EXTRACTION OF NON-TIMBER FOREST PRODUCTS ON SOUTH NANDI FOREST STRUCTURE AND ITS IMPACTS ON LIVELIHOODS OF ADJACENT COMMUNITIES

BY

MAUA JAMES ODHIAMBO

A THESIS SUBMITTED TO THE DEPARTMENT OF BIOLOGICAL SCIENCES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN ENVIRONMENTAL BIOLOGY

MOI UNIVERSITY

2021

DECLARATION

Declaration by the Candidate

This thesis is my original work and has not been presented for a degree in any other University. No part of this thesis may be reproduced without the prior written permission of the author and/or Moi University.

Signature: ___________________________ Date: ___________________________

Maua James Odhiambo

PHD/EB/04/14

Declaration by the Supervisors

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

Signature: ____________________________ Date: ___________________________

Prof. Mugatsia H. Tsingalia

Department of Biological Sciences

Moi University, Eldoret, Kenya

Signature: _____________________________Date: ___________________________

Dr. J. Cheboiwo

Department of Socio-economics, Policy and Governance

Kenya Forestry Research Institute,

Nairobi, Kenya

DEDICATION

Dedicated to forest adjacent community members who are motivated to conserve our forests for present and future generation.

ACKNOWLEDGEMENTS

I wish to thank the Kenya Forestry Research Institute (KEFRI) for supporting this research financially and granting me time to pursue my PhD study. I am extremely grateful to the KEFRI management for this support. I thank the former Director, KEFRI, Dr. Ben Chikamai, who provided me with necessary logistics during fieldwork.

I thank my supervisors, Prof. M. H. Tsingalia and Dr. J. Cheboiwo for shaping my proposal and providing unparalleled advice while I was in the field and in the write-up of this thesis. Many thanks also go to Dr. Jacque Makatiani of Moi University for giving useful comments on this work during presentation of my fieldwork results.

My gratitutude also goes to the Director; Kenya Forest Service, for allowing me to do my research in the South Nandi Forest. I also thank the Forester, Kobujoi Forest station, Mr. Cherotich, for supporting me during data collection and providing Forest Rangers to boost our security during fieldwork. I equally thank him for giving useful ideas and documents related to South Nandi Forest.

The generous assistance of numerous individuals in Kakamega and Kobujoi are gratefully acknowledged, particularly, Ms. Jessica Sonye and Mr. Japheth Mwikoma (both of KEFRI), who assisted me in handling some of the data from the field and driving me during fieldwork respectively. I cannot forget the 431 respondents and Kobujoi Community Forest Association members who willingly gave information that supported my study. I also thank all the enumerators and community members who provided information on uses of trees/plants from South Nandi Forest. To all of you I say a big thank you.

The following KEFRI staff, Abuid Saya and Celestine Ingutia of Biometrics Section, were helpful in checking the data analysis and providing useful comments. Thank you!

The support of many friends at different times and in different ways greatly eased the tasks before me. I must particularly mention Dr. David Langat and Dr. John Otuoma, for their comments during the proposal development for my PhD study; Humphrey Agevi, MosesWabusya and Betty Olal who were my PhD course classmates for making comments on my work especially during the several presentations done at the University. To all friends and collegues whom I have not mentioned by name, I say thank you for that assistance and company that made writing this thesis less stressful.

Last but not least, I sincerely thank my family for their patience, understanding and encouragement which they offered during my PhD study.

ABSTRACT

Non-timber forest products (NTFPs) are forest-derived products other than commercial timber that significantly contribute socio-economically to rural livelihoods. With increasing population, it is expected that the level of NTFPs extraction will increase hence exert greater pressure on the forest ecosystems to the detriment of their ecological integrity. Though NTFPs offer good opportunities for improving livelihoods, the impact of their extraction and productivity levels per unit area for most NTFPs are not known. Further, there is inadequate information on NTFPs utilization by different gender groups living adjacent to the South Nandi forest to inform their sustainable management decisions. The objectives of the study were to: 1) determine the types of NTFPs extracted for subsistence or income generation; 2) quantify the NTFPs forest adjacent households extract by gender and its impact on forest structure in terms of population structure, regeneration status, and species composition; 3) estimate the economic value of the key NTFPs extracted from the forest, and 4) assess the socio-economic factors that influence households' dependence in South Nandi forest. A questionnaire that covered both quantitative and qualitative data from the sample populations and forests was used. The study covered a total of 431 household heads from 9 villages. These were interviewed using a stratified random sampling method from May to September 2016. Indirect opportunity cost, direct pricing, and cost of collection methods were used to estimate the economic value of NTFPs accruing to each household. Thirty-five nested-plots of size 600 m^2 (30 m X 20 m) were used to collect vegetation data. The plants were categorized into three groups; seedlings, saplings, and mature based on DBH classes then the population structure and status of natural regeneration determined. A total of 128 plant species belonging to 105 genera and 55 families were cited from South Nandi Forest. Twenty-two types of NTFPs were determined in this study. The most common NTFP uses were firewood, grazing, and herbal medicine. In terms of gender, the collection of firewood is mostly done by the female, grazing by the male, whereas both male and female collect herbal medicine. The DBH class distributions showed five patterns. A classic inverse-J curve pattern occurs in a healthy forest with active regeneration and recruitment of new individuals. The other four patterns emerged due to removing trees in various DBH classes, which distorted the inverse-J curves suggesting a disturbance in the forest. Disturbance in the forest was also corroborated from the households' heads perception that NTFPs stock condition in the forest had reduced compared to ten years ago. The species with low Importance Value Index values and poor regeneration status should be prioritized for conservation. The economic value of all NTFPs extracted per hectare per year was US$824.15, whereas the value of NTFP extraction per household per year was US$579.51. NTFPs contributed 32.7% - 48.7% of households' incomes, indicating the forest's importance. The mean annual firewood extraction was 7285.4±1586.9kg per household. Twelve variables were significantly associated with dependence on the forest. These included distance to forest ($\chi2_{(16, 431)} = 51.235$, $p<0.001$); membership in Community Forest Association ($\chi2_{(1, 431)} =9.481$, $p<0.05$); and main occupation of household head ($\chi2_{(4,431)} =7.143$, $p<0.05$). Years of formal education, land-size, and distance to the forest from home were positively correlated to dependence on the forest, whereas age, occupation, and distance to market negatively correlated with dependence on the forest. This study provides information that is extremely useful for the development of sustainable management of South Nandi Forest to enhance local incomes and livelihoods. Further research is required in studies that integrate socio-economic and ecological information to understand better ecological problems associated with human use.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DEFINITION OF TERMS AND ABBREVIATIONS

The definitions here relate to the context in which the words, phrases or abbreviations have been used in this thesis.

Basal area: The total cross-sectional area occupied by a stand of trees, measured at 1.3m height above ground and expressed as m^2ha^{-1}

DBH: The tree diameter at breast height, measured in centimeters at 1.3m height

Ethnobotany: Broadly defined as a cultural study of how the people perceive the plants, give names, use and organize the information about the plants around them (Arshad *et al.*, 2014)

Forest: Land with tree crown cover (or equivalent stocking level) of more than 10 % and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ (FAO, 2001). Forest according to National Forest Programme (Kenya) means a land area of more than 0.5 ha., crown cover of at least 10%, trees of at least 2.5 m height, which is primarily under agricultural or other specific non-forest land use. In line with the constitution, the NFP also operates with "tree cover", e.g. including trees on farm (MENR, 2016).

Inverse J curve: In uneven aged forest, diameter class distribution shows a geometric progression in numbers of trees from one diameter class to another (Changhui, 2000) resulting in an inverse J shape.

IVI (Importance Value Index): A measure of tree species dominance, calculated as the mean value of relative frequency, relative density and relative basal area

KEFRI: Kenya Forestry Research Institute

KFS: Kenya Forest Service

Livelihood: A livelihood is defined as ‘the activities, the assets, and the access that jointly determine the living gained by an individual or household’ (Ellis, 1999).

NTFP: Non-Timber Forest Product. These are any products from the forest other than timber e.g. firewood, honey, poles, sand, resin, gums etc

Relative density: The number of individuals of a species as a proportion of the total number in a forest

Relative frequency: The proportion of sample plots in which a species is represented out of the total number of sample plots in a forest

SNF: South Nandi Forest

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Forests play an essential role in the global carbon cycle, the biodiversity of habitats, and many tangible and intangible benefits to communities living around them (Mutenje *et al*., 2011). Non-timber forest products (NTFPs) are 'defined as all tangible forest products other than industrial wood which can be collected from forests for subsistence as well as for trade' (Ros-Tonen et al., 1995), whereas (de Beer and McDermott, 1996) defined NTFPs as 'all biological materials other than timber which are extracted from forests for human use.' In rural households adjacent to the forest, non-timber forest products (NTFPs) are known to contribute significantly to these communities' economies (FAO, 1997; Stanley *et al*., 2012; Melaku *et al*., 2014). NTFPs provide domestic subsistence and consumption needs, thus increasing disposable income to the households (Sumukwo *et al*., 2013); serve as insurance premium during times of economic hardships (Paumgarten *et al*., 2009); and also contribute direct monetary benefits through sales (Shackleton *et al*., 2007).

Extraction of NTFPs is considered low impact forest use compatible with conservation than other forms of forest extraction activities such as logging, mining, and plantation agriculture. This is because NTFPs extraction involves collecting wild nuts and fruits, leaves, bark, resin, and roots that do not affect much the structure and function of forests (Stanley *et al*., 2012). However, in some cases, the NTFP market can grow rapidly, and the value of NTFPs can be higher than those derived from commercial timber (CERUT, 1999). This demonstrates that NTFP can be beneficial to local livelihoods, but intervention measures may be needed to address overexploitation risk (de Beer and McDermott, 1996; Sumukwo *et al.*, 2013).

Studies in many countries have confirmed the socio-economic importance of NTFPs to adjacent forest communities. In Nepal, for example, the economic contribution of Chinese caterpillar fungus to the livelihoods of mountain communities was 35.5% of the total households and 76.7% of the total cash income (Shrestha and Bawa, 2014). Further, the study found that dependence on the Chinese caterpillar fungus among households was significant in essential household needs such as education, food security, and debt payments. In 17 case studies from 10 countries in Africa, the majority of the products (82.3%) contributed less than 50% to household incomes; and only in three cases did NTFPs contribute significantly (over 70%) to the household incomes (Sunderland *et al*., 2004). It was also noted that this contribution was significant at times of economic need, such as payment of fees (Paumgarten *et al.*, 2009) or when agricultural labor needs were low, for example, during the rainy season. In most cases, forest products are extracted predominantly from the wild, often in unmanaged, open-access situations, together with agricultural products providing access to the household cash incomes. Contribution from the major NTFPs such as forest coffee, honey, and spices accounted for 47% of annual household income in Bonga forest, southwest Ethiopia when all livelihood activities, for instance, crop and livestock production, as well as off-farm activities were considered (Melaku *et al*., 2014)

Non Tree Forest Products are generally easily collected, processed, and marketed by the rural poor and offer good opportunities for improving livelihoods. However, several studies have shown that as human populations grow, forest areas reduce, markets change, and local communities become more aware of the economic value of NFTPs. The sustainable production of many NTFPs cannot be guaranteed (Stanley *et al*., 2012). For instance, an increase in international rattan prices in the 1980s and 1990s in Asia resulted in over-exploitation of the available resources by commercial firms leading to destruction and loss of local biodiversity that left many people without a source of livelihood (Cunningham, 2000). This demonstrates that 'not all NTFPs remain 'environmentally benign' when extracted on a large scale, and not all resources remain accessible to poor, landless producers once their value becomes apparent to more powerful' (Dove, 1993). The NTFP sector, despite its importance, faces many challenges that hinder the realization of its full socio-economic potential. Some challenges, e.g., availability of reliable data and information on NFTPs, difficulties in assessing the total economic value, limited access to markets, insufficient capital, and generally weak bargaining power of the poor among those who exploit NTFPs (Cunningham, 2000).

Studies across countries indicate that in most cases, NTFPs collection and use are gender-sensitive. For example, in Mali, the collection and use of NTFPs from natural forests and crop fields were linked to gender (Gakou *et al.*, 1994). Products such as shea nuts for oil/butter, firewood, leaves for sauces, seeds for condiments, and nuts/seeds for soap were frequently collected by women, whereas men mostly collected products like utensils, animal feed, house materials, and construction materials. Further, the study found that ninety percent of the products collected were found in the natural forests; 63% were collected from trees on fallow lands and 51% from scattered trees in crop fields (Gakou *et al.*, 1994). These observations imply that NTFPs extraction and use differ according to gender roles in the society; hence gender segregation in studies is necessary to determine livelihoods and optimum levels of extraction to ensure sustainability. Studies also point out that sustainable management is only possible where the products harvested are abundant or regenerate quickly, with classical examples being the 'Brazil nut (Bertholletia excelsa) found in Brazil and Bolivia (Assies, 1997) and palm heart from multistemmed species like Euterpe oleracea found in Guyana (Andel *et al.*, 1998)'.Similarly, the economic benefits of extraction of NTFPs are viable overtime only if harvesting is done in an ecologically sustainable manner. This implies that the harvests done in a population should not exceed the natural rate of regeneration in a given time period (Stanley *et al*., 2012). The global value of NTFPs removals in 2005 amounted was US$18.5 billion; out of this, food products accounted for the greatest share (FAO, 2010). However, information is still scanty in many countries such as Kenya, where NTFPs are highly important, yet the actual value of commercial and subsistence use is rarely captured. Therefore, the reported statistics probably cover only a fraction of the actual total value of harvested NTFPs (FAO, 2010). For example, Kakamega forest's earlier estimation of the economic value of NTFPs to adjacent communities was US$160 per household per annum (Barrow *et al*., 2009). However, many changes have occurred since then, including the now-repealed Forests Act 2005 and its successor, Forest Conservation and Management Act 2016 (GoK, 2005; GoK, 2016), population increase, changes in poverty levels, and dependence ratios that have implications on the way forests are managed and extraction rates hence the need for updated information on the current utilization and economic benefits to the adjacent forest communities. About 86% of the rural poor in South Nandi depended on forests for their livelihoods (Sumukwo *et al*., 2013). The study also showed that 80% of the respondents depended on South Nandi forest for reducing household income risk or consumption risk during times of economic stress, like famines, retrenchment or death of household head, unprecedented rise in food prices, periods between crop harvests, and emergencies. Further, the study noted that the forest products could not be underestimated, and any changes that affect access to the forest products will have a significant impact on household incomes and livelihoods. Firewood, herbal medicine, grass, food, and fruits were identified as the main NTFPs in South Nandi Forest Reserve (Mbuvi *et al*., 2010). The current study emphasized the livelihood aspects of extracting NTFPs from the South Nandi Forest Reserve and their sustainable utilization where nearly all forest products are extracted predominantly from the wild and open access situations, which raises concerns on whether the optimum level of extraction is being practiced.

1.2 Problem Statement

Though NTFPs offer good opportunities for improving livelihoods, the extraction and productivity levels per unit area for most of them are not known (Shanker *et al*., 1998). Further information on their value addition at various points along the marketing value chains is scanty. With the increase in population, it is expected that the level of extracting NTFPs may increase, thus exerting pressure on the forest ecosystem to the detriment of the forest ecosystem's ecological integrity. Therefore, data and information on the level of NTFPs extraction from South Nandi forest must be available to inform decisions on their sustainable utilization by the adjacent forest communities. Therefore, the data and information gaps informed the decisions to undertake studies on the impacts of NTFPs extraction on forest ecosystem resilience and livelihoods of the local communities. Though women, men, and youth depend on the forest for different NTFPs, a knowledge gap exists in valuing NTFPs by gender since little information has been documented on types of NTFPs that different gender groups extract, their values, and contribution to the overall economic condition of the forest adjacent communities in Nandi South forest. The study provides comprehensive estimates of various NTFPs quantities extracted and utilized by forest adjacent communities and shares by gender at the local level. The study greatly contributes to the deepening of knowledge on sustainable utilization of key NTFPs in South Nandi forest to inform community and policy actions that enhance sustainable forest management. The study focused on South Nandi Forest because not much research has targeted it compared to Kakamega forest and other forests in Western Kenya.

1.3 Justification

The importance of non-timber forest products to adjacent forest communities' livelihood strategies is recognized in many studies (Croituru, 2007; FAO, 2010).

Also, in the last three decades, much attention has focused on non-timber forest products as it is considered to have low ecological impact compared to other extraction activities such as logging and plantation agriculture (Stanley *et al.*, 2012).

Many studies indicate that NTFPs may provide significant benefits to the local people while simultaneously conserving the standing forest's biological resources. Understanding the increased dependence on NTFPs requires an economic valuation to improve the sustainable utilization and planning of NTFP resources in the forest. Further, the NTFPs are poorly valued, thus lowers the contribution of forests to the GDP. This study's results are useful as they build on the database that would be used to improve on budgetary allocations given to the forestry sector and create awareness on the importance and value of NTFPs to rural households living adjacent to forests.

Understanding the increased dependence on NTFPs requires an economic valuation to improve on sustainable utilization and planning of NTFP resources in the forest. Further, the NTFPs are poorly valued, thus lowering the contribution of forests to the GDP. This study's results are useful as they build on the database that the Kenyan government would use to improve on budgetary allocations given to the forestry sector and creates awareness of the importance and value of NTFPs to rural households living adjacent to forests. Additionally, this study determined the number of socio-economic factors that influence the dependence of households on forests. The findings will be significant in designing target-specific interventions that reduce dependence on the forest, planning, policy development, and sustainable management strategies. Therefore, this study provides information that will contribute to the optimal extraction of NTFPs and sustainable management of these resources in the South Nandi Forest Reserve.

1.4 Objectives

1.4.1 Broad Objective

This study's main objective was to assess the impact of extraction of non-timber forest products by forest adjacent households on the forest structure and its impetus on livelihoods in South Nandi Forest (SNF) in Kenya.

1.4.2 Specific Objectives

1. To determine the types of NTFPs extracted by forest adjacent households for subsistence or income generation

2. To quantify the NTFPs forest adjacent households extract by gender and its impact on forest structure in terms of population structure, regeneration status, and species composition
3. To estimate the economic value of the key NTFPs extracted from the SNF
4. To assess the households' dependence on NTFPs and socio-economic factors that influence households' dependence on SNF.

1.5 Research Questions

1. What types of non-timber forest products are extracted from the forest by gender by the forest adjacent households for consumption and income generation?
2. What are the quantities of NTFPs that the forest adjacent households extract by gender, and how does extraction of NTFP impact on forest structure or DBH classes of individual tree species in SNF?
3. What is the estimated economic value of the main non-timber forest products extracted from the South Nandi forest?
4. What are the household's dependence levels and the socio-economic factors that influence households' dependence on NTFP from SNF?

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview of challenges in NTFPs extraction and trade

NTFPs are products of the forest system that are generally not cultivated (Girmay *et al.,* 2013) and comprise 'plants and plant materials such as fodder, fuelwood, food, medicine, wrapping materials, dyes, biochemical as well as animals, birds, reptiles and fishes, for food and feathers' (Adepoju and Salau, 2007). They may be all or part of a living or dead plant, lichens, fungi or other forest organisms. NTFPs are known for their consumptive, social and economic values (Girmay *et al.,* 2013)'.

Various reports have indicated that promotion of NTFPs could result in a 'win-win' situation for poverty reduction and biodiversity conservation (Golam *et al.,* 2008). The reason being that NTFPs can contribute significantly to the livelihoods of forest dependent communities household food security and nutrition (Shackleton and Shackleton, 2004); generate extra employment and income; and provide opportunities for NTFP related enterprises (Shackleton and Shackleton, 2004). However, a number of challenges need to be considered for sustainable exploitation and valuable use of NTFPs.

Changing economic conditions, rates and sources of deforestation, and climate change suggest increased pressures upon forests. Some studies have pointed to the potential of population pressure and climate change on overall forest resources resilience and livelihoods of dependent communities. Studies indicate that the ethnobotanical foundation of Tibetan culture and religion will by the end of the century be threatened due to overharvesting of medicinal species in the Tibet's "Medicine Mountains" combined with temperature increases (Salick *et al.,* 2009).

Studies also point out the persistent methodological problems in valuation of the returns of non-timber forest products (Stanley *et al*., 2012). These authors' points out four areas of concern: 'economic analyses bundle products together and fail to delineate specific outcomes by single products and species; the absence in so many economic reports of scientific names of NTFPs limits the scope of analysis as well as the opportunity for interdisciplinary comparison'. Similarly, sustainability needs to be measured in both ecological and economic terms that may not be possible in a single extractive enterprise. In this study, ecological sustainability refers to ecosystem integrity, carrying capacity and biodiversity where the resources are harvested at a rate lower than their regeneration; and economic sustainability implies a system of production that satisfies present consumption levels without compromising future needs (Kahn, 1995). Therefore, studies on NTFPs require a team of interdisciplinary researchers during the process of study design and implementation to ensure that both ecological and economic issues are addressed.

Many analyses fail to account for household labour time by period or by person across seasons and the year (Stanley *et al.*, 2012). Few studies have considered the number of collecting trips and value of the total products collected per year. Furthermore, studies fail to specify the number of household members working in gathering compared to the members consuming from the income streams generated. The gaps indicate that the future survey instruments should include time use patterns and collection rates and returns across all seasons (Stanley *et al.*, 2012).

The issue of ecological sustainability is crucial to long-term success of extractive activities (Pandey *et al.*, 2015). It is noted that "each of the ecological studies referred to discusses this feature either in their introduction or conclusion, and most employ field methods and quantitative analyses to explore the question. Yet a surprising number of studies fail to make explicit statements regarding the relative sustainability of the harvest activity" (Stanley *et al.*, 2012). There is need to determine whether the current NTFPs harvests under the present conditions are sustainable and to make informed recommendations that would foster future sustainability.

Most studies in the ecological analysis, for instance, (Ticktin, 2004; Shahabuddin and Prasad, 2004), "report physical extraction rates over a short study period, usually two years or less. Ultimately a longer-term analysis is needed, since extraction quantities and prices can affect household incomes. The Homma model of extractive production suggests a rapid expansion, followed by stabilization and then decline in the ratio of production/extraction (Homma, 1996). If extraction and cultivation eventually occur at the same time, prices will fall. While standard economic theory suggests that higher prices create a greater quantity supplied, what often matters to poor people is meeting a subsistence income threshold. In other words, falling prices could also create pressure for over-extraction as gatherers seek more. Future research is needed on the dynamic interaction between economic and ecological sustainability across studies or within a single study". This study seeks to address the issues mentioned above with the exemption of the short study period due mainly to limitation of financial resources.

The relation between the economic benefits of NTFPs and their resource base, local availability and sustainability, and condition of their sources is poorly understood (Hall and Bawa, 1993). Another complication is the scarce information on the ecological productivity, growth forms, life history and conservation of the various species involved in production of NTFPs hinder development of management scenarios (Zuidema, 2000). The lack of adequate information has led some scientists to propose that intense harvesting of NTFPs is feasible because of the supposedly low associated ecological impacts (Ndangalasi *et al.,* 2007). Generally, it has been established that the overall ecological effects, impacts and responses of forest utilization are underpinned by floristic composition, the magnitude or intensity, and the modes and seasons of harvesting (Peters, 1994; Ndangalasi *et al.,* 2007).

The actual impact of harvesting NTFPs depends on the specific growth form or type of resource that is removed. Intensive and uncontrolled harvesting can reduce the abundance of solitary plants (Ndangalasi *et al.,* 2007). Rising demands have led to over-exploitation of many multi-stemmed species with collectors cutting plants too young or too close to the ground, which might inhibit re-sprouting. Kahn (1988) reported that harvesting of leaves may have a negligible effect on the plant population being exploited if: (i) individual plants are not killed in the process; (ii) a sufficient number of healthy leaves are left on each plant to photosynthesize; (iii) the reproductive structures and apical buds are not damaged, and (iv) sufficient time is allowed between successive harvests for the plant to produce new leaves. The harvesting of roots, bulbs and bark usually kills or fatally weakens the exploited plant species (Davenport and Ndangalasi, 2002).

NTFPs may sometimes fail to make a positive contribution to sustainable development suggesting the need to analyze the ecological, socio-economic and cultural factors that determine the success of NTFP commercialization (Marshal *et al.,* 2006). Such analyses could enable successful commercialization of NTFP's of high potential, or the identification of those at high risk of failure, prior to major investment decisions being made (Marshal *et al.,* 2006). Although a great deal of research has been undertaken on NTFPs, much of this has been highly specific in nature, relating to individual case studies. It should be noted that “differences in the objectives and methods of different studies, and wide variation in the ecological and socio-economic characteristics of NTFPs, have restricted the development of standard analytical frameworks that enable the results of different investigations to be integrated or compared (Neumann and Hirsch 2000)”. The lack of such comparative analyses has hindered the development of generalizations about the factors influencing success of NTFPs commercialization. Although some important attempts have been made to develop models and theories relating to NTFP commercialization (Homma, 1996), to date, these efforts have largely been qualitative in nature with limited practical applicability.

The current study attempts to overcome some of the research gaps by examining the impacts of extraction of non-timber forest products on South Nandi forest and livelihoods of adjacent households to date, these efforts have largely been qualitative in nature, and their practical applicability has been limited.

2.2 Diversity of NTFPs

NTFPs in tropical forests are generally grouped into four categories (Ndangalasi *et al.,* 2007); fruits and seeds harvested mainly as fleshy fruit, nuts and oil seeds; plant exudates such as latex, resin and floral nectar; vegetative structures like apical buds, bulbs, leaves, stems, barks and roots; and small stems, poles and sticks harvested for housing, fencing, fuelwood, and craft and furniture materials.

The numbers of products available from NTFPs are numerous, thus, in the market setup; they have been classified into edibles and non-edibles, which in turn are further divided into four general categories to simplify trade in the NTFP industry. The four categories are: 1) edibles, 2) medicinal and dietary supplements, 3) floral products and 4) specialty wood products (Adepoju and Salau, 2007).

There is a diversity of plants ranging from 92 to 480 plant species used as NTFPs as shown in a number of studies. For instance, 92 plant species used for ethnobotanical use, fuelwood, animal fodder, construction materials and edible forest products in Ri-Bhoi District, Meghalaya, India (Sharma *et al.*, 2016). About 109 species of NTFPs in Malaysia were locally traded and used for wild edible plants (35 species), 32 species of medicinal plants, 8 species of orchids, 4 species of bamboos, 6 species of rattans, 8 species of wild fruits among others (Kodoh *et al*., 2009). Further, 480 plant species (25% of recorded flora) from 117 families and 334 genera used as NTFPs by local people in China (Ghorbani *et al.*, 2012). It was noted that forests in India, which were once known for their valuable timber, have changed roles to provision of NTFPs with 183 species having shifted emphasis to provision of NTFPs (Omkar *et al.,* 2012). Those harvested for NTFPs belonged to 149 genera representing 64 families: Dicots/Magnoliopsida (164) and Monocots/Liliopsida (19) whereas the growth forms were dominated by trees (111), Shrubs (29), Herbs (21), Climbers (19) and Lianas (3) indicating that the floral elements are primarily woody forest trees. The shift to NTFPs could have been due to the degradation of the forest that changed structure from predominantly timber species to shrubs and climbers.

Overall, NTFPs provide many uses as they contribute to food and other basic needs; thus, a better understanding of the extent and nature of the role of NTFPs is necessary to make decisions about forest management that adequately meets the society's demands upon the forest resource (Adepoju and Salau, 2007). The challenges to availability of NTFPs are linked to anthropogenic pressures mainly caused by increased human population, heavy extraction levels and grazing livestock. Therefore, sustainable harvesting and management strategies should take into consideration these factors to ensure there is a balance between growth and extraction to prevent overexploitation of the specific species (Adepoju and Salau, 2007; Ghorbani *et al.,* 2012).

2.3 Quantification of NTFPs from Forests

2.3.1 Dependence on NTFPs

Many rural dwellers in tropical regions depend on non-timber forest products (NTFPs) for their livelihood and income needs (Heubach *et al.,* 2011; Maua *et al.,* 2019). NTFPs play significant economic benefits to the local community in the following ways i.e. provide domestic subsistence and consumption needs for improved disposable income to the household (Heubach *et al.,* 2011); serve as insurance premium during hard economic times and NTFPs contribute to direct monetary benefits through sales (Shackleton and Shackleton, 2004). It was noted that "valuation of natural insurance demand for NTFP in South Nandi, Kenya, showed that majority (55%) of the respondents were willing to contribute extra money, above the normal maximum Willingness to Pay (WTP) amounts for improved forest products management, as guarantee for future availability of NTFPs" (Sumukwo *et al.,* 2013).

In a study in Northern Benin, West Africa, it was reported that "average income from NTFPs accounted for 39% of total household income and had a strong equalizing effect. However, the economic relevance of NTFPs differed between households with the poorer households being more dependent on NTFPs in order to fulfill their basic needs than relatively wealthier households" (Heubach *et al.,* 2012). Contribution of

NTFPs to household income has also been reported by many authors e.g. Melaku *et al.,* (2014); Sumukwo *et al.,* (2013); and Sunderland *et al.,* (2004). The markets play an important role in enabling forest-dependent households to exchange NTFPs for cash through sales. Therefore, increased market demand and access with increased urbanization expands the volumes of NTFPs that flow to local and regional markets.

Agrawal *et al*. (2013) confirmed the importance of NTFPs at global level, these include: "employment of more than 13 million people in forest sector activities in the formal sector; 40-60 million people employed in the informal sector of small and medium forest enterprises; estimated that 1- 1.15 billion people get direct and indirect contributions to livelihoods and incomes; and unlike most other sectors, forests also contribute immensely to ecosystem services that humans value on, though these are not traded and it is difficult to put economic value to them. However, different economic valuation strategies peg the economic value of ecosystem services from forests in the summing up to billions of dollars".

2.3.2 Marketed NTFPs and their commercial values

Studies indicate that globally, 4,000 - 6,000 NTFPs are of commercial value and some 150 of them are important in International trade (FAO, 1997). Further, it estimates that the total value of internationally traded NFTPs to be USD1.1 billion annually. However, the link between the economic benefits of NTFPs and their resource base (including local availability and sustainability) and sources is poorly understood (Hall and Bawa, 1993; Sunderland and Ndoye, 2004). Therefore, chances of a specific product succeeding in new commercial markets have to be confirmed in market viability studies. The focus on developing market outlets for NTFPs needs to be kept in balance with consideration on the continuing use of NTFPs to meet subsistence needs; sustainability of the production; the impact on socio-economic structures of the community, and the position of the NTFP in relation to similar (NTFP) products. Such studies do not consider the classification of NTFP based on their supply and demand characteristics and the driving market mechanisms (FAO, 1997). There are several supplies related NTFP characteristics that influence the flow of products from forests namely: sustainability of extraction, regenerative production, ease of cultivation and ease of stimulating production by technological means. The other supply characteristics are more related to production organization that include access to NTFP resources and gender division of production responsibilities. NTFPs demand characteristics differ depending on the main drivers for their collection and uses. Some of the key demand characteristics for NTFPs include opportunistic collected products for subsistence consumption not related to main household needs such as for snack fruits, occasionally collected products purposely to meet emergency needs such as medicinal products, and emergency foods during droughts (FAO, 1997). Others are products for regular household consumption, products for sale at various market types (local, regional/national, international) and products demanded in manufactured forms, and which can be locally produced giving them added value (e.g. palm sugar, liquors).

Manish *et al*. (2015) reported that "global pharmaceutical market was worth US $550 billion in 2004 and was expected to exceed US $1100 billion or more by the year 2015. The herbal industry shares about US $100 billion annually with good growth potential (Manish *et al.,* 2015). Herbal medicine is reported to be the mainstay of about 75 - 80% of the world population, mainly in the developing countries, for primary health care".

Foster and Duke (1990) catalogued about "500 medicinal plants of eastern and central North America and reported that in 1990, the annual herb product sales was about US $250 million and by 2000, sales had surpassed US$ 3 billion largely as the result of Dietary and Supplement Act on 1994, that created the regulatory category of "dietary supplements" and moved herb products from health and natural food stores into the mass market" (Foster and Duke, 2000). Marketing and distribution of herbal products has been boosted by online marketing from the mid 1990s.

A study done in Cameroon found that "more than 1,100 traders, mainly women, were engaged in the distribution of NTFPs and the quantity marketed was significant, amounting to at least US$1.75 million in the first half of 1995" (Ndoye *et al.,* 1998). Furthermore, the marketing margins obtained by traders varied depending on the NTFPs; between 16% (for *Dacryodes edulis*) and 30% (for *Irvingia* spp.) of the value of sales. These findings confirm the important role of NTFPs as a source of employment and income to gatherers and traders, and hence the importance of markets in enhancing incomes and livelihoods (Ndoye *et al.,* 1998).

Barrow *et al*. (2016) highlighted the economic value of forests to forest adjacent households in 14 countries in Africa including Kenya. In Kenya, economic value of Mau forest was US$350- US$450 per household per annum and worth $US 100 million per annum overall; other forests were: Kakamega forest - US$160; Arabuko Sokoke - US$ 135; US$ 213 for Mt. Kenya; US$285 for Aberdares and US$ 100 for Oldonyo Orok.

The Kenya National Bureau of Statistics (KNBS) revealed forestry's contribution to GDP to be 1%, which is too low according to a study the Forestry Society of Kenya

(FAO, 2016). This is supported by (Katerere, 1998) who argued that NTFPs are generally undervalued by planners and policy makers though forests and trees provide food, fiber, fodder, fuel, and medicinal products (Agrawal *et al.,* 2013). Data gaps and the absence of reliable information flow are major challenges in estimating the economic contributions of forests beyond what is available in official reports (Agrawal *et al.,* 2013; Maua *et al.,* 2019). Country- and region-specific efforts indicate that where such data are reliably available, the non-cash economic contributions of forests to household and national economies range between 3 and 5 times the formally recognized, cash contributions (Agrawal *et al.,* 2013). It is difficult for many countries to quantify and include data on forestry activities from both the informal and other non-monetary sectors due to missing information. If these were to be included, the share of forestry to GDP would be significantly higher (FAO, 2008).

Challenges in forest quantification arises mainly due to: 1) data gaps and absence of reliable information in estimating the economic contributions of forests beyond what is available in official reports and 2) the absence of aggregated data on the economic contributions related to non-timber forest products (NTFPs) and their value, and 3) the lack of information systems that can incorporate such data systematically. These are some of the major bottlenecks in better understanding of the forest sector contribution to GDP**.**

2.3.3 NTFPs and Gender

In this study, gender is defined as “the socially constructed characteristics of women and men, such as norms, roles, and relationships of and between groups of women and men. It varies from society to society and can be changed (WHO, 2020). Several studies have confirmed that both men and women play different roles and their interests in NTFPs are different as women play greater roles as primary harvesters, processors and marketers of NTFPs (Terry and Cunningham 1993) than men. An examination of gender roles in NTFPs extraction and utilization is critical in understanding the impacts of NTFP commercialization on society's social justice, equity and welfare. This is because studies have shown that the existence of gender division of labour and income control can vary spatially, by species, by level of technology, and by the type of task in the chain of activities from harvesting to marketing (Neumann and Hirsch, 2000). Similarly, studies have confirmed that women's social, political and economic status can be helped or harmed through NTFP commercialization efforts (Neumann and Hirsch, 2000; Marshall *et al*. 2006). The most negative impacts occur under two conditions; "when men have control over the income derived from NTFP collection and sale and women are not likely to directly benefit from commercialization. Secondly, when mechanization and centralization of processing is part of the commercialization process that end in displacing women processors from the market value chain". The most positive situations for women are those that include an institutional or organizational component specifically designed to increase women's power that enable them to defend their economic interests in NTFPs. In the absence of specific mechanisms to redress existing gender inequities, NTFP commercialization efforts can and do result in negative economic and social consequences for roles of women (Neumann and Hirsch, 2000). Thus, there are important issues and concerns relating to gender that need to be addressed whenever planning and implementing projects that promote commercialization of NTFPs (Neumann and Hirsch, 2000). Some of the concerns that need consideration include the following: "when women are main primary harvesters, processors and marketers of NTFPs; the labour for various activities involved in getting NTFPs from the forest to the market is commonly divided between gender, though not in an easily generalizable pattern; when women are actively involved in harvesting and use but don't have direct control of the income derived from commercialization of NTFPs". There is a general pattern of women being displaced by men when new labour-saving technologies for NTFP processing are introduced. NTFP commercialization projects that explicitly empower women to participate can have the effect of increasing women's political and economic power vis-à-vis men.

In Kenya, currently information on NTFP exploitation in relation to gender role is scanty. However, legally, the forest adjacent communities are allowed to exploit NTFPs through the CFAs which also participate in forest protection and conservation (GoK, 2016). Secondly, NTFPs extraction contributes significantly to poverty reduction by providing safety nets which reduce the vulnerability of economically disadvantaged households living adjacent to forests when crops fail. Some of the challenges highlighted in a study on NTFP harvesting and forest degradation at Kabaru (Maina, 2016) are that " 1) women lack appropriate tools to use while harvesting of NTFPs, 2) there is need to improve the women's capacity to engage in value addition as this will improve the economic benefits from the NTFPs, 3) the forest adjacent communities need to be trained to improve their harvesting, post-harvesting techniques of NTFPs because this adds value to products hence economic benefits, 4) there is need to strengthen policy to deter illegal exploitation of NTFPs and that such a policy should ensure NTFP users are registered and operate under the umbrella CFA; and 5) improving forest laws might empower women to harvest

NTFPs in ways that do not pose a threat to forest sustainability.” The situation in Kabaru is replicated in other forests including South Nandi forest.

2.3.4 Forest product certification

Forest product certification seeks to link trade in forest products to the sustainable management of forest resources, and is therefore an important marketing tool for management to consider. Certified products enter different markets with other opportunities compared to the traditional, non-certified, trade markets. There are three main certification schemes, Forest Stewardship Council (FSC, Sustainable Forest Management), International Federation of Organic Agricultural Movements (IFOAM, biological control) and Fairtrade Labeling Organization (FLO, Fair Trade). Some products, like shade coffee and chicle in Mexico and palm heart in Brazil, have already been certified by different certification schemes (Yadav and Dugaya, 2013). In Kenya, the Forest Conservation and Management Act 2016 (Section 59) supports grading and valuation of timber and other forest products including appointment of a professional grader. This gives the traders in NTFPs and KFS an avenue to explore use of high quality products, value addition in NTFPs and sustainable NTFP production.

Impediments to NTFP certification are numerous and these include “lack of knowledge about Species biology, ecology and management, complex trade chains, unorganized and powerless producers, poor working conditions, illegal or quasi-legal harvest and an inability to pay for certification. Certification systems are still evolving and have yet to address the topic in a flexible , practical manner. They also require political support, social stability and existence of strong local institutions to flourish. Research to date suggests that species with large, established markets will be the best candidates for NTFP certification and that further education efforts are sorely needed (Pierce *et al.*, 2003)".

2.3.5 Sustainable management of forests and NTFPs

Sustainable forest management is "the process of managing permanent forest land to achieve one or more clearly specified objectives of management with regards to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment (ITTO definition in Lammerts van Bueren and Blom, 1997)". In order to develop sustainable harvesting methods of NTFPs a number of key-ecological questions need to be answered (e.g. phenology, ecology, reproduction biology) in order to determine best harvesting practices, species and suitable areas. The determination of a sustainable harvesting level depends on information on volume and reproduction. There are many challenges towards NTFPs management that include inadequate information on the ecological productivity, growth forms, life history and conservation of the various species involved which complicate management scenarios (Zuidema, 2000). This presents a danger of excessive extraction of forest products which is likely to impact negatively on the population dynamics of the plants being exploited and may lead to changes in community structure and organization (Moegenburg and Levey, 2002). Furthermore, dealing with NTFPs in general is not easy as different parts of plants are harvested. However, their harvests may produce impacts that can be either beneficial or detrimental to the species. Actual impact of harvesting depends on the specific growth form, part that is harvested (e.g. fruit, bark, stem, foliage) or type of resource that is removed. Additionally, the time or season of harvesting e.g. harvesting plant parts during the dry or wet season may have more detrimental effects on the plant especially if roots or stem parts are harvested. This is because this may exercabate drought effects on the plant. Intensive and uncontrolled harvesting affects the abundance of especially solitary plants.

Seventy studies on the ecological impacts of harvesting NTFP from plant species were reviewed by Ticktin (2004) that generally focused on single NTFP populations and human communities. The study emphasized the need to direct more efforts towards assessing the effects of harvest on community and ecosystem-level processes and effects of harvests concurrently on different ecological levels (Ticktin, 2004). It was noted that other factors which affect local harvesting strategies are socio-economic, political and ecological in nature. Thus, for the NTFP species that are harvested in wide and diverse areas, larger-scale, comparative approaches are needed that consider variation in both social and ecological factors. This will be necessary for assessing sustainability and other factors that may influence it.

Some of the studies that have documented population structure and regeneration in Western Kenya forests, which are close to the study area include Tsingalia, (1988) in Kakamega forest; Kiama and Kiyiapi, (2001) in Kakamega forest; Hitimana *et al.,* (2004) in Mt Elgon forest; Fashing *et al.,* (2004) in Kakamega forest; Girma, (2011) in North and South Nandi forest; Njunge and Mugo, (2011) in South Nandi Forest; Otuoma *et al.,* (2016) in Kakamega forest; Wanjohi *et al.,* (2017) in Nabkoi forest; Onyango *et al.,* (2018) in South Nandi forest. However, information on the forest structure due to changes in human activities is scanty. These studies contribute knowledge which is useful to understanding population dynamics and regeneration status which in turn help in developing strategies to sustainably manage and conserve the forests. For example, it was noted that the high human population density around Kakamega forest has led to considerable long-term human influence on the forest due to use as source of charcoal, fuelwood, gold, honey, medicinal plants, and construction materials (Tsingalia 1988; Wass 1995). Information on population structure indicates the history of past disturbances to species and the environment and thus used to forecast the future trend of the population of that particular species (Peters, 1994). Further, the overall pattern of population dynamics of seedlings, saplings and matureplants of a species can exhibit the regeneration profile, which is used to determine their regeneration status (Malik and Bhatt, 2016). Therefore, better ecological information on floristic composition, population structure, and regeneration status of a given forest patch are required to determine the status of the forest in order to manage it in a sustainable manner.

2.4 Economic Valuation of NTFPs

FAO (1997) cited at least 150 documented NTFPs as important in international trade. Harvesting and consumption of plant products from natural forests accounts for a large proportion of the livelihood of people living close to such habitats (Padoch, 1992). In the same study, FAO estimated that the total value of internationally traded NTFPs is about USD 1.1 billion annually. There is, however, inadequate information on NTFP management specifically on sustainable NTFP management. Most studies on NTFP valuation have been biased towards a few species, using direct observation methods and quantification and investigation of market, shadow or barter prices (Svarrer and Olsen, 2005).

2.4.1 Choice of economic valuation method

The type of forest product being estimated determines the method to be adopted for approximation (Adepoju and Salau, 2007). Estimation of direct use values normally adopt market analysis-based approaches (Emerton, 1996). Three main methods have been commonly applied by many scholars in the estimation of NTFP values. These methods "utilize market prices and include: i) Direct pricing method (DPM) for commercially traded NTFPs (Peters *et al.,* 1989), ii) Cost of collection method (CoC) that estimates the value of time expended in gathering NTFPs (Delang, 2006), and iii) Direct Substitutes method (DSM), which infers value based on close direct substitutes that have market prices (Delang, 2006)".

