EFFECTS OF COMMUNITY FOREST ASSOCIATION ON MANAGEMENT, CONSERVATION AND UTILIZATION OF FOREST RESOURCES IN NORTH NANDI FOREST, KENYA

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(Conservation Option)

BY

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APPROVAL SHEET

This thesis entitled: **Effects of community forest association on management, conservation and utilization of forest resources in North Nandi Forest, Kenya,** written and submitted by Muskiton Kenneth Chepkonga, in partial fulfillment of the requirements for the degree of Master of Science in Biological Sciences (Conservation Option), is hereby accepted and approved.

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DECLARATION

DECLARATION BY THE CANDIDATE

This thesis proposal is my original work and to the best of my knowledge this work has not been published and/or presented to any University for an award of a degree.

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DECLARATION BY THE SUPERVISORS

This thesis proposal has been submitted for examination with our approval as University supervisors.

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ABSTRACT

A key feature of forest conservation and management is the practice of Participatory Forest Management (PFM). In PFM there is inclusion and collaboration with the local community members in managing and conserving forest resources mostly through the adjacent forest community, commonly referred to as Community Forest Association '(CFA)'. However, to date, most of the objectives of CFA on achieving management and conservation of forest resources are rarely met. This study assessed the effects of community forest association on management and conservation of plants, mammals and birds with a specific focus on local community sustainable forest utilization, forest structure, status of threatened biodiversity (plants and animals) conservation in North Nandi Forest. A Stratified systematic sampling method was employed to capture the relevant data. The study surveyed mammals' abundance using straight and parallel transects. Transects were 500m long with sample plots laid at an interval of 100 m and 60 m from the edge of each habitat. To determine the structure of the forest, tree diameters, and tree heights were measured and the total number of trees in the sample plots were counted along each transect line. Removal of forest produce along the transect lines was also noted during sampling. To determine the utilization of plants, a household survey was carried out on the households within the sampling sites. Primary data was collected using questionnaires as well as holding discussions with focus groups and key informants. To determine sustainable utilization of forest resources, data was analyzed using frequency distributions and percentages. The Ordination was used to examine spatial patterns in forest structure, animal as well as plant abundance relative to human variables highlighted by the CFA. Joint forest management between the government and the community, use of sensitization meetings through barazas, workshops or conferences, the involvement of indigenous people within and outside the forest and the use of county and national government policies to support the conservation and protection of North Nandi Forest were the most significant strategies for the forest management and protection. The study found out that monkeys (mammals), and Hornbills (birds) were the most dominant species in all the forest sites. This is an indication that both colobus and black monkeys inhabit North Nandi Forest. Large trees such as *Olea capensis, Fagaropsis angolensis, Celtis africana, Cassipourea malosana, Syzygium cordatum*, *Diospyros abyssinica* and *Croton megalocarpus* were illegally exploited for fencing posts, timber, fuelwood and herbal medicine. These illegal activities have reduced the number of these trees in the forest leaving invasive saplings such as *Cestrum aurantiacum* and *Solanum mauritianum* to take over large areas of the forest. From the analysis it is s recommended that well thought out policies on expansion of land for agriculture and other development activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber need to be put in place by both the national and county governments. In addition, there is need for strategies of controlling invasive plant species in North Nandi Forest. It is anticipated that the findings of this study will contribute to the development of recommendations for forest conservation interventions in Kenya.

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LIST OF ABBREVIATIONS AND ACRONYMS

CBD: Convention on Biological Diversity

CBFC: Community-Based Forest Conservation

CBFM: Community-Based Forest Management

CBNFRM: Community-Based Natural Forest Resource Management

CF: Community Forest

CFA: Community Forest Association

CFM: Community Forest Management

DBH: Diameter at Breast Height

FAC: Forest Adjacent Communities

FAO: Food and Agriculture Organization

GPS: Global Positioning System

ICCN: International Convention on Conservation of Nature

IUCN: International Union for Conservation of Nature

IVI: Important Value Index

KFS: Kenya Forest Service

KFWG: Kenya Forest Working Group

NWFP: Non-Wood Forest Product

PCA: Principal Component Analysis

PFM: Participatory Forest Management

PFM: Participatory Forest Management

SFM: Social Forestry/Forest Management or Sustainable Forest Management

TSC: Timed Species Counts

CHAPTER ONE

INTRODUCTION

Background of the Study

Forests supply energy, construction materials, can be sources of food and medicines (Karki and Chowdhary, 2019; Sheppard *et al.*, 2020). Accompanying these direct resource needs is the ecosystem services provided by forests such as water catchments functions, soil fertility enhancement, amelioration of climate and carbon budgets (Baig *et al.*, 2019; Higginbottom *et al.*, 2019; Hong and Saizen, 2019). Moreover, the rural dwellers that are poor in resource base rely on forest resources for livelihood sustenance. In this aspect, approximately 300 million people globally, mostly from developing countries of Africa depend largely on forest resources for their subsistence (Arfin-Khan and Saimun, 2020).

As a result of the continued use and increasing demands of forest resources, forest utilization has reached an alarming level of over-exploitation especially by the adjacent forest dwellers (Sedano *et al.*, 2016; Szulecka, 2019; Ceccherini *et al.*, 2020; Watanabe, 2020). Poor governance contributes to a substantial decline of forest resources through exploitation or unsustainable over-use of resources including the floral and faunal biodiversity (Mitchell *et al.,* 2006). There is a consensus that the management of these forests needs to focus on the local community members (Kimutai and Watanabe, 2016).

Worldwide, participation or involvement of the local communities to manage forest resources is gaining increasing significance over the years (Maraseni *et al.*, 2019; Apipoonyanon *et al.*, 2020) and is currently identified as a successful approach in the management of forest sources (Akamani and Hall, 2019). It is becoming obvious that for forests to be sustainably managed, the Forest Adjacent Communities (FAC) should be incorporated into the management decision-making processes and including subsequent action plans on the adjacent forest landscapes (Volker, 2020). There is overwhelming evidence of engaging communities living adjacent to the forest in Africa and Asia, in advancing and managing neighbouring forests under Participatory Forest Management (PFM) arrangement (Kabir *et al.*, 2019; Nzau *et al.*, 2020). The process and mechanisms of PFM enable stakeholders of the forest ecotones to be included as part of the decision-makers in managing the forest resource (Wood *et al.*, 2019; Walle and Nayak, 2020). Most of the PFM has been practiced through the Community Forest Associations (CFAs).

In several countries of Sub Saharan Africa which mostly have large parts of their forest surrounded by local communities, the role of CFA has been highlighted as core in the management of the forest resource for almost three decades (Okumu and Muchapondwa, 2020a). This has been accomplished in several ways but the main one involves the members of the local forest community entering a formal corporation with single or several bodies including the government through formally registered CFAs (Laura *et al.*, 2020). The underlying principle for participating in forest management through local community partnerships is based on the underlying assumption that shared resources leads to collective prosperity (Kahsay and Bulte, 2019). The local community members in such forms of partnerships have certain alienable freedoms that may see them sustainably utilize and manage their adjacent forest resources (Sungusia *et al.*, 2020) subjects to minimize conflicts with the resources under their custody (Sarkki *et al.*, 2019; Tiwary, 2019).

The CFA is supposed to ensure that by regulating the utilization of forest resource, they allow for proper forest growth and generation even if the forest resources are being harvested and used (Sarkki *et al.*, 2019). In several countries, the CFA educate the local community members on the dangers of illegal cutting down of trees, encourage them to collect firewood that has just fallen from the main trees and to ensure they don't interfere with the ecological processes of the forests (Boiyo, 2019; Wegi and Eshetu, 2019). This is to ensure that there is the maintenance of the best forest structures that will ensure optimal forest production of resource (Kasim and Hussen, 2019; Wood *et al.*, 2019; Apipoonyanon *et al.*, 2020).

The key function of CFA is to ensure sustainability in the utilization of forest resources (Kayama and Himmapan, 2017; Lefèvre *et al.*, 2020). The forests are capital resources that the current generation should sustainably manage for future generations (Rahimian and Irvani, 2017). Inappropriate use of these resources may endanger the interests of future generations (Zheng, 2017; Wendiro *et al.*, 2019). Sustainable forest utilization is geared towards maintaining the health and vitality of forest ecosystems and, thereby, for maintaining their protective future roles (Siry *et al.*, 2018; Uisso *et al.*, 2019). Thus sound utilization of tree-plant resources should encompass biological diversity such as forest genetic resources, plant resources, as well as animal resource within the forests (Poudyal *et al.*, 2020).

Forest structure should be considered to enhance forest management (Shiferaw *et al.*, 2018) and looks at the distribution of individual plants relative to interactions with a process in the ecological conditions in space and time (Melin *et al.*, 2016). Forest structure may be a pointer of flora and fauna complexity and a substitute for ecosystem health (Hudak *et al.*, 2016; Camarretta *et al.*, 2020). The influence of forest structure on forest growth, forest productivity, species diversity, ecological processes, and ecosystem function is widely recognized (Cazcarra-Bes *et al.*, 2017) and drives the forest overall ecosystem (Savage *et al.*, 2018). To understand the forest ecosystem, forest growth indicators that include tree diameters, heights and volume measurements are required (Feng *et al.*, 2016; Hui *et al.*, 2019). The overall aim of understanding forest structure lies in improving forest diversity and quality (Lucas-Borja *et al.*, 2016).

Forest biodiversity help in preserving the ecosystem multifunctionality and ecological roles (Joa *et al.*, 2018; Arroyo-Rodríguez *et al.*, 2020). Therefore forest biodiversity stocks should be incorporated in forest management plans, to ensure proper ecosystem functions (Rahman *et al.*, 2016; Kumar *et al.*, 2020). CFAs play an integral role in the conservation and management of forest ecosystem biodiversity from over-exploitation by the local community members (Foncha and Ewule, 2020). Proper forest management activities are supposed to help in the efforts aimed at conserving biodiversity through a variety of strategies for example involvement of community members (Asmin *et al.*, 2019). The forest management guidelines will also help in conserving values and species deemed rare, sensitive, and “at- risk” (Poudyal *et al.*, 2019).

In several forests which have avian life, there are opportunities that allow for CFA to help in the conservation of birds (Corace, 2018). The birds have a more prominent role to play in forest ecosystems and therefore the increased needs for local community participation to conserve them (Ram *et al.*, 2020). It is now widely recognized that, any negative impact or change in the habitat affects birds profoundly in a restricted range as well as those that are forest specialists (Augustynczik *et al.*, 2019; Tellería, 2019). The main effect of poor management of the forest resources may have a significant effect on the population structure and vulnerability of birds and mammals, which exposes them to human interfaces (Betts *et al.*, 2018; Mikusiński *et al.*, 2018). However, in many countries of Sub-Saharan Africa, much is not known of how the CFAs affect the population of birds in the forest habitats.

In Kenya, the North Nandi Forest was gazetted vide proclamation no.76 of 1936 and declared a central government forest vide legal notice no. 174 of 20th May 1964 and covers an area of 11,845.41 Ha (Maua *et al.*, 2020). A total area of 1,345.41 Ha has been de-gazetted and hived off for allocation to individual resident in the area. In the remaining 10,500 Ha of the forest area, 8,000 Ha consist of indigenous closed-canopy while the rest is under wetlands, grasslands, plantation and tea belts (Wachiye *et al.*, 2013). The area is important for flora and fauna including avian biodiversity. The forest was delineated as one of the areas that need conservation efforts by involving the CFAs (Gichuki and Schifter, 1990). However, not much is known as far as CFA and conservation efforts in the forest are concerned.

Statement of the Problem

North Nandi forest in Nandi County has faced increased human population and weak environmental regulations enforcement in the past leading to over-exploitation and unsustainable utilization of forest resources (Njunge and Mugo, 2011). The scenario can be managed by improving governance and addressing the legitimate needs of the people, and seeing them actively engage in forest management. In Kenya, endeavours to manage forests in the past have partly failed to be associated with the importance of Forest Adjacent Communities (FAC). Currently, there is very little information known about how CFA affect the utilization and sustainable forest management of forest resources in North Nandi Forest. Moreover, the perception of the non-CFA members critiquing legally registered CFAs on inadequate participatory forest management objectives has not been adequately addressed. Additionally, there is a lack of information on the perceptions and attitudes of the local communities towards participation in the management and conservation of forests. Similarly, conserving biodiversity including plants, mammals and birds species of the forest resources relies on the KFS but due to the vast nature of the forest, this role cannot be adequately addressed by the KFS alone. The communities living in areas adjacent to the forest through their CFA have often had limited access to the forest and if they are not involved in biodiversity conservation, then some of the rare, threatened or at-risk plants and mammals may be over-exploited leading to extinction. However, in North Nandi Forest, there are currently no studies that have evaluated how CFA can help in the conservation of biological resources in the forest.

Research Objectives

Broad Objective

The main objective of the study was to determine the effects of community forest association on management, conservation and utilization of forest resources in North Nandi Forest, Kenya.

Specific Objectives

i. To evaluate the influence of CFA on local community sustainable forest utilization in North Nandi Forest
ii. To examine the role of CFA on forest structure in North Nandi Forest
iii. To evaluate the impact of CFA on mammal biodiversity conservation in North Nandi Forest
iv. To establish the influence of CFA on bird biodiversity conservation in North Nandi Forest.

Research Questions

I. What influence does CFA have on local community sustainable forest utilization in North Nandi Forest?
II. What role does CFA play on management of forest structure in North Nandi Forest?
III. What is the impact of CFA on mammal biodiversity conservation in North Nandi Forest?
IV. What influence does CFA have on bird biodiversity conservation in North Nandi Forest?

Hypotheses

H_{01}: CFA has no significant influence on local community forest utilization in North Nandi Forest

H_{02}: CFA has no significant influence on the forest structure in North Nandi Forest.

Significance of the Study

The study will provide information and insights on the management of forests under the jurisdiction of National and County Governments. The entire ministry of environment and forestry will benefit from the findings of this study in formulating policies which will help evade the challenges hindering forest conservation. This study will also help private forest owners on how they can better conserve their forests. It will enlighten community forest associations on how they can better perform their duties on forest conservation. Lastly, this study comes as a stepping stone for researchers who wish to conduct research on forest resource conservation in Nandi County.

Justification of the Study

Although there are a number of studies focusing on CFAs in many adjacent forests, there is scanty information on their activities that conserve biodiversity. Currently, there are no studies that have evaluated how CFA help in the conservation of biological resources in North Nandi Forest, therefore this study will be of great benefit.

The study will provide scientifically based information that will inform the participation of the local community members in the sustainable management of forests. The findings of the study will also allow the local communities improve their livelihoods and relationships with the adjacent forest which will also reduce perennial conflicts.

Recommendations derived from the findings of this study will help in forest biodiversity conservations which may improve the population of the endangered mammal species such as antelopes and encourage the growth of the rare plant species such as *Olea capensis.* Conservation of biodiversity will also result in additional benefit to international conventions such International Convention for Conservation of Nature (ICCN). All these will help to better policies to facilitate more- balanced participatory forest management.

Theoretical Framework

This study used the "common property rights theory" as an underpinning model to highlight the role of CFAs in the sustainability and management of forest. The theory applies to the power to carry out actions relative to a specific realm. Common property connotes a conspicuous conglomeration of regulatory and managerial practices which are made collectively (Amanor, 2003). It allows the recognition of forest as a resource for open access use under the common tenureship of the society. The rights can be classified into the following sets, namely; - nature/kinds, vested individual/groups, and the social norms/values of the property (Bromley, 1989). Different actors can have defined forests rights based on societal or social settings. The term common property rights connote an explicit explanation of the kind of tenure enjoyed by an individual and the resource is not entirely within their ownership (Arts and De Koning, 2018). The rights are tied to the users according to how they can have access to the forest resource.

The rights to property are recognized through the application of statutory law such as formal property rights or informally (Akamani and Hall, 2019). Common property resources, renders critical social, ecological, economic, and socio-cultural services, to sustain livelihoods especially for the poor adjacent forest dwellers lacking access to other assets. The government is working ardently to introduce new regulations on common property rights through privatization which may benefit or harm societies (Demsetz, 2017).

Through the lens of the forest environment, rights are analyzed and regarded from two standpoints: (a) interest group impeccability through participation in various activities under statutory laws and structures governing forest resources management, and (b) the capability of ecotone communities in the forest to advocate and participate in the forest resource utilization such as the right for timber harvesting among others (FAO, 2016). Forest management utilizing the local community members remains a form of common property right, despite remaining a contested debate (Fragallah, *et al.*, 2021).

This theory therefore guided by the common property rights which provide insights into the underlying analysis of the conservation efforts spearheaded by the local community and other interested parties in managing forest resources. The theory guided in examining and explaining how the CFAs impacted the management of North Nandi Forest and livelihood improvement through their specified activities.

Conceptual Framework

The figure below outlines a detailed account of the relationship between the various variables that guide the study: both the independent and dependent variables. As shown in the figure, the four constructs comprising sustainable utilization of forest resources, conservation of plant resources, conservation of mammal resource and conservation of birds' species were the dependent variables in this study. Meanwhile, the intended outcomes of adopting these practices were measured in the form of improved utilization status of forest resources, conservation of biodiversity and improvement of overall forest management.

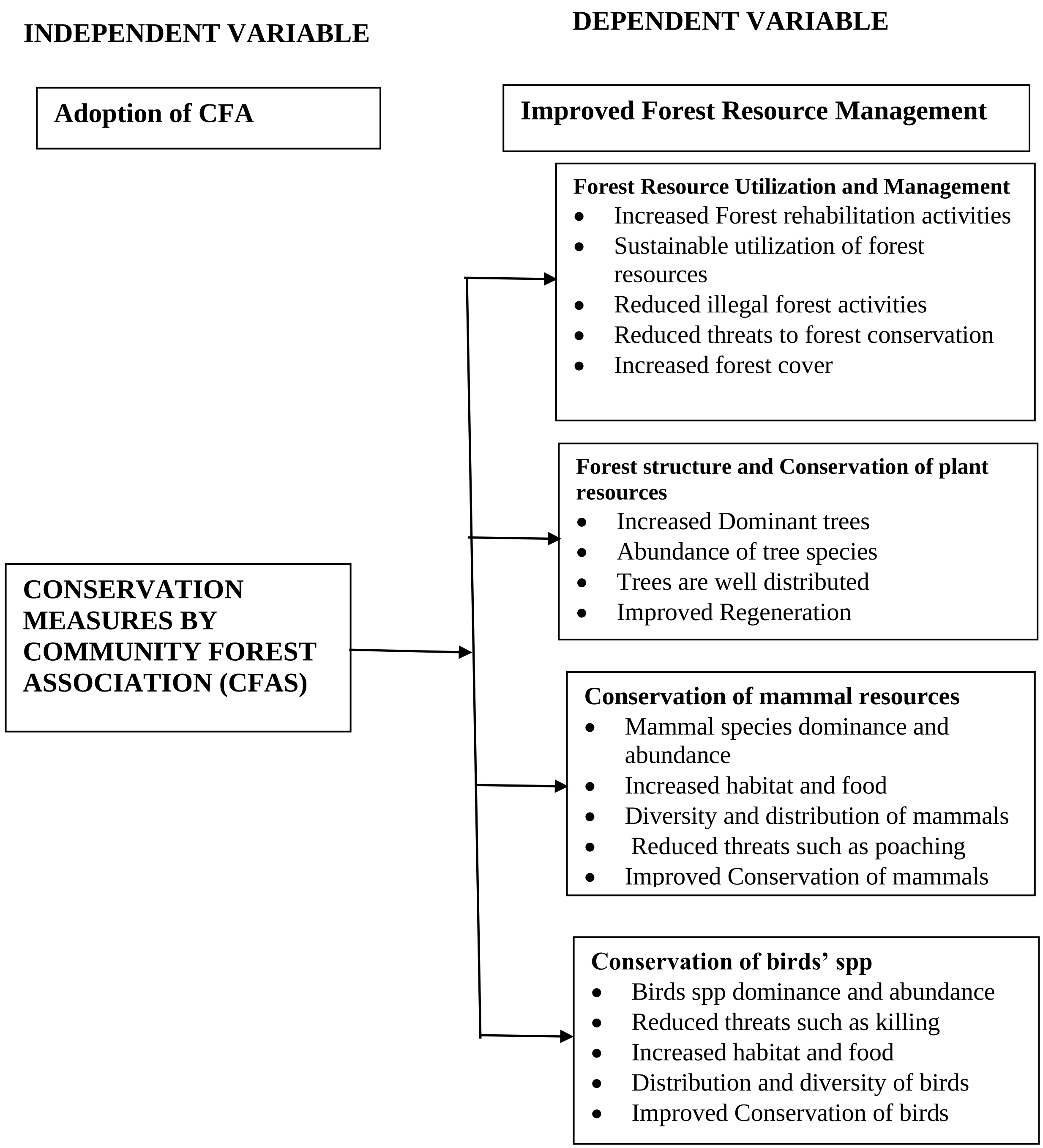

Figure 1: Association between Conservation Measures and Outcomes of Improved Forest Resource Management

Scope of the Study

The North Nandi Forest forms a critical component of the Kenya forests which are situated in the Western region. While carrying out the study, the researcher used a stratified systematic sampling method to capture data that could sufficiently represent each of the forests. Data collection employed comparative analysis; line transects as well as questionnaires. The research was conducted in North Nandi Forest which is deemed to capture the aspirations of all the counties in Kenya with CFAs.

Limitations of the Study

The research was undertaken in North Nandi Forest which has steep, hilly and poor terrain with thick undergrowth making it difficult to access easily. This resulted in a lot of time taken in clearing the transect lines. The forest stretches up to 30km long with 3-5km width, hence the research was undertaken in part of this forest. Data could not be taken during rainy days as it could interfere with accuracy of data particularly that of birds and mammals. Some of the people interviewed were not cooperative while some of them wanted to be given some cash for their time taken.

Definition of Terms

Community Forest Association:	Group of people adjacent to the forest who come together and register an association for joint management of forests with Kenya forest service
Conservation:	This is the planned protection and preservation of natural resources to prevent destruction, neglect or exploitation.
Forest:	A forest is an area of land that has dominant trees.
Management	The process of dealing with forest resources in a sustainable manner.
Resources:	This is a supply or source which produces a benefit and has a utility

CHAPTER TWO

REVIEW OF RELATED LITERATURE AND STUDIES

Community Involvement in Forest Resource Utilization and Management

Past conservation strategies in managing forests encompass fencing off the boundaries or reserve areas that totally exclude the local community members from the reserves (Murray Li, 2007; Gatiso, 2019). This was a form of protectionism that has been the cornerstone of conservation for ages and for a time now has been regarded as the mainstream form of conservation (Okumu and Muchapondwa, 2020b). This method created a kind of unique geographical areas such as national forest reserves and parks and game reserves. They are managed through legal instruments with guiding principles that may exclude the adjacent community members or allow minimal contact to the forest (Duguma *et al.*, 2018). This approach was advanced because the objective of development envisaged by the local community members was deemed to clash or conflict with conservation objectives espoused by conservation agencies (Tajuddin *et al.*, 2019).

The fortress approach presents various viewpoints to the local community members as a threat to the management of the forest. It has also, given a new paradigm that identifies the socio-economic demands and desires of the local community members in ensuring there is advancement in conservation efforts and management of forests (Okumu and Muchapondwa, 2017; Abate, 2018). In order to overcome those shortcomings of the fortress approach, new methods that recognize the local community members as potential partners in the conservation was recommended (Garekae *et al.*, 2020). The approach looks at conservation from two distinct perspectives which permit the adjacent forest communities to the confined/zoned area with defined user rights for purposes of conservation and participation process by the community members. This attempts to accelerate and improve localized development needs of the forest adjacent communities (Johann *et al., 2019).* The approach looks at conservation as a cost that requires the local community to meet though their engagement and hence attains conservation of the forest resource (Horwich *et al.*, 2015; Mawa *et al.*, 2020).

Suggestions have been drawn that community involvement in forest conservation or management allows the local community members to be empowered to conserve forest conservation and foster development. The need for the local community members to be involved in conservation stems from the realization that government cannot implement enforcement and forest conservation laws solely but instead, rely on the help of the local community members to undertake such tasks. In the past, the idea of carrying out enforcement led to local community resistance and thus creating a conflict with the local community members in the conservation efforts (Sungusia *et al.*, 2020).

