eventually decrease the chances of survival for many tree species. Overexploitation will lead to extinction of many versatile plant species needed for other future uses that have not been explored in Chemususu forest apart from medicinal plants (KFS, 2015).

2.2 Human impact on tree species diversity and abundance

Forest resources are over exploited through logging, excessive cutting of trees in stressed environments for firewood as energy source and harvesting of other non-timber products. Collection of fuel wood, harvesting of trees for timber, collection of raw materials for local industries (Todaria *et al.*, 2010) are all forms of human disturbances, that impacts negatively on forest trees. The economic activities, such as logging, charcoal burning, and shifting cultivation are the most important activities affecting ecological functioning and biodiversity integrity of the forest (Kimaro *et al.*, 2013).

Felling of trees injure neighboring trees during logging, especially crowns. The skidding, which is the pulling of cut trees out of the forest during logging operations tends to increase tree mortality in the very short term (Bertault and Sist, 1995; 1997; Pinard and Putz,1996; Sist *et al*, 1998). In conventionally logged forest in Indonesia, Sist *et al.* (2003) found that skidding was responsible for twice the number of tree deaths as felling. This is because skid trails can be re-used, and felled tree gaps can overlap.

Fuelwood gathering was considered to be the main cause of deforestation and forest degradation in El Salvador (Repetto, 1990). In the drier areas of the tropics, fuelwood gathering can be a major cause of deforestation and degradation. Unsustainable use of forest resources, for example, through logging and shifting cultivation, has potential impact on forests ecological functioning due to sudden changes on their structure and composition (Denslow, 1995). Understanding the factors related to human disturbance that affect the tree biodiversity and forest vegetation structure can help conservation managers to suggest best forest management practices in ways that can best protect these values (Pickett, 1995).

The Kenya Forest Service noted that there is massive destruction of the Lembus Forest. Hundreds of acres of the forest have been plundered and evidence of decimation cannot be missed, sawed wood lies uncollected on the floor of the forest (KFS, 2010a). The trees that are mainly targeted are podo and cedar, freshly cut trees, sawn beams and huge logs lie everywhere showing that the activities take place deep into the night (KFS, 2010b). Local communities are highly dependent on the forest for livestock grazing, and heavily rely on the forest as their main source of firewood (Kimutai and Watanabe (2016). These observations indicate that ongoing human activities have already had some impacts on useful plants and possible negative effects on the livelihoods of the adjacent local communities.

2.3 The relationship between species diversity, abundance and population structure of trees with distance from the human settlement

The structure and function of forest ecosystem is determined by the plant component more than any other living component of the system (Richards 1996). Plant diversity at any site is influenced by species distribution and abundance patterns (Palit *et al*., 2012) and the richness of plant species is controlled by a variety of biotic and abiotic parameters (Rannie, 1986; Huston, 1994).The species diversity and composition have been shaped in many ways by human beings, and it is believed that no part of it remains without human influence (WWF-SARPO, 2001).

According to Ingram *et al*., (2005) and Oyugi (2007), human activities have significant impact on species composition, diversity and forest cover changes. Human activities particularly, overexploitation of forest for timber, firewood and charcoal, illegal grazing, agricultural encroachment and deliberate fire setting. The over exploitation of a particular trees species can result in species or a group of species being driven to local extinction or even global extinction (Vuyiya *et al.,* 2014).

Kakamega forest in western Kenya is one of the heavily fragmented and disturbed forests (Kokwaro, 1988) due to the high human population densities that surround the forest. Most of the community is involved in small-scale agriculture. Anthropogenic disturbances like selective logging, grazing, debarking and charcoal burning can reduce the diversity of plant and animal species, thereby reducing the seedling species richness and hence affecting ecosystem integrity in the long run (Vuyiya *et al.,* 2014). Moreover, Asner *et al*., (2005) noted that selective logging reduces plant species diversity thereby reducing seedling species richness and hence forest seedling density in the long-term. Logging also causes habitat destruction and a general decline in forest species abundance and diversity (Lawton *et al*., 1988).

In their study in Arabuko-Sokoke forest Oyugi *et al.,* (2007) found that, the metrics which includes tree species diversity, density, dispersion patterns and size class distributions in *Brachystegia* woodland varied with human disturbance, the differences in disturbance resulted from past and current logging activities with tree densities being greater in the undisturbed sites than in the disturbed ones. Disturbance whether of natural or anthropogenic activities like deforestation leads to all species being at risk of going extinct (Lalfakawma *et al.,* 2009). Disturbances also have profound effect on the regeneration of non-pioneer under storey trees (Kwit *et al.,* 2003). Clement, (1936) viewed disturbance as a negative force that destroys climax assemblages and brings instability in the system. Species richness has been related to the occurrence of natural disturbance (Grubb, 1977; Huston 1979; Pickett 1980). Extraction of timber and non-timber products cause direct and indirect impacts on forest plants and ecological functions of the forest.

According to a study by Kimutai and Watanabe (2016) in Lembus forest ,the forest as a whole has experience a significant decline in the rate of forest cover, but the three forest blocks forming the Lembus forest (Chemorgok, Chemususu and Narasha) have experienced certain variations in their forest-cover change dynamics, Chemorgok forest block remained stable . The Chemususu forest block, however, revealed a totally different pattern: the percentage of forest decline was higher. The increase in the percentage of forest decline resulted from the clearance of forest-cover to pave the way for dam construction in the Chemususu forest block and the higher rates of illegal logging and forest encroachment may have resulted from high population pressure.

Chemususu forest is a gazetted forest reserve and no exploitation was allowed. However, for their livelihood the local community have to take out forest resources illegally (KLR, 2013). Studies on human impact have been carried out in different forests with emphasis being on vegetation within selected sites in the forest. Studies involving human impact on trees from forest edge extending towards the interior of the forest are minimal. Chemususu forest block is surrounded by human settlements and has experienced changes in forest cover. It is therefore necessary to study and determine the human activities and their impact on the forest trees along a gradient from the forest edge.

CHAPTER THREE: MATERIALS AND METHODS

3.1 Study area

Chemususu forest (Figure 3.1) forms part of the Lembus block within the larger Mau Complex ecosystems and is located in Koibatek Sub- County, Baringo County in Kenya. It covers an area of approximately 11, 304 ha and it is managed by Kenya Forest Service (KFS) under Ecosystem Conservator of Baringo County. It lies between the latitude 0º 1' 46''N and 0º 10' 27''N and longitude 35º 34' 24''E and 35º 41' 34''E.The climatic condition is within that of expansive Mau complex forests largely influenced by its altitude of 2480m above sea level. There are two distinct rainy seasons, the long rains starting at the end of March to the beginning of July, while the short rains are between September and November. The mean annual rainfall range is between 1200 mm to a high of 1800 mm. The mean annual temperature ranges from 10ºC to 24ºC.

Chemususu Forest forms an important habitat for plants and tree species. The Vegetation distribution depends on density of particular trees and plant species in an area, topography, soil type, soil depth, soil moisture and level of human related activities (KFS 2015a). The forest is typical to Mau Forest complex described as montane due to its altitude, the moist montane forest is dominated by broadleaved species of a variety of species like *Tabernaemontana stafiana*, *Prunus africana*, *Olea capensis* and *Dombeya goetzenii.*

The forest block also has a mixed conifer forest, where coniferous species like *Juniperus procera, Pinus patula and Cupressus lusitanica* intersperse the broadleaved species. The species in plantations areas includes *Cupressus lusitanica*, *Eucalyptus saligna*, and *Pinus patula*. There is occurrence of invasive species such as *Lantana camara* and *Solanum sp*. found mostly in the open areas along roads and paths, but this is not a major threat to the forest or its rehabilitation. (KFS, 2015b).

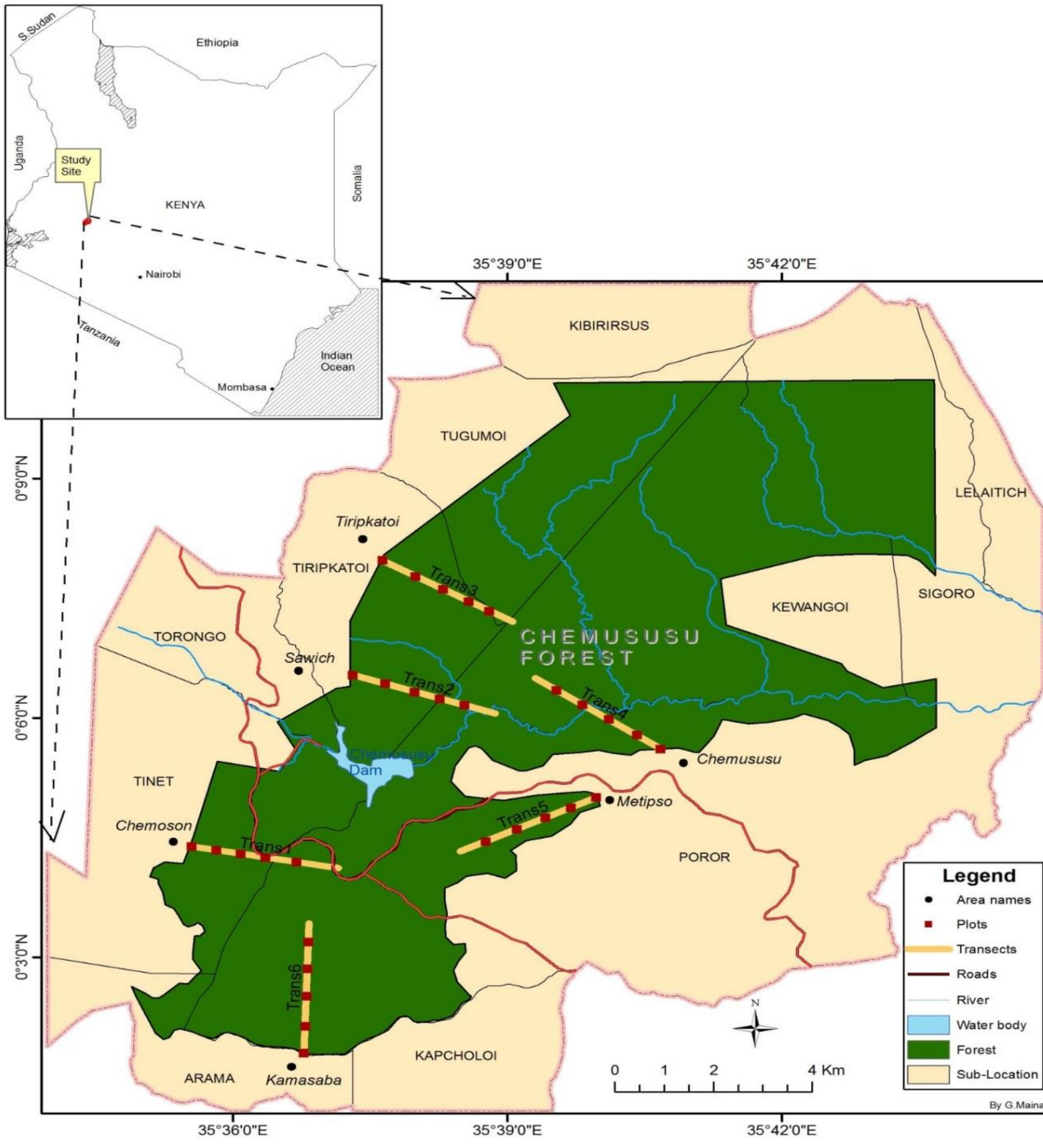


Figure 3.2: Map of Chemususu Forest and its environs
Source. Kipkoech Morogo,M.Sc.thesis, 2020

Chemususu forest has a wide range of fauna from large to the small mammals, birds, reptiles and a variety of insects. The most common mammals found in the forest include Hyenas (*Crocuta crocuta)***,** Kirk's Dik-dik (*Madoqua kirkii)*, Black Columbus monkey (*Colombus angolensis)*, Olive Baboons (*Papio anubis)* Warthog (*Phacochoerus africanus*). Snakes (*Dispholidus typus* and *Daspelits scabra)* Lizards *(Trachylepis striata)* and Chameleons *(Chamaeleo laevigatus) and* Frogs (*Bufo gutturalis).* There are also Bees (*Apis mellifera*), Butterflies (*Vanesa cardui*) and (*Capys cupreus*); Termites (*Macrotermes subhyalinus*) and black ants (*Carebara vidua*) are some of the main insect species of in the forest (KFS, 2015a).

Red-billed Horny bill (*Tockus erythrorhynchus*), African mourning Dove (*Streptopelia decipiens*), Pied Crow (*Corvus albus)* Speke's weaver (*Ploceus spekei*), Long-crested Eagle (*Lophaetus occipitalis*), Bateleur (*Terathopius ecaudatus*), Black kite (*Milvus migrans*), Grey-headed Sparrow (*Passer griseus*), African scops-owl (*Otus senegalensis*) forms part of the rich biodiversity. The existence of both plants and animals species has faced many threats from anthropogenic activities. Illegal extraction of timber, fencing posts and building materials affecting mainly *Podocarpus latifolius* and *Juniperus procera.* Damage of newly planted tree by domestic animals, fires by honey hunters, encroachment of forest boundaries by farmers neighbouring the forest, although herbal medicine is not a major threat, those who carryout whole some debarking of trees leads to eventual death, this has affected *Prunus africana* and *Warburgia ugandensis*. Poaching of wildlife especially through snaring of small game was done and the Columbus monkeys are threatened due to the demand for their skin used in making traditional headgears (KFS, 2015a).

The continued destruction was attributed to local communities and other stakeholders not participating in the forest management. Interference by provincial administrators and politicians in day-to-day administration and operations of the forest also contributed to forest destruction, but the enactment of the forest act 2005, created room to address the issues with the local community being involved. Chemususu participatory Forest management plan 2015-2019 was part of the intervention (KFS, 2015b).

The geology and soil types of the forest and the surrounding areas are influenced by ancient volcanic activities. The underlying rocks are mainly volcanic with texture and structure varying according to age. Layered porous basalts rocks are more dominant in the area with shiny black layered rock beds along riverbeds. The forest area is dominated by red-loamy volcanic soils, which have been developed by ashes and other pyroclastic rocks of volcanic activities. The soil type can be described as podzol red-brown and tuffs with distinct soil variation in areas within the forest due to their parent rock, mineral composition, soil texture and structure classes, soil moisture and level of organic matter contents. The soils are well drained, very fertile thus with great potential of agricultural production and livestock farming (KFS, 2015a).