Estimation of the gross annual direct use value involves measurement of quantities of NTFPs consumed and converting these (local units) to kilogrammes. The time a unit of NTFPs consumed last in each household when used continuously can be determined. Frequency of particular NTFP consumption in the previous 12 months is recorded and annual gross direct-use value of an NTFP calculated (Peters *et al.* 1989).

Cost of Collection method involves establishment of time spent gathering NTFPs from the forest. It is the "average time starting from the moment one leaves for the forest to collect the NTFPs until the time they get back home is measured (Kiplagat *et al.,* 2008). This method considers the value of household's heads labor time and their occupation including the average net earnings per working day (Delang, 2006; Kiplagat *et al.,* 2008). The main advantage of using the wage equivalent method is that the resultant value per hour reflects the opportunity cost of labour of households entering the forest to harvest NTFPs (Kiplagat *et al.,* 2008). This is thought to be better since use of wage rate could have concealed the variation of income earnings within the sampled households (Delang, 2006). Cost of Collection method has nevertheless been a subject of criticism; “it has been observed that the exact time spent gathering particular NTFPs cannot be exactly determined since there is a possibility of collectors carrying out more than one activity in the forest”.

The total economic value (TEV) of forests is derived as the sum of “direct use values (DUV), indirect use values (IUV) and option values (OV)”. Direct use value is the value derived as a result of direct consumptive or non-consumptive utilization of the forest (Pearce and Warford, 1992; Kiplagat *et al.,* 2008). These values include “timber, NTFPs and recreation amongst others. IUVs denote to those that are attained through the influence of forest existence and include most ecological functions such as modification of local climate or control of soil degradation. On the other hand, option values refer to value derived by holding a premium of the forest for future unknown uses. Bequest values (BV) and existence values (EV) are also a part of TEV (Kiplagat *et al.,* 2008; Rizal *et al.*, 2018).

2.4.2 Experiences in NTFP valuation

There are a number of approaches which have been used to value NTFP. For example, Svarrer and Olsen (2005) used a different methodological approach by investigating the labour input in NTFP extraction activities and calculating the opportunity cost, which is then treated as an approximation of the economic value of all NTFPs extracted. This approach has mainly been used in studies estimating values of time spent collecting water in dry areas (Whittington *et al.*, 1990) and investigating gender issues in household surveys (Svarrer and Olsen, 2005).

Knowledge of the value of non-timber forest products (NTFPs) and their use patterns may provide input to the management of tropical forests to the benefit of local people (Svarrer and Olsen, 2005). The direct use value of NTFPs has only been included in forest evaluation studies since the late 1980s (Kant, 1997). The direct use value of NTFPs has only been included in forest evaluation studies since the late 1980s (Kant, 1997). Many studies (De Beer and McDermott, 1996; Kant, 1997; Peters *et al.,* 1989) focus on limited traded species and attempt to estimate traditional capital values, typically value of products per hectare, rather than estimate the value of extraction to rural households (Svarrer and Olsen, 2005).

Due to differences in methods, "comparison of findings should be done with caution. Studies may be distinguished by their focus on (i) stock values or flow values, (ii) gross values or net values, and (iii) choice of discount rate. Furthermore, results may differ, even if applied methods are similar, due to the biological and economic diversity of the different study sites and the different products studied (Godoy and Lubowski, 1992; Svarrer and Olsen, 2005)".

2.4.3 Socio-economic factors that influence dependence on NTFPs

Mcelwee (2008) reported that better understanding of why some households harvest forest goods while others do not help explain some of the problems encountered in NTFP promotion. It is important to know the socio-economic characteristics of forest-dependent households which play roles in explaining forest use. She highlighted key socio-economic characteristics reported in several studies as summarized: For instance, in Philippines - it was the elderly people who were more likely to collect NTFPs because of their extensive knowledge of forest plants and wildlife (Lacuna-Richman, 2002). However, elsewhere, the younger households were reported to be more dependent on wild collected products as they set out to start families and have lower agricultural assets than older better-established households (McSweeney, 2004). Other studies showed that age, household size and wealth status, education level and gender was found to influence household's decision to participate in NTFPs sale or not (Tassou, 2017). Meanwhile, Amusa *et al.*, (2017) noted that in addition to the above mentioned factors, ethnicity, distance to market and access to roads significantly influenced market knowledge and information among households involved in the trade of NTFPs.

Relationship between income and forest use is another factor; it was found that households with the lowest level of rice self-sufficiency relied mostly on rattan harvesting. In the Philippines (Siebert and Belsky, 1985) and in Sri Lanka, contributions of NTFPs to incomes declined as income rose (Gunatilake *et al.*, 1993). Other studies which found similar results include Cavendish (2000) and Mahapatra and Tewari (2005). The poor mostly rely on forest income as a safety net in times of particular need such as an agricultural shortfall or another kind of emergency (Paumgarten, 2005). Other studies reveal that medium-income or richer households are, in some situations, more likely to get more forest income than the poor, owing to high labour requirements or elite capture of valuable resources (Wickramasinghe *et al.*, 1996).

Land tenure is another important variable; the landless and land-poor are often more dependent on forest products collection than the land-rich (Lacuna-Richman, 2002; Robinson et al., 2013). For those with no access to land for agriculture, NTFPs can provide much-needed source of support, especially when NTFPs are collected from common or open-lands (McElwee, 2008). In Orissa (India), Fernandes and Menon

(1987) reported that dependence on forests was strongly correlated with the size of landholdings with the landless being particularly being the most dependent. Robinson *et al*. (2013) emphasized that land tenure is inextricably linked to many socio-economic and governance factors, thus it is difficult to separate tenure from other direct and indirect drivers of deforestation.

Other social variables that may also influence forest use include household debt, labour availability, gender, distance to the forest, involvement in non-agricultural activities and incorporation into market (Gunatilake, 1998). At the household level socio-economic variables that influence income of the households are education level, marital status of household head and whether the household head was born in the village or not (Hassan *et al.,* 2002; Kar, 2010). These variables may give different results from one location to another; therefore, generalizing results has to be done with caution i.e. where other characteristics are also similar. Socio-economic characteristics such as age, education, place of current residence, occupation, marital status, income and number of family members, etc., are known to have impact and influence on the way of thinking, attitudes and perceptions and behavior of the people towards the adoption of innovations (Hassan *et al.,* 2002).

There are several village- or community-level factors, such as difference in villages, road access to the village, transport types used to carry NTFPs and main forest-tenure types which influence NTFP household incomes. A study done in Bangladesh's Chittagong Hill Tracts revealed that the NTFP income of the households differed significantly between 14 study villages due to heterogeneity in the villages (Kar, 2010).

Factors such as the size and labour capacity of households (Mamo *et al.*, 2007), migration status (Lacuna-Richman, 2006), opportunity costs of collection and the substitutions of forest products by market purchased goods, and the strength of markets for forest produce may also be important. Previous studies have mentioned heterogeneity even within smaller forest-extracting communities (Al-Subaiee, 2016), thus more studies are required to carefully account for use of forest products across a range of ecological locations and social situations.

2.5 Research Needs

Sustainable forest management should be guided by sound scientific foundation. Ros-Tonen (1999) divides "NTFP research into two categories based on the primary objective namely forest oriented and people-oriented research. The forest oriented approach focuses on the development of an ecologically sustainable extraction system and the people oriented approach focuses both on the recovery of local knowledge, its application in participatory management, and to improvement of people's livelihood (Table 1)".

This schedule of research needs makes it clear that there is a challenge ahead for continued collaborative NTFP research for the benefit of forest conservation and the people who depend on NTFP for their livelihood. It is difficult to make any kind of prioritization as all aspects are important to a NTFP production harvesting system contributing to the conservation of forest and the quality of local livelihood.

Table 1: Categories of NTFP research needs derived from the management options

Forest-oriented approach	People oriented approach	
Forest conservation	*Participatory management*	*Improved livelihoods*
"Supply scientific basis, with scientific data on key ecological functions like phenology and reproductive biology, to develop sustainable harvesting methods and levels;	Develop participatory management models taking into account traditional/local knowledge and ensuring a broad support for management;	Develop market viability studies and closely related market monitoring tools for specific NTFP products to be applied by local management;
Develop tools to monitor the sustainability of the extraction at species and ecosystem level.	Hence, science should take into account that all management tools are to be applied and understood by local management.	Assess the role of NTFP certification as a marketing tool in (international) trade and provide scientific support for certification like objective indicators ;
Point out the role of NTFP extraction as a suitable and compatible land use option in land use planning and forest management plans.		Study the potential of domestication of commercial attractive forest products and their integration into silvo-/agro-forestry systems;
		Develop yield raising methods and techniques;
		Provide insight into land tenure and property and access rights;
		Provide insight into the socio-economic dynamics of NTFP extraction both for subsistence and commercial extraction".

(Adapted from Ros-Tonen, 1999)

2.6 Legislative Framework

The first formal forest policy in Kenya was developed in1957, and revised in 1968 as Sessional paper No 1 of 1968. This policy document focused on management and conservation of forests on public land, but did not provide for the participation of stakeholders in forest management. Implementation of the policy was supported by the Forest Act Cap 385 of 1964. Due to emergent challenges facing the sector, a revised legislation; the Forests Act No 7 of 2005 was enacted. The Forests Act (2005) provided for management of forests outside public land and introduced participatory forest management, by engaging local communities through community forest associations and the promotion of the private sector investment in gazetted forest reserves, accompanied by concomitant institutional and organization change, notably the establishment of the Kenya Forest Service (KFS), and the formation of Community Forest Associations. The reforms in the forestry sector in Kenya culminated in the repeal of the Forest Act, 2005 and the enactment of the Forest Conservation and Management Act, 2016 (GoK, 2016).

The forest adjacent communities through the Community Forest Associations benefit from use of NTFPs and joint management of the forest with the backing of the Forest Conservation and Management Act, 2016 (FCMA 2016). The type of NTFPs that the CFAs are allowed to extract is specified in section 49(2). These include medicinal herbs, harvesting of honey, fuel-wood, grass harvesting and grazing, collection of forest produce for community based industries among others. The FCMA 2016 gives incentives for increasing forest and tree cover as well as benefit sharing (section 53). The FCMA also has a section which opens ways for licensing and trade in forest products. This supports promotion of use of NTFPs by forest adjacent communities through CFAs.

The other supportive legal documents that are related to NTFP extraction include the Constitution of Kenya, 2010; Agriculture (Farm Forestry) Rules, 2009; Draft Forestry Policy, 2015; Charcoal Rules, 2009. In view of the support, the CFAs and KFS should develop Participatory Forest Management plans which promote utilization of NTFPs inside and outside the forests.

2.7 Theoretical /Conceptual Framework

It is expected that with the understanding of the socio-economic factors that influence households to collect NTFPs from the forest; in addition to knowing the types and quantities of NTFPs extracted from the forest; doing their valuation using the right methods; all these together with understanding the regenerative capacity of NTFPs will result in sustainable utilization of NTFPs, which is core to the efficient management of natural resources. The other areas are having political goodwill, and regular update of legislation to incorporate advancement of NTFPs harvesting and handling recommendations (Figure 1)

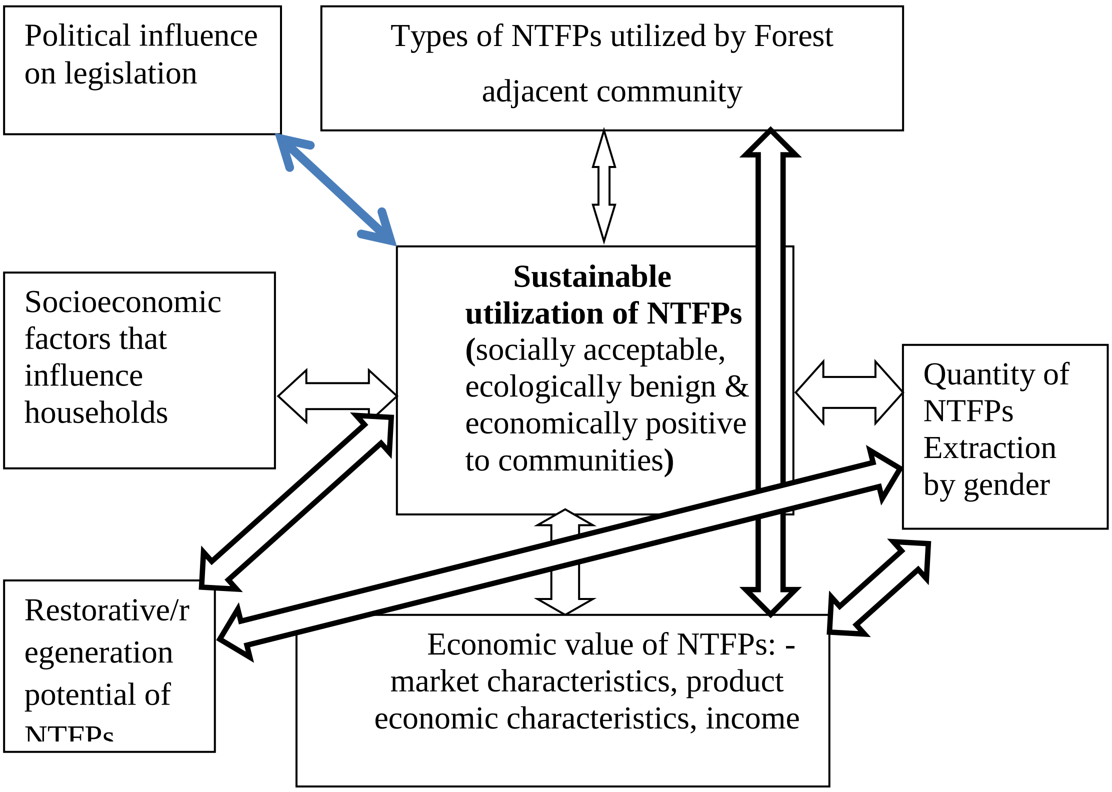


Figure 1: Conceptual framework for sustainable utilization of NTFPs *(Adapted from Dlamini and Geldenhuys, 2011).*

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Site Description

The South Nandi forest (Figure 2) is the eastern-most remnant of the Guineo–Congolian rainforest, which in the past millennium stretched across the entire expanse of West and Central Africa to the East African highlands (Young, 1984; Maua *et al.,* 2019). It is one of the last remnants of pristine sub-humid tropical rainforests that is located in a densely populated and intensely cultivated region (Maua *et al.,* 2019). South Nandi Forest is situated in Nandi County. Five Counties borders SNF: Kakamega to the West, Kisumu to the South, Kericho to the South East, Vihiga to the South West, and Uasin Gishu to the North East. Geographically, the unique jug-shaped structure of Nandi County is bound by the Equator to the south and extends northwards to latitude $0^0$34'N. The Western boundary extends to Longitude $34^0$45'E, while the Eastern boundary reaches Longitude $35^0$25'E (ICTA, 2015).

Conservation of South Nandi Forest started in 1936 when it was declared a Trust Land under colonial rule vide Legal Notice No. 76, covering an area of about 26,903.1 Ha and in 1964, its status changed to a forest reserve (KFS, 2015). The forest is managed by Kenya Forest Service as a forest reserve and currently consists of 13,000 ha of closed-canopy forest, 1,400 ha of exotic trees plantations, 340 ha planted with tea and 3,260 ha of scrub, grassland or under some form of cultivation (Birdlife 2007; KFS, 2015). Deforestation resulted in separation of South Nandi Forest reserve from Kakamega forest which used to be one continuous forest (Birdlife 2007). The forest altitude ranges from 1700 to 2000m above sea level. The mean annual rainfall in the area is between 1600 and 1900 mm, which makes it classified as a ‘moist forest’ under the Forest and Agricultural Organization of the United Nations (FAO) guidelines (Brown 1997; KFS, 2015). Presently, it is classified as a transitional forest between the lowland forests of West and Central Africa and the montane forests of Rift Valley and Central Kenya (KIFCON, 1994; KFS, 2015). The soils in the southern Nandi forest are composed of well drained, extremely deep dark to reddish brown with friable clay and thick humic top layer principally developed on biotite-gneisses parent material and is heavily leached with pH < 5.5. (Kagezi *et al.,* 2011; Maua *et al.*, 2020).

Two rivers (Kimondi and Sirwa) merge within the forest to form the Yala River flow through the South Nandi forest that subsequently passes through Kakamega forest and then drains into Lake Victoria. Other rivers which also flow through the forest include Mokong, Orobo and Kundos. These rivers are perennial and provide water for domestic and industrial use and have waterfalls which can be harnessed for hydroelectric power and ecotourism (GoK, 2008).

The main economic activities in the region are growing of tea, maize, sugarcane and horticulture mostly as cash crops. South Nandi Forest Reserve is jointly managed by the Kenya Forest Service (KFS) and the forest adjacent communities through the Community Forest Association. The forest adjacent community uses the forest for their livelihoods by obtaining wood, non-wood forest products and environmental services such as carbon sequestration, water and air purification (Muchiri and Mbuvi, 2010; Maua *et al.*, 2020). The South Nandi forest reserve like many other indigenous forests in the country is threatened by environmental degradation due to pressure from surrounding population such as charcoal burning and illegal logging. Sustainable management of South Nandi Forest Reserve is important considering that South Nandi Sub-County where the forest is surrounded with locations with high population densities such as Kobujoi and Kaptumo. The population of Nandi south for the year 2019 was 172,750 with male (85,718) and female (87,029) and an average household size of 4.7 (KNBS, 2019).

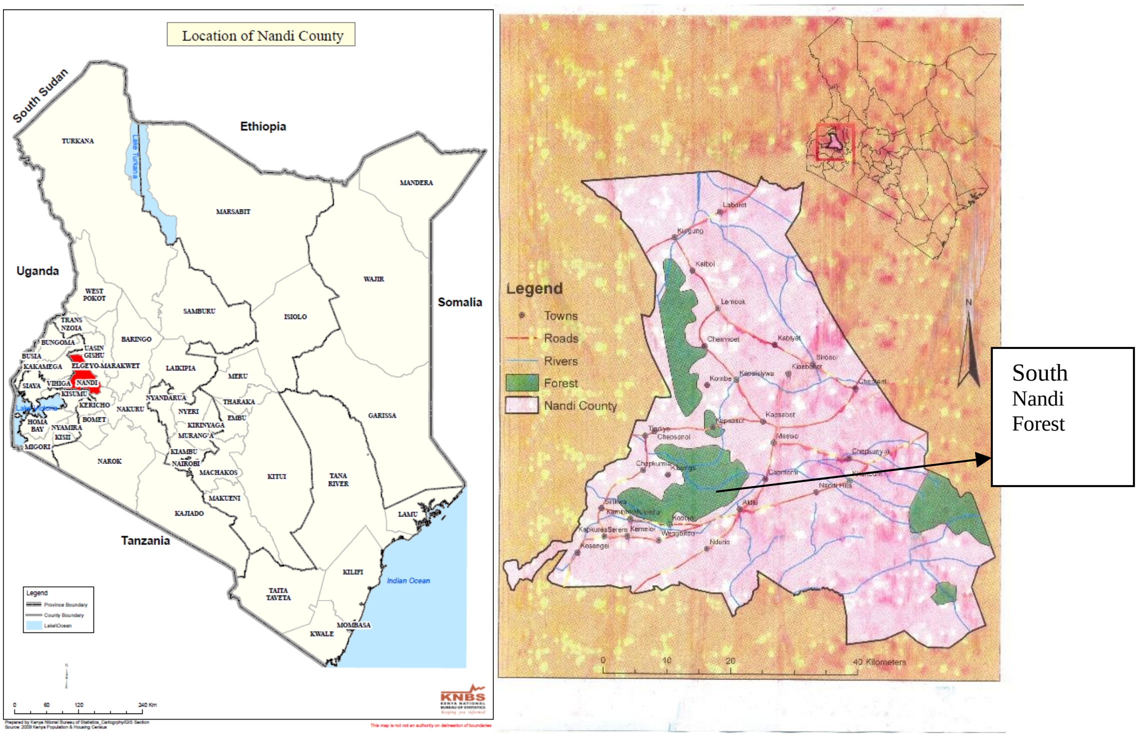


Figure 2: Location of the study area in Nandi County, Kenya.
(Source: Kenya National Bureau of Statistics, 2013).

3.2 Data Collection

3.2.1 Secondary data

The study involved collection of secondary data from literature review on social and historical conditions in the area; government reports provided information on social, economic, environmental, and developmental features. The local Kenya Forest

Service (KFS) office provided various documents such as large-scale maps and records of extraction of various NTFPs from within the study area.

3.2.2 Data sampling techniques

The overall approach used in South Nandi Forest Reserve was a combination of use of semi-structured household questionnaires based interviews; transect walks, focused group discussions with forest adjacent communities and key informant interviews with resource users. Villages were adapted as sampling units for NTFPs if they were within a distance of 5 km from the forest edge and that the forest was accessible to the communities for utilization of various products (Wass, 1995). South Nandi Forest was surrounded by at least 16 villages adjacent to it, out of these, 7 villages were randomly selected for the household survey. The forest sections adjacent to these 7 villages were also selected for vegetation sampling. There were two villages which were farther than 5 km, (Kimeloi and Ndurio), which were purposively selected as controls to check influence of distance on NTFP utilization (Table 2).

The number of households for sampling is given as shown in Table 2 (Israel, 1992). The determination of the sample size was based on the formula by Yamane (1967):

$$n = \frac{N}{[1 + \mathrm{N}\,(e)\,2]} \quad \text{(Equation 1)}$$

Where *n* is the sample size, N is the population size, and *e* is the level of precision.

Table 2: Location, Sub-location and Villages adjacent to South Nandi Forest and the population by sex and number of households used in household survey

Location	Sub-location	Village	Male	Female	Total	No. of house-holds	No. of house-holds sampled
Kamobo	Kamobo	Kamobo**	3,605	3,604	7,209	1414	61
Chepkumia	Chepkumia	Kipteden**	5,525	5,246	10,771	2112	92
Chepkumia	Cheboite	Burende**	4,300	4,586	8,886	1742	76
Kaptumo	Chepkongony	Koimwe**	1,790	1,794	3,584	703	31
Kaptumo	Ibanja	Ibanja	1,700	1,938	3,638	713	
Kaboi	Kamarich	Kamarich	1,069	1,079	2,148	421	
Kaboi	Kamarich	Kipsiorori	1,144	1,233	2,377	466	
Mugen	Kamemei	Kimeloi*	2,810	3,022	5,832	1144	50
Mugen	Mugen	Kipchuteywo	2,530	2,911	5,441	1067	
Bonjoge	Kapkeben	Sebetetwo**	27	31	1,558	305	13
Bonjoge	Kereri	Chemagal	73	12	785	154	
Bonjoge	Bonjoge	Chepkuny	71	59	730	143	
Bonjoge	Bonjoge	Kenyor	31	35	1,466	287	
Chebilat	Chebilat	Chebision	1,242	1,361	2,603	510	
Chebilat	Kapsagawat	Chemamul**	812	934	1,746	342	15
Chebilat	Chepketemon	Kaptebengwo**	1,449	1,739	3,188	625	27
Chebilat	Kiptaruswo	Tamboiywa	1,238	1,356	2,594	509	
Ndurio	Ndurio	Ndurio*	1,937	1,862	3,799	745	32
Total			**33,353**	**35,002**	**68,355**	**13,402**	**397**

NB.

* » Village purposively selected as control because it was more than 5 km from the forest

**» Villages which were randomly selected for household survey/forest adjacent to them were vegetation sampling was done

Source: Based on Kenya National Bureau of Statistics, Kapsabet office/Own survey

A village list of households was updated from the study by Mbuvi *et al*. (2010) who had worked in villages adjacent to South Nandi Forest. A total of 431 households were included in this study. A household was defined as a group of people who eat from a common pot, sharing the same dwelling and may cultivate the same land (Katani, 1999; Maua *et al.*, 2019). The key respondent during the household survey was the household head as they are the main decision makers for the households (Kajembe, 1994). However, in his/her absence; a responsible person over 18 years familiar with the household setting was interviewed. If there was none, the next household in the list was chosen.

3.2.3 Household survey

Participatory Rural Appraisal (PRA) method was used to identify and document the availability and use of local NTFPs, with interviews conducted in local community households following methodology of Chambers (1994). A total of thirty (30) questionnaires were pretested in three villages around North Nandi forest to ascertain instrument effectiveness and where ambiguities were noted necessary adjustments were done (Reynolds *et al.*, 1993). The semi-structured questionnaires had both closed and open-ended questions. The questionnaire captured data including household characteristics of the forest adjacent communities, NTFP status and use; NTFP incomes; and environment and forest conservation aspects of NTFP business (Appendix 1). According to some studies, thirty units is the recommended minimum number for a statistical data analyses to be done irrespective of the population size (Bailey, 1994).

3.2.4 Focused Group Discussions

Focus groups discussions (FGD) are defined as "carefully planned series of discussions designed to obtain perceptions on a defined area of interest in a permissive, nonthreatening environment (Krueger and Casey, 2009)". The FGD sought to encourage collective response at village level on the link between NTFP collected, livelihoods and forest conservation. A checklist on plants documented in South Nandi Forest (KFS, 2015) was used during FGD to determine the use of various plants found in this forest as NTFPs. Three FGDs were done consisting of 6-9 persons who were conversant with NTFPs extracted from SNF to generate information on uses of plants and to enrich the list of plants found in South Nandi Forest. The selection of people to participate in the focused group discussion was based on: 1) knowledge of forest plants in the local language (Nandi) and well versed with their uses and 2) be living adjacent to the South Nandi Forest. They were purposively selected per site (Koimwe, Kaptebengwo and Kabungu) after consultation with KFS, the local community leaders and field assistants on people meeting the above criteria. For each plant species, all its known uses were mentioned and consensus reached among members of the group before recording them (Maua *et al.,* 2019). Additional species mentioned but not in the KFS management plan checklist were also recorded. Focused group discussions per forest site were done separately in different locations in September 2016 (Maua *et al*., 2019)

Other aspects addressed during FGDs at village level were demographics, infrastructure, and markets for NTFPs, wages and prices and forest resource base. The economic benefits of NTFPs, rules governing access to forests, changes in product availability over time as well as reasons for change were also discussed. Focused group discussion was used to triangulate the information collected through semi-structured questionnaires. In addition to the FGDs, 6 formal and 8 informal discussions were done with the forestry staff, community leaders and traders in NTFPs to understand the various aspects on dependence of the households on South Nandi Forest.

3.2.5 Transect walk

A transect walk is “a tool for describing and showing the location and distribution of resources, features, landscape, main land uses along a given transect” (Van Staden *et al.,* 2006).

An earlier assessment of the forest before the transect walk was done to determine the number of sample plots (30m X 20m) required to adequately sample respresentative species. "A species–area curve which describes the relationship between the area of a habitat, or of part of a habitat, and the number of species found within that area" (Downer, 2012) was used. Five sample plots (30m X 20m) were found to be representative of the forest per transect. One (1)-km transect walks were done from the forest edge of each adjacent village where household surveys was done. Five sample plots (30m X 20m) along each transect at intervals of 200m were established to facilitate forest species counts to enable generation of information on species representation in the specific forest areas (Maua *et al.,* 2020). For the whole forest, seven 1-km transects (N1, N5, N7, N11, N13, N21, and N24) were used equivalent to 35 sample plots for assessment of trees and shrubs, 70 subplots each for assessment of saplings and seedlings respectively. All the sample plots were geo-referenced as shown in Figure 3. These plots were used to assess plant diversity in terms of species richness and evenness. Other parameters assessed were density, abundance, dominance, population structure, regeneration status and important value indices of the woody plants using a nested plot technique of vegetation sampling (Figure 4). In this technique, there was a main plot (30m X20m), where all trees with over 10cm dbh were measured using a diameter tape; two Sub-plots of B (10m X 5m) – where all tree saplings, lianas and shrubs, diameter at breast height (DBH) = 2 cm - 9.99 cm, at least 1.5 m height were assessed and two Sub-plots of C (1m X 2m) - seedlings, herbs (erectile and creeping) and grass counted as per details in the data sheet (Appendix 2). It is difficult to sample plants of different life forms (i.e. shrubs and grasses) within the same plot frame, thus the use of the nested plot (Bonham, 2013).

The first main plot of 30m X 20m was established 50m west of the first reference point, the next 50m east of the reference point, and thereafter subsequent plots followed the alternating sequence until the fifth plot was done. Rectangular quadrats were used because they incorporate a greater biodiversity when the long axis of the quadrat is oriented parallel to environmental gradient (Littler and Littler, 1985; Maua *et al*., 2020).

The identification of plants was done by at least two local scouts with wide knowledge of NTFPs in vernacular names and by referring to the flora books of Kenya (Dale and Greenway, 1961; Beentje, 1994; KFS, 2015). Types of data collected are shown in the data sheet (Appendix 2).

Figure 3: Villages in the study area where household survey/transect walk was done in 2016

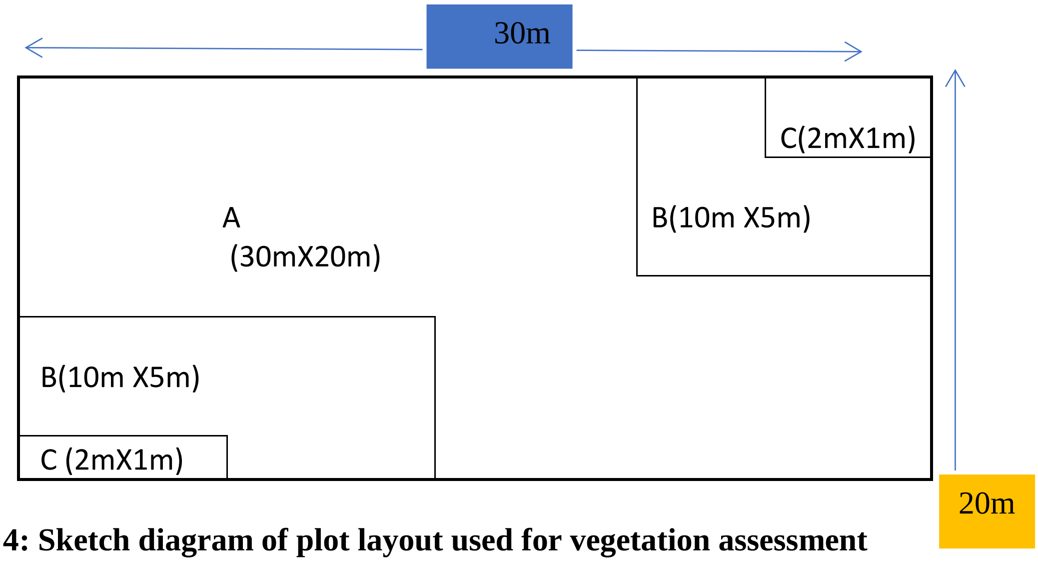


Figure 4: Sketch diagram of plot layout used for vegetation assessment

3.2.6 Data Analysis of the forest plots (forest site status)

Structural data analysis

The forest plot data was summarized according to standard protocols; the stems for seedlings, saplings, and trees were expressed as the number of stems per hectare (density). Basal area (BA), which is equivalent to the cross-sectional area of the tree, was calculated as follows:

$BA = 0.000078539816d^2$ ($BA= m^2$, d=cm) …………… (equation 2)

Where d is the diameter of the stem at breast height (1.3m) of the stem in cm

The other parameters used for the description of the forest structure were: relative density, relative frequency, relative dominance, abundance, species richness, diversity, diameter class distribution, height class distribution, frequency, Importance Value Index, and dominance of trees, shrubs and herbs species (Curtis and McIntosh, 1950; Mueller-Dombois and Ellenberg, 1974, Kent and Coker, 1992). Quantitative analysis was done at the seven sites; this involved determining the density, height, frequency, Importance Value Index, relative density, relative frequency, relative dominance, abundance, species richness, diversity and dominance of trees, shrubs and herb species (Curtis and McIntosh, 1950; Mueller-Dombois and Ellenberg, 1974, Kent and Coker, 1992). The vertical structure of South Nandi Forest was analysed using IUFRO classification scheme (Lamprecht, 1989). The scheme categorizes the forest into upper storey where the tree height is greater than 2/3 of the top height; middle storey where the height is between 1/3 and 2/3 of the top height and lower storey where the height is less than 1/3 of the top height (Maua *et al.*, 2020)

'The following equations describe the parameters above:

1) RDe $= \frac{(number\ of\ individuals\ of\ a\ species)}{Total\ number\ of\ individualsH} X\ 100; \ldots \ldots \ldots \ldots \ldots \ldots \ldots .$ (equation 3)

Where RDe is Relative density

2) Species richness which is a measure of alpha (α) diversity was expressed as:
$Species\ Richness\ (S) = \frac{Number\ of\ species}{\text{Quadrat}},$ .... (equation 4)

3) Simpson (1949) index of Dominance (D) = Σ (pi)^2……………..…(equation 5)
where, D = Simpson index of dominance; where pi = the proportion of important
value of the ith species ($pi = \frac{\text{ni}}{N}$) , ni is the important value index of *ith* species and N is the important value index of all the species). As D increases, diversity
decrease

4) Simpson's index was therefore expressed as:
1 – D or *1/ D* ………………………………………………..….. (equation 6)

5) Simpson's evenness $(E) = \frac{1/D}{S}$………………………………...……(equation 7)
S where S is species richness (Morris et al., 2014)

6) Frequency was:

$$Frequency\ (\%) = \frac{Number\ of\ quadrats\ in\ which\ a\ species\ ocurred}{\text{oTtal number of quadrats studied}} \quad \ldots\ldots\ldots\ldots \text{(equation 8)}$$

7) Relative Frequency:

$$Relative\ Frequency\ (\%) = \frac{(Frequency\ of\ a\ species) X\ 100}{\text{Sum of all frequencies}} \quad \ldots\ldots\ldots \text{(equation 9)}$$

8) Abundance:

$$Abundance = \frac{Total\ number\ of\ individuals\ of\ a\ species\ in\ all\ quadrats}{\text{Total number of quadrats in which a species occurred}} \ldots \text{(equation 10)}$$

9) Relative dominance:

$$Relative\ dominance\ (\boldsymbol{RDo}) = \frac{(Total\ basal\ area\ for\ a\ species)\ X\ 100}{\text{Total basal area of all species}} .. \text{(equation 11)}$$

10) Importance Value index(*IVI*):

$IVI = RDo + RDe + RF$……………………………………………………….…(equation 12)

11) Shannon-Wiener's index of diversity ($\boldsymbol{H}$):

$\boldsymbol{H} = -\Sigma pi \ln pi$ ……………………………………………………..(equation 13)

where pi = ni/N; ni is the number of individual trees present for species i, and N is the total number of individuals (Magurran, 2004)

12) Jaccard's similarity coefficient *(J)*:

$$J = \frac{C}{\text{A+B}-\text{C}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(equation 14)}$$

where C is the number of species common to both sites, A is number of species present in one of the sites and B is the number of species present in the other site (Magurran, 2004)'

Regeneration data analysis

The status of regeneration of species determined based on the population size of seedlings, saplings and adults (Gebrehiwot and Hundera, 2014). The regeneration status was categorized as follows: '1) "Good" regeneration, if seedlings > or < saplings > adults; 2) "Fair" regeneration, if seedlings > or ≤ saplings ≤ adults; 3) "Poor" regeneration, if a species survives only in sapling stage , but no seedlings (though saplings may be < or ≥ adults); 4)“None” or not regenerating, if it is absent both in sapling and seedling stages, but only found in adults; and 5) “New”, if a species has no adults, but only saplings and/or seedling stages’.

Comparison of results of DBH distribution to de Liocourt model

To test whether South Nandi forest conforms to the de Liocourt model often used as a management tool in uneven aged forests (Davis and Johnson, 1987); the number of trees in successive diameter classes, going from largest to smallest, were tested to see if the number of trees formed the classical reverse-J curve of a normal forest. The mathematical expression of this model is given as:

$$Y = Ke^{-ax} \quad \text{……………………………………………..(equation 15)}$$

Where K and a are constants, and only Y and X are variables. Y is the number of stems/ha and X is the diameter. This equation was transformed into a linear equation:

$$LogY = LogK - (aLoge)X \quad \text{……………………………….. (equation 16)}$$

Where logK is the regression constant and aLog$e$ the regression coefficient

NB. Both Y and K (numbers per hectare) are in the logarithmic scale but X (diameter), is untransformed. The constants “K” and “a” were calculated from data obtained from the forest inventory. A goodness of fit test (χ2) was done to compare the diameter classes of hypothetical UNO (1994) model for structurally stable East African natural forest to that of SNF.

Information on socio-economic survey on uses of tree species and the perception on status of the forest were summarized using Microsoft excel 2010.

3.2.7 Records of extraction of NTFPs

The records from KFS office at Kobujoi on use of various NTFPs for the last 10 years were used to estimate the level of extraction of products such as firewood through payment of monthly fuelwood license; grazing through monthly grazing permits and PELIS through annual cultivation permits (Maua *et al.*, 2019).

3.2.8 Data on firewood collection and use

A survey was done to collect more information on firewood which is used by 89% of the households for cooking in South Nandi Sub-County (KNBS and SID, 2013). Thirty respondents were interviewed from four exit points from the forest to the villages. Thirty items/people is the minimum number for studies where statistical data can be analyzed irrespective of the population size (Bailey, 1994). Data collected included the preferred tree species; weight of a headload of firewood, species of trees currently collected, quantities of firewood extracted from forest annually, firewood merchants in Kobujoi market, abundance of firewood and condition of the forest (Appendix 3).

3.2.9 Economic Valuation of the NTFPs

Indirect opportunity Cost (IOC) Method

The IOC method is used to “estimate the value of non-market environmental goods when individual labour is used in harvesting or collection” (Wollenberg, 1996).

The indirect opportunity cost method (Chopra, 1993) was used to approximate the NTFP extraction value; this was possible because NTFP extraction requires the expenditure of human effort with only minor investment in capital equipment (Richards, 1994). The IOC method considers: “i) the perception that time is a resource, and that individuals must make decisions about how to manage their time, reflecting the constraints and opportunities in relation to their objectives (Wollenberg, 1996); ii) microeconomic theory and utility maximization thus it is assumed that the respondents will always choose the productive use of labor with the highest wage rate. The IOC method assumes that the decision to spend time on NTFP collection is weighed against alternative productive uses of labor and/or time” (Svarrer and Olsen, 2005; Maua *et al.*, 2019).

The economic value of the NTFPs extracted per hectare per year (V_1) and the economic value of NTFPs extracted per household per year (V_2) were derived from the following functions (Svarrer and Olsen, 2005; Maua et al., 2019): ‘

$V_1 = \frac{a*l*d*t*w*h*p}{H}$.. (equation 17)

$V_2 = a*l*d*t*w*p$...................................... (equation 18)

Where:

a=the number of adults per household;
l=hours of productive labor per day per adult;
d=yearly working days per adult;
t=relative amount of time spent on NTFP extraction;
w=rural labor wage rate;
h=number of households;
p= the US$ equivalent for Purchasing Power Parity (PPP)*; and
H=the number of hectares used for NTFP extraction

In all calculations, the exchange rate of US$ 1 = Ksh 104.168 (the rate for September 2016) was used**.**

*****The value for price level ratio of PPP conversion factor (GDP) to market exchange rate in Kenya was 0.460 as of 2016 (https://www.indexmundi.com/facts/kenya/indicator/PA.NUS.PPPC.RF)’

Direct Pricing Method –used for firewood and fodder utilized

The economic valuation method used for firewood was Direct Pricing Method. This uses market prices to value forest products that are traded in local markets and Cost of Collection methods that estimate the value of the product by time expended in gathering NTFPs (Mavsar *et al.*, 2013; Maua *et al.*, 2019). For grazing in the forest, a direct substitutes method was used as a bale of hay, which had market price was used to estimate grazing in the forest. It has been estimated that a cow consumes dry matter at rate of 3-4% of its body weight, thus a 300kg cow will require 9-12 kg of dry matter per day (The Organic Farmer, 2015). The net economic value for grazing cattle in the forest per annum was calculated based on the procedure of Langat *et al.,* (2016).

The gross annual direct use values were determined from the empirical data as the product of quantity used per year and the local market price. The following formula was used in the calculation (Balama *et al.*, 2016):

$$‘am = Qm * Vu \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(equation 19)}$$

Where;

am is the mean annual value in KES,

Qm is mean annual quantity of NTFPs collected per household (Kg), and

Vu is unit value in KES per unit measure.

A discounting formula was used to estimate the economic value of the NTFPs, it was expressed as follows:

$$PV = \boldsymbol{a} \{(1 + r)^n - 1\}/\{r(1+r)^n\} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(equation 20)}$$

Where;

PV is present value of NTFPs in KES

a is the estimate of annual actual value of NTFPs in KES, and

r is the social discount rate’**.**

Discounting is recommended when extraction and consumption or sale occur at different times (Timmer *et al.,* 1983) and to take care of the cost capital when calculating the marginal costs of NTFP extraction. The social discount rate was important in the study because benefits of the forest are generally public property and attached to community values that account for more than individual preference (Balama *et al.,* 2016). Social discount rate is preferred to market discount rate because some NTFPs are non-marketed products and do not have monetary value. This study used a lower social discount rate of 10% as it is argued that high discount rates may discriminate against future generations therefore it is lowered to reflect environmental concerns and issues of intergenerational equity (Azar and Sterner, 1996). Given that the benefits are expected to flow to the households from the forest for infinity annual series assuming sustainable forest management, then n in the equation above approaches to infinity and the formula becomes

$$PV = \frac{a}{r} \text{ .... (equation 21)}$$

From equation above, the annual actual value ‘a’ was calculated as follows:

$$am = Qm * Vu * Pr * Hte \text{............................ (equation 22)}$$

where;

Pr is the proportion of respondents using the product in percentage and

Hte is total number of households in the study area i.e. households adjacent to South Nandi Forest (Balama *et al.,* 2016; Maua et al., 2019)’.

Frequency of particular NTFP consumption in the previous 12 months was recorded to estimate the annual gross direct-use value of an NTFP per year (Table 3).

Table 3: Methods of valuing NTFPs

Valuation method	NTFP	Value captured	Affected population captured	Benefits of method	Limitations of method
Market price	Those traded in markets e.g. small implements, firewood, charcoal	Directand indirect use	Users	Market data available and robust	Limited to market goods and services
Cost of collection	Those traded in markets e.g. small implements, firewood, charcoal	Direct and indirect use	Users	Easy to calculate opportunity cost	Estimation of time per product not easy as households combine activities while going to the forest
Cost of collection	Grazing/fodder	Indirect use e.g. Hay	Users	Amount of fodder eaten can be measured	Estimating amount of fodder through grazing is difficult

This study used the wage equivalent to infer value on time and main occupations of household heads established together with their average net earnings per working day (Delang, 2006). One major advantage of using the wage equivalent method is that the resultant value per hour reflects more on the opportunity cost of labor of households entering the forest to harvest NTFPs. This is thought to be better since use of wage rate could have concealed the variation of income earnings within the sampled households (Delang, 2006; Kiplagat *et al.*, 2008).

3.2.10 Analysis of socio-economic factors influencing dependence on NTFPs and economic dependence on the forest

A contingency table was used to show the relationship between the dependent variable(s) against the independent variables generated from the questionnaires. A binary regression analysis was then used to analyze qualitative data generated from the questionnaires in this study. Logistic regression was chosen because it is more flexible and results in fewer classification of errors compared to other techniques such as discriminant analysis (Montgomery *et al.*, 1987), and does not require that all of the predictors are continuous variables, normally distributed, or linearly related (Tabachnick and Fidell, 2007). Moreover, logistic regression has straightforward statistical tests and ability to incorporate non-linear effects and a wide variety of diagnostics (Hair *et al.*, 1998). It is therefore a preferred statistical technique for analyzing models of dichotomous dependent variables (Hosmer and Lemeshow, 1989).