Involvement of the forest adjacent communities in forest conservation is a decadal long tradition but has regularly transformed in theory and practices over the ages (Parhusip *et al.*, 2020; Sturiale *et al.*, 2020). Seeing its development, several countries have attempted to coin and label it using various names such as community-based forest conservation (CBFC), community-based natural forest resource management (CBNFRM), community-based forest management (CBFM), social forestry/forest management (SFM), sustainable forest management (SFM), collective/joint forest management (CFM), community forestry (CF), as well as participatory forest management (PFM) (Kellert *et al.*, 2000; Larson *et al.*, 2019). Diverse viewpoints are now available expressing the implementation of community in forest conservation and management to ensure efficiency, equitability, sustainability and local community benefits (Senganimalunje *et al.*, 2016). The effectiveness of the local community involvement and subsequent benefits that the stakeholders derive from the practice that clearly separates it from the traditional exclusionary forest management (Putraditama *et al.*, 2019).

Proper forests management is accomplished by seeking a balance between forest utilization in a sustainable manner, local community interests, and local duty and decision making among forest resource users (Arts and De Koning, 2018). The Convention on Biological Diversity Programme focuses on sustainable utilization of forest to enable local community stakeholders to develop and implement adaptive forest management initiatives (Jafari *et al.*, 2018). Community forestry may be used to illustrate effective use of forest among members of the local communities resulting in several aspects of management. There is overwhelming evidence that sustainable community forest allows individual and collective roles in forest conservation management, a decision that improves and promotes integrated forest management intending to achieve societal objectives such as social, economic and cultural (Pelletier *et al.*, 2016).

Several authors disagree with the notion that local community members can sustainably use forest resources. While there is a general agreement that sustainable forest use aims to empower local people, there is no consensus that the original objectives for initiating local community involvement are sufficient reason to warrant forest conservation (Gregory *et al.*, 2020). Thus, a notion comes out here that allowing the local community members a hand on sustainable utilization is an admission of failure of the authorities to properly conduct their management initiatives of the forest. However, there is a continued raging debate concerning the role of forest adjacent community involvement in the conservation and management of forests.

Several interested parties support community initiatives in the management of the forest to tackle rural livelihood (MacDicken *et al.*, 2015). This realization has seen governments and other agencies encouraging and promoting prospects for the stakeholders' participation especially for the local communities, local community members, individuals as well as forest inhabitants. There is a further need to develop forest policies that recognize and identify the rights of forest adjacent communities in the management of forest resources (Rahimian and Irvani, 2017). These policies are geared to ensure that the local community utilize forest and allied resources (Pokharel *et al.*, 2015).

In Kenya, involving the local people in community forestry has a long history in many regions (Okong'o, 2017). In Kenya, there is much incentive of providing the local community members opportunities to enhance sustainable forest management in ensuring that there is the protection of forest resources (Malupi *et al*., 2018). In realization of this, a number of issues have been put into place to ensure the rehabilitation of forests by engaging the forest adjacent communities in sustainable management of the forest. Communities adjacent to forests rely on forests resource for their sources of livelihood such as firewood, food, pasture, or vegetables. There are activities executed by the forest adjacent communities that contribute to improper utilization of forest, these include; - overgrazing, logging, charcoal production among others (Maloba *et al.,* 2018).

Involvement in participatory forest management has therefore been recommended as a way to enhance the livelihoods of the local community members (Ngugi *et al.*, 2018). In particular, the local community forest associations (CFAs) ought to be supported to vigorously participate in forest resources management.

Sustainable utilization of forest resources by communities living adjacent to the forest exhibit good management practices, especially those that have historical claims to forest areas, and have inhabited those forests for a sizeable amount of time. It is also, evident that, there are communities that inhabit agricultural or pastoralist areas adjacent to the forests, and utilizes the forest resources either legally or illegally. Kenyan history places most communities adjacent to the forests to be locally and actively involved in the forest resources management (Rajula, 2017).

Reputable organizations such as Kenya Forest Working Group (KFWG) have defined Participatory Forest Management as "a management approach that deliberately involves the forest-adjacent communities and other stakeholders in the management of forests within a framework that contributes to community's livelihoods" (FAO, 2016). Legal instruments and policies for instance the Forest Management and Conservation Act 2016, provides for Participation in Forest Management by communities living adjacent to the forests and does not decentralize power for successful joint-management of the said resource. Communities adjacent to the forest get organized to form CFA to become legally recognized to participate in forest management. Nevertheless, communities with good structures, active and existent have not fully provided a consistent and coherent role in Participatory Forest Management (Okumu and Muchapondwa, 2017).

In Kenya, the forest adjacent communities' role in the utilization and management of forest resources is governed by regulations' that are developed by the central government (Okumu and Muchapondwa, 2020). These laws include the Kenya's 2010 Constitution which is supreme to other statutory laws. A section of the articles calls for "every person to cooperate with the state organs to protect and conserve the environment and ensure ecologically sustainable development and the use of natural resources." The Forest Management and Conservation Act, 2016, allows for participation and management of forests by the communities living adjacent to the forest by requiring a member of any forest adjacent community together with other interested persons and resident in the same area, to register a Community Forest Association (CFA) as a Society. They must fulfill relevant requirements of the Registrar of Societies Act for them to obtain legal status and recognition before applying to the Chief Conservator of Forests for consideration and approval to participate in the conservation and management of the forest.

It is generally recognized and appreciated that communities adjacent to the forest areas are very essential to the success of forest conservation and management efforts. There is an assumption that the aforesaid communities have the capacity, knowledge and information to manage and conserve the forest resources on which they entirely rely on (Wanjohi et al., 2017). Researchers have pointed out various proposals that focus on a wide range of natural resources and their management strategies, for instance, infrastructural development opportunities, emphasis on community engagement, analysis of economic aspects of community engagement in the development and sustainable management of forest, potential consideration of decentralizing and instituting reforms that advocates for the management of forest resources and measures that tackles new emerging issues and challenges of forest sector. In countries where community participation is evident, there is enhanced households' wealth and improved governance on local community projects. It is noteworthy that; no research has been conducted in the same field regarding the impact of community institutions (CFAs) on the management of forests and socio-economic implications on the livelihood of communities adjacent to the forest in Kenya.

Community Forest Association in Conservation on Forest Structure

Studies have postulated and proven that the model of involving communities living adjacent to the forest to participate and manage the forest have significantly reduced deforestation or illegal activities and improved the structure of the forest (Malombe, 2014; Gregory *et al.*, 2018; Georgine, 2019). Community forest associations undertake activities that help in reducing pressure on the forest for livelihood (Hristo *et al.*, 2020). Conservation friendly entities have noted with a lot of concern that CFA is only prioritizing activities that aim at sustainable management of forest resources and are not safeguarding the components of forest structure (Hilostle, 2018). At present, there is proof that CFAs are gradually moving towards active participation in the management of forests. Sound management of forests resources paves the way to the sustainable production of goods and services and at the same breath maintains the structural components of the forest (Raul *et al*., 2018).

There are impeccable sources of work that have detailed the value of involving community forest associations in the management of the forest. Debb (2018) noted that the participation of CFAs in the management and conservation of forests contradicts the conservation protocols. In its findings, forest types are gradually converted into monoculture and tree diversity diminishes slowly, while shrubland areas are progressively converted into high forest land of plantation species. The participation and management of forests support a particular tree species that may introduce more homogeneity that result in to complete change of the structure and diversity of the forest. The modification of forest types witnessed in this kind of arrangement may alter the ecosystem structure, ecological functions and services of the forests. Thoms (2015) found out that, the involvement of the community in managing forestry has yielded good results in terms of forest security and management through the engagement of the forest community but at the expense and detriment of the destitute households. From the foregoing, the program of community participation in forest management is flourishing in conservation as opposed to livelihood improvement of the participating communities (Gautam *et al*., 2016). The studies conducted by Nagendra (2017) on National Park, gazetted government and community forests found that the vegetation density decreases in the above order of the aforementioned arrangement. The study further noted that the management of forest under the community is considerably poorer in comparison to national forests in the diversity of species richness. Further, the trees that are located in the community forests are much taller with good density than those within the national forests, and there is no distinction in the size of the diameter of the trees.

Some studies have looked at the contribution of CFAs to forest diversity and structure, equity, benefit sharing and how the established forest types have helped in forest homogeneity and structure (Gregory, 2018). A study conducted by Bhatta (2016) in Phulchowki, Lalitpur watershed on mixed broad-leaved forests showed that the forest structure was good due to the better above-ground biomass of tree species. An observation by Shrestha and McManus (2020) noted that the forest is well protected and managed through organized user groups and community forest scouts, in the application of both the scenarios; the communities greatly assisted in the improvement of the overall forest structural integrity. The participation by the community contributes immensely to the improvement in forest situation by invalidating degradation through tree planting of trees in degraded areas with a limited focus on biodiversity conservation. Baral and Katzensteiner (2015) observed that such managed forests have low species diversity and are dominated by fewer species of trees and poles with a maximum tree height of 13.5 m and the maximum Diameter at Breast Height of 29.5 cm. The activities in Community Forests have seen a reduction in plant composition, species distribution and richness and age class distribution of the trees. In managed forests, there are many trees with higher diameters and higher basal areas as compared to a range of trees of 5–15 cm DBH with a higher basal area in Community Forests. Studies also suggest that Community Forest is fewer in species diversity and uniformity in stands of tree species as compared to Managed Forests. The overall species diversity of a forest is restored under strict management guidelines by doing enrichment planting and making available proper niches for undergrowth. Fecofun (2017) carried out a study survey of 104 community forests (CF) in Nepal on three watershed areas, upon analyzing the results, he found out that the Diameter at Breast Height of all the trees along the strata are distributed and followed a left-skewed trend, an indication that the majority of the trees species in all the strata are younger, a good potential of the trees to increase forest carbon stock.

Paudel *et al.,* (2019) researched a forest managed by communities and found out that there is an increase in plants and animals' composition as the forest gets denser than in the past. However, measurements carried out in 2014 for Carbon stocks in all forms of plants in the same forests showed that there was a higher carbon sequestration rate of 1.52 ton/ha as compared to the measurements of 2012. The tree species that dominated this community forest when conducting the annual measurements include *Castanopsis indica, Schima wallichi, Pinus roxburg*i and *Alnus nepalensis*.

In Nepal, a District of Syangja measurement of biomass below-ground and above-ground was performed in the community forest. The results showed that the above-ground biomass of trees was highest for all the tree species mentioned above followed by below-ground biomass, sapling biomass and leaf litter, herbs and grass. The carbon stock of the forest was also measured and was found to be increasing every year. The forest was also critical in mitigating atmospheric carbon dioxide (CO_2) every year (Rodney *et al.,* 2018).

Notwithstanding, the research unearthed what the CFAs were giving much attention to self-motivating short-term economic gains at the expense of the ecosystem functions and services, an area of interest in this research. They are not sensitive to what the environment presents if not maintained and sustainably managed (Maloney *et al.,* 2018). Biological diversity is eroded when hunting of wildlife, the encroachment of forest is done unabated when communities adjacent to the forests are greedy and acting on malice towards biodiversity conservation of plant and animal species (Omole *et al.,* 2019).

Community Forest Association and Conservation of mammal Biodiversity

Classification of forest types available in the world is known to accommodate various life forms in terrestrial and aquatic. Due to their uniqueness, tropical forests are known to present a higher diversity of plant and animal species (Volker, 2020). There is a substantial amount of evidence showing when forests are properly managed, quality environmental services and functions are increased (Brockerhoff *et al.*, 2017). Scientists have deployed several strategies to address ecosystem provisional services and species diversity interactions. Species traits and the area they occupy is significant in understanding how the ecosystem functions over a specified time frame (Isbell *et al*., 2011). The composition and diversity of plant species growing together under similar environmental conditions are deemed to increase the growth of some tree mixtures (Thompson *et al.*, 2014). For instance, trees that are nitrogen-fixing supports and promotes the growth of other tree species within their proximity to areas with limited nitrogen accumulation (Forrester and Bauhus, 2016). The diversity of species in an ecosystem enables the stability of the forest and the realization of increased environmental goods and services (Jactel *et al*., 2017).

In developing countries, the management of forests by local communities has contributed to the conservation of fauna and flora. Rodger *et al.*, (2018) asserted that minimal research studies on the role of CFAs in the conservation and management of fauna in developing countries have been undertaken. The destruction of food crops especially on farmlands bordering the forest is attributed to the increased number of wildlife population in the forest. This is supported by research conducted in community forest where local people lost their crops and livestock due to wildlife (Pokhrel and Shah, 2019). In areas where a community participation programme is implemented, there is a justification that the degradation of forest resources decreases and the conservation of wildlife is enhanced (Jenns, 2018, Jonhson *et al.*, 2019). The practitioners focus only on direct and indirect benefits that are short term rather than long term biodiversity products that are important for future generations (Omar, 2018). Some community organizations carry out fencing, planting and meetings. At the same time, they prepare operational plans and develop measures, strategies that guide the management and conservation of the forest and its biodiversity (Richards, 2016).

Community Forests offers an opportunity to increase tree cover, ecological services, water resources, biodiversity conservation, carbon stock, poverty reduction, creates rural employment and air quality improvement among others (Thompson *et al.*, 2014). Community forest management contributes to the mitigation of atmospheric carbon dioxide and biodiversity conservation on a local, national and global scale (Mauricio *et al.*, 2018).

In several countries, Nepal for example, dating back to the 1950s, the government instituted reforms that excluded community members from the management of forests (Tiwary, 2019). The communities were never accorded a chance to participate in conservation and viewed the state as an enemy. The community saw the exclusion as a threat to their livelihood and other benefits obtained from the forest, they ignored state rules, went to the forest against the will of the government and undertook activities that led to the loss and destruction of 2.2 million hectares of forests. The decision by the community triggered a rigorous sensitization initiative by the government that bore no fruit. During the last two decades, the government reviewed the historical injustices meted against the community and reintroduced the Community participation plan of managing forest resources jointly with the state. This convinced the community and currently, there is an overall improvement in forest protection and biodiversity conservation in the country (Mauricio *et al.,* 2018). The development has absolved the country from entering into the list of threatened species based on the classification of the International Union for Conservation of Nature's (IUCN).

Influence of CFA on the Composition and Abundance of Bird Species

Increased human population has led to fragmentation, excisions and destruction of forests without regard to it being home to birds and other wild animals (Kwok and Corlett, 2010). The activities prioritized by humans in forest ecosystems compromises the survival of major bird species by restricting them only in a specifically defined area (Raman, 2016). The habitat destruction contributes to decrease in population size of birds and increased chances of extinction especially in tropical forest where bird species narrowly distributed and cannot tolerate harsh climatic conditions outside the forest (Simberloff, 2015, Turner, 2018).

The worrying trends of bird losses have risen to capture the attention of scientists and politicians (Cardinale *et al*., 2012). The changes similarly have led to an increased spread of pests and diseases (Armstrong, 2017). National, Regional and global discussions have been initiated by various organizations on factors that remedy further biodiversity loss, and considering setting aside large proportions of forest areas as a major management tool (Pollock *et al*., 2017). Other identified factors include the conversion of forest land into other uses being attributed to the immediate causes for the decline of specific bird species (Wade *et al*., 2013).

The North Nandi Forest supports bird species diversity of both national and regional significance. It is paramount to note that there is scanty information on the bird species of North Nandi Forest (Musila, *et al.,* 2010). It has not been established whether ecosystems such as farmlands, disturbed and plantation forests could act as an alternative habitat to sustain bird communities when natural forests have been altered. When there is a change in forest structure or formation, birds may respond in a noticeable way and acclimatize to the situation. When the primary forest is modified some bird species persist to adapt to the environment, by developing a specialized mechanism that is likely to be positive to its existence (Svein *et al.,* 2016). This study, therefore, assessed bird species diversity, richness and abundance in the disturbed and pristine natural forest, exotic tree plantations and farmlands adjacent to the North Nandi Forest Reserve.

CHAPTER THREE

MATERIALS AND METHODS

Research Design

This study involved the collection of data on sustainable utilization of forest resources as well as sampling of plants, mammals and birds. The study therefore applied a mixed-method design. This research employed the use of qualitative and quantitative approaches as an enabler to a better understanding of the research problem. In the collection of data on sustainable utilization of forest resources, the study is also envisaged to use specific designs such as exploratory design where there is a difficulty in getting information. The main reason is to gain insights and familiarization for later investigation when problems are at an initial stage of an examination. Meanwhile, in sampling plants, mammals and birds, a survey design was used. The researcher used a stratified systematic sampling method to capture data that sufficiently represented the plants, mammals and birds in the forests.

Study Area

North Nandi Forest is located on longitude 34°51’0″ E and 35°10’0″ E and latitude 0°33’30″N and 0°40’30″ N in Nandi County, Kenya. It lies at an altitude of 1,700-2,130 m above sea level. It is a distinctive mid-altitude ecological unit, transitional in species composition and structure between the eastern-most remainder of the Guineo–Congolian tropical rain forest which in the past millennium stretched across the entire expanse of West and Central Africa to the East African highlands and western Kenya.

The soils are derived from undifferentiated basement system rocks and are well drained, deep, and red to yellowish red friable sandy clays (Gebreselasse, 2011).

The gazetted forest area currently stands at 10,500 Ha. The indigenous closed-canopy forest is approximately 8,000 Ha, and the rest consists of scrubland, grassland and plantations of different exotic trees and tea bushes (Blackett, 1994). The area is under the high potential agro-ecological classification zone and obtains an average mean annual rainfall of between 1,200 and 2,000 mm per annum. The distribution of precipitation is bimodal, with a primary wet season lying between March and June, and a secondary wet period is between September and October (Mitchell *et al*., 2006). North Nandi forest is a drainage system comprising of a number of permanent streams and rivers such as Kipkaren, Clare, Nyonkie, Kingwal and the Kingwal swamp leading into Kimondi and Yala River.

North Nandi Forest is rich in fauna and flora. Several plants are found in North Nandi forest which are of significant value to the local community. The fauna include monkeys, antelopes, porcupines, bats and birds. The forest is situated in Chesumei and Mosop sub-counties respectively. The forest is a strip of the high canopy with valuable tree species located along the Nandi Escarpment, over and directly east of Kakamega tropical rain forest. The forest is very expansive covering 3–5 km for most of its width and stretches more than 30 km north to southwards (Figure 2).

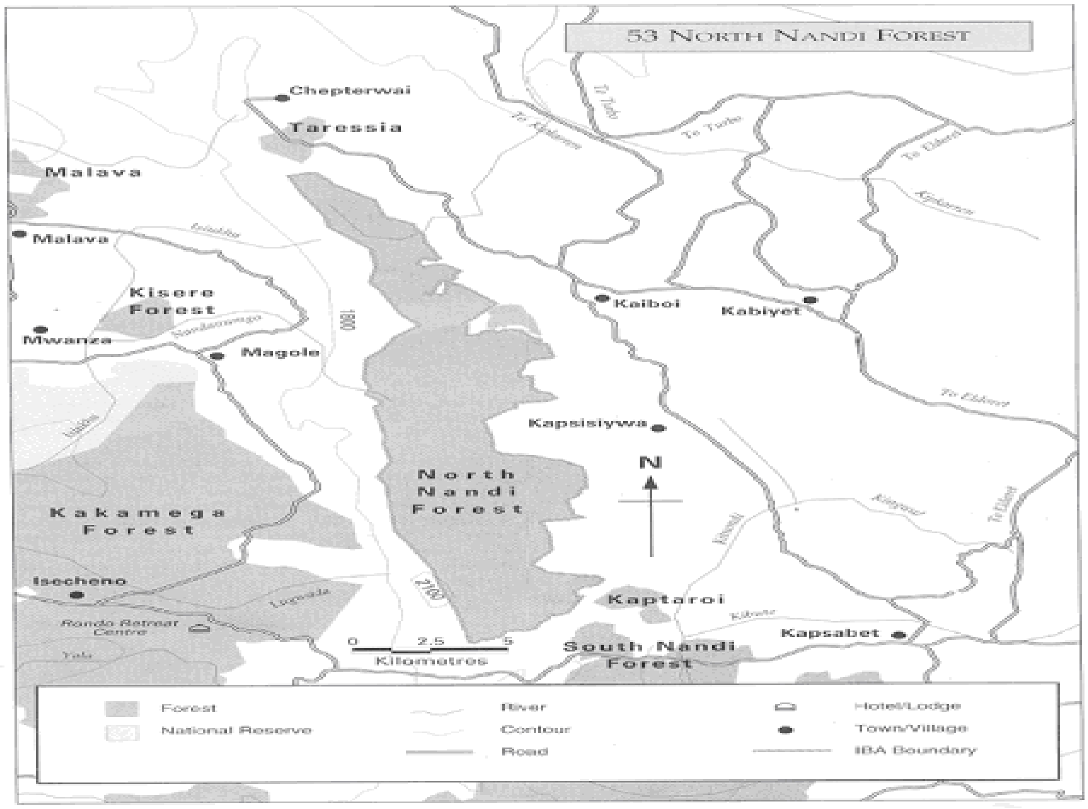

Figure 2: Sketch Map Showing the Position of North Nandi Forest

Sampling Technique for studying plants, mammals and birds

The research was undertaken on the eastern area of the North Nandi Forest owing to ease of access, closeness to the forest adjacent community that constantly interact with the forest for the allied resource. The research looked at various components that encompass farmlands, virgin and disturbed natural and plantation forest as central for data collection. The indigenous forest area formed the largest portion and major forest ecosystem of the study. The disturbed forest lies immediately at the boundary adjoining exotic tree plantations covering a strip of approximately 500 m. Similarly, the farmland territory forms the outermost environment and borders the tea buffer zone with an approximate strip of 5km. Informed by the aforementioned criterion, forest adjacent communities resident in the area based on administrative units namely; - 'Kiptangus', 'Kipsamoite', 'Kombe' and 'Kiptuiya' were systematically selected as representative of the ten administrative units in the study site.

Measurement of Forest Structure

A stratified systematic sampling method was employed to capture data that represented the forest stratum. The transect was constructed using linear tape and a panga and it consisted of 500m long with sample plots of 12m radius at an interval of 100m. The start of a transect line was located at 60 metres from the boundary of each forest habitat. One transect was covered per habitat and per sub-location. Sampling specifically focused on trees, woody saplings and seedlings of woody species. Major data collected used a considerable number of tools, for example: - tree heights were measured using Suunto clinometer, diameter at breast height (DBH) used diameter tape, and counts were done to establish number of trees, seedlings/ saplings and indicators of disturbance. Other useful data for instance geo-referencing using GPS instrument and site description were recorded on field datasheets.

The most important species as well as the majorly targeted tree species that produce valuable wood products and timber were evaluated so as to tell whether they displayed desirable developmental transition and healthy regeneration patterns. The information would also guide the debate on way forward for communities regarding the necessity of forest utilization for wood and NWFP. Specifically, the information is needful for designing and implementation of sustainable forest management (SFM).

From the collected data the following aspects were analyzed: - Biodiversity measures, species similarity and plant communities, the population density of trees, saplings and seedlings; frequency and distribution ratios of trees, saplings and seedlings; tree basal area, tree population structure, height structure, DBH- height relationship and estimation of levels of disturbance.

Mammal Sampling Protocol

The study surveyed all mammals present and their abundance using a defined transects line that followed a straight- or parallel-line during data collection. Transect was laid randomly at 500m long by 20 m wide. The transect lines were located at 60m from the boundary of each habitat. One transect line was covered per habitat and per sub-location. Data collected during line transect survey protocols combined acoustic data such as those sighted during daytime, sounds, dung, foot prints, nest, furrowing (Figure 13) and food-searching disturbances were also counted. Morning walk between 06.30 a.m. to 10.00 a.m. at an average speed of 1 km per hour was conducted for 30 days; any mammal spotted or sighted was captured. At least ten different measures, observations and recordings were done. The observations were done along a perpendicular distance for the purposes of obtaining data on animal densities. For shy and elusive species, dung counts were used as it was considered more practical than direct sightings.

Birds Sampling Procedure

Birds were determined using the transect method involving one transect of 500m long in every habitat sampled. The transect lines were located at 60m from the boundary of each habitat and from the forest boundary. The point count method was utilized for collecting the data on the population of the birds' species in the study area (Bibby, Burgess *et al.*, 1992). Further, five-point counts centres measuring 50m in radius was established on each transect at 100 m intervals. A total of 55-point count centres were covered in the whole study area. Point counts were carried out in the morning between 0700 hours and 1100 hours respectively. Bird counts were made by observation for about 10 minutes at every centre and all observed bird species were recorded in the data recording sheet. Counts were avoided when there was heavy downpour or light showers, stormy or foggy to evade biases that was brought about by unfavourable climatic conditions. Additionally, opportunistic bird species counts were also observed and recorded in the species checklist.

Githiru *et al.*, (2009) recommended that in plantation forest and farmlands, distance line transects were used to sample bird species. The numbers of birds sighted were all recorded in a well-developed datasheet with the specific classification of bird feeding habits for instance insectivores, granivores, frugivores, raptors, nectarivores and Omnivores.