The forest remains an important source of employment through saw milling. The community has strong cultural, spiritual and religious attachment to it. Traditional rituals, such as circumcision, worship offerings to their God (Asis), conflict resolution and resolving family and marriage disputes by community elders were done in sacred sites inside the forest (KFS, 2015b).

3.2 Data collection on uses of forest trees

3.2.1 Study design

The study used descriptive survey design; According to Kerlinger and Lee (2000) descriptive survey design is used widely to obtain data useful in evaluating present practice and in providing basis for decision. The design was adopted because it does not require one to manipulate variables or arrange for events to happen (Orodho, 2003). The main feature of survey research design is to describe specific characteristics of a large group of persons, objects or institutions, through questionnaires (Jaeger, 1988). Descriptive survey was appropriate for gathering information on uses of forest tress and human activities by the local community.

Questionnaires were prepared beforehand and it was divided into three parts; social Demographic information, background of Chemususu Forest and individual involment in forest activities to get information on the potential impact they were posing on the forest.. This was done in due regard to the objectives of the study. Open-ended questions were used to get information especially where the respondents appeared uneasy in their response to uses of forest resources that were considered illegal when extracted without the consent of the Kenya Forest Service. Photographs were also taken to capture the intensity of human activities.

3.2.2 Target population.

The study was carried out in six villages bordering the forest: (1) Metipso (2) Chemususu (3) Kamasaba (4) Chemoson (5) Sawich and (6) Tiripkatoi of Lembus sub-location.The target population was 650 households located in six villages living within a stretch of 3 kms from the forest edge. The households were distributed as follows: Metipso114, Chemususu 89, Kamasaba 81, Chemoson 148, Sawich 99 and Tiripkatoi 119 making a total of 650 households.

3.2.3 Sample size estimate

Sample size was determined using table for determining sample size using Krejcie and Morgan (1970) formula.

$S = X^2 NP(1-P) \div d^2(N-1) + X^2 P(1-P)$. (Equation 1)

Where *S*= required sample size,

X^2 = the table value of chi-square for 1 degree of freedom at the desired confidence level (3.841).

N = the population size.

P= the population proportion (assumed to be 0.50).

d = the degree of accuracy expressed as a proportion (0.05).

The table on Sample Size (Appendix 1) provided the number of households that were sampled depending on the target population and in this case 242 households in the six villages with each village contributing a proportion equivalent to the target population in each village. The households were selected randomly from a detailed list of households provided by local chiefs and elders.

3.2.4 Sampling procedure

Data on ethnobotanical uses of trees was collected using questionnaires. The questionnaires had demographic items, structured and semi structured questions and combined both open ended and closed items. The target group were adults aged 18 years and above from the families settling within 3km stretch from the edge of the forest. Gender, age, educational background and experience on uses of trees by the respondents were taken into consideration.

In most cases, the head of the household were interviewed and in his absence, the wife or the eldest son was interviewed, a total 242 respondents were interviewed. For the respondents who could not read and write, the field guides used the questionnaires to conduct interviews and fill them, with translations being done where necessary. The consent of each respondent was sought before they provided any information for the study. To ensure confidentiality, the questionnaires were given numerical codes instead of names and no respondent was forced into the exercise.

Two field guides who had knowledge on trees in Chemususu forest were identified and trained to collect data from traditional healthcare practitioners, traditional artisans, and timber or non-timber forest product collectors. The respondents were asked for a common name(s) of the trees species and the use. Voucher specimens of unidentified species were collected and prepared using standard herbarium techniques and taken to East African Herbarium at National Museums of Kenya for identification. Some identification was carried out in the field with the aid of available floristic guides

3.3 Ecological Data collection

Ecological data were collected using systematic sampling design along six parallel belt transects. Each transect was laid out from the edge of the forest in each village, and as perpendicular as possible to the general orientation of the forest boundary. Using Global Positioning System (GPS) and a compass, each transect was 20m in width and running for 3kms into the forest. Five sample quadrats 20m x 20m (for trees) were laid down per transect making a total of 30 quadrats for each size for all the transects. The first quadrat on each transect was established 50m inside the forest boundary and further plots-established at 500 m intervals. In each of the plots, all the trees were identified, counted and diameter at breast height (DBH), measured at the height of 1.36m to the nearest centimetre using a diameter tape (DBH≥10cm) for trees. Saplings for the different species of trees identified were counted in each quadrat.

The identity of trees was recorded using local names given by informants and scientific names were obtained using identification keys in books and herbarium specimens (Beentje, 1994; Maundu and Tengnäs 2005). Samples of plant specimens from each tree species encountered for the first time were collected, tagged, pressed and later taken to East African Herbarium at National Museums of Kenya, where there is a large reference collection for confirmation. Voucher specimens were deposited in the Herbarium for future reference. In all the 30 quadrats studied indicators of human impact were recorded, The evidence of charcoal burning kilns, pit sawing, and split stems were recorded as either present or absent while the number of pole cuttings, and debarked trees in each plot was counted (standing trees and recently cut or coppicing stumps) encountered in each plot.

3.4 Data analysis

3.4.1 Ethnobotanical uses of forest trees

Quantitative data from both questionnaires and interview guide were categorized, coded and entered into the computer excel spreadsheets for computation for descriptive and inferential statistics. Statistical Package for Social Sciences (SPSS) version 21 and excel spread sheets were used to run descriptive analyses to produce tables and charts of frequency distribution, percentages, means and standard deviations. The qualitative data generated from open-ended questions was categorized in themes in accordance with research objectives and reported in narrative form along with quantitative presentation.

3.4.2 Human impact on tree species diversity and abundance

The data on human activities was summarized using descriptive statistics and presented using graphs. Analysis of Variance (ANOVA) was used to test whether there was significant variation in mean of the counts of cut stems and debarked trees with distance from the forest edge and post hoc Tukey test done to separate the means. Shannon-Wiener Diversity index (Magurran, 1988) was computed. ANOVA was used to test for variation in diversity indices, tree species abundance and DBH with distance from forest edge. Pearson's correlations was used to investigate the relationship between pole cuttings, mean species abundance, diversity and DBH with distance from human settlement. Chi-square test was performed for the difference on uses of trees and services derived from the farmland and forest and respondents opinion on the state of the forest during the initial and current state after settlement. All statistical tests were considered significant at $p < 0.05$.

CHAPTER FOUR: RESULTS

4.1 Demographic information

A total of 242 respondents took part in the study, 135 (55.79%) participants were male and the remaining 107(44.21%) participants were female. Nearly 40% of the respondents were aged between 18–30 years, the remaining percentage was distributed across other age groups; 31 – 45(30.99%), 46 – 59(20.25); sixty years and above represented 9.50% (Figure 4.1).

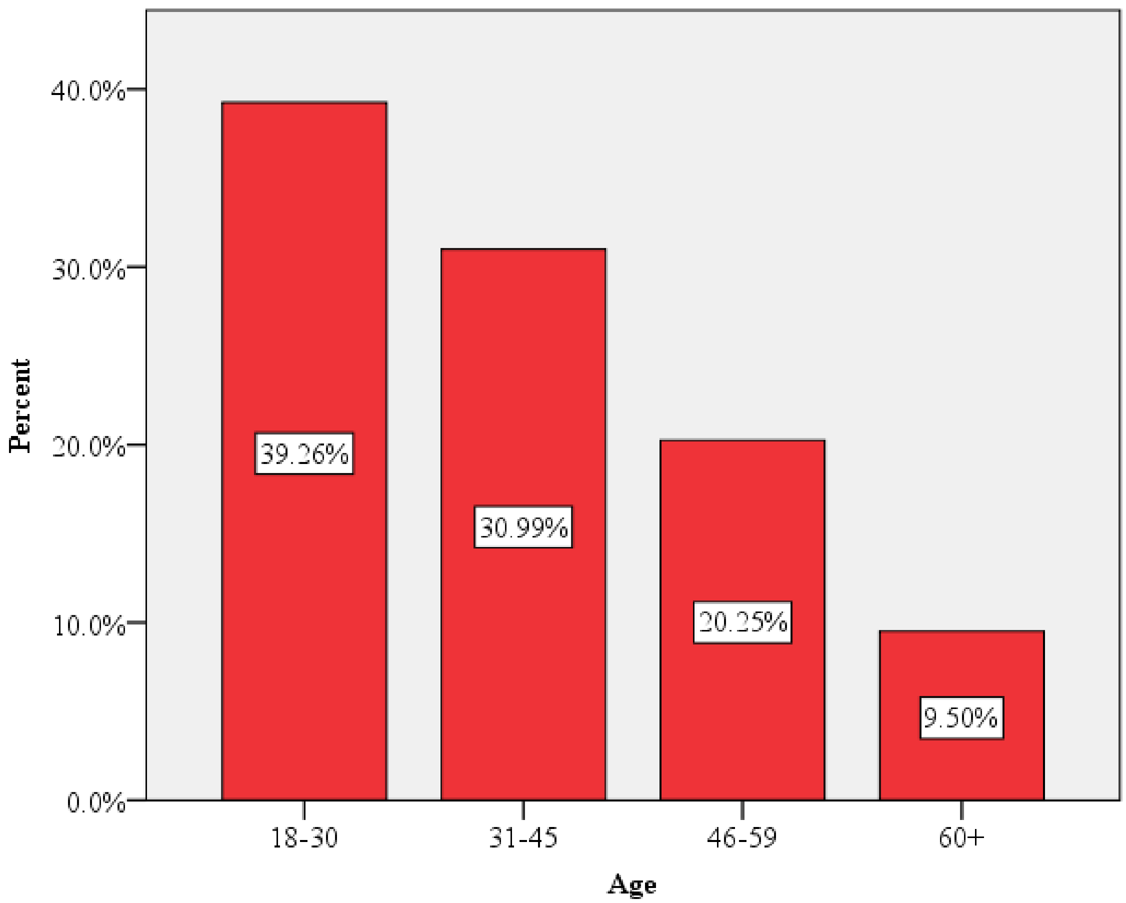


Figure 4.1: Respondents' distribution by relative age classes

The educational level of the participants varied from those who had no formal training to university graduates. Most of them (65.18%) had primary and secondary education, college and university graduates 12.40%, technical and vocational training 3.30% while non-formal education training 18.18 %. (Figure 4.2).

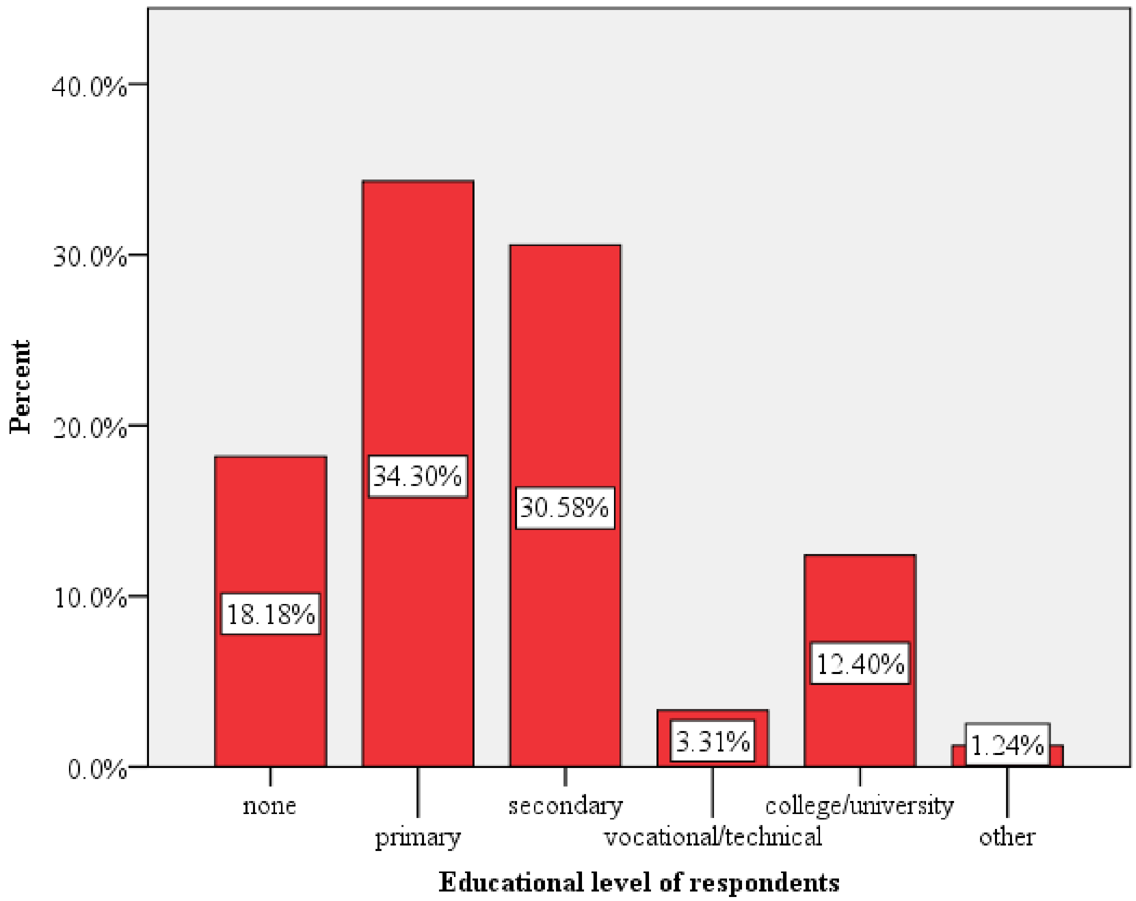


Figure 4.2: Participants' educational level.

The participants' length of stay around the Chemususu Forest varied; a larger percentage (81.82) had stayed in the region for more than 15 years (Figure 4.3).