Variables included in the models

Using the results from the household survey, a set of variables was assembled for use in the construction of the logits. These were then run for binary regression and the output carefully scrutinized. Two logit models were developed with the dependent variables being; factors influencing dependence of households on NTFPs from the forest; and factors influencing the economic dependence on the forest. The two dependent variables were chosen because they were among the major factors which impact negatively on the sustainable management of the adjacent forest. This study used a qualitative response model similar to the one used by Dewees (1991) and

Nyang (1999). The logit model was based on the cumulative probability function for more than one independent variable (Mukras, 1993; Tabachnick and Fidell, 2007):

$$P(z) = \frac{1}{\left(1 + e^{-z}\right)} \quad \text{………………………………………… (equation 23)}$$

Where;

P(z) is the probability of the event and

z is the linear combination:

$$Z = B_0 + B_1X_1 + B_2X_2 + \ldots + B_pX_p$$

Where;

X_0 ,X_1, X_2, … and X_p are independent variables, for example, various household decisions and

B_0, B_1, B_2… and B_p are coefficients from the data.

Similarly, from this equation,

$$e^{-z} = \frac{1}{P(z)} - 1 \text{ or } \frac{1 - P(z)}{P(z)} \quad \text{…………………………… (equation 24)}$$

$$\text{so, } \; Z = \log \frac{P(z)}{1 - P(z)} \quad \text{……………………………………..…(equation 25)}$$

The outcome is simply that the dependent variable in the regression equation is equal to the logarithm of the odds that a particular choice will be made (Dewees 1991). The coefficients B_0, B_1, B_2…….. and B_p denotes the effects of the predictor variable on the odds of dependence on NTFPs from the forest. The hypothesized factors (X_i) influencing dependence of households on NTFPs from the forest in South Nandi was taken as:

1. Age of the household head in years
2. Years of formal education of the household head

3. Marital status of household head
4. Household size
5. Gender of respondent
6. Ethnic group
7. Original home district of household head
8. Whether household was located in rural or peri-urban area
9. Land size which the household occupies
10. Having a plot in the urban centre
11. Whether land was registered in their name
12. House type (material used in building of the house)
13. Main occupation of household head
14. Total value of household assets
15. Owning a motorcycle
16. Household head owning a fixed/mobile phone
17. Owning truck or pickup to transport NTFPs over long distances
18. Distance to forest edge from house
19. Distance to market
20. Whether household got NTFPs from the forest or not
21. Geographic location of village adjacent to forest

The following factors (X_i) were hypothesized as influencing the economic dependence on the forest:

1. Location of village household head stays- less or more than 5 km
2. Type of NTFPs collected
3. Gender of NTFP collector (Generally male, female or both)
4. Distance from house to forest
5. Stock condition of forest compared to 10 years ago
6. Number of years household head have been engaged in NTFP business

7. Time spent collecting NTFP
8. Whether household head was a member of Community forest association
9. Whether NTFP business was the primary source of income
10. Average monthly household income including subsistence and support
11. Whether permission to collect NTFPs was required from KFS
12. Whether permission to transport NTFPs was required from KFS or County Government
13. If the household sells any NTFPs
14. If there was a change in the general availability of NTFPs
15. Age of household head
16. Marital status
17. Household size
18. Having a plot in the urban centre
19. Type of house
20. Total value of household assets
21. Gender of the respondent
22. Owning a truck or pickup to transport NTFPs over long distances
23. Distance to forest edge from house
24. Distance to the market
25. Whether household got NTFPs from the forest
26. Main occupation of the household head
27. Years of formal education

Summary of analysis

Table 4 shows the methods of analysis used during the analysis of data addressing the research questions in the study.

Table 4: Research questions, data collected and analytical methods used.

Research questions	Data topic and other information used for analysis	Statistical methods
1. What types of non-timber forest products do the forest adjacent community utilize?	Inventory of main NTFPs, Status and utilization of NTFPs, NTFP household, Questionnaire, FGD	Species of NTFP identified, Species distribution, Descriptive statistics, Chi-square analysis
2. What are the quantities of NTFPs that the forest adjacent community consume or use for income generation?	KFS records, Status and utilization of NTFPs (NTFP household questionnaire/transects); vegetation data, firewood collection survey, demographic and asset data annual income data	Descriptive statistics, correlation matrix, linear regression analysis
3. What is the economic value of the main non-timber forest products extracted from Nandi-South forest?	KFS records, Indirect opportunity cost, Direct Use Values, Cost of Collection, impacts and sustainability (NTFP household surveys), Changing trend, policy change, conservation action	Descriptive statistics, chi-square test
4. What are the socio-economic factors that influence households NTFP dependence in SNF	NTFP household Questionnaire, Status and utilization of NTFPs, Sustainability in NTFP uses, NTFP household questionnaire	Contigency tables, logistic regression, descriptive statistics, correlation matrix,

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents and discusses the main findings from the four objectives of this study. In the first objective, knowledge, and use of NTFPs, diversity of NTFPs, multiple uses of NTFPs, plant parts used, utilization of NTFPs by gender, domestic versus commercial use of NTFPs are discussed. For the second objective, annual firewood extraction, quantification of fodder consumed, the status of regeneration and important value indices of species, the status of NTFP stock condition and forest adjacent to the villages, and sustainable use of NTFPs are discussed. For the third objective, the overall economic value of all NTFPs combined, the quantity and value of annual extraction of firewood and grazing in the forest are addressed. Additionally, species used for firewood and fodder are discussed. Finally, for the fourth objective, the factors influencing the utilization and sale of NTFPs are discussed.

4.2 To determine the types of NTFPs extracted by forest adjacent communities for subsistence and income generation

4.2.1 Knowledge and use of NTFPs

A total of 128 species belonging to 105 genera and 55 families were reported during the FGD (Appendix 5). There were no significant differences in responses among the three groups of community members versed with plant uses from sites (Control, Koimwe, Kaptebengwo, and Kabungu) adjacent to the forest ($\chi2_{(3,89)} = 2.06$, p =0.115), suggesting that they had similar knowledge on the names and uses of the plants. A study on traditional ecological knowledge of a riverine forest in Turkana, Kenya, also stated that the local Turkana informants had relatively similar ethnobotanical knowledge (Stave *et al.*, 2007). Ethnobotanical knowledge for a given area can provide valuable information to interest groups such as researchers. Local knowledge has been recommended as a tool for rapid assessment of plant resources (Dalle and Potvin, 2004). This is because a researcher can get data on many species, including less abundant ones using less labor-intensive methods. This study confirmed that it is possible to obtain any data from the local informants. However, some studies have reported heterogeneous local knowledge on plant uses (Bruschi *et al.*, 2014), suggesting that caution is required when using local knowledge. Therefore, it is suggested that at least six to ten informants be used (Krueger and Casey, 2009), and consensus among them be reached before recording the local names of plant and their uses (Figure 5).

Figure 5: Focused group discussion with members selected from Koimwe village at Kobujoi CFA office.

4.2.2 Socio-economic characteristics of household's heads adjacent to South Nandi Forest

The forest adjacent households' heads' socio-economic characteristics were as follows: 85.8% of the surveyed group were married, 1.2% divorced, 2.6% widows, 1.6% widowers, and 8.8% were single. In terms of ethnicity, the majority were Kalenjins (81.0%) followed by Luhyas (17.4%), others were Luo (0.7%), Gusii (0.7%), and Kikuyu (0.2%). Most households (91.7%) lived in the rural setting, with only 8.3 % living in the peri-urban areas. Over 71% of the households did not have a title deed for their land. Most of the houses were semi-permanent (80%), followed by brick-walled (15%), and the rest mud-walled/grass-thatched houses. The main occupation of the household heads was farming (68.4%), followed by small-scale business (22.3%), civil servants (7.0%), and the rest were casual workers (2.3%).

The following socio-economic characteristics of the households' heads are likely to influence the utilization and economic value of NTFPs. For instance, over 80% of the houses were semi-permanent, which suggested that use of building poles from the forest were prevalent. The mean age of household heads was 45.9 years old, implying that most households are still physically strong and likely to be involved in NTFPs extraction activities, usually labor-intensive. Sinha *et al*. (2010) in Bhopal described the middle-aged people (31-50 years old) as generally economically active, enthusiastic, innovative, and hardworking with more physical strength, vigor, zeal, and aptitude (Islam *et al.*, 2015). The closer distance of the homes to the forest and the market encouraged the use and sale of NTFPs as less cost and time were expended than households far from the forest. This finding is consistent with other studies elsewhere, which exhibited that proximity to the forests increased households' likelihood to show greater reliance on forests compared to the distant ones (Garekae *et al.*, 2017). The average farm size was 1.2 ha. This is small given that the mean household size was 5.6 people; this is likely to encourage household members to use the forest more to supplement their households' subsistence needs and income. Similar findings have been reported by (Kabubo-Mariara and Gachoki, 2008), where the land-poor families in Kenya were unable to produce enough food for their households and income needs, thus largely depended on the forest products to complement their livelihoods. The main occupation of the household heads was farming, followed by small businesses. This implies that in case of a crop failure, most households are likely to depend on the forest during times of hardship. NTFPs serve as insurance premiums to forest adjacent communities during challenging economic times (Paumgarten *et al*., 2009).

Table 14 summarizes the contribution of NTFP to total monthly income; NTFPs contributed between 32.7% and 48.7% of the monthly income in most households, with the wealthier households benefitting more than households in the other income brackets. This finding is consistent with other studies elsewhere that have recorded similar results. For example, in Nepal, a study showed that the economic contribution of Chinese caterpillar fungus to mountain communities' livelihoods was 35.5% of the total household income (Shrestha and Bawa, 2014). In the Bonga forest area of Jimbo and Decha Districts of Kaffa Zone, southwest Ethiopia, the contribution from the significant NTFPs (forest coffee, honey, and spices) accounted for 47% of annual household income when all livelihood activities such as crop and livestock production, as well as off-farm activities were considered (Melaku *et al*., 2014). Another study in East Mau, Kenya, showed that forest income contributed between

25% and 36.5% of household income (Langat *et al.*, 2016). This study's findings are consistent with findings elsewhere and corroborate the importance of NTFPs to the livelihoods' of forest adjacent households' (Heubach *et al*., 2011; Saragih, 2011; Kalaba *et al*., 2013). It was also noted that the more affluent households derived higher absolute income from the forest than poor households (Langat *et al*., 2016). The likely reasons are that more affluent households extract higher value products and access financial and social capital.

Most household heads had 7.5 years of formal education, implying that they are unlikely to be employed in a highly-skilled labor market; thus, the option of relying on the adjacent forest for their subsistence and income is high. This is supported by the high relative amount of time (54.5%) spent on NTFP extraction (Table 6).

More than 80% of the respondents had motorcycles and mobile phones, whereas very few had vehicles (e.g., a pick-up truck, 5.5%). This suggests movement and communication was enhanced in the area. The other characteristics such as age, years of formal education, household size, the value of assets and distance to forest, and distance to market are presented in Table 6. The frequency of NTFP extraction is shown in Table 7; most of the respondents collected NTFPs daily, however, and the mean number of days for the collection of NTFPs in a year was 225.7 ± 11.58.

Table 5: Contribution of NTFPs to monthly income among households

Income level (Kshs)	*Descriptive statistics*					Percentage NTFP contribution
	n	Mean of total income	Mean from NTFP	S.E.	S.D.	
< 10,000	68	5091.3	2036.5	226.9	1871.4	40.4
10,000 - 20,000	31	11644.8	4238.7	641.7	3573.1	36.4
20,000 - 30,000	12	21916.5	7166.7	1696	5875	32.7
30,000 - 40,000	6	32156.9	13666.7	4889.9	11977.8	42.5
40,000 and above	11	51241.3	24954.5	6185.2	20514	48.7

Table 6: Summary of the socio-economic characteristics of forest adjacent household heads

Statistics	Age	Years of formal education	House-hold size	Land size (Ha)	Total value of net assets (KES)	Distance to forest edge in Km	Distance to market centre in Km	Time spent on NTFP extraction (Hrs)
n	431	416	403	416	230	420	417	236
Mean	45.9	7.45	5.6	1.2	56,242.40	1.9	1.5	4. 36
S.D.	15.6	3.8	2.6	1.5	267,006.50	1.8	1.5	2.67
Mini-mum	18	0	0	0	0	0.01	0	1.0
Max-imum	94	18	24	11.8	3,000,000.00	10	10	10.0

Table 7: Frequency of NTFP extraction per year forest adjacent households

Frequency of NTFP collection	No. of respondents	Days/year
Daily	98	365
Four times/week	1	192
Thrice/week	4	144
Twice/week	19	96
Once/week	20	48
Once/month	34	12
Mean days /year		225.7
S.D.		158.7

In terms of the total value of net assets, the study revealed a significant variation among households in South Nandi, possibly due to income generated in the labor market and transfers of economic resources across generations, and differences in age between households. The older households are more likely to have accumulated more wealth than younger ones. Additionally, higher income and reception of inheritance are likely to increase wealth holding, thus causing a difference in net assets (Semyonov and Lewin-Epstein, 2013).

4.2.3 Socio-economic characteristics of firewood collectors

Approximately 97% of the firewood collectors were female aged between 20 and 40 years old, whereas the remaining 3% were males between 15 and 34. They paid a monthly fuelwood license of KES. 100 to the local KFS station at Kobujoi, to be allowed to collect a headload of firewood daily from the forest for a whole month. The value of a headload of firewood is KES 100 in the local market at Kobujoi and its environs. Over 65% of the respondents had 5 to 8 years of basic education. The ethnicity of the firewood collectors was Kalenjin (55%) and Luhya (44%). Firewood was used for domestic (67%) and domestic and commercial purposes (33%). The frequency of firewood collection for the surveyed group was: daily (25%), 3-4 times per week (51%), 5-6 times per week (9%), and 1-2 times weekly (14%). Most of the wood used (95%) are collected from fallen trees and branches or deadwood.

4.2.4 Diversity and uses of NTFPs

Twenty-two types of Non-timber Forest products were cited during the informants' focused group discussions (Figure 6; Table 8). There was a significant difference between uses of NTFPs ($\chi2$ (22,89) = 6.41, $p<0.001$). Tukey HSD test showed that there are significant differences between the specific uses (Table 8).

The number of NTFPs used by the forest adjacent households was comparable to those found in other studies in Africa. For instance, in Benin, the households used 121

NTFPs belonging to 90 genera and 38 families; out of these, ten species had multiple uses and high economic importance. These were *Vitellaria paradoxa, Parkia biglobosa, Adansonia digitata, Irvingia gabonensis, Blighia sapida, Tamarindus indica, Dialum guineense, Vitex doniana, Borassus aethiopum,* and *Garcinia kola* (Assogbadjo *et al*., 2017).

Further, in Cameroon, Congo, and the Central African Republic, ten common types of NTFPs were used as sources of income to households. The NTFPs were honey, medicinal plants, bush mangoes (*Irvingia* spp), Gnetum africanum (Okok), cola nuts, palm wine, meats, mushrooms, and Marantaceae leaves (Endamana *et al.*, 2016). Locally, in Kakamega (Kenya), the main NTFPs consumed by the households were firewood, herbal medicine, and grazing in the forest (Kiplagat *et al*., 2008). These findings in Kakamega were similar to the main uses of NTFP in South Nandi Forest except that in South Nandi, grazing in the forest followed firewood collection, which was the most dominant NTFP utilized.

In Asia, a total of 739 species of NTFPs were used by the local people of Kangchenjunga landscape (a transboundary landscape shared by Bhutan, India, and Nepal) for 24 different purposes; medicinal and edible plants were the most frequently used NTFP categories in the landscape (Uprety *et al.*, 2016). A similar trend was revealed among the tribal communities who used 163 out of 343 NTFPs (47.52%) for medicinal purposes in Arunachal Pradesh state, which forms a significant part of the humid tropics of the eastern Himalayan region of India (Saha and Sundruyal, 2012). In this study, 51.56% of all the species were used for medicinal purposes (Figure 6). The above observations indicate that NTFPs that affect food security, health, and basic products used by the households need special consideration when planning activities affecting forest conservation. However, locality-specific surveys must be done to take care of varying characteristics and cultures of different regions.

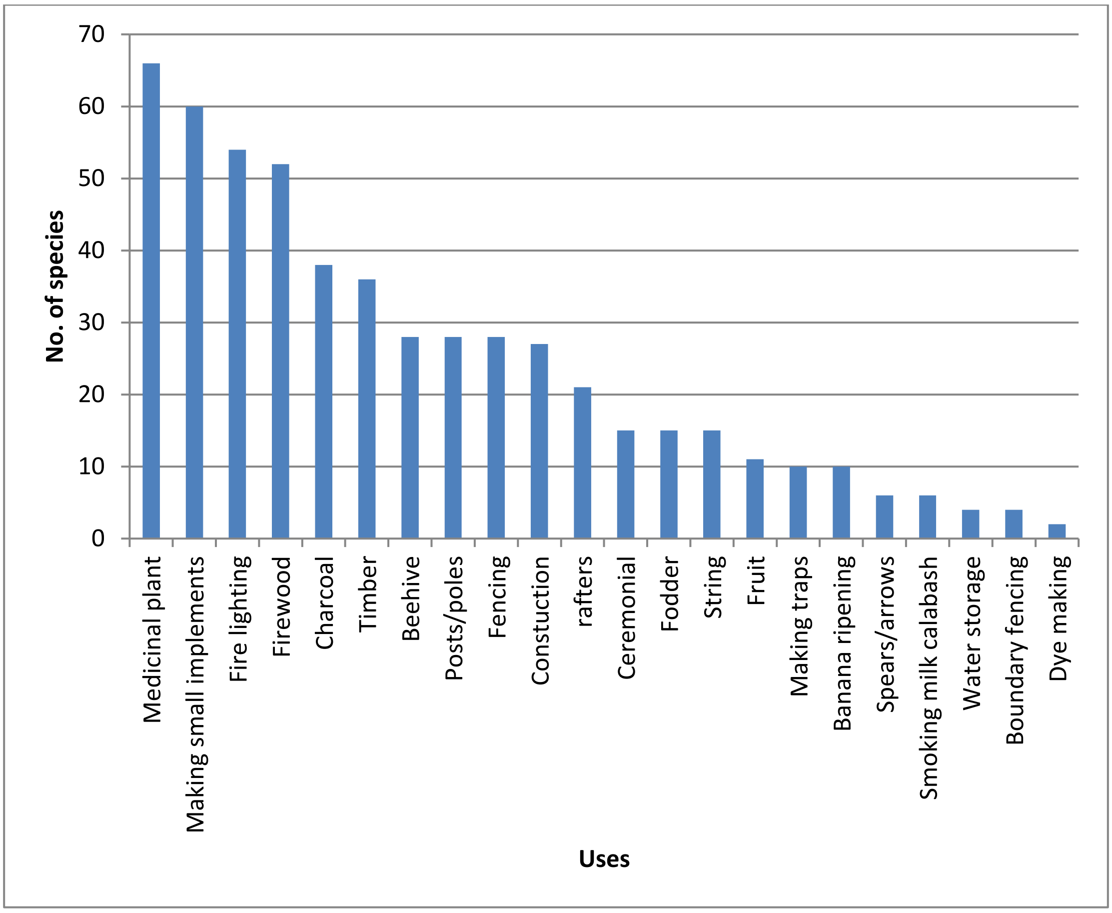


Figure 6: Summary of uses of plants per species cited in FGDs by informants living adjacent to SNF

Table 8: Tukey HSD test for different tree/plant uses mentioned by forest adjacent communities during focused group discussions in South Nandi Forest

Uses	Mean	SEof mean	Confidence interval
Rafters	1.108 ab	0.4627	1.108±0.4627
Spears/arrows	1.197 abc	0.4744	1.197±0.4744
Traps	1.242 abc	0.2318	1.242±0.2318
String	1.746 abcd	0.3507	1.746±0.3507
Ceremonial	1.951 abcd	0.1415	1.951±0.1415
Fruit	2.004 abcd	0.1645	2.004±0.1645
Fodder	2.17 abcd	0.5702	2.17±0.5702
Construction	2.181 abcd	0.2086	2.181±0.2086
Food/spices	2.283 abcd	0.2404	2.283±0.2404
Beehive	2.301 abcd	0.2649	2.301±0.2649
Posts/poles	2.306 abcd	0.3206	2.306±0.3206
Fencing	2.51 abcd	0.3479	2.51±0.3479
Fire lighting	2.606 bcd	0.67	2.606±0.67
Timber	2.635 bcd	0.1651	2.635±0.1651
Charcoal`making	2.685 bcd	0.3212	2.685±0.3212
small implements	3.088 cd	0.3579	3.088±0.3579
Firewood	3.226 d	0.1407	3.226±0.1407
Medicinal	3.658 d	0.1255	3.658±0.1255
Lsd = 1.049			

NB. Any two variables that have different letters imply that they are significantly different at 0.05 levels.

4.2.5 Multiple uses of plant species as NTFPs

Most of the plant species had multiple uses, with over 78% (Appendix 5) having more than one known use suggesting that the South Nandi forest played an essential role in the household's subsistence and income generation. Plants with multiple uses, especially more than five uses, are considered versatile species. For instance, *Syzygium guineense and Allophylus abyssinicus* had 14 uses each: fire lighting, water storage, food/spices, medicinal, timber, firewood, making beehives, posts/poles, fencing, construction, rafters, fruits (*S. guineense*), making traps (*A. abyssinicus*) and making small implements. Most multipurpose species are targeted by the forest adjacent households for the various uses mentioned above. Most of the plants in this study are used as NTFPs by the households living adjacent to SNF. These findings corroborate other studies that show NTFPs support the bulk of rural households in developing countries and a considerable proportion of urban households in terms of their energy, nutritional, health, house construction, or other needs (Modi and Trivedi, 2013; Pandey *et al.*, 2016; Tewari *et al.*, 2017). Thus, there is a greater need to have forest policies that support the wise use of species known for NTFP. Currently, NTFP does not get the importance they need when it comes to forest conservation and support for enterprises grounded on NTFP (e.g., the Baringo Aloe plant, which closed down and failed honey processing units in various Counties).

The NTFPs in this study were grouped into four categories according to (Modi and Trivedi, 2013): Firstly, NTFPs for food security, which includes species useful for honey, mushroom, edible fruits and nuts, foliage, and rhizomes: 20 species were food/spices and 11 species fruit;

Secondly, NTFP for wood and biomass included species for fuel, furniture, thatching, forage, and manure: 60 species of small implements, 54 species fire lighting, 53 species firewood, 38 species charcoal, 28 species making beehives, 28 species posts/poles, 28 species fencing, 27 species construction, 21 species rafters, 15 species making strings, 15 species fodder, ten species making traps, ten species banana ripening, six species smoking calabashes, five species spear/arrow making, four species boundary live fence, and three species water storage;

Thirdly, NTFP for medicine and plant protection included herbal medicine for human beings, animals and for control of pests and diseases in crops 66 species medicinal and 15 species ceremonials; and, Fourthly, NTFP for aromatics, dyes, and oilseeds for medicinal and industrial uses: 2 species for dye-making.

Overall, most NTFP uses in this study were found in the second category on wood and biomass and are linked to domestic uses.

4.2.6 Plant parts used

The plant parts extracted as NTFPs are determined by the intended use. The main parts used for firewood were branches (79.9%), followed by stems (11.8%) and deadwood (6.3%). Roots were also used by 1.4% of the respondents suggesting that the whole tree was used for firewood, mainly when there were scarcities. The grass was also used as fuel but mainly for lighting purposes. For grazing in the forest, grass (95.3%) and leaves (4.7%) were the main parts eaten by livestock, particularly cattle and sheep. Roots and bark (75.0%) and leaves (25.0%) were the plant parts used for medicinal purposes. The relationship between the type of NTFP sourced and the specific part collected (Table 9) was statistically significant ($\chi2_{(10,281)} = 446.334$, $p<0.0001$).

Table 9: Relationship between type of NTFP and part collected

			Part of NTFP used						
			Leaves	Grass	Branches	Roots and/or bark	Deadwood	Stems	Total
Type of NTFP	Herbs	Count	2	0	0	6	0	0	8
		% within Type of NTFPs	25.00%	0.00%	0.00%	75.00%	0.00%	0.00%	100.00%
	Firewood	Count	0	1	115	2	9	17	144
		% within Type of NTFPs	0.00%	0.69%	79.86%	1.39%	6.25%	0.00%	100.00%
	Grazing	Count	6	123	0	0	0	0	129
		% within Type of NTFPs	4.65%	95.34%	0.00%	0.00%	0.00%	0.00%	100.00%
Total		Count	8	124	115	8	9	17	281
		% within Type of NTFPs	2.85%	44.13%	40.93%	2.85%	3.20%	6.04%	100.00%

Test statistic : Pearson Chi-Square $\chi2_{(10, 281)}= 446.334$, $p<0.0001$

The 66 medicinal plants identified treated ailments in the following categories: stomach/digestive-related, skin-related, respiratory-related, and procreation-related such as aphrodisiacs, venereal diseases, and gynecological ones. Others were stress-related ailments such as headaches, hypertension, heart, nervous and pain-producing sicknesses. The plant parts used were mainly roots and/or bark (76.8%), leaves (20.8%), grass (3.4%), branches (0.6%) and seeds (0.6%). Harvesting methods that involve complete removal of plants or ring barking should be discouraged (Turner, 2001), especially if the target plants are rare in the forest. It is suggested that management strategies that reduce damage to the whole plant be developed in SNF to ensure sustainable exploitation of the forest. This is especially necessary where the active ingredients derived from the roots are also available in other parts of the plant, such as the leaves, bark, seeds, and buds.

Many parts of a plant, such as leaves, roots, bark, fruit, seeds, and flowers, can have medicinal properties (Focho *et al.*, 2010). Other parts used can be a bulb, rhizome, tubers, and stem/wood. The different parts of plants may contain different active ingredients within one plant. For example, roots and bark are the most commonly used parts in remedies (Ngarivhume *et al.*, 2015). Thus, one part of the plant could be toxic, while another portion of the same plant could be harmless. Plants, especially with potent bioactive compounds, are often characterized as both poisonous and medicinal, and a beneficial or an adverse result may depend on the amount eaten and the context of intake (Bernhoft, 2010; Ngarivhume *et al*., 2015). This suggests that herbal medicine use requires traditional medicine experts' advice to reduce fatalities or complications arising from the use of the wrong part of the plant. This study looked at the extraction of parts used from a conservation point of view. For example, in SNF, 66 species were utilized for health care and livelihoods; most of the species were multipurpose; thus, the intensity of use is likely to be high, and therefore, overexploitation is possible. A study in Mt. Cameroon reported that barks of trees were the most used parts followed by the leaves and fruits, whereas seeds, sap, and roots were the least used parts (Focho *et al*., 2010) and that overexploitation in traditional medicine was noted (Okoegwale and Omefezi, 2001; Focho *et al*., 2009). Therefore, harvesting methods that involve complete removal of plants or ring barking should be discouraged as that may result in resource exhaustion and even species extinction(Turner, 2001), especially if the target plants are rare in the forest. This is true in Kenya, where efforts by the Government to protect some useful plants from over-exploitation are not supported by field practitioners (e.g., Aloe, Prunus Africana, Osyris lanceolata).

Studies on the harvesting of fruits suggest that removing these parts may not directly affect the health of a single tree therefore only has little effect on the plant population exploited (Hall and Bawa, 1993). Using their leaves as a remedy can be a benign alternative for herbal drugs made of whole plants or roots. For example, extracts from ginseng leaf-stems and roots had similar pharmacological properties, but ginseng leaf-stem had the advantage of being a more sustainable resource use method (Wang *et al*., 2009). Therefore, the sustainable use of medicinal plants should be considered, and good harvesting practices must be formulated.

4.2.7 Utilization of NTFPs and division of labor by gender

In this study, there was a significant difference in gender bias in the division of labor/roles on NTFPs ($\chi2$ (8, 371) = 189.628, $p<0.0001$) except for herbal medicine and cultivation in the forest, which were done equally by both men and women (Table 10). Several studies have confirmed that both men and women play different roles and their interests in NTFPs were relatively different as women play more significant roles as primary harvesters, processors, and marketers of NTFPs (Terry and Cunningham 1993). Therefore, an examination of gender roles in NTFPs extraction and utilization is critical in understanding the impacts of NTFP commercialization on society's social justice, equity, and welfare.

Other studies have shown that gender division of labor and income control can vary spatially, by species of plants, by the level of technology, and by the type of task in the chain of activities from harvesting to marketing (Neumann and Hirsch, 2000).

Table 10: The relationship between gender and the type of NTFP collected in SNF

			Type of NTFP			Total
			Grazing	Firewood	Herbs	
Gender	Male and Female equally	Count	58	11	4	73
		% within type of NTFPs	29.59%	6.58%	50.00%	19.67%
	Mostly male	Count	112	15	1	128
		% within type of NTFPs	57.14%	8.98%	12.50%	34.50%
	Mostly female	Count	26	141	3	170
		% within type of NTFPs	13.26%	84.43%	37.50%	45.82%
Total		Count	196	167	8	371
		% within type of NTFPs	100.00%	100.00%	100.00%	100.00%

Test statistic : Pearson Chi-Square $\chi2_{(8, 371)}$= 189.628, p<0.0001

4.2.8 Domestic versus commercial use of NTFPs

The NTFPs collected from the forest were used for domestic and for commercial purposes (Table 11). In all the cases, there was a significant difference between domestic and commercial use of the NTFPs ($\chi2_{(4,319)}$ = 24.209, p<0.0001).

The majority of the households used NTFPs mainly for subsistence purposes; other studies that have found similar findings include Lynser and Tiwari (2016) in Meghalaya, North-East India; Sharma *et al*., (2015) in Arunachal Pradesh, India; and Mbuvi and Boon (2009) in Makueni District, Kenya. Within the households adjacent to the South Nandi forests, almost all NTFPs such as firewood, grazing (fodder), and herbs were used mainly for subsistence.

Table 11: The purpose of collecting NTFPs in South Nandi Forest

			Purpose of the NTFPs			
			Commercial	Domestic	Both domestic and commercial	Total
Type of NTFPs	Herbs	Count	2	5	0	7
		% within Type of NTFPs	28.57%	71.42%	0.00%	100.00%
	Firewood	Count	2	146	1	149
		% within Type of NTFPs	1.34%	97.99%	0.67%	100.00%
	Grazing	Count	3	157	3	163
		% within Type of NTFPs	1.83%	96.32%	1.83%	100.00%
Total	Count		7	308	4	319
		% within Type of NTFPs	2.19%	96.55%	1.25%	100.00%

Test statistic : Pearson Chi-Square $\chi2_{(4, 319)} = 24.209$, $p<0.0001$

4.3 To quantify the NTFPs forest adjacent households extract by gender and its impact on forest structure in terms of population structure, regeneration status, and species composition

4.3.1 Quantification of NTFPs and impact on forest structure

4.3.1.1 Annual firewood extraction and species used for firewood

Out of 128 species listed, 53 are used as firewood by the forest adjacent households (Appendix 5). The growth habits of preferred firewood species were trees (58%) and shrubs (30%) (Figure 7). Firewood was obtained from plant species in thirty (30) families (Appendix 5). Euphorbiaceae and Rutaceae families were the most preferred for firewood (Figure 8). The species most harvested in the Euphorbiaceae family were *Drypetes gerrardii, Croton megalocarpus, Croton macrostachyus, Macaranga kilimandscharica, Erythrococa bongensis, Ricinus communis,* and *Neoboutonia* *macrocalyx*, whereas those in Rutaceae family were *Fagaropsis angolensis*, *Zanthoxylum gillettii*, *Tecla nobilis*, and *Toddalia asiatica* (Appendix 5).

Twenty-eight tree species were identified from headloads carried by respondents during the survey (Table 12). This comprised about half of all tree species listed by informants during the FGD for species preferred for firewood. This study revealed that the average annual consumption of firewood per household was 7285.4 ± 1586.9 kg. This is higher than the annual consumption recorded in other studies. For example, Saha and Sundriyal (2012) in the humid tropics of Northeast India got between 3581 and 4887 kg per household per year.

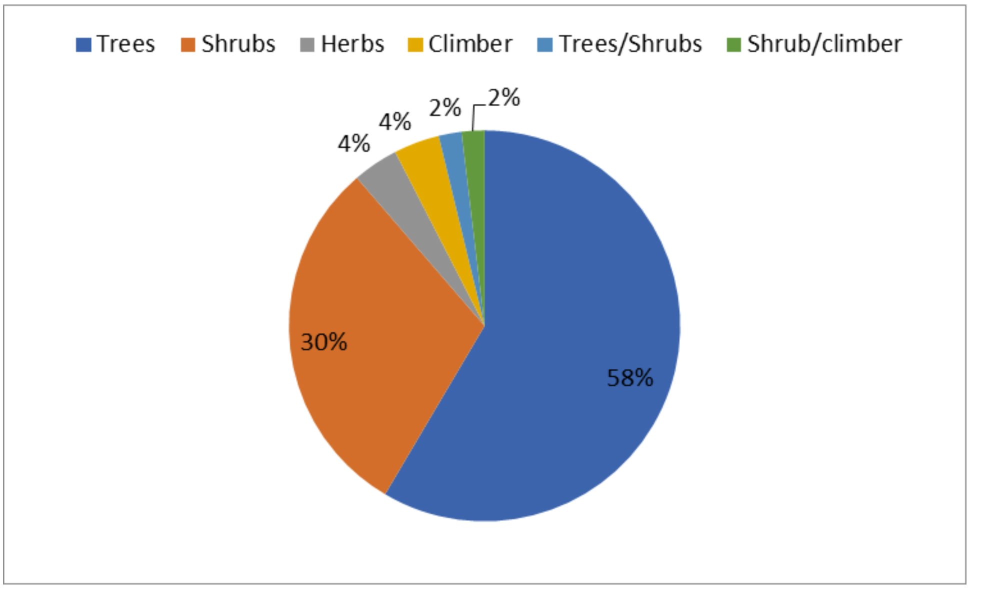


Figure 7: Growth habit of species preferred for firewood (N=53)

Ndayambaje *et al*. (2012) in rural Rwanda reported that 96% of households consumed about 5200 kg of firewood per year, whereas Langat *et al*. (2016) estimated that 90.3% of households collected firewood from the forest and the annual consumption in East Mau Forest Ecosystem, Kenya was 4,070.45 ± 167.67 kg. The likely reason for the high consumption in South Nandi Sub-County is that the households also sell firewood collected from the forest as a source of supplementary income. The high extraction of firewood by the households needs to be checked by the forest managers who also work together with the Community Forest Association in the area, particularly using a management plan that ensures sustainable utilization of firewood and other forest products. The survey estimated extraction from South Nandi Forest was 63.77 times higher than that determined from the KFS records of monthly fuelwood licenses (Table 13). This indicates that only 1.6% of the households paid for the monthly fuelwood license suggesting that there is inefficient policing by forest/CFA managers and firewood collection is mostly free. Therefore, licensing procedures and monitoring of firewood leaving the forest need to be streamlined.

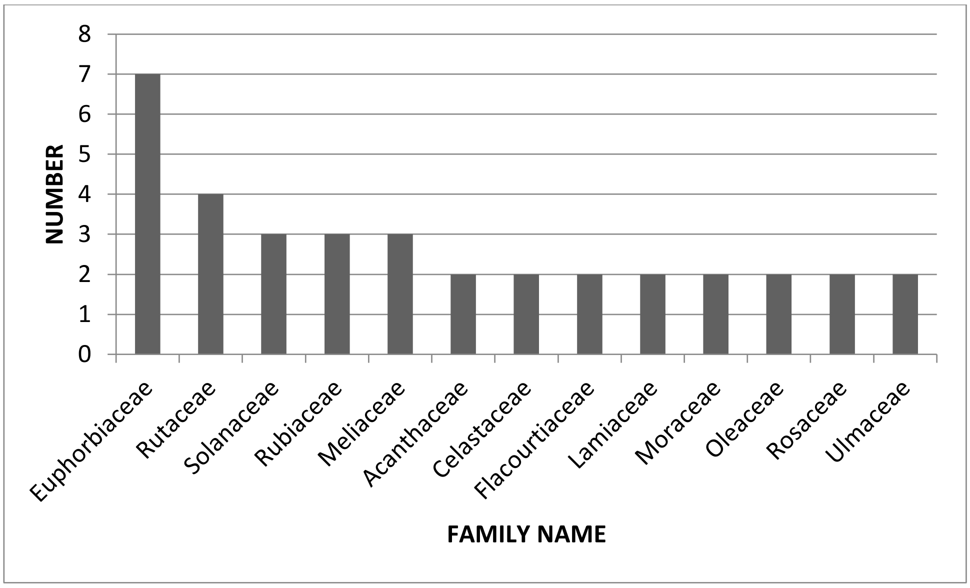


Figure 8: Families with at least two species used for firewood in South Nandi Forest

Table 12: Tree species identified from headloads of firewood at 4 exit points in South Nandi Forest

Species	Species	Species
Pinus patula	*Ekerbergia capensis*	*Clerodendrum johnstonii*
Cupressus lusitanica	*Macaranga capensis var. kilimandscharica*	*Maesopsis eminii*
Polyscias fulva	*Celtis mildbraedii*	*Allophyllus* spp
Croton megalocarpus	*Solanum mauritianum*	*Hippocratea africana*
Eucalyptus spp	*Heinsenia diervilleoides*	*Solanum* spp
Tabernaemontana stapfiana	*Mimulopsis arborescens*	*Spathodea campanulata*
Zanthoxylum gillettii	*Prunus africana*	*Casearia battiscombei*
Strombosia scheffleri	*Vernonia* spp	
Ficus sur	*Syzygium guineensii*	
Neoboutonia macrocalyx	*Erythrococca atrovirens*	

Table 13: Summary of 10-year extraction of firewood from South Nandi Forest

Year	No. of Headloads extracted*
2005	15,627
2006	24,620
2007	57,463
2008	37,370
2009	26,533
2010	48,533
2011	34,860
2012	104,310
2013	123,990
2014	112,950
2015	113,460
Mean extraction/year	63,610.55
Standard deviation	41,471.9
Standard error	12,504.25

***** One permit of Monthly fuelwood licence equals 30 headloads of firewood
Source: KFS records – Kobujoi Forest Station

Species preferred for firewood

Practically all tree species can be used for firewood, but some species are generally preferred, for instance, species that burn without excessive neither smoke nor unpleasant odors (FAO, 2003). Other traits that influence quality heating and ignition of a particular species include the density of wood, green vs. dry wood, the calorific value of wood species, ease of splitting, and ease of igniting firewood (Nix, 2017). However, species' choice may be restricted in some localities due to the unavailability of some of the preferred species in sufficient quantities, thus resulting in a collection of firewood from the next alternative species. Most of the species used for firewood in South Nandi Forest are indigenous. These plants belonged to 30 different families and 49 genera, as shown in Appendix 5. The most common plant families, Euphorbiaceae and Rutaceae were cited at 13.2% and 7.5%, respectively; followed by Rubiaceae, Meliaceae, and Solanaceae, 5.7% each, while the rest varied between 3.8% and 1.9%. There were also exotic tree species used for firewood in the area, such as Eucalyptus spp., Pines and Cypress. This study has therefore revealed undocumented firewood species that are preferred by the local community. This information will be necessary for forest managers and CFAs in SNF for planning purposes.

Some species mentioned as preferred for firewood during the FGDs, were not encountered during the floristic survey (Table 28), namely, *Chionanthus mildbraedii*, *Cordia abyssinica* and *Maytenus heterophylla* suggesting that extraction of firewood/NTFPs was negatively impacting the presence of some species in SNF. Other species also used for firewood, such as *Albizia gummifera*, *Prunus africana*, and *Zanthoxylum gilletii* (Appendix 4), were poorly represented in some DBH classes (Table 14). The missing DBH classes were due to anthropogenic disturbances such as illegal logging, charcoal burning, and firewood collection. A study on the same site found out that 71.6% of the respondents living around SNF earn less than KES 15,000 per month, which was not enough to meet their basic needs (Koech, 2018). This may be prompting them to engage in forest income-generating activities such as charcoal burning, which results in forest destruction and interference with the forest structure.

4.3.1.2 Quantification of fodder consumed in South Nandi forest

Species used for fodder

Out of 128 species listed in the study, 15 (11.7%) were used for fodder by the forest adjacent households (Table 15). The growth habits of these plants were; herbs (54.0%), shrubs (20.0%), and trees (13%). The dominant fodder family was Acanthaceae and Asteraceae (Figure 9).

Fodder plants were found to be multipurpose in this study (Table 15). For instance, none of the species given by the informants was used for fodder alone except *Ipomoea wightii*. Seven out of the 15 species in SNF which were used for fodder were also used for medicine. Similar findings have been reported in Cameroon where the agropastoralists living adjacent to Mbam and Djerem National Park used 25 woody species to feed and treat their animals (Konsala *et al*., 2013). Findings in Nikyal valley in Pakistan also showed that most of the plants were used for both medicinal and fodder purposes (Amjad and Arshad, 2014). However, the respondents in that study argued that grazing, browsing, overexploitation, deforestation, and soil erosion were mainly responsible for reducing medicinal flora. This shows that even though the plants may be multipurpose, there is always a preferred use of the plants among the households.