Analysis of Sustainable Utilization of Plants

In order to determine the sustainable utilization of plants, a household survey was done at the sampling sites. The study population comprised the household families who reside along the North Nandi Forest where the sampling sites were located. According to the Kenya National Bureau of Statistics, (2010) survey, the demographic population of the study area is approximately 68,053 people. Approximately 7,807 persons that translate to 11.5% of the population access the forest for their needs. Therefore, the following formula $n = z^2(\frac{pq}{d^2})$ was used to calculate the number of households for the administration of the questionnaires (Ellen, 2012);

Whereby: n = the desired minimum sample size, z = the standard normal deviation at a set confidence interval, d = the acceptable range of confidence level (0.05), p = the proportion of individuals accessing the forest, and q = the proportion of individuals not accessing the forest = 1–p. Hence; d = 0.05, p = 0.115, z = 1.96 at 95% confidence level, q = 0.885.

Thus, $n = \frac{1.96*1.96\ (0.115*0.885)}{0.05^2} = 156$

In conclusion, a total of 156 local community households formed the desired sample size for this research. The use of a structured questionnaire was a major useful qualitative tool employed in collecting the data. The researcher administered a questionnaire that had both open and closed-ended questions particularly for collection of data on the influence of CFA on local community forest utilization. The community members who were not in a position to understand the questionnaires were interviewed based on the content of the questionnaires with the assistance of an enumerator.

Data Analysis

Data analysis was done using recognized and approved tools such as SPSS 23.0 and Microsoft Excel spreadsheet 2020. The data obtained was analyzed for normality after cleaning and the application of appropriate transformation methods was taken into consideration in case of any pronounced deviation from the normal distribution (Zar, 1996). To determine the sustainable utilization of forest resources, data was analyzed using frequency distributions, percentages mean and standard Deviations. The abundance of various species was expressed as a proportion of the total population in the plantations, disturbed and undisturbed forests in the four sub-locations.

Ethical Considerations

Discipline, etiquette and professionalism was considered in every aspect when conducting the research. The research was guided by good morals and standards (Pietilä et *al.*, 2020) that consists of principles aimed at protecting the study participant and professional ethical research standards to ensure high scientific application and accountability (Mustajoki and Mustajoki, 2017). Ethical considerations were used to protect respondents' rights, dignity, and welfare; to obtain valid informed consent, to protect the privacy of the research and the security of personal information obtained. This study used the principles of responsible research such as truthfulness, impartiality, cautiousness, frankness, privacy and high esteem for the respondents (Resnik and Shamoo, 2017).

The researcher ensured honesty at every stage of the research, planning, executing and reporting; and was willing to divulge any probable conflicts of interest in the study. The researcher ensured no fabrication, falsification and misrepresentation of the findings during scientific communication. To ensure objectivity, the research was not interfered with by any person regardless of its standing in society and strove to achieve content and value with minimal bias. Confidentiality of the study was ensured by maintaining the privacy of the research work such as responses by respondents, documents, personal details and demographic information, as well as ensuring anonymity of personal data obtained from the participants. The study also valued intellectual property such as copyrights and the work of others and did not use unpublished data or findings without permission and avoiding plagiarism.

CHAPTER FOUR

PRESENTATION OF FINDINGS, ANALYSIS AND INTERPRETATION

Socio-demographic Characteristics of Respondents

Questionnaires were administered to 156 household heads present at the time of questionnaire administration from the four forest sites of Kombe, Kipsamoite, Kiptangus and Kiptuiya locations to evaluate the influence of CFA on local community sustainable forest utilization in North Nandi Forest. However, 136 respondents dully filled and returned the questionnaires. First the respondents were asked to indicate their gender. The results are presented in Figure 3.

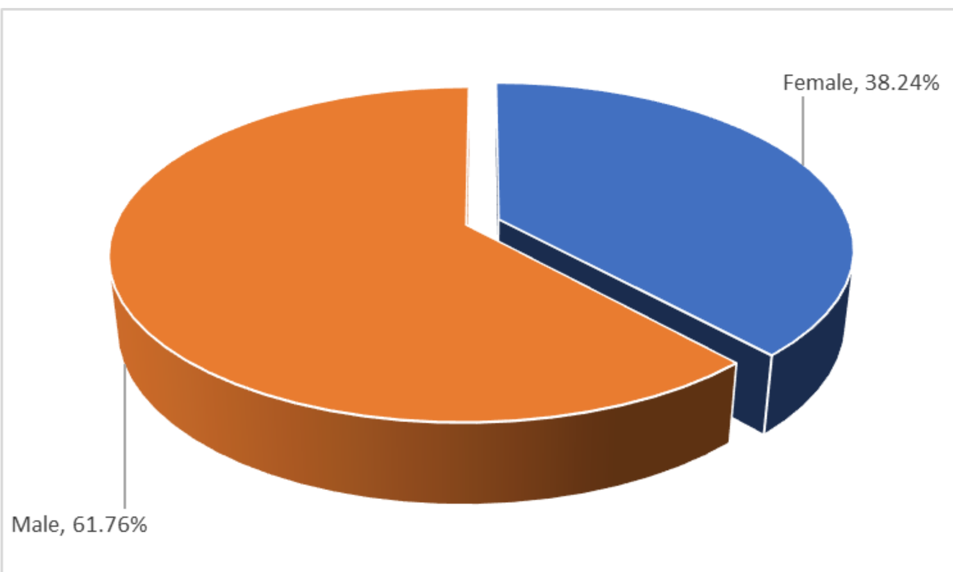

Figure 3: Gender of the Respondents.

Figure 3 shows that 61.76% of the respondents were male while 38.24% were female showing that majority of respondents were male. This is also an indication that the membership of CFAs in the study area is male dominated. CFA is one of the forest management strategies adopted where the community is involved in forest management. Participatory Forest Management (PFM) through CFAs is being adopted widely in many developing countries as an alternative method of managing forestry resources (Wily, 2002). PFM is increasingly being used as an approach through which to achieve the sustainability of threatened forests and conservation of biodiversity. This is done through a process of inclusion, equity, and democratization of governance of the forest resources (Amanor 2003).

Education Level

In addition, the respondents were asked to indicate their level of education. The results are presented in Figure 4.

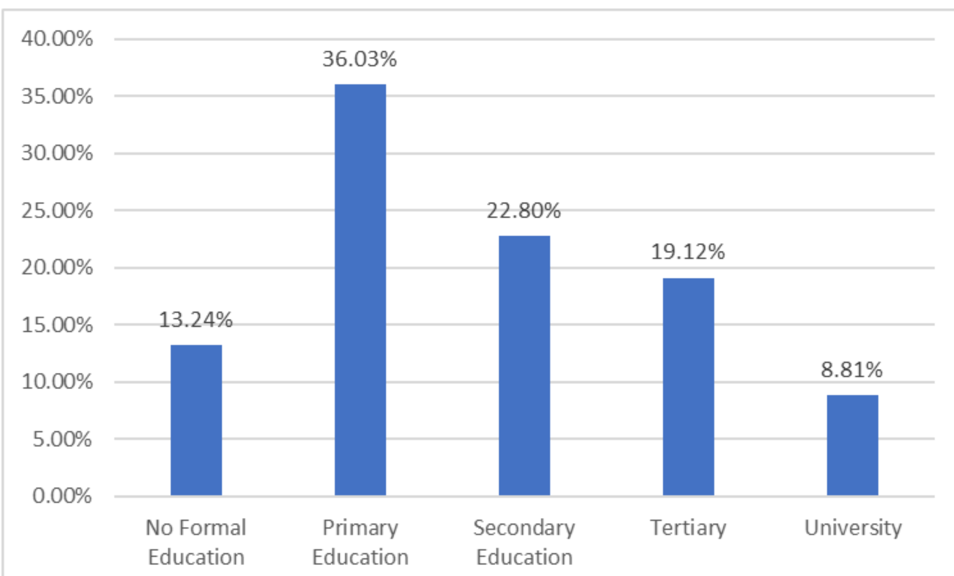

Figure 4: Education Level of the Respondents

Figure 4 shows that 49(36.03%) respondents had primary school level of education, 31(22.80%) respondents had secondary school level of education, 26(19.12%) had tertiary level including certificates/diplomas and 18(13.24%) respondents had no education while 12(8.81%) respondents had degrees. From the responses it emerged that most (36.03%) of the respondents had primary school level of education. Education level is related to dependency of forest resources and depletion. Higher education attainment, for example, is connected with less dependency on forest resources (Fonta and Ayuk, 2013). This is due to the fact that education provides various alternative livelihood choices that may yield large returns when compared to forest extraction activities (Htun, Wen and Ko, 2017). In this study, people who have no education or lower levels of education like primary and secondary education are not employed thus depend on forest resources for their livelihoods.

Components Improved by CFAs for enhanced forest utilization

Respondents were asked to indicate the components that have been improved by the existing CFAs to enhance forest utilization. The respondents were allowed to indicate more than one (multiple responses allowed). Responses were tabulated and the results are presented in Table 1.

Table 1

Components Improved by CFAs for Enhanced Forest Utilization

Component	Frequency	Percent
Knowledge of plant use	121	60.20
Knowledge of mammals and birds	48	23.88
Traditional social organization	32	15.92
Total	**201**	**100.00**

Table 1 shows that a total of 121(60.2%) respondents reported that their knowledge on plant use had been improved by CFAs in their areas and 48(23.88%) respondents indicated that they had enhanced their knowledge on mammals and birds while 32(15.92%) respondents acknowledged that they had enhanced traditional social organization thus improving on forest utilization. Therefore, majority (60.2%) of the respondents had benefited from their CFAs on knowledge on plant use.

Strategies Used to Protect and Conserve Forests

The respondents were further asked to indicate the strategies that have been employed to protect and conserve forests in their locations. Multiple responses were allowed in this section. Their responses were tabulated and the results are presented in Table 2.

Table 2

Strategies used to protect and Conserve Forest

Strategy	**Frequency**	**Percent**
County and national government policies support	109	15.01
Community and school-based conservation and management approach	72	9.93
Conservation and Environmental clubs in institutions	54	7.45
Joint forest management between the government and the community	136	18.73
Cultural conservation in management of forests	63	8.69
Involvement of indigenous people within and outside the forest	131	18.04
traditional laws	28	3.86
Sensitization meetings through barazas, workshops or conferences	133	18.32
Total	**726**	**100.00**

Table 2 shows that 136(18.73%) respondents indicated that joint forest management between the government and the community was used as a strategy for protection and conservation of North Nandi Forest, 133(18.32%) respondents acknowledged the use of sensitization meetings through barazas, workshops or conferences and 131(18.04%) respondents reported that the involvement of indigenous people within and outside the forest was used to conserve and protect the forest while 109(15.01%) respondents noted that the use of county and national government policies supported the conservation and protection of North Nandi Forest. Millions of people depend on forests for livelihood. Hence, there is the need to direct policies toward improving forest management in order to promote ecologically sustainable management where ecological processes are maintained, biodiversity is preserved, and a full range of benefits accrue to the society within the natural limits of a given natural forest (Thorn *et al.*, 2020). Community participation is the process "whereby people act in groups to influence the direction and outcome of development programs that will affect them." Participation may be thought of as the deliberate action of the people and government to respond jointly in the formulation, planning, and implementation of a strategy to satisfy a particular need (Fragallah *et al.*, 2021).

Threats to Traditional Forest Conservation

In addition, the respondents were asked to indicate direct threats to traditional forest conservation. Multiple responses were allowed in this section. Their responses were tabulated and the results are presented in Table 3.

Table 3

Threats to Traditional Forest Conservation

Threat	Frequencies	Percent
Variation in Traditional livelihood strategies	128	37.76
Disintegration of traditional rights	23	6.78
Break down of traditional Institutions	52	15.34
Over-use of natural resources	136	40.12
Total	**339**	**100.00**

Table 3 shows that 136(40.12%) respondents reported that over-use of natural resources was a threat to traditional forest conservation, 128(37.76%) respondents acknowledged that variation in traditional livelihood strategies was a threat to traditional forest conservation while 52(15.34%) respondents reported that break down of traditional institutions was a threat to traditional forest conservation. From the results it emerged that variation of traditional livelihood strategies and over-use of natural resources were the greatest threats to traditional forest conservation. Forests and their associated products have been vital in sustaining livelihoods since time immemorial (Mukul *et al.*, 2016), notably for the residents of forest-dependent communities who live in abject poverty (Kabubo-Mariara, 2013). Numerous researches on the forest-livelihood nexus have shown that forests play an important role in livelihood sustenance and diversification, as well as a path to poverty reduction (Mukul *et al.*, 2016). Forests are critical for meeting fundamental necessities, saving money, and providing safety nets (Bwalya, 2013;). They provide energy, jobs, medicine, and other necessities for the majority of local communities, particularly in developing countries (Suleiman *et al.*, 2017).

Further the respondents were asked to indicate threats to traditional forest conservation according to their CFAs. Multiple responses were also allowed in this section. Their responses were tabulated and the results are presented in Table 4.

Table 4

Factors contributing to threats to Traditional Forest conservation

Factor	**Frequency**	**Percent**
Strict government policies, laws and regulations	15	3.66
Expansion of land for agriculture and other developmental activities	136	33.17
Excision of forest for settlement	123	30.00
Illegal cutting of trees for posts, charcoal, fuelwood and timber	136	33.17
Total	**410**	**100.00**

Table 4 shows that 136(33.17%) respondents reported that expansion of land for agriculture and other developmental activities was a threat to forest conservation, 136(33.17%) respondents also reported that illegal cutting of trees for posts, charcoal, fuelwood and timber was a threat to traditional forest conservation while 123(30.0%) respondents acknowledged that excision of forest land for settlement was a threat to forest conservation. Thus, in this study, expansion of land for agriculture and other developmental activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber were the major factors affecting traditional forest conservation in North Nandi Forest. Agriculture is the most prevalent human-environment interaction, affecting more natural resources than any other human activity (Barrios *et al.,* 2018). As the world's population rises, the agricultural industry is under growing pressure to produce more food (Tschora and Cherubini, 2020). In response to increased food demand, agriculture is being intensified, which can lead to soil quality degradation, and is being spread into forest environments (Jayathilake *et al.*, 2021). Overdependence on land-based resources for income or food (Antwi *et al.,* 2014), farming activities and illegal felling of trees has threatened the existence of forests in Africa (Kamwi *et al.*, 2017).

Actions Employed to Conserve Forest Resources

The respondents were further asked to indicate the actions they undertake in their CFAs as a way of conserving forest resources. This was also multiple responses item. Their responses were tabulated and the results are presented in Table 5.

Table 5

Actions Employed to Conserve Forest Resources

Actions	**Frequencies**	**Percent**
Use of local indigenous Knowledge	76	31.54
Adhering to government policies, laws and regulations	29	12.03
Participatory forest management	136	56.43
Total	**241**	**100.00**

Table 5 shows that 136(56.43%) respondents acknowledged that they were using participatory forest management as a way of conserving the forest, 76(31.54%) reported that they were using local indigenous Knowledge to conserve the forest while 12.03% of the respondents reported that they were adhering to government policies, laws and regulations on conservation of forests. The results pointed out that most of the respondents were using participatory forest management as a way of conserving the forest. Following massive failures of centralized systems of forest management, many developing countries have experimented with some form of decentralized forest governance (Lund *et al.,* 2018). This involves a shift in forest governance towards increased involvement of local communities in the management of forests (Kairu *et al.,* 2018). Decentralized forest management has been promoted on the basis that it can improve efficiency and equity in natural resource management (Ribot *et al.,* 2010). Participation in forest management involves planning which entails involving local actors in decision-making, creating new rules or modifying old ones, formulating alternative planning activities and allocation of rights, responsibilities and resources among the forest management actors (Tadesse *et al.,* 2017). Participation in planning allows the dynamic nature of stakeholder needs, priorities and interests to be captured and integrated throughout project implementation (Reed *et al.*, 2009). Implementation involves bringing the forest associations into forest management activities (Luswaga and Nuppenau, 2020).

The study further noted that different age groups were involved in forest management through planting of more tree species, reporting any illegal activities in the forest, ensuring that harvesting of medicinal plants were conducted in a sustainable way and in sensitization of the community members through barazas on the importance of the forest and its resources. Among the plant parts that were used by the communities included roots, leaves, barks, followers, stem and branches. The respondents noted that there are some trees in the forest which are medicinal and thus are protected by community members. These trees included *Olea carpensis, Fagaropsis angolensis, Solanum mauritianum Celtis africana, Cassipourea malosana, Croton macrostachyus, Syzygium cordatum, Zanthoxylum gilletii, Podocarpus spp and Prunus africana*.

The respondents noted that the indigenous plants in the forest provided with medicine, protected water catchment areas, maintained soil fertility, provided food and shelter to other animals, shade for animals, feed for livestock particularly during dry season, provides them with firewood and fencing posts. A rising number of studies shows the value of forests as a source of income for many rural people in developing countries (Nguyen *et al.*, 2020). According to the Food and Agriculture Organization (FAO), forest extraction accounts for a major portion of one billion people's income (FAO, 2016). Studies from tropical forest areas demonstrate the numerous significant functions of forests in rural livelihoods, including the provision of a wide range of subsistence goods, marketable products for cash income creation, agricultural productivity inputs, and vital safety nets during difficult times (Chilongo, 2014).

Influence of CFA on community forest utilization

The first hypothesis stated that;

H_{01}: CFA has no significant influence on local community forest utilization in North Nandi Forest

Chi-square tests were performed to determine the influence of CFA on local community forest utilization in North Nandi Forest. The results are presented in Table 6.

Table 6

Effect of CFA on local community forest utilization

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	48.846[a]	16	.000
Likelihood Ratio	46.232	16	.000
Linear-by-Linear Association	8.744	1	.003
N of Valid Cases	136		

Table 4.6 shows that there was a significant effect of CFA on local community forest utilization in North Nandi Forest ($p \leq .0.05$). The hypothesis which stated that CFA has no significant influence on local community forest utilization in North Nandi Forest was rejected and the alternate accepted showing that CFA has an influence on community forest utilization in North Nandi Forest.

Forest Structure in North Nandi Forest

The study further surveyed all trees and saplings present and their abundance using a defined transects line that followed a straight- or parallel-line during data collection in the four forest areas of Kiptuiya, Kombe, Kipsamoite and Kiptangus. Major data collected were tree heights which were measured using Suunto clinometer, diameter at breast height (DBH) which used diameter tape, and counts were done to establish the number of seedlings and saplings. The study found out that *Cupressus lusitanica* was the most dominant plant species in Kipsamoite plantation and had a mean diameter of 35.58 ±8.14cm and a mean height of 20.95±4.74m. In addition, saplings were counted in Kipsamoite Plantation and the results are presented in Table 7.

Table 7

Saplings in Kipsamoite Plantation

Sapling species	**Frequency**	**Percentages**
Cupressus lusitanica	83	42.35
Vernonia auriculifera	38	19.39
Solanum mauritianum	3	1.53
Dovyalis abyssinica	1	0.51
Cassipourea malosana	22	11.22
Bersama abyssinica	39	19.90
Zanthoxylum gilletii	1	0.51
Momordica foetida	3	1.53
Croton macrostachyus	1	0.51
Vangueria madagascariensis	1	0.51
Prunus africana	3	1.53
Ehretia cymosa	1	0.51
Total	**196**	**100.0**

Table 7 shows that *Cupressus lusitanica* was the most dominant sapling in Kipsamoite plantation and accounted for 42.35% of all the saplings. This was followed by *Bersama abyssinica* (19.90%) and *Vernonia auriculifera* (19.39%). Thus, after the harvesting of the plantations, it is more likely that *Bersama abyssinica* and *Vernonia auriculifera* could be the dominant species thus aiding in the regeneration of the forest. It has been noted that *Erythrina abyssinica* which belongs to the same genus as *Bersama abyssinica* enhances soil fertility and because of this value, it plays an important role in phytorestoration and forest regeneration particularly in polluted soils (Majid, *et al.*, 2011; Abay, 2018). Similarly, counts, height and diameter measurements of tree species in disturbed part of Kipsamoite forest were undertaken. The results are presented in Table 8.

Table 8

Counts, Height and Diameter Measurements of Trees in Kipsamoite Disturbed Forest

Species	**Number counted**	**Percent**	**Mean Diameter (cm)**	**Mean Height (Metres)**
Croton megalocarpus	13	23.21	33.09 ± 22.89	21.11 ± 11.37
Diospyros abyssinica	10	17.86	33.45 ± 8.53	26.30 ± 6.07
Momordica foetida	7	12.5	25.47 ± 11.08	16.51 ± 8.48
Ehretia cymosa	6	10.71	26.35 ± 10.83	14.22 ± 8.200
Cassipourea malosana	5	8.93	19.04 ± 3.34	16.80 ± 3.14
Solanum mauritianum	4	7.14	11.40 ±1.99	8.30 ± 1.86
Albizia gummifera	3	5.36	17.67 ± 2.81	9.97 ± 3.51
Scutia myrtina	2	3.57	7.65 ± 3.04	10.30 ± 4.95
Bersama abyssinica	2	3.57	20.55 ±11.24	11.55 ± 2.47
Neoboutonia macrocalyx	2	3.57	13.45 ± 3.61	5.55 ± 1.06
Celtis africana	1	1.79	57.8	33.3
Tabernaemontana stapfiana	1	1.79	16.9	9.3
Total	**56**	**100.00**		

As shown in Table 8, in Kipsamoite disturbed forest area the most dominant species was *Croton megalocarpus,* which accounted for 23.21% of tree species in the area followed by *Diospyros abyssinica* (17.86%) *and Momordica foetida* (10.71%). In terms of diameter, *Celtis africana* had the greatest diameter *of* 57.8cm, followed by

Diospyros abyssinica with a mean of 33.45 ± 8.53 cm and *Croton megalocarpus* with a mean diameter of 33.09 ± 22.89cm. However, in terms of height *Celtis africana*, had the greatest height of 33.3m followed by *Diospyros abyssinica* (26.30 ± 6.07m) and *Croton megalocarpus* (21.11 ± 11.37). In a study by Zanne and Chapman (2005) and Chapman *et al*., (2010) regarding building on habitat associations of trees in Kibale, four large-gap species that were not early successional were identified. These four species often persist to be canopy level trees in old-growth forest and were *Celtis africana, Celtis gomphophylla, Diospyros abyssinica, and Funtumia latifolia*. The lifespan of these trees is unknown, but it is likely that they live at least a few hundred years. Thus, in the Kipsamoite disturbed forest, *Celtis africana* and *Diospyros abyssinica* were found showing that these tree species are not highly targeted by humans. In this region, the most notable disturbance was that of *Croton megalocarpus* which was targeted for firewood while *Syzygium guineense* and *Ehretia cymosa* were targeted for posts. Similarly, saplings were counted in the disturbed part of Kipsamoite forest, the results are presented in Table 9.

Table 9

Saplings in Kipsamoite disturbed forest

Sapling	**Frequency**	**Percent**
Croton megalocarpus	36	13.69
Bersama abyssinica	12	4.56
Cassipourea malosana	35	13.31
Solanum mauritianum	18	6.84
Neoboutonia macrocalyx	7	2.66
Vernonia auriculifera	3	1.14
Acanthus eminens	150	57.03
Vangueria madagascariensis	2	0.76
Total	**263**	**100.00**

In Kipsamoite disturbed, the dominant sapling was *Acanthus eminens* at 57.03%, followed by croton megalocarpus at 13.69% and *Cassipourea malosana* at 13.31% while the least species was *Vangueria madagascariensis (0.76%) and Vernonia auriculifera* (1.14%). In this forest, the most dominant species was *Acanthus eminens* which was also found by Wanjohi et al (2018) as among the most dominant saplings in Nabkoi Forest reserve. Further, counts, height and diameter measurements of tree species in undisturbed part of Kipsamoite forest were undertaken. The results are presented in Table 10.