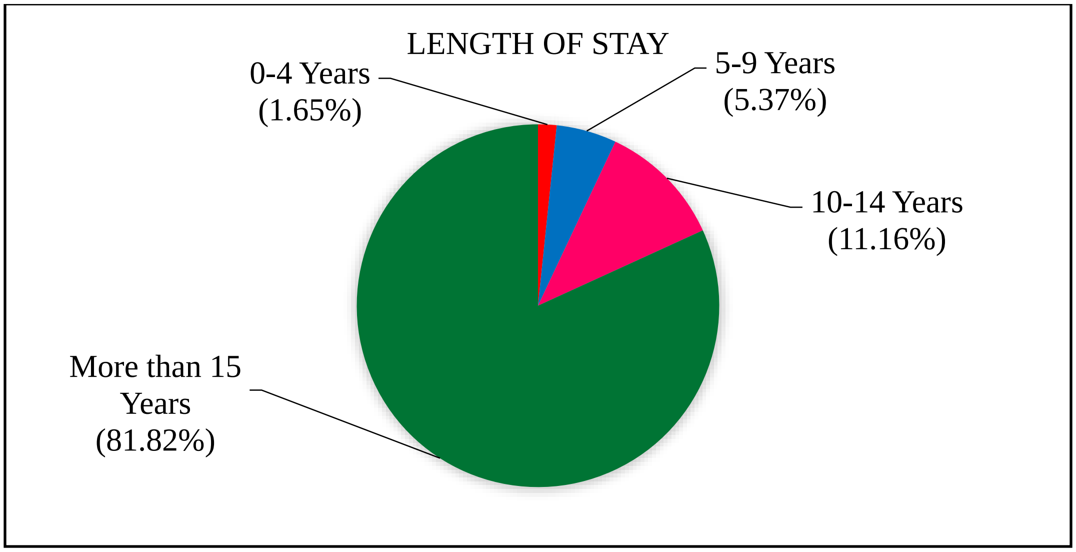


Figure 4.3: The participants' duration of residence around Chemususu Forests

4.2 Uses of trees in Chemususu Forest

The local community living around Chemususu forest used the forest for a wide range of purposes (Table 4.1). It was established that the respondents mainly depended on forest for firewood (82.2%), timber (97.52%), and Charcoal (79.8%). The degree of dependence on the forest varied with uses of different trees. On ecosystem services majority (98.4%) of the respondents benefited from the forest for spiritual and cultural purposes, while protection of water quality was 97.9%. Other significant uses of forest were tourism and recreation (96.3%) and hunting by 97.1% of the respondents.

Chi-square test on the difference in response on uses of trees and services derived from the farmland and the forest revealed a statistically significant difference on firewood, charcoal, food/fruits and bee keeping, while timber, herbal medicine and the rest were not significantly different.

Table 4.1: Goods and services derived from the farmland and forest

Ecosystem Goods/ Services	Number of respondents				
	Farmland	Forest	Chi-Square results		
	Frequency	Frequency	Total	χ^2	p
Firewood	43	199	242	11.299	**0.001**
Charcoal	49	193	242	15.593	**0.000**
Bee keeping	66	176	242	34.031	**0.000**
Food/Fruits	69	173	242	38.497	**0.000**
Timber/Poles	6	236	242	0.156	**0.692**
Herbal Medicine	10	232	242	0.450	**0.503**
Hunting	7	235	242	0.311	**0.577**
Tourism and recreation	9	233	242	0.361	**0.548**
Protection of water quality	5	237	242	0.108	**0.743**
Spiritual/ cultural purpose	4	238	242	0.086	**0.770**

The photographs in Plate 1 shows the uses of trees in marking the position and placing bee hives.

Plate 1: Log Beehives placed on *Juniperus procera*, *Dombeya torrida* and *Dodonaea anguistifolia* at Chemoson, Chemususu and Kamasaba respectively

Trees were ranked based on percentage response on uses for ten selected trees species on each category (Table 4.2). With regard to plants used for firewood *Juniperus procera* (Ednl) was the most used tree (77.3%) followed by *Dombeya torrida* (JFGmel.) (69.4%) *Olea europaea* L. (69.0%) and *Olea capensis* L. (60.3%), which were mainly indigenous trees. *Juniperus procera* (Ednl) (88.0%) topped the list of trees used for timber followed by the exotic trees *Cupressus lusitanica* Miller. (75.6%) and *Pinus patula* Schiede ex Schltdl. & Cham (75.6%).

Table 4.2: Trees preferred for firewood and timber

Firewood			**Timber**	
Plant name	Percentage respondents (%)		Plant name	Percentage respondents (%)
Juniperus procera	77.3		*Juniperus procera*	88.0
Dombeya torrida	69.4		*Cupressus lusitanica*	75.6
Olea europaea	69.0		*Pinus patula*	75.6
Olea capensis	60.3		*Podocarpus falcatus*	71.7
Arundinaria alpina K.Schum	60.3		*Podocarpus latifolius*	70.7
Pinus patula	56.6		*Grevillea robusta* A.Cunn.ex R.Br.	58.7
Acacia mearnsii De Wild	56.2		*Faurea saligna* Harv.	39.7
Podocarpus falcatus Mirb	55.4		*Eucalyptus saligna* C.A.Sm.	34.7
Olea hochstetteri Bak	54.5		*Prunus africana* (Hook.f.)Kalkm.	32.2
Podocarpus latifolius (Thunb.)Mirb	54.5		*Dombeya torrida*	26.0

The trees species commonly used to burn charcoal and as a source of fruits and their respective percentage use are shown in table 4.3. *Olea europaea* (72.7%), *Acacia lahai* Benth. (71.9%) and *Acacia mearnsii* (68.2%) were trees preferred for burning charcoal while *Rhus natalensis* Krauss. (66.5%), *Dovyalis abyssinica* (A.Rich.) Warb. (63.6%), *Vangueria madagascariensis* G Mel. (57.0%) and *Macaranga kilimandscharica* Pax. (44.2%) were the source of fruits.

Table 4.3: Trees used for charcoal, fruits, and their percentage use values

Charcoal		**Fruits**	
Plant name	Percentage respondents (%)	**Plant name**	Percentage respondents (%)
Olea europaea	72.7	*Rhus natalensis*	66.5
Acacia lahai	71.9	*Dovyalis abyssinica*	63.6
Acacia mearnsii	68.2	*V. madagascariensis*	57.0
Olea hochstetteri	49.6	*M. kilimandscharica* Pax	44.2
Rapanea rhodondendroides (L.) Mez	38.4	*Dovyalis macrocalyx* (Oliv.) Warb	33.5
Olea capensis	26.4	*Ekebergia capensis* Sparrm.	21.9
Dombeya torrida	25.6	*Acokanthera schimperi* (A.DC.) Schweinf.	15.7
Nuxia congesta Fres.	24.8	*Flacourtia indica* (Burm.f.) Merrill	15.7
Erica arborea L.	23.6	*Halleria lucido* L.	15.3
Acacia xanthopholea Benth.	21.1	*Cussonia spicata* Thunb.	10.7

The most utilized trees for medicinal purposes were *Myrica salicifolia* A.Rich.(70.7%), *Schlefflera volkensii* (Engl.) Harms (65.3%), *Syzygium guineensis* (Willd) D.C (63.2%), *Trachonanthus camphoralus* L. (63.3%), *Euphorbia candelabrum* Kotschy (62.4%), and 55.4% for *Warburgia ugandensis* Sprague *ssp. ugadensis* . Roots and leaves were frequently used parts of the plant followed by the bark for the selected 30 species, stems, fruits, seeds and sap were rarely used (Table 4.4).

Table 4.4: Trees species used for medicinal purposes and parts used

Plant names	Percentage respondents (%)	Part used
Myrica salicifolia	70.7	Bark
Schefflera volkensii	65.3	Roots
Syzygium guineensis	63.2	Fruits
Tarchonanthus camphoratus	63.2	Leaves
Euphorbia candelabrum	62.4	Sap
Warburgia ugandensis	55.4	Bark, Roots
Olinia rochetiana A. Juss	48.3	Leaves, Roots
Ficus thonningii Bl.	45.0	Bark , Roots,
Rhamnus stado A.Rich.	43.0	Leaves
Bersama abyssinica Fres.	38.4	Leaves
Croton macrostachycus Del.	38.0	Bark, Leaves ,Roots
Dovyalis abyssinica	35.1	Roots
Maesa lanceolata Forssk.	31.8	Roots
Rhus natalensis	30.6	Roots
Acokanthera schimperi	24.0	Roots
Maytenus heterophylla (Eckl. & Zeyh.) Robson	21.5	Roots, Leaves
Cussonia spicata	15.7	Roots
Juniperus procera	15.7	Leaves
Pittosporum viridiflorum Sims.	15.3	Bark, Leaves
Rapanea rhodondendroides	15.3	Seeds
Rhamnus prinoides L'Herit.	13.6	Leaves, Roots
Faurea saligna	12.8	Bark
Ekebergia capensis	12.4	Bark
Dombeya torrida	11.6	Bark
Acacia lahai	11.2	Stems, Roots
Dodonaea anguistifolia L.f.	11.2	Leaves
Albizia gummifera (JF Gmel.) C.A.Sm.	10.3	Bark
Olea europaea.	9.9	Leaves
Prunus africana	9.9	Bark, Leaves
Schinus molle L.	9.1	Leaves

Some trees had other additional uses other than for timber. Among the trees are *Arundinaria alpina*, which was most, mentioned at 61.2%, used in making arrows, fencing, water containers and house construction. *Rhamnus prinoides* (54.1%) ash was used in flavouring milk, *Teclea simplicifolia* Verdoorn (45.9%) for wooden handles, walking sticks and bows. *Juniperus procera* (36.8%) was used for making post, poles, feeding troughs, beehives and the bark was used for roofing. *Dodonaea anguistifolia* (33.0%) was used for making arrows. According to 32.2% of the respondents, *Olea capensis* was used for making walking sticks, bows and house construction (Table 4.5).

Table 4.5: Trees and their uses

Plants names	Percent of respondents	Uses
Arundinaria alpina	61.2	Marking arrows, water containers, Fencing and house construction
Rhamnus prinoides	54.1	Flavouring milk
Teclea simplicifolia	45.9	Wooden handles, walking sticks and bows
Juniperus procera	36.8	Making posts, poles, feeding troughs and bee hives
Dodonaea anguistifolia	33.0	Making arrows
Olea capensis	32.2	Walking sticks, bows and house construction
Croton megalocarpus Hutch.	28.5	Building houses, edge plant
Dombeya torrida	25.6	Handles, walking sticks, Bee hives and robes
Ehretia cymosa Thonn.	24.4	Tool handles, walking sticks and yokes
Cussonia spicata	23.6	Roots are eaten

Many respondents (65.7%) stated that the forest had not been degraded during the initial settlement, which varied between zero to more than fifteen years for different respondents. Nearly twenty seven percent (26.9%) of the respondents were of the opinion that the forest was moderately degraded while 11 (4.5%) stated that the forest had been degraded (Table 4.6). The remaining 7 (2.9%) had no idea on the status of the forest during their initial settlement.

The participants' responses on the current status of the forest varied. Most of participants 131 (54.1%) stated that the forest had been degraded over the years. The respondents who noted that the forest was moderately degraded were 106 (43.8%) and only 4% noted that the forest has not been degraded at all. The respondents' opinion on the state of the forest was subjected to Chi-square test, to test for the difference on the state of the forest during the initial settlement and the current state. There was a significant difference on whether it was degraded, moderately degraded and those who had no idea. The opinion that it was not degraded at all did not vary significantly.

Table 4.6: Respondents opinion on the initial and current conservation status of Chemususu Forest

	Initial forest status	**Current forest status**	**Chi-Square results**		
Respondents	Frequency	Frequency	Total	χ^2	p
Degraded	11	131	142	9.764	**0.002**
Moderately degraded	65	106	171	114.022	**0.000**
Not degraded at all	159	1	160	0.524	**0.469**
Had no idea	7	4	11	136.543	**0.000**

Majority of the respondents 237 (97.9%) were of the opinion that the status of the Chemususu Forest has changed over time. The change was attributed to various human activities; especially timber extraction (39.7%) charcoal burning (38.8%) over harvesting of wood and grazing (20.3%) and for medicinal purposes (1.2%) (Figure 4.4). The respondents were more involved activities that were detrimental to the forest as opposed to protection and conservation. Few respondents were involved in the extraction of underground honey, establishment of nurseries and tree planting.

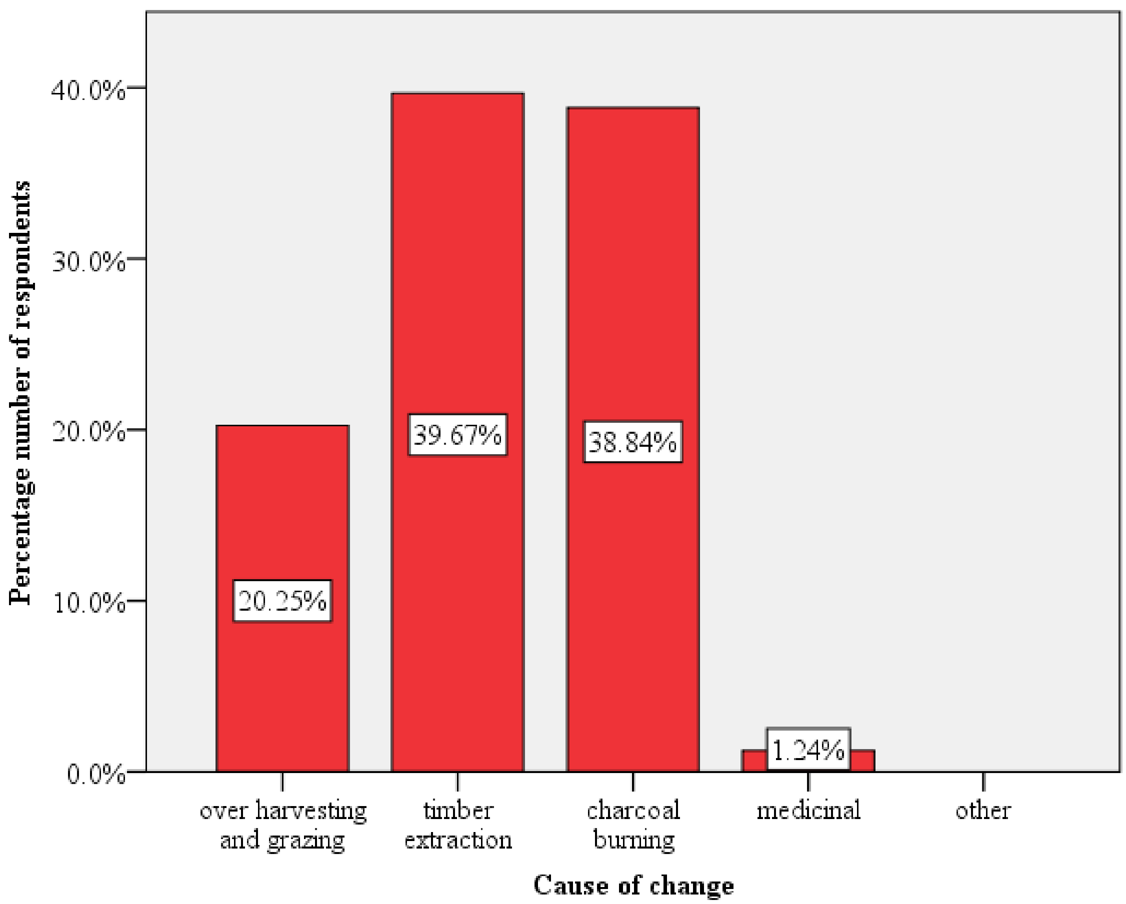


Figure 4.4: Human activities responsible for change as per respondents in Chemususu Forest

4.3 Changes in the level of use with distance from the forest edge

4.3.1 Charcoal burning

A number of quadrats (8) with charcoal kilns (Plate 2) were observed. The number of charcoal kilns decreased with increasing distance from the forest edge but the relationship was not statistically significant (r = **-** 0.849, *P* = 0.0689) (Figure 4.5).The six out of nine kilns detected were found within half a kilometer from the forest edge.