Table 14: Status of selected tree species in South Nandi Forest

No.	Species	Status
1	*Syzigium guineense*	Had few individuals in DBH class 1 and not represented in other classes
2	*Allophylus abyssinicus*	Tended towards inverse –J shape but not represented from DBH class 7
3	*Tabernaemontana stapfiana*	Tended towards inverse –J shape but with few individuals in DBH class 1
4	*Cordia abyssinica*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
5	*Olea capensis*	Represented only in DBH class 1 and 8
6	*Albizia gummifera*	Poorly represented; only in DBH class 1 and 2
7	*Strombosia scheffleri*	Tended towards inverse –J shape but not represented from DBH class 6
8	*Chionanthus mildbraedii*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
9	*Cassipourea ruwensorensis*	Represented by few individuals up to DBH class 3
10	*Prunus africana*	Germinated seedlings were abundant but these were didn't transit into other DBH classes
11	*Fagaropsis angolensis*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
12	*Zanthoxylum gilletti*	Only represented in DBH class 1 and 2
13	*Celtis mildbraedii*	Tended towards inverse –J shape but not represented in DBH classes 5, 7 and 10
14	*Maytenus heterophylla*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
15	*Diospyros abyssinica*	Represented by few individuals up to DBH class 5
16	*Drypetes gerrardii*	Tended towards inverse –J shape but not represented from DBH class 8
17	*Trilepisium madagascariense*	Germinated seedlings were abundant but poorly represented in other DBH classes
18	*Casearia battiscombei*	Tended towards inverse –J shape but not represented from DBH classes 6
19	*Croton megalocarpus*	Tended towards inverse –J shape only missing individuals in DBH class 10
20	*Macaranga kilimandscharica*	Tended towards inverse –J shape but had few individuals in DBH class 1
21	*Maesopsis eminii*	Represented only in DBH class 1
22	*Mimulopsis arborescens*	Represented only in DBH classes 1and 2
23	*Ficus sur*	Represented in all DBH classes except 5 and 8 but didn't show inverse – J shape
24	*Neoboutonia macrocalyx*	Tended towards inverse –J shape only missing individuals as from DBH class 5
25	*Polyscias fulva*	Represented in all DBH classes except 1 but doesn't form an inverse –J shape
26	*Solanum mauritianum*	Represented only in DBH classes 1and 2

Table 15: Species listed for fodder use by informants with their family and local name and, their growth habit

No.	Species	Family name	Local name (Nandi)	Growth habit
1	*Nuxia congesta*	Loganiaceae	Choruwet	S
2	*Ficus sur*	Moraceae	Mukoiyot	T
3	*Dombeya burgessiae*	Sterculiaceae	Silipchet	T
4	*Ocimum suave*	Laminaecea	Mwokiot	H
5	*Brillantaisia madagascariense*	Acanthaceae	Kipongiat	S
6	*Brillantaisia nitens*	Acanthaceae	Sietet	H
7	*Hippocratea sp.*	Celastraceae	Chepseleitet	C
8	*Acalypha sp*	Euphorbiaceae	Sambachet or chesumeiyot	H
9	*Macrorungia pubinervia*	Acanthaceae	Kipongiet	H
10	*Pseuderanthemum*	Acanthaceae	Chesumeiyot	S
11	*Bidens sp.*	Asteraceae	Chepketel	H
12	*Galinsoga parviflora*	Asteraceae	Kipkoleitet	H
13	*Plantago palmate*	Plantaginaceae	Yakariet	H
14	*Laportea alatipes*	Urticaceae	Sambachet	H
15	*Ipomoea wightii*	Convolvulaceae	Kimoiyat	C

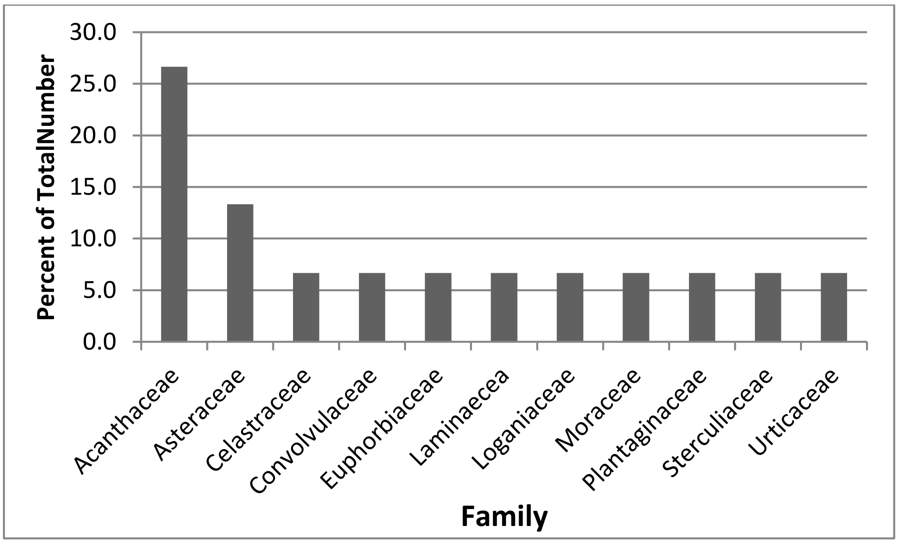


Figure 9: Families of preferred fodder species in South Nandi Forest

Comparison of data on fodder consumption from KFS records with estimates from the survey showed that the records from KFS were up to 46 times less than the number of cattle grazing in the forest, suggesting that only 3.05% of the households paid for the monthly grazing permits. The quantity of fodder consumed by livestock was estimated to be hay equivalent between 1,767,631.1 and 2,356,841.21 bales per year (see section 4.5.3) Like the case of firewood collection, there seems to be inadequate control of livestock that graze in the forest; if there were efficient policing of the forest, the number of permits and livestock in the forest would have been equivalent. Due to inadequate vigilance, probably due to the inadequate number of forest rangers, the revenue collected from monthly grazing permits is very low, and the adjacent households mostly graze their cattle for free. This is supported by another study's findings on the same site, which showed that 65.4% of the respondents interviewed indicated that they do not pay for grazing in the forest (Koech, 2018).

4.3.1.3 Medicinal plants in South Nandi forest

Medicinal plants are among the top three NTFPs utilized by households in South Nandi and play an important role in their primary healthcare (appendix 6). A total of 66 plant species were reported in South Nandi comprising 41 families dominated by Asteraceae (10.6%), Euphorbiaceae (7.6%), Lamiaceae (6.1%), Papilionaceae, and Rutaceae (4.5% each), with the rest of the families comprised of 3% or less (Table 16). No valuation or costing was done due to inadequate data on the number of herbs collected, the frequency of collection per household, and their market value since most of the market products are a concoction of several plants. The ailments treated by the 66 medicinal plants fell in the following categories: stomach/digestive-related, skin-related, respiratory-related, and procreation-related such as aphrodisiacs, venereal diseases, and gynecological ones. Others were stress-related ailments such as headaches, hypertension, heart, nervous and pain-producing sicknesses (Appendix 6).

Table 16: Species richness of medicinal plant species in South Nandi Forest

No.	Family name	No. of medicinal plant species	% of total species mentioned as medicine
1	Asteraceae	7	10.6
2	Euphorbiaceae	5	7.6
3	Lamiaceae	4	6.1
4	Papilionaceae	3	4.5
5	Rutaceae	3	4.5
6	Solanaceae	3	4.5
7	Apocynaceae	2	3
8	Flacourtiaceae	2	3
9	Liliaceae	2	3
10	Meliaceae	2	3
11	Oleaceae	2	3
12	Rosaceae	2	3
13	Acanthaceae	1	1.5
14	Asclepiadaceae	1	1.5
15	Boraginaceae	1	1.5
16	Caesalpiniaceae	1	1.5
17	Celastraceae	1	1.5
18	Commelinaceae	1	1.5
19	Crassulceae	1	1.5
20	Cucurbitaceae	1	1.5
21	Dracaenaceae	1	1.5
22	Lobeliaceae	1	1.5
23	Malvaceae	1	1.5
24	Melianthaceae	1	1.5
25	Menispermaceae	1	1.5
26	Mimosaceae	1	1.5
27	Moraceae	1	1.5
28	Myrsinaceae	1	1.5
29	Myrtaceae	1	1.5
30	Passifloraceae	1	1.5
31	Phytolaccaceae	1	1.5
32	Piperaceae	1	1.5
33	Plantaginaceae	1	1.5
34	Rhamnaceae	1	1.5
35	Rubiaceae	1	1.5
36	Sapindaceae	1	1.5
37	Tiliaceae	1	1.5
38	Ulmaceae	1	1.5
39	Urticaceae	1	1.5
40	Vitaceae	1	1.5
41	Zingiberaceae	1	1.5
	TOTAL	**66**	**100**

4.4 Status of the forest adjacent to the villages/South Nandi forest

The 1-km transects that walk into the forest adjacent to the villages revealed several species characteristics: density and DBH distribution, Inverse - J curves, height, population structure, species richness and diversity indices, status of regeneration in South Nandi Forest, and importance value index.

4.4.1 Species characteristics in South Nandi Forest

4.4.1.1 Species-Area curve

A reconnaissance survey was done using plots of 30m X 20m. The number of species in each plot was identified and the cumulative number of new species recorded; then a species-area curve was plotted; the curve showed signs of reaching a plateau on the fifth sample plot (Figure 10), i.e., less likelihood of encountering a new species reduced after the fifth plot implying that the optimum number of plots per transect had been reached for a representative sample of South Nandi Forest. For the whole forest, seven 1-km transects equivalent to 35 sample plots giving a sampling area of 2.1ha.

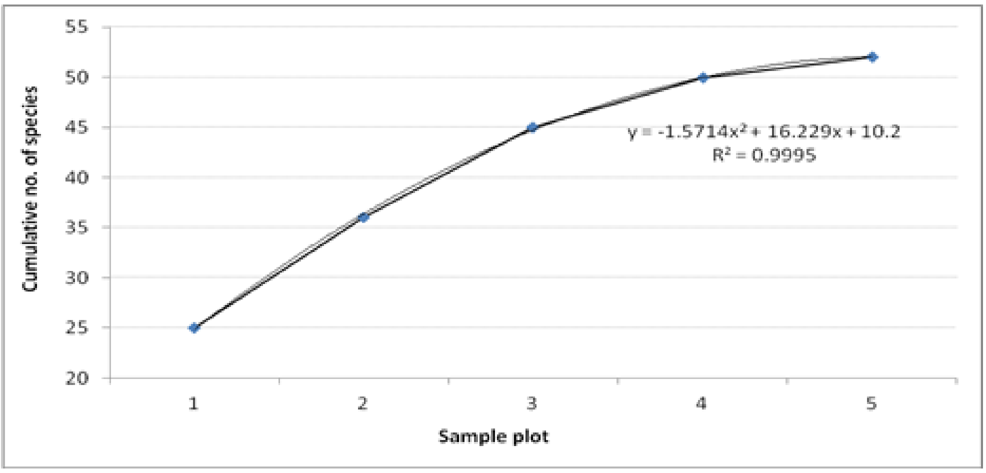


Figure 10: Species area curve for plant species recorded in 5 sample plots in South Nandi Forest

4.4.1.2 Population structure

Species richness and diversity

This study encountered 68 species from 37 families and 60 genera of woody plants. The species-rich families comprised 64.1% of all plants. These were Euphorbiaceae (8 species), Rubiaceae (7), Rutaceae (4), Bignoniaceae (3), Meliaceae (3), Moraceae

(3), Ulmaceae (3), Araliaceae (2), Boraginaceae (2), Compositae (2), Flacourtiaceae (2), Rhamnaceae (2) and Sapindaceae (2). The remaining 21 families were represented by a single species.

Table 17 shows the various diversity indices used to characterize the seven forest sites adjacent to the villages sampled in SNF. Bonjoge and Morongiot forest sites had the least species richness, whereas Ngerek had the highest. Shannon Weiner and Inverse Simpson's diversity indices indicated that Bonjoge had the lowest species diversity. Jaccard's similarity coefficient showed a range between 0.39 and 0.52, with the higher figure indicating higher floristic similarities. The mean basal area of the forest sites studied was 26.8 ±12.0 m2ha-1; the forest sites adjacent to Bonjoge and Chepkumia villages had the lowest and highest basal areas, respectively (Table 17). An earlier study in the same forest had recorded a higher number of woody plant species (86) than in this study. The difference may be due to the sampling intensity used; for example, in Njunge and Mugo (2011), the total number of sampling plots was 57, whereas this study had 35. However, this study's results were reasonably representative as over 79% of the species were represented.

Euphorbiaceae and Rubiaceae families in this study were among the top 10 species-rich families in SNF, just as observed in most tropical rain forests (Senbeta et al., 2014). The likely reason is that these families usually dominate the understory layer, and most Rubiaceae families are pioneer plants (Göltenboth *et al.,* 2006). Therefore, these families are likely to come up as pioneers whenever gaps are created in the forest, either due to natural or anthropogenic disturbances. Euphorbiaceae have also been reported as an essential component of forest strata up to 30 m height (Göltenboth *et al*., 2006); this study confirmed this finding as the family had the highest representation in terms of the number of species and dominance (Table 17; Maua *et al*., 2020).

Table 17: Comparison of parameters used to characterize forest sites adjacent to the villages

Forest site	S	N	BA	H'	1/D	E	J'
Chepkumia	33*	447*	45.1*	2.86	10.45*	0.32	0.49*
Ngerek	35*	560	14.6*	2.63	6.1	0.17*	0.52*
Chepkongony	32	520	35.2	3.42*	10.45*	0.33	0.48
Morongiot	26	553	26.3	2.42	6.06	0.23	0.39*
Serem-Chebilat	30	637*	34.1	2.61	8.29	0.28	0.45
Chebilat	27	427*	20.2	2.77	10.9*	0.4*	0.4*
Bonjoge	26	603*	12.0*	1.79	2.66*	0.1*	0.39*
Mean	29.86	535.29	26.8	2.64	7.84	0.26	0.45
S.D.	3.63	77.04	12.0	0.49	3.06	0.10	0.05

(S=Species richness; N=density of trees/ha; BA=Basal area (m^2ha^{-1}); H' =Shannon Weiner diversity index; 1/D = Inverse Simpson diversity index; E =Simpson's evenness and J'= Jaccard's similarity coefficient). Asterisk on the value indicates that there is a significant difference in the variable along column at p=0.05 level.

A higher Shannon-Wiener index value indicated relatively high species diversity in the forest adjacent to the adjacent village. In this study, the Shannon-Wiener index (H') value was a mean of 2.64 for the whole of the South Nandi forest. These results were similar to what Girma (2011) found in the same forest (2.74) except for the evenness, which he obtained as 0.67. This may be attributed to changes that may have taken place due to overexploitation of the forest, affecting the species distribution. Simpson evenness represents the degree to which individuals are split among species with low values indicating that one or a few species dominates and high values indicating that relatively equal numbers of individuals belong to each species (Morris *et al*., 2014). Many studies have shown that tropical woodlands usually have Shannon-Wiener index values between 1.5 and 3.5 (Savadogo *et al.*, 2007). Ecosystems with Shannon-Wiener index greater than two are considered medium to highly diverse in species (Giliba *et al*., 2011). Thus, the South Nandi forest falls in a forest with high diversity (Maua *et al*., 2020).

Jaccard's similarity coefficient showed a range between 0.35 and 0.47, with the higher figure indicating higher floristic similarities. There was a significant difference between sites near Chepkumia, Ngerek, and Serem-Chebilat villages compared to the mean of all sites combined. The Jaccard similarity index in this study was higher than that reported by Girma (2011), who got incidence based Jaccard of 0.25.

Density

Bonjoge forest site had the highest woody plants, whereas Chebilat had the lowest (Table 18). The average density for all the seven sites was 537.3±74.8 stems/ha. A significant difference was noted between the densities in the DBH categories ($F_{(2, 20)} = 16.84$, $p = 0.00033$). For instance, between DBH class 2-10cm and DBH class > 20cm; and also between DBH class 2-10cm and DBH class >10- 20cm at p=0.05 level. There was no significant difference in density between the sites ($F_{(6,20)} = 0.34$, $p=0.97$).

The density of individuals with DBH (2-10.0 cm) was 299 stems/ha, and individuals with 10-20 cm were 123 stems/ha and the other DBH sizes in South Nandi Forest (Table 18). The ratio of individuals with 10-20 cm (a) to DBHs over 20cm (B) was 0.93. This implies the proportion of medium-sized individuals and individuals more significant than 20cm are more or less the same. Trees with the largest diameters were *Schefflera volkensii* (223.0 cm), *Ficus thonningii* (200.0 cm), *F. sur* (159.2), *Prunus africana* (132.0 cm), *Polyscias fulva* (118.9 cm), and *Trilepisium madagascariense* (106.0 cm).

Table 18: Density of trees/shrubs by DBH class at various forest sites adjacent to the village

DBH class (cm)	Forest site adjacent to the village Chepkongony	Bonjoge	Serem - Chebilat	Chepkumia	Ngerek	Chebilat	Moro-ngiot	Mean±S.D.
2 -10	193	453	330	260	367	200	290	299±93[a]
>20	217	37	120	150	97	120	120	123± 54[b]
>10 - 20	133	153	157	57	103	117	87	115±36[b]
Density/site	543	643	607	467	567	437	497	537.3±74.8

NB. Values with different letters in superscripts indicate significant difference at p <0.05 level

The stem density in this study was low compared to the results of other tropical forests. For example, studies in two forests in Ethiopia; 709 stems/ha for Berbere Afromontane forest and Asabot Afromontane forest had a density of 876 stems/ha (Tura *et al*., 2017). However, the study area's stem density was higher than the stem density of Kakamega forest, which was 357-582 stems/ha (Mutiso *et al*., 2013). An interesting observation from Mutiso et al. (2013) was that disturbed transects had higher stem density than undisturbed sites. A similar case was noted in this study as Bonjoge site, which was more disturbed than other sites, recorded the highest density of woody plants.

DBH class distribution

The general trend of the density of woody plant species against DBH size showed an inverse –J shape (Figure 15). As much as the diameters of all woody plant species combined gave Inverse – J curves, a more accurate interpretation of the forest is achieved when individual woody species are investigated. For example, the DBH characteristics of some of the tree species mentioned by forest adjacent households as having more than ten uses were analyzed to check the DBH distribution (Appendix 4).

Appendix 4 shows all the species cited during FGD by informants; plants with a single-use were 16 (12.50%); over two uses were 101 out of 128 (78.90%), and those whose use was unknown to the informants were 11 (8.6%) plant species. Most of the plants had multiple uses, with over 44 (34.38%) plant species mentioned having over five uses as NTFPs. The highest number of uses from a single plant was 14; Syzygium guineense and Allophylus abyssinica. The analysis of individual species gave a clear view of the species' status in the forest (Table 19 and Figure 15), and the level of exploitation may be linked to their multiple uses.

Table 19: Status of selected tree species in South Nandi forest

No.	Species	Status
1	*Syzigium guineense*	Had few individuals in DBH class 1 and not represented in other classes
2	*Allophylus abyssinicus*	Tended towards inverse –J shape but not represented from DBH class 7
3	*Tabernaemontana stapfiana*	Tended towards inverse –J shape but with few individuals in DBH class 1
4	*Cordia abyssinica*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
5	*Olea capensis*	Represented only in DBH class 1 and 8
6	*Albizia gummifera*	Poorly represented; only in DBH class 1 and 2
7	*Strombosia scheffleri*	Tended towards inverse –J shape but not represented from DBH class 6
8	*Chionanthus mildbraedii*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
9	*Cassipourea ruwensorensis*	Represented by few individuals up to DBH class 3
10	*Prunus africana*	Germinated seedlings were abundant but these were didn't transit into other DBH classes
11	*Fagaropsis angolensis*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
12	*Zanthoxylum gilletti*	Only represented in DBH class 1 and 2
13	*Celtis mildbraedii*	Tended towards inverse –J shape but not represented in DBH classes 5, 7 and 10
14	*Maytenus heterophylla*	Not encountered during assessment but was mentioned during FGD as key NTFP tree
15	*Diospyros abyssinica*	Represented by few individuals up to DBH class 5
16	*Drypetes gerrardii*	Tended towards inverse –J shape but not represented from DBH class 8
17	*Trilepisium madagascariense*	Germinated seedlings were abundant but poorly represented in other DBH classes
18	*Casearia battiscombei*	Tended towards inverse –J shape but not represented from DBH classes 6
19	*Croton megalocarpus*	Tended towards inverse –J shape only missing individuals in DBH class 10
20	*Macaranga kilimandscharica*	Tended towards inverse –J shape but had few individuals in DBH class 1
21	*Maesopsis eminii*	Represented only in DBH class 1
22	*Mimulopsis arborescens*	Represented only in DBH classes 1and 2
23	*Ficus sur*	Represented in all DBH classes except 5 and 8 but didn't show inverse – J shape
24	*Neoboutonia macrocalyx*	Tended towards inverse –J shape only missing individuals as from DBH class 5
25	*Polyscias fulva*	Represented in all DBH classes except 1 but doesn't form an inverse –J shape
26	*Solanum mauritianum*	Represented only in DBH classes 1and 2

The DBH class distribution showed an inverse-J curve with most individuals in the lower DBH class when all woody species were combined, suggesting that SNF is a healthy forest with active regeneration and new individuals (Jew *et al*., 2016).

However, some studies have challenged the reliance on inverse-J distributions in forest management based on a biologically unrealistic assumption of equal mortality among size classes (Isango, 2007). Virillo *et al*. (2011) argue that declining populations may also show classic inverse-J curves, and some stable populations may not show that shape due to differences in growth rates among size classes.

Impact of extraction on DBH class distribution

In this study, the DBH class distribution of individual species which the forest adjacent households had mentioned as having more than ten uses showed the following characteristics:

i. *Syzygium guineense, Olea capensis, Albizia gummifera, Fagaropsis angolensis, Zanthoxylum gilletti, Trilepisium madagascariense,* and *Prunus africana* had not been represented in some DBH classes suggesting that it has been overexploited in South Nandi forest (Figure 15). It shows the impact of extraction on the population of these species, possibly due to the numerous uses as shown in Appendix 4;

ii. *Cordia abyssinica, Chionanthus mildbraedii,* and *Maytenus heterophylla* was not encountered during the survey indicating that these species are now rare in the forest, possibly due to overexploitation by the forest adjacent households. This shows that if NTFPs are exploited without periodic assessments and following sustainable forest management principles, then there is a risk of losing some species in this forest;

iii. *Allophylus abyssinicus, Tabernaemontana stapfiana, Strombosia scheffleri, Drypetes gerrardii, Celtis mildbraedii, Casearia battiscombei, Croton* *megalocarpus*, and *Macaranga kilimandscharica* tended towards an inverse-J curve indicating a stable population; and

iv. Ficus sur and Polyscias fulva were represented in almost all DBH classes but did not show an inverse-J curve suggesting a case of a stable population that ignores the inverse-J shape as argued by Virillo *et al*. (2011).

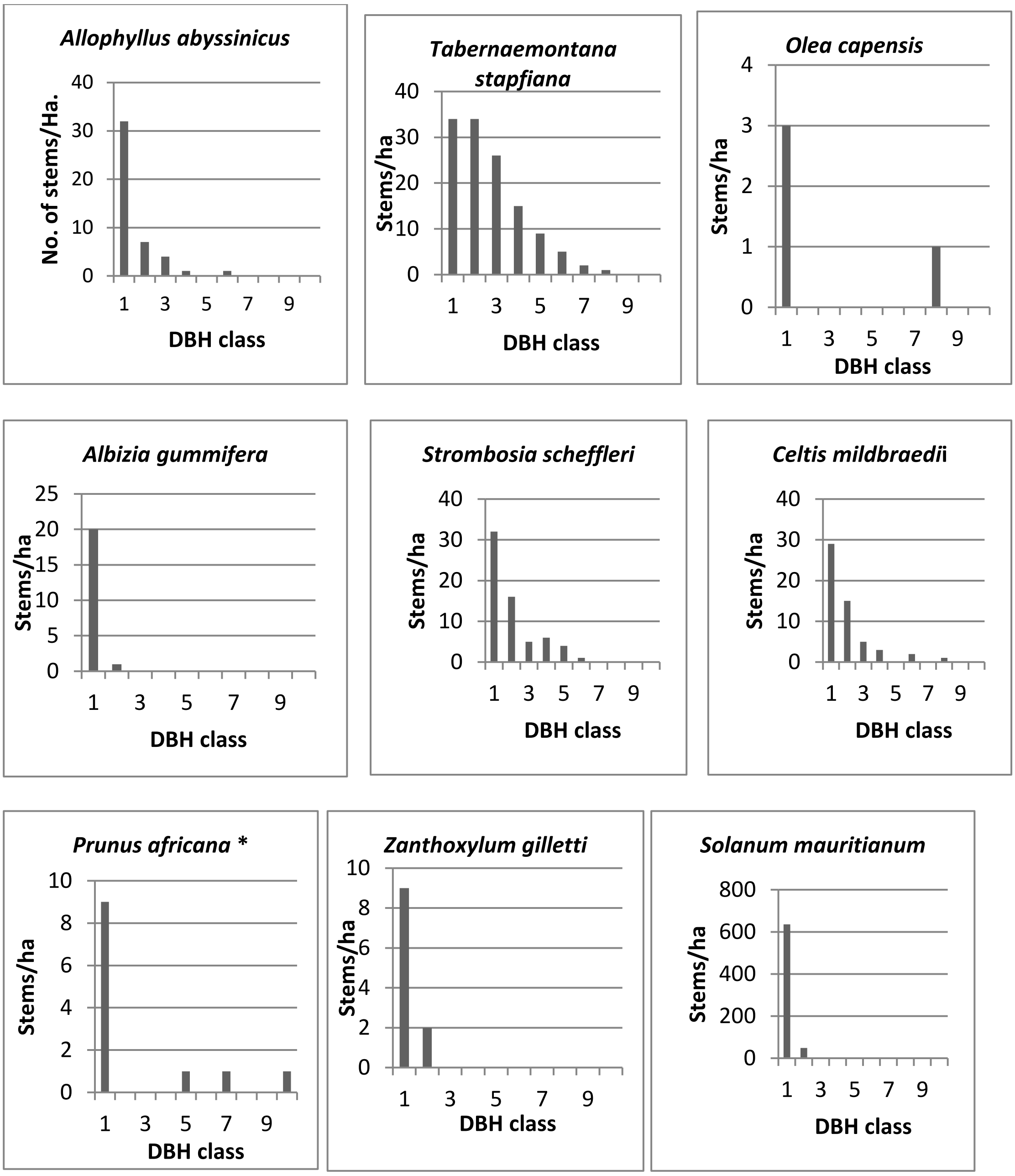
All in all, five patterns emerged from DBH class distributions in this study, for example, a classic inverse-J curve where the woody plant species had good regeneration- this showed a high number of individuals in the lowest DBH class followed a reduction in the number of individuals in the progressive DBH classes. The other four patterns emerged as a result of removing trees in various DBH classes, which in turn distorted the inverse-J curves suggesting a disturbance in the forest (Maua *et al*., 2020). It was likely that anthropogenic activities such as firewood extraction, grazing, and poles for construction and cottages industries contributed to the distortions in the inverse-J curves.

Basal Area

The Basal Area from the sample plots ranged from 3.6 to 13.6 m^2ha^{-1} while for the whole forest, it was 54.9 m^2ha^{-1}, which was comparatively higher than results from similar studies such as 21.3 m^2 ha^{-1} in Mau (Kinyajui, 2009); Mau Forest complex 17 m^2 ha^{-1} (Blackett, 1994) and South Nandi 32.1 m^2 ha^{-1} (Girma, 2011). The difference in these results could be due to species site differences, temporal differences, and weather changes over the years. The ten most dominant tree species that contributed about 82.9% of the total Basal area; were *Polyscias fulva* (16.1%), *Tabernaemontana stapfiana* (12.4%), *Ficus sur* (11.9%), *Croton megalocarpus* (9.1%), *Schefflera volkensii* (7.9%), *Macaranga kilimandscharica* (6.5%), *Ficus thonningii* (5.7%), *Strombosia Scheffleri* (3.7%), *Prunus africana* (3.4%), *Celtis mildbraedii* (3.2%) and *Trilepisium madagascariense* (3.1%). It has been stated that basal area provides a better measure of species' relative importance than simple stem count (Lamprecht, 1989). Analysis of the number of individuals by basal area revealed that for some species, the largest contribution came from even a single tree (*Ficus thonningii*) and two trees in the case of *Schefflera volkensii*. Thus the largest basal area does not necessarily have to come from species with the largest density, but the diameter size matters most.

4.4.1.3 Status of forest sections adjacent to the villages

The inverse - J curves on the forest structure fitted very well (R2 > 0.88) at all sites except in Bonjoge area (Figure 11), and when the stems/ha were inversely transformed, it showed similar results except that of Bonjoge area equation did not fit well (Figures 12 and 13).



*Seedling count for *Prunus africana* was 20,214 but very few transit to saplings stage

Figure 11: Diameter at breast height (DBH) frequency distribution of some tree species at South Nandi Forest and all species combined.

Note DBH class: 1= < 10cm; 2=10-20cm; 3=20-30cm; 4=30-40cm; 5=40-50cm; 6=50-60cm; 7=60-70cm; 8=70-80cm; 9=80-90cm; and 10=>90cm.

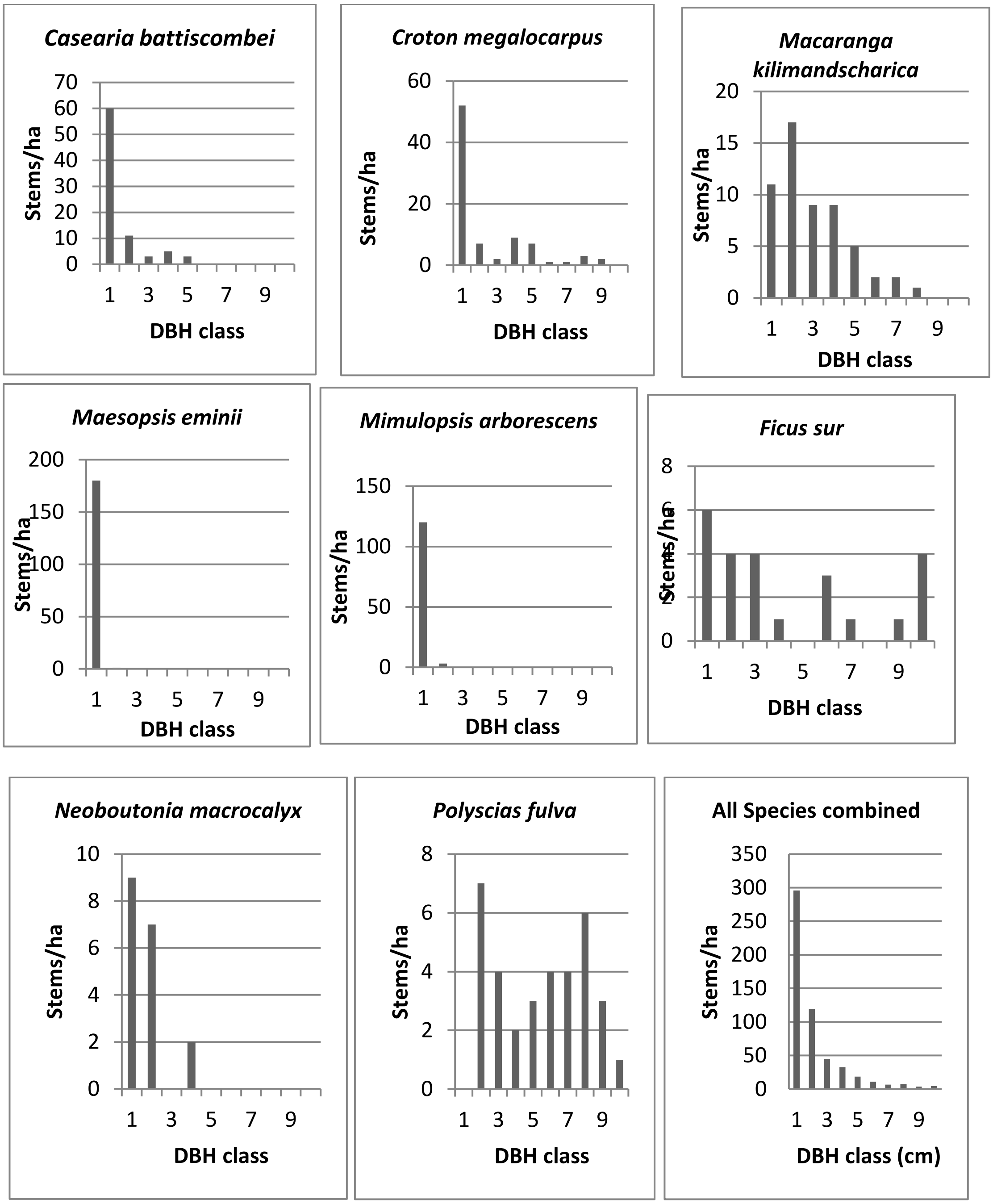


Figure 11: Continued: Diameter at breast height (DBH) frequency distribution of some tree species at South Nandi Forest and all species combined.

Note DBH class: 1= < 10cm; 2=10-20cm; 3=20-30cm; 4=30-40cm; 5=40-50cm; 6=50-60cm; 7=60-70cm; 8=70-80cm; 9=80-90cm; and 10=>90cm

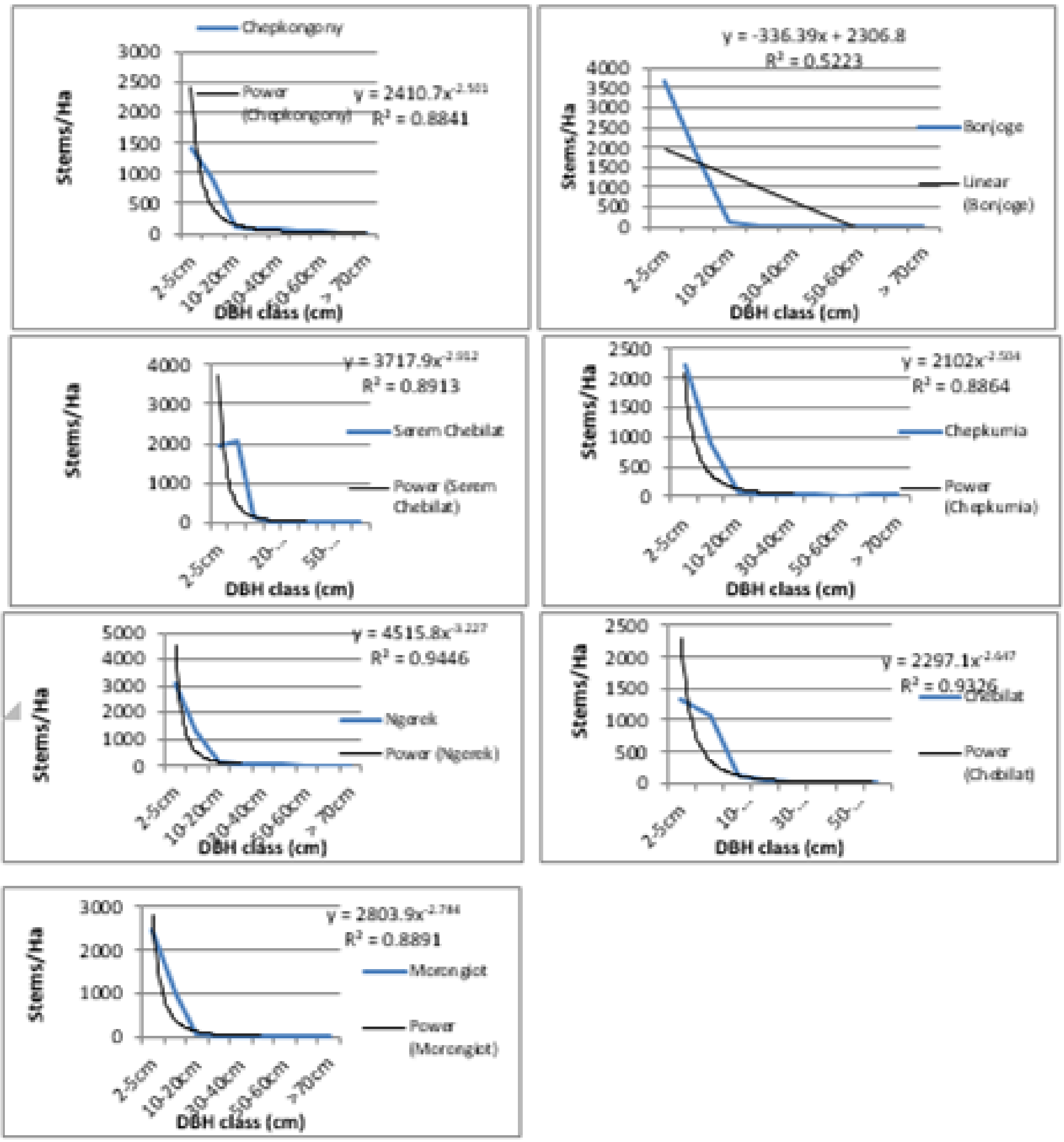


Figure 12: Inverse J forest structure curves for the forest areas adjacent to 7 villages

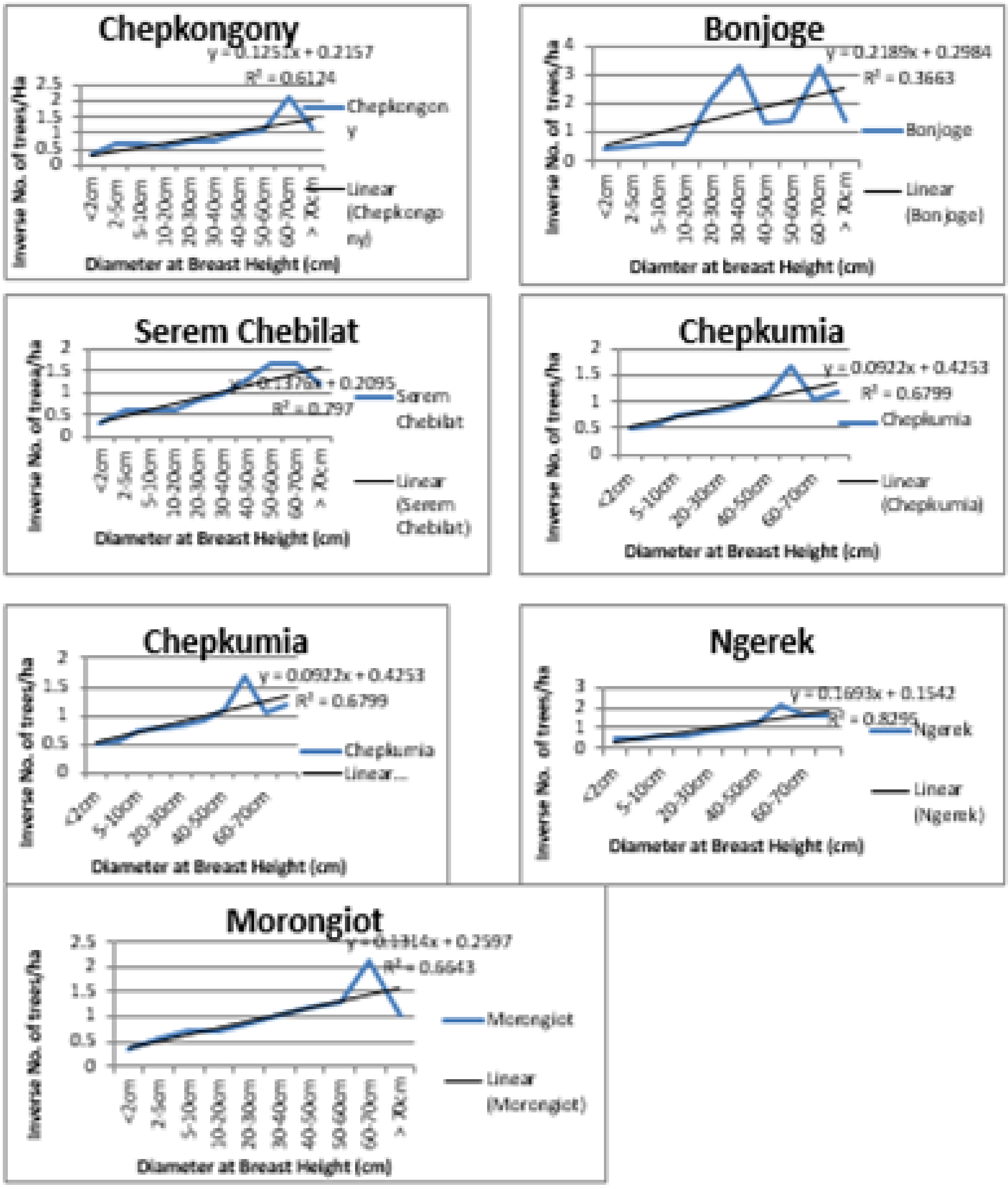


Figure 13: Inverse transformed trees/ha in forest areas adjacent to the villages in SNF

Height class distribution

There was a significant difference in the number of stems/ha between height classes ($F_{(4,34)}$ =13.86; p = 0.000005). However, there was no significant difference in stems/ha between the forest sites (Table 20). All individuals' height class distribution showed more or less an inverse – J shape just as the DBH class distribution; however, there were fewer individuals with less than 2m. A higher proportion (41.7%) of woody plants had a height of between 6m. to 15m.; followed by individuals with less than 6m height (38.1%); over 15m to 30m (14.3%), whereas individuals with over 30m in height were 9.1% of all the woody plants (Figure 14). This implies that 79.8% of woody plants in the South Nandi forest are dominated by plants of up to 15m in height. The domination of the forest (79.8%) with woody plants of less than 15m in height suggests small-sized individuals' dominance. Some authors reported similar results and argued that it could be due to a high rate of regeneration and high mortality rate of large-sized individuals, which is also a characteristic of stable size distribution common in natural forests (Endris *et al.*, 2017). In South Nandi forest, the low density of trees could also be attributed to the removal of such trees due to anthropogenic disturbances (Figure 15) such as illegal logging (pit sawing) and charcoal burning; reported to be common in Nandi forests (Maua *et al.*, 2020).

Table 20: Density of individual stems by height class (m) in different sites adjacent to villages in South Nandi Forest

Height class (m)	Density/ forest site adjacent to village							Stems/ha (Mean ± S.D.)
	Chepkon -gony	Bonjoge	Serem - Chebilat	Chepkumia	Ngerek	Chebilat	Morongiot	
>6 -15	173	323	310	117	183	227	143	211 ±80 [a]
>2 – 6	57	260	143	197	280	167	267	196 ±81 [a]
>15-30	130	27	113	77	77	37	77	77 ±37 [b]
>30	177	27	40	67	20	3	7	49 ±60 [b]
<2	7	7	0	10	7	3	3	5 ±3 [b]

NB. Values with different letters in superscripts indicate significant difference at $p < 0.05$ level

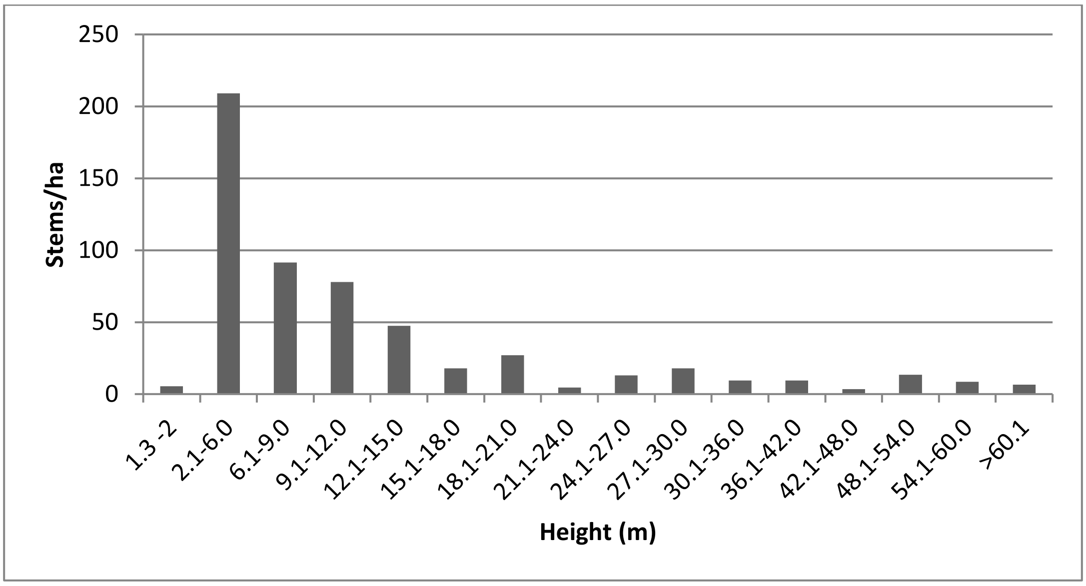


Figure 14: Density of individual stems by height class (m) in South Nandi Forest

a) b) c) d)

Figure 15: "Photographs showing anthropogenic activities in South Nandi Forest
a and b:Grazing in the forest-cow with a bell fixed on its neck to enable owner trace it in the forest; c: Traditional beehive set on a tree in the forest; d:making of a traditional beehive from trunk of a tree;

Figure 15 contd.

e: An enumerator appreciating the diameter of a huge tree of *Prunus africana* f: illegal logging in the forest; g and h: firewood collection from forest; i) Nyayo tea zone around the forest to control encroachment into the forest; and j): An enumerator resting on a huge extensive climber of *Tiliacora keniensis* in the forest"(Adopted from Maua *et al.*, 2020).