Table 10

Counts, Height and Diameter Measurements of Trees in Kipsamoite undisturbed Forest

Tree species	**Frequency**	**Percent**	**Diameter (cm)**	**Height (m)**
Tabernaemontana stapfiana	6	9.09	19.32 ± 11.30	9.72 ± 2.56
Ehretia cymosa	5	7.58	7.38 ± .71	7.2 ± 1.34
Croton megalocarpus	20	30.30	29.54 ±16.00	22.25 ± 9.35
Celtis africana	6	9.091	46.07 ±13.41	29.38 ± 2.92
Macaranga kilimandscharica	8	12.12	32.11 ± 17.47	21.11 ± 7.97
Schrebera alata	1	1.52	9.5	9.3
Craibia brownie	6	9.09	32.28 ± 29.75	20.55 ± 4.95
Diospyros abyssinica	3	4.55	35.70 ± 10.47	25.30
Syzygium guineense	1	1.52	44	21.8
Cassipourea malosana	4	6.06	26.83 ±10.83	25.43 ± 2.43
Momordica foetida	1	1.52	21.3	18.8
Vangueria madagascariensis	1	1.52	17	11.3
Polyscias fulva	4	6.06	41.60 ± 17.21	25.05 ± 2.98
Total	**66**	**100.00**		

Table 10 shows that in the undisturbed part of Kipsamoite forest, the most dominant tree species was *Croton megalocarpus* followed by *Macaranga kilimandscharica* while the least dominant was *Schrebera alata, Syzygium guineense, Momordica foetida* and *Vangueria madagascariensis*. *Celtis africana* was found to have the largest diameter with a mean of 46.07 ±13.41cm followed by *Syzygium guineense* (44cm), *Polyscias fulva* (41.60 ± 17.21cm), *Diospyros abyssinica* with a mean diameter of 35.70 ± 10.47cm and *Craibia brownii* with a mean diameter of 32.28 ± 29.75cm. In terms of height, *Celtis africana* was the highest (29.38 ± 2.92m), followed by *Cassipourea malosana* (25.43 ± 2.43m), *Polyscias fulva* (25.05 ± 2.98m) and *Croton megalocarpus* (22.25 ± 9.35m). As shown by the results the dominant species in the undisturbed forest in Kipsamoite was *Croton megalocarpus* this species was found by Odhiambo (2021) to contribute to 9.1% of the plant cover in Nandi South Forest. In addition, saplings were counted in Kipsamoite undisturbed forest area, the results are presented in Table 11.

Table 11

Saplings in Kipsamoite Undisturbed

Sampling	**Frequency**	**Percentage**
Acanthus eminens	200	48.08
Vangueria madagascariensis	41	9.9
Doryalis macrocalyx	26	6.25
Cassipourea malosana	84	20.19
Celtis africana	13	3.13
Syzygium guineense	6	1.44
Diospyros abyssinica	13	3.13
Fagaropsis angolensis	2	0.48
Ochna insculpta	4	0.96
Bersama abyssinica	3	0.721

Neoboutonia macrocalyx	1	0.240
Momordica foetida	2	0.480
Fagaropsis angolensis	2	0.481
Olea capensis	1	0.2405
Solanum mauritianum	3	0.721
Bersama abyssinica	2	0.481
Tabernaemontana stapfiana	1	0.240
Vernonia auriculifera	3	0.721
Ochna insculpta	3	0.721
Croton megalocarpus	4	0.962
Fagaropsis angolensis	2	0.481
Total	**416**	**100.0**

Table 11 shows that *Acanthus eminens* (48.08%) was the most dominant sapling in the undisturbed area of Kipsamoite forest, followed by *Cassipourea malosana* (20.19%) while the least dominant was *Neoboutonia macrocalyx* (0.24%), *Olea capensis* (0.24%) and *Tabernaemontana stapfiana* (0.24%). In Nabkoi forest reserve by Wanjohi *et a*l., (2017) *Olea hochstetteri* was the most significant plant species followed by *Acanthus eminens* showing that *Acanthus eminens* is a significant plant in forest floors in Kenya. In Kiptangus plantation, the mean height for *Pinus Patula* was 20.72 m with a standard deviation of 3.222 while the mean diameter for the same species was 23.53±4.764m. Saplings counted in the plantation are presented in Table 12.

Table 12

Sapling species in Kiptangus plantation

Plant species	Frequency	Percent
Vernonia auriculifera	24	25.53
Cestrum aurantiacum	36	38.30
Rubus apetalus	19	20.21
Solanum mauritianum	6	6.38
Bersama abyssinica	1	1.06
Vangueria madascariensis	6	6.38
Ehretia cymosa	2	2.13
Total	**94**	**100.0**

The most dominant plant species in the pine plantation was *Cestrum aurantiacum* (38.3%), followed by *Vernonia auriculifera* (25.53%) and *Rubus apetalus* (20.21%) while the least dominant was *Bersama abyssinica* (1.06%) followed by *Ehretia cymosa* (2.13%). This shows that *Vernonia auriculifera* and *Cestrum aurantiacum* could take over the forest plantations after harvesting of the planted pines. Further trees in the disturbed part of Kiptangus forest were counted, their diameters and heights determined and the results are presented in Table 13.

Table 13

Tree Species found in Kiptangus Disturbed Forest Area

Species	**Frequency**	**Percent**	**Mean Height (m)**	**Mean Diameter (cm)**
Croton macrostachyus	8	26.67	20.70 ± 9.83	19.94 ± 9.02
Ficus thonnimgii	2	6.67	23.05 ±1.06	71.70 ± 43.13
Celtis africana	7	23.33	27.30 ± 6.06	47.10 ±10.68
Diospyros abyssinica	9	30.00	21.47 ± 5.12	43.57 ± 4.41
Ehretia cymosa	2	6.67	13.55 ± 1.06	27.30 ± 4.95
Bersama abyssinica	1	3.33	12.3	31.4
Albizia gummifera	1	3.33	13.8	12.6
Total	**30**	**100.00**		

From the Table 13**,** *Diospyros abyssinica* was the most abundant tree species in the disturbed forest of Kiptangus and accounted for 30.0% of the tree species in the area. This was followed by *Croton macrostachyus* (26.67%) and *Celtis africana* (23.3%). *Celtis africana* had the greatest height with a mean of 27.30 ± 6.06m followed by *Ficus thonnimgii* (23.05 ±1.06m) and *Croton macrostachyus* (20.70 ± 9.83m) while *Bersama* *abyssinica* was the shortest with a height of 12.3m followed by *Albizia gummifera* with a height of 13.8m. Saplings were also counted in Kiptangus disturbed forest area. Table 14 presents the results.

Table 14

Saplings in Kiptangus Disturbed Forest

Species	**Frequency**	**Percent**
Vernonia auriculifera	25	3.39
Solanum mauritianum	16	2.17
Vangueria madagascariensis	2	0.27
Cestrum aurantiacum	670	90.79
Croton macrostachyus	5	0.68
Rubus apetalus	6	0.81
Caesalpinia decapetala	2	0.27
Acanthus eminens	12	1.63
Total	**738**	**100.0**

Table 14 shows that *Cestrum aurantiacum* species was the most dominant sapling species (90.79%) while the least dominant was *Caesalpinia decapetala* (0.27%). This shows that in the disturbed forest area of Kiptangus, *Cestrum aurantiacum* is more likely to take over the area since it was the most dominant species. In this case C. *aurantiacum* is an invasive species and thus have the potentials of affecting the biodiversity and plant community of Kiptangus native forest which is the remnant of the Guineo– Congolian rainforest. In addition, trees species in undisturbed part of Kiptangus forest area were also sampled. The diameters and height were taken and the results are presented in Table 15.

Table 15

Trees found in Kiptangus Undisturbed Forest

Tree species	**Number**	**Percent**	**Mean Diameter (cm)**	**Mean height (m)**
M. kilimandscharica	2	4.35	42.90 ± 25.60	20.80± 6.36
Celtis africana	13	28.26	42.75 ± 13.65	31.38 ± 7.17
Prunus africana	4	8.70	54.83 ±15.29	28.55 ± 6.74
Diospyros abyssinica	20	43.48	41.84 ± 10.82	29.24 ±7.43
Albizia gummifera	4	8.70	29.63 ± 17.21	19.18 ±10.31
Cesrum aurantiacum	3	6.52	7.93 ± 2.22	10.30 ± 1.80
Total	**46**	**100.00**		

Table 15 shows that *Prunus africana* had the largest diameter with a mean of 54.83 ±15.29 cm followed by *Macaranga kilimandscharica* with a mean diameter *of* 42.90 ± 25.60 cm and *Celtis africana* with a mean diameter of 42.75 ± 13.65cm while *Cesrum aurantiacum* had the smallest diameter of 7.93 ± 2.22cm. In terms of height, Celtis africana was the tallest tree with a mean height of 31.38 ± 7.17m followed by *Diosyros abyssinica* with a mean height of 29.24 ±7.43m and *Prunus africana* with a mean height of 28.55 ± 6.74m while *Cesrum aurantiacum* was the shortest tree species with a mean height of 10.30 ± 1.80m. The most dominant tree was *Diosyros abyssinica* and accounted for 43.48% of the plants in the forest area. Saplings in the undisturbed part of Kiptangus forest were also counted. Table 16 presents the findings.

Table 16

Saplings in Undisturbed Kiptangus Forest

Sapling Species	**Frequency**	**Percent**
Cestrum aurantiacum	261	78.61
Dovyalis macrocalyx	39	11.75
Solanum mauritianum	11	3.31
Diospyros abyssinica	3	0.90
Vangueria madagascariensis	1	0.30
Carissa spinarum	1	0.30
Acanthus eminens	9	2.71
Albizia gummifera	1	0.30
Polyscias fulva	1	0.30
Bersama abyssinica	4	1.20
Total	**332**	**100.0**

Table 16 shows that *Cestrum aurantiacum* was the most abundant sapling in the undisturbed part of Kiptangus forest followed by *Dovyalis macrocalyx* species. However, the least abundant species were *Vangueria madagascariensis, Solanum mauritianum, Carissa spinarum, Albizia gummifera* and *Polyscias fulva. Cestrum aurantiacum* is exotic species in Kenya and native to Central America (Neville, Murphy and Preston, 2003) and is known as an escape species from living collection and has an invasive potential in many forest areas (Monro, 2012). It has been identified as a wide-spread and well-established invasive species in many countries around the world (Pyšek, Jarošík and Hulme, 2012). *C. aurantiacum* was identified as an exotic invasive plant causing several adverse impacts including displacing native plants from their habitat (Henderson, 2007). Secondly, *C. aurantiacum* is poisonous to humans and animals (Sivaraj, Vidya, Nandini and Sanil, 2015). The main concern on the effect of *C. aurantiacum* as invasive species is the possible risk caused by the species invasion to forest ecosystems and economy (Junaedi, 2012).

Further, plants were counted in Kiptuiya *Eucalyptus* plantation and it emerged that *Eucalyptus* species had a mean diameter of 29.27 ± 7.30cm with a mean height of 20.92 ±6.14m while one plant of Polyscias fulva with 17cm diameter and a height of 16.3m was also found in the plantation. Within the plantation, saplings were also counted and are presented in Table 17.

Table 17

Saplings in Kiptuiya Eucalyptus Plantation

Species	**Frequency**	**Percent**
Solanum mauritianum	282	63.37
Eucalyptus saligna	14	3.15
Markhamia lutea	3	0.67
Croton megalocarpus	16	3.60
Lantana camara	13	2.92
Vernonia auriculifera	31	6.97
Spathodea campanulata	1	0.22
Ocimum species	78	17.53
Caesalpinia decapetala	4	0.90
Croton macrostachyus	3	0.67
Total	**445**	**100.0**

In the *Eucalyptus* plantation in Kiptuiya, the most common sapling was *Solanum mauritianum (*63.37%) followed by *Ocimum* species (6.97%) while the least abundant was *Spathodea campanulata* (0.22%). This implies that *Solanum mauritianum which is an invasive species* is more likely to take over the *Eucalyptus* plantation in Kiptuiya forest. *Solanum mauritianum* is a small, broad-leafed, perennial tree typically reaching four meters in height. The leaves and stems are covered in pubescent, felt-like hairs which are a dermal and respiratory irritant, making the plant highly unpalatable and deterring any wild game or domestic herbivores (Olckers, 2009). The unripe fruits are high in alkaloids, namely solasodine, rendering the plant toxic to both humans and animals (Henderson and Wilson, J2017), excluding frugivorous species which feed on the ripe fruits with impunity. The invasion of *S. mauritianum* often results in the formation of dense stands, which outcompete and shade-out surrounding vegetation (Hendersonand Wilson, 2017). These invasions are particularly troublesome in commercial forestry, where *S. mauritianum* interferes with the growth and establishment of saplings, including *Pinus* spp. and to a lesser extent Eucalyptus spp (Atkinson *et al.*, 2014). Additionally, in natural forests like Kiptuiya, the availability of S*. mauritianum's* fruit has resulted in dietary shifts of native frugivores, namely birds, towards the weed, to the detriment of native fruiting species (Mokotjomela *et al.,* 2013). In addition, tree species were counted in the Kiptuiya disturbed forest area. The results are presented in Table 18.

Table 18

Tree species in Kiptuiya Disturbed Forest

Tree species	**Frequency**	**Percent**	**Mean Diameter (cm)**	**Mean Height (m)**
Ficus sycomorus	4	14.29	50.35 ± 26.48	23.75 ± 3.13
Polyscias fulva	7	25.00	47.41 ± 32.39	19.66 ± 6.61
Strombosia scheffleri	5	17.86	26.14 ± 15.79	13.36 ± 6.15
Celtis africana	3	10.71	32.00 ± 29.72	17.47 ± 9.70
Diospyros abyssinica	2	7.14	35.90 ± 16.26	13.05 ± 10.25
Albizia gummifera	2	7.14	23.80 ± 14.85	5.80 ± 2.83
Ficus thonningii	1	3.57	35.7	23.3
Zanthoxylum gilletii	1	3.57	21	19.8
Bridelia micrantha	3	10.71	8.07 ± 3.14	7.77 ±.503
Total	**28**	**100.00**		

In Kiptuiya disturbed forest, *Ficus sycomorus* had the largest diameter of 50.35 ± 26.48cm followed by Polyscias fulva which had a mean diameter of 47.41 ± 32.39cm and *Diospyros abyssinica* which had a mean diameter of 35.90 ± 16.26cm. In terms of height, *Ficus sycomorus* had the greatest height of 23.75 ± 3.13m followed by *Ficus thonningii* which had a height of 23.3m. However, in terms of tree abundance, *Polyscias fulva* was the most abundant and accounted for 25.00% of the tree species in the area followed by *Strombosia scheffleri* which accounted for 17.86% of the trees. Saplings were also counted in the disturbed forest of Kiptuiya and results are presented in table 19.

Table 19

Saplings in Kiptuiya Disturbed Forest

Saplings	**Frequency**	**Percent**
Solanum mauritianum	28	31.11
Croton megalocarpus	10	11.11
Vernonia auriculifera	2	2.22
Trichocladus ellipticus	2	2.22
Zanthoxylum gilletii	2	2.22
Syzygium guineense	2	2.22
Teclea nobilis	3	3.33
Ocotea kenyensis	2	2.22
Vangueria madagascariensis	2	2.22
Acanthus eminens	37	41.11
Total	**90**	**100.0**

Saplings counted as shown in Table 19 shows that *Acanthus eminens* was the common sapling in Kiptuiya disturbed area (41.11%) followed by *Solanum mauritianum* at 31.11% while the least common was *Vangueria madagascariensis, Vernonia auriculifera, Trichocladus ellipticus, Zanthoxylum gilletii, Syzygium guineense and*

Ocotea kenyensis at (2.22%) each. *Solanum mauritianum* is an invasive species and the weed's invasion is facilitated by large seed banks (Goodall *et al*., 2017) and dispersal by frugivorous birds and mammals, which readily feed on the abundant fruit, dispersing seeds over long distances (Jordaan *et al.*, 2011). Trees were counted in Kiptuiya undisturbed forest and their heights and diameters taken. The results of the analysed data are presented in Table 20.

Table 20

Trees in Kiptuiya Undisturbed Forest

Tree species	**Number counted**	**Percent**	**Mean Diameter (cm)**	**Mean Height (m)**
Bridelia micrantha	4	8.16	32.13 ±16.65	17.43 ±2.95
Albizia gummifera	1	2.04	13	9.3
Diospyros abyssinica	3	6.12	32.67 ±16.79	16.80±3.00
Ocotea kenyensis	2	4.08	7.60 ±.14	6.05 ±1.06
Strombosia scheffleri	1	2.04	51.2	16.3
C.megalocarpus	10	20.41	30.35 ±17.97	16.61 ±8.06
M. kilimandscharica	1	2.04	32.2	16.3
T. stapfiana	2	4.08	15.25 ± 6.72	7.80 ± 2.83
Polyscias fulva	5	10.20	48.36 ± 29.45	19.10 ± 6.05
Craibia brownie	2	4.08	23.30 ±9.90	15.55 ±2.48
V. madagascariensis	1	2.04	12.1	9.3
Olea capensis	2	4.08	28.35 ± 16.48	22.30 ±8.49
Celtis africana	4	8.16	11.55 ± 2.71	11.15 ± 3.01
Myrsine africana	1	2.04	6.8	5.8
Ficus sycomorus	1	2.04	110.5	30.3
Ehretia cymosa	4	8.16	20.23 ± 5.92	8.80 ±3.92
C. macrostachyus	2	4.08	33.05 ± 1.49	19.30 ± .71
Syzgium guineense	1	2.04	15.1	7.8
Momordica foetida	1	2.04	11.8	13.3
Bridelia micrantha	1	2.04	21.4	12.8
Total	**49**	**100.0**		

In Kiptuiya undisturbed forest area, the most dominant species was *Croton megalocarpus* while the least dominant was *Bridelia micrantha, Momordica foetida, Syzygium guineense, Ficus sycomorus, Myrsine africana, Vangueria madagascariensis, Macaranga kilimandscharica,* and *Albizia gummifera.* In terms of diameter, *Ficus sycomorus* had the largest diameter (110.5cm) followed by *Polyscias fulva* (48.36 ± 29.45cm), *Croton macrostachyus* (33.05 ± 1.49cm) and *Diospyros abyssinica* (32.67 ±16.79cm) while *Myrsine africana* had the smallest diameter (6.8cm). *Ficus sycomorus* was also the tallest tree with a height of 30.3m followed by *Olea capensis* with a mean height of 22.30 ± 8.49m while *Myrsine africana* was the shortest tree (5.8m). Saplings were also counted in Kiptuiya undisturbed forest and the results are presented in Table 21.

Table 21

Saplings in Kiptuiya undisturbed forest

Species	**Frequency**	**Percent**
Solanum mauritianum	36	9.55
Diospyros abyssinica	2	0.53
Ocotea kenyesis	14	3.71
Acanthus eminens	298	79.04
Croton megalocarpus	6	1.59
Celtis africana	2	0.53
Cassipourea malosana	1	0.27
Albizia gummifera	1	0.27
Bersama abyssinica	6	1.59
Dovyalis macrocalyx	11	2.92
Total	**377**	**100.0**

As shown in table 21, *Acanthus eminens* (79.04%) was the most dominant sapling in the undisturbed forest in Kiptuiya followed by *Solanum mauritianum (9.55%)* while the least dominant was *Cassipourea malosana* (0.27%) and *Albizia gummifera* (0.27%).

This shows that in the undisturbed forest, *Acanthus eminens* remains the dominant sapling species. *Acanthus eminens* is a medicinal plant used mostly by locals to treat wounds as pointed out by Bussmann *et al.,* (2011) who found out that *Acanthus eminens* was used in Ethiopia as medicine where leaves were dried, grounded, mixed with butter and applied on wounds. Further tree species were surveyed in Kombe disturbed forest, their diameters, heights and abundance were recorded and the results are presented in Table 22.

Table 22

Tree Abundance, Diameters and Heights in Kombe Disturbed Forest

Tree species	**Number**	**Percent**	**Mean Diameter (cm)**	**Mean Height (m)**
Craibia brownie	3	10.34	49.93 ± 20.24	19.97 ± 7.97
Celtis africana	1	3.45	55.6	26.3
Macaranga kilimandscharica	2	6.90	53.00 ± 26.87	25.05 ± 10.25
Polyscias fulva	4	13.79	28.55 ± 11.74	24.43 ± 6.91
Croton megalocarpus	4	13.79	35.08 ± 24.07	19.55 ±8.33
Albizia gumnifera	1	3.45	9.9	15.8
Diospyros abyssinica	8	27.59	38.76 ±12.45	23.05 ±4.03
Syzygium guineense	2	6.90	86.90 ± 34.22	26.55 ±2.47
Olea capensis	2	6.90	8.55 ± 3.32	7.05 ± 3.18
Ficus thonningii	1	3.45	164	22.8
Tabernaemontana stapfiana	1	3.45	13	6.8
Total	**29**	**100.00**		

Table 22 shows that most dominant tree species in Kombe disturbed forest was *Diospyros abyssinica* followed by *Polyscias fulva* and *Croton megalocarpus* but in terms of diameter, *Ficus thonningii* had the largest diameter of 164cm followed by *Syzygium guineense* (86.90 ± 34.22cm*), Macaranga kilimandscharica* with a diameter of 53.00 ± 26.87 and *Craibia brownii* with a diameter of 49.93 ± 20.24cm while *Albizia gummifera* had the lowest diameter of 9.9cm. In terms of height, *Syzygium guineense* was the tallest tree with a height of 26.55 ±2.47m followed by *Macaranga kilimandscharica* with a height of 25.05 ± 10.25m but *Tabernaemontana stapfiana* was the shortest tree with a height of 6.8m. Thus, the most dominant tree in Kombe disturbed forest was *Diospyros abyssinica.* The fruits of *Diospyros abyssinica* are consumed by birds and various mammals, and are an important part of the diet of primates and fruit bats. Saplings were also counted in Kombe disturbed forest and the results of the analysed information is presented in Table 23.

Table 23

Saplings at Kombe disturbed forest

Species	**Frequency**	**Percent**
Solanum mauritianum	125	72.25
Vernonia auriculifera	22	12.72
Vangueria madagascariensis	10	5.78
Croton macrostachyus	2	1.16
Momordia foetida	2	1.16
Bersama abyssinica	2	1.16
Craibia brownii	1	0.58
Albizia gummifera	1	0.58
Croton megalocarpus	5	2.90
Ehretia cymosa	1	0.58
Macaranga kilimanscharica	1	0.58
Dovyalis macrocalyx	1	0.58
Total	**173**	**100.0**

From the table 23, *Solanum mauritianum* (72.25%) was found to be the most abundant sapling in the disturbed forest area of Kombe followed by *Vernonia auriculifera* (12.72%) and *Vangueria madagascariensis* (5.78%) while the least abundant species were *Craibia brownii, Albizia gummifera, Ehretia cymosa, Macaranga kilimandscharica* and *Dovyalis macrocalyx.* Thus, the most dominant sapling in Kombe disturbed forest was *Solanum mauritianum.* As discussed, earlier, *Solanum mauritianum* is an invasive species and the weed's invasion is facilitated by large seed banks (Goodall *et al.*, 2017) and dispersal by frugivorous birds and mammals, which readily feed on the abundant fruit, dispersing seeds over long distances (Jordaan *et al.*, 2011). Thus, the sapling is more likely to colonize Kombe disturbed forest due to its invasiveness. Tree species in Kombe undisturbed forest were also counted, their diameter and heights measured and the results are presented in Table 24.

Table 24

Trees in Kombe undisturbed Forest

Trees	**Frequency**	**Percent**	**Mean Diameter (cm)**	**Mean Height (m)**
Pouteria adolfi	7	7.14	34.66 ± 24.29	20.30 ± 12.25
Diospyros abyssinica	8	8.16	22.98 ±10.43	21.99 ± 6.39
Strombosia scheffleri	3	3.06	25.40 ± 15.98	21.98 ± 12.47
Cassipourea malosana	16	16.33	18.84 ± 6.27	17.80 ± 5.57
Ekebergia capensis	1	1.02	56.2	26.3
Glycine wightii	2	2.04	9.05 ±1.20	8.80 ±3.54
Polyscias fulva	8	8.16	38.35 ± 26.99	21.11 ± 8.32
M. kilimandscharica	21	21.43	25.45 ± 12.53	21.40 ± 7.12
T. stapfiana	8	8.16	22.54 ±12.76	11.93 ± 5.40
Schefflera volkensii	1	1.02	18.8	10.8
Celtis Africana	4	4.08	23.60 ± 13.93	16.80 ± 6.61
Aframomum keniense	3	3.06	18.70 ± 4.11	15.30 ± 5.77
Fagaropsis angolensis	2	2.04	28.20 ± 9.05	17.80 ± .71
Croton megalocarpus	3	3.06	21.77 ± 5.97	22.63 ± 2.31
Olea capensis	1	1.02	4.3	13.3
Momordica foetida	1	1.02	42.3	47.3
Drypetes gerrardii	5	5.10	23.82 ± 15.93	23.50 ± 8.29
Syzygium guineence	4	4.08	51.53 ± 5.36	25.30 ± 5.35
Total	**98**	**100.00**		

From the Table 24, *Macaranga kilimandscharica (*21.43%*)* was the most dominant tree species in the undisturbed Kombe forest followed by *Cassipourea malosana* (16.33%), *Tabernaemontana stapfiana* (8.16%) and *Diospyros abyssinica* (8.16%) while the least dominant tree species was *Ekebergia capensis,* (1.02%), *Schefflera volkensii* (1.02%), *Olea capensis* (1.02%) and *Momordica foetida* (1.02%). *Ekebergia capensis* had the largest diameter of 56.2cm followed by *Syzygium guineence* with a mean diameter of 51.53 ± 5.36cm and *Momordica foetida* with a diameter of 42.3cm while *Olea capensis* had the smallest diameter of 4.3cm. In terms of height, *Momordica foetida* was the tallest tree species with a mean height of 47.3m followed by *Syzygium guineence* with a mean height of 25.30 ± 5.35m and *Drypetes gerrardii* (23.50 ± 8.29m) while the shortest tree species was *Glycine wightii* with a mean height of 8.80 ±3.54m. Thus, from the table, it can be deduced that *Macaranga kilimandscharica* was the most dominant tree species in Kombe undisturbed forest area. The tree is harvested from the wild for local use as a medicine and source of wood and is used as a pioneer species for restoring woodland and protecting the soil (Magadula, 2014). Further, saplings were counted in Kombe undisturbed forest. Results are presented in Table 25.