Plate 2: Charcoal kilns at Sawich and Chemoson villages around Chemususu Forest

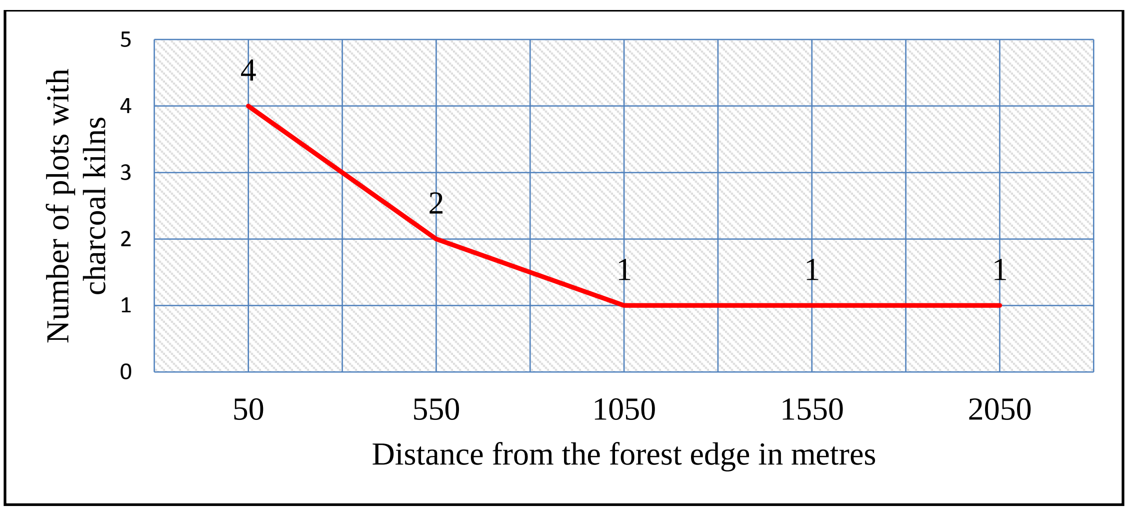


Figure 4.5: Charcoal kilns with distance from the forest edge

4.3.2 Split stems for firewood

The number of plots with evidence of split stems (Plate 3) decreased significantly with increase in distance from the forest edge (r = - 0.892; *P* = 0.0428) (Figure 4.6). Nearly 66% of the split stems for firewood were found within 500m of forest edge. This implies that firewood collectors were penetrating the forest from the edges and the trees preferred for firewood became scarce at the forest edge.

Plate 3: Split stems in Sawich, Chemoson from *Juniperus procera* and Kamasaba on *Olea europaea*

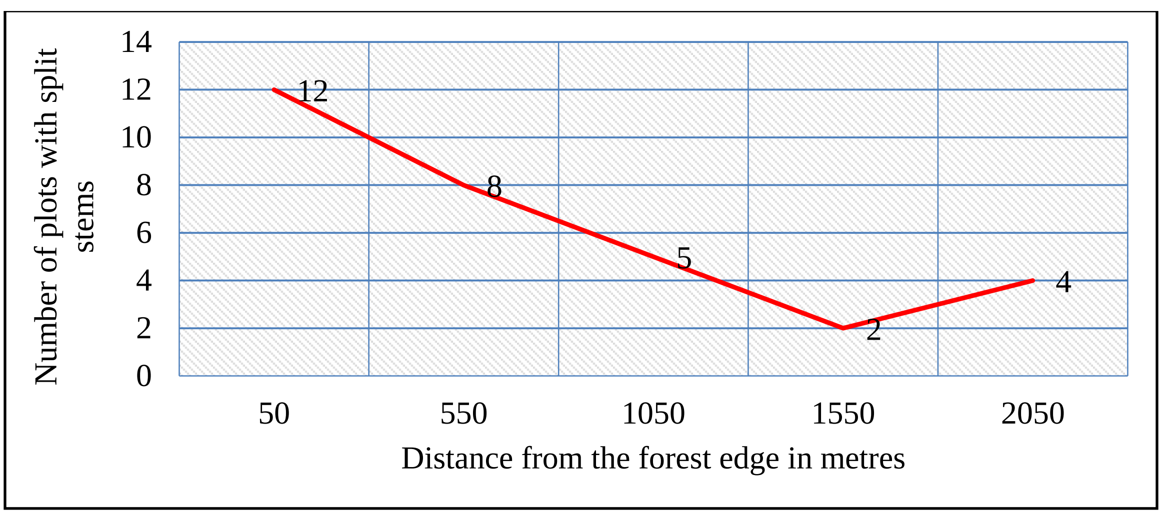


Figure 4.6: Evidence of split stems with distance from the forest edge

4.3.3 Pit sawings

There was no evidence of pit sawing in the first quadrats in all the transects but one was observed in the second and the fourth quadrats. The third quadrat had three while fifth quadrat had two pits as shown in Figure 4.7. The relationship between number of plots with evidence of pit sawing and distance from forest edge was not significant (r = 0.555; *P* = 0.333).The figure also shows that pit sawing activities were increasing away from the forest edge. Plate 4 shows pit sawing in Chemoson and Sawich while plate 5 shows *Cupressus lusitanica* logs collected from illegal tree harvesters in Chemususu forest station. A lot of stumps and recently fallen trees belonging to *Juniperus procera* were observed compared to other trees. The section of the forest plantation with *Pinus patula* appeared undisturbed at the edge of the forest in Sawich, but inside a lot of trees had been cut with sawing done right inside.

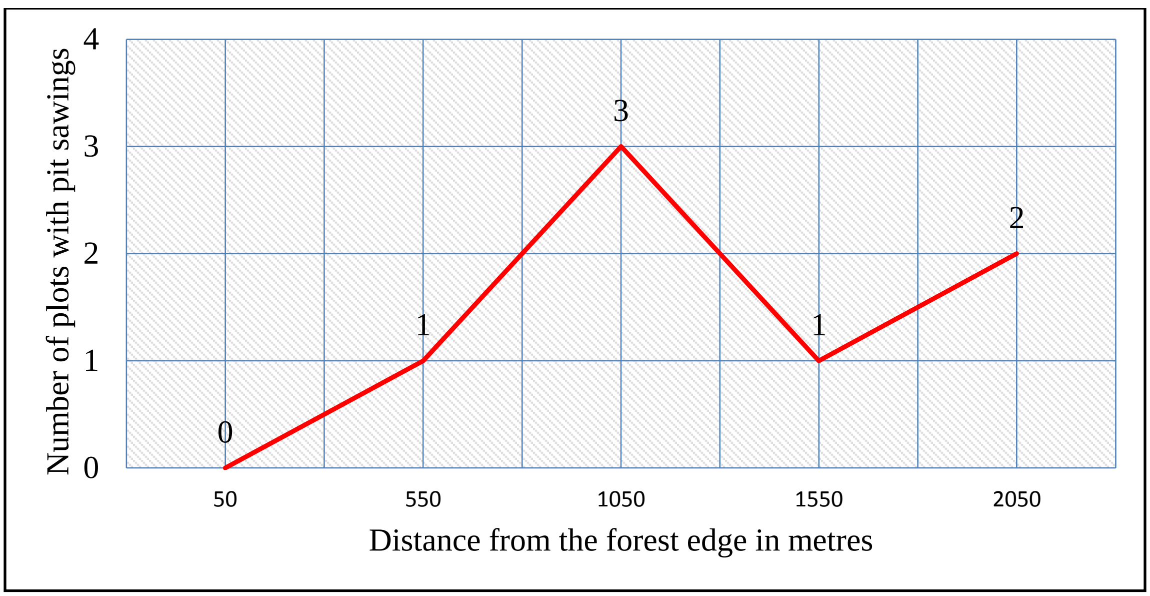


Figure 4.7: Plots with pit sawings from the forest edge

Plate 4: Illegal sawings of trees *Juniperus procera* and *Pinus patula* in Chemoson and Sawich villages respectively

Plate 5: Logs confiscated from illegal sawyers at Chemususu Forest Station

4.3.4 Pole cuttings

Pole cuttings were expressed as means at intervals along all the six transects (Figure 4.8) and there was a decrease with increasing in distance from forest edge. There was a significant variation in the number of cut stems with distance from forest edge ($F_{(4, 25)}$ = 3.002; *P*= 0.034). Post hoc Tukeys test revealed that there was a significant difference between the first and the fourth quadrant. There was also a significant but negative correlation (r = -0.923; *P*=0.025) between mean number of poles cut and distance from the forest edge. The tree species that were mainly cut for poles were *Cupressus lusitanica* (Plate 6).

Plate 6: Pole cuttings at Metipso plantation forest of *Cupressus lusitanica*

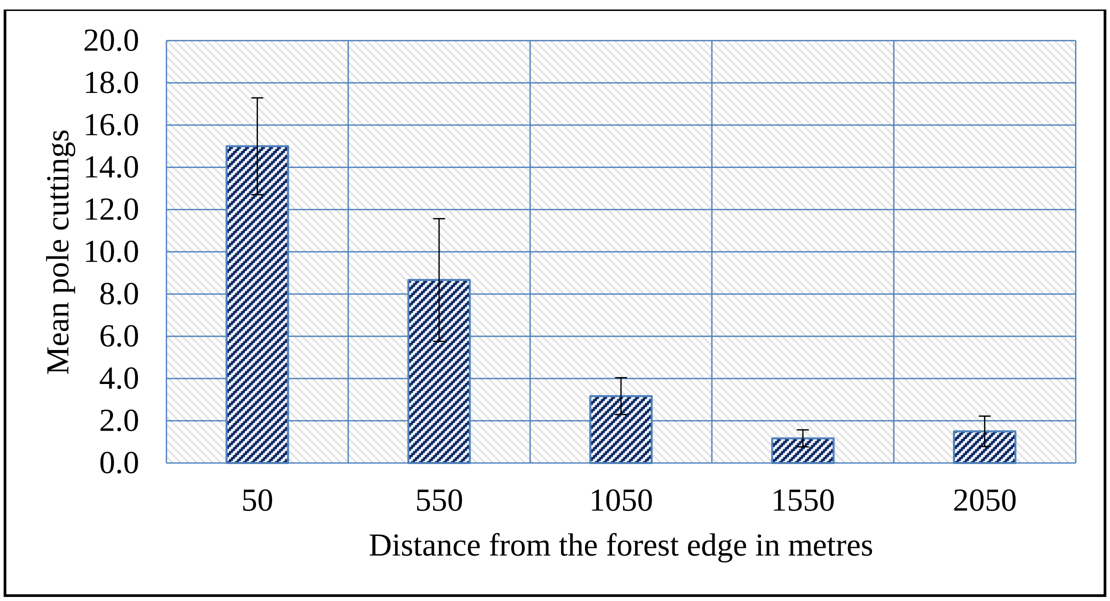


Figure 4.8: Mean pole cuttings with distance from the forests edge

4.3.5 Debarked trees

The mean number of debarked trees was highest at edge of the forest, it decreased slightly for the next two quadrat then increased (Figure 4.9). Plate 7 shows debarked trees *Myrica salicifolia, Dombeya torrida* and *Prunus africana,* which are medicinal trees. Debarking was done for medicinal purpose, getting the barks for roofing and as a way of drying some trees for subsequent use as firewood (Plate 8), debarking damages trees when it's done without due regard to the survival of some trees. There was no significant variation in the mean number of debarked trees with distance from forest edge ($F_{(4, 25)}$ = 1.795; *P*= 0.1614).

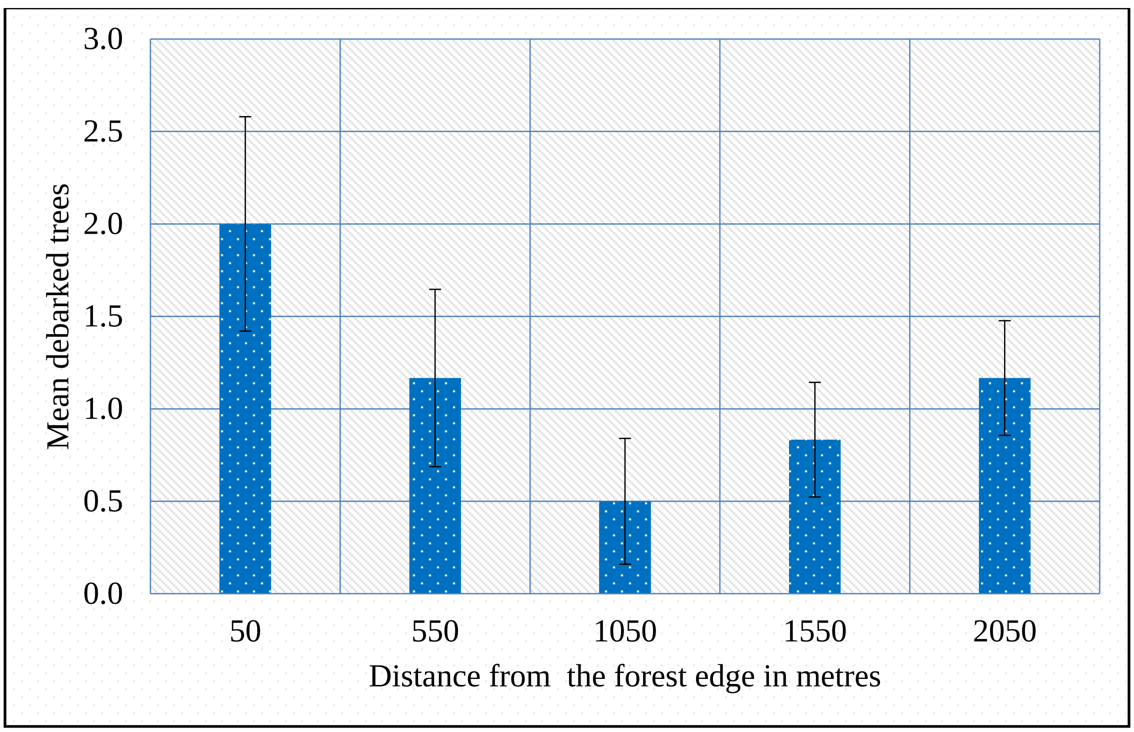


Figure 4.9: Mean number of debarked trees with distance from the forest edge

Plate 7: Debarked trees, *Myrica salicifolia*, *Dombeya torrida* and *Prunus africana*

Plate 8: Debarked *Cupressus lusitanica* and *Podocarpus latifolius*

4.4. Effect of human activities on tree abundance, diversity and population structure

4.4.1 The abundance of trees with distance from human settlement

The mean and standard deviations at distance intervals for selected trees species, including transect mean and standard deviations were calculated. The abundance of trees per plot did not vary significantly with distance from the human settlements for all the selected trees species (Table 4.7).