Vertical structure

South Nandi Forest's vertical structure was analyzed based on the IUFRO classification scheme, categorizing the forest into the upper, middle, and lower storeys (Lamprecht, 1989). The tallest tree species in the upper storey included *Xymalos monospora, Trilepisium madagascariense, Cassipourea ruwensorensis, Croton megalocarpus, Diospyros abyssinica, Drypetes gerrardii, Deinbollia kilimandscharica, Macaranga kilimandscharica*, and *Schefflera volkensii.* The density of species in the upper storey was low, which is reflected in the ratio of density to species (Table 21). The lower storey comprised about 61.9% of all species and 84.0% of the overall density. There was a significant difference between the species number, and the density is lower and middle storey and in the upper storey. However, there was no significant difference between species in the middle and upper storey.

Table 21: The vertical structure of trees in the South Nandi forest

Storey	Height (m)	Density/ha (A)	Density %	Species number (B)	Species %	Ratio of A to B
lower	< 21.7	440 [a]	84.5	60[a]	61.9	7.3:1
Middle	21.7 - 43.3	51 [b]	9.8	19[b]	19.6	2.7:1
Upper	> 43.3	30 [b]	5.7	18[b]	18.5	1.7:1

NB. Values with different letters in superscripts along the column indicate significant difference at p <0.05 level

Forest vertical structure is important as it indicates a forest's diversity and vitality (Kwon *et al.*, 2017). For instance, a species with regular vertical distribution appears in the three storeys in the IUFRO classification scheme (Lamprecht (1989). In SNF, some of the species which were recorded in the three storeys included *Cassipourea ruwensoriensis, Casearia battiscombei, Croton megalocarpus, Celtis mildebraedii Drypetes gerrardii, Ficus sur, Tabernaemontana stapfiana, Polyscias fulva,* *Trilepisium madagascariense*, and *Macaranga kilimandscharica*. These are the species whose natural regeneration is assured and a sustained yield may be expected. Some species were found only in the lower storey and upper story and not in the middle storey; others only in the upper storey, while some only in the lower story. Those species which only occur in the upper storey suggest a case of a natural regeneration that is threatened requires assisted regeneration to avoid local extinction.

Status of regeneration in South Nandi Forest

There was a significant difference in the regeneration categories of woody plant species $F_{(4,\ 34)}$= 10.25, p= 0.00005; however, there was no significant differences between forest sites $F_{(6,34)}$ = 0.93, p = 0.49 (Figure 16).

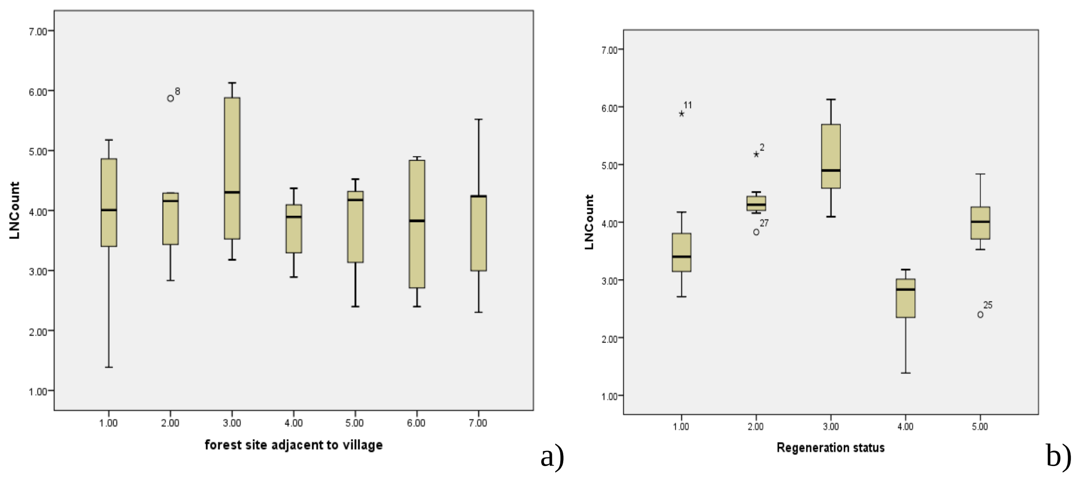


Figure 16 : "Boxplot showing LN(plant count) in: (a) forest sites adjacent to villages
1=Bonjoge, 2=Chebilat, 3=Chepkongony, 4=Chepkumia, 5=Morongiot, 6=Ngerek, and 7=Serem-Chebilat; (b) Shows the regeneration status- 1=Fair, 2=Good, 3=New, 4=None, and 5=Poor.

The means comparisons showed that there was a significant difference between "new" regeneration and "poor" categories, between "new" regeneration and "fair" regeneration categories, and also between "new" regeneration and "none" regeneration categories. There was also a significant difference between "poor" regeneration and “none” categories. The various regeneration categories accounted for: "none" regeneration (3.0%); "poor" regeneration (13.2%); "fair" regeneration (17.4%); and "good" regeneration (19.2%) and "new" regeneration (47.2%). Overall, the total density of seedlings (87,257 individuals/ha) was higher than the saplings (1870 individuals/ha) and mature trees (239 individuals/ha). The species which exhibited “none” regeneration constituted about 11% of woody plant species encountered during the transect walk, that is, no seedlings or saplings recorded but with some trees (Table 22, Appendix 14).The species with “poor” regeneration were about 16% of woody plant species encountered during the assessment (Table 22).

The following species had “good” regeneration and constituted about 21% of the woody plant species: *Bersama abyssinica, Casearia battiscombei, Cassipourea ruwensorensis, Celtis africana, Celtis mildbraedii, Croton megalocarpus, Diospyros abyssinica, Markhamia lutea, Solanecio mannii, Solanum mauritianum, Strombosia scheffleri, Tabernaemontana stapfiana, Xymalos monospora, Trilepisium madagascariense, Trichia emetica, Heinsenia diervilleoides,* and *Drypetes gerrardii*.

The species that showed “fair regeneration” were about 6% of the woody plant species encountered during the assessment. These were *Polyscias fulva, Maesa lanceolata, Macaranga kilimandscharica, Dracaena laxissima,* and *Allophyllus* spp.

The species described as “new” regeneration were present at the seedling or sapling stage but without adult stage representation. They comprised 45% of woody plant species encountered during the assessment. These were *Vernonia amygdalina, Vangueria madagascariensis, Turraea holstii, Triumfetta brachyceras, Teclea nobilis, Syzigium guineense, Rytigynia bugoyensis, Rawsonia lucida, Psidium guajava, Piper* *capense, Phytolacca dodecandra, Pavetta abyssinica, Pafornia urens, Ocimum kilimandscharica, Nuxia congesta, Lobelia gibberoa, Lepidotrichilia volkensii, Lantana camara, Keetia gueinzii, Justicia japonica, Erythrococca bongensis, Dovyalis macrocalyx, Dombeya torrida, Deinbollia kilimandscharica, Coffea eugenioides, Clausena anisata, Clerodendrum johnstonii,* and *Acanthus eminens*.

The pattern of population dynamics of seedlings, saplings, and mature trees species can exhibit the regeneration profile used to determine their regeneration status (Khan *et al.*, 1987; Malik and Bhatt, 2016). The species showing no or low regeneration comprised a remarkable 26 % of all woody plant species. Some of the reasons for no or low regeneration include unfavorable environmental conditions such as rocky land and poorly developed soil and anthropogenic disturbances, particularly livestock grazing (Zegeye *et al*., 2011).

New regeneration was the species that had individuals in seedling and sapling stages but no mature trees. One reason for this kind of pattern is that all mature trees had been overexploited since some species falling in this group have been known to have mature trees in this forest in the past, for instance from a floristic survey (Njunge and Mugo, 2011); these include species such as *Syzigium guineense, Lepidotrichilia volkensii,* and *Dombeya torrida*. The other reason could be that some of these species are new in the study area, and seeds have been brought by dispersal agents such as birds and animals, subsequently getting favorable sites to germinate and thrive.

Overall, with the changing lifestyles and overexploitation of forests due to population increase, change of land-use among other factors; negative impacts can result on the forest ecology, including local extinction of some medicinal plants, reduction of plant stock, disruption of regeneration, and loss of nutrients in harvested materials (Peters *et al*., 1989; Murkherjee and Chaturvedi, 2017). Other factors that may affect woody plant extraction's sustainability are the collection of premature plants, grazing, forest fires, and soil erosion. Therefore, all stakeholders should make deliberate efforts to ensure that these multipurpose plants are used sustainably. This plan should outline management strategies that contribute to the conservation of the forest, such as enrichment planting/protection of the species from trampling by livestock and encouraging agroforestry, private forestry, and growing of NTFPs outside the gazetted forests. The main stakeholders include the local community, County governments, Kenya Forest Service, herbalists, and environmentalists. A quick conservation and management action is required to prevent the plants from local extinction.

Table 22: Woody species that had none or poor regeneration in 7 forest sites within South Nandi forest.

Regeneration category	Woody species per forest sites adjacent to villages						
	Serem-Chebilat	Bonjoge	Chepkongony	Chebilat	Chepkumia	Morongiot	Ngerek
None	fs, ds, ec, os, se	cb, sc	ts, fs, cm, ka, zg	cm, ec, sm, hm, fs, ha, nm	ca, mk, cm, pf, sv	fs, cb, sm, ec, ml, nm, ca, sc	cg, aa, ba,cb, cma, ml, oc
Poor	ma, cb, cm, ba, nm, ca, zg	ba, cg, cv, cm, dg, ea, fa, lv, mk, ma, ra, sv, sm, ts, va, zg	xm, nm, ba, ec, dk, eb, ag, cv, kg, rl, ra, vr, va	ma, ts, cm, ag, cma, dt, dg, la, ml, nc, pg, zg, ca, can, cv, os, pa, tb	Cb, cm, lv, fs, th, zg, rl, ss, tn, va, ba, can, ec , ml, oc, rb, sg, vr	Eb, cr, ba	sma, mk, ts, al, cm, os, ha, va, xm, lv, nm, se, bm, ec, ka, sg

The codes for the abbreviations in the table are: *ag=Albizia gummifera, aa=Aningeria altissima, ba=Bersama abyssinica, bm=Bridellia micrantha, cb=Casearia battiscombei,ca=Celtisafricana, cg=Celtis gamphophylla, cm=Celtis malbraedii, can=Clausena anisata, cv=Clerodendrum volkensii, cma=Croton macrostachyus, cm=Croton megalocarpus, dt=Dombeya torrida, ds=Dracaena steudneri, dg=Drypetes gerrardii, ea=Ehretia albacea, ec=Ehretia cymosa, eb=Erythrococca bongensis, fs=Ficus sur, ha=Hippocratea africana, hm=Harungana madagascariensis, kg=Keetia gueinzii, ka=Kigelia africana, lv=Lepidotrichilia volkensii, mk=Macaranga kilimandscharica, mla=Maesa lanceolata, ml=Markhamia lutea, nm=Neoboutonia macrocalyx, oc=Olea capensis, os=Oncoba spinosa, pf=Polyscias fulva, pa=Prunus africana, ra=Ritchiea albersii, rl=Rawsonia lucida, sv=Schefflera volkensii, se=Shirakiopsis elliptica, sm=Solanecio mannii, sma=Solanum mauritianum, sc=Spathodea campanulata, ss=Strombosia scheffleri, sg=Syzygium guineense, ts=Tabernaemontana stapfiana, th=Turrea holstii, xm=Xymalos monospora, zg=Zanthoxylum gillettii*

Importance value index (*IVI*) of dominant species per site

Appendices (7-13) shows the dominant species in forests adjacent to the villages; *Tabernaemontana stapfiana* was among the top four dominant species in five out of the seven sites, followed by *Solanum mauritianum* and *Polyscias fulva* in four out of the seven sites, whereas *Croton megalocarpus* was dominant in three sites out of the seven sites. When the species from all sites were combined, the IVI indicated the top ten dominant species as *T. stapfiana, Polyscias fulva, Macaranga kilimandscharica, Ficus sur, C. megalocarpus, S. mauritianum, Strombosia scheffleri, Celtis* *mildbraedii, Casearia battiscombei,* and *Schefflera volkensii* (Table 23). These ten species accounted for 60.89% of the total IVI's cumulative value; the remaining species accounted for 39.11% of the IVI.

In terms of conservation, species with low IVI require high conservation approaches thus should be prioritized for conservation. Some of the species which should be prioritized for conservation due to their low IVI include *Albizia gummifera, Kigelia africana, Oxyanthus speciosus, Markhamia lutea,* and *Olea capensis.* Even though the above species in South Nandi Forest currently do not fall on the red list, i.e., according to the IUCN criteria of threatened species (IUCN, 2017), they need to be managed the principles of sustainable forest management. Detailed principles of sustainable harvesting of NTFPs are discussed in a report by Turner (2001); she points out five areas that forest managers should consider as general factors, ecological and biological factors, harvesting factors, and cultural and social, and also marketing and economic factors.

Table 23: Importance value index (IVI) of the dominant tree species in South Nandi forest

Family	Species	NOI	BA	F	RD	RDO	RF	IVI	% IVI
Apocynaceae	*Tabernaemontana stapfiana*	92	6.82	100	18.29	12.43	4.10	34.82	11.61
Araliaceae	*Polyscias fulva*	34	8.82	100	6.76	16.06	4.10	26.92	8.97
Euphorbiaceae	*Macaranga kilimandscharica*	45	3.59	100	8.95	6.55	4.10	19.59	6.53
Moraceae	*Ficus sur*	18	6.51	100	3.58	11.86	4.10	19.54	6.51
Euphorbiaceae	*Croton megalocarpus*	31	4.99	100	6.16	9.09	4.10	19.35	6.45
Solanaceae	*Solanum mauritianum*	50	0.59	100	9.94	1.08	4.10	15.12	5.04
Strombosiaceae	*Strombosia Scheffleri*	32	2.04	100	6.36	3.72	4.10	14.18	4.73
Ulmaceae	*Celtis mildbraedii*	26	1.73	100	5.17	3.15	4.10	12.42	4.14
Salicaceae	*Casaeria battiscombei*	22	1.30	100	4.37	2.37	4.10	10.84	3.61
Araliaceae	*Schefflera volkensii*	2	4.31	40	0.40	7.86	1.64	9.89	3.30
Euphorbiaceae	*Drypetes gerrardii*	15	1.52	80	2.98	2.76	3.28	9.02	3.01
Sapindaceae	*Allophyllus abyssinicus*	13	0.61	100	2.58	1.11	4.10	7.80	2.60
Myrsinaceae	*Maesa lanceolata*	13	0.86	80	2.58	1.57	3.28	7.43	2.48
Moraceae	*Ficus thonningii*	1	3.14	20	0.20	5.72	0.82	6.74	2.25
Rosaceae	*Prunus africana*	4	1.87	40	0.80	3.40	1.64	5.83	1.94
Moraceae	*Trilepisium madagascariense*	5	1.70	40	0.99	3.09	1.64	5.73	1.91
Asteraceae	*Solanecio mannii*	9	0.14	80	1.79	0.25	3.28	5.32	1.77
Boraginaceae	*Ehretia cymosa*	8	0.17	80	1.59	0.30	3.28	5.17	1.72
Euphorbiaceae	*Neoboutonia macrocalyx*	9	0.30	60	1.79	0.54	2.46	4.79	1.60
Melianthaceae	*Bersama abyssinica*	6	0.16	80	1.19	0.29	3.28	4.77	1.59
Monimiaceae	*Xymalos monospora*	7	0.21	60	1.39	0.37	2.46	4.23	1.41
Ulmaceae	*Celtis africana*	4	0.44	60	0.80	0.79	2.46	4.05	1.35
Ebenaceae	*Diospyros abyssinica*	6	0.62	40	1.19	1.13	1.64	3.96	1.32
Rutaceae	*Zanthoxylum gillettii*	4	0.04	60	0.80	0.08	2.46	3.33	1.11
Meliaceae	*Trichilia emetica*	3	0.05	60	0.60	0.09	2.46	3.14	1.05
Ulmaceae	*Celtis gamphophyla*	8	0.12	20	1.59	0.21	0.82	2.62	0.87
Rhizophorace	*Cassipourea*	4	0.08	40	0.80	0.14	1.6	2.58	0.86

ae	*ruwensoriensis*						4		
Acanthaceae	*Mimulopsis arborescens*	4	0.05	40	0.80	0.09	1.64	2.52	0.84
Bignoniaceae	*Spathodea campanulata*	2	0.22	40	0.40	0.40	1.64	2.43	0.81
Rubiaceae	*Heinsenia diervilleoides*	3	0.06	40	0.60	0.10	1.64	2.34	0.78
Euphorbiaceae	*Shirakiopsis elliptica*	2	0.06	40	0.40	0.11	1.64	2.15	0.72
Oleaceae	*Olea capensis*	1	0.46	20	0.20	0.83	0.82	1.85	0.62
Clusiaceae	*Harungana madagascariensis*	1	0.41	20	0.20	0.75	0.82	1.77	0.59
Sapotaceae	*Aningeria altissima*	1	0.32	20	0.20	0.58	0.82	1.60	0.53
Malvaceae	*Dombeya torrida*	3	0.03	20	0.60	0.05	0.82	1.47	0.49
Asparagaceae	*Dracaena laxissima*	2	0.12	20	0.40	0.22	0.82	1.43	0.48
Bignoniaceae	*Markhamia lutea*	2	0.09	20	0.40	0.17	0.82	1.38	0.46
Cupressaceae	*Cupressus lusitanica*	1	0.12	20	0.20	0.22	0.82	1.24	0.41
	Unknown	1	0.06	20	0.20	0.11	0.82	1.13	0.38
Euphorbiaceae	*Croton macrostachyus*	1	0.06	20	0.20	0.10	0.82	1.12	0.37
Salicaceae	*Oncoba spinosa*	1	0.03	20	0.20	0.05	0.82	1.07	0.36
Celastraceae	*Hippocratea africana*	1	0.03	20	0.20	0.05	0.82	1.07	0.36
Asteraceae	*Vernonia amygdalina*	1	0.02	20	0.20	0.03	0.82	1.05	0.35
	unknown (Kipkompotiet)	1	0.02	20	0.20	0.03	0.82	1.05	0.35
Bignoniaceae	*Kigelia africana*	1	0.01	20	0.20	0.02	0.82	1.04	0.35
	Unknown2	1	0.01	20	0.20	0.02	0.82	1.04	0.35
Rubiaceae	*Oxyanthus speciosus*	1	0.01	20	0.20	0.01	0.82	1.03	0.34
Fabaceae	*Albizia gummifera*	1	0.01	20	0.20	0.01	0.82	1.03	0.34
Total		**503**	**54.9**	**2440**	**100**	**100**	**100**	**300**	**100**

(NOI = No. of individuals, BA=Basal Area, F = Frequency, RD= Relative Density, RDO=Relative dominance, RF= Relative Frequency, IVI=Importance Value Index)

4.4.1.4 Comparison of status of South Nandi Forest to hypothetical UNO (1994) model

When the study area's diameter class distribution was compared with the model for balanced structurally stable East African natural forests (UN0, 1994) in terms of density distribution per diameter class (Table 24), there was a low density per diameter class for all the seven sites sampled. This indicates that the South Nandi Forest structure has been declining, though, at the moment, it is not significantly different from the structurally stable East African natural forest (Table 24).

Table 24: Densities (stems/ha) in various diameter classes of hypothetical UNO (1994) model for structurally stable East African natural forest compared with sections of South Nandi Forest

Forest section	Stems/ha in diameter class (cm)				t-value	df	p-value
	<10	**10-20**	**>20-50**	**>50**			
UNO Forest Model	**1200**	**400**	**200**	**32**			
Chepkongony	1275	40	52	13	1.2	3	0.32
Bonjoge	340	44	5	3	2.0	3	0.14
Serem Chebilat	1064	47	27	9	2.6	3	0.08
Chepkumia	168	17	31	14	1.8	3	0.17
Ngerek	262	31	24	5	1.9	3	0.16
Chebilat	240	34	29	7	1.9	3	0.16
Morongiot	787	26	24	11	2.7	3	0.07
Mean for whole forest*	**591±448**	**34±11**	**27±14**	**9±4**	**2.3**	**3**	**0.10**

NB * implies Mean ±S.D.

4.4.1.5 Perception on NTFP stock condition

The NTFP stock condition was perceived by the households to have reduced compared to ten years ago (Figure 17). The reasons for stock degradation were mainly due to increased human population and over exploitation (74%) and lack of NTFP domestication options (11%). The other reasons are shown in Figure 18.

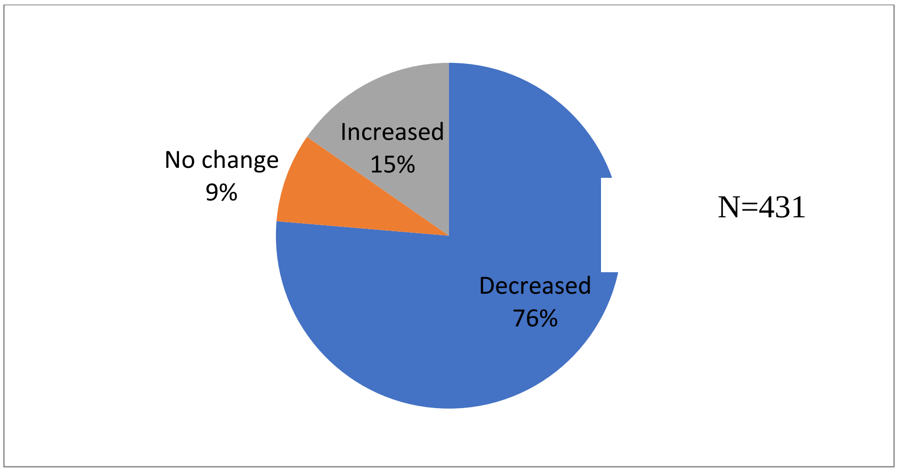


Figure 17: Perception of the households on the NTFP stock condition now compared to ten years ago.

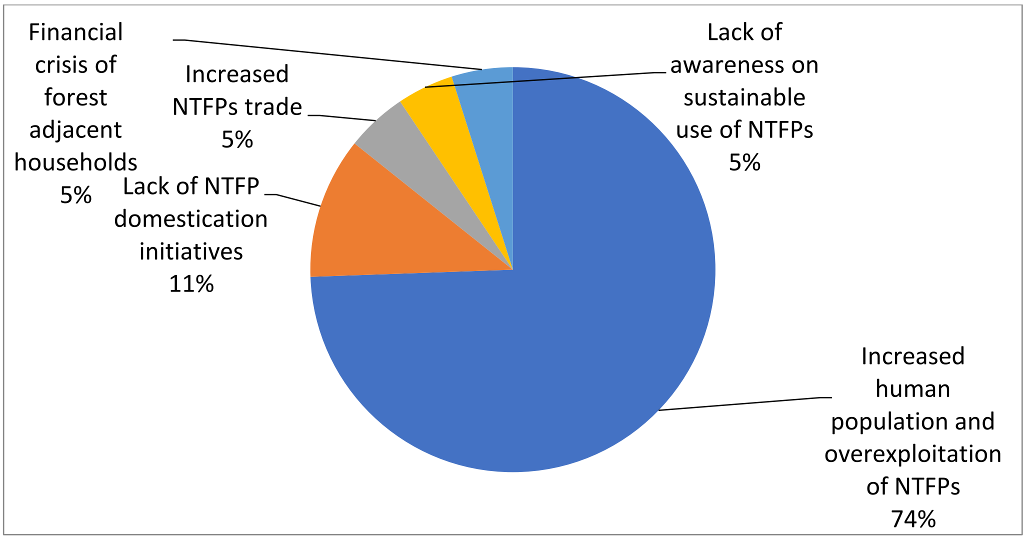


Figure 18: Reasons for degradation of NTFP stock condition in the last ten years

The NTFP Stock condition was perceived by the households to have reduced compared to ten years ago. The reasons for stock degradation were increased human population and overexploitation of NTFPs, lack of NTFP domestication initiatives, lack of awareness, increased trade in NTFP, and financial crisis in households adjacent to the forest hence over-relying on the forest resources. This finding may be linked to the current status of South Nandi Forest; when the diameter class distribution from the study area was compared with the model for balanced structurally stable East African natural forests (UN0, 1994) in terms of density distribution per diameter class (Table 24); there was low density per diameter class for all the seven sites sampled suggesting that South Nandi Forest was probably degraded. The Landsat satellite images of five land-use/land cover types between 1994 and 2008, in an area neighboring to the study area, showed that the forest cover had reduced by 17.95% (Tanui and Saina, 2015). The reduction is expected in the study area as most households in Nandi Hills and SNF is similar in utilizing the forest. The declining status of the forest had a negative impact on population structure and contributed to the declining standard of living. The main reasons for deforestation and degradation were over-exploitation of timber and NTFPs such as fuelwood, land for cultivation, and grazing in the forest.

4.5 Quantification of the annual economic value of NTFP extracted

This involved using various methods to estimate the annual economic values of NTFPs, for example, the economic value for all NTFPs combined - the indirect opportunity cost (IOC) method was used. To estimate the annual value of firewood and grazing in the forest, the direct-use value and close direct substitutes, which have market prices, were used, respectively. The Cost of collection (COC) method was used to get the net annual economic values for firewood and grazing in the forest.

4.5.1 Quantification of All NTFPs combined

This study estimated the economic value of all NTFPs extracted by the forest adjacent households from South Nandi Forest based on the IOC method, which uses the opportunity cost of labor as an approximation for the value of NTFP. Thus, species identification and NTFP quantification per use were not required, and data collection is limited to structured interviews and focused group discussions. The results gave the value of NTFP extracted per hectare per year as US$824.15 whereas the value of NTFP extracted per household per year was US$579.51, and the NPV of NTFP extraction per hectare was US$ 5795.11 (Table 25). These are the values for all NTFPs extracted combined as the IOC method assumes that the decision to spend time on NTFP collection is weighed against alternative productive labor uses (Svarrer and Olsen, 2005). Comparing the results of this study and other studies on the economic value of NTFP extraction is shown in Table 26. These results were within the range of values recorded in other studies; for example, Peters *et al*. (1989), Pearce (1998), and Bann (1999). However, some studies, such as Ruitenbeek (1989), while valuing medicinal plants in Cameroon, showed shallow monetary values per annum, possibly because other NTFPs were left out (Table 26). The findings of this study were higher than those done by Barrow *et al.* (2016). They found that the economic value of forests to forest adjacent households in some forests in Kenya was US$350-US$450 per household per annum and worth $US 100 million per annum overall (Mau forest); Kakamega forest - US$160; Arabuko Sokoke - US$ 135; US$ 213 for Mt. Kenya; US$285 for Aberdares and US$ 100 for Oldonyo Orok.

Table 25: Annual economic value of NTFP extraction per ha and per household in South Nandi Forest

Parameter	Value
Average No. of adults/hh (a)	3
Working hours/day/adult (l)	8
Yearly working days/adult (d)	225.74
Relative amount of time spent on NTFP extraction(t)	0.545
Labor wage rate, US$/hour(w)	0.42
PPP* conversion factor for 2016 for Kenya(P)	0.4673
Value of NTFP extraction, US$/ hh/year	1,240.13
Value of NTFP extraction, PPP US$/ ha/year ($V_1$)	824.15
Number of households (hh) (h)	20,479
Area used for NTFP extraction, ha (H)	14,400
Value of NTFP extraction, US$/ ha/year	0.057
Value of NTFP extraction, PPP US$/ hh/year ($V_2$)	579.51
NPV** of NTFP extraction, US$/ha	0.57
NPV of NTFP extraction, PPP US$/ha	5795.11

NB.
*PPP (Purchasing power parity) is an economic theory that compares different countries' currencies through a 'basket of goods' approach. According to this concept, two currencies are in equilibrium or at par when a basket of goods (taking into account the exchange rate) is priced the same in both countries.
** The study used a nominal social discount rate of 10% to calculate NPV of NTFP extraction

Table 26: Comparison of economic value of NTFPs extraction in South Nandi Forest with other studies

Study	**Location**	**Product/service measured**	**Monetary value (US$/year)**	**PPP value US$/ha/yr**	**PPP NPV US$/ha**
Kramer *et al*. (1995)	Madagascar	Extracted forest and farm products	91/hh	-	-
Peters *et al*., (1989)	Peru	Fruits and latex	422/ha.	776	11,647
Pearce (1998)	All tropical forests	Carbon storage	600 – 4,400/ha	-	-
Saragih (2011)	Paser, Indonesia	NTFPs	32.90/ha	-	-
Bann (1999)	Peninsular Malaysia	Various NTFPs	900/ha	2106	17,999
Gunatilake *et al*., (1993)	Sri Lanka	Various NTFPs	92/ha	340	3400
Svarrer and Olsen (2005)	Peninsular Malaysia	Various NTFPs	417/ha	41	4179
Chopra (1993)	India	Fuelwood and fodder	122	583	4723
Ruitenbeek (1989)	Cameroon	Medicinal plants	0.2-0.7/ha	-	-
Barrow *et al*.(2016)	Kenya (Mau forest, Kakamega forest, Mt Kenya forest, Aberdares forest, Arabuko Sokoke forest and Oldonyo Orok forest)	Various NTFPs	100-450/hh/yr	-	-
This study	**Kenya (South Nandi Forest)**	**Various NTFPs**	**579.5/hh/yr**	**824.15**	**5795.11**

4.5.2. Quantification of firewood utilization and monetary values

The average weight of a headload of firewood was 33.1kg ± 0.9kg. It was estimated that annual extraction per household was 7285.4 kg of firewood (Table 27). Given that the households adjacent to the forest were 49.1 % of the total households in Aldai Constituency and projected to increase to 41,708.9 by 2017 (KNBS, 2013), with 90% relying on firewood for cooking energy; the total annual extraction of firewood is estimated to be 134,278,394.3 kg valued at KES 405,674,910, note that the monthly fuelwood license is KES 100 whereas one headload of firewood has a market value of KES 100 in the local market. The gross annual direct use value for firewood utilization per household was estimated between KES 5,200 and KES 36,400 depending on firewood collection frequency (Table 27).

About 61% of the respondents took 2-3 hours to collect firewood from the forest, while 31% took 1-2 hours (Figure 19). The mean firewood collection time was 2.9 hours, and the cumulative hours/year ranged from 152.7 to 1071.6 depending on the frequency of collection by households i.e.once per week to daily firewood collection, respectively. The local labor rate per day was KES 350 for working about 8 hours. Therefore, the value of time expended per annum ranged from KES 6678.9 to KES 46,882.6 depending on the frequency of firewood extraction with a mean of KES 21,233.3 ± 1,150.9 (Table 20). Deduction of the value of time expended on the collection of firewood from the gross direct use value resulted in a negative value suggesting that firewood collection was not economical if the value of time is taken into account. It is worth noting that firewood collectors took an average of 2.9 hours to collect one headload of firewood worth KES 100. To break even, the firewood collectors should take not more than 2.2 hours to collect firewood.

Table 27: Firewood extraction by adjacent households from South Nandi Forest per annum and value of time expended

Frequency	No. of times per week	No. of hh*	Weight of firewood extracted/week (Kg)	Weight of firewood extracted/yr (Kg)	Firewood collection (Days/year)	Hours taken to collect firewood/Year	Value of time expended (KES)	Use of firewood/hh/yr (Kg)	Direct annual value/hh** (KES)	Present value (KES)
Daily	7	29	6719.3	349403.6	365	1071.6	46881.1	12048.4	36400	364000
6 times	6	5	993	51636	312	916.0	40073.7	10327.2	31200	312000
5 times	5	5	827.5	43030	260	763.3	33394.7	8606.0	26000	260000
3-4 times a week	3.5	60	6951	361452	182.5	535.8	23440.5	6024.2	18200	182000
twice a week	2	6	397.2	20654.4	104	305.3	13357.9	3442.4	10400	104000
once a week	1	11	364.1	18933.2	52	152.7	6678.9	1721.2	5200	52000
Total		116		845109.2	1275.5	3744.6				
Mean				7285.4	212.6	624.1	27304.5	7028.2		

***hh=household, **Local market price =Ksh 100/headload, Local labour rate/day =KES 350, Mean collection time= 2.9 hours**

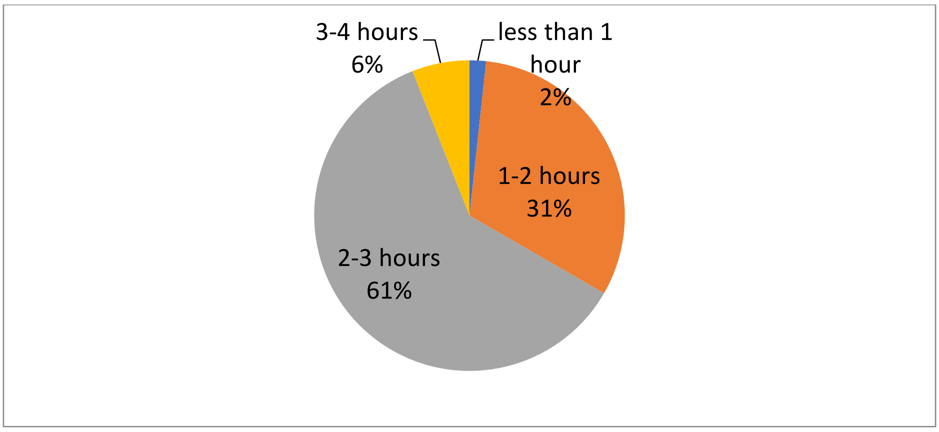


Figure 19: Time taken to collect firewood from the forest by forest adjacent households

4.5.3 Quantities of fodder consumed and monetary values

Most cattle taken to the forest are crossbreeds, which are hardy compared to pure exotic breeds. Dairy lactating dairy cows are rarely taken to the forest as walking them for long distances reduces milk production (d'Hour *et al.*, 1994). Cattle are taken to the forest in the morning and returned to the homes in the evening (about 8 hours for grazing). Some bulls are left to stay in the forest with their owners, only occasionally checking their presence and health status. Since it is difficult to calculate the value of grazing in the forest directly, the amount of fodder consumed indirectly was calculated. It has been estimated that a cow consumes dry matter at the rate of 3-4% of its body weight (The Organic Farmer, 2015). Thus a 300kg cow will require 9-12kg of dry matter per day. A survey by Wambugu *et al.* (2014) in Kaptumo Division (which is within the study area) indicated that 92% of the households owned dairy cattle, 67% chicken, 26% goats, 27% sheep, and no pigs. An estimated 24,000 cattle of these 3,000 were improved exotic breeds, 14,200 crossbreeds, and 5,000 bulls (both improved and crossbreed).

The average cattle herd per household was five, which was relatively high for smallholder farmers with an average landholding of 0.8 hectares. It was estimated that 64% of the households kept their cattle predominantly in paddocks, 21% grazed them on communal lands/forests, and 10% tethered the animals (Wambugu *et al*., 2014). The average land size used for the paddock was 0.6 hectares.

The total households in the Aldai constituency were 41,708.9 (KNBS, 2013), with those living close to the forest estimated at 49.1% (20,479.07 households) of all households. Based on the information from Wambugu et al. (2014) above, the number of livestock grazing in the forest was calculated as: (0.92 * 20479.07 * 3.4 * 0.21 = 13,452.29). The total dry-matter requirements for the livestock for the whole year from the forest were calculated as follows: {13452.29 * (9 – 12) * 365} being equivalent to 44,190,777.37 – 58,921,030.2 kg. The estimated quantities of dry matter were then converted to hay equivalent; one bale of hay with dimensions 19” * 16” * 36” weighed 25 kg and sold at Kobujoi area at between KES 300-400 and US$ 2.88 – 3.84. The hay equivalent was equal to 1,767,631.1 and 2,356,841.21 bales valued at between KES 530,289,330 (US$ 5,090,712.41) and KES 942,736,484 (US$ 9,050,154.40) whereas the equivalent economic value per household per year ranged from KES 25,894.21 to KES 46,034.15 (US$ 248.58 – US$ 441.92). The economic value of fodder at a discounted rate of 10% was therefore between KES 5,302,893,300 (US$ 50,907,124.1) and KES 9,427,364,840 (US$ 90,501,544). Table 28 summarizes gross economic value, time expended, and net economic value of grazing in South Nandi forest by forest adjacent households.

Each household had an average of 5 cows; two were dairy and therefore not taken to the forest. Thus, an average of 3 was grazed in the forest. Taking the cows for grazing and back takes 8 hours daily. That implies that in a year, the time expended on grazing is 365 days. Only 21% of the livestock are grazed on communal land and in the forest; thus, about 13452.29 animals graze daily. The cumulative time is (13452.29 *8*365/3.4) = 11,553,143.18 hours per annum. .

The net economic value for grazing cattle in the forest per annum was KES 24,839,316 to KES 437,286,470 (US$ 238,454.38 to US$ 4,197,896.38) and was positive, implying that grazing/fodder was economical when the value of time for grazing was taken into account. The annual utilization of fodder in this study was higher than those of the East Mau ecosystem, Kenya, where the use of the forest as a source of fodder was estimated to range from US$ 133.00 to US$ 200.00 per household per year (Langat *et al.*, 2016). The economic value of fodder at a discounting rate of 10% was therefore between KES 5,302,893,300 (US$ 50,907,124.1) and KES 9,427,364,840 (US$ 90,501,544).

The livestock number was determined indirectly from monthly grazing permits issued from Kobujoi Forest Station between 2005 and 2015. The amount paid for monthly grazing permits was KES 20 up to December 2008, and as from January 2009, it was increased to KES 50 for every cow grazing in the forest. Thus the number of permits issued was equivalent to the number of cows legally allowed to graze in the forest (Table 29). Comparison with estimates from the survey shows that the records from KFS were up to (13452.29 /409.6 = 46.00) times less than the actual number of cattle grazing in the forest, suggesting that only 3.05% of the households pay for the monthly grazing permits.

Table 28: Gross economic value, time expended and net economic value of grazing in South Nandi forest by forest adjacent households.

Parameter	**Value**
Gross value	
No. of households (hh)	20479.07
No. of cattle grazing in forest	13452.29
Bales of hay/yr	1,767,631.1 - 2,356,841.1
Value of hay/yr (KES)	530,289,330 - 942,736,484
Economic value/hh/yr (KES)	25,894.21 -46,034.15
Cost	
Cumulative time expended (hrs/yr)	11,553,143.18
Value of time expended/yr (KES)	505,450,014
Value of time expended/hh/yr (KES)	24,681.30
Net value	
Net economic value/yr SNF (KES)	24,839,316 - 437,286, 470
Net value/hh/yr (KES)	1212.91 -21,352.85

Table 29: Mean monthly grazing permits issued for grazing in South Nandi Forest

Year	Mean number of cows' grazing/month	Standard error
2005	32.2	15.8
2006	58.3	10.9
2007	57.5	12.6
2008	128.7	37.6
2009	126.3	29.6
2010	175.7	28.6
2011	205.3	36.3
2012	312.9	47.2
2013	281.6	26.8
2014	282.2	38.9
2015	409.6	87.2

Source: KFS records – Kobujoi Forest Station.

4.6 Socio-economic factors that influence dependence on NTFPs

4.6.1 Socio-economic characteristics of households

The socio-economic characteristics of the households are already described in sections 4.2.2 and 4.2.3.

4.6.2 Key independent and dependent variables

A contingency table was used to check internal relationships amongst the independent variables (Tables 30 and 31), which were significantly associated with patterns of independence of households on forest or factors influencing the selling of NTFPs. Only the variables that showed significant association at either 0.01, 0.05, and 0.1 levels are presented in the tables.

4.6.2.1 Household dependence on NTFPs

The village where a household lived was strongly associated with the likelihood of getting NTFPs ($\chi 2_{(9,\ 431)} = 297.313$, $p<0.001$) from the forest. Overall, 81.4% of households in the villages got NTFPs from the forest (Table 30). However, in one control village, Kemeloi, which was far from the forest, only 27.8% of its members got NTFPs from the forest, whereas in the other control village (Ndurio), all households did not get NTFPs from the forest.

The distance from the household head's house to the edge of the forest was significantly associated with getting NTFPs from the forest ($\chi 2_{(16,\ 431)} = 51.235$, $p<0.001$). Households who live closer to the forest drew more benefits than those living farther; Figure 21 shows the trend. The time spent (hours) by the household to get NTFPs determined the likelihood of going to the forest for NTFPs ($\chi 2_{(10,\ 431)} = 37.073$, $p<0.001$), as shown in Figures 21 and 22. The stock condition of the NTFP was also associated with getting NTFPs from the forest ($\chi 2_{(2,\ 431)} = 4.972$, $p<0.083$). About 86.9% of those who got NTFPs had indicated that the NTFP stock had decreased compared to ten years ago. Membership in the community forest association increased the likelihood of getting NTFPs with almost all members benefitting from the forest ($\chi2_{(1, 431)}$ =9.481, $p<0.05$); there was a high percentage (96.5%) of non-CFA members willing to join CFAs in order to benefit from the forest. Overall, there was a strong association of those willing to join CFA and getting NTFPs from the forest ($\chi2_{(1, 431)}$ =13.204, $p<0.001$).

For households who relied on the forest as a source of primary income, the findings indicated an association with collecting NTFPs from the forest ($\chi2_{(1, 431)}$ = 6.213, $p<0.05$); 16.8% of those whose derived benefits from the forest stated that NTFP was their primary source of income. The primary source of income was farming and getting NTFPs (91.1%), others such as business, self-employed, and getting NTFPs from the forest (77.8%). The number of people who rely on the forest was significant ($\chi2_{(1, 431)}$ = 6.558, $p<0.05$). There was a strong association between households selling NTFPs and getting NTFPs from the forest ($\chi2_{(1,431)}$ =10.946, $p<0.001$).

In terms of marital status, 90.5% of the married household heads'; 100% divorced and widowers; 63.6% of widowed; and 89.5% of those single got NTFPs from the forest, suggesting that the dependence on the forest was significant ($\chi2_{(4, 431)}$ = 9.980, $p<0.05$). The ethnic group dominant in the study area was Kalenjin (81.1%), followed by Luhya (17.4%). In terms of dependence on the forest for NTFPs, 98.7% and 88.5% of the Luhyas and Kalenjin households got NTFPs from the forest, respectively, and this was a significant association with getting products from the forest ($\chi2_{(4, 431)}$ = 10.850, $p<0.05$). The main occupation was also significantly associated with getting NTFPs ($\chi2_{(4,431)}$ =7.143, $p<0.05$).

This study demonstrates that 12 variables were strongly associated with the likelihood of getting NTFPs from the forest (Table 30).