Table 25

Saplings in Kombe Undisturbed Forest

Species	**Frequency**	**Percent**
Cassipourea malosana	42	4.28
Diospyros abyssinica	7	0.71
Vangueria madagascariensis	4	0.41
Syxygium guineense	2	0.20
Acanthus eminens	42	4.28
Brillantaisia madagascariense	262	26.71
Bracaena laxissima	16	1.63

Acanthus eminens	300	30.68
Strombosia scheffleri	6	0.61
Brillantaisia nitens	300	30.48
Total	**981**	**100.00**

Table 25 shows that *Acanthus eminens (30.68%) and Brillantaisia nitens (30.48%)* were the most dominant saplings in Kombe undisturbed forest followed by Brillantaisia madagascariense (26.71%) while the least dominant was *Syxygium guineense* at 0.20% followed by *Vangueria madagascariensis at 0.41%*. Thus, *Brillantaisia nitens* and *Acanthus eminens* were the most dominant saplings.

Comparison of dorminant trees and saplings in disturbed and undisturbed forests in the four sub locations

In Kipsamoite disturbed forest, the most dominant species were *Croton megalocarpus*, Diospyros *abyssinica* and *Momordica foetida* and the most dominant tree species in Kombe disturbed forest was *Diospyros abyssinica* followed by Polyscias *fulva* and *Croton megalocarpus* and in the disturbed part of Kiptangus forest, *Diospyros abyssinica* was the most abundant tree species, followed by *Croton macrostachyus* and *Celtis Africana.* While in Kiptuiya, the dorminant tree species was *Polyscias fulva.* Figure 5 shows the comparisons of dominant tree species in the four sub-locations

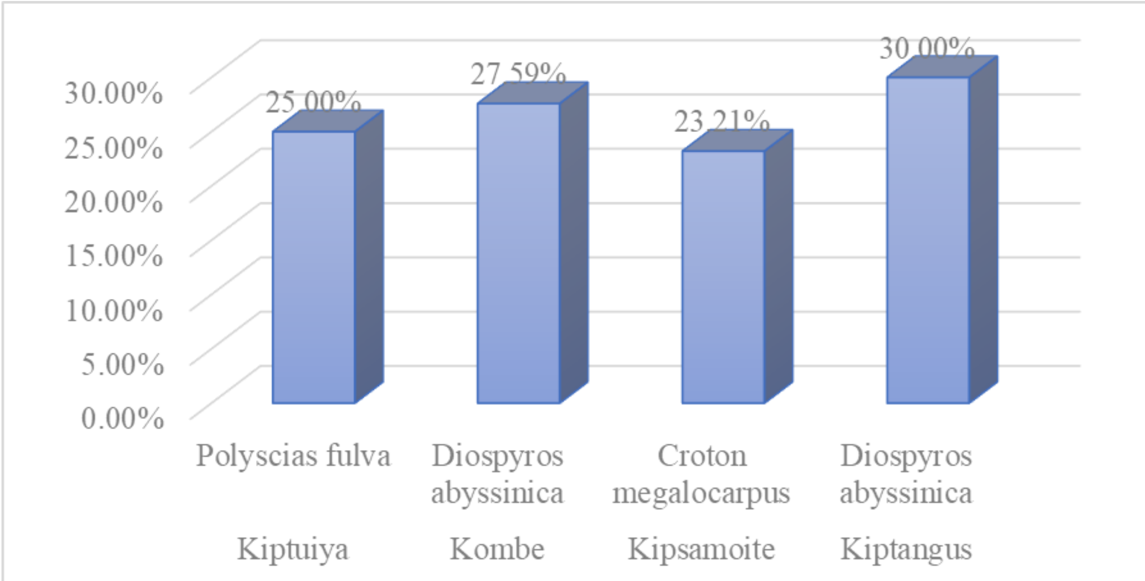

Figure 5: Dominant tree species in disturbed forests in the four Sub-Locations

In Kipsamoite undisturbed forest, *Croton megalocarpus* was the most dominant tree species followed by *Macaranga kilimandscharica*. *Macaranga kilimandscharica* was the most dominant tree species in the undisturbed Kombe forest followed by *Cassipourea malosana.* In Kiptuiya undisturbed forest area, the most dominant species was *Croton megalocarpus and in Kiptangus forest, the dorminant species was Diospyros abyssinica.* Figure 6 presents a summary of most dominant tree species in the undisturbed forests in the four sub-locations.

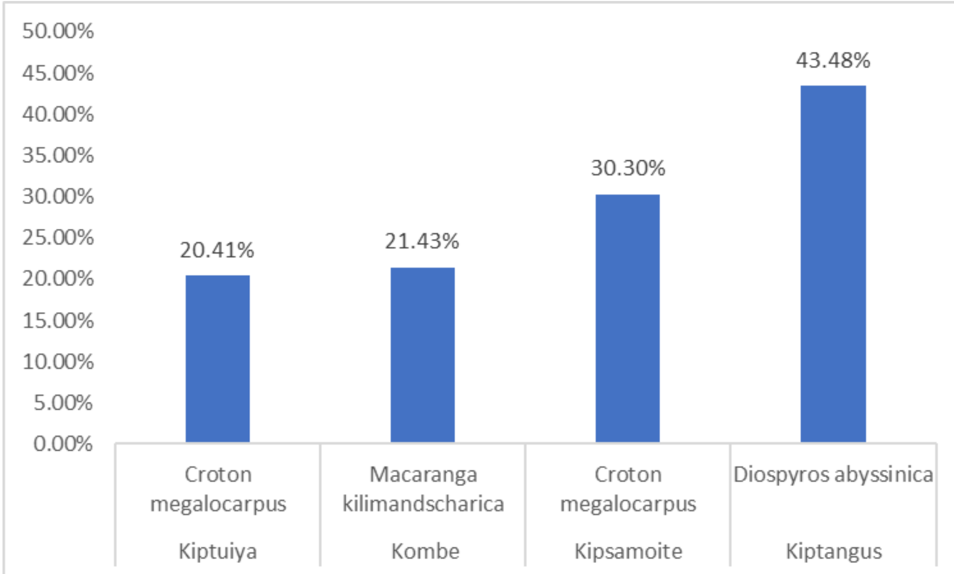

Figure 6: Dominant tree species in the Undisturbed forests in the four Sub-Locations

Acanthus eminens was the most dominant sapling, followed by *Cassipourea malosana* in Kipsamoite disturbed forest while *Cestrum aurantiacum* was the most dominant sapling in the disturbed forest of Kiptangus. *Cestrum aurantiacum* is more likely to take over the area since it was the most dominant species and is an invasive species and thus have the potentials of affecting the biodiversity and plant community of native forest (Figure 14: *Cestrum aurantiacum). Solanum mauritianum* was found to be the most abundant sapling in the disturbed forest area of Kombe followed by *Vernonia auriculifera* and *Vangueria madascariensis.* In Kiptuiya disturbed forest, *Acanthus eminens* was the common sapling followed by *Solanum mauritianum.* Solanum mauritianum is an invasive species and the weed's invasion is facilitated by large seed banks and dispersal by frugivorous birds and mammals, which readily feed on the abundant fruit, dispersing seeds over long distances. Figure 7 shows the comparisons of dominant saplings in the disturbed forests in the four sub-locations.

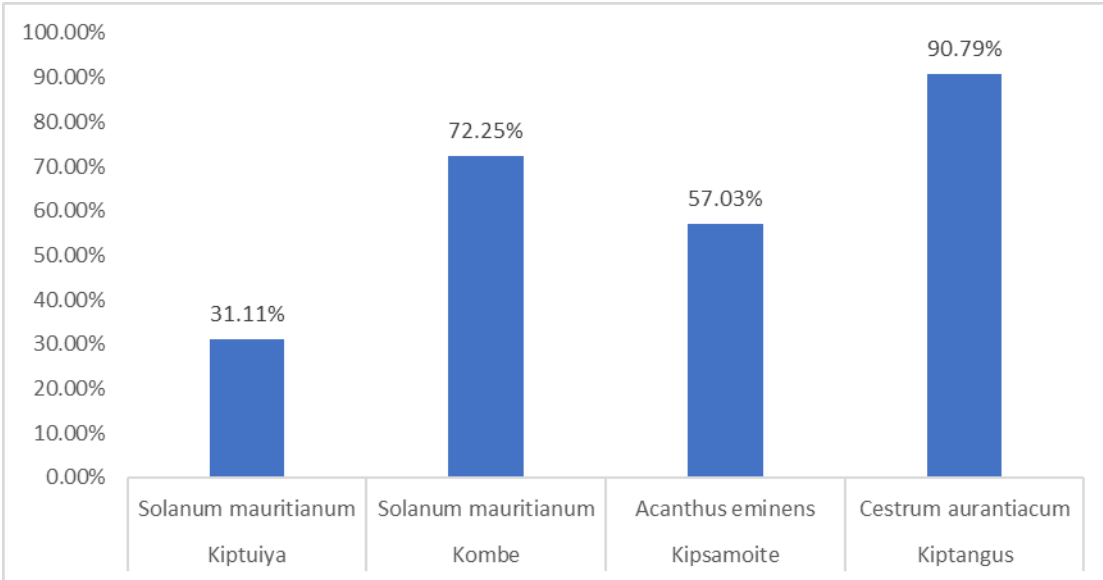

Figure 7: Dominant Saplings in disturbed forests in the four Sub-Locations

In Kombe undisturbed forest, *Acanthus eminen*s was the most dominant sapling followed by *Brillantaisia madagascariense*. In undisturbed part of Kiptangus forest area it emerged that *Cestrum aurantiacum* was the most abundant sapling followed by *Dovyalis macrocalyx* species. Cestrum aurantiacum is exotic species in Kenya and native to Central America and is known as an escape species from living collection and has an invasive potential in many forest areas. In Kiptuiya undisturbed forest area, *Acanthus eminens* was the most dominant sapling followed by *Solanum mauritianum. Also, in Kipsamoite undisturbed forest*, *Acanthus eminen*s was the most dominant sapling. Figure 8 presents a comparison of dominant saplings in the undisturbed forest in the four sub-locations.

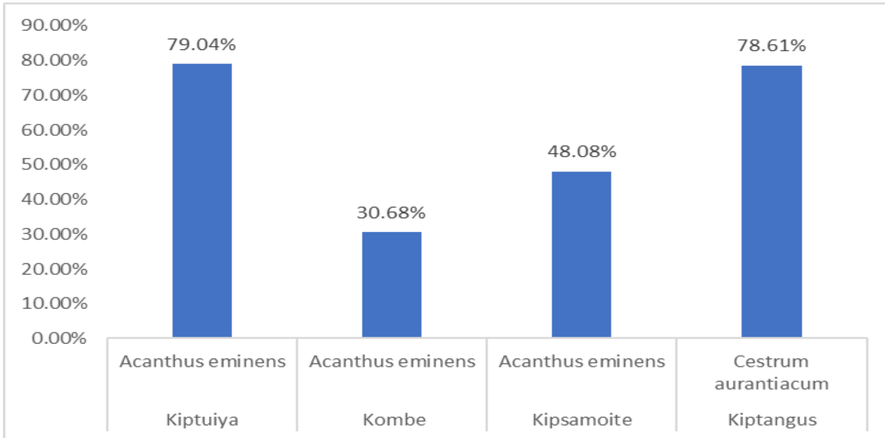

Figure 8: Dominant saplings in the undisturbed forest in the four sub-locations

Comparison of Dominant Tree Heights in Metres and Diameters in Centimeters in Disturbed and Undisturbed Forests in the Four Sub-Locations

Dorminant tree heights (metres) and tree diameters (cm) in the disturbed forests in the four sub-locations are presented in Figure 9 and 10 respectively.

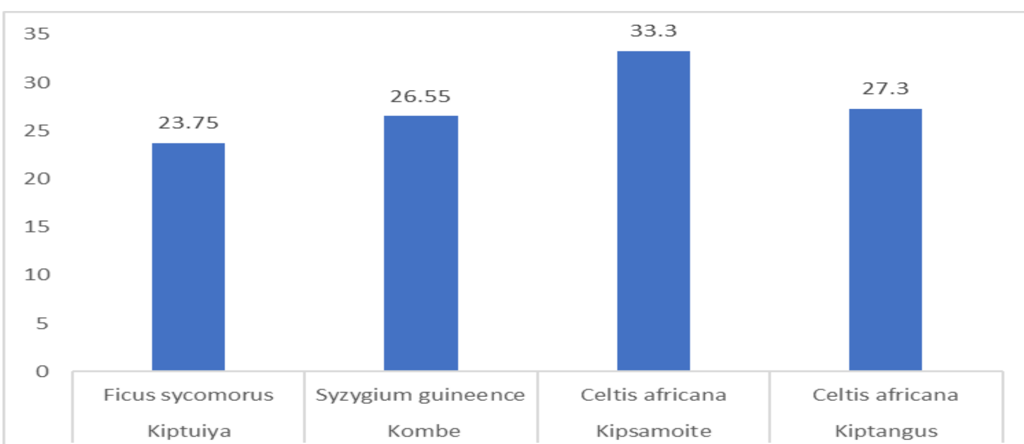

Figure 9: Dominant tree heights in meters in the disturbed forests in the four sub-locations

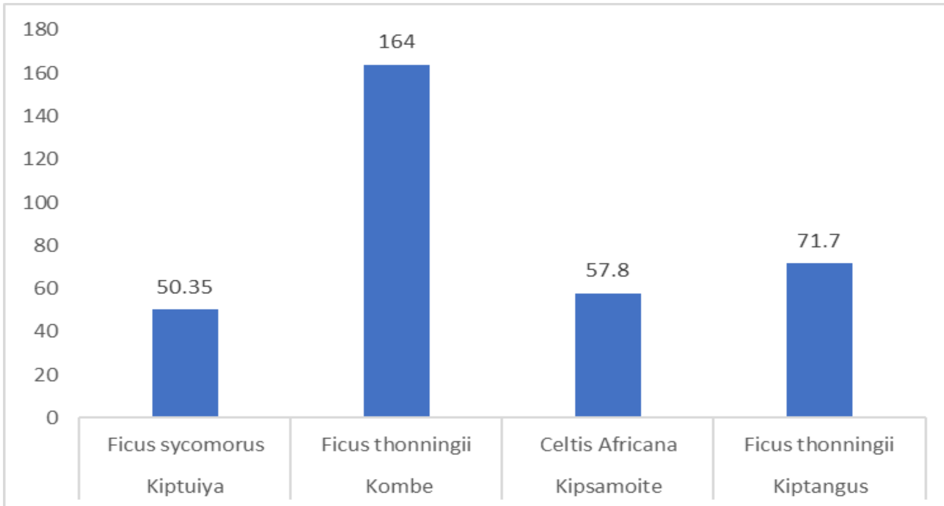

Figure 10: Dorminant tree diameters in centimeters in the disturbed forests in the four sub-locations

Dorminant tree heights (metres) and tree diameters (cm) in the undisturbed forests in the four sub-locations are presented in Figure 11 and 12 respectively.

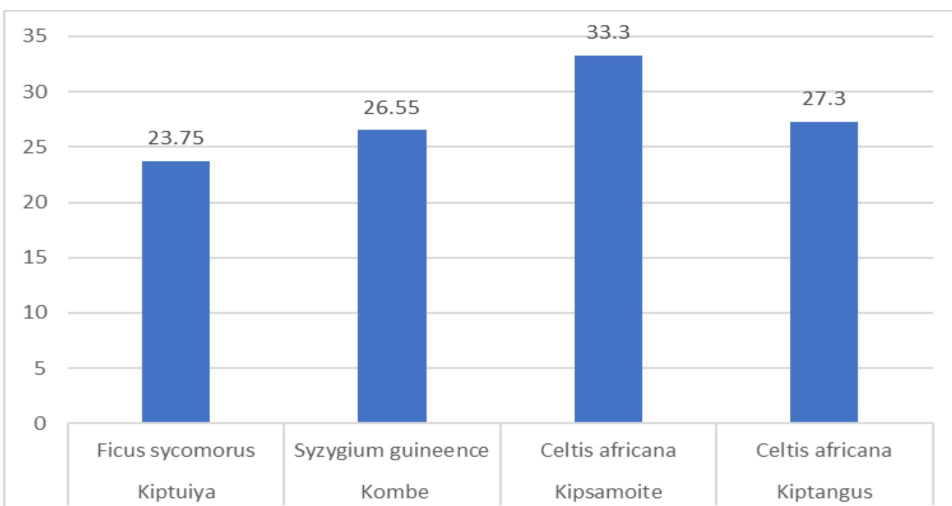

Figure 11: presents dominant tree heights (meters) in the undisturbed forests in the four sub-locations

Figure 12 presents the dominant diameter in tree species in the undisturbed forests in the four sub-locations

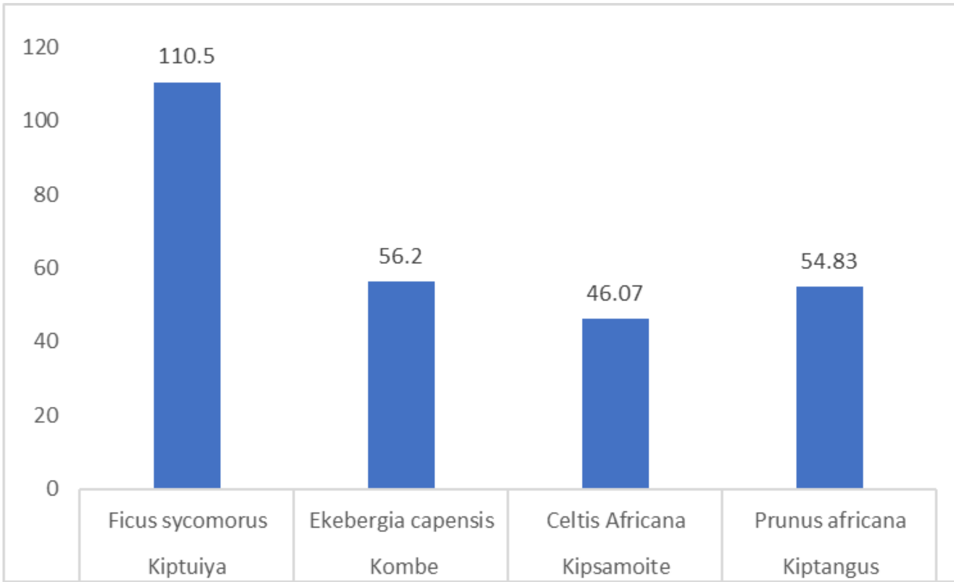

Figure 12: Dominant diameter in tree species in the undisturbed forests in the four sub-locations.

Disturbances in the Forest

Table 26 presents the type of trees that were targeted in North Nandi Forest.

Table 26

Disturbance in North Nandi Forest

Tree Species	**Number**	**Percentage**	**Type of Disturbance**
Croton megalocarpus	19	22.35	for Fuelwood
Syzygium guineense	18	21.18	for posts
Ehretia cymosa	2	2.35	For Jembe pins and Posts
Tabernaemontana stapfiana	4	4.71	For Jembe pins and Posts
Craibia brownie	6	7.06	For Jembe pins and Posts
Macaranga kilimandscahrica	10	11.76	for making cooking sticks and jembe pins
Polyscias fulva	3	3.53	for making cooking sticks and

			jembe pins
Croton macrostachyus	3	3.53	for Fuelwood
Celtis africana	6	7.06	For Posts andd Fuelwood
Ehretia cymosa	1	1.18	For Jembe pins and fuelwood
Diospyros abyssinica	12	14.12	For Posts and fuelwood
Bridelia micrantha	1	1.176	Posts and Fuelwood
Total	**85**	**100.00**	

In Kipsamoite disturbed indigenous forest, *Croton megalocarpus* was targeted for firewood while *Syzygium guineense, Ehretia cymosa and Tabernaemontana stapfiana* were targeted mainly for jembe pins and fencing posts. In the undisturbed forest area of Kipsamoite *Syzygium guineense, Craibia brownii, Tabernaemontana stapfiana, Croton megalocarpus, Macaranga kilimandscahric and Polyscias fulva* were mainly targeted for fencing posts, making of cooking sticks, jembe pins and firewood. Photos of tree stumps targeted are presented in Figure 15.

In Kiptangus forest plantation, the kind of disturbance that was noted on *Pinus patula* was silvicultural thinning by the Kenya Forest Service. While in the disturbed indigenous forest, illegal cutting of trees including *Croton macrostachyus, Syzygium guineanse*, *Celtis africana and Ehretia cymosa* were cut mainly for firewood, fencing posts, jembe pins and timber. Also, in the undisturbed part of the forest, *Celtis africana* and Diospyros abyssinica were illegally cut mainly for firewood, posts and making of jembe pins.

In Kiptuiya forest plantation, *Eucalpytus saligna* was targeted illegally for posts and in Kiptuiya disturbed indigenous forest area, illegal cutting of trees particularly *Polyscias fulva*, *Diospyros abyssinica* and *Bridelia micrantha* were cut for fencing posts, firewood jembe pins and during honey harvesting. While *Celtis africana, Macaranga* *kilinacharica* and *Croton megalocarpus* were illegally targeted in the undisturbed part of the forest for fuelwood.

In Kombe disturbed indigenous forest, illegal cutting of trees particularly *Croton megalocorpus, Craibia brownii, Diospyros abyssinica, Macaranga kilimandscharica, Zyzygium guineense and Polyscias fulva* were mainly cut for fencing posts, fuelwood, making of Jembe pins and timber. In the undisturbed forest *Syzygium guineense* and *Macaranga Kilimandscharica* were targeted for posts and fuelwood.

Influence of CFA on Forest Structure

The second hypothesis stated that;

H_{02}: CFA has no significant influence on the forest structure in North Nandi Forest.

This hypothesis was tested using chi-square tests on the actions undertaken by CFA to conserve forest and number of trees that had been illegally cut in all the four sub-locations of the forest. The results are presented in Table 27.

Table 27

Influence of CFA on Forest Structure

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	32.591[a]	12	.001
Likelihood Ratio	37.108	12	.000
Linear-by-Linear Association	11.573	1	.001
N of Valid Cases	136		

Table 27 shows that CFA had an influence on forest structure since the p-values were less than 0.05. This shows that there was a significant effect of involvement of CFA on forest conservation and the number of illegally cut trees in the forest. The null hypothesis was therefore rejected and the alternate accepted. This shows that involvement of CFAs reduces on the number of trees that are illegally cut and thus improving on the abundance of trees in the forest.

Mammalian Abundance

The study surveyed all mammals present and their abundance using a defined transects line that followed a straight- or parallel-line during data collection in the four forest areas of Kiptuiya, Kiptangus, Kombe and Kipsamoite. In the four sites, animals were counted in the plantations (except Kombe since there were no plantations in this forest site), disturbed and undisturbed forest areas. Table 28 presents the results of mammals counted in Kiptuiya Forest area.