Table 4.7: Variation of abundance of trees with distance from human settlements in Chemususu Forest

	Mean number of tress per plot at varying distances from forest edge													
Distance in metres	**50**		**550**		**1050**		**1550**		**2050**					
Species	M	SD	M	SD	M	SD	M	SD	M	SD	TM	SD	F	p
D. torrida	0.3	**0.5**	0.2	**0.4**	0.5	**1.2**	1.7	**2.4**	1.2	**1.8**	3.7	**4.3**	1.07	**0.39**
O. europaea	1.5	**1.8**	1.2	**1.9**	2.5	**3.1**	0.8	**1.6**	1.8	**1.8**	5.0	**2.0**	0.55	**0.70**
C. macrostachycus	2.8	**0.8**	2.5	**0.8**	4.3	**0.8**	1.5	**1.1**	4.5	**0.5**	1.2	**1.6**	0.46	**0.77**
D. abyssinica	0.2	**0.4**	0.7	**1.6**	0.7	**1.0**	1.3	**1.2**	0.7	**1.0**	2.2	**3.5**	0.8	**0.53**
E. capensis	0.3	**0.8**	0.0	**0.0**	0.0	**0.0**	0.7	**0.8**	0.7	**1.0**	1.2	**1.5**	*	*
F. saligna	0.0	**0.0**	0.0	**0.0**	0.5	**0.8**	0.3	**0.8**	0.5	**0.8**	1.3	**1.63**	*	*
F. thonigii	4.2	**1.2**	3.8	**1.2**	6.2	**1.8**	2.2	**2.5**	7.2	**1.2**	4.2	**4.9**	0.43	**0.78**
J. procera	0.7	**1.0**	1.3	**1.6**	0.7	**1.6**	0.5	**1.2**	1.0	**1.5**	4.2	**4.8**	0.32	**0.86**
M. kilimandscharica	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.3	**0.8**	1.2	**1.3**	1.5	**1.8**	*	*
O. capensis	8.7	**20.7**	3.3	**5.6**	0.5	**0.8**	0.5	**1.2**	1.2	**1.8**	13.0	**25.6**	0.77	**0.55**
O. hochstetteri	1.0	**1.7**	0.3	**0.8**	1.5	**2.8**	0.3	**0.5**	1.0	**1.6**	4.2	**5.9**	0.53	**0.71**
P. falcatus	0.2	**0.4**	2.5	**3.2**	1.7	**2.3**	0.2	**0.4**	1.8	**3.3**	6.0	**7.8**	1.26	**0.31**
P. latifolius	4.8	**5.5**	3.8	**5.0**	8.2	**10.4**	8.2	**10.3**	5.8	**8.3**	30.8	**35.1**	0.34	**0.85**
R. rhodondendroides	0.0	**0.0**	0.2	**0.4**	0.3	**0.8**	0.3	**0.8**	0.8	**1.3**	1.7	**2.7**	*	*
R. natalensis	1.5	**1.7**	2.3	**3.6**	4.3	**4.8**	0.8	**1.2**	1.0	**1.8**	11.2	**8.0**	1.29	**0.3**
S. volkensii	0.3	**0.8**	0.3	**0.8**	0.0	**0.0**	0.0	**0.0**	0.5	**1.2**	1.2	**2.9**	*	*
S. guineensis	0.0	**0.0**	0.5	**1.2**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.5	**1.2**	*	*
T. camphoratus	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.0	**0.0**	0.3	**0.8**	0.3	**0.8**	*	*
V. madagascariensis	0.0	**0.0**	0.7	**1.6**	0.3	**0.8**	0.0	**0.0**	0.3	**0.8**	1.3	**3.3**	*	*

M = mean; S.D = Standard Deviation; TM=Transect Mean;* = F and *Ps* Values not computed; F = F-Statistic; P =Significance level.

4.4.2 Diversity of trees with distance from human settlement

Tree diversity did not vary significantly with distance from human settlements ($F_{(4, 25)}$ = 1.67; *P*=0.1884). The mean diversity indices ranged from 1.2 to 2.1(1.2, 1 .8, 1.9, 2.0 and 2.1 respectively for each of the distance intervals).The standard deviations were low 1.07, 0.52, 0.35, 0.13 and 0.56 respectively (Figure 4.10)

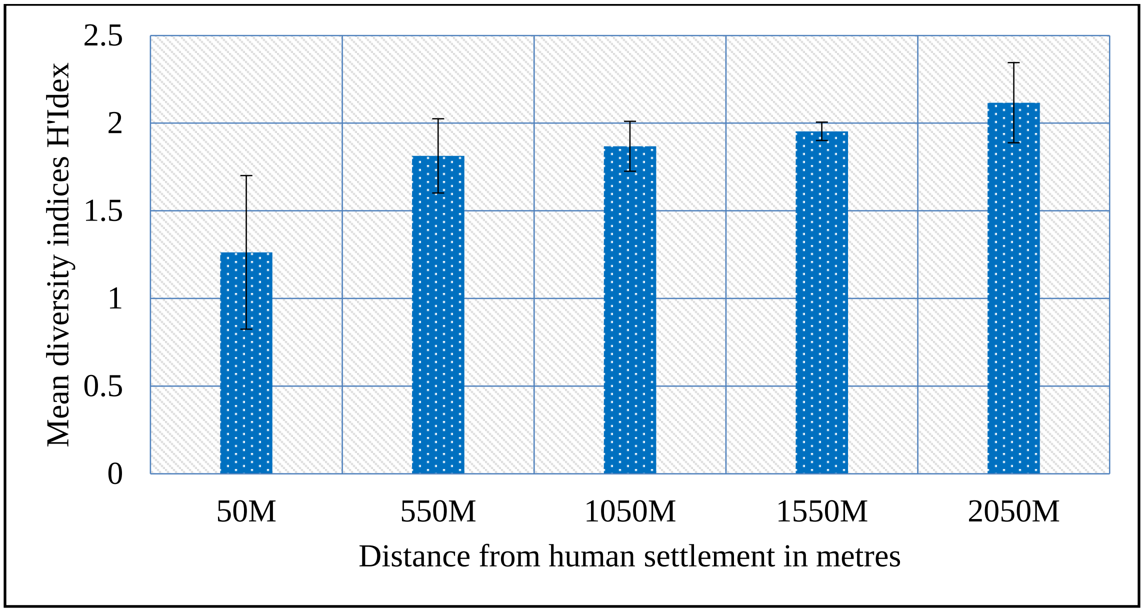
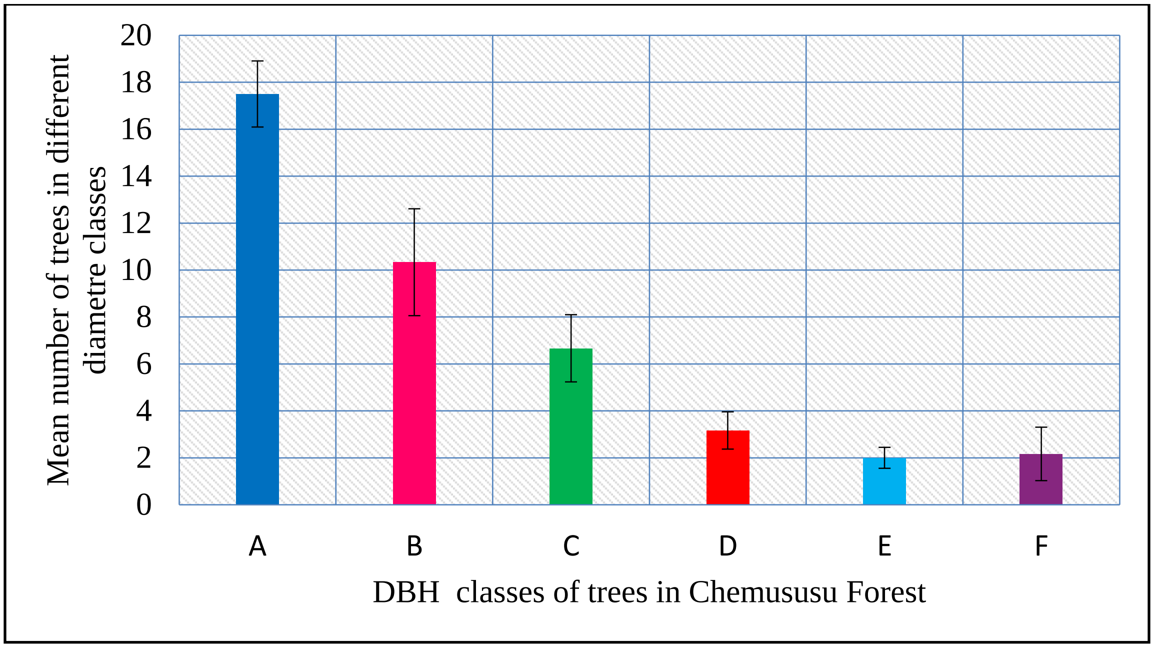


Figure 4.10: Variation of mean diversity indices with distance from human settlement

4.4.3 Population structure with distance from human settlement

The mean number of trees for various DBH classes indicates a continuous decline with trees in classes E and F being almost the same as shown in figure 4.11.The forest has more trees in the lower DBH classes. ANOVA test revealed a statistically significant difference in the mean number of trees in different DBH classes ($F_{(4, 25)}$ = 5.181; *P* =0.002)



DBH Class sizes:
A= 10.1 - 20 cm; B = 20.1 - 30 cm; C= 30.1 - 40 cm; D= 40.1 - 50 cm; E = 50.1- 60 cm; F = 60 cm and above. The letters represents the DBH sizes range in cm.

Figure 4.11: Mean number of trees with DBH classes

The mean DBH for selected trees species did not vary significantly with distance from the forest edge. *Podorcarpus latifolius* mean did increased, being constant in the third and fourth plot and the highest in the innermost plot. *Olea europaea* had the highest DBH mean at the edge of the forest. Juniperus procera had relatively lower DBH with no trees registered in the second plot (Table 4.8).

Table 4.8: The mean DBH for selected trees at distance intervals from human settlement in Chemususu Forest

Species	**Mean dbh of trees at various distances from human settlement**						
	50m	550m	1050m	1550m	2050m	**F**	**P**
Buddleia polystachya	0.6	0.2	0.2	0.4	0.8	0.51	0.73
Juniperus procera	0.2	0	0.6	0.2	0.6	0.52	0.72
Macaranga kilimandscharica	0.2	1.4	0.2	0.4	0.6	2.21	0.10
Olea europaea	1.4	0.6	0.4	0.4	0.4	1.11	0.38
Podorcarpus latifolius	0.6	0.4	1.6	1.6	2	1.03	0.41
Rapanea rhodondendroides	0.2	1.2	0.4	0.6	0.4	1.02	0.42

The mean number of trees in each DBH cluster for all the plots at intervals are shown in table 4.9. Their means indicates a higher number of trees in classes A in all the quadrants followed by B and C, the other two classes were irregular although there was a general decrease.

Table 4. 9: The mean number of trees at various DBH class sizes for all the plots at intervals of 500m

Distance from the forest edge in metres	DBH Classes	Mean	Standard Error
50m	A	4.00	0.58
	B	2.33	0.84
	C	2.00	0.52
	D	0.67	0.42
	E	0.50	0.22
	F	0.83	0.48
550m	A	2.67	0.49
	B	2.00	0.82
	C	1.17	0.48
	D	0.83	0.65
	E	0.33	0.33
	F	0.33	0.21
1050m	A	3.33	0.61
	B	1.67	0.76
	C	1.17	0.48
	D	0.83	0.48
	E	1.00	0.52
	F	0.17	0.17
1550m	A	3.17	0.95
	B	2.17	0.65
	C	0.83	0.48
	D	0.67	0.49
	E	0.00	0.00
	F	0.50	0.34
2050m	A	4.33	0.56
	B	2.17	0.54
	C	1.50	0.34
	D	0.17	0.17
	E	0.17	0.17
	F	0.33	0.21

DBH Class sizes:
A= 10.1 - 20 cm; B = 20.1 - 30 cm; C= 30.1 - 40 cm; D= 40.1 - 50 cm; E = 50.1- 60 cm; F = 60 cm and above. The letters represents the DBH sizes range in cm.

CHAPTER FIVE: DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

5.1 Discussion

5.1.1 Uses of forest trees by the local community

Majority of the people living around the Chemususu forest (Tugen, Kipsigis and Okiek) depend on the forest for ecosystem products and services. The forest is the main source of firewood, charcoal, timber, herbal medicine and food, including wildlife meat, tourism and recreation, protection of water quality, spiritual-cultural purposes and bee keeping as evidenced by the number of bee hives placed on trees. Statistical test from Chi-square showed a high dependence by the local community on forest for firewood, charcoal, food/fruits and bee keeping rather than the farmland. Farmland complemented forest as a source of firewood, charcoal and bee keeping to a smaller extent.