Table 30: Contingency table of independent variables versus dependence of households on the forest

	No	Yes	Pearson Chi Square
Do you get NTFPs from the forest?			
1. Village**	80	351	X^2 df(9,N=431)=297.313, p<0.001)
Kiptenden	2	90	
Ndurio	38	0	
Sebetetwo	0	21	
Kamobo	3	64	
Burende	0	88	
Kemeloi	26	10	
Kaptebengwo	6	21	
Koimwe	5	37	
Chemumul	0	20	
Chepkumia	0	20	
2. Distance to forest from house**	43	388	X^2 df(16,N=431)=51.235, p<0.001)
3. Time spent collecting NTFP**	43	388	X^2 df(10,N=431)=37.073, p<0.001)
4. NTFP stock condition compared to 10 years ago**	43	388	X^2 df(2,N=431)=14.809, p<0.001)
Decreased	43	286	
No change	0	36	
Increased	0	66	
5. Membership in CFA focused on NTFP trade*	43	388	X^2 df(1,N=431)=9.481, p<0.05)
No	40	276	
Yes	3	112	
6. Would household head like to join CFA**	43	388	X^2 df(1,N=431)=13.204, p<0.001)
No	37	223	
Yes	6	165	
7. Is NTFP primary source of income*	43	388	X^2 df(1,N=431)=6.213, p<0.05)
No	42	323	
Yes	1	65	
8. What's the primary source of income*	43	388	X^2 df(1,N=431)=6.558, p<0.05)
Other (business, self employed, civil servant etc)	8	28	
Farmer	35	360	
9. If household sells NTFP	43	388	X^2 df(1,N=431)=10.946, p<0.001)
No	41	280	
Yes	2	108	
10. Marital status*	43	388	X^2 df(4,N=431)=9.980, p<0.05)
Married	35	335	
Divorced	0	5	
Widow	4	7	
Widower	0	7	
Single	4	34	
11. Ethnic group*	43	388	X^2 df(4,N=431)=10.850, p<0.05)
Kalenjin	40	309	
Luo	1	2	
Luhya	1	74	
Kikuyu	0	1	
Gusii	1	2	
12. Main Occupation*	43	388	X^2 df(4,N=431)=7.143, p<0.05)
Farmer	32	263	
Casual labor	0	10	
Civil servant	6	24	
Business	5	91	

4.6.2.2 Households selling NTFPs

The village where a household is located was strongly associated with the likelihood of selling NTFPs ($\chi2_{(9,\ 431)} = 26.842$, $p<0.001$) from the forest. Overall, 25.5% of households in the villages sold NTFPs from the forest (Table 31). However, in control villages, Kemeloi and Ndurio, which were far from the forest, only 8.3% and 2.6% of the households sold NTFPs from the forest, respectively.

The distance from households to the edge of the forest was significantly associated with selling NTFPs from the forest ($\chi2_{(16, 431)} = 89.887$, $p<0.001$). Households closer to the forest drew more benefits than those living farther (Figure 20). The time spent (hours) by households to get NTFPs determined the likelihood of selling NTFPs from the forest ($\chi2_{(10,431)} =32.190$, $p<0.001$), as shown in Figure 21.

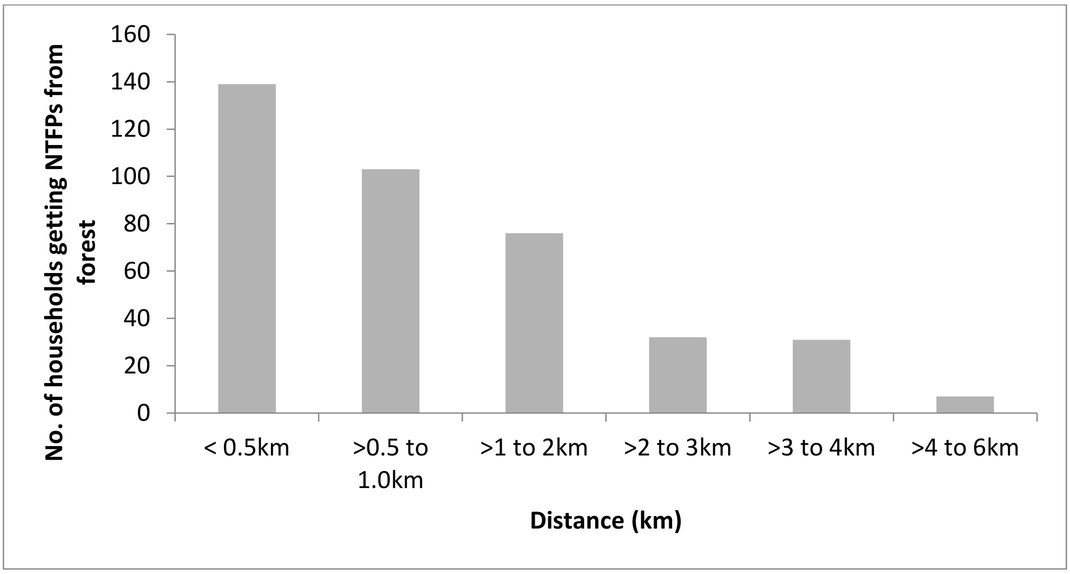


Figure 20: Trend in number of households getting NTFPs with increase in distance from forest to house

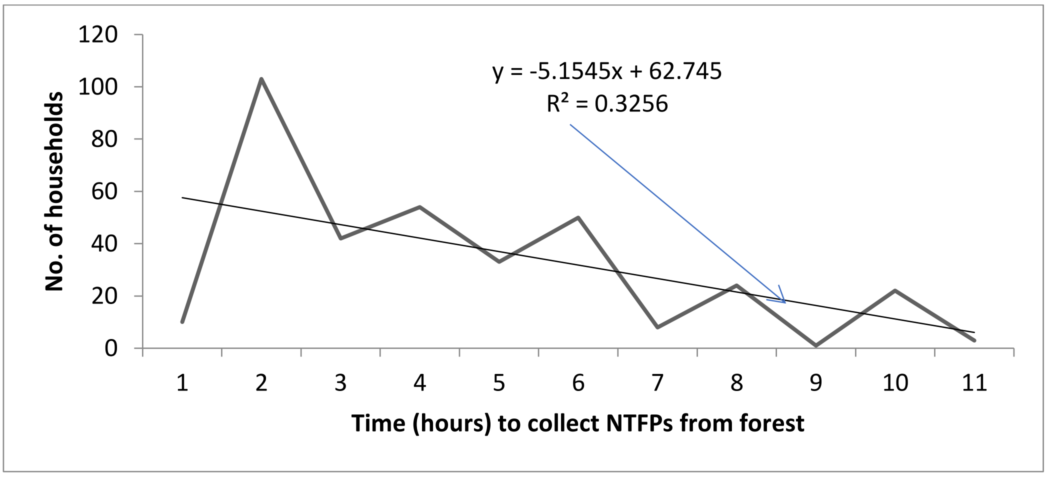


Figure 21: Number of households getting NTFPs versus time taken

The condition of the NTFP stock was weakly associated with selling NTFPs from the forest ($\chi2_{(2, 431)}$ = 4.972, p<0.083). About 73.7% of those who sold NTFPs indicated that the NTFP stock had decreased compared to ten years ago.

About 84.0% of the households had been engaged in selling NTFPs for less than 20 years (Figure 22).

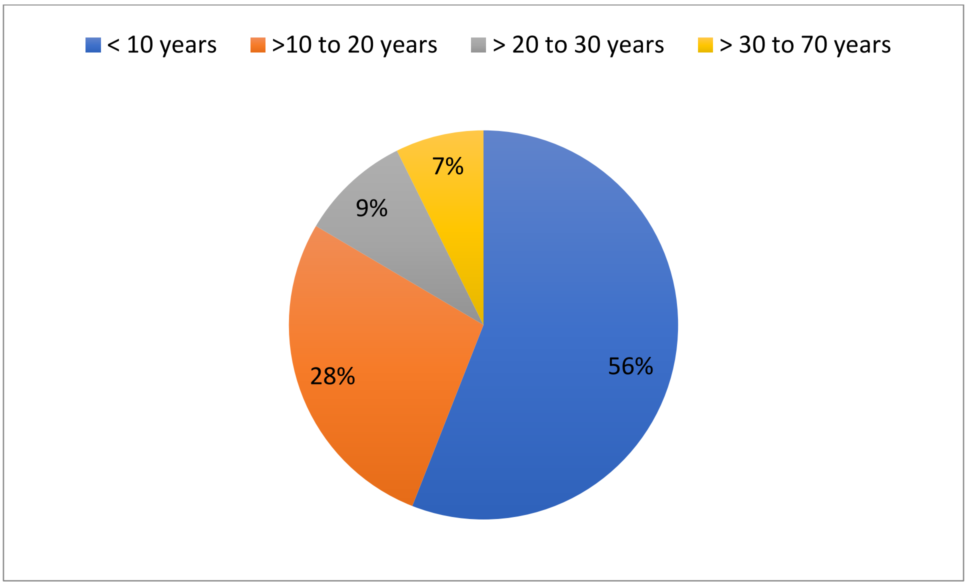


Figure 22: Years the households' heads have been involved in NTFP business

A high percentage (71.8%) of non-CFA members engaged in selling NTFPs from the forest were willing to become CFA members. Overall, there was a strong association of those willing to join CFA and selling NTFPs from the forest ($\chi2_{(1, 431)}$ = 10.513, p<0.001).

For households who relied on the forest as a source of primary income, the findings indicated a strong association with selling NTFPs from the forest ($\chi2_{(1, 431)}$ =103.468, p<0.001); 45.5 % of those who sold NTFPs from the forest stated that it was their primary source of income. There was a significant association between household heads selling NTFP with their average monthly income ($\chi2_{(43, 431)}$ = 63.408, p<0.05) as well as the portion of the income from NTFP ($\chi2_{(35, 431)}$ = 95.142, p<0.001).

In terms of marital status, those selling NTFPs from the forest comprised the following: 89.1% were married; 2.7% divorced, 3.6% widowers; and 4.6% single, indicating that married people are more likely to engage in selling NTFPs. Their dependence on the forest was significant ($\chi2_{(4, 431)} = 13.816$, $p<0.05$).

There was a strong association between the costs of acquiring transport licence ($\chi2_{(3, 77)} = 29.262$, $p<0.001$) and trade licence ($\chi2_{(2, 77)} = 14.047$, $p<0.001$), with the household head selling NTFPs. The other variables which showed significant association with selling of NTFPs were value of assets ($\chi2_{(52, 431)} = 68.415$, $p<0.05$); distance to the market ($\chi2_{(29, 431)} = 44.168$, $p<0.05$); and getting NTFPs from forest ($\chi2_{(1, 431)} = 10.946$, $p<0.001$).

Table 31: Contingency table of independent variables versus households selling NTFPs

	Yes	No	Pearson Chi Square
Do you sell NTFPs?			
1. Village**	110	321	X^2 df(9,N=431)=26.842, p<0.001)
Kiptenden	27	65	
Ndurio	1	37	
Sebetetwo	9	9	
Kamobo	21	46	
Burende	20	68	
Kemeloi	3	33	
Kaptebengwo	9	18	
Koimwe	10	32	
Chemumul	7	13	
2. Distance to forest from house**	110	321	X^2 df(16,N=431)=89.887, p<0.001)
3. Time spent collecting NTFP**	110	321	X^2 df(10,N=431)=32.190, p<0.001)
4. NTFP stock condition compared to 10 years ago	110	321	X^2 df(2,N=431)=4.972, p<0.083)
Decreased	92	237	
No change	8	28	
Increased	10	56	
5. Years household involved in NTFP business*	109	315	X^2 df(36,N=424)=51.913, p<0.05)
6. Would household head like to join CFA**	110	321	X^2 df(1,N=431)=10.513, p<0.001)
No	31	84	
Yes	79	237	
7. Is NTFP primary source of income**	110	321	X^2 df(1,N=431)=103.468, p<0.001)
No	60	305	
Yes	50	16	
8. Average monthly income*	110	321	X^2 df(43,N=431)=63.408, p<0.05)
9. Portion of monthly income from NTFP**	110	321	X^2 df(35,N=431)=95.142, p<0.001)
10. Marital status*	110	321	X^2 df(4,N=431)=13.816, p<0.05)
Married	98	272	
Divorced	3	98	
Widow	0	11	
Widower	4	3	
Single	5	33	
11. Costs for acquiring transport licence (Ksh)**	14	63	X^2 df(3,N=77)=29.262, p<0.001)
0	8	63	
50	1	0	
500	2	0	
600	3	0	
12. Cost of acquiring trade licence**	14	63	X^2 df(2,N=77)=14.047, p<0.001)
13. Value of assets*	110	321	X^2 df(52,N=431)=68.415, p<0.05)
14. Distance to market*	110	321	X^2 df(29,N=431)=44.168, p<0.05)
15. Getting NTFPs from forest**	110	321	X^2 df(1,N=431)=10.946, p<0.001)

4.6.2.3 Effects of socio-economic factors on dependence on NTFPs

The logistic regression model results revealed that age and occupation of household head and the distance to the market had a significant positive correlation on NTFPs extraction (Table 32). Besides, land size, grazing need, years of formal education, demand for fuelwood had significant positive correlations with dependence on NTFPs from South Nandi forest. The age of the respondent had a positive association with the collection of NTFPs in the forest. This implied that the older people are more likely to go to the forest than the younger people in South Nandi Forest. This is unexpected because the older people have children who are more likely to go to the forest on their behalf. However, for some NTFPs, such as medicinal plants, older people are more knowledgeable on their forest sources thus are more likely to go for their extraction. Similar observations have been reported in the Philippines, where it was noted that the older people were more likely to collect NTFPs because of their extensive knowledge of forest plants and wildlife (Lacuna-Richman, 2002).

A unit increase in occupation results in an increase by a factor of 16.243 in the likelihood of depending on the forest for NTFPs. In this study, 75.8% of the respondents were engaged in farming/agriculture, which has also been reported as a common occupation among NTFP gatherers in many developing countries such as south-eastern Nigeria (Bisong and Ajake, 2000) and Southern Cameroon (Brown and Lapuyade, 2001). Therefore, it is possible that these households also engage in NTFP gathering, especially during the low peak seasons when their workload is low. This is confirmed by a similar study on more than 9,500 African households in 11 countries in Africa, namely Burkina Faso, Cameroon, Ghana, Niger, Senegal, Egypt, Ethiopia and Kenya, South Africa, Zambia, and Zimbabwe that reported that agriculture was one of the most important economic sectors which provide livelihoods to a high proportion of the population (Waha *et al*., 2016). In Kenya, Senegal, and South Africa, more than 80% of the farms were small or medium-scale farms. The small land sizes make households rely on the forests to increase their income levels from the use of NTFPs. It is reported that agriculture was one of the most important economic sectors and provided livelihoods to a high proportion of the population.

A unit increase in distance to the market increases the likelihood that a household head will depend on NTFPs. This finding is unexpected since respondents who live closer to the marketplace are more likely to collect and depend more on NTFPs compared to those who live far from the market place.

A unit increase in years of formal education results in a decrease by a factor of 0.467 in the likelihood that a household will depend on the forest, implying that those with more years of formal education are less likely to depend on the forest. Studies have shown that NTFP collectors in developing countries tend to have relatively low education levels (Sherstobitoff, 2004). For instance, in Bolivia and Mexico and North eastern Honduras, low education levels were reported among commercial and non-commercial NTFP extracting households with median education of 3.6 years (Willem te Velde, 2004).

A unit increase in land size results in a decrease by a factor of 0.311 in the likelihood that a household will depend on the forest. This relationship is expected because possession of land increases ones' economic potential and the ability to have adequate space for grazing livestock or even growing own NTFPs. For instance, paddocking land for grazing and a woodlot to provide various products, particularly firewood, is a significant source of cooking energy. Similar findings have been reported in Orissa (India) by Fernandes and Menon (1987), who found out that dependence on the forest was strongly correlated with landholdings' size, with the landless being the most dependent.

There was a negative correlation between distance to the forest edge and dependence on NTFPs. A unit increase in distance to the forest decreases the odds by a factor of 0.033 in the likelihood that a household will depend on the forest. This relationship is expected because a long distance from the forest increases the cost of collecting NTFPs in terms of money and time expended and therefore limits collecting NTFPs. Other studies have also reported that distance influences the household's decision to collect or sell NTFPs (Gunatilake, 1998).

Overall, this study revealed that age, occupation of household head, and distance to the market were positively and significantly correlated with dependence on NTFPs. Also, years of formal education, land size, and distance to the forest were negatively and significantly correlated with dependence on NTFPs.

Table 32: Summary of logistic regression result of the factors influencing dependence on NTFPs in South Nandi Forest

Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Age (years)	0.183	0.087	4.398	1	0.036	1.201
Education (< 8 years formal education)	4.341	1.850	5.507	1	0.019	76.801
Formal education in years	-0.761	0.276	7.578	1	0.006	0.467
Land-size	-1.168	0.425	7.540	1	0.006	0.311
Occupation			5.680	3	0.128	
Occupation(1 Farmer)	2.788	1.515	3.387	1	0.066	16.243
Distance to forest in Km	-3.412	1.619	4.445	1	0.035	0.033
Distance to market in Km	1.859	0.609	9.315	1	0.002	6.414
Formal education (yrs)* Landsize (ac) *NTFPs (Grazing)	0.072	0.030	5.831	1	0.016	1.075
Formal education (yrs) * Landsize* NTFPs (firewood)	0.187	0.090	4.304	1	0.038	1.205
Age * NTFPs1			5.059	1	0.024	
Age by NTFPs1(Grazing)	-0.219	0.098	5.059	1	0.024	0.803
Constant	28.144	93872.483	0.000	1	1.000	########

Model X^2 =230.372, df=67, p=0.000
-2loglikelihood =48.776
Hosmer and Lemeshow : X^2 = 3.183, df =8, p=0.922
Cox and Snell R^2 = 0.416
Nagelkerke R^2 = 0.869
Overall accuracy of classification (%) = 97.7

*p<0.05; **p<0.001

4.6.2.4 Effects of socio-economic factors on selling of NTFPs

Negative interaction was noted in all factors influencing the selling of NTFPs in South Nandi Forest (Table 33). These relationships are explained in the following sections:

The distance to the forest – the farther from the forest reduces the likelihood of selling NTFPs due to cost implications and time expended as indicated in the case of dependence on the forest above.

A unit increase in interest of becoming a CFA member decreases the odds by a factor of 0.524 in the likelihood that a household head will sell NTFP. This relationship is unexpected since most households join the CFAs intending to benefit more from the forest. However, it has been reported that household heads who are members of a social group are less likely to be involved in the illegal extraction of forest resources. This is because household heads that are well informed and belong to a social group are expected to distance themselves from any acts that may inflict externalities on others or have a legal implication (Suleiman *et al*., 2017).

A unit increase in getting permits to transport NTFPs decreases the odds by a factor of 0.094 in the likelihood that a household will sell NTFPs. This relationship is unexpected since households usually get a permit to derive more benefits from the sale of NTFPs and not otherwise.

A unit increase in whether the land was registered in the household head's name decreases the odds by a factor of 0.536 in the likelihood that a household head will sell NTFPs. This is expected since a household head with a title deed to his land is likely to invest in other areas that are more profitable, for example, engaging in planting a cash crop like tea than selling NTFPs. A land title deed also enables the household head to use it as collateral, allowing him/her to develop financially. A unit increase in whether the household head has a motorcycle decreases the odds by a factor of 0.391 in the likelihood that a household head will sell NTFPs. This relationship is expected as the household head can diversify in other income sources, such as using motorcycles in the transport business instead of going to the forest to get NTFPs. Other studies have shown that households engaged in other sectors of the economy, such as trading and formal employment, are less likely to be dependent on NTFPs than their counterparts in the farming enterprise (Daneji and Suleiman, 2011). A unit increase in whether NTFP was the primary source of income of the household head decreases the odds by a factor of 0.264 in the likelihood that a household head will sell NTFPs. This relationship is unexpected as the household's primary source of income is NTFPs from the forest, which he/she sells in order to get income.

Table 33: Summary of logistic regression result of the factors influencing households to sell NTFPs in South Nandi Forest

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Distance to where NTFP is collected (Km)	-.670	.179	14.065	1	.000	.512
Interest in becoming CFA member	-.646	.309	4.371	1	.037	.524
do you acquire permission to transport NTFPs	-2.368	.405	34.124	1	.000	.094
Whether land is registered in your name	-.625	.374	2.795	1	.095	.536
Whether you own a motorcycle	-.939	.402	5.451	1	.020	.391
Whether NTFP is primary source of income	-1.332	.442	9.097	1	.003	.264
Constant	3.253	1.435	5.136	1	.023	25.874

Model X^2 =182.266

-2loglikelihood =305.573

Hosmer and Lemeshow : X^2 =6.943, df =8, p=0.543

Cox and Snell R^2 = 0.347

Nagelkerke R^2 = 0.510

Overall accuracy of classification (%) = 85.7

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents the conclusions and recommendations for further research in the related study.

5.2 Conclusions

1. A total of 128 tree/plant species belonging to 105 genera and 55 families were cited from South Nandi Forest. Twenty-two types of NTFPs were determined in this study. The most common uses were firewood, grazing, and herbal medicine. In terms of gender, the collection of firewood is mostly done by the female; grazing, beekeeping, posts, and harvesting of sand are mostly done by males, whereas herbal medicine and cultivation in the forest are done equally by both males and females.
2. The annual extraction for firewood from the forest per household was 7285.4 ± 1586.9 kg, whereas the annual hay equivalent for grazing in the forest per household was 86 bales. The impact of extraction on forest structure was evident in cases where some species cited were not encountered during the floristic survey indicating the species were rare in the forest, possibly due to overexploitation by the adjacent forest communities. The DBH class distributions showed five patterns. For example, a classic inverse-J curve occurs when a forest is healthy with active regeneration and new individuals' recruitment (Jew *et al.*, 2016). The other four patterns emerged as a result of removing trees in various DBH classes, which in turn distorted the inverse-J curves suggesting a disturbance in the forest. The NTFPs stock condition in

the forest was perceived by the households to have reduced compared to ten years ago.

3. The economic value of all NTFPs extracted per hectare per year was US$824.15, whereas the value of NTFP extraction per household per year was US$579.51. The gross annual extraction of firewood in South Nandi forest was 134,278,394.3 kg valued at KES 405,674,910 (US$ 3,894,429.29). The net economic value for grazing cattle in the forest per annum was KES 24,839,316 to 437,286,470 (US$ 238,454.38 to US$ 4,197,896.38) NTFPs contributed 32.7 to 48.7% of the mean monthly income to households depending on the income level of the household. These findings indicate that the South Nandi forest played an important role in forest adjacent households' livelihoods.
4. Twelve independent variables associated with dependence and 15 independent variables associated with the selling of NTFPs from South Nandi forest. The study's findings revealed that the households living adjacent to the South Nandi forest were highly dependent on the forest for NTFPs.
5. The logistic regression model indicated that years of formal education, land size, and distance to the forest from home were positively correlated to dependence on the forest. In contrast, age, occupation, and distance to market negatively correlated with dependence on the forest. In the case of factors influencing selling of NTFPs in South Nandi Forest; distance to forest, interest in becoming a CFA member, permission to transport NTFPs, land registration, owning a motorcycle, and whether NTFP was the primary source of income were negatively associated with the selling of NTFPs by households.

5.3 Recommendations

5.3.1 Recommendations from the findings of this study

1. Species that showed no or low regeneration in South Nandi Forest are recommended for enrichment planting;
2. Species with a low importance value index (IVI) are recommended for conservation to avoid local extinction
3. The South Nandi Forest has a high economic value in terms of the main NTFPs, and a sustainable utilization approach should be adopted to conserve the forest and ensure utilization of NTFPs for posterity; and
4. The socio-economic study revealed factors that should be considered when initiating activities in the forest that involve adjacent forest households.

5.3.2 Recommendations for future studies

1. A long-term study (more than two years) needs to be done to understand better socio-economic factors that affect NTFP collection and utilization. This is important to capture a change in perceptions across seasons that may affect NTFP utilization.
2. Studies that integrate socio-economic and ecological information are essential for a better understanding of the ecological problems of South Nandi Forest
3. This study was unable to quantify medicinal plant utilization; it is recommended that quantifying them be explored since using direct methods is challenging.

REFERENCES

Adepoju, A.A. & Salau, A.S. (2007). Economic valuation of non-timber forest products.Retrieved September 17, 2017 from: https://mpra.ub.uni-muenchen.de/2689

Agrawal, A., Cashore, B., Hardin, R., Shepherd, G., Benson, C. & Miller, D. (2013). Economic contributions of forests, Background paper prepared for the United Nations Forum on Forests., Retrieved September 27, 2017 from: http://www.un.org/esa/forests/pdf/session_documents/unff10/EcoContrForests

Al-Subaiee, F.S. (2016). Socio-economic factors affecting conservation of natural woodlands in Central Riyadh area- Saudi Arabia. Saudi Journal of Biological Sciences 23: 20-21.

Amjad, M.S. & Arshad, M. (2014). Ethnobotanical inventory and medicinal uses of some important woody plant species of Kotil, Azad Kashmir, Pakistan. Asian Pac. J. Trop. Biomed. 4(12): 952-958. Retrieved June 20, 2017 from: doi: 10.12980/APJTB.4.201414B381.

Amusa, T.O., Jimoh, S.O. and Azeez, I.O. (2017). Socio-economic factors influencing marketing of non-timber forest products in tropical lowland rainforests of South-western Nigeria. Southern Forests: a journal of forest science 79(2):161-168.

Andel, T.R. van, Huyskerns, P & Broker, K. (1998). Palm heart harvesting in Guyana's North West District: exploitation and regeneration of Euterpe oleraceae swamps. The Tropenbos-Guyana Report 98-1, Tropenbos Guyana Programme, Georgetown, Guyana

Assies, W. (1997). Going nuts for the rainforest Non-timber forest products, forest conservation and sustainability in Amazonia. Thela Latin American Series, Thela Publishers, Amsterdam, the Netherlands.

Assogbadjo, A.E., Idohou, R., Chadare, F.J., Salako, V.K., Djagoun, C.A.M.S., Akouehou, G., and Mbairamadji, J. (2017). Diversity and prioritization of non-timber forest products for economic valuation in Benin (West Africa). African Journal of Rural Development 2(1): 105-115.

Azar, A. and Sterner, T. (1996). Discounting and distributional considerations in the context of global warming. Ecological Economics 19(2): 169-184.

Bailey, K.D. (1994). Methods of Social Research. Fourth Edition. Free Press. Toronto. 588p.

Balama, C., Augustino, S., Mwaiteleke, D., Lusambo, L.P. & Makonda, F.B.S. (2016). Economic Valuation of Non-timber Forest Products under the Changing Climate in Kilombero District, Tanzania. International Journal of Forestry Research Volume 2016, Article ID 7893143, 13 pp. Retrieved September 10, 2017 from: http://dx.doi.org/10.1155/2016/7893143

Bann, C. (1999). An economic assessment of the mangroves of Johor State, Malaysia. Danish Cooperation for Environment and Development (DANCED), Forestry Department of Peninsular Malaysia, and Johor State, Kuala Lumpur.

Barrow, E., Kamugisha- Ruhombe, J., Nhantumbo, R. Oyono, and M. Savadogo (2009). Forests are important to the rural people of Africa—Some Empirical Data. Washington: Rights and Resources Initiative.

Barrow, E., Kamugisha-Ruhombe, J., Nhantumbo, I., Oyono, R. & Savadogo, I. (2016). Who owns Africa's forests? Exploring the impacts of forest tenure reform on forest ecosystems and livelihoods, 25(2): 132-156. Retrieved October 10, 2017 from: http://dx.doi.org/10.1080/14728028.2016.1159999

Beentje, H. (1994). Kenya Trees, Shrubs and Lianas. National Museums of Kenya, Nairobi.

Bernhoft, A. (2010). A brief review of bioactive compounds in plants In: Bioactive compounds in plants – benefits and risks for man and animals. Aksel Bernhoft editor Oslo: The Norwegian Academy of Science and Letters. Retrieved September 29, 2017 from: http://www.dnva.no/geomed

Birdlife (2007). South Nandi Forest (Important Bird Areas of Kenya): Birdlife IBA Factsheet. Retrieved July 12, 2016 from: http://www.birdlife.org/datazone/sitefactsheet.php?id=6448

Bisong, F.E. & Ajaka, A.O. (2000). An economic analysis of women dependence on forest resourcesin the rainforest communities of south-western Nigeria. Glob. J. of Pure & App. Sci. 7(2): 345-350.

Blackett, H. L. (1994). Forest inventory reports for Kenya's indigenous forests. KIFCON Report: Nairobi.

Bonham, C.D. (2013). Measurements for Terrestrial Vegetation (2nd Edition) .Wiley-Blackwell. 260 p. Retrieved September 16, 2017 from: http://eu.wiley.com/WileyCDA/WileyTitle/productCd-0470972580.html

Brown, K. & Lapuyade, S. (2001). A livelihood from the forest: Gendered vision of social, economic and environmental change in southern Cameroon. J. of Int, Dev 13:1131-1149.

Brown, S. (1997). Estimating Biomass and Biomass Change of Tropical Forest: a Primer. A Forest Resources Assessment publication . (FAO Forestry Paper - 134). Food and Agriculture Organization of the United Nations, Rome.

Bruschi, P., Mancini, M., Mattioli, M., Morganti, M. & Signorini, M.A. (2014). Traditional uses of plants in a rural community of Mozambique and possible links with Miombo degradation and harvesting sustainability. Journal of Ethnobiology and Ethnomedicine, 10:59. Retrieved October 31, 2017 from: https://doi.org/10.1186/1746-4269-10-59

Cavendish, W. (2000). Empirical regularities in the poverty-environment relationship of rural households: evidence from Zimbabwe. World Dev28 (11):1979–2003

CERUT (1999). The wealth of forest in Cameroon - results of field testing a methodology for the valuation of non-timber forest products in Northwest and Southwest Cameroon. Aid environment, Amsterdam, the Netherlands.

Chambers, R. (1994). The Origins and Practice of Participatory Rural Appraisal. World Development 22(7): 953-969.

Changhui, P. (2000). Growth and yield models for uneven-aged stands: Past, present, and future. Forest Ecology and Management. 132 : 259 - 279.

Chopra, K. (1993). The value of non-timber forest products: An estimation for tropical deciduous forests in India. Economic Botany 47(3):251-257.

Clark, L.E. & Sunderland, T.C.H. (2004). (Eds). The key Non-Timber Forest Products of Central Africa: State of the knowledge, Technical Paper No. 122.

Cox, D.R. & Snell, E.J. (1989). The analysis of binary data. 2nd edn. Chapman and Hall.London.

Cunningham, A.B. (2000). Applied ethnobotany: people, wild plant use and conservation. Earthscan, London. 300p.

Curtis, J. T. & R. P. McIntosh. (1950). The interrelations of certain analytic and synthetic photosociological characters. Ecology 31: 434-455.

Dale, I.R. & Greenway, P.J. (1961). Kenya Trees and Shrubs. Xxvii, 654pp.

Dalle, S.P & Potvin, C. (2004). Conservation of useful plants: An evaluation of local priorities from two indigenous communities in Eastern Panama. Economic Botany 58(1): 38-57.

Daneji, M.I., & Suleiman, M.S. (2011). Accessibility and utilization of agricultural information among farmers in Wudil Local Government Area, Kano State, Proceedings of the 36th Annual Conference of the Nigerian Society for Animal Production (NSAP) held at Abuja 13th – 16th March., pp 652–654.

Davenport, T.R.B. & Ndangalasi, H.J., (2002). An escalating trade in orchid tubers across Tanzania’s Southern highlands-assessment, dynamics and conservation implications. Oryx 37, 55–61.

Davis, L.S. and Johnson, K.N. (1987). Forest Management (3rd Edition). McGraw Hill Book Company. New York. 790 pp.

d’Hour, P., Hauwuy, A., Coulon, J.B., and Garel, J.P. (1994). Walking and dairy cattle performance. Annales de zootechnie, INRA/EDP Sciences 43(4):369-378. Hal -00889057

De Beer, J.H. and McDermott, M.J. (1996). The Economic Value of Non-Timber Forest Products in Southeast Asia. Netherlands Committee for IUCN, Amsterdam.

Delang, C.O. (2006). Not just minor forest products: The economic rationale for the consumption of wild food plants by subsistence farmers. Ecological Economics 59 (1):64-73.

Dewees, P.A. (1991). The Impact of Capital and Availability on Smallholder Tree Growing in Kenya. D.Phil. Dissertatation. UK: University of Oxford.

Dlamini, C.and Geldenhuys, C.J.(2011). Towards a theoretical framework for management for management of non-timber forest products (NTFPs) in Swaziland: A review. Journal of Geography and regional planning 4(15): 715-730.

Downer, M.R. (2012)."Plant Species Richness and Species Area Relationships in a Florida Sandhill". *Graduate Theses and Dissertations.* Retrieved September 17, 2017 from: http://scholarcommons.usf.edu/etd/4030

Dove, M. (1993). A revisionist view of tropical deforestation and development. Environmental Conservation 20 (1): 17-24.

Ellis, F. (1999). Rural livelihood diversity in developing countries: evidence and policy implications. Natural resource perspectives. Number 40, April 1999.

Emerton, L. (1996). Maasai Livelihoods, Forest Use and Conservation in Oldonyo Orok, Kenya, Applied Conservation Economics Discussion Paper No. 2, African Wildlife Foundation, Nairobi.

Endamana, D., Angu, K.A., Akwah, G.N., Shepherd, G., and Ntumwel, B.C. (2016). Contribution of non-timber forest products to cash and non-cash income of remote forest communities in Central Africa. International Forest Review XX(X):1-16

Endris, A., Seid, A. & Asefa, A. (2017). Structure and regeneration status of woody plants in the Hallideghie wildlife reserve, North East Ethiopia. International Journal of Biodiversity and Conservation 9 (6): 200-211.

FAO (1997). Gender: the key to sustainability and food security. SD Dimensions. Retrieved August 30, 2017 from: www.fao.org/sd.

FAO (2001). Global Forest Resources Assessment 2000. Main report. FAO Forestry Paper 140, 479p.

FAO (2003). Past trends and future prospects for the utilisation of wood for energy. Global Forest Products Outlook Study Working Paper GFPOS/WP/05. Rome.

FAO (2008). Contribution of the forestry sector to national economies, 1990-2006. Retrieved August 30, 2017 from: ftp://ftp.fao.org/docrep/fao/011/k4588e/k4588e00.pdf

FAO (2010). Global Forest Resources Assessment (2010). FAO Forestry Paper 163. Food and Agriculture Organization of the United Nations, Rome.

Fashing, P.J., Forrestel, A., Scully, C. & Cords, M. (2004). Long-term tree population dynamics and their implications for the conservation of the Kakamega forest, Kenya. Biodiversity and conservation 13: 753-771.

Fernandes, W. & Menon, G. (1987). Tribal Women and Forest Economy. New Delhi, India: Indian Social Institute.

Focho, D.A., Newu, M.C., Anjah, M.G., Nwana, F.A. & Ambo, F.B. (2009). Ethnobotanical survey of trees in Fundong, Northwest Region, Cameroon. J. Ethnobiol. Ethnomed., 5: 17.

Focho, D.A. , Egbe, E.A., Chuyong, G. & Mekou, Y. B. (2010). An ethnobotanical investigation of the annonaceae on Mount Cameroon. Journal of Medicinal Plants Research. 4. . Retrieved September 28, 2017 from: https://www.researchgate.net/publication/267565944_An_ethnobotanical_investigation_of_the_annonaceae_on_Mount_Cameroon

Foster, S. & Duke, J.A. (1990). A field guide to medicinal plants: Eastern and Central North America. ISBN 0-395-46722-5

Gakou, M., Force, J.E., & McLaughlin, W.J. (1994). Non-timber forest products in rural Mali: A study of village use. Agroforestry Systems 28(3), 213-226.

Garekae, H., Thakadu, O.T., and Lepetu, J. (2017). Socio-economic factors influencing household forest dependency in Chobe enclave, Bostwana. Ecological Processes 6:40. Retrieved December 5, 2017 from: https://doi.org/10.1186/s13717-017-0107-3

Gebrehiwot, K., & Hundera, K. (2014). Species composition, plant community structure and natural regeneration status of Belete moist evergreen montane forest, Oromia Regional State, Southwestern Ethiopia. Momona Ethiopian Journal of Science 6: 97-101.

Ghatak, S. (1995). A recipe for success: women and non-timber forest products in Southwest Bengal, India. In: Fox, J., Donovan, D. and DeCoursey, M. (eds.) Voices from the field: Sixth workshop on 'Community Management of Forest Lands', 164-79. East-West Center, Honolulu, Hawaii.

Ghorbani, A., Langenberger, G., Liu, J., Wehner, S., & Sauerborn, J. (2012). Diversity of Medicinal and Food plants as Non-timber Forest Products in Naban River Watershed National Nature Reserve (China): Implications for livelihood Improvement and Biodiversity Conservation 66(2) 178-191. Retrieved September 24, 2016 from: doi: 10.1007/s12231-012-9188-1

Giliba, R. A., Boon, E. K., Kayombo., C. J., Musamba, E. B., Kashindye, A.M. and Shayo, P. F. (2011). Species composition, richness and diversity in Miombo Woodland of Bereku Forest Reserve Tanzania, Journal of Biodiversity, 2 (1): 1–7.

Girma, A. (2011). Plant communities, species diversity, seedling bank and re-sprouting in Nandi forests, Kenya. PhD Thesis. Universitat Koblenz-Landau.

Girmay, Z., Abebe, G., & Tillahun, A. (2013). Training manual on:Non –timber forest products in the context of sustainable forest management and REDD+. Hawassa university Wondo Genet college of forestry and natural resources, Ethiopia. 117pp.

Godoy, R.A. & Lubowski, R. 1992. Guidelines for the Economic Valuation of Non-Timber Tropical Forest Products. Current Anthropology 33: 423-433.

Golam, R., Karki, M. & Sah, R. P. (2008). The role of non-timber forest products in poverty reduction in India. Development in Practice, 18(6):779-788

GOK, (2005). Kenya Gazette Supplement Acts No. 88 (Acts No.7). The Forest Act, 2005. Date of Assent: 18th November, 2005.

GOK (2008). Kenya Vision 2030. Sector Plan for Environment, Water and Sanitation. 2008 – 2012. Ministry of Planning and National Development, Government of Kenya (GoK), Nairobi.

GOK (2013). County Integrated Development Plan. County Government of Nandi. Republic of Kenya. 262pp.

GOK, (2016). Kenya Gazette Supplement Acts No. 155 (Acts No. 34). The Forest Conservation and Management Act, 2016, Date of Assent: 31st August, 2016.

Gunatilake, H.M. (1998). The role of rural development in protecting tropical rainforests: evidence from Sri Lanka. J. of Env Man 53: 273-292.

Gunatilake, H.M., Senaratne, D.M.A.H., & Abeygunawardena, P. (1993). The Role of Non-Timber Forest Products in the Economy of Peripheral Communities of Knuckles National Wilderness Area of Sri Lanka: A Farming System Approach. Economic Botany 47: 275-281.

Hair, J.F., Anderson, R.E., Tatham, R.L. & Black, W.C. (1998). Multivariate data analysis. Prentice Hall, London.

Hall, P. & Bawa, K.S. (1993). Methods to assess the impact of extraction of non-timber tropical forest products on plant populations. Economic Botany (47): 234–247.

Hassan, M.Z.Y., Siddiqui, B.N., & Irshad, M.N. (2002). Effect of socio-economic aspects of Mango growers on the adoption of recommended horticultural practices. Pak. J. Agric. Sci. (39): 20-21.

Heubach, K., Wittig, R., Nuppenau, E. and Hahn, K. (2011). The economic importance of non-timber forest products (NTFPs) for livelihood maintenance of rural west African communities: A case study from northern Benin. *Ecological Economics*, **70** (11):1991-2001. Retrieved October 2017 from 10.1016/j.ecolecon.2011.05.015.

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

Homma, A.K.O. (1996). ‘Modernisation and technological dualism in the extractive economy in Amazonia’, in M. Ruiz Pérez and J.E.M. Arnold (eds.). Current issues in non-timber forest product research. CIFOR, Bogor, Indonesia.

Hosmer, D. & Lemeshow, S. (1989). Applied logistic regression. Wiley, New York.

ICTA (2015). County ICT Roadmap 2015- 2020. Mininistry of Information, Communication and Technology. 40p.

International Union of Conservation of Nature (IUCN, 2017). The IUCN Red List of Threatened Species(tm). Retrieved July 21, 2017 from: http://www.iucnredlist.org/about

Isango, J.A. (2007). Stand structure and tree species composition of Tanzania miombo woodlands of community-based forest managementin Iringa District in Proceedings of the 1st MITMIOMBO Project Workshop, Vol. 50 of Working Papers of the Finnish Forest Research Institute, pp 43-56, Morogoro, Tanzania.

Islam, M.A., Rai, R., Quli, S.M.S., and Tramboo, M.S. (2015). Socio-economic and demographic descriptions of tribal people subsisting in forest resources of Jharkhand, India. Asian Journal of Bioscience 10(1):75-82.

Israel, G.D. (1992). Sampling the evidence of extension program impact program evaluation and organizational development, IFAS, University of Florida. PEOD-5. October.

Jew, E.K.K., Dougill, A.J., Sallu, S.M., O’Connell, J., & Benton, T.G. (2016). Miombo woodland under threat: consequences for tree diversity and carbon storage. Forest ecology and management 361: 144-153.

Jimoh, S.O., Azeez, I.O. (2002). Prospects of community participation in the management of shasha forest reserve, Osun State, Nigeria. In: Abu JE, Oni PI, Popoola L (eds) Proceedings of the 28th Annual Conference of Forestry Association of Nigeria. Forestry and Challenges of Sustainable Livelihood, Akure, pp 208–216.

Kabubo-Mariara, J. and Gachoki, C. (2008). Forest Dependence and Household Welfare. Empirical Evidence from Kenya. CEEPA Discussion Paper No. 41

Kagezi, G., Kaib, M., Nyekos, P., Bakuneeta, S., Schädler, M., and Brandl, R. (2011). Decomposition of tissue baits and termite density along a gradient of human land-use intensification in Western Kenya, Afr. J. Ecol.(49): 267–276.

Kahn, M. (1995). Concepts, definitions, and key issues in sustainable development: the outlook for the future. *Proceedings of the 1995 International Sustainable Development Research Conference, Manchester, England, Mar. 27-28,1995*, Keynote Paper, 2-13.

Kahn, F. (1988). Ecology of economically important palms in Peruvian Amazonia. Advances in Economic Botany 6, 42–49.

Kalaba, F.K., Quin, C.H., & Dougill, A.J. (2013). Contribution of forest provisioning ecosystem services to rural livelihoods in the Miombo woodlands of Zambia. Population and Environment 35 (2): 159-182.

Kajembe, G.C. (1994). Indigenous Management system as a basic for community forest in Tanzania. A case study of Dodoma Urban and Lushoto Districts. Tropical Resource Management Paper No. 6. Wageningen Agriculture University, The Netherlands. 194pp.

Kant, S. (1997). Integration of Biodiversity Conservation in Tropical Forest and Economic Development of Local Communities. Journal of Sustainable Forestry 4: 33-62.

Kar, S.P. (2010). Non-timber Forest Product (NTFP) utilization and livelihood development in Bangladesh. PhD thesis. The Pennsylvania State University.

Katani, J. Z. (1999). The role of gender based indigenous knowledge in developing coping strategies against deforestation. Dissertation for Awards of MSc Degree at Sokoine University of Agriculture, Morogoro, Tanzania, 110pp.

Katerere, Y. (1998). Non-timber products key in Central Africa's forests. Forum 13(1):85-88.

Kent, M. & Coker, P. (1992). Vegetation description and analysis. Ambo practical approach. New York, USA. 363pp.

Khan, M. L., Rai, J. P. N., & Tripathi, R. S. (1987). Population Structure of Some Tree Species in Disturbed and Protected Subtropical Forests of Northeast India. Acta Oecologica Oecologia Applicata, 8, 247-255.

Kiama, D. & Kiyiapi, J. (2001). Shade tolerance and regeneration of some tree species of a tropical rain forest in Western Kenya. Plant Ecology 156(2): 1833-191.

KIFCON (Kenya Indigenous Forest Conservation Programme) 1994. Forest Inventory Report No. 11 South Nandi and Ururu

KFS (2015). North and South Nandi Forests Strategic Ecosystem Management Plan 2015- 2040. 53p.