Table 28

Mammals in Kiptuiya Forest

	Eucalyptus plantation		**Disturbed forest**		**Undisturbed forest**	
Animal	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Baboon	10	13.7	5	10.4	11	9.8
Antelope	2	2.7	3	6.3	3	2.7
Monkey	44	60.3	16	33.3	54	48.2
Squirrel	4	5.5	4	8.3	11	9.8
Fox	2	2.7	1	2.1	19	17.0
Hare	2	2.7	0	0	1	0.9
warthog	1	1.4	0	0	2	1.8
Porcupine	4	5.5	15	31.3	2	1.8
Rat	1	1.4	2	4.2	2	1.8
Mouse	2	2.7	2	4.2	4	3.6
Mongoose	1	1.4	0	0	2	1.8
Hedgehog	0	0	0	0	1	0.9

Total	**73**	**100**	**48**	**100**	**112**	**100**

Table 28 shows that a total of 73 mammals were counted in Eucalyptus plantation and the most dominant mammals were the monkeys (60.3%) followed by baboons (13.7%), squirrels (5.5%) while the least dominant was the mongoose (1.4%) and warthogs (1.4%). In the disturbed forest section, a total of 48 mammals were counted and the most dominant were monkeys (33.3%), and porcupines (31.3%) while least dominant was the fox (2.1%). In the undisturbed forest section, a total of 112 mammals were counted and it emerged that monkeys were dominant (48.2%), followed by fox (17.0%), baboons (9.8%) and squirrel (9.8%) while the least dominant was hedgehog (0.9%) and hare (0.9%). From the results it emerged that monkeys were dominant in the eucalyptus plantation, disturbed and undisturbed forest areas of Kiptuiya. According to Mong'ina and Muok, (2021) for exotic, (those which come from other countries), or natural forests (which are wholly indigenous forests and plants) the monkey strips the bark off the trees to feed on underlying vascular tissues, destroying the habitat. In one of the few quantitative studies, *Prunus africana* accounted for up to 17% of the annual diet of red colobus monkeys in the Kibale Forest, Uganda, and had the highest feeding time/stem density ratio of any tree species in the diet (Chapman and Chapman, 2002). Table 29 presents the results of mammals counted in Kombe Forest area. In this area, there were no plantations and thus only the disturbed and undisturbed forest areas were covered.

Table 29

Mammals in Kombe Forest

Animal	Disturbed forest		Undisturbed forest	
	Frequency	**%**	**Frequency**	**%**
Black Monkey	41	75.9	145	67.8
Colobus Monkey	0	0	20	9.3
Squirrel	6	11.1	16	7.5
Rat	0	0	2	0.9
Hare	3	5.6	0	0
Fox	1	1.8	1	0.5
Antelope	2	3.7	15	7.0
Porcupine	1	1.8	8	3.7
Buck	0	0	5	2.3
Antbear	0	0	1	0.5
Leopard	0	0	1	0.5
Total	**54**	**100**	**214**	**100**

In Kombe, black monkey (75.9%) was the most dominant mammals in the disturbed forest area, followed by squirrels (11.1%) and hare (5.6%) while least dominant was the porcupine (1.8%) and fox (1.8%). It also emerged that in the undisturbed forest area, black monkey was the most dominant (67.8%) mammal followed by colobus monkey (9.3%), squirrel (7.5%) and the antelope (7.0%) while the least dominant was leopard (0.5%) and antbear (0.5%). In the undisturbed forest, the water buck, antbear, leopard and colobus monkey were the notable mammals which were not spotted in the disturbed forest area. It has been acknowledged that any form of disturbance on the forest structure by human activities could alter habitat of most mammals to an extent that it influences spatial distribution, population density, habitat selection and use by a given species or an assemblage of primate species (McDonald, *et al.*, 2019). For example, the colobus monkey were only found in the undisturbed part of Kombe forest but were not found in the disturbed forest and this could be attributed to loss of habitat as indicated in a study by Yihune, Bekele and Tefera, (2009). Similarly, mammals were counted in Kipsamoite forest area and the results are presented in Table 30.

Table 30

Mammals in Kipsamoite Forest area

	Cypress Plantation		**Disturbed forest**		**Undisturbed forest**	
Animal	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Colobus Monkey	16	30.2	34	35.8	14	25.9
Squirrel	11	20.8	20	21.1	4	7.4
Fox	3	5.7	2	2.1	2	3.7
Deer	3	5.7	1	1.1	3	5.6
Warthog	3	5.7	3	3.2	2	3.7
Black Monkey	8	15.1	23	24.2	21	38.9
Moose	1	1.9	0	0	0	0
Antelope	2	3.8	4	4.2	3	5.6
Hare	5	9.5	2	2.1	0	0
Hyena	1	1.9	0	0	1	1.9
Antbear	0	0	3	3.2	2	3.7
Hedgehog	0	0	3	3.2	2	3.7
Total	**53**		**95**	**100**	**54**	**100**

Table 30 shows that in Kipsamoite, the most dominant mammal in the Cypress plantation was the colobus monkey (30.2%), squirrels (20.8%) and the black monkey (15.1%) while the least dominant was the moose (1.9%) and hyena (1.9%). Antbear and hedgehog were however, not found in the plantations but were found in the disturbed and undisturbed regions of the forest. In the disturbed region, the colobus monkey (35.8%) was also the most dominant followed by black monkeys (24.2%) and the squirrels while the least dominant was the deer (1.1%). In this region the moose and hyena were not spotted. Further, in the undisturbed forest, the black monkey was the most dominant

(38.9%), followed by the colobus monkey (25.9%) and the squirrel (7.4%). The least dominant was the hyena (1.9%) followed by the warthog (3.7%). Moose and hare were not found in the undisturbed forest region. In Kakamega Forest, Kenya Von Hippel *et al.*, (2000) indicated that the distribution of *C. guereza* was highly influenced by human activities, he noted that in Kakamega Forest, these monkeys experienced a striking decline in density over a six-year period during which the forest was degraded by human activity. Thus, the distribution of mammals in Kipsamoite forest area is also influenced by human activities. Further mammal counts were done in Kiptangus forest and the results are presented in Table 31.

Table 31

Mammal Counts in Kiptangus Forest

Animal	**Pine Plantation**		**Disturbed forest**		**Undisturbed forest**	
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**
Squirrel	-	-	4	8.5	4	5.7
Monkey	23	39.7	22	46.8	28	40.0
Ant bear	4	6.9	3	6.4	5	7.1
Snake	3	5.2	2	4.2	8	11.4
Fox	3	5.2	2	4.2	0	0
Rat	10	17.2	4	8.5	6	8.6
Warthog	3	5.2	6	12.8	3	4.3
Hare	1	1.7	3	6.4	0	0
Bat	5	8.6	1	2.1	2	2.8
Mongoose	0	0	0	0	10	14.3
Antelope	1	1.7	0	0	2	2.9
Porcupine	1	1.7	0	0	1	1.4
Kideche	0	0	0	0	1	1.4
Baboon	1	1.7	0	0	0	0
Mouse	3	5.2	0	0	0	0
Total	**58**	**100.0**	**47**	**100.0**	**70**	**100.0**

In Kiptangus, monkeys were the dominant (39.7%) mammals in the pine plantation, followed by rats (17.2%) while the least dominant was the baboons (1.7%), porcupines (1.7%), antelope (1.7%) and hare (1.7%). The squirrels and mongoose were not found in the plantations. In the disturbed forest section, monkeys were the dominant mammals (46.8%), followed by the warthogs (12.8%) and the squirrels (8.5%) respectively while bats were the least dominant (2.1%). However, mongoose, antelopes, porcupines and mice were not spotted in the disturbed forest. Moreover, in the undisturbed forest area, monkeys were dominant mammals (40.0%) followed by mongoose (14.3%) and snakes (11.4%) respectively. However, fox, hare, baboons and mice were not spotted in the undisturbed forest area of Kiptangus. It also emerged that snakes were spotted in this particular section of the forest as opposed to the other sections where snakes were not spotted. In this particular forest, snakes feed on rats and this explains their presence in this forest area. According to Campanella, *et al.,* (2019) since habitat selection is behaviourally mediated, it is the primary mechanism that animals use to mitigate environmental stressors. For example, prey species may adaptively alter their patterns of movement in response to real or perceived threats of predation (Ruttenberg, *et al.*, 2011). Additionally, environmental perturbations can decrease the availability of suitable habitat by degrading the physical attributes of an environment or shifting abiotic factors that affect the ecology of many species (Delgado, *et al.,* 2019).

From the results obtained in the four sub-locations monkeys were the most dominant mammals in all the forest sites (Figure 15: Monkeys in North Nandi Forest). This indicates that both colobus and black monkeys inhabit North Nandi Forest. Baboons were only found in Kiptuiya forest but were not found in the other three locations. More mammals were found in the indigenous forest compared to forest plantations. This is due to availability of food and habitat for shelter.

Bird Biodiversity Conservation in North Nandi Forest

The study surveyed all birds present and their abundance using a defined transects line that followed a straight- or parallel-line during data collection in the four forest areas of Kiptuiya, Kiptangus, Kombe and Kipsamoite. In the four sites, birds were counted in the plantations (except Kombe), disturbed and undisturbed forest areas. Table 32 presents the results of birds counted in Kiptuiya forest area.

Table 32

Birds found in Kiptuiya plantation, disturbed and undisturbed forest sites

Bird Type	Eucalyptus Plantation		Disturbed forest		Undisturbed forest		Feeding Habit
	Frequency	%	Frequency	%	Frequency	%	
Guinea fowls	0	0	13	11.6	65	27.2	Granivore
Song bird	6	4.3	2	1.8	4	1.7	Insectivore
weaver bird	20	14.5	1	0.9	3	1.3	Frugivore
Sparrow	0	0	2	1.8	3	1.3	Insectivore
Woodpecker	6	4.3	0	0	2	0.8	Granivore
Thrush bird	13	9.4	6	5.4	13	5.4	Granivore
Hornbill	37	26.8	28	25.0	64	26.8	Granivore
Humming bird	12	8.7	8	7.1	7	2.9	Nectarivore
Pigeon	7	5.1	4	3.6	24	10.0	Frugivore
Eagle	1	0.7	1	0.9	2	0.8	omnivore
Blue bird	6	4.3	3	2.7	8	3.3	Insectivore
Wagtail	15	10.9	0	0	5	2.1	Insectivore
King bird	3	2.2	11	9.8	5	2.1	Insectivore
Swallow bird	2	1.4	0	0	4	1.7	Insectivore
Hawk	1	0.7	0	0	3	1.3	Omnivore
Nightingale	0	0	0	0	2	0.8	Insectivore
Crane	1	0.7	17	15.2	22	9.2	Omnivore
Gold fish	2	1.4	0	0	3	1.3	Insectivore
Raven	0	0	2	1.8	0	0	Insectivore
Driole bird	0	0	10	8.9	0	0	Insectivore
Tyrantfly catchot	0	0	4	3.6	0	0	Insectivore
Oriole bird	5	3.6	0	0	0	0	Insectivore
Black chinned	1	0.7	0	0	0	0	Nectarivore
Total	**138**	**100.0**	**112**	**100.0**	**239**	**100.0**	

From Table 32 it emerged that in the plantations, the dominant bird types were the hornbill (26.8%), weaver birds (14.5%), wagtails (10.9%) and thrush bird (9.4%) while the least dominant was the black chinned (0.7%), Hawk (0.7%), eagle (0.7%) and the crane (0.7%). In the disturbed forest area of Kiptuiya, the dominant birds were the hornbill (25.0%), the crane (15.2%), guinea fowls (11.6%) and Driole (8.9%) respectively while the least dominant were the weaver bird (0.9%), the eagle (0.9%) and the Raven (1.8%). However, in the undisturbed forest area, the most dominant bird species were the guinea fowls (27.2%), hornbill (26.8%), pigeon (10.0%) and the crane (9.2%) while the least dominant were the eagle (0.8%), wood pecker (0.8%), nightingale (0.8%), goldfish (0.8%) and magpie (0.4%).

From the findings, hornbill was the most dominant bird in all the three forest areas. Most tropical forest now occurs as fragments and within such production landscapes there are many studies that have highlighted the ecological role of forest fragments and the surrounding landscape matrix of commercial agroforestry plantations in sustaining tropical biodiversity (Balmford *et al.,* 2005; Bhagwat *et al.,* 2008; Foley *et al.,* 2011). The effects on birds of such landscape changes and the accompanying changes in habitat structure and resource availability may vary depending on their ecological traits such as body size, home-range size, dietary niche and site fidelity (Murphy and Romanuk 2012; Newbold *et al.,* 2013; MoranteFilho *et al.,* 2015; Karanth *et al.,* 2016). Among birds, large-bodied, frugivorous species are vulnerable to forest loss and fragmentation due to their large home-ranges and dependence on spatio-temporally patchy fruit resources (Bregman *et al.,* 2014). For example, the hornbills which are frugivores are confined to large tracts of tropical forests (Kinnaird and O'Brien 2007) and in this particular case, North Nandi Forest forms part of the tropical forests in Kenya attracting the hornbills particularly in the undisturbed environment and the presence of the fruits in the forest. Birds were also counted in both the disturbed and undisturbed part of Kombe forest the results are presented in Table 33.

Table 33

Birds in Kombe Forest area

Name of the Bird	**Disturbed Forest**		**Undisturbed Forest**		**Feeding habits**
	Number	**Percent**	**Number**	**Percent**	
Mouse Bird	33	12.55	13	5.56	Frugivores
Tilyos	23	8.75	11	4.70	Insectivores
Hornbill	24	9.13	8	3.42	Insectivores
Dove	5	1.90	9	3.85	Granivores
Crane	8	3.04	2	0.85	Insectivores
Hummingbird	7	2.66	29	12.39	Nectarivores
Norchill Fiscal Yellow Vended	2	0.76	3	1.28	Insectivores
Bulbul	25	9.51	3	1.28	Frugivores
Sunbird	3	1.14	0	0	Insectivores
Butieru	15	5.70	3	1.28	Frugivores
Shrike	5	1.90	0	0	Granivores
Hawk	2	0.76	0	0	Insectivores
Nortorn Fiscal	3	1.14	0	0	Omnivores
Kulyos	10	3.80	3	1.28	Insectivores
Sparow	24	9.12	25	10.68	Insectivores
Butete	10	3.80	2	0.85	Insectivores
Chepkeshok	7	2.66	0	0	Frugivores
Meadow Pitpit	4	1.52	3	1.28	Insectivores
Chesiliot	6	2.28	5	2.14	Insectivores
Tinkor Bird	8	3.04	0	0	Insectivores
Eagle	7	2.66	14	5.98	Insectivores
Swallow	8	3.04	0	0	Omnivores
Chebal Tokotet	3	1.14	0	0	Insectivores
Kimorit	2	0.76	0	0	Omnivores
Quelea Bird	4	1.52	31	13.25	Granivores
Chebitoriet	1	0.38	0	0	Insectivores
Turaco	4	1.52	7	2.99	Insectivores
Chepkoshok	6	2.28	2	0.85	Insectivores

Cheserut (Nandi)	3	1.14	0	0	Insectivores
Butlem (Nandi)	1	0.38	0	0	Insectivores
Chepkutkutyet (Nandi)	0	0	10	4.27	Insectivores
Kipkamoriet (Nandi)	0	0	17	7.26	Insectivores
Ibis	0	0	13	5.56	Insectivores
Chepkabut	0	0	1	0.43	Insectivores
Pin tailed whydah	0	0	1	0.43	Insectivores
Wood pecker	0	0	8	3.41	Insectivores
Kimol (Nandi)	0	0	1	0.43	Insectivores
Chepkabuti (Nandi)	0	0	2	0.85	Insectivores
Cheserut (Nandi)	0	0	2	0.85	Insectivores
Tapkoshet (Nandi)	0	0	4	1.71	Insectivores
Cheborkortet (Nandi)	0	0	1	0.43	Insectivores
Weaver bird	0	0	1	0.43	Insectivores
Total	263	100.00	234	100.00	

From the Table 33, the most common bird in the disturbed forest area of Kombe location was the mouse bird (12.55%) which is frugivores followed by bulbul (9.51%) which is also frugivores, hornbill (9.13%) and sparrow (9.13%) which are both insectivores. In the undisturbed forest, Quelea Bird which is granivores in its feeding habit was the most common bird (13.25%) followed by humming bird (12.39%) which is nectarivores and sparrow (10.68%) which is insectivores in nature. From the results above, frugivores were common due to the occurrence of *Ficus thonningii* which provides food for the birds. Ficus generally known as fig tree is one of the significant keystone species plays an important role in avifauna conservation (Shanahan *et al.,* 2001). Ficus help in avifauna conservation for its seasonal fruiting capacity. The diversity of frugivores is correlated with the abundance and diversity of fig tree species (Kissling *et al.*, 2007). Similarly, studies by Mahanta, *et al.*, (2014) pointed out that different kinds of bird species visited Ficus for different purposes. Some tree species were visited more frequently than the other tree species mainly because of food and resting purposes. The presence of sparrows in the forest area could be attributed to its dependency and co-evolvement with human agricultural development (Sætre *et al.*, 2012; Liebl *et al.*, 2015). Further birds were also counted in Kiptangus Forest and the results are presented in Table 34.

Table 34

Birds in Kiptangus Forest area

Birds	Plantation forest		Disturbed forest		Undisturbed forest		Feeding habit
	Frequency	Percent	Frequency	Percent	Frequency	Percent	
Horn Bill	18	29.03	14	22.95	6	11.54	Frugivores
Weaver Bird	20	32.26	11	18.03	6	11.54	Granivores
Owl	2	3.23	4	6.56	8	15.38	Insectivores
Humming Birds	6	9.68	7	11.48	5	9.62	Insectivores
Funikombe	0	0	7	11.48	0	0	Insectivores
Detepwani	0	0	4	6.56	2	3.85	Omnivores
Turaco	0	0	2	3.28	9	17.31	Frugivores
African Green Pigeon	2	3.23	2	3.29	0	0	Omnivores
Dove	4	6.45	3	4.92	9	17.31	Granivores
Meadow Pipit	2	3.23	2	3.28	0	0	Insectivores
Eagle	3	4.841	3	4.92	0	0	Carnivores
Chebuitaa (Nandi)	0	0	2	3.28	0	0	Granivores
Nuthatch	2	3.23	0	0	0	0	Granivores
Crested Crane	3	4.84	0	0	0	0	Granivores
Orioles	0	0	0	0	2	3.85	Granivores
Blue dacnis	0	0	0	0	3	5.77	Granivores
Yellow rumped Tinkor bird	0	0	0	0	2	3.85	Frugivores
Total	**62**	**100**	**61**	**100.00**	**52**	**100**	

Table 34 shows that weaver birds were the dominant species in Kiptangus plantation and accounted for 32.26% of the total birds in the plantation, followed by horn bill which accounted for 29.03% of the total birds in the plantation. Weaver birds according to Maurice *et al.,* (2020) feed on cereals such maize, rice, sorghum, millet, palms and as such stay near farmlands where food are in plenty thus being the dominant species in the plantations of Kiptangus.

In the disturbed forest area of Kiptangus, Horn Bill was the dominant bird species and accounted for 22.95% followed by weaver birds which accounted for 18.03% of the total birds in the area. While in the undisturbed forest doves were the most dominant followed by hornbills and weaver birds.

In the four sub-locations, Hornbills were dominant in all the sites and this was attributed to the presence of Ficus trees which provides these birds with fruits for food (Figure 16: *Ficus thonningii*). Schebens (2020) noted that the most determining for the presence of hornbills and turacos is the disturbance intensity of the forests thus in the current study Turacos and hornbills were found in the disturbed and undisturbed forests due to presence of both feeding, resting and nesting trees.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary of the findings

Influence of CFA on local community sustainable forest utilization

Education level is related to dependency of forest resources and depletion. This is due to the fact that education provides various alternative livelihood choices that may yield large returns when compared to forest extraction activities. In this study, people who have no education or lower levels of education like primary and secondary education are not employed thus depend on forest resources for their livelihoods leading to over-exploitation of forest resources and disturbance of the ecosystem, displacement of mammals and birds due to habitat loss and loss of food. The study further found out that majority (60.2%) of the respondents had benefited from their CFAs on knowledge on plant use.

The results also showed that joint forest management between the government and the community (18.73%), use of sensitization meetings through barazas, workshops or conferences (18.32%), the involvement of indigenous people within and outside the forest (18.04%) and the use of county and national government policies (15.82%) supported the conservation and protection of North Nandi Forest.

The study also found out that variation of traditional livelihood strategies (40.12%) and over-use of natural resources (37.76%) were the greatest threats to traditional forest conservation. Forests and their associated products have been vital in sustaining livelihoods since time immemorial notably for the residents of forest-dependent communities who live in abject poverty.

Expansion of land for agriculture (33.17%) and other developmental activities (33.17%), excision of forest for settlement (30.00%) and illegal cutting of trees for posts, charcoal, fuelwood and timber (3.66%) were the major factors affecting traditional forest conservation in North Nandi Forest. Agriculture is the most prevalent human-environment interaction, affecting more natural resources than any other human activity.

The results pointed out that most of the respondents were using participatory forest management as a way of conserving the forest. Following some failures of centralized systems of forest management, many developing countries have experimented with some form of decentralized forest governance. Participation in forest management involves planning which entails involving local actors in decision-making, creating new rules or modifying old ones, formulating alternative planning activities and allocation of rights, responsibilities and resources among the forest management actors.

The study further noted that different age groups were involved in forest management through planting of more tree species, reporting any illegal activities in the forest, ensuring that harvesting of medicinal plants were conducted in a sustainable way and in sensitization of the community members through barazas on the importance of the forest and its resources. Among the plant parts that were used by the communities included roots, leaves, barks, flowers stem and branches. The respondents noted that there are some trees in the forest which are medicinal and thus are protected by community members. These trees included *olea carpensis, Fagaropsis angolensis, Solanum mauritianum Celtis africana, Cassipourea malosana, Croton macrostachyus, Syzygium cordatum, Zanthoxylum gilletii, Podocarpus spp and Prunus africana.*

The respondents noted that the indigenous plants in the forest provided with medicine, protected water catchment areas, maintained soil fertility, provided food and shelter to other animals, feed for livestock particularly during dry season, provides them with firewood and fencing posts.

Forest Structure in North Nandi Forest

The study further surveyed all trees and saplings present and their abundance using a defined transects line that followed a straight- or parallel-line during data collection in the four forest areas of Kiptuiya, Kiptangus, Kombe and Kipsamoite. Major data collected were tree heights which were measured using Suunto clinometer, diameter at breast height (DBH) which used diameter tape, and counts were done to establish the number of trees and saplings. The study found out that *Cupressus lusitanica* was the most dominant plant species in Kipsamoite plantation and had a mean diameter of 35.58 ±8.14cm and a mean height of 20.95±4.74m. In addition, saplings were counted in Kipsamoite plantation and emerged that *Cupressus lusitanica* was the most dominant sapling and accounted for 42.35% of all the saplings in the plantation. This was followed by Bersama *abyssinica* (19.90%) and *Vernonia auriculifera* (19.39%).

Similarly, counts, height and diameter measurements of tree species in disturbed part of Kipsamoite forest were undertaken. The results showed that the most dominant species was *Croton megalocarpus,* which accounted for 23.21% of tree species in the area followed by *Diospyros abyssinica* (17.86%) *and Momordica foetida* (10.71%). In terms of diameter*, Celtis africana* had the greatest diameter *of* 57.8cm, followed by *Diospyros abyssinica* with a mean of 33.45 ± 8.53 cm and *Croton megalocarpus* with a mean diameter of 33.09 ± 22.89cm. However, in terms of height *Celtis africana*, had the greatest height of 33.3m followed by *Diospyros abssinica* (26.30 ± 6.07m) and *Croton megalocarpus* (21.11 ± 11.37). In the Kipsamoite disturbed forest*, Celtis africana* and *Diospyros abyssinica* were found, showing that these tree species are not highly targeted by humans. In this region, the most notable disturbance was that of *Croton megalocarpus* which was targeted for firewood while *Syzygium guineense* and *Ehretia cymosa* were targeted for posts.

Further, counts, height and diameter measurements of tree species in undisturbed part of Kipsamoite forest were undertaken. The results showed that in the undisturbed part of Kipsamoite forest, the most dominant tree species was *Croton megalocarpus* followed by *Macaranga kilimandscharica* while the least dominant was *Schrelebera alata, Syzygium guineense, Momordica foetida* and *Vangueria madagascariensis*. *Celtis africana* was found to have the largest diameter with a mean of 46.07 ±13.41cm followed by *Syzygium guineense* (44cm), *Polyscias fulva* (41.60 ± 17.21cm), *Diospyros abyssinica* with a mean diameter of 35.70 ± 10.47cm and *Craibia brownii* with a mean diameter of 32.28 ± 29.75cm. In terms of height, *Celtis africana* was the highest (29.38 ± 2.92m), followed by *Cassipourea malosana* (25.43 ± 2.43m), *Polyscias fulva* (25.05 ± 2.98m) and *Croton megalocarpus* (22.25 ± 9.35m). As shown by the results the dominant species in the undisturbed forest in Kipsamoite was *Croton megalocarpus*.