Most of the plant species of a particular area can be used as foodstuff, fuel, source of income and medicinal purposes (Hamayun, 2005). Plants not only provide goods such as food, shelter, fodder, drugs, timber, fuel but also provide other services such as regulating atmospheric gases, water recycling and control of soil erosion (Hussain *et al.*, 2018). Around the Lembus Forest, the diversity of wild foods collected from the forest included mushrooms, wild vegetables, such as *Solanum nigrum* L.(*managu*) and *Amaranthus retroflexus* L. *(terere*) and fruits, such as *syzigium guineensis* (*lamaiywet*),which are used both for nutritional as well as medicinal purposes (Kimokiy, 2007).

Exotic trees are the main sources of timber in the forest. Although extraction is controlled. However, illegal logging continues and it extends to the indigenous trees targeting *Podocarpus latifolius* and *Juniperus procera,* which were used to make post and poles for fencing. These species are preferred because they are extremely durable and resistant to termite attack unlike other species. Rampant illegal logging affects both indigenous and exotic tree species. Cedar trees have been mostly affected by illegal logging due to high demand for cedar posts by local people. Cedar trees are felled and chopped into cedar posts, which local people use to construct houses and fences (Kimutai and Watanabe, 2016).

Medicinal trees documented only form a section of the many plants used to treat many ailments by the local community in Chemususu forest. The parts used were the bark, leaves and roots. Debarking of tress for medicinal purposes was evident with trees damaged when it was done without due regard to survival of the trees. Blythe (2006) attributed the common use of the bark to its medicinal contents. Togola *et al.,* (2005) argued that the need for the use of stem bark would increase when the leaves are not available. In another study of plants used for wound healing in Dogonland (Mali), Inngjerdingen *et al.,* (2004) found that the roots, followed by the leaves were the most frequently used plant parts. Trees with soft trunks were carved into beehives, mortars, and troughs. The bamboo tree (*Arundinaria alpina*) was used in making arrows, quivers for arrows and water containers, *Rhamnus prenoides* ash was used in flavouring milk, while *Olea capensis* was used for making walking sticks and bows.

The study found that the forest had not been degraded during the initial settlement by the various respondents and majority of the respondents accepted that the state of the forest has changed over time as confirmed by chi-square test, with major human activities responsible for the change being timber extraction and charcoal burning.

5.1.2 Changes in the level of use with distance from the forest edge

5.1.2.1 Charcoal burning, split stems from firewood, pole making, pit sawings and pole cuttings

Trees cut for charcoal burning were mainly indigenous trees and this was more intensive in Chemoson village where *Olea europaea* had been overexploited due to higher demand for charcoal and proximity to Seguton trading center. Charcoal burning was carried out more at the edge of the forest for ease in transporting it out of the forest. There was evidence of trees being felled and moved close to the edge of the forest where old kilns were reused. Sedano *et al., (*2016) stated that kiln locations are usually selected based on the availability of suitable trees in the area and the access to trails and roads. Charcoal burning is detrimental to species diversity due to overexploitation of certain species for charcoal production in the interior of the forest where the local community does not adhere to the rules and regulations (Vuyiya *et al.,* 2014). The activities that open up intact forests are encroachment, clearing, logging, charcoal making, cutting of trees in the process of firewood collection, trampling by livestock and incidences of forest fires which could be human induced or natural (Ronoh, 2016).

Although the forest was protected from extraction of trees by KFS, the local community still access the forest for firewood. The most preferred trees are those easy to cut, split, and stalk as firewood. Most of the heaps of wood splits identified during the study were from *Juniperus procera* and *Olea europaea* for pole making and splitting of firewood respectively. More wood splits were found closer to the edge of the forest due to accessibility. *Olea* burns readily even when fresh as though it contains oil, hence its use remains steadfast even in villages where it has to be obtained up to eight kilometres away due to its extermination in closer areas. The other species were used only occasionally, a finding also reported in a study on Ethnobotany of Maasai in Loita Forest in Narok County by Maundu *et al.* (2001). Hitimana *et al.* (2004) who postulated that human activities like tree cutting and intensive firewood collections are major forest destructive activities to tree density.

There was irregular distribution of pit sawings because the extraction targeted specific trees used for timber and the local community would move to the innermost part of the forest regardless of distance searching for them. A lot of old stumps and recently fallen trees belonged to *Juniperus procera*. In a study conducted in Kakamega, it was found that on terrain where it was too difficult to bring the single tree out of the forest they, sawed the trees at the place of felling, the sawmillers cut the trees by saws and brought them out of the forest by oxen (Mitchell, 2004).

Despite the official rules that prohibit the use and the exploitation of forests, several illegal activities were observed in Kakamega Forest. Pit sawing is a serious problem in the forest, documented by several cut stems and numerous sights of previous cutting in Malava (Oyugi 1996).The removal of trees for construction, sale, and charcoal production (Kutsch *et al.,* 2011), and the collection of Non-Timber Forest Products (NTFP) for medicines, food and livestock fodder (Dewees *et al.,* 2010), usually occurs in easily accessible areas, such as around field margins and alongside paths and tracks (Jew *et al.*, 2016).

Pole cuttings had a significant impact on forest trees , young trees were easy to extract and carry out of the forest because they have a wide range of uses, firewood, house building and commercially in the construction industry where they are in high demand . The intensity of pole cuttings was higher at the edge of the forest, where young trees were indiscriminately cut for poles, the most affected trees species was *Cupressus lusitanica*. In a study by Sassen and Sheil (2013), the collection of stems used as crop-supports reduces regeneration and the density of smaller stems. Maundu *et al. (*2001) in their study in Loita Forest in Narok County found that *Olea europaea* species was the most commonly used species for poles for construction of Maasai traditional houses, while *Juniperus procera* was the most preferred species for poles, fences and in construction of livestock bomas.

5.1.2.2 Debarked trees

Debarking was mainly done for medicinal purposes and mainly involved (*Myrica salicifolia* and *Prunus africana*). In some instances, it was done to get barks for roofing and as a means of drying trees for subsequent use as firewood. In a related study in Kakamega forest (Vuyiya *et al.*, 2014) noted that debarking was mainly practiced by herbalist from the community around the forest. The trees species debarked for medicinal purpose included *Prunus africana* and *Grevillea spps*. This leads to the death of mature trees and slowed the growth rate in trees, since the removal of the bark interfered with translocation of manufactured food. As stated by Purohit e*t al*. (2001) the depth of the bark removed is an important factor for the poor growth of the tree, because once the bark was stripped-off up to the cortex, the remaining part of the bark on the tree automatically splits up, even up to the top crown.

5.1.3 Effects of human activities on abundance, diversity and population structure

5.1.3.1 The abundance of trees with distance from human settlement

Podocarpus latifolius was the most abundant tree species in Chemususu forest evidenced by the relatively higher numbers than all the other species per plot. The number of trees did not vary significantly with distance from human settlement; this could have been influenced by the choice of distance from human settlement selected for study. According to Popradit *et al.* (2015) when distance from the village boundaries was not evenly placed the detectability of distance effects was greatly reduced. In the mountain, this unevenness in plot locations is unavoidable because of geographical constraints and heterogeneity of the target natural forests. Even with these severe limitations, effects are still observed.

Medicinal plants were extremely low and absent in most plots, this could be due to overexploitation of these species. *Myrica salicifolia* was extremely exploited due to its medicinal use and several pharmacological effects including bronchodilator (Patel *et al.*, 2008). There was an increase in abundance of some species because they were considered less valuable for domestic use (Acanakwo, 2010).

5.1.3.2 Diversity of trees with distance from human settlement

The diversity of trees increased from the forest edge towards the interior of the forest, but this variation was not significant, this was in contrast with most of the human activities, pole cuttings and split stems which decreased with distance. An ecosystem with H' value greater than 2 has been regarded as medium to high diverse in terms of species (Rands *et al.,* 2010); the highest diversity was recorded in the innermost quadrant. The range of diversity index from the study (1.2-2.1) reflects a moderate tree diversity. The Shannon-Weiner diversity index normally varies from 1.5 to 3.5 and rarely exceeds 4.5 (Kent & Coker 1992) and is generally higher in tropical forest.

Removal of trees creates space and reduces shading hence colonization by new trees, which leads to increase in species diversity despite removal of trees through human activities at the edge of the forest. The removal of bigger trees for charcoal or pit sawing may open up space and encourage seedling regeneration as long as there is enough mature tree to produce seed (Gebreselasse, 2011). Frequent and less severe disturbances have often been shown to increase diversity (Kpontsu, 2011).

According to Giliba *et al.* (2011), opening forest canopy creates wider gaps, which enhance emergence of suppressed understory species. Omeja *et al.* (2004) and Hitimana *et al.* (2004) have indicated that selective species harvesting of trees with economic and social significance may adversely affect species composition, richness, diversity and density within a forest, as a result their distribution is reduced and may cause local species extinction (Omeja *et al.,* 2004). Vuyiya *et al.* (2014), in a study in Kakamega

Forest found out that anthropogenic disturbances like selective logging, debarking and charcoal burning can reduce the diversity of plant and animal species.

5.1.3.3 Variation of population structure with distance from human settlement

Population structure is expressed in terms of number of individuals present in each of the definite girth class distribution of tree species (Saxena and Singh 1984).The highest proportion of the trees counted were in the lowest diameter size class. These varied slightly at distance intervals in each quadrant where trees in A DBH class were more followed by B and C respectively in all the quadrants at distance intervals, but the abundance of trees in classes E and F were relatively the same.

The trees in higher DBH classes were mainly targeted for timber and pole marking. Similarly, Kimaro and Lulandala (2013) reported that most timber loggers preferred trees with large diameter and in a straight shape. An inverted" J" distribution pattern, where there are more small trees than large trees with an almost constant reduction in numbers from one size class to the next (Peters,1996) is an indicator of healthy regeneration of the forest and species, and shows a good reproduction and recruitment capacity (Feyera, 2006).

5.2 Conclusions

i. The forest is important to the local community for ecosystem goods and services; the forest was the source of charcoal, timber, firewood and medicine in addition to spiritual and cultural purposes, protection of water quality, tourism and recreation as well as hunting and bee keeping to a smaller extent.

Medicinal trees identified represented only a fraction of plants used to treat many ailments, many herbs and shrubs in the forest form a rich diverse source of medicinal plants. *Myrica salicifolia* is the most utilized medicinal tree; the few available trees were highly debarked.

ii. Although, human activities were intense at the forest edge, species diversity kept increasing though insignificantly because of growth of new trees in spaces created by removal of trees. The number of trees did not vary significantly with distance from human settlement despite various human activities, because of selective extraction of trees. The significant decrease in the number of plots with split stems with distance from human settlement denotes a non-discriminatory utilization of forest, and is a serious challenge in forest management and conservation; it also implies that accessibility of the forest is to its fullest. The forest is under serious threat.

iii. The number of trees in each DBH class varied significantly and there were few trees in higher DBH classes because many large sized trees species in Chemususu forest had been removed prior to the study. *Podocarpus latifolius* was the only tree species with a high density in Chemususu forest. Although variation of species diversity with distance was not significant, the increase in species diversity from the forest edge showed a direct influence of destructive human activities on species diversity with those species being targeted being eliminated.

5.3 Recommendations

i. The community surrounding Chemususu forest depends on the forest for their livelihood. Hence, there is need to encourage multiple land use systems by planting exotic and indigenous trees, especially those used for wood and charcoal, so as to minimize over reliance on forests.

ii. The local community should be encouraged to use alternative sources of fuel, biogas, natural gas and efficient cooking stoves. This will reduce Charcoal burning and illegal extraction of timber, which are serious degrading human activities in Chemususu Forest.

iii. The role of Community Forest Association (CFA) and Lembus Forests Integrated Conservation and Development Project (LFICDP) should be encouraged and enhanced. The requests by the Lembus Advocacy, welfare and Lembus Council of Elders to the Ministry of Environment and Forest in March 2018 on the need to reconstitute CFAs should be implemented (MEF,2018).

iv. The establishment of indigenous forests in areas where trees have been cleared should be under taken. This has already worked at Chemususu forest Station where *Juniperus procera* and *Dombeya torrida* have been planted.

5.4 Recommendations for further study

i. A study on medicinal plants in Chemususu Forest, specific trees debarked for medicinal purpose and measures to conserve them should be undertaken.

ii. A study on vegetation distribution and regeneration capacity in the forest.

REFERENCES

Abbasi, A. M., Khan, M.A., Ahmad, M. and Zafar. (2012). Medicinal Plant Biodiversity of Lesser Himalayas Pakistan. XIII, 220P. 116 illus. http://www.springer.com/978-1-4614-1574-9

Abu, J. E. and Adebisi, L. A. (2002). A review of traditional forest uses. *In*: Popoola, (ed.). Proceedings of a National Workshop organized by FANCONSULT and Edo State Chapter of FAN held in Benin City, Edo State between 5th and 6th of September, 2002. Pp 42-50.

Acanakwo, E. F. (2010). Tree Diversity, use and Land cover changes in Mt. Otzi Forest Reserve, Northern Uganda.

Agbogidi, O. M. and Eshegbeyi, O. F. (2008). Forestry development for a safe environment. *In:* Onykwelu, J.C., Adekunle, V.A.J. and Oke, D. O. (eds.). Proceedings of the 1st National Conference of the Forests and Forest Products Society of Nigeria (FFPN) held at the Federal University of Technology, Akure, Ondo State between 16th-18th April 2008. Pp 95-98.

Aimufia, D. I. (2002). Forests, people and the environment: a keynote address. *In*: Popoola, (ed.). Proceedings of a National Workshop organized by FANCONSULT and Edo State Chapter of FAN held in Benin City, Edo State between 5th and 6th of September, 2002. Pp 5-14.

Asner, G. P., David. K., Paulo, B., Machael, K. and Jose, S. (2005).Selective logging in the Brazilian Amazon Science 310:410-482.

Awoyemi, O.K., Ewa, E.E., Abdulkarim. I.A., Aduloju, A.R. (2012). Ethnobotanical Assessment of herbal plants in Southwestern Nigeria. *Academic Research International*, 2: 50-57.

Ayuyo, I.O. and Sweta, L. (2014). Land Cover and Land Use Mapping and Change Detection of Mau Complex in Kenya Using Geospatial Technology. *International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064*

Badshah, L., Hussain F. and Sher, Z. (2012). An overview of people plant interaction in the range land of District Tank, Pakistan. *Journal of Medicinal Plants Research* 6: 2820-2826.

BCGADP. (2014).The Baringo County Government Annual Development Plan 2015-2016. pg 7.

Beentje, H.J. (1994). Kenya trees, shrubs and lianas, National Museum of Kenya, Nairobi.