Kiplagat, A.K., Mburu, J. and Mugendi, D.N. (2008). Consumption of non-timber forest products in Kakamega forest, Western Kenya: accessibility, role, value and resident rural households. A paper presented to the 2008 IASC Bienniel International Conference 14-19 July 2008, University of Gloucestershire, Cheltenham, England.

Kinyanjui, M.J. (2009). The effect of human encroachment on forest cover, composition and structure in the Western blocks of the Mau forest complex. PhD Thesis. Retrieved September 17, 2017 from: doi: 10.13140/2.1.2110.4964

Koech, C.K. (2018). Household factors affecting implementation of forest conservation strategies. A case of South Nandi forest, Nandi County, Kenya. Masters thesis-Arts in sociology (Rural sociology and community development). University of Nairobi.

Konsala, S., Bernard-Alloys, N., Gilbert, T., Roger-Corneille, F., Bernard, F., Elvire-Hortense, B. and Tchobsala, F. (2013). Use of wild trees and shrubs as fodder and traditional veterinary medicine in Cameroon: Ecological impacts and conservation. Int. J. Forest, Soil and Erosion 3(3): 87-91.

KNBS & SID. (2013). Pulling apart or pooling together. Kenya National Bureau of Statistics (KNBS) and Society for International Development (SID).ISBN-978-9966-029-18-8. 79pp.

KNBS(2013). Statistical Abstract 2013. Copyright © Kenya National Bureau of Statistics. 320p.

KNBS (2019). 2019 Population and Housing Census. Counting Our People for Sustainable Development and Devolution of Services. Vol. I, Kenya National Bureau of Statistics (KNBS), Nairobi, Kenya.

Kodoh, J., Mojilol, A.R., & Lintangah, N. (2009). Some common Non-Timber Forest Products Traded by Indigenous Community in Sabah, Malaysia. Journal of Sustainable Development 2 (2): 148-154.

Kramer, R., Sharma, N. and Munasinghe, M., 1995. Valuing Tropical Forests: Methodology and Case Study of Madagascar. Environment Paper No.13 World Bank, Washington, D.C.

Krueger, R.A., & Casey, M.A. (2009). Focus groups: A practical guide for applied research (4th Ed.).Thousand Oaks, CA: Sage Publications.

Kwon, S.K., Jung, H.S., Baek, W.K. & Kim, D. (2017). Classification of forest vertical structure in South Korea from aerial orthophoto and Lidar data using an artificial neural network. Appl. Sci. 7, 1046; doi: 10.3390/app7101046 www.mdpi.com/journal/applsci.

Lacuna-Richman, C. (2002).The socio-economic significance of subsistence non-wood forest products in Leyte, Philippines. Environmental Conservation 29 (2): 253–262.

Lammerts van Bueren, E.M. & Blom, E.M. (1997). Principles, Criteria, Indicators. Hierarchical Framework for the Formulation of Sustainable Forest Management Standards. Tropenbos Foundation, The Netherlands.

Lamprecht, H. (1989). Sericulture in the tropics. Tropical forest ecosystems and their tree species possibilities and methods are the long term utilization, T2-verlagsgeslls chaft, RoBdort.

Langat, D. K., Maranga, E. K., Aboud, A. A. & Cheboiwo, J. K. (2016). Role of Forest Resources to Local Livelihoods: The Case of East Mau Forest Ecosystem, Kenya. International Journal of Forestry Research. Article ID 4537354, 10 pp. Retrieved September 24, 2017 from: http://dx.doi.org/10.1155/2016/4537354

Littler, M.M. & Littler, D.S. (eds). (1985). Handbook of psychological methods. Ecological field methods: macroalgae

Lynser, M.B. & Tiwari, B.K. (2016). Diversity and Utilization of Floral Non Timber Forest Products by the Communities in Rural Meghalaya, North-East India. . Journal of Forest and Environmental Science 31 (1): 39-54. Retrieved 30th October 2017 from http://dx.doi.org/10.7747/JFES.2016.32.1.39

Magurran, A.E. (2004). Measuring biological diversity. Malden and Oxford: Blackwell Publishing.

Mahapatra, A.K. & Tewari, D.D. (2005) Importance of non-timber forest products in the economic valuation of dry deciduous forests of India. Forest Policy and Economics (7): 455–467.

Malik, Z.A. & Bhatt, A.B. (2016). Regeneration status of tree species and survival of their seedlings in Kedarnath Wildlife Sanctuary and its adjoining areas in Western Himalaya, India. Tropical Ecology 57(4): 677-690.

Mamo, G., Sjaastad, E. & Vedeld, P. (2007). Economic dependence on forest resources: a case from Dendi District, Ethiopia. Forest Policy and Economics 9 (8): 916–927.

Manish, G., Naing,T.W., Saini, R.S., Ahmad, A., Naidu, J.R. & Kumar, I. (2015). Marketing trends and future prospects of herbal medicine in the treatment of various diseases. World Journal of Pharmaceutical research wjpr 4 (9): 132-155. Retrieved October 10, 2017 from: www.wjpr.net

Marshall, E., Schreckenberg, K. and Newton, A.C. (eds) (2006). Commercialization of Non-timber Forest Products: Factors Influencing Success. Lessons Learned from Mexico and Bolivia and Policy Implications for Decision-makers. UNEP World Conservation Monitoring Centre, Cambridge, UK.

Maina, P.M. (2016). Non-timber forest products (NTFPs) and forest degradation: a study of Kabaru forest, Nyeri County, Kenya. Paper presented in EAMAC3 conference at USIU, 15-17 November 2016.

Maua, J.O., Tsingalia, H.M., Cheboiwo, J., & Odee, D. (2020). Population structure and regeneration status of woody species in a remnant tropical forest: A case study of South Nandi Forest, Kenya. Global Ecology and Conservation 21.https//doi.org/10.1016/j.gecco.2019e00820

Maua, J.O., Tsingalia, H.M., and Cheboiwo, J. (2019). Economic value of non-timber forest products utilized by the households adjacent to the South Nandi forest reserve in Kenya, East African Agricultural and Forestry Journal, 83:4, 368-391, DOI: 10.1080/00128325.2019.1660037

Mavsar, R., Varela, E., Gouriveau, F., & Herreros, F. (2013). Methods and tools for socio-economic assessment of goods and services provided by Mediterranean forest ecosystems. Project Report for Component 2 of the project "Optimized production of goods and services by Mediterranean forest ecosystems in the context of global changes", 53-57.

Mbuvi, M. T. E., Gichuki, J. & Musyoki J. K. (2010). Socio-economic report for South Nandi forest Adjacent Communities. Nature Kenya - Kenya Forestry Research Institute publication.

Mbuvi, D. and Boon, E. (2009). The livelihood potential of non-wood forest products: The case of Mbooni Division in Makueni District, Kenya. Environ. Dev. Sustain.(11): 989-1004.

Mcelwee, P. (2008). Forest environmental income in Vietnam: Household socio-economic factors influencing forest use. Environmental Conservation 35:147-159.

McSweeney, K. (2004). Forest product sale as natural insurance: the effects of household characteristics and the nature of shock in eastern Honduras. Society and Natural Resources 17 (1): 39–56.

Melaku, E., Ewnetu, Z., & Teketay, D. (2014). Non-timber forest products and household incomes in Bonga forest area, southwestern Ethiopia. Journal of forestry research, 25(1), 215–223.

MENR. (2016). National Forest Programme of Kenya. Ministry of Environment and Natural Resources (MENR), Nairobi, Kenya

Mettrick, H. (1993). Development Oriented Research in Agriculture. An ICRA textbook. Wageningen, the Netherlands. 287p.

Modi, A. G. & Trivedi, J. Y. (2013). Non-Timber Forest Products in Sustainable Forest Management. Retrieved September 24, 2017, from: https://ssrn.com/abstract=2195929 or http://dx.doi.org/10.2139/ssrn.2195929

Moegenburg, S.M. & Levey, D.J. (2002). Prospects for conserving biodiversity in Amazonian extractive reserves. Ecology Letters 5:320-324.

Montgomery, M.E., White, M.E., & Martin, S.W. (1987). A comparison of discriminant analysis and logistic regression for the prediction of coliform mastitis in dairy cows. Can. J.Vet. res. 51: 495-498.

Morris, E.K., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T.S., Meiners, T., Müller, C., Obermaier, E., Prati, D., Socher, S.A. Sonnemann, I., Wäschke, N., Wubet, T., Wurst, S. & Rillig, M.C. (2014). Choosing and using diversity indices: insights for ecological applications from German biodiversity exploratories. Ecology and Evolution 4(18): 3514-3524.

Muchiri, M.N & Mbuvi, M. T. E. (2010). Tree resources inventory of South Nandi forest reserve. Nature Kenya-Kenya Forestry Research Institute publication.

Mukherjee, S. & Chaturvedi, S.S. (2017). Utilization aspects of floral non-timber forest products: A review. Asian Journal of Multidisciplinary Studies 5(4): 161-166. Retrieved June 20, 2017 from: www.ajms.co.in/sites/ajms2015/index.php/ajms/article/download/2413/pdf_454

Mukras, M.S. (1993). Elementary Econometrics: Theory, Application and Policy. English Press Ltd. 647pp.

Mueller-Dombois, D & Ellenberge, H. (1974). Aims and methods of vegetation ecology. John Wiley and Sons, New York.

Mutenje, M.J., Ortmann, G.F., & Ferrer, S.R.D. (2011). Management of non-timber forestry products extraction: Local institutions, ecological knowledge and market structure in South Eastern Zimbabwe. Ecological Economics 70, 454-461.

Mutiso, F.M., Hitimana, J., Kiyiapi, J.L., Sang, F.K., Eboh, E., 2013. Recovery of Kakamega tropical rainforest from anthropogenic disturbances. J. Trop. For. Sci. 25 (4), 566e576. https://www.jstor.org/stable/23616998.

Nagelkerke, N.J.D. (1991) A Note on a General Definition of the Coefficient of Determination. Biometrika, 78, 691-692. https://doi.org/10.1093/biomet/78.3.691

Ndangalasi, H.J., Bitariho, R., & Dovie, D.B.K (2007). Harvesting of non-timber forest products and implications for conservation in two montane forests of East Africa. Biological Conservation 134, 242-250.

Ndayambaje JD, Heijman WJM, Mohren GMJ (2012) Household determinants of tree planting on farms in rural Rwanda. Small-scale Forestry, http://dx.doi.org/10.1007/s11842-012-9196-0.

Ndoye, O., Manuel, R. P. & Eyebe, A. (1998). Non-wood forest products markets and potential forest resource degradation in central Africa: the role of research in providing a balance between welfare improvement and forest conservation. In Sunderland, T. C. H., Clark, L. E. & Vantomme, P. (eds), pp. 183/206. FAO, Rome.

Neumann, R.P. & Hirsch, E. (2000). Commercialization of Non-Timber Forest Products: Review and Analysis of Research. CIFOR, 187p.

Ngarivhume, T., van 't Klooster, C. I. E. A., de Jong, J. T. V. M. & Westhuizen, J. H. (2015). Medicinal plants used by traditional healers for the treatment of malaria in the Chipinge district in Zimbabwe. Journal of Ethnopharmacology, 159, 224-237. Retrieved 10th October 2017 from: doi: 10.1016/j.jep.2014.11.011

Nix, S. (2017). "Heating Properties of Firewood by Tree Species." ThoughtCo, Jun. 4, 2017, thoughtco.com/heating-properties-firewood-by-tree-species-1342848. Retrieved 30th July 2018, from: https://www.thoughtco.com

Njunge, J.T. & Mugo, J.M. (2011). Composition and succession of the woody flora of south Nandi forest, Kenya. Research Journal of Botany 6(3): 112-121.

Nyang, F.O. (1999). Household Energy Demand and Environmental Management in Kenya. Universitet van Amsterdam, Faculteit der Economische Wetenchappen enEconometrie, The Netherlands. 224pp.

Okoegwale, E. E. & Omefezi, U. (2001). Some herbal preparations among the people of Isoko Clan of Delta State, Nigeria. Journal of Applied Science (4):2350–2371.

Omkar, K., Suthari, S., Alluri, S., Ragan, A. & Raju, V.S. (2012). Diversity of NTFPs and their utilization in Adilabad district of Andhra Pradesh, India. J. Plant Stud.,1(1) : 33-46.

Onyango, A.E., Hitimana, J., Sirmah, P.K. & Matonyei, T. (2018). Population structure of Prunus africana (Hoo. f.) Kalkm. and Olea europea L. in South Nandi Afromontane Forest, Kenya. Asian Journal of Research in Agriculture and Forestry 1(4): 4-13.

Otuoma, J., Anyango, B., Ouma,G., Okeyo, D., Muturi, G.M. & Oindo, B. (2016). Determinants of aboveground carbon offset additionality in plantation forests in a moist tropical forest in western Kenya. Forest ecology and management 365: 61-68.

Padoch, C. (1992). Marketing of non-timber forest products in western Amazonia: general observations and research priorities. Advances inEconomic Botany 9: 43-50.

Pandey, A., Shackleton, C., & Ticktin, T. (Eds) . (2015). Ecological sustainability of non-timber forest products: Dynamics and case studies of harvesting. Routledge Taylor & Francis Group, People and Plants International Conservation.

Pandey, A.K., Tripathi, Y.C & Kumar, A.(2016). Non timber forest products (NTFPs) for sustained livelihood: Challenges and strategies. Res.J. For., CC: CC-CC. Retrieved October 31, 2017 from: https://www.researchgate.net/publication/DOI: 10.3923/rjf.2016

Parren, Marc P.E. and de Graaf, N.R. (1995). The quest for natural forest management in Ghana, Cote D'Ivoire and Liberia. The Tropenbos Foundation, Wageningen, The Netherlands.

Paumgarten, F., & Shackleton, C.M. (2009). Wealth differentiation in household use and trade in non-timber products in South Africa. Ecological Economics 68, 2950-2959.

Pearce, D.W. & Warford, J. (1992). World Without End: Economics, Environment and Sustainable Development. Oxford University Press: New York and Oxford.

Peters, C.M. (1994). Sustainable harvest of non-timber plant resources in tropical moist forest: an ecological primer. Biodiversity support program c/o World Wildlife Fund, Washington, D.C. 45p.

Peters, C. M., Gentry, A. H. & Mendelsohn, R. O.(1989). Valuation of an Amazonian rainforest. *Nature* 339:655–656.

Pierce, A.R., Shanley, P. & Laird, S. (2003). Certification of non-timber forest products: Limitations and implications of a market-based conservation tool. Paper presented at the international conference on rural livelihoods, forests and biodiversity, 19-23 May 2003, Bonn, Germany.

Reynolds, N., Diamantopoulos, A. & Schlegelmilch, B. (1993). Pretesting in questionnaire design: A review of the literature and suggestions for future research. Journal of the market research society 35(2) 171-182.

Richards, M. (1994). Towards valuation of forest conservation benefits in developing countries. Environmental Conservation 21: 308-319.

Rizal, A., Sahidin, A., Herawati, H. (2018). Economic value estimation of mangrove ecosystems in Indonesia. Biodiversity Int J.; 2(1):98–100. Retrieved 11th August 2018 from: DOI: 10.15406/bij.2018.02.00051

Robinson, B.E., Holland, M.B. & Naughton-Treves, L. (2013). Does secure land tenure save forests? A meta-analysis of the relationship between land tenure and tropical deforestation. Global Environ. Change (2013), Retrieved 16th October 2017 from: http://dx.doi.org/10.1016/j.gloenvcha.2013.05.012

Ros-Tonen, M.A.F., Lammerts van Bueren, E.M. & Dijkman, W. (1995). Commercial and sustainable extraction of non-timber forest products. Towards a policy and management oriented research strategy. The Tropenbos Foundation, Wageningen, the Netherlands.

Ros-Tonen, M.A.F. (1999). Introduction: NTFP research in the Tropenbos programme. In: Tropenbos (1999). NTFP research in the Tropenbos programme: results and perspectives. Tropenbos Foundation, Wageningen, the Netherlands.

Ruitenbeek, J. (1989). The rainforest supply price. Ecological economics: 1:57-78.

Saha, D. & Sundriyal, R.C. (2012). Utilization of non-timber forest products in humid tropics: Implications for management and livelihood. Forest Policy and Economics (14): 28-40.

Salick, J., Fangb, Z., & Byg, A. (2009). Eastern Himalayan alpine plant ecology, Tibetan ethnobotany, and climate change. Global. Environ.Chang., 19(2): 147-155.

Saragih, B. (2011). Economic value of non-timber forest products among Paser Indigenous People of East Kalimantan. Retrieved 6th August 2018, from: https://openaccess.leidenuniv.nl/bitstream/handle/1887/18078/Thesis%20Bernaulus%20Saragih.pdf;sequence=2

Savadogo, P., Tigabu, M., Sawadogo, L. and Od´en, P. C. (2007). Woody species composition, structure and diversity of vegetation patches of a Sudanian savanna in Burkina Faso," *Bois et Forets des Tropiques*, vol. 294, no. 4, pp. 5–20.

Semyonov, M., & Lewin-Epstein, N. (2013). Ways to Richness: Determination of Household Wealth in 16 Countries. European Sociological Review 29 (6): 1134–1148. Retrieved 31st July 2018, from: www.esr.oxfordjournals.org

Senaratne, A., Abeygunawardena, P. & Jayatilake, W. (2003). Changing role of non-timber forest products (NTFP) in rural household economy: the case of Sinharaja World Heritage site in Sri Lanka. Environmental Management 32 (5): 559–571.

Shackleton, C.M. & Shackleton, S.E. (2004). The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa. South African Journal of Science (100): 658-664.

Shackleton, C.M., Shackleton, S.E., Buiten, E., & Bird, N. (2007). The importance of dry woodlands and forests in rural livelihoods and poverty alleviation in South Africa. Forest Policy and Economics (9): 558-577.

Shahabuddin, G. & Prasad, S. (2004). Assessing ecological sustainability of non-timber forest produce extraction: The Indian scenario. Conservation & Society 2(2):236-250

Shankar, U., Murali, K.S., Shaanker, R.U., Ganeshaiah, K. N., and Bawa, K.S. (1998). Extraction of non-timber forest products in the forests of Biligiri Rangan Hills, India. 4. Impact on floristic diversity and population structure in a thorn scrub forest. Economic Botany 52(3):302-315. DOI: 10.1007/BF02862149

Sharma, D., Tiwari, B.K., Chaturvedi, S.S., Diengdoh, E. (2015). Status, utilization and economic valuation of Non-Timber Forest Products of Arunachal Pradesh. Indian J. For. Environ. Sci. 31(1): 24-37.

Sharma, S., Choudrhury, P., and Chetry, N. (2016). Diversity of Non-Timber Forest Products (NTFPs): A Provisioning Ecosystem Services among Marwet Community, Ri-Bhoi District, Meghalaya. International Journal of Scientific and Research Publications 6(9):48-55.

Sherstobitoff, M.M. (2008). Socio-economic factors affecting Non-timber Product collection in the Komi Republic, Russia. Masters thesis, The University of Northern British Columbia

Shrestha, U.B. & Bawa, K.S. (2014). Economic contribution of Chinese caterpillar fungus to the livelihoods of mountain communities in Nepal. Biological Conservation (177): 194–202.

Siebert, S.F. & Belsky, J. (1985) Forest product trade in a lowland Filipino Village. Economic Botany 39 (4): 522–533.

Sinha, B., Kala, C.P. and Katiyar, A.S. (2010). Enhancing livelihoods of forest dependent communities through synergizing FDA activities with other development programs. RCNAEB sponsored project, Indian Institute of Forest Management (IIFM), Bhopal.

Stanley, D.; Voeks, R.; and Short, L. (2012). Is Non-Timber Forest Product Harvest Sustainable in Less Developed World? A systematic Review of Recent Economic and Ecological Literature. Ethnobiology and Conservation 2012, 1:9 ISSN 2238-4782.

Stave, J., Oba, G., Nordal, I., and Stenseth, N. C. (2007). Traditional Ecological Knowledge of a Riverine Forest in Turkana, Kenya: Implications for Research and Management. Retrieved June 20, 2017 from: https://www.researchgate.net/publication/225578249 doi: 10.1007/s10531-006-9016-y.

Suleiman, M.S., Wasonga, V.O., Mbau, A.S. , Suleiman, A. & Elhadi, Y.A. (2017). Non-timber forest products and their contribution to households income around Falgore Game Reserve in Kano, Nigeria. Ecological Processes 6:23. Retrieved September 27, 2017, from: doi 10.1186/s13717-017-0090-8

Sumukwo, J.; Adano, W.R.; Kiptui, M.; Cheserek, G.J. and Kipkoech, A.K. (2013). Valuation of Natural Insurance Demand for Non-Timber Forest Products in South Nandi, Kenya. Journal of Emerging Trends in Economics and Management Sciences (JETEMS) 1 (1): 89-97.

Sunderland, T.C.H., Cunningham, A.B., Tchoundjeu, Z., Ngo-Mpeck, M.L., & Laird, S.A.(2004). Yohimbe. (Pausinystalia johimbe), In: Clark, L.E., Sunderland, T.C.H. (Eds.). The Key Non-Timber Forest Products of Central Africa: State of the Knowledge.Technical Paper No. 122, USAID, pp. 121–140.

Sunderland, T. & Ndoye, O. (eds) 2004. Forest Products, Livelihoods and Conservation: Case Studies of non-Timber Forest Product Systems, Vol. 2 – Africa. ISBN 979-3361-25-5 © 2004 by CIFOR 128p.

Svarrer, K. & Olsen, C. S. (2005). The Economic Value of Non-Timber Forest Products—A Case Study from Malaysia', Journal of Sustainable Forestry, 20: 1, 17 — 41. Retrieved October 9, 2017 from: http://dx.doi.org/10.1300/J091v20n01_02 doi: 10.1300/J091v20n01_02.

Tabachnick, B.G. & Fidell, L.S. (2007). Using multivariate statistics. Fifth edition. Harper Collins college publishers, New York.

Tanui, J.G. and Saina, C.K. (2015). The physical state of forest cover and landuse in Kenya – A case of Nandi Hills in Nandi County, Kenya. European Journal of Agricultural and Forestry Research 3(3): 1-14.

Tassou, M. (2017). Factors affecting household participation in non-timber forest products market in Eastern Uganda. MSc. Thesis. University of Nairobi.

Terry, M.E. & Cunningham, A.B. (1993). Impact of commercial marketing on the basketry of southern Africa. Journal of Museum Ethnography 4:25-48.

Tewari J.C., Pareek, K., Shiran, K. & Roy, M.M. (2017). Non Timber Tree Products: Alternative Source of Livelihood in Man-Crop/Grass-Livestock Tree/Shrub Continuum of Arid Regions. MOJ Eco Environ Sci 2(4): 00030. Retrieved October 9, 2017 from: doi: 10.15406/mojes.2017.02.00030

The Organic Farmer (2015). The magazine for sustainable agriculture in Kenya. Submitted by the organic farmer on Wed, 01/28/2015-22:35. Retrieved July 10, 2017 from: http://theorganicfarmer.org/content/importance-good-dairy-feeding

Ticktin, T. (2004). The ecological implications of harvesting non-timber forest products. Journal of Applied Ecology 41: 11–21.

Timmer, C.P., Falcon, W.P., & Pearson, S.R. (1983). Food Policy Analysis. Published for the World Bank. The John Hopkins University Press. Baltmore and London.318pp

Tiwari, S.C. & Itoo, M.A. (2014). A biodiversity perspective on the NTFP potential of Bilaspur Forest Division of Chhattisgarh. The Indian Forester (founded in 1875). A pioneer monthly journal in forestry research and education. 140 (9). Retrieved October 17, 2017 from: http://www.indianforester.co.in/index.php/indianforester/article/view/52352

Tsingalia M.H. (1988). Animals and the Regeneration of an African Rainforest Tree. Ph.D. Thesis, University of California, Berkeley, California.

Tura, T.T., Soromessa, T., Leta, S. & Argaw, M. (2017). Plant community composition and structure of Asabot dry Afromontane forest, West Harare Zone, Ethiopia. J. Biodivers. Endanger. Species 5: 202. doi: 10.4172/2332-2543.1000202.

Turner, N.J. (2001). “Doing it Right”: Issues and practices of sustainable harvesting of non-timber forest products relating to First Peoples in British Columbia. B.C. Journal of Ecosystems and Management 1(1): 1-11. Retrieved October 20, 2017 from: http://www.siferp.org/jem/2001/vol1/no1/art6.pdf

Uganda Forest Association report (2014). Forestry Contribution to the Economy and Trade in Uganda.

UNO (United Nations Organization) (1994). Conservation and Management of Closed Forest: A manual of field techniques for students and trainees. UNO/RAF/006/GEF. E.A. Forest Field Workshop, Uganda, April-May, 1994.

Uprety, Y., Poudel, R.C., Chettri, N. & Chaudhary, R.P. (2016). Traditional use and management of NTFPs in Kangchenjunga Landscape: Implications for conservation and livelihoods. Journal of Ethnobiology and ethnomedicine 12:19. Retrieved September 27, 2017 from: DOI 10.1186/s 13002-016-0089-8

Van Staden, D., Rogers, E., Makaudi, I., Winkler, J., White, J., Kangale, M., Rudman, N., Nkosi, S., Dreyer, T.R. & Coetzer, T. (2006). A transect walk undertaken in Itereleng informal settlement to observe community vulnerability. Pretoria: City of Tshwane Metropolitan Municipality Disaster Risk Management Centre. Unpublished report.

Vantomme, P. Markkula, A. & Leslie, R.N. (2002). Non-wood forest products in 15 countries of tropical Asia: An overview. In P. Vantomme, A. Markkula & R. N. Leslie (eds.), Information and analysis for sustainable forest management: linking national and international efforts in South and Southeast Asia, EC-FAO Partnership Programme, FAO, Rome.

Vedeld, P., Angelsen, A., Bojo, J., Sjaastad, E. & Berg, G.K. (2007). Forest environmental incomes and the rural poor. Forest Policy and Economics 9, 869-879.

Virillo, C.B., Martins, F.R., Tamashiro, J.Y., & dos Santos, F.A. (2011). Is size structure good measure of future trends of plant populations? An empirical approach using five woody species from the cerrado (Brazilian savanna). Acta Botanica Brasilica 25 (3): 593-600.

Waha, K., Zipf, B., Kurukulasuriya, P. & Hassan, R.M. (2016). An agricultural survey for more than 9500 African households. Retrieved August 30, 2017 from: http://dx.doi.org/10.6084/m9/figshare.c.1574094

Wambugu, C., Franzel, S., and Rioux, J. (2014). Options for climate-smart agriculture at Kaptumo site in Kenya. ICRAF Workin Paper No. 185. Nairobi. World Agroforestry Centre. Retrieved August 15, 2017 from DOI: http://dx.doi.org/10.5716/ WP 14394.PDF

Wang, H.W., Peng, D.C., and Xie, J.T. (2009). Ginseng leaf-stem: bioactive constituents and pharmacological functions. Chin Med. (4):20.

Wanjohi, B., Njunge, J.T., Otieno, D.F., & Okoth, E.O. (2017). Plant species composition, structure and diversity in Nabkoi Forest Reserve (Kenya). Researchjournali's Journal of Forestry 4(3):1-21.

Wass, P. (Ed) (1995). Kenya's Indigenous Forest: status, management and conservation. IUCN/ODA Publication.

Wenger, K.F. (Ed.) (1984). Forestry Handbook 2nd Edition. A Wiley Inter Science Publication. John Wiley & Sons. 1335pp.

Whittington, D., Mu, X., & Roche, R. 1990. Calculating the Value of Time Spent CollectingWater: Some Estimates for Ukunda, Kenya. World Development (18): 269-280.

WHO (2020). Gender and non-communicable diseases in Europe. Analysis of STEPS data. WHO/EURO: 2020-1664-41415-56457

Wickramasinghe, A., Perez, M.R. & Blockhus, J.M. (1996). Nontimber forest product gathering in Ritigala forest (Sri Lanka): household strategies and community differentiation. *Human Ecology* 24 (4): 493–519.

Willem te Velde, D. (2004). Successful NTFP commercialization: A quantitative analysis based on household and trader level data. Overseas Development Institute. Paper for a project by UNEP-WCMC and ODI participants: Eleine Marshall and Adrian Newton (UNEP-WCMC), Kate Schreckenberg and Dick Willem te Velde(ODI). Retrieved August 29, 2017 from: http://www.research4development.info/PDF/outputs/Forestry/R79256.successful_NTFP_QuantitativeanalysisPdf

Wollenberg, E. (1996). An evaluation of methodologies used in time allocation research. pp 127-145 in Poats, S., Scmink, M., & Spring, A. (Eds.). Gender issues in farming systems research and extension. Westview Press, Boulder.

Yadav, M and Dugaya, D. (2013). Non-timber forest products certification in India: opportunities and challenges. Environ Dev Sustain 15:567–586. Retrieved October 10, 2017 from: doi 10.1007/s10668-012-9393-1

Yamane, T. (1967). Statistics, An Introductory Analysis, 2nd Ed., New York: Harper and Row.

Young, T. P. (1984). Kenya's indigenous forests: Status , threats and prospects for conservation action. IUCN/WWF

Zegeye, H., Teketay, D. & Kelbessa, E. (2011). Diversity and regeneration status of woody species in Tara Gedam and Abebaye forests, north-western Ethiopia. Journal of Forestry Research (2011) 22: 315. https://doi.org/10.1007/s11676-011-0176-6

Zhaohua, Z. (2001). Non-timber products and forest biodiversity in China. International Academic Publishers/World Publishers Company.

Zuidema, P. A. (2000). Demography of exploited tree species in the Bolivian Amazon. Dissertation. Utrecht University, The Netherlands. PROMAB Scientific Series 2.

APPENDICES

Appendix 1: NTFP-related household questionnaire

Introduction

This survey is being undertaken to find out the impact of Non-Timber Forest Products on the condition of South Nandi Forest and local livelihoods of adjacent communities. The information provided by the respondents will be kept confidential and therefore nobody will be victimized for information provided. The results of the survey will contribute towards sustainable forest utilization in the area and will also be used for academic purposes only.

A. Identification

Interviewer: ___________________________________Date___________________

Time started_______________ Time ended____________________

Household name_______________________________

Code_________________________

Village name__________________________________

Code_________________________

Location_______________________________________

Sub-County name______________________________

Code_________________________

Primary respondent: ___________________________

B. NTFPs Status and utilization

1. List down the NTFPs collected and/ or sold by your household round the year? (*Please tick and note their uses and status detail in the table below*)

NTFPs	Most important 6 NTFPs for househod use (rank 1- 6)	Type/ parts of the plants collected	Gender of person who collects NTFP (1= Mostly F, 2=Mostly M, 3=MandF equally)	Used for what purpose	How far from household		Time spent for collection of NTFPs by household members (Hours/ year)	NTFP resourcesbase	
					km	Min.		Stock condition compared to 10 years ago (1=decreased, 2=No Change and 3=Increased)	Reason for degradation (rank 1-3) [1] (please note below the table with reason in case of stock increased)

[1]*Codes: 1= over population and over exploitation, 2= increased NTFP trade, 3=increased product ----- cutting, 4 = financial crisis of forest-adjacent households, 5 = land clearing for-----, 6= lack of awareness, 7= lack of domestication initiative, 8= lack of administrative/ organizational support,9 = lack of law and policy implementation, 10 = other, specify…………*

C. General Information about NTFP Business

1. Please provide the basic information about the NTFP business

1. How many years have you been engaged in the NTFP business?			
2. During the past 6 months, how many people from your own household were employed or worked on your NTFP business?			
3. During the past 6 months, how many people outside of your own household have you employed? (*i.e. only those engaged in NTFP business)*			
4. What was the type of the employment? (1= full time; 2= part-time, 3=seasonal or contract basis; 4= day labor; 5= other, specify?			
5. Do you belong to a community forest association (cfa) that is focused on the NTFP trade? *(0=No; 1=Yes)*			
5a. If not, would you like to form or be a member of such a cfa? *(0=No; 1=Yes)*			
6. Is the NTFP business your primary source of income? *(0=No; 1=Yes)*			
7. If No, what is your primary source of income?			
8. What is your average monthly household income including subsistence and support? (in ksh)			
9. Roughly how much of your average monthly household income is from NTFP business? (in ksh)			
	Rank1	Rank2	Rank3
10. During which months is the demand for NTFP highest (pick)?			
11. During which months is the demand for NTFP lowest (off-pick)?			
12. Which places does the majority of NTFP that passes through your business come from?			

2. What are the major problems/challenges your business currently faces (rank 1 to 3)?

1. Main problem/challenge	
2. Secondary problem/challenge	
3. Tertiary problem/challenge	

D. NTFP income

1. Do you sell Non-Timber Forest Products? Yes…. No…..

2. If yes, what are the most important NTFPs in terms of income for **selling in the market** (name and rank)?

3. What were the quantities and prices of NTFP that you collected/ purchased and sold in (6 months ago) ----------, and now---------------

	1.Quantity collected/ Purchased	2.Unit	3.Conversion factor	4.Price per unit purchased[1]	5. Quantity sold	6. Price per unit sold	7. Gross income (column 5x6 -1x4) ksh.
----2016 (now)							
-----2016 (6 months ago)							

**If NTFP purchased/ sold was of varying qualities or was purchased/sold in a variety of units (for example, some 80 kg sacks, some 40 kg sacks), please record as separate entries.*

[1] *For collectors, column 4 not applicable and value of this column should be noted as zero.*

4. What were the quantities, prices and gross income of processed/ produced NTFPs that you sold in (6 months ago) ----------, and now---

------------?

	1.Processed or produced products	2.Quantity sold	3.Unit	4.Conversi on factor	5.Price Per unit sold	6.Raw NTFPs used as input	7.Quantity Collected or Purchased	8. Unit	9.Conver -sion factor	10.Price per unit of raw NTFP	11. Gross income column (2x5 -7x10) ksh.
----2016 (now											
-----2016 (6 months ago)											

**If NTFP purchased/ sold was of varying qualities or was purchased/sold in a variety of units (for example, some 80 kg sacks, some 40 kg sacks), please record as separate entries*

5. Gross Income and information related specifically to NTFP sales:

(ask all respondents that identify their primary/ secondary/ tertiary role as: agent/broker/middleman or transporter)

	(now)	(6 months ago)
1. Gross income from contract or piece rate work		
2. Gross income from commissions		

6a. If the *respondents identify their primary/ secondary/ tertiary role as agents/brokers/middlemen:*

1. How many orders did you fill in March 2016	
2. How many orders did you fill in December 2015?	
3. Who do most of the orders you fill come from? (*1=NTFP from same area; 2=NTFP from another area; 9=Other, specify)*	

6b. If the *respondents identify their primary/ secondary/ tertiary role as transporters:*

What mode do you use to transport NTFP? (*1=Own truck; 2=Rented truck; 3=Truck owned by employer;4=Bodaboda, 5= Bicycle;11=Other, specify*	
2. What is the average distance you travel to deliver a load of NTFP? *Kms*	
3. How many loads did you carry in ----2016? (now) *(number of loads)*	
4. How many loads did you carry in -----2015 (6 months ago)? *(number of loads)*	

7. What are the costs associated with your NTFP business?

	Now	6 months ago,
Costs *(only those related to the specific month):*		
1. Purchased inputs, forest based *(i.e. fibres, standing trees; plants'parts; acres of forested*		

land etc.)		
2. Purchased inputs, other		
3. Hired labor		
4. Taxes		
5. Bribes/tokens		
6. Transportation		
7. Marketing *(i.e. including air time)*		
8. Rental of storage space/stall/shop		
10. Market dues		
11a. Other costs, specify		
11b. Other costs, specify		
12. Total Costs		
13. Value of capital stock *(i.e. trucks, vans, bicycles, saws etc.; include any stored NTFP that was carried over from previous month)*		

8. One time only or irregular costs associated with NTFP purchases and sales

	Amount paid per year *(July 20- June 20)*
1. Transport license	
2. Trading license December 20_____	
3. Other, specify	
4. Other, specify	

9. Rights Associated with Collecting, Transporting and Selling NTFP

	Collect	Transport	Sell
De Jure or Formal Rights			
1. Do you require permission to collect /transport or sell NTFP? (*0=No; 1=Yes)*			
1a. If yes, who grants permission? (1=*KFS.;2=CFA;3=Other, specify)*			
1b. Is the permission written or verbal? (*1=Written; 2=Verbal)*			
1c. Do you have to pay to obtain permission? (*0=No; 1=Yes)*			
De facto Rights	Collect	Transport	Sell
2. Over the past 6 months have you collected/ transported or sold NTFP? (*0=No; 1=Yes)*			

2a. If yes, did you obtain formal permission to do so? *(0=No; 1=Yes)*			
2b. Who granted the permission? (1=*KFS.;2=CFA;3=Other, specify)*			
2c. Was the permission written or verbal? *(1=Written;2=Verbal)*			
2d. Did you have to pay for the permission? *(0=No; 1=Yes)*			
2e. During the past 6 months, how many times have you asked for permission to transport/sell NTFP?			
2f. During the past 6 months, approximately how many times have you or a representative of your business interacted *(i.e. in person)* with representatives of the government organizations (KFS/KWS) regarding your NTFP business?			

10. Major trends/changes in NTFP business since 2011 (last 5 years)

Since 2011, how have the following changed:	General Trend *1=Decreased;2=No change;3=Increased*	Reason for Change *If applicable*
1. The price of a standard unit of NTFP during the pick season?		
2. The price of a standard unit of NTFP during the off-pickseason?		
3 The general availability of NTFP		
4. The distance that NTFP is transported from forest gate to end market *(i.e. where the consumer buys)*		
5. The demand for NTFP by consumers		
6. Number of rules and regulations regarding transporting		
7. Number of rules and regulations regarding selling		
8. The cost of obtaining permission to legally transport NTFP		
9. The cost of obtaining permission to legally sell NTFP		
10. The enforcement of rules and regulations regarding transporting NTFP		

11. The enforcement of rules and regulations regarding selling NTFP		

2. Since 2011, what major events or policies that have had either a positive or negative effect on the NTFP business?

1. Main event/policy	
2. Secondary event/policy	
3. Tertiary event/policy	

11. Environment and forest conservation aspect of NTFP Business

1. Do you consider the environmental and forest conservation issues for your NTFP business (i.e. environmental pollution and balance, forest biodiversity and stock for sustainable supply)?*(0= No 1= yes)*

1a. If yes, what's your action taken for that:

1.b. If not, why not and are you aware of the future environmental and resource stock challenge for your business?

F. Socio-economic information

1. What year were you born?
2. How many years of formal education have you completed?
3. Marital status (married =1;divorced=2;widow=3;widower=4;single =5)
4. How many members do you have at your household?
5. What is the gender of the respondent? *(0=Male; 1=Female)*
6. What ethnic group do you belong to? *(1=Kalenjin, 2=Luo, 3=Luhya, 4=Kikuyu,* 5=Gusii*9=Other (specify))*
7. What is your home District? *(i.e. district of origin)*
8. Where is your household located (is it rural=1; peri-urban=0)?
9. How many acres of land do you own? *(i.e. in a rural setting)*
10. How many urban plots do you own? *(i.e. plots in urban centers)*
11. Is the land above registered in your name *(0=No; 1=Yes)*
12. What's the type of your house? (1= Grass thatched; 2= semi-permanent; 3=Brickbuilt; 4= other, specify)
13. Main occupation of household head
14. What's the total current value of other assets
(eg. Electronic goods, Furniture, agricultural implements, others if you have? (in

ksh)

15. Do you own a motorcycle? *(0=No; 1=Yes)*

16. Do you own a fixed/ mobile phone? *(0=No; 1=Yes)*

17. Do you own a truck or Pick-up that is large enough to transport large volumes of NTFP over long distances? *(0=No; 1=Yes)*

18. Distance to forest edge (_______km, walking_________mins)

19. Distance to market centre (_______km, walking_________mins)

20.Do you get any products from the forest? *(0=No; 1=Yes)*

G. Enumerator's comments on irregularities or interesting issues of note with interview:

Appendix 2: Vegetation sampling during transect walk

DATASHEET B: DATA COLLECTION WITHIN A PLOT

County___________________ Forest ______________________

Vegetation type __________________________Forest block _______________

GPS co-ordinates of reference point(UTM)______________________________

Locality notes: (Descriptive text of a major landmark or attributes that can assist in locating the site during subsequent monitoring) ___________________

Sample plot No._________ GPS coordinates UTM ______________________

Elevation (m): _________

Topography ____________________________

(A) Disturbance indicators within the sample plot

Physical disturbance indicators

Physical disturbance indicators	Present (1)	Absent (0)	Count	Remarks (where applicable)
Dung				
Browsing				
Evidence of fires				
Soil erosion				
Other (specify)				

Biological disturbance indicators

Biological disturbance indicators	Present (1)	Absent (0)	If present, give names of pest species or disease if known or else describe
Invasive species			
Game damage			
Pest and disease damage			
Other (specify)			

Socio-economic disturbance indicators

Socio-economic disturbance indicators	Present (1)	Absent (0)	If present, give the number of stumps, charcoal kilns and area under cultivation or encroachment
Stumps			
Charcoal kilns			
Livestock tracks			
Encroachment (specify)			
Foot paths			
Other (specify)			

(B) Utilization indicators within the sample plot

Utilization indicators	Present (1)	Absent (0)	Remarks (where applicable)
Collection of firewood			
Harvesting of resins			
Controlled grazing, grass harvesting			
Timber harvesting			
Medicinal herbs			
Butterfly collection			
Bee keeping			
Other (specify)			

(C) Assessment of plant resources within the sample plot

Main Plot A (20m by 30m) for assessing trees (Trees ≥ 10 cm DBH)					
Tree no.	Botanical name	Local name	Total height (m)	Dbh (cm)	Remarks

Sub-plot B (10m by 5m) for assessing tree saplings, lianas and shrubs, DBH = 2 cm - 9.99 cm, at least 1.5 m height)					
Tree no.	Tree species	Local name	Total height (m)	Dbh (cm)	Remarks

Sub-plot B (10m by 5m) for assessing tree saplings, lianas and shrubs, DBH = 2 cm - 9.99 cm, at least 1.5 m height)					
Tree no.	Tree species	Local name	Total height (m)	Dbh (cm)	Remarks

Sub-plot C (1m by 2m) for assessing seedlings, herbs (erectile and creeping) and grass						
Species	Life form	Local name	Count	% cover (only applicable to grasses)	Estimated general height of erectile herbs (m)	Remarks
Musa masaika				10	0.3	C
Cynodon dactylon				65		
Azadirachta indica						

Assessment of dead wood within the main plot (30m by 20m plot)

Tree species	Diameter 1 (cm)	Diameter 2 (cm)	Length (m)	Remarks

Assessment done by: ________________ Date: _____________ Signature: __________

Checked by: ______________ Date: _______________ Signature: _________________

Appendix 3: Firewood use datasheet

No._____

This survey is being undertaken to find out the impact of firewood extraction on forest condition and local livelihoods in the South Nandi Forest Ecosystem. The information provided by the respondents will be kept confidential and therefore nobody will be victimized for information provided. The results of the survey will contribute towards sustainable firewood supply in the area and writing a PhD thesis at Moi University, Eldoret.