In Kipsamoite undisturbed forest area, the results showed that *Acanthus eminens* (48.08%) was the most dominant sapling, followed by *Cassipourea malosana* (20.19%) while the least dominant was *Neoboutonia macrocalyx* (0.24%), *Olea capensis* (0.24%) and *Tabernaemontana stapfiana* (0.24%).

In Kiptangus plantation, the mean height for *Pinus patula* was 20.72 m with a standard deviation of 3.222 while the mean diameter for the same species was 23.53±4.764m. Saplings counted in the plantation showed that the most dominant plant species in the pine plantation was *Cestrum aurantiacum* (38.3%), followed by *Vernonia auriculifera* (25.53%) and *Rubus apetalus* (20.21%) while the least dominant was *Bersama abyssinica* (1.06%) followed by *Ehretia cymosa* (2.13%). This shows that *Vernonia auriculifera* and *Cestrum aurantiacum* could take over the forest plantations after harvesting of the planted pines.

In the disturbed part of Kiptangus forest *Diosyros abyssinica* was the most abundant tree species and accounted for 30.0% of the tree species in the region. This was followed by *Croton macrostachyus* (26.67%) and *Celtis africana* (23.3%). *Celtis africana* had the greatest height with a mean of 27.30 ± 6.06m followed by *Ficus thonningii* (23.05 ±1.06m) and *Croton macrostachyus* (20.70 ± 9.83m) while *Bersama abyssinica* was the shortest with a height of 12.3m followed by *Albizia gummifera* with a height of 13.8m. Saplings were also counted in Kiptangus disturbed forest area and it emerged that *Cestrum aurantiacum* species was the most dominant sapling species (90.79%) while the least dominant was *Caesalpinia decapetala* (0.27%). This shows that in the disturbed forest area of Kiptangus, *Cestrum aurantiacum* is more likely to take over the area since it was the most dominant species. In this case C. *aurantiacum* is an invasive species and thus have the potentials of affecting the biodiversity and plant community of Kiptangus native forest which is the eastern-most remnant of the Guineo– Congolian tropical rain forest.

In undisturbed part of Kiptangus forest area it emerged that *Prunus africana* had the largest diameter with a mean of 54.83 ±15.29 cm followed by *Macaranga kilimandscharica* with a mean diameter *of* 42.90 ± 25.60 cm and *Celtis africana* with a mean diameter of 42.75 ± 13.65cm while *Cestrum aurantiacum* had the smallest diameter of 7.93 ± 2.22cm. In terms of height, Celtis africana was the tallest tree with a mean height of 31.38 ± 7.17m followed by *Diosyros abyssinica* with a mean height of 29.24 ±7.43m and *Prunus africana* with a mean height of 28.55 ± 6.74m while *Cestrum aurantiacum* was the shortest tree species with a mean height of 10.30 ± 1.80m. The most dominant tree was *Diosyros abyssinica* and accounted for 43.48% of the plants in the forest area.

Saplings in the undisturbed part of Kiptangus forest were also counted. The results showed that *Cestrum aurantiacum* was the most abundant sapling in the undisturbed part of Kiptangus forest followed by *Dovyalis macrocalyx* species. However, the least abundant species were *Vangueria madagascariensis, Solanum mauritianum, Carissa spinarum, Albizia gummifera* and *Polyscias fulva.*

Cestrum aurantiacum is exotic species in Kenya and native to Central America and is known as an escape species from living collection and has an invasive potential in many forest areas.

In Kiptuiya *Eucalyptus* Plantation, *Eucalyptus* species had a mean diameter of 29.27 ± 7.30cm with a mean height of 20.92 ±6.14m while *Polyscias fulva* had a diameter of 17cm and a height of 16.3m. The most common sapling was *Solanum mauritianum (*63.37%) followed by *Ocimum* species (6.97%) while the least abundant was *Spathodea campanulata* (0.22%). This implies that *Solanum mauritianum which is an invasive species* is more likely to take over the eucalyptus plantation in Kiptuiya forest.

In Kiptuiya disturbed forest, *Ficus sycomorus* had the largest diameter of 50.35 ± 26.48cm followed by *Polyscias fulva* which had a mean diameter of 47.41 ± 32.39cm and *Diospyros abyssinica* which had a mean diameter of 35.90 ± 16.26cm. In terms of height, Ficus sycomorus had the greatest height of 23.75 ± 3.13m followed by *Ficus thonningii* which had a height of 23.3m. However, in terms of tree abundance, *Polyscias fulva* was the most abundant and accounted for 25.00% of the tree species in the area followed by *Strombosia scheffleri* which accounted for 17.86% of the trees.

Acanthus eminens was the common sapling in Kiptuiya disturbed area (41.11%) followed by *Solanum mauritianum* at 31.11% while the least common was *Vangueria madagascariensis, Vernonia auriculifera, Trichocladus ellipticus, Zanthoxylum gilletii, Syzygium guineense and Ocotea kenyensis* at (2.22%) each. *Solanum mauritianum* is an invasive species and the weed's invasion is facilitated by large seed banks and dispersal by frugivorous birds and mammals, which readily feed on the abundant fruit, dispersing seeds over long distances.

In Kiptuiya undisturbed forest area, the most dominant species was *Croton megalocarpus* while the least dominant was *Bridelia micrantha, Momordica foetida, Syzygium guineense, Ficus sycomorus, Myrsine africana, Vangueria madagascariensis, Macaranga kilimandscharica,* and *Albizia gummifera.*

In terms of diameter, *Ficus sycomorus* had the largest diameter (110.5cm) followed by *Polyscias fulva* (48.36 ± 29.45cm), *Croton macrostachyus* (33.05 ± 1.49cm) and *Diospyros abyssinica* (32.67 ±16.79cm) while *Myrsine africana* had the smallest diameter (6.8cm). *Ficus sycomorus* was also the tallest tree with a height of 30.3m followed by *Olea capensis* with a mean height of 22.30 ± 8.49m while *Myrsine africana* was the shorted tree (5.8m).

Acanthus eminens (79.04%) was the most dominant sapling in the undisturbed forest in Kiptuiya followed by *Solanum mauritianum (9.55%)* while the least dominant was *Cassipourea malosana* (0.27%) and *Albizia gummifera* (0.27%). This shows that in the undisturbed forest, *acanthus eminens* remains the dominant sapling species.

The most dominant tree species in Kombe disturbed forest was *Diospyros abyssinica* followed by Polyscias *fulva* and *Croton megalocarpus* but in terms of diameter, *Ficus thonningii* had the largest diameter of 164cm followed by *Syzygium guineense* (86.90 ± 34.22cm*), Macaranga kilimandscharica* with a diameter of 53.00 ± 26.87 and *Craibia brownii* with a diameter of 49.93 ± 20.24cm while *Albizia gumnifera* had the lowest diameter of 9.9cm. In terms of height, Syzygium *guineense* was the tallest tree with a height of 26.55 ±2.47m followed by *Macaranga kilimandscharica* with a height of 25.05 ± 10.25m but *Tabernaemontana stapfiana* was the shortest tree with a height of 6.8m. Thus, the most dominant tree in Kombe disturbed forest was *Diospyros abyssinica.* The fruits of *Diospyros abyssinica are* consumed by birds and various mammals, and are an important part of the diet for the primates and fruit Bats.

Solanum mauritianum (72.25%) was found to be the most abundant sapling in the disturbed forest area of Kombe followed by *Vernonia auriculifera* (12.72%) and *Vangueria madagascariensis* (5.78%) while the least abundant species were *Craibia brownii*, *Albizia gummifera*, *Ehretia cymosa*, *Macaranga kilimanscharica* and *Dovyalis macrocalyx.* Thus, the most dominant sapling in Kombe disturbed forest was *Solanum mauritianum.*

*Macaranga kilimandscharica (*21.43%*)* was the most dominant tree species in the undisturbed Kombe forest followed by *Cassipourea malosana* (16.33%), *Tabernaemontana stapfiana* (8.16%) and *Diospyros abyssinica* (8.16%) while the least dominant tree species was *Ekebergia capensis,* (1.02%), *Schefflera volkensii* (1.02%), *Olea capensis* (1.02%) and *Momordica foetida* (1.02%). *Ekebergia capensis* had the largest diameter of 56.2cm followed by *Syzygium guineence* with a mean diameter of 51.53 ± 5.36cm and *Momordica foetida* with a diameter of 42.3cm while *Olea capensis* had the smallest diameter of 4.3cm. In terms of height, *Momordica foetida* was the tallest tree species with a mean height of 47.3m followed by *Syzygium guineence* with a mean height of 25.30 ± 5.35m and *Drypetes gerrardii* (23.50 ± 8.29m) while the shortest tree species was *Glycine withii* with a mean height of 8.80 ±3.54m. Thus, from the table, it can be deduced that *Macaranga kilimandscharica* was the most dominant tree species in Kombe undisturbed forest area. The tree is harvested from the wild for local use as a medicine and source of wood and is used as a pioneer species for restoring woodland and protecting the soil.

Brillantaisia nitens and *Acanthus eminens* were the most dominant (30.58%) saplings in Kombe undisturbed forest followed by *Brillantaisia madagascariense* (26.71%) while the least dominant was *Syxygium guineense* at 0.20% followed by *Vangueria madagascariensis at 0.41%.* Thus, *Brillantaisia nitens* and *Acanthus eminens* were the most dominant saplings.

Disturbance in the forest

In four sub-locations both in the undisturbed and disturbed forests, *Croton megalocarpus* (22.35%) *Syzygium guineense* (21.18%), *Diospyros abyssinica* (14.12%) *Macaranga kilimandscahrica* (11.76%) and *Celtis africana* (7.06%) were the most targeted trees in North Nandi Forest and were illegally targeted mostly for fencing posts, making of cooking sticks, jembe pins, fuelwood and timber.

Mammalian Abundance

The study surveyed all mammals present and their abundance using a defined transects line that followed a straight- or parallel-line during data collection in the four forest areas of Kiptuiya, Kiptangus, Kombe and Kipsamoite. The results showed that monkeys were dominant in the *Eucalyptus* plantation, disturbed and undisturbed forest areas of Kiptuiya. In Kombe, black monkeys were the most dominant mammals in the disturbed forest area (75.9%), and in the undisturbed forest (67.8%). It has been acknowledged that any form of disturbance on the forest structure by human activities could alter habitat of most animals to an extent that it influences spatial distribution, population density, habitat selection and use by a given species or an assemblage of primate species.

In Kipsamoite, the colobus monkeys were the most dominant mammals in the Cypress (30.2%), and disturbed forest (35.8%) area while black monkeys were dominant in the undisturbed forest accounting for 38.9% of the total animals in the region. This shows that the distribution of mammals in Kipsamoite forest area is also influenced by human activities which disturb the forest leading to loss of habitat for the mammals.

In Kiptangus, monkeys were the dominant in pine plantations (39.7%), disturbed forest (46.8%) and in the undisturbed forest area (40.0%). Environmental perturbations can decrease the availability of suitable habitat by degrading the physical attributes of an environment or shifting abiotic factors that affect the ecology of many animal species.

Bird Biodiversity Conservation in North Nandi Forest

The study surveyed all birds present and their abundance using a defined transects line that followed a straight- or parallel-line during data collection in the four forest areas of Kiptuiya, Kiptangus, Kombe and Kipsamoite. It emerged that hornbills were dominant in the plantation, (26.8%) and disturbed forest (25.0%) area of Kptuiya. However, in the undisturbed forest area, the most dominant bird species were the guinea fowls (27.2%) and hornbill (26.8%). From the findings, hornbills were the most dominant bird in all the three forest categories. Among birds, large-bodied, frugivorous species are vulnerable to forest loss and fragmentation due to their large home-ranges and dependence on spatio-temporally patchy fruit resources. For example, the hornbills which are frugivores are confined to large tracts of tropical forests and in this particular case, North Nandi Forest forms part of the tropical forests in Kenya attracting the hornbills particularly in the undisturbed environment and the presence of the fruits in the forest.

In Kombe forest, mouse bird (12.55%) which is frugivores followed by bulbul (9.51%) and hornbill (9.13%) which are also frugivores, and sparrow (9.13%) which is insectivore were dominant in the disturbed forest while in the undisturbed forest, quelea bird which is granivores in its feeding habit was the most dominant (13.25%) followed by humming bird (12.39%) which is nectarivores and sparrow (10.68%) which is insectivores in nature. From the results above, frugivores were common due to the occurrence of *Ficus Thonningii* which provides food for the birds. *Ficus* generally known as fig tree is one of the significant keystone species and plays an important role in avifauna conservation.

Ficus Sp. help in avifauna conservation for its seasonal fruiting capacity. *Ficus* help in avifauna conservation for its seasonal fruiting capacity.

In Kiptangus forest, weaver birds were the dominant species in plantation and accounted for 32.26% of the total birds in the plantation, followed by horn bills which accounted for 29.03% of the total birds in the plantation. In the disturbed forest area, Horn Bill was the dominant bird species and accounted for 22.95% followed by weaver birds which accounted for 18.03% of the total birds in the area. While in the undisturbed forest, doves were the most dominant followed by hornbills and weaver birds. Presence of hornbills and turacos follows the disturbance intensity of the forests thus in the current study Turacos and hornbills were found in the disturbed and undisturbed forests due to presence of both feeding, resting and nesting trees.

Conclusions of the Study

Joint forest management between the government and the community, use of sensitization meetings through barazas, workshops or conferences, the involvement of indigenous people within and outside the forest and the use of county and national government policies to support the conservation and protection of North Nandi Forest were the most significant strategies for management and protection of North Nandi Forest. However, expansion of land for agriculture and other developmental activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber were the major factors affecting traditional forest conservation in North Nandi Forest.

The study concluded that in the four sub-locations monkeys were the most dominant mammals in all the forest sites. This indicates that both colobus and black monkeys inhabit North Nandi Forest. Baboons were only found in Kiptuiya forest but were not found in the other three sub-locations. More mammals were found in the indigenous forest compared to forest plantations. This is due to availability of food and habitat for shelter.

In all the four sub-locations of North Nandi Forest, hornbills were dominant due to presence of *Ficus* species. The hornbills which are frugivores are confined to large tracts of tropical forests and in this particular case, North Nandi Forest forms part of the tropical forests in Kenya attracting the hornbills particularly in the undisturbed environment and the presence of the fruits in the forest. Hornbills were common due to the occurrence of *Ficus thonningii* which provides food for the birds. *Ficus* generally known as fig tree is one of the significant keystone species and plays an important role in avifauna conservation. Ficus help in avifauna conservation for its seasonal fruiting capacity.

Large trees such as *Olea capensis, Fagaropsis angolensis, Celtis africana, Cassipourea malosasana, Syzygium cordatum, Diospyros abyssinica, Croton megalocarpus, Bridelia micrantha, Momordica foetida, Syzgium guineense, Myrsine africana, Vangueria madascariensis, Macaranga kilimandscharica,* and *Albizia gummifera* have been targeted by humans for timber, fencing posts and in some instances for medicine (*Prunus africana*). These illegal activities have reduced the number of these trees in the forest leaving invasive saplings to take over large areas of the forest.

Recommendations

Policies on expansion of land for agriculture and other developmental activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber need to be put in place by both the national and county governments. The effective implementation of these policies with the CFAs will ensure effective management and conservation of North Nandi Forest.

The presence of mammals such as monkeys (both colobus and black) and baboons is an indication that the forest is a habitat to these animals and thus conservation efforts targeting the forest need to be undertaken and by extension promote and preserve the animals. This could enhance tourism in the area.

There is need for conservation of *Ficus thonningii* and other plants since they provide nesting, feeding and resting habitats for both birds and mammals.

The presence of *Cestrum aurantiacum* and *Solanum mauritianum* in the four sub-locations is a threat to the existence of native forest trees in North Nandi Forest. These are *invasive* species and thus have the potentials of affecting the biodiversity and plant community of North Nandi native forest. Therefore, there is need for strategies of controlling invasive plant species in North Nandi Forest.

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APPENDICES

Appendix I: Questionnaire on Sustainable Utilization of Plants

My name is Mr. Muskiton Kenneth Chepkonga undertaking a study on the Effects of community forest association on management and utilization of forest resources in North Nandi Forest, Kenya. The study involves understanding the influence of CFA on local community sustainable forest utilization in North Nandi Forest. You are kindly requested to answer the questions as honestly as possible. A seven-page interview questionnaire is provided to you for ease of reference throughout the interview. The enumerator will guide you along the process and will note answers to the questions and, with your express permission, will also record the discussion with an audio recorder that will form part of the documentation and research findings.

The information that will be provided by all the respondents for this study will be protected to ensure privacy and confidentiality is safe and secure. The results of this interview and all relevant data collection tools or materials including recordings will be kept under safe custody.

A: General information

1) Name of respondent: …………………………………………………

2) Gender: Male ☐ Female ☐ Age …………………

3) Your marital status: Married ☐ Single ☐

4) The number of years lived in the village: …………………

5) Level of education: ……………………………………..

6) Main economic activity: ……………………………….

7) Ethnic group…………………………………………..

8) Locality?...

Section B: CFA and sustainable forest utilization

1. Which CFA do you belong to………………………………………………….
2. How long has the CFA been in existence…………………… Years
3. How would your CFA rate the general changes that have occurred in the forest in your locality during the past 20 years?

□ Remarkable loss □ Loss □ Small loss □ No change □ Small gain
□ Increase □ Incredible gain □ Know knowledge

4. In your opinion, what factors have been identified by your CFA as causing changes in the forest in your sub location?

……………………………………………………………………………………….
……………………………………………………………………………………….
……………………………………………………………………………………….
……………………………………………………………………………………….

5. What component has been improved to enhance forest utilization in your CFA?

□ Knowledge of plant □ Knowledge of animal names
□ Knowledge of plant use □ Knowledge of plant parts used
□ Knowledge of craft and tool making □ Traditional social organization

6. Which strategies are currently employed to protect and conservation forest in your CFA? Kindly mark the required boxes appropriately

□ County and National Government policies support
□ Community and School based conservation and management approach
□ Conservation and environmental clubs in learning institutions
□ Joint forest management between the Government and the Community
□ Cultural considerations in management of forests
□ Involvement of Indigenous people within or outside the forest
□ Traditional laws
□ Sensitization meetings through barazas, workshops or conferences
□ Others (kindly specify)……………….……………………………………………….

7. Which of the following are direct threats to traditional forest conservation?

□ Variation in traditional livelihood practices □ Disintegration of traditional rights
□ Breakdown of traditional institutions □ Over-use of natural resources
□ Assimilation □ Collapse of traditional religion, language and belief

8. What are the underlying threats to traditional forest conservation according to your CFA?

□ Strict government policies, Laws and Regulations □ Cultural attachments
□ Expansion of land for agriculture and other infrastructural development □ Excisions
□ Land exchanges

9. What are some of the forest conservation actions you employ to conserve forest resources in your CFA?

□ Local Indigenous Knowledge □ Policies, Laws and Regulations
□ Participatory Forest Management □ Others (Specify………………..)

10. Among members of the CFA, who is responsible for knowledge generation on forest utilization and conservation?

…………………………………………………………………………………………………
…………………………………………………………………………………………………

………………………………………………………………………………………………………
……………………………

11. How is a traditional knowledge of forests conservation is being utilized and shared among generations in CFAs?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………

12. What is the role of different age groups in the use and management of forest resources?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………

13. a) Do you understand the traditional use of forests?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………

b) Identify the useful plants from the forests used by the community

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………

c) Identify the role of indigenous plants from the forest

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………

d) What plant parts were used by the community members?

………………………………………………………………………………………………………
………………………………………………………………………………………………………
………………………………………………………………………………………………………
……………………………

e) Identify the animals that are living in the forests?

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……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………

14. a) What traditional methods are used to regulate the utilization of the forest resources?
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………
b) What cultural practices are put in place to regulate the use of indigenous plant resources?
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………

c) Were the local community members encouraged to plant wild plants in their homesteads?
…………………………………………………………………………………

d) If Yes in c above, what plant species and what was their use?
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………

e) Were some trees protected by culture because they are valuable to the community?
……………………………………………………………………………………………
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15. What kind of protection and maintenance did these important trees receive traditionally?
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………

16. What were the traditional forest conservation methods?
……………………………………………………………………………………………
……………………………………………………………………………………………
………………………………………………………

17. a) What is the community cultural orientation towards livestock grazing in the forest?
……………………………………………………………………………………………
……………………………………………………………………

17 b). What measures did the community put in place towards livestock overgrazing in the forest?

…………………………………………………………………………………………………
……………………………………………………………………………

18. What cultural changes towards the forest have you observed since you have known the forest?

…………………………………………………………………………………………………
……………………………………………………………………………

19. (a) Is the forest under protection against external aggression/invaders?

Yes ☐ No ☐

(b) If no above, explain what kind of destruction is seen in the forest

…………………………………………………………………………………….
……………………………………………………………………………………..

(c) Who may be involved in forest destruction? ………………………………………

(d) Your opinion on the best way to conserve the forest …………………………….
…………………………………………………………………………………….

20. Have you always been involved in contributing to ideas, suggestions or decisions towards forest use and management?

☐ Yes No

Thank you

Appendix II: Photos

Furrows done by Antbear

Cestrum aurantiacum

Disturbance (Illegal logging) in North Nandi forest

Monkeys in North NandiForest

Ficus Thonningii **(fruits-food for birds)**

Appendix III: Work Plan

Activities	Apr.- July 2020	Aug.- Dec 2020 and Jan 2021	Jan. 2021	Jan.- Feb. 2021	Feb. - Mar. 2021	Mar.- Apr. 2021	Apr. - May 2021	May- Jun. 2021	June 2021
Proposal development									
Literature review									
Proposal presentation									
Reconnaissance survey									
Data collection									
Data coding and analysis									
Thesis writing									
Thesis presentation									
Thesis submission									

Appendix IV: Budget

Items/ Activities	Quantity and unit of measure	Unit Cost (Ksh)	Total Cost (Ksh)
Proposal preparation			
i. Transport	2 trips	3000	6,000
ii. Typesetting	450 pages	10	4,500
iii. Printing	450 pages	5 per page	2,250
iv. Photocopy	450 pages	3 per page	1,350
v. Binding	6	300 per copy	1,800
Sub-total			**15,900**
Purchase of equipment			
• Assortments	50,000	-	50,000
Sub-total			**50,000**
Data collection			
• Field work	60	1000	60,000
• Transport	30	2000	60,000
• Accommodation	30	2000	60,000
Sub-total			**180,000**
Thesis			
• Typesetting/ printing	120 pages	30	3,600
• Accommodation	4 days	2000	8,000
• Binding	6 copies	100	600
• Miscellaneous			3,000
Sub-total			**15,200**
Grand Total			**261,100**

Appendix V: Curriculum Vitae

CURRICULUM VITAE

Kenneth Chepkonga Muskiton
P.O. Box 2196-30100, Eldoret, Kenya
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Email: kenchekiton@gmail.com

PERSONAL DETAILS

Year of birth: 16th October 1971

EDUCATION

- ❖ Certificate on Restoration of Degraded Eco-environment and Biodiversity conservation, Gansu Desert Control Research Institute – China; August 2015
- ❖ Certificate on Adaptation to Climate Change in Africa through Social Forestry, KEFRI and JICA; February 2015
- ❖ Certificate on Basic Paramilitary Induction Course, Kenya Forestry College , Londiani; February 2013
- ❖ Certificate on Marketing Analysis and Development, KFS (MMMB Programme);March 2012
- ❖ Certificate on Building Capacity in Extension Management for the Kenya Forest Service , Egerton University; June 2010
- ❖ Certificate on TOT course in Farm Forestry Field School Methodology, KFS (GZDSP); April 2009
- ❖ Bachelor of Science in Forestry, Moi University; May 2006
- ❖ Diploma in Forestry, Kenya Forestry College Londiani; July 1998

PROFESSIONAL EXPERIENCE

- Coordinating forestry activities in Nandi county
- Coordinated Northen Mau Project's field activities
- Coordinated Farm Forestry Field Schools activities
- Management of Forest Station activities; Forest conservation and Forest plantations
- Management of Forest Inventory activities
- Undertaken Forest Extension activities

MEMBERSHIP

- Forestry Society of Kenya; 2017 to date

REFEREES

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Appendix VI: Approval Letters

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B3725032021

March 25, 2021

TO: Muskiton Kenneth Chepkonga
School of Science and Technology
Department of Biological Sciences
University of Eastern Africa, Baraton

Dear Kenneth,

RE: Effects Of Community Forest Association Conservation Status Of Plants, Mammals And Birds In North Nandi Forest

This is to inform you that the Research Ethics Committee (REC) of the University of Eastern Africa Baraton has reviewed and approved your above research proposal. Your application approval number is UEAB/REC/37/03/2021. The approval period is 25th March, 2021 – 25th March, 2022.