Blythe, S. (2006).*An introduction to medicines from plants.* Online http:// www.rainforesteducation.com

Bertault, J.G. and Sist, P. (1995).The effects of logging in natural forests. Revue Bois*et Forets des Tropiques* 245: 5-20.

Bertault, J. G. and Sist. P. (1997). An experimental comparison of different harvesting intensities with reduced impact and conventional logging in East Kalimantan, Indonesia. Forest Ecology and *Management* 94: 209-218.

Bradsaw, C. J., Sodhi, N. S. and Brook, B. W. (2009). Tropical turmoil: a biodiversity tragedy in progress. *Frontiers in Ecology and the Environment,* **7,** 79-87.

Cannon, C.H., Peart, D.R. and Leighton, M. (1998). Tree species diversity in commercially logged Bornean rainforest. *Science* 281: 1366–1368.

Carabelli, F. S., Claverie, R., Jaramillo, H. and Gomez, M. (2006). Changes on landscape heterogeneity and spatial patterning of native forests in Patagonia, Argentina. Invest *Agrar: Sist Recur For.*, 15(2): 160-170.

Carlowitz, P.V. (1984).*Multipurpose trees and shrubs, opportunities and limitations. The establishment of a multipurpose tree database*. (ICRAF working paper no.17) .Nairobi International Council for Research in Agroforestry. Mimeograph.

Chapin, F. S., Zavaleta, E. S., Eviner, V. T., Naylor, R. L., Vitousek, P. M., Reynolds, H. L., Hooper, D. U., Lavorel, S., Sala, O. E., Hobbie, S. E., Mack, M. C.and Diaz, S. (2000). Consequences of changing biodiversity. *Nature,* 405**,** 234-242.

Clement, F.E. (1936). Nature and structure of the climax. – *Journal of Ecology* 24: 252284.

Denslow, J. S. (1995).Disturbance and diversity in tropical rain forests: the density effect, *Ecological Applications*, vol. 5, no. 4, pp. 962–968.

Dewees, P.A., Campbell, B.M., Katerere, Y., Sitoe, A., Cunningham, A.B., Angelsen, A., Wunder, S., 2010. Managing the Miombo woodlands of southern Africa: policies, incentives and options for the rural poor. *J. Nat. Resour. Policy Res*. 2, 57–73.

Feyera, S. W. (2006). Biodiversity and ecology of Afromontane rainforests with wild Coffee arabica L. populations in Ethiopia. Cuvillier Verlag, Göttingen.

Food and Agricultural Organization of the united Nation. (1995). *Forest Resources Assessment 1990: Global Synthesis*. FAO Forestry Paper 12.

Food and Agricultural Organization of the United Nation. (2010). Global Forest Assessment; FAO: Rome, Italy.

Food and Agricultural Organization of the United Nation. (2012). State of the FAO; World's Forest: Rome, Italy.

Gebreselasse, A.G. (2011).Plant Communities, Species Diversity, Seedling Bank and Resprouting in Nandi Forests, Kenya. Page 137-139.

Giliba, R. A., Boon, K. E., Kayombo, J. C., Musamba, B.E., Kashindye, M. A. and Shayo, F. P. (2011). "Species composition, richness and diversity in Miombo Woodland of Bereku Forest Reserve Tanzania," *Journal of Biodiversity, vol.* 2, no. 1, pp. 1–7.

Grubb, P.J. (1977).The maintenance of species richness in plant communities: the importance of the regeneration niche. *Biological Review* 52: 107-145.

Hamayun, M. (2005) .Ethnobotanical profile of Utror and Gabral valleys, district Swat, Pakistan. Ethnobotanical Leaflets; (1):9.

Hamilton, A.C., Pie, S.J., Kessey, A.A., Khan, S., Lagos, W and Shinwari, Z.K. (2003). The purpose and teaching of applied ethnobotany. *People and Plants Working Paper*, pp. 1- 76.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Kommareddy, A. (2013).High-resolution global maps of 21st-century forest cover change. Vol.342, Issue 6160, pp 850–853.

Hitimana, J., Kiyiapi J. L and Njunge, J.T. (2004). Forest structure characteristics in disturbed and undisturbed sites of Mt. Elgon moist lower montane forest, western Kenya. *Forest Ecology and Management,* 194, 269-291**.**

Huang, W.D., Pohjonen, V., Johansson, S., Nashanda, M., Katigula, M.I.L. and Luukkanen, O. (2003). Species diversity, forest structure and species composition in Tanzanian tropical forests. For. Ecol. Manage. 173, 11–24.

Hubbell, S. P., Foster, R. B., O'Brien, S. T., Harms, K. E., Condit, R., Wright, S. J. and Looda, L.S. (1999).Light-gap disturbances, recruitment limitation and tree diversity in a Neotropical forest. *Science*, 283: 554–557.

Hussain, W., Badshah, L., Ullah. M., Ali, M., Ali, A. and Hussain, F. (2018).Quantitative study of medicinal plants used by the communities residing in Koh-e-Safaid Range, northern Pakistani-Afghan borders. *Journal of Ethnobiology and Ethno medicine. 14:30.*

Huston, M.A. (1979). A general hypothesis of species diversity. – American *Naturalist* 113: 81-101.

Huston, M.A. (1994).*Biological Diversity*. Cambridge University Press, Cambridge.
IUCN (2014) The IUCN red list of threatened species, version 2014.1. IUCN Red List Unit, Cambridge U.K. Available from: http://www.iucnredlist.org/(accessed: 28 June. 2014).

Ingram, C.J., Whittaker, R.J. and Dawson, P.T. (2005).Tree Structure and Diversity in Human-Impacted Littoral Forests. *Journal of Environmental Management*, 35: 779–798.

Inngierdingen, K., Nergard, C.S., Diallo, D., Mounkoro, P.P.and Paulsen, B.S. (2004).An Ethnopharmacological survey of plants used for wound healing in Dogonland Mali, West Africa.*Ethnopharmacoloy*, 92; 233-244.

Israel, G. D. (1992). *Sampling The Evidence Of Extension Program Impact*. Program Evaluation and Organizational Development, IFAS, University of Florida. PEOD-5. October.

Jaeger, R. M. (1988). *Survey Methods in Educational Research*. Washington D.C.: Brooking Institution Press.

Jew, E. K.K., Dougill, A. J., Sallu, S. M., Connell, J. O and Benton, T. G. (2016). Miombo woodland under threat: Consequences for tree diversity and carbon storage.

Joudi .L and Habibi B. G. (2010). Exploration of medicinal species of Fabaceae, Lamiaceae and Asteraceae families in llkhji region, Eastern Azarbaijan Province (Northwestern Iran). J. *Med. Plants Res*., 4: 1081-1084.

Keay, R.W.J., Onochie, C.F.A. and Stanfield, D.P. (1989). Trees of Nigeria: a revised version of Nigeria trees vols 1 and 2. National Press Ltd, Apapa Lagos. Published by the Department of Forestry Research Institute, Ibadan.

Kent, M. and Cocker, P. (1992). Vegetation Description and Analysis: A practical approach. Belhaven Press, London.

Kenya Forest Service. (2010a). Destruction in Lembus forest by East African Standard; a KFS publication available on the web-site.

Kenya Forest Service. (2010b). General Order No. 260; a KFS publication available on the KFS web-site.

Kenya Forest Service. (2015a).Chemususu participatory Forest management plan 2015-2019).

Kenya Forest Service. (2015b).Chemususu-Chermorgok plantation management plan 2015-2025)

Kenya Law Report. (2013).Director Kenya Forest Services & another. Pg. 8-14 http://www.kenyalaw.org

Kerlinger, F. N. (1973). *Foundation of behavioral science.* New York: Holt, Renehard and Winston.

Kigen, G. Some, F. Kibosia, J. Rono, H. Kiprop, E. *et al.* (2014). Ethnomedicinal Plants Traditionally Used by the Keiyo Community in Elgeyo Marakwet County, Kenya. J Biodivers Biopros Dev 1: 132.

Kimaro, J. and Lulandala, L. (2013). Human Influences on Tree Diversity and Composition of a Coastal Forest Ecosystem. Hindawi Publishing Corporation International *Journal of Forestry Research Volume 2013, Article ID 305874, page7* http://dx.doi.org/10.1155/2013/305874 , retrieved on March 2016

Kimokiy K. (2007). List of Medicinal Plants Used by Communities Living around the Lembus Forests. Eldama Ravine, Kenya.

Kimutai, D. K and Watanabe.T. (2016). Forest-Cover Change and Participatory Forest Management of the Lembus Forest, Kenya. Pg 16,31.

Köhler, J. (2004). Biodiversity in conversion: The influence of fragmentation and disturbance on the biodiversity of East African highland rain forests, in: BIOTA East Africa, Final report phase I: 2001 – 2004.Pg 6.

Kokwaro, J.O. (1988), Conservation status of the Kakamega Forest in Kenya: The eastern most relic of the equatorial rain forests of Africa, Monographs in Systematic Botany from the Missouri Botanical Garden, 25: 471-489.

Kpontsu, E. A. (2011). Patterns of woody plant species richness, diversity and structure a long a disturbance gradient in the Atiwa Range Forest Reserve, Eastern Region, Ghana. Pg. 36, 49.

Krebs, C.J. (1989). *Ecological Methodology*. New York: Hamper Collins Publishers, P. 654.

Krejcie, R.V. and Morgan, D.W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement*, *30*, 607-610.

Kutsch, W.L., Merbold, L., Ziegler, W., Mukelabai, M.M., Muchinda, M., Kolle, O., Scholes, R.J. (2011). The charcoal trap: Miombo forests and the energy needs of people. Carbon Balance Manage. Pg 5-6.

Kwit, C. and Platt, W.J. (2003): Disturbance history influences regeneration of non-pioneer under storey trees. – Ecology 84(10): 2575-2578.

Lalfakawma, U. K., Sahoo, S., Roy, K. and Vanlalhriatpuia, P. C. (2009). Community Composition and tree population structure in undisturbed and disturbed tropical semi-evergreen forest stands of North-East India. *Applied Ecology and Environmental Research,* 7: 303-318.

Langat, D., Maranga, E.K., Cheboiwo, J. and Aboud, A.A. (2015).Forest use and Dependence by forest adjacent households on East Mau forest ecosystem, Kenya. *Journal of Agricultural Economics, Extension and Rural Development: ISSN-2360-798X, Vol. 3(10): pp 326-337.*

Lawton, J.H., Bignelle, D.E., Bolton, B., Bloemers, G.F., Eggleton, P., Hammond, P.M., Hodda, M., Holt, R.D., Larsen, T.B., Mawdsley, N.A., Stork, N.E., Srivastava, D.S. and Watt, A.D. (1988). Biodiversity inventories, indicator taxa and effects of habitat Modification in tropical forest. Nature 391, 72-76.http://dx.doi.org/10.1038/34166.

Magurran, A.E. (1988). *Ecological Diversity and its measurement*. Princeton University Press, Princeton.

Martin, G. J., (1995). *Ethnobotany: A Methods manual*. Chapman and Hall. London.

Mathu. W. and Ng'ethe R.K. (2011). Forest plantations and woodlots in Kenya. African Forest Forum Working Paper Series, Vol.1 Issue 13, 2011, Nairobi, Kenya. P 9.

Matiru. V. and Osur. J. (2008).The Link between HIV/AIDS and the Environment-IUCN. pp. 9, https://cmsdata.iucn.org/downloads/hiv aids and environment_1.pdf retrieved on February 2016

Maundu, P., Berger, D.J., ole Saitabau, C., Nasieku, J., Kipelian, M., Mathenge, S.G., Morimoto, Y. and Höft, R. (2001). *Ethnobotany of the Loita Maasai: Towards Community Management of the Forest of the Lost Child - Experiences from the Loita Ethnobotany Project.* People and Plants working paper 8.UNESCO, Paris.

Maundu. P and Tengnäs. B. (2005).Useful trees and shrubs of Kenya. Technical handbook No 35.Nairobi Kenya: World Agroforestry Centre-Eastern and Central Africa Regional Programme (ICRAF-ECA).

Meijaard, E., Sheil, D., Nasi, R. and Stanley, S.A. (2005). *Life After Logging: Reconciling Wildlife Conservation and Production Forestry in Indonesian Borneo.* CIFOR, Bogor.

MEF (2018). Taskforce Report on Forest Resources Management and Logging Activities in Kenya. Nairobi Kenya Pg. 4, 31,49.

MENR (1994). ‘A 25 year Master Plan for Forestry sector Development in Kenya’ Kenya Forestry master plan (KFMP) Development Programmes Ministry of Environment and Natural resources Forest Department Headquarters Nairobi.

Mitchell, N. (2004). The exploitation and disturbance history of Kakamega Forest, Western Kenya, BIOTA East Report No. 1, Bielefelder Ökologische Beiträge, Band 20, Bleher, B. & Dalitz, H. (eds.)

Mozaffari, N. A.S. (2010). *Study of Eucalyptus pharmaceutical and nutritional effect. National Conference of Medicinal and Aromatic Plants, Varamin - Iran, p.* 140.

Nowak D. J. and Crane D. E. (2002). Carbon storage and sequestration by Urban trees in USA. Environmental Pollution 116:381-389.

Nowak D. J., Hoehn R. and Crane D. E. (2007). Oxygen production by urban trees in United.

Nyariki, D.M., Kinyua, P.I.D. and Wasonga, V. (2007). A comparative study of commercial consumptive and non-consumptive utilization options for wildlife conservation strategies in Kenya, IFAW. ISBN 9966-7229-1-2.

Omeja, P., Obua J. and Cunningham, B. (2004). Regeneration, density and size class distribution of tree species used for drum making in central Uganda. *African Journal of Ecology*, 42, 129–136.

Ongong’a, I. and Sweta, L.A. (2014).Land Cover and Land Use Mapping and Change Detection of Mau Complex in Kenya Using Geospatial Technology. *International Journal of Science and Research (IJSR)*. University of Nairobi, Nairobi, Kenya.

Orodho, A. J. (2003). *Essentials of education and social science research methods*. Nairobi. Kenya: Pauline Publishers.

Oyugi, J.O. (1996) Kakamega Forest is dying, EANHS Bulletin, Vol. 26: 3-4.

Oyugi, O.J., Brown, S. J. and Whelan, J.C. (2007). Effects of Human Disturbance on Composition and Structure of *Brachystegia* Woodland in Arabuko-Sokoke Forest. *African Journal of Ecology*, 46: 374–383.

Palit, D., Pal, S., and Chanda, S. (2012). Diversity and richness of plants in Darjeeling Himalaya with an eye on Gaddikhana forest beat, Senchal east zone forest range, Darjeeling. *Indian Journal of Forestry* 35: 39–44.

Peters, C. M. (1996). The ecology and management of non-timber forest resources. World Bank Technical Paper number 322.

Pickett, S.T.A. (1980). Non-equilibrium coexistence of plants. – Bulletin of Torrey Botanical Club 107: 238-248.

Pickett, S. A. (1995). Drivers and dynamics of change in biodiversity, in *Global Biodiversity Assessment*, V. H. Heywood and R.T. Watson, Eds., pp. 311–318, United Nations Environment Programme, Cambridge, UK.

Pinard, M. A. and Putz. E. (1996). Vine infestation of large remnant trees in logged forest in Sabah Malaysia: *Biomechanical facilitation in vine succession. Journal of Tropical Forest Science 6: 302-309.*

Popradit, A., Srisatit, T., Kiratiprayoon, S., Yoshimura, J., Ishida, A., Shiyomi, M., Murayama, T., Chantaranothai, P., Outtaranakorn, S. and Phromma. I. (2015). Anthropogenic effects on a tropical forest according to the distance from human settlements.

Putz, F.E., Redford K.H., Robinson J.G., Fimbel, R. and Blate, G.M. (2000). Biodiversity Conservation in the Context of Tropical Forest Management. The World Bank Environmental Department, Washington DC. Rahbek C. The role of spatial scale and the perception of large-scale species-richness patterns. *Ecology Letter* 2005; 8:224-239.

Purohit, A., Maikhuri, R. K., Rao, K. S. and Nautiyal, S. (2001). Impact of bark removal on survival of *Taxus baccata* L. (Himalayan yew) in Nanda Devi Biosphere Reserve, Garhwal Himalaya, India.

Rands,M.R.W.,Adams,W.M.,Bennum,L.,Butchart,S.M.,Clements,A.,Coomes,D. and Vira, B. (2010).Biodiversity conservation Challenges beyond 2010.*Science* 329 (5997):1298-1303.

Rannie, W.F. (1986). Summer air temperature and number of vascular species in arctic Canada. *Arctic* 39: 133– 137.

Repetto, R. (1990). *Deforestation in the Tropics*. Scientific American April, pp. 37.

Republic of Kenya. (2009).*Report of the Government's Task Force on the Conservation of the Mau Forests Complex.* Nairobi: Government Printer, pp 75.

Richards, P.W. (1996).*The tropical rain forest: an ecological study*. - Second edition. Cambridge University Press, London. Concern. In: *Managing the world's forest: looking for balance between conservationand developments*, ed. Sharma, N. P. pp 33-46. Kendall/Hunt Publishing Company, Iowa.

Ronoh, L.K. (2016). An assessment of effects of human activities on vegetation characteristics in Chepalungu Forest; Bomet County, Kenya. Pg 122,124.

Sah, S.P. and Dutta, I. C. (1996). Inventory and Future management strategies of MPTS for Non-timber forest products (NTFPs) in Nepal. Leaky RRB, Temu AB, Melney K, Vantomme P (eds). Domestication and Commercialization of NTFPs in Agroforestry systems. FAO Non Wood Forest Products series. 9:1-297.

Sassen, M. and Sheil, D. (2013). Human impacts on forest structure and species richness on the edges of a protected mountain forest in Uganda.

Saxena, A.K and Singh, J.S. (1984). Tree population structure of certain Himalayan forest associations and implications concerning their future composition. *Vegetation* 58: 61–69.

Sedano, F., Silva1, J. A., Machoco, R., Meque, C.H., Sitoe, A., Ribeiro, N., Anderson, K., Ombe, Z.A., Baule, S.H. and Tucker, C.J (2016). The impact of charcoal production on forest degradation: a case study in Tete, Mozambique.

Seth, M. K. (2004). Trees and their economic importance. *The Botanical Review* 69 (4): 322-324.

Shearman, P. L., Ash, J., Mackey, B., Bryan, J. E. and Lokes, B. (2009).Forest Conversion and degradation in Papua New Guinea 1972–2002. *Biotropica*, 41, 379-390.

Singh, A. and Singh P.K. (2009). An ethnobotanical study of medicinal plants in Chandauli District of Uttar Pradesh, India. *Journal of Ethnopharmacology* 121: 324-329.

Sist, P., Nolan T., Bertault J. G. and Dykstra.D. (1998). Harvesting intensity versus sustainability in Indonesia. *Forest Ecology and Management* 108: 251-260.

Sist, P., Sheil, D., Kartawinata, K. and Priyadi, H. (2003). Reduced impact logging in Indonesian Borneo: some results confirming the need for new silvicultural prescriptions. *Forest ecology and Management* 179:415-427.

Spector, S. and Forsyth, A.B. (1998). Indicator taxa for biodiversity assessment in the Vanishingtropics. *In:* Mace, G. M., Balmford, A., Ginsberg, J.R. (ed.) *Conservation in a changing world.* Cambridge University Press, Cambridge.

Speed, J. D. M. (2010). Plant community properties predict vegetation resilience to herbivore disturbance in the Arctic. *Journal of Ecology, Issue 5.* Pp 1002-1013.

Swain, S. and Mohapatra, G.C. (2013). Multiple usages of forest trees by the tribes of Kalahandi District, Orissa, India. *International Journal of Biodiversity and Conservation Vol. 5(6), pp. 333-341*. DOI: 10.5897/IJBC11.129 ISSN 2141-243X Academic Journals, http://www.academicjournals.org/IJBC

Terborgh, J. (1992). Maintenance of diversity in tropical forests. *Biotropica*, 24: 253–292.

Togola, A.T., Diallo, D.S., Barsett, H. and Paulsen, B.S. (2005).Ethnopharmacological Survey of different uses of seven medicinal plants from Mali, (West Africa) in the regions Doila, Kokokani and siby.*Ethnobiology and Ethnomedicine*, 1:7.

Todaria, N. P., Uniyal, P., Pokhriyal, P., Dasgupta, S. and Bhatt, D. (2010). Plant Diversity in two forest types along the disturbance gradient in Dewalgarh Watershed and Garhwal Himalaya. India, Garhwal University. Thesis CURRENT SCIENCE, VOL. 98, NO. 7.

Turner, N. (1988). The importance of a rose: Evaluating the cultural significance of plants in Thompson and Lillooet Interior Salish. The American Anthropologist 90: 272-290.

Udo, E. S. (2001). The position of forestry in Awa Ibom State. *In*: Udo, E. S. (ed.). Proceedings of the 1st workshop of the Forestry Association of Nigeria Akwa Ibom State Branch in collaboration with the Department of Forestry and Wildlife, University of Uyo, State Ministry of Environment and the UNDP, Akwa Ibom State held in Uyo, Akwa Ibom State between 10th and 11th April 2001. Pp 31-43.

Unni B.G., Borah, A., Wann, S.B., Singh H.R., Devi .B. and Bhattacharjee, M. (2009). Phytochemical and antibacterial study of traditional medicinal plants of Northeast India on Escherichia coli. *Asian J. Exp. Sci*. 23:103-108.

Veblen, T. and Lorenz, D. (1987). Post-fire stand development of *Austrocedrus-Nothofagus* forests in northern Patagonia.*Vegetation.*71: 113-126.

Vuyiya, E., Konje, M., Tsingalia, H., Obiet, L., Kigen, C., Wamalwa, S. and Nyongesa, H. (2014). The impacts of human activities on tree species richness and diversity in Kakamega Forest, Western Kenya. *International Journal of Biodiversity and Conservation, Vol6 (6).PP428-435,* http://www.academicjournals.org/IJBC

Whitmore, T.C. and Sayer, J.A. (1992).*Tropical Deforestation and Species Extinction*. Chapman and Hall, London.616:428-435.

Wright, S. J. (2005) .Tropical forests in a changing environment. *Trends in Ecology and Evolution*, 20**,** 553-560.

Wright, S. J. (2010).The future of tropical forests. *Annals of the New York Academy of Sciences*, 1195**,** 1-27.

WWF-SARPO. (2001). *Conserving the Miombo Eco-region*. Reconnaissance Summary pp. 2. WWF-Southern Africa Regional Programme Office, Harare, Zimbabwe.

APPENDICES

Appendix 1: Table for Determing Sample Size from a Given Population

N	**S**	**N**	**S**	**N**	**S**
10	10	220	140	1200	291
15	14	230	144	1300	297
20	19	240	148	1400	302
25	24	250	152	1500	306
30	28	260	155	1600	310
35	32	270	159	1700	313
40	36	280	162	1800	317
45	40	290	165	1900	320
50	44	300	169	2000	322
55	48	320	175	2200	327
60	52	340	181	2400	331
65	56	360	186	2600	335
70	59	380	191	2800	338
75	63	400	196	3000	341
80	66	420	201	3500	346
85	70	440	205	4000	351
90	73	460	210	4500	354
95	76	480	214	5000	357
100	80	500	217	6000	361
110	86	550	226	7000	364
120	92	600	234	8000	367
130	97	**650**	**242**	9000	368
140	103	700	248	10000	370
150	108	750	254	15000	375
160	113	800	260	20000	377
170	118	850	265	30000	379
180	123	900	269	40000	380
190	127	950	274	50000	381
200	132	1000	278	75000	382
210	136	1100	285	1000000	384

Note.—***N*** is population size.
S is sample size. (Krejcie and Morgan, 1970)

Appendix 2: Research Authorization Letter from the University

KENYATTA UNIVERSITY
Department of Plant Sciences
P.O. Box 43844
Nairobi, Kenya
Tel: 8710901/8711278
Ext. 57177
Email – chairman-pms@ku.ac.ke

16th March, 2016

The County Forest Officer
Kenya Forest Service
Baringo County

Dear Sir/Madam,

RE: INTRODUCTORY LETTER FOR MOROGO HOSEA KIPKOECH – I56/CE/28501/2013

This is to confirm that the above named person is a Master of Science (Plant Ecology) student in this Department. He has successfully completed his coursework. Mr. Morogo has already written and presented his proposal on Diversity and Abundance of Trees in Chemususu Forest Block of Lembus Forest. He requires to access the forest for the purpose of his data collection.

This is to request that you accord him the necessary assistance to enable him carry out his research work.

KENYATTA UNIVERSITY
P.O. BOX 43844 - 00100 NAIROBI
16 MAR 2016
DEPARTMENT OF PLANT SCIENCES

DR. OMBORI OMWOYO
CHAIRMAN, DEPARTMENT OF PLANT SCIENCES

OO/gk

Appendix 3: Cover letter

KENYATTA UNIVERSITY

Key Informants Interview guide

Introduction

Dear sir/ madam

I am a Master of Science student from Kenyatta University conducting research on human impacts on the diversity and abundance of trees in Chemususu forest block of Lembus forest, Baringo County. This questionnaire has been prepared to gather information which shall be applied purely for academic study. You have been selected to participate in this study, and your contribution is highly appreciated. Kindly answer each of the questions to the best of your ability. You are hereby assured that the information provided will be treated with confidentiality and any images or photographs captured and obtained during this field work are only to serve none other than academic purposes. You are highly welcomed to this interview which will last between 25 to 30miutes of your time.

Thank you

Hosea Kipkoech Morogo
Department of Plant Sciences
School of Pure and Applied Sciences
Kenyatta University, Nairobi
Research student
Email: morogoh@gmail.com

Appendix 4: Questionnaire

QUESTIONNAIRE

Questionnaire No………...….Time………………………...Interview date ………………

Part I: Socio-Demographic Information

1. Kindly tick as appropriate in the tables below: (√)

a) Gender of the respondent

Gender	1.Male	2.Female

b) Age of the respondent

Coding	**Age bracket**	**Please tick (√)**
1.	18-30	
2.	31-45	
3.	46-59	
4.	Above 60	

(c) Educational level of the respondent. Please tick (√)

Coding	**Educational level**	**Please tick (√)**
1.	None	
2.	Primary	
3.	Secondary	
4.	Vocational/technical	
5.	College/ university	
6. Other. (Specify)		

Part II: Background of Chemususu Forest.

2. a) How long have you been staying here (years)? Please tick (√)

(1). 0 - 4 [ ] (2). 5 – 9 [ ] (3). 10 - 14 [ ] (4). 15+ [ ]

b) What was the state of the forest reserve as at that time? Please tick (√)

(1).Degraded [ ] (2).Moderately Degraded [ ] (3) Not degraded at all [ ] (4). I have no idea [ ]

c) What is the state of the reserve as at now? Please tick (√)

(1). Degraded [ ] (2).Moderately Degraded [ ] (3) Not degraded at all [ ] (4). I have no idea [ ]

3. If there is any change what do you attribute the change to. Please tick (√)

(1). Over harvesting and Grazing [ ] (2). Timber extraction [ ] (3). Charcoal burning [ ]

(4) Medicinal [ ] (5) Other (s) specify...

....

Part III. Individual involvement in forest activities.

4. a) Have you ever been involved in any form of activities in Chemususu forest? Please tick (√)

(1). Yes [ ] (2) No [ ]

If yes specify

…………………………………………………………………………………...

…………………………………………………………………………….......

b) How long were you involved in this activity (in years)? Please tick (√)

(1) 0 - 4 [ ] (2) 5 – 9 [ ] (3) 10 – 14 [ ] (4) 15 + [ ]

c) Was your activity in anyway detrimental to the forest? Please tick (√)

(1). Yes [ ] (2) No [ ]

Give reasons for your answer…………………………………………………………........

…………………………………………………………………………………………………

…………………………………………………………………………………………………

Part IV: Ethnobotanical uses of forest trees species to the local community in Chemususu Forest

5. a) The table below shows Ethnobotanical uses and services obtained from trees, The sources can vary from forest, farmlands or any other. Please confirm the sources you obtain them from by indicating

1. for Forest.

2. for Farmland.

3. for Other.

Ethnobotanical uses/Services	Forest	Farmland	Other
For firewood			
Charcoal			
For hunting			
Bee keeping			
Tourism /For recreation/			
For timber and poles			
For herbal medicine			
Food and fruits			
To protect water quality			
Spiritual and Cultural purposes			
For any other reason(s) (Specify)			

b) The table below gives the names of trees found in Chemususu forest. Please give the uses of the trees that you know and indicate part used for medicinal plants only.

Local name	**Uses**	**Part used(medicinal plants only)**

Any other comment...

....

....

THANK YOU