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by the Research Ethics Committee (REC) of the University of Eastern Africa Baraton.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to the Research Ethics Committee (REC) of the University of Eastern Africa Baraton within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to the Research Ethics Committee (REC) of the University of Eastern Africa Baraton within 72 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to the Research Ethics Committee (REC) of the University of Eastern Africa Baraton.

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and also obtain other clearances needed.

Sincerely yours,

Prof. Jackie K. Obey, PhD
Chairperson, Research Ethics Committee

University of Eastern Africa, Baraton
25 MAR 2021
P. O. Box 2500-30100
Research Ethics Committee

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OFFICE OF DIRECTOR OF GRADUATE STUDIES AND RESEARCH
UNIVERSITY OF EASTERN AFRICA, BARATON
P.O. Box 2500, Eldoret, Kenya

April 1, 2021

National Council for Science, Technology, and Innovation
P.O. Box 30623 – 00100
Nairobi, Kenya

Dear Sir/Madam,

Mr. Muskiton Kenneth Chepkonga is a graduate student pursuing the degree of Master of Science in Biological Sciences (Conservation Option) at the University of Eastern Africa, Baraton. He is currently writing his thesis entitled: ***Effects of Community Forest Association Conversation Status of Plants, Mammals and Birds in North Nandi Forest.***

I am asking you to please allow him to conduct his research in selected respondents in Kenya. The research permit you will grant him will surely facilitate his data-gathering.

Any assistance given to Kenneth will be greatly appreciated.

Sincerely yours,

UNIVERSITY OF EASTERN AFRICA, BARATON
DIRECTOR
01 APR 2021
GRADUATE STUDIES

Dr. Moses Kibirango, PhD
Ag. Director of Graduate Studies

Cc: Chair, Department of Biological Sciences & Agriculture
Office File

Appendix VII: Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **678881**

Date of Issue: **20/April/2021**

RESEARCH LICENSE

This is to Certify that Mr.. Kenneth Chepkonga Muskiton of University of Eastern Africa, Baraton, has been licensed to conduct research in Nandi on the topic: EFFECTS OF COMMUNITY FOREST ASSOCIATION ON CONSERVATION STATUS OF PLANTS, MAMMALS AND BIRDS IN NORTH NANDI FOREST. for the period ending : 20/April/2022.

License No: **NACOSTI/P/21/10087**

678881

Applicant Identification Number

Director General

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

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Appendix VIII: Publication

Journal of Research Innovation and Implications in Education

Center for Research Implications & Practice

Website:www.jriiejournal.com ISSN 2520-7504 (Online) Vol.6, Iss.2, 2022 (pp. 168 - 176)

Influence of Community Forest Association (CFA) on Local Community Sustainable Forest Utilization in North Nandi Forest, Kenya

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Email: kenchekiton@gmail.com

Abstract: *A key feature of forest conservation and management is the practice of Participatory Forest Management (PFM). In the PFM there is inclusion and collaboration with the local community members in managing and conserving the forest resources, mostly through Community Forest Association (CFA). However, most of the roles of CFA on achieving management objectives of the forest resources are rarely met. The study evaluated the influence of CFA on local community sustainable forest utilization in North Nandi Forest. The study targeted 7,807 people living along the forest and a sample size of 156 respondents was used. Primary data was collected using questionnaires and Focus Group Discussions. Validity was ensured through expert judgement while Cronbach Alpha was calculated to determine reliability. To determine the sustainable utilization of forest resources, data was analyzed using frequency distributions and percentages. The study found out that joint forest management between the government and the community, use of sensitization meetings, the involvement of indigenous people within and outside the forest and the use of county and national government policies to support the conservation and protection of Nandi North Forest were the most significant strategies for management and protection. It was recommended that policies on expansion of land for agriculture and other developmental activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber need to be put in place by both the national and County governments. The findings of this study will help to develop recommendations for forest conservation interventions.*

Keywords: *Community, Association, Sustainable, Forest, Utilization*

How to cite this work (APA):

Chepkonga, K., Ramesh, F. & Kapyask W. K. (2022). Influence of Community Forest Association (CFA) on Local Community Sustainable Forest Utilization in North Nandi Forest, Kenya. *Journal of Research Innovation and Implications in Education, 6*(2), 168 – 176.

1. Introduction

Forests supply energy, construction materials, can be sources of food and medicines (Sheppard *et al.*, 2020). Accompanying these direct resource needs is the ecosystem services provided by forests, such as water catchments functions, soil fertility enhancement, amelioration of climate and carbon budgets (Hong & Saizen, 2019). Moreover, the rural dwellers that are poor in resource base rely on forest resources for livelihood sustenance. In this aspect, approximately 300 million people globally, mostly from developing countries of

Africa, depend largely on forest resources for their subsistence (Arfin-Khan & Saimun, 2020).

As a result of the continued use and increasing demands of forest resources, forest utilization has reached an alarming level of over-exploitation, especially by the adjacent forest dwellers (Ceccherini *et al.*, 2020). Poor governance contributes to a substantial decline of forest resources through exploitation or unsustainable over-use of resources, including the floral and faunal biodiversity (Kimutai & Watanabe, 2016). There is a consensus that the management of these forests needs to focus on the local community members.

Worldwide, participation or involvement of the local communities to manage forest resources is gaining increasing significance over the years (Apipoonyanon *et al.*, 2020) *and* is currently identified as a successful approach in the management of forest sources (Akamani

& Hall, 2019). It is becoming obvious that for forests to be sustainably managed, the Forest Adjacent Communities (FAC) should be incorporated into the management decision-making processes and including subsequent action plans on the adjacent forest landscapes (Volker, 2020). There is overwhelming evidence of engaging communities living adjacent to the forest in Africa and Asia, in advancing and managing neighbouring forests under Participatory Forest Management (PFM) arrangement (Nzau *et al.*, 2020). The process and mechanisms of PFM enable stakeholders of the forest ecotones to be included as part of the decision-makers in managing the forest resource (Wood *et al.*, 2019). Most of the PFM has been practiced through the Community Forest Associations (CFAs).

In several countries of Sub Saharan Africa which mostly have large parts of their forest surrounded by local communities, the role of CFA has been highlighted as core in the management of the forest resource for almost three decades (Okumu & Muchapondwa, 2020a). This has been accomplished in several ways but the main one involves the members of the local forest community entering a formal corporation with single or several bodies, including the government through formally registered CFAs (Laura *et al.*, 2020). The underlying principle for participating in forest management through local community partnerships is based on the underlying assumption of shared resources leads to collective prosperity (Kahsay & Bulte, 2019). The local community members in such forms of partnerships have certain alienable freedoms that may see them sustainably utilize and manage the adjacent forest resources (Sungusia *et al.*, 2020) subjects to minimize conflicts with the resources under their custody (Sarkki *et al.*, 2019).

The CFA is supposed to ensure that by regulating the utilization of forest resource, they allow for proper forest growth and generation even if the forest resources are being harvested and used (Sarkki *et al.*, 2019). In several countries, the CFA educate the local community members on the dangers of illegal cutting down of trees, encourage them to collect firewood that has just fallen from the main trees and to ensure they don’t interfere with the ecological processes of the forests (Boiyo, 2019). This is to ensure that there is the maintenance of the best forest structures that will ensure optimal forest production of resource (Apipoonyanon *et al.*, 2020).

The key function of CFA is to ensure sustainability in the utilization of forest resources (Lefèvre *et al.*, 2020). The forests are capital resources that the current generation should sustainably manage for future generations (Rahimian & Irvani, 2017). Inappropriate use of these resources may endanger the interests of future generations (Wendiro *et al.*, 2019). Sustainable forest utilization is geared towards maintaining the health and vitality of forest ecosystems and, thereby, for maintaining their protective future roles (Uisso *et al.*, 2019). Thus sound utilization of tree-planting resources should encompass biological diversity such as forest genetic resources, plant resources, as well as an animal resources within the forests (Poudyal *et al.*, 2020).

North Nandi forest, in Nandi County, has faced increased human population and weak environmental enforcement in the past, leading to over-exploitation and unsustainable utilization of forest goods and services (Njunge & Mugo, 2011). The scenario can be managed by improving governance and addressing the legitimate needs of the people, and seeing them actively engage in forest management. In Kenya, endeavours to manage forests in the past have partly failed to be acquainted with the importance of Forest Adjacent Communities (FAC). Yet to date, there is very little information known about how CFA affect the utilization and sustainable forest management of forest resources in North Nandi Forest. Moreover, the perception of the non-CFA members critiquing legally registered CFAs on inadequate participatory forest management objectives has not been adequately addressed. Therefore, this study investigated the influence of Community Forest Association (CFA) on local community sustainable forest utilization in North Nandi Forest, Kenya with particular interest on components used by CFAs to enhance forest utilization, strategies used to protect and conserve forests, threats to traditional forest conservation and actions employed to conserve forest resources

2. Literature Review

Past conservation strategies in managing forests encompass fencing off the boundaries or reserve areas that totally exclude the local community members from the reserves (Gatiso, 2019). This was a form of protectionist that has been the cornerstone of conservation for ages and for a time now has been regarded as the mainstream form of conservation (Okumu and Muchapondwa, 2020b). This method created a kind of unique geographical areas such as national forest reserves and parks and game reserves. They are managed through legal instruments with guiding principles that may exclude the adjacent community members or allow minimal contact to the forest (Duguma *et al.*, 2018). This approach was advanced because the objective of development envisaged by the local community members was deemed to clash or conflict with conservation objectives espoused by conservation agencies (Tajuddin *et al.,* 2019).

The fortress approach presents various viewpoints to the local community members as a threat to the management of the forest. It has also, given a new paradigm that identifies the socio-economic demands and desires of the local community members in ensuring there is advancement in conservation efforts and management of forests (Okumu and Muchapondwa, 2017). In order to overcome those shortcomings of the fortress approach, new methods that recognize the local community members as potential partners in the conservation was recommended (Garekae *et al.*, 2020). The approach looks at conservation from two distinct perspectives which permit the adjacent forest communities to the confined/zoned area, with defined user rights for purposes of conservation and participation process by the community members. This attempts to accelerate and improve localized development needs of the forest adjacent communities (*Johann et al.,* 2019). The approach looks at conservation as a cost that requires the local community to meet through their engagement and hence attains conservation of the forest resource (Mawa *et al.*, 2020).

Involvement of the forest adjacent communities in forest conservation is a decadal long tradition but has regularly transformed in theory and practices over the ages (Parhusip *et al.*, 2020; Sturiale *et al.*, 2020). Seeing its development, several countries have attempted to coin and label it using various names such as community-based forest conservation (CBFC), community-based natural forest resource management (CBNFRM), community-based forest management (CBFM), social forestry/forest management (SFM), sustainable forest management (SFM), collective/joint forest management (CFM), community forestry (CF), as well as participatory forest management (PFM) (Larson *et al.*, 2019). Diverse viewpoints are now available expressing the implementation of community in forest conservation and management to ensure efficiency, equitability, sustainability and local community benefits (Putraditama *et al.*, 2019). The effectiveness of the local community involvement and subsequent benefits that the stakeholders derive from the practice that clearly separates it from the traditional exclusionary forest management.

In Kenya, involving the local people in community forestry has a long history in many regions (Okong'o, 2017). In Kenya, there is much incentives of providing the local community members opportunities to enhance sustainable forest management in ensuring that there is the protection of forest resources (Malupi *et al*., 2018). In realization of this, a number of issues have been put into place to ensure the rehabilitation of forests by engaging the forest adjacent communities in sustainable management of the forest. Communities adjacent to forests rely on forests resource for their sources of livelihood such as firewood, food, pasture, or vegetables. There are activities executed by the forest adjacent communities that contribute to improper utilization of forest, these include; - overgrazing, logging, charcoal making, among others (Maloba *et al.*, 2018). Involvement in participatory forest management has therefore been recommended as a way to enhance the livelihoods of the local community members (Ngugi et al., 2018). In particular, the local community forest associations (CFAs) ought to be supported to vigorously participate in forest resources management.

Sustainable utilization of forest resources by communities living adjacent to the forest exhibit good management practices, especially those that have historical claims to forest areas, and have inhabited those forests for a sizeable amount of time. It is also, evident that, there are communities that inhabit agricultural or pastoralist areas adjacent to the forests, and utilizes the forest resources either legally or illegally. Kenyan history places most communities adjacent to the forests to be locally actively involved in the forest resources management (Rajula, 2017).

Studies have postulated and proven that the model of involving communities living adjacent to the forest to participate and manage the forest have significantly reduced deforestation or illegal activities and improved the structure of the forest (Georgine, 2019). Community forest associations undertake activities that help in reducing pressure on the forest for livelihood (Hristo *et al.*, 2020). Conservation friendly entities have noted with a lot of concern that CFA is only prioritizing activities that aim at sustainable management of forest resources and are not safeguarding the components of forest structure (Hilostle, 2018). At present, there is proof that CFAs are gradually moving towards active participation in the management of forests. Sound management of forests resources paves the way to the sustainable production of goods and services and at the same breath maintains the structural components of the forest (Raul *et al*., 2018).

3. Methodology

This study involved the collection of data on sustainable utilization of forest resources as well as sample plants, mammals and birds. The study therefore applied a mixed-method design. This research employed the use of qualitative and quantitative approaches as enabler to a better understanding of the research problem. The study was conducted in North Nandi Forest which is located on longitude 34°51’0″ E and 35°10’0″ E and latitude 0°33’30″N and 0°40’30″ N in Nandi County, Kenya.

In order to determine the sustainable utilization of plants, a household survey was done at the sampling sites. The study population comprised the household families who reside along the North Nandi Forest where the sampling sites were located. According to the Kenya National Bureau of Statistics, (2010) survey, the demographic population of the study area is approximately 68,053. Approximately 7,807 persons that translate to 11.5% of the population access the forest for their needs.

The formula $n = z^2 \left(\frac{pq}{d^2}\right)$ was used to calculate the number of households for the administration of the questionnaires (Ellen, 2012);

Whereby: n = the desired minimum sample size,

z = the standard normal deviation at a set confidence interval,

d = the acceptable range of confidence level (0.05),

p = the proportion of individuals accessing the forest, and

q = the proportion of individuals not accessing the forest = 1–p.

Thus, n =1.96*1.96 (0.115*0.885)
=156 0.05^2

A sample size of 156 respondents was used.

The use of a structured questionnaire was a major useful qualitative tool employed in collecting the data. The researchers administered a questionnaire that had both open and closed-ended questions. In ensuring validity of the research instruments, supervisors were consulted and their comments used to improve the instruments while in ensuring reliability of the research instruments, a pilot study was conducted in the nearby Nandi South Forest and Cronbach Alpha was calculated. A Cronbach Alpha of 0.82 was obtained on the

Data analysis was done using recognized and approved tools such as SPSS 23.0 and Microsoft Excel spreadsheet 2020. The data obtained was analyzed for normality after cleaning and the application of appropriate transformation methods was taken into consideration in case of any pronounced deviation from the normal distribution (ZAR, 1996). To determine the sustainable utilization of forest resources data was analyzed using frequency distributions, percentages mean and standard Deviations.

4. Results and Discussion

4.1 Components used by CFAs to enhance forest utilization

Respondents were asked to indicate the components that have been improved by the existing CFAs to enhance forest utilization. The respondents were allowed to indicate more than one (multiple responses allowed). Responses were tabulated and the results are presented in Table 1.

Table 1: Components for Enhanced Forest utilization

Component	Frequency	Percent

Knowledge of plant use	121	60.20
Knowledge of animals	48	23.88
Traditional social organization	32	15.92
Total	**201**	**100.00**

[redacted]

Table 1 shows that a total of 121(60.2%) respondents reported that their knowledge on plant use had been improved by CFAs in their areas and 48(23.88%) respondents indicated that they had enhanced their knowledge on animals and birds while 32(15.92%) respondents acknowledged that they had enhanced traditional social organization thus improving on forest utilization. Therefore, majority (60.2%) of the respondents had benefited from their CFAs on knowledge on plant use.

4.2 Strategies used to Protect and conserve Forests

The respondents were further asked to indicate the strategies that have been employed to protect and conserve forests in their locations. Multiple responses were allowed in this section. Their responses were tabulated and the results are presented in Table 2.

Table 2: Strategies used to protect and Conserve Forest

Strategy	Frequency	Percent
County and national government policies support	109	15.01
Community and school-based conservation and management approach	72	9.93
Conservation and Environmental clubs in institutions	54	7.45
Joint forest management between the government and the community	136	18.73
Cultural conservation in management of forests	63	8.69
Involvement of indigenous people within and outside the forest	131	18.04
Traditional laws	28	3.86
Sensitization meetings through barazas, workshops or conferences	133	18.32
Total	**726**	**100.00**

Table 2 shows that 136(18.73%) respondents indicated that joint forest management between the government and the community was used as a strategy for protection and conservation of North Nandi Forest, 133(18.32%) respondents acknowledged the use of sensitization meetings through barazas, workshops or conferences and 131(18.04%) respondents reported that the involvement of indigenous people within and outside the forest was used to conserve and protect the forest while 109(15.01%) respondents noted that the use of county and national government policies supported the conservation and protection of North Nandi Forest. Millions of people depend on forests for livelihood. Hence, there is the need to direct policies toward improving forest management in order to promote ecologically sustainable management where ecological processes are maintained, biodiversity is preserved, and a full range of benefits accrue to the society within the natural limits of a given natural forest (Thorn *et al.*, 2020). Community participation is the process "whereby people act in groups to influence the direction and outcome of development programs that will affect them." Participation may be thought of as the deliberate action of the people and government to respond jointly in the formulation, planning, and implementation of a strategy to satisfy a particular need (Fragallah *et al.*, 2021).

4.3 Threats to traditional Forest Conservation

In addition, the respondents were asked to indicate direct threats to traditional forest conservation. Multiple responses were allowed in this section. Their responses were tabulated and the results are presented in Table.3.

Table 3: Threats to Traditional Forest Conservation

Threat	Frequencies	Percent
Variation in Traditional livelihood strategies	128	37.76
Disintegration of traditional rights	23	6.78
Breakdown of traditional Institutions	52	15.34
Over-use of natural resources	136	40.12
Total	**339**	**100.00**

Table 3 shows that 136(40.12%) respondents reported that over-use of natural resources was a threat to traditional

forest conservation, 128(37.76%) respondents acknowledged that variation in traditional livelihood strategies was a threat to traditional forest conservation while 52(15.34%) respondents reported that break down of traditional institutions was a threat to traditional forest conservation. From the results it emerged that variation of traditional livelihood strategies and over-use of natural resources were the greatest threats to traditional forest conservation. Forests and their associated products have

been vital in sustaining livelihoods since time immemorial (Mukul *et al.*, 2016), notably for the residents of forest-dependent communities who live in abject poverty (Kabubo-Mariara, 2013). Numerous researches on the forest-livelihood nexus have shown that forests play an important role in livelihood sustenance and diversification, as well as a path to poverty reduction (Mukul *et al.*, 2016). Forests are critical for meeting fundamental necessities, saving money, and providing safety nets (Bwalya, 2013;). They provide energy, jobs, medicine, and other necessities for the majority of local communities, particularly in developing countries (Suleiman *et al.*, 2017).

Further, the respondents were asked to indicate threats to traditional forest conservation according to their CFAs. Multiple responses were also allowed in this section. Their responses were tabulated and the results are presented in Table.4.

Table 4: Factors contributing to threats to Traditional Forest conservation

[redacted]

Factor	**Frequency**	**Percent**
Strict government policies, laws and regulations	15	3.66
Expansion of land for agriculture and other developmental activities	136	33.17
Excision of forest for settlement	123	30.00
Illegal cutting of trees for posts, charcoal, fuelwood and timber	136	33.17
Total	**410**	**100.00**

[redacted]

Table 4 shows that 136(33.17%) respondents reported that expansion of land for agriculture and other developmental activities was a threat to forest conservation, 136(33.17%) respondents also reported that illegal cutting of trees for posts, charcoal, fuelwood and timber was a threat to traditional forest conservation while 123(30.0%) respondents acknowledged that excision of forest land for settlement was a threat to forest conservation. Thus, in this study, expansion of land for agriculture and other developmental activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber were the major factors affecting traditional forest conservation in North Nandi Forest. Agriculture is the most prevalent human-environment interaction, affecting more natural resources than any other human activity (Barrios *et al.*, 2018). As the world's population rises, the agricultural industry is under growing pressure to produce more food (Tschora & Cherubini, 2020). In response to increased food demand, agriculture is being intensified, which can lead to soil quality degradation, and is being spread into forest environments (Jayathilake *et al.,* 2021). Overdependence on land-based resources for income or food (Antwi *et al.,* 2014), farming activities and illegal felling of trees has threatened the existence of forests in Africa (Kamwi *et al.,* 2017).

4.4 Actions Employed to Conserve Forest Resources

The respondents were further asked to indicate the actions they undertake in their CFAs as a way of conserving forest resources. This was also multiple responses item. Their responses were tabulated and the results are presented in Table 5.

Table 5: Actions Employed to Conserve Forest Resources

Actions	Frequencies	Percent
Use of local indigenous Knowledge	76	31.54
Adhering to government policies, laws and regulations	29	12.03
Participatory forest management	136	56.43
Total	**241**	**100.00**

Table 5 shows that 136(56.43%) respondents acknowledged that they were using participatory forest management as a way of conserving the forest, 76(31.54%) reported that they were using local indigenous Knowledge to conserve the forest while 12.03% of the respondents reported that they were adhering to government policies, laws and regulations on conservation of forests. The results pointed out that most of the respondents were using participatory forest management as a way of conserving the forest. Following massive failures of centralized systems of forest management, many developing countries have experimented with some form of decentralized forest governance (Lund *et al.,* 2018). This involves a shift in forest governance towards increased involvement of local communities in the management of forests (Kairu *et al.,* 2018). Decentralized forest management has been promoted on the basis that it can improve efficiency and equity in natural resource management (Ribot *et al.,* 2010). Participation in forest management involves planning, which entails involving local actors in decision-making, creating new rules or modifying old ones, formulating alternative planning activities and allocation of rights, responsibilities and resources among the forest management actors (Tadesse *et al.,* 2017). Participation in planning allows the dynamic nature of stakeholder needs, priorities and interests to be

captured and integrated throughout project implementation (Reed *et al.,* 2009). Implementation involves bringing the forest associations into forest management activities (Luswaga & Nuppenau, 2020).

In addition, it emerged different age groups among the CFA members were involved in forest management through planting of more tree species, reporting any illegal activities in the forest, ensuring that harvesting of medicinal plants were conducted in a sustainable way and in sensitization of the community members through barazas on the importance of the forest and its resources. Among the plant parts that were used by the communities included roots, leaves, barks, followers, stem and branches. The respondents noted that there are some trees in the forest which are medicinal and thus are protected by community members. These trees included olea *carpensis, Fegaropsis Angolensis, Solanum Spp, Celtis Africana, Cassipourea Molosasana* and *Syzygium Cordatum,*

During the Focus Group Discussions, it emerged that the indigenous plants in the forest provided them with medicine, protected water catchment areas, maintained soil fertility, provided food and shelter to other animals, shade for animals, feed for livestock particularly during dry season, provides them with firewood and fencing posts. A rising number of studies shows the value of forests as a source of income for many rural people in developing countries (Nguyen *et al.,* 2020). According to

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the Food and Agriculture Organization (FAO), forest extraction accounts for a major portion of one billion people's income (FAO, 2016). Studies from tropical forest areas demonstrate the numerous significant functions of forests in rural livelihoods, including the provision of a wide range of subsistence goods, marketable products for cash income creation, agricultural productivity inputs, and vital safety nets during difficult times (Chilongo, 2014).

5. Conclusion and Recommendations 5.1

Conclusion

Joint forest management between the government and the community, use of sensitization meetings through barazas, workshops or conferences, the involvement of indigenous people within and outside the forest and the use of county and national government policies to support the conservation and protection of Forest were the most significant strategies for management and protection of the Forest. However, expansion of land for agriculture and other developmental activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber were the major factors affecting traditional forest conservation in Nandi North Forest.

5.2 Recommendation

Policies on expansion of land for agriculture and other developmental activities, excision of forest for settlement and illegal cutting of trees for posts, charcoal, fuelwood and timber need to be put in place by both the national and County governments. The effective implementation of these policies with the CFAs will ensure effective management and conservation of North Nandi Forest.

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Appendix IX: Plagiarism Report

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Document Information

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School of Science and Technology
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