Background information

1. Date of survey ___________________________
2. Area where survey is conducted______________________________________
3. Name of person conducting survey_____________________________________
4. Name of person interviewed (optional)__________________________1. Female 2. Male
5. Age_____________
6. Marital status **1.** Single **2.** Married **3.** Separated/divorced **4.** Widow **5.** widower
7. Education level **1**. No formal education **2.** Std 1-4 **3.** Std 5-8 **4.** Form 1-2 **5.** Form 3-4 **6.** College **7.** Other (specify)_____________
8. Is person walking alone or in group? 1. Alone 2. Group
9. If in group, count number of persons in the group_________________
10. Size of Household of person being interviewed____________________
11. Ethnic group **1.** Kalenjin **2.** Luo **3.** Luhya **4.** Other (specify)______________

Questions relating to fuel wood collection and usage

12. What is the weight of firewood carried by the person (headload)? ________kg
13. Please record the species of pieces of wood in the headload; measure length (m) and diameter(cm) in table below

No.	Species	L (m)	Dia.(cm)	Remarks
1				
2				
3				
4				
5				

14. How long have you been collecting firewood in this locality?
    1. less than 1 Year
    2. 1 - 3 Years
    3. 3 - 5 Years
    4. Other (specify)_____________
15. What is the wood collected used for?
    1. Commercial
    2. Subsistence/domestic cooking
    3. Both commercial and domestic use
    4. Other(specify)________________
16. If both commercial and domestic use. State percent Commercial_______Domestic______
17. What is the frequency of collecting Fuelwood?
    1. Daily
    2. 3-4 times a week
    3. Other (specify)____________________

18. What is the distance covered (to and fro) while collecting firewood ?

    1. 0-500m
    2. 0.5 -1.0 km
    3. 1.0 -2.0 km   4. Other (specify)______________________________

19. What amount of time is spent collecting firewood?

    1. less than 1 Hour
    2. 1-2 hours
    3. 3-4 hours
    4. Other (specify)_______________

20. Do you pay for firewood collection? 1. Yes 2. No

21. If Yes, how much? ________________________________

22. What do you do for a living? _____________________

23. Give approximate income you get per month? __________________Ksh

24. How much does firewood contribute to your income________________Ksh

25. Do you have an energy-saving stove in your house? 1. Yes 2. No

26. Did you collect any firewood from fallen (trees, branches)? 1. Yes 2. No

27. Did you collect any firewood from standing (trees not fallen over)? 1. Yes 2. No

28. Was it dead or alive? 1. Dead 2. Alive 3. Both

29. What are the species of trees preferred for firewood? _____________________________________

30. What's the preferred season for collecting firewood?

    1. During dry spell
    2. During wet season
    3. Other (specify)______________________________

31. Approximately how much firewood has your household used in the last 12 months? (convert weekly consumption to annual) ______________________

32. Did you get any wood from any other source? 1. Yes 2. No

33. If yes, what proportion of your total firewood collection?

    1. Less than 10% **2.** 10 -25%

    3. Other (specify)_______________________________

34. What are the other types of fuel wood used in your household?

    1.Charcoal **2.** Kerosene **3.** LPG (gas) **4.** Other (specify)__________________

35. Estimate the proportions of firewood compared to other types of fuelwood used in the household weekly.

Firewood	100	80	60	40	20	10	0	
Other (e.g. Charcoal)	0	20	40	60	80	90	100	

Questions related to abundance of resources and condition of the forest

36. How has the forest resources changed in the last 10 years? **1.** Increased 2**.** No change **3.** Decreased

37. What is the main reason for the changes in the forests resources? ____

38. Are there preferred species for firewood which are now difficult to get? **1.** Yes **2.** No

39. If yes, which species? ____

Questions related to Firewood Merchants *(N.B. some firewood collectors may also be merchants)*

40. How long have you been selling firewood? ------years

41. What is the selling price per headload________Ksh
42. Can you give an estimate of how much wood you supplied during the last year? Indicate headloads/week which will be converted to annual supplied___
43. What type of wood do you supply? **1.** Dead and dry **2.** Cut and dry **3.** Other (specify)______
44. Where does it come from? **1.** Forest **2.** Private farm **3.** Buy from firewood collectors **4.** Other (specify)_____________
45. Can you tell me the species? **1.** Yes **2.** No
46. If Yes, which ones? _______________________________________
47. How much of each species do you sell? Give percentage of each ___________
48. Who are your main suppliers? (Give the names of your main suppliers if possible)

    ____
49. What percentage comes from small suppliers? _________________________
50. What locality does your firewood come from? _________________________
51. Name the closest towns or localities *(If you cannot give the locality, give the distance from you)* _______________________________________
52. What is the tenure of the land from where most of your firewood is collected from?
    1. KFS land
    2. Private land
    3. Other (specify)_______________________________
53. Do you have any other comments concerning firewood trade? _____________

CONCLUDE: Thank you very much for your assistance. The results of this survey will be used to assist in ensuring a sustainable firewood supply.

Appendix 4: Species listed during FGD by informants with their family name, local name, growth habit and their uses

No.	Species	Family name	Local name (Nandi)	GH	Uses	TU
1	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Lamaiywet	T	1,3,6,7,8,9,10,12,13,14,16,19,21,22	14
2	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae	Sakamwet	T	1,3,5,7,8,9,10,12,13,14,16,17,19,22	14
3	*Tabernaemontana stapfiana* Britte	Apocynaceae	Mobondet	T	1,7,8,9,10,12,13,14,16,17,19,22	12
4	*Cordia abyssinica* R. Br. ex A. Rich.	Boraginaceae	Tepesuet	T	1,4,7,8,9,10,12,13,14,16,17,22	12
5	*Olea capensis* L.	Oleaceae	Murkuiywet	T	1,3,7,8,9,10,12,13,14,16,19,22	12
6	*Albizia gummifera* (JF Gmel.) C. A. Sm.	Mimosaceae	Seet	T	1,7,8,9,10,11,12,13,16,22,23	11
7	*Strombosia scheffleri* Engl.	Olacaceae	Chepkorkoriet	T	1,8,9,10,12,13,14,15,16,19,22	11
8	*Chionanthus mildbraedii* (Gilg and Schellenb.) Strean	Oleaceae	Kwomurguiwet	T	1,2,7,9,10,13,14,16,18,19,22	11
9	*Cassipourea ruwensorensis* (Engl.) Alston	Rhizophoraceae	Martit	T	1,9,10,13,14,15,16,17,19,21,22	11
10	*Prunus africana* (Hook. f.) Kalkm.	Rosaceae	Tenduet	T	1,7,8,9,10,12,13,14,16,19,22	11
11	*Fagaropsis angolensis* Engl.	Rutaceae	Noiwet	T	1,7,8,9,10,12,13,14,16,19,22	11
12	*Zanthoxylum gilletti* (De Wild.) Waterm.	Rutaceae	Sagawaitet	T	1,7,8,9,10,12,13,14,16,19,22	11
13	*Celtis mildbraedii* Engl.	Ulmaceae	Sertet	T	1,8,9,10,12,13,14,16,17,21,22	11
14	*Maytenus heterophylla* (Eckl. and Zeyh.) Robson	Celastaceae	Kukerwet	T	1,8,9,10,12,13,14,16,19,22	10
15	*Diospyros abyssinica* (Hiern) F. White	Ebenaceae	Kendoiywet	T	1,4,8,9,10,13,15,16,19,22	10
16	*Drypetes gerrardii* Hutch.	Euphorbiaceae	Mekunyet	T	1,8,9,10,12,13,16,17,19,22	10
17	*Lepidotrichilia volkensii* (Gürke) Leroy	Meliaceae	Sakamwet	T	1,8,9,10,12,13,14,16,19,22	10
18	*Trilepisium madagascariense* DC.	Moraceae	Mbaraka	T	1,6,8,9,10,12,16,19,21,22	10
19	*Craibia brownii* Dunn	Fabaceae	Mekunyet	T	1,7,8,9,10,13,14,16,17,22	10
20	*Vangueria madagascariensis* Gmel.	Rubiaceae	Kimolwet/kipmowet	T	1,6,7,9,10,13,14,17,21,22	10
21	*Teclea nobilis* Del.	Rutaceae	Kuriot	T/S	1,8,9,10,12,13,14,16,19,22	10
22	*Croton megalocarpus* Hutch	Euphorbiaceae	Masinaidet	T	1,4,8,9,10,12,16,19,22	9
23	*Dovyalis macrocalyx* (Oliv.) Warb.	Flacourtiaceae	Kapchopinyat	S	1,6,7,8,9,10,14,21,22	9
24	*Ekebergia capensis* Sparrm.	Meliaceae	Teldet	T	1,7,8,9,10,13,14,16,22	9
25	*Croton macrostachyus* Del.	Euphorbiaceae	Tebesuet	T	1,4,7,9,10,16,19,22	8
26	*Macaranga kilimandscharica* Pax.	Euphorbiaceae	Sebesebet	T	1,8,9,10,13,14,16,22	8
27	*Nuxia congesta* Fres.	Loganiaceae	Choruwet	S	1,4,9,10,11,13,14,22	8
28	*Trichilia emetica* Vahl.	Meliaceae	Noiywet	T	1,8,9,13,14,15,17,23	8
29	*Ficus sur* Forssk.	Moraceae	Mukoiyot	T	1,6,8,9,10,11,21,22	8
31	*Bersama abyssinica* Fres.	Melianthaceae	Kipumetiet	T	1,4,7,9,10,17,22	7
32	*Coffea eugenioides* S. Moore	Rubiaceae	Noruyot Noriot	S	1,8,9,10,12,13,22	7
33	*Heinsenia diervilleoides* K. Schum.	Rubiaceae	Sekerbanga	T	1,3,8,13,14,16,19	7
34	*Dombeya burgessiae* Gerr. ex Harv.	Malvaceae	Silipchet	T	1,9,10,11,19,20,22	7
35	*Ensete ventricosum* (Welw.) Cheesm.	Musaceae	Sasusuwet	S	4,6,16,18,21,22	6

36	*Maesa lanceolata* Forssk.	Myrsinaceae	Kipapusitanyet	T	1,2,7,9,10,22	6
37	*Triumfetta ruwenzoriensis*	Malvaceae	Miswot	H	7,8,12,20,22,23	6
38	*Caesalpinia volkensii* Harms	Caesalpiniaceae	Chepkomon	S	1,5,7,9,14	5
39	*Erythrococa bongensis*	Euphorbiaceae	Sekelipagang or Chesicheiyot	S	1,7,9,19,22	5
40	*Ricinus communis* L.	Euphorbiaceae	Imaniat	S	1,4,7,9,22	5
41	*Ocimum suave* Willd.	Lamiaceae	Mwokiot	H	7,8,9,11,12	5
42	*Rubus apetalus* Poir.	Rosaceae	Momonyet	S	1,7,9,15,21	5
43	*Solanum mauritianum* Scop.	Solanaceae	Cheptomotwo	S	1,9,13,14,22	5
44	*Solanum* sp.	Solanaceae	Mororuwet	S	1,4,7,9,22	5
45	*Brillantaisia madagascariensis* T. Anderson ex Lindau	Acanthaceae	Kipongiat	S	1,11,13,14,	4
46	*Brillantaisia nitens* Lin-dau	Acanthaceae	Sietet	H	11,12,22,23	4
47	*Hippocratea graciliflora*	Celastraceae	Kipcheiyot	C	1,7,20,22	4
48	*Hippocratea* sp.	Celastraceae	Chepseleitet	C	8,9,10,11	4
49	*Hippocratea africana* (Willd.) Loes	Celastraceae	Ng'ngichet	C	6,14,18,20	4
50	*Solanecio mannii* (Hook. f.) C. Jeffrey.	Asteraceae	Chepkurbet	S	1,7,9,22	4
51	*Dracaena laxissima*	Dracaenaceae	Chepkitonget	S	1,,10,20,22	4
52	*Acalypha ornata* A.Rich	Euphorbiaceae	Sambachet or chesumeiyot	H	6,7,11,22	4
53	*Neoboutonia macrocalyx* Pax	Euphorbiaceae	Kipsebwet	T	1,9,10,22	4
54	*Stephania abyssinica* (Dillon and A. Rich.) Walp.	Menispermaceae	Taparariet	C	6,20,22,23	4
55	*Tiliacora funifera* (Miers) Oliv.	Menispermaceae	Mborosiet	C	6,7,18,20	4
56	*Pavetta abyssinica* Fres.	Rubiaceae	Sekerbanga	S	1,9,16,19	4
57	*Toddalia asiatica* (L.) Lam.	Rutaceae	Kipkoskosit	C	1,7,9,22	4
58	*Solanum aculeastrum* Dunal	Solanaceae	Sikowet	S	1,5,7,9	4
59	*Trema orientalis* (L.) Bl.	Ulmaceae	Kipsartet	T	1,9,10,22	4
60	*Acanthus eminens* C. B. Cl.	Acanthaceae	Indakariat	S	1,7,9,	3
61	*Achyranthes aspera* L.	Amarathaceae	Chesirmit	H	12,18,22	3
62	*Momordica foetida* Schumach.	Cucurbitaceae	Cheptenderet	C	4,7,20	3
63	*Dracaena steudneri* Engl.	Dracaenaceae	Lepekwet	T	7,18,22	3
64	*Achyrospermum schimperi* (Hochst. ex Briq.) Perkins	Lamiaceae	Inyonyoitat	S	6,7,8	3
65	*Leonotis nepetifolia* (L.) W.T. Ait.	Lamiaceae	Sisiyat	S	1,7,9	3
66	*Hibiscus calyphyllus* Cav.	Malvaceae	Motosheiet	S	1,7,9	3
67	*Adenia bequaertii* Robyns and Lawalree.	Passifloraceae	Chemyalelder	C	7,8,20	3
68	*Gouania longispicata* Engl.	Rhamnaceae	Riksoit	C	3,14,23	3
69	*Chlorophytum galabatense* Schweinf. ex Baker.	Liliaceae	Sikotiet	H	7,15	2
70	*Macrorungia pubinervia* (T. Anders) C. B.Cl.	Acanthaceae	Kipongiet	H	9,11	2
71	*Pseuderanthemum ludovicanum* (Büttner) Lindau	Acanthaceae	Chesumeiyot	S	11,12	2
72	*Landolphia* sp.	Apocynaceae	Ngingichet	C	20,22	2
73	*Landolphia buchananii* (Hall. f.) Stapf.	Apocynaceae	Ngigiye/Ngingichet	C	21,22	2

74	*Rauvolfia volkensii* (K.Schum.) Stapf	Apocynaceae	Kipcheiyot	C	7,20	2
75	*Asplenium sandersonii* Hook.	Aspleniaceae	Kataputiet	F	6,22	2
76	*Asplenium theciferum* (Kunth) Mett.	Aspleniaceae	Kataputiet	F	6,22	2
77	*Commelina latifolia* A. Roch.	Commelinaceae	Lepulopitiet	H	6,7	2
78	*Bidens pilosa* L.	Asteraceae	Chepketel	H	7,11	2
79	*Galinsoga parviflora* Cav	Asteraceae	Kipkoleitet	H	7,11	2
80	*Vernonia auriculifera* Hiern	Asteraceae	Kipsabuni	S	7,12	2
81	*Kalanchoe densiflora* Rolfe	Crassulceae	Kuserwet	H	7,23	2
82	*Phyllanthus odontadenius* Mull. Arg.	Euphorbiaceae	Mengeiwet	H	8,12	2
83	*Tragia brevidens*	Euphorbiaceae	Sambachet	H/C	4,7	2
84	*Ocimum kilimandscharicum* Gürke	Lamiaceae		S	7,12	2
85	*Gloriosa superba* L.	Colchicaceae		H	7,23	2
86	*Lobelia gibberoa* Hemsl.	Lobeliaceae	Sereguet	H	7,22	2
87	*Turraea holstii* Gürke	Meliaceae	Kosositiet	S	7,22	2
88	*Ficus* sp.	Moraceae	Kipchimdet	C	7,20	2
89	*Calpurnia* spp.	Papilionaceae	Senendet	S	4,7	2
90	*Desmodium repandum* (Vahl) DC.	Papilionaceae	Chemigoiyot	H	6,7	2
91	*Passiflora edulis* Sims	Passifloraceae	Kerenderiat or Chemagururiet	C	6,20	2
92	*Plantago palmata* Hook. f.	Plantaginaceae	Yakariet	H	7,11	2
93	*Helinus mystacinus* (Aiton) E.Mey. ex Steud	Rhamnaceae	Sesiat	C	7,22	2
94	*Scutia myrtina* (Burm. f.) Kurz	Rhamnaceae	Sumbeiywet	S/C	1,9	2
95	*Psychotria peduncularis* (Salisb.) Steyerm.	Rubiaceae	Rogoret or chelelkatiat	S	4,22	2
96	*Physalis peruviana* L.	Solanaceae	Mbomiat	H	5,21	2
97	*Solanum nigrum* L.	Solanaceae	Sojo or isochot	H	6,7	2
98	*Urtica dioica* L.	Urticaceae	Sabajet	H	4,7	2
99	*Laportea alatipes* Hook. f.	Urticaceae	Sambachet	H	11,12	2
100	*Cyphostemma kilimandscharica* (Gilg)	Vitaceae	Simet	C	7,22	2
101	*Aframomum keniense* R.E.Fr.	Zingiberaceae	Chemagururiet	S	6,7	2
102	*Lactuca capensis* - Thunb.	Asteraceae	Cheparaa	H	7	1
103	*Lactuca glandulifera* Hook. f.	Asteraceae	Cheparaa	H	7	1
104	*Eulophia galeoloides* Kraenzl.	Orchidaceae	Sigotiet	H	23	1
105	*Culcasia scandens* P.Beauv.	Araceae	Kataputiet	C	8	1
106	*Mondia whytei* (Hook. f.) Skeels	Asclepiadaceae	Chemangururiet	C	7	1
107	*Blumea crispata* (Vahl) Merxm.	Asteraceae	Taptiet	H	23	1
108	*Commelina benghalensis*	Commelinaceae	Sochet	H	6	1
109	*Sonchus* sp.	Asteraceae	Cheparaa	H	7	1
110	*Ipomoea wightii* (Wall.) Choisy	Convolvulaceae	Kimoiyat	C	11	1
111	*Neonotonia wightii* (Wight and Arn.) J.A. Lackey	Fabaceae	Ng’wang’wanyet	H	12	1
112	*Sida cuneifolia* Roxb., Fl. Ind.,	Malraceae	Kerundut	H	8	1

113	*Phytolacca dodecandra* L'Hért.	Phytolaccaceae	Patakwet	S	7	1
114	*Piper capense* L.	Piperaceae	Kiptutung'it	H	7	1
115	*Rumex usambarensis* (Dammer) Dammer	Polygonaceae	Chemideleliet	H	8	1
116	*Pentas lanceolata*	Rubiaceae	Cheruriet	H	8	1
117	*Rutidea orientalis* Bridson	Rubiaceae	Tinguet	C	20	1
118	*Mimulopsis arborescens* C. B. Cl.	Acanthaceae	Sietet	S		0
119	*Meyna tetraphylla* (Hiern) Robyns	Celastraceae	Chebikonyat	S		0
121	*Momordica friesiorum* (Harms) C. Jeffrey	Cucurbitaceae	Ng'wang'wanyet	C		0
122	*Dumasia villosa* DC. var. villosa	Fabaceae	Ng'wang'wanyet	C		0
123	*Vigna* sp	Fabaceae	Ngw'angw'anyet	C		0
124	*Turraea* sp	Meliaceae	Chemuriat	T		0
125	*Olea* sp.	Oleaceae	Itaat	T/S		0
126	*Calpurnia aurea* (Aiton) Benth.	Papilionaceae	Ipembetiet	S		0
127	*Thalictrum rhynchocarpum* Quart.-Dill. and A.Rich.	Ranunculaceae	Chesumeiyot	H		0
128	*Allophylus rubifolius* (Hochst. ex A.Rich.) Engl.	Sapindaceae	Chemoriat	S		0

SUMMARY

SUMMARY																							
USES*	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Total no. of species/use	54	2	4	15	4	20	66	36	52	38	15	28	28	28	6	27	10	6	21	15	11	60	10

KEY:

*1= fire lighting; 2= dye making; 3= water storage; 4= ceremonial; 5= boundary fencing; 6= Food/spices; 7= Medicinal; 8= Timber; 9= Firewood; 10= Charcoal; 11= Fodder; 12= Making beehive; 13= Posts/poles; 14= Fencing; 15= Spears/arrows; 16= construction; 17=Making traps; 18= smoking milk calabash; 19= Rafters; 20= Strings; 21=Fruits; 22= Making small implements; 23= Banana ripening

GH =Growth habit; T=Tree, S=Shrub, H=Herb, C=Climber; TU=Total number of uses per species.

Appendix 5: Species listed for firewood use by informants with their family name, local name and its growth habit

No.	Species	Family name	Local name (Nandi)	GH
1	*Syzygium guineense*	Myrtaceae	Lamaiywet	T
2	*Allophylus abyssinicus*	Sapindaceae	Sakamwet	T
3	*Tabernaemontana stapfiana*	Apocynaceae	Mobondet	T
4	*Cordia abyssinica*	Boraginaceae	Tepesuet	T
5	*Olea capensis*	Oleaceae	Murkuiywet	T
6	*Albizia gummifera*	Mimosaceae	Seet	T
7	*Strombosia scheffleri*	Olacaceae	Chepkorkoriet	T
8	*Chionanthus mildbraedii*	Oleaceae	Kwomurguiwet	T
9	*Cassipourea malosana*	Rhizophoraceae	Martit	T
10	*Prunus africana*	Rosaceae	Tenduet	T
11	*Fagaropsis angolensis*	Rutaceae	Noiwet	T
12	*Zanthoxylum gillettii*	Rutaceae	Sagawaitet	T
13	*Celtis mildbraedii*	Ulmaceae	Sertet	T
14	*Maytenus heterophylla*	Celastaceae	Kukerwet	T
15	*Diospyros abbysinica*	Ebenaceae	Kendoiywet	T
16	*Drypetes gerrardii*	Euphorbiaceae	Mekunyet	T
17	*Lepidotrichilia volkensii*	Meliaceae	Sakamwet	T
18	*Trilepsium madagascariense*	Moraceae	Mbaraka	T
19	*Craibia brownie*	Papilionaceae	Mekunyet	T
20	*Vangueria madagascariensis*	Rubiaceae	Kimolwet/kipmowet	T
21	*Teclea nobilis*	Rutaceae	Kuriot	T/S
22	*Croton megalocarpus*	Euphorbiaceae	Masinaidet	T
23	*Dovyalis macrocalyx*	Flacourtiaceae	Kapchopinyat	S
24	*Ekebergia capensis*	Meliaceae	Teldet	T
25	*Croton macrostachyus*	Euphorbiaceae	Tebesuet	T
26	*Macaranga kilimandscharica*	Euphorbiaceae	Sebesebet	T
27	*Nuxia congesta*	Loganiaceae	Choruwet	S
28	*Trichilia emetica*	Meliaceae	Noiywet	T
29	*Ficus sur*	Moraceae	Mukoiyot	T
30	*Dovyalis abyssinica*	Flacourtiaceae	Nukiat	S
31	*Bersama abyssinica*	Melianthaceae	Kipumetiet	T
32	*Coffea eugenioides*	Rubiaceae	Noruyot Noriot	S
33	*Dombeya burgessiae*	Sterculiaceae	Silipchet	T
34	*Maesa lanceolata*	Myrsinaceae	Kipapusitanyet	T
35	*Caesalpinia volkensii*	Caesalpiniaceae	Chepkomon	S
36	*Erythrococa bongensis*	Euphorbiaceae	Sekelipagang or Chesicheiyot	S
37	*Ricinus communis*	Euphorbiaceae	Imaniat	S
38	*Ocimum suave*	Lamiaceae	Mwokiot	H
39	*Rubus apetalus*	Rosaceae	Momonyet	S
40	*Solanum mauritianum*	Solanaceae	Cheptomotwo	S
41	*Solanum sp.*	Solanaceae	Mororuwet	S
42	*Hippocratea sp.*	Celastraceae	Chepseleitet	C
43	*Solanecio mannii*	Compositae	Chepkurbet	S
44	*Neoboutonia macrocalyx*	Euphorbiaceae	Kipsebwet	T
45	*Pavetta sp.*	Rubiaceae	Sekerbanga	S
46	*Toddalia asiatica*	Rutaceae	Kipkoskosit	C
47	*Solanum aculeastrum*	Solanaceae	Sikowet	S
48	*Trema orientalis*	Ulmaceae	Kipsartet	T
49	*Acanthus eminens*	Acanthaceae	Indakariat	S

50	*Leonotis nepetifolia*	Lamiaceae	Sisiyat	S
51	*Hibiscus calyphyllus*	Malvaceae	Motosheiet	S
52	*Macrorungia pubinervia*	Acanthaceae	Kipongiet	H
53	*Scutia myrtina*	Rhamnaceae	Sumbeiywet	S/C

Key:

GH =Growth habit; T=Tree, S=Shrub, H=Herb, C=Climber

Appendix 6: Species listed for medicinal use by informants with their family name, local name, growth habit and the total number of diseases treated

No.	Species	Family name	Local name (Nandi)	GH	Diseases treated
1	*Lactuca capensis*	Asteraceae	Cheparaa	H	Anodyne, antispasmodic, digestive, diuretic, hypnotic, narcotic and sedative properties
2	*Lactuca glandulifera*	Asteraceae	Cheparaa	H	Anodyne, antispasmodic, digestive, diuretic, hypnotic, narcotic and sedative properties
3	*Chlorophytum galabatense*	Liliaceae	Sikotiet	H	Cough, cold, Hair conditioner
4	*Acanthus eminens*	Acanthaceae	Indakariat	S	Spleen, Liver, Alimentary canal, skin diseases, wound, eye infections
5	*Rauvolfia sp.*	Apocynaceae	Kipcheiyot	C	Tonsils, Hypertension, insomnia
6	*Tabernaemontana stapfiana*	Apocynaceae	Mobondet	T	Leaf decoction – appetizer and treat colic
7	*Mondia sp.*	Asclepiadaceae	Chemangururiet	C	Appetizer, increase libido
8	*Cordia abyssinica*	Boraginaceae	Tepesuet	T	Cover broken limb
9	*Caesalpinia volkensii*	Caesalpiniaceae	Chepkomon	S	Wound
10	*Hippocratea graciliflora*	Celastraceae	Kipcheiyot	C	Tonsils
11	*Commelina latifolia*	Commelinaceae	Lepulopitiet	H	Stomach ache
12	*Bidens sp.*	Asteraceae	Chepketel	H	Used in Fresh wound, digestive disorders
13	*Galinsoga parviflora*	Asteraceae	Kipkoleitet	H	Wounds and skin inflammations
14	*Solanecio mannii*	Asteraceae	Chepkurbet	S	Cold, Chest infections, Otitis media, Malaria, Stomach ache, heartburn
15	*Sonchus sp.*	Asteraceae	Cheparaa	H	Tonsils, Cough
16	*Vernonia sp*	Asteraceae	Kipsabuni	S	Labor, Malaria, Afterbirth
17	*Kalanchoe densiflora*	Crassulceae	Kuserwet	H	rheumatism and inflammation
18	*Momordica sp*	Cucurbitaceae	Cheptenderet	C	Malaria, Tuberculosis
19	*Dracaena steudneri*	Dracaenaceae	Lepekwet	T	Stomach problems
20	*Acalypha sp*	Euphorbiaceae	Sambachet or chesumeiyot	H	Skin problem
21	*Croton macrostachyus*	Euphorbiaceae	Tebesuet	T	Ring worrms, diarrhorea, fever in cows

22	*Erythrocooca bongensis*	Euphorbiaceae	Sekelipagang or Chesicheiyot	S	Vegetable, anthelmintic, antitussive, stomachic and tonic
23	*Ricinus communis*	Euphorbiaceae	Imaniat	S	offers relieve to several diseases, ailments and discomforts e.g. Constipation, worms, Arthritis, muscle aches and back ache, urinary tract infections
24	*Tragia brevidens*	Euphorbiaceae	Sambachet	H/C	Gonorrhea, promote conception, lower labour pain,
25	*Dovyalis abyssinica*	Flacourtiaceae	Nukiat	S	Stomach ache, boost body immunity, chest ailments
26	*Dovyalis macrocalyx*	Flacourtiaceae	Kapchopinyat	S	Constipation, Peptic ulcers
27	*Achyrospermum schimperi*	Lamiaceae	Inyonyoitat	S	Antimalarial
28	*Ocimum suave*	Lamiaceae	Mwokiot	H	aromatic, stimulant, antispasmodic, antiseptic
29	*Leonotis nepetifolia*	Lamiaceae	Sisiyat	S	swellings, fever, gastro-intestinal troubles
30	*Ocimum kilimandscharicum*	Lamiaceae		S	lower fever and many ailments
31	*Gloriosa superba*	Liliaceae		H	tonic, anti-periodic, anti- helminthic and laxative
32	*Lobelia gibberoa*	Lobeliaceae	Sereguet	H	Asthma, Bronchiti, Cough
33	*Hibiscus calyphyllus*	Malvaceae	Motosheiet	S	Stomach ache, General fever
34	*Ekebergia capensis*	Meliaceae	Teldet	T	Back ache, Chest pains, Dysentery, Diarrhorea
35	*Turraea sp*	Meliaceae	Kosositiet	S	Convulsions, Cough
36	*Bersama abyssinica*	Melianthaceae	Kipumetiet	T	Stomach ache, Pneumonia, TB, Malaria, East coast fever
37	*Tiliacora keniensis*	Menispermaceae	Mborosiet	C	Fever relief, Pneumonia, antiinflammation
38	*Albizia gummifera*	Mimosaceae	Seet	T	Sexually transmitted infections, stomach ache
39	*Ficus sp.*	Moraceae	Kipchimdet	C	Diarrhorea, Vomiting
40	*Maesa lanceolata*	Myrsinaceae	Kipapusitanyet	T	Heartburn
41	*Syzygium guineense*	Myrtaceae	Lamaiywet	T	anthelmintic, antispasmodic, laxative, purgative and tonic, antifungal, antibacterial, diarrhorea
42	*Chionanthus mildbraedii*	Oleaceae	Kwomurguiwet	T	Pneumonia, Chest pain

43	*Olea capensis*	Oleaceae	Murkuiywet	T	Cough, TB, Malaria, Peptic ulcers, Stomach ache
44	*Calpumea sp.*	Papilionaceae	Senendet	S	Swollen body
45	*Craibia brownie*	Papilionaceae	Mekunyet	T	cough
46	*Desmodium repandum*	Papilionaceae	Chemigoiyot	H	Stomach ache
47	*Adenia sp.*	Passifloraceae	Chemyalelder	C	treat many conditions, including gastrointestinal problems, inflammation, pain, fever, malaria, leprosy, scabies, cholera, anemia, bronchitis, sexually transmitted diseases, menorrhagia, and mental illness
48	*Phytolacca dodecandra*	Phytolaccaceae	Patakwet	C	anti-inflammatory, treats many ailments e.g. venereal diseases, bilharzia, rabies, malaria, sore throat and other respiratory problems, rheumatic pain and jaundice
49	*Piper capense*	Piperaceae	Kiptutung'it	H	Cough
50	*Plantago palmate*	Plantaginaceae	Yakariet	H	Tonsils, pneumonia, eye problems, stomach ache, venereal diseases, typhoid, antidiarrhorea
51	*Helimus mystacinus*	Rhamnaceae	Sesiat	C	Epilepsy
52	*Prunus Africana*	Rosaceae	Tenduet	T	Prostate cancer, Stomach ache
53	*Rubus apetalus*	Rosaceae	Momonyet	S	Stomach ache, Food poisoning
54	*Vangueria madagascariensis*	Rubiaceae	Kimolwet/kipmowet	T	Worms, food supplement
55	*Fagaropsis angolensis*	Rutaceae	Noiwet	T	
56	*Toddalia asiatica*	Rutaceae	Kipkoskosit	C	Worms in cattle, Malaria, Stomach ache, Chest pains, Urinary tract, TB, Cough
57	*Zanthoxylum gillettii*	Rutaceae	Sagawaitet	T	Cough and Chest pains, Anthrax, measles, tonic, urinary tract infections
58	*Allophylus abyssinicus*	Sapindaceae	Sakamwet	T	Head ache, heart ache, Back ache
59	*Solanum aculeastrum*	Solanaceae	Sikowet	S	Stomach ache
60	*Solanum nigrum*	Solanaceae	Sojo or isochot	H	Dropsy, General debility, Diuretic, anti dysenteric
61	*Solanum sp.*	Solanaceae	Mororuwet	S	Stomach ache
62	*Triumfetta ruwenzoriensis*	Tiliaceae	Miswot	H	internal ulcerations, antihypertensive, astringent, diuretic, mucilaginous and emollient, leprosy

63	*Trema orientalis*	Ulmaceae	Kipsartet	T	gargle, inhalation, drink, lotion, bath or vapour bath for coughs, sore throat, asthma, bronchitis, gonorrhoea, yellow fever, toothache
64	*Urtica sp.*	Urticaceae	Sabajet	H	Circumcision ceremonies, boils, worms
65	*Cyphostemma orondo*	Vitaceae	Simet	C	wounds
66	*Aframomum keniense*	Zingiberaceae	Chemagururiet	S	painful menstruation, excessive lactation, post-partum haemorrhage and infertility

Key:

GH = Growth habit; T=Tree; S=Shrub; H=Herb; C=Climber

Appendix 7: Determination of Relative density, Dominance, Frequency and Importance Value Index (IVI) in forest section adjacent to Chepkongony village

No.	Family	Species	No.	BA	Freq	RD1	R.D.	R.F.	IVI
1	Euphorbiaceae	*Croton megalocarpus*	15	2.7	100	9.2	25.5	8.2	42.9
2	Apocynaceae	*Tabernaemontana stapfiana*	17	1.1	80	10.4	10.6	6.6	27.6
3	Euphorbiaceae	*Macaranga kilimandscharica*	9	1.3	80	5.5	12	6.6	24.1
4	Olacaceae	*Strombosia Scheffleri*	16	0.7	60	9.8	6.7	4.9	21.4
5	Euphorbiaceae	*Drypetes gerrardii*	9	1	40	5.5	9.3	3.3	18.1
6	Rubiaceae	*Heinsenia diervilleoides*	16	0.1	60	9.8	0.9	4.9	15.6
7	Rasaceae	*Prunus africana*	1	1.4	20	0.6	12.9	1.6	15.2
8	Solanaceae	*Solanum mauritianum*	12	0	80	7.4	0.1	6.6	14.1
9	Ulmaceae	*Celtis africana*	4	0.4	60	2.5	3.7	4.9	11
10	Monimiaceae	*Xymalos monospora*	8	0.1	60	4.9	0.6	4.9	10.4
11	Sapindaceae	*Allophyllus africanus*	4	0.3	40	2.5	3.3	3.3	9
12	Sapindaceae	*Deinbollia kilimandscharica*	2	0.5	40	1.2	4.5	3.3	9
13	Ebenaceae	*Diospyros abyssinica*	5	0.4	20	3.1	4.2	1.6	8.9
14	Melianthaceae	*Bersama abyssinica*	4	0.1	40	2.5	1.1	3.3	6.9
15	Rhizophoraceae	*Cassipourea ruwensoriensis*	4	0.1	40	2.5	0.7	3.3	6.5
16	Flacourtiaceae	*Casearia battiscombei*	4	0.1	40	2.5	0.7	3.3	6.5
17		*Bererait (unknown)*	7	0	20	4.3	0.2	1.6	6.1
18	Euphorbiaceae	*Neoboutonia macrocalyx*	5	0.1	20	3.1	0.6	1.6	5.3
19	Boraginaceae	*Ehretia cymosa*	4	0.1	20	2.5	0.6	1.6	4.7
20	Euphorbiaceae	*Erythrococca bongensis*	2	0	40	1.2	0	3.3	4.5
21	Moraceae	*Ficus sur*	2	0.1	20	1.2	0.9	1.6	3.8
22	Flacourtiaceae	*Dovyalis macrocalyx*	2	0	20	1.2	0	1.6	2.9
23	ulmaceae	*Celtis mildbraedii*	1	0.1	20	0.6	0.5	1.6	2.8
24	Bignoniaceae.	*Kigelia africana*	1	0	20	0.6	0.1	1.6	2.4
25	Rutaceae	*Zanthoxylum gillettii*	1	0	20	0.6	0.1	1.6	2.3
26	Meliaceae	*Trichilia ementica*	1	0	20	0.6	0.1	1.6	2.3
27	Achariaceae	*Rawsonia lucida*	1	0	20	0.6	0.1	1.6	2.3
28	Rubiaceae	*Keetia gueinzii*	1	0	20	0.6	0	1.6	2.3
29	Lamiaceae	*Clerodendron volkensii*	1	0	20	0.6	0	1.6	2.3
30	Capparaceae	*Ritchiea albersii*	1	0	20	0.6	0	1.6	2.3
31	Mimosaceae	*Albizia gummifera*	1	0	20	0.6	0	1.6	2.3
32	Moraceae	*Vangueria ruwenzori*	1	0	20	0.6	0	1.6	2.3
33	compositae	*Vernonia sp.*	1	0	20	0.6	0	1.6	2.3
		Total	163	10.6	1220	100	100	100	300

Key:

BA= Basal Area; No. =Number of individuals; Freq= frequency; RD1 =Relative density;R.D. =Relative dominance; R.F=Relative frequency; IVI =Importance value index

Appendix 8: Determination of Relative density, Dominance, Frequency and Importance Value Index (IVI) in forest section adjacent to Bonjoge village

No.		Species	No.	BA	Freq	RD1	R.D.	R.F.	IVI
1	Solanaceae	*Solanum mauritianum*	109	0.454	100	10	13	57	79
2	Araliaceae	*Polyscias fulva*	3	0.744	60	6	21	2	28
3	Euphorbiaceae	*Croton megalocarpus*	10	0.432	100	10	12	5	27
4	Apocynaceae	*Tabernaemontana stapfiana*	11	0.471	60	6	13	6	25
5	Ulmaceae	*Celtis mildbraedii*	4	0.495	60	6	14	2	22
6	Araliaceae	*Schleffera volkensii*	1	0.407	20	2	11	1	14
7	Olacaceae	*Strombosia scheffleri*	5	0.19	40	4	5	3	12
8	Compositae	*Solanecio mannii*	9	0.041	60	6	1	5	12
9		*Unknown (Bereriat)*	11	0.027	40	4	1	6	10
10	Rutaceae	*Zanthoxylum gillettii*	3	0.018	60	6	1	2	8
11	Flacourtiaceae	*Casearia battiscombei*	1	0.179	20	2	5	1	7
12	Ulmaceae	*Celtis gamphophyla*	5	0.052	20	2	1	3	6
13	Melianthaceae	*Bersama abyssinica*	3	0.002	40	4	0	2	6
14	Compositae	*Vernonia sp.*	2	0.019	40	4	1	1	5
15	Acanthaceae	*Mimulopsis solmisii*	2	0.005	40	4	0	1	5
16	Moraceae	*Trilepisuim madagascariense*	2	0.001	40	4	0	1	5
17	Moraceae	*Ficus sur*	1	0.025	20	2	1	1	3
18	Bignoniaceae	*Spathodea campanulata*	1	0.019	20	2	1	1	3
19	Boraginaceae	*Ehretia albacea*	1	0.003	20	2	0	1	3
20	Euphorbiaceae	*Macaranga kilimandscharica*	1	0.003	20	2	0	1	3
21	Meliaceae	*Lepidotrichilia volkensii*	1	0.001	20	2	0	1	3
22	Euphorbiaceae	*Drypetes gerrardii*	1	0.001	20	2	0	1	3
23	Sapindaceae	*Allophyllus sp.*	1	0.001	20	2	0	1	3
24	Euphorbiaceae	*Erythrococca bongensis*	1	0.001	20	2	0	1	3
25	Rutaceae	*Fagaropsis angolensis*	1	0.001	20	2	0	1	3
26	Capparaceae	*Ritchiea albersii*	1	0.001	20	2	0	1	3
27	Lamiaceae	*Clerodendrum volkensii*	1	0	20	2	0	1	2
		Total	192	3.6	1020	100	100	100	300

Key:

BA= Basal Area; No. =Number of individuals; Freq= frequency; RD1 =Relative density;R.D. =Relative dominance; R.F=Relative frequency; IVI =Importance value index

Appendix 9: Determination of Relative density, Dominance, Frequency and Importance Value Index (IVI) in forest section adjacent to Serem Chebilat village

No.		Species	No.	BA	Freq	RD1	R.D.	R.F.	IVI
1	Moraceae	*Ficus thonningii*	1	3.142	20	1	30.8	1	33
2	Apocynaceae	*Tabernaemontana stapfiana*	23	1.372	100	12	13.5	7	33
3	Araliaceae	*Polyscias fulva*	9	2.024	100	5	19.8	7	32
4	Acanthaceae	*Mimulopsis arborescens*	43	0.152	80	23	1.5	6	30
5	Solanaceae	*Solanum mauritianum*	39	0.144	80	20	1.4	6	28
6	Moraceae	*Ficus sur*	6	1.81	80	3	17.7	6	27
7	Flacourtiaceae	*Casearia battiscombei*	14	0.211	100	7	2.1	7	17
8	Euphorbiaceae	*Macaranga kilimandscharica*	6	0.376	80	3	3.7	6	13
9	Ulmaceae	*Celtis mildbraedii*	6	0.207	80	3	2	6	11
10	Euphorbiaceae	*Croton megalocarpus*	4	0.089	60	2	0.9	4	7
11	Euphorbiaceae	*Erythrococca bongensis*	4	0.003	60	2	0	4	6
12	Olacaceae	*Strombosia scheffleri*	2	0.128	40	1	1.3	3	5
13	Meliaceae	*Trichilia emetica*	4	0.013	40	2	0.1	3	5
14	Dracaenaceae	*Dracaena laxissima*	2	0.118	40	1	1.2	3	5
15	Myrsinaceae	*Maesa lanceolata*	3	0.062	40	2	0.6	3	5
16	Sapindaeceae	*Allophylus abyssinicus*	3	0.039	40	2	0.4	3	5
17	Compositae	*Vernonia auriculifera*	2	0.022	40	1	0.2	3	4
18	Melianthaceae	*Bersama abyssinica*	2	0.011	40	1	0.1	3	4
19	Sapindaceae	*Deinbollia kilimandscharica*	2	0.003	40	1	0	3	4
20	Rubiaceae	*Paveta*	4	0.003	20	2	0	1	4
21	Cupressaceae	*Cupressus lusitanica*	1	0.121	20	1	1.2	1	3
22	Euphorbiaceae	*Croton macrostachyus*	1	0.091	20	1	0.9	1	3
23	Euphorbiaceae	*Neoboutonia macrocalyx*	2	0.024	20	1	0.2	1	3
24		*Unknown*	2	0.012	20	1	0.1	1	3
25	Hamamelidaceae	*Trichocladus ellipticus*	1	0.049	20	1	0.5	1	2
26	Boraginaceae	*Ehretia cymosa*	1	0.012	20	1	0.1	1	2
27	Salicaceae	*Oncoba spinosa*	1	0.008	20	1	0.1	1	2
28	Fabaceae	*Albizia gummifera*	1	0.006	20	1	0.1	1	2
29	Ulmaceae	*Celtis africana*	1	0.004	20	1	0	1	2
30	Rutaceae	*Zanthoxylum gillettii*	1	0.002	20	1	0	1	2
		Total	191	10.2	1380	100	100.6	100	300.6

Key:

BA= Basal Area; No. =Number of individuals; Freq= frequency; RD1 =Relative density;R.D. =Relative dominance; R.F=Relative frequency; IVI =Importance value index

Appendix 10: Determination of Relative density, Dominance, Frequency and Importance Value Index (IVI) in Chepkumia area

No.	Family	Species	No.	BA	Freq	RD1	R.D.	R.F.	IVI
1	Apocynaceae	*Tabernaemontana stapfiana*	34	2.6	80	25	19.3	6	50
2	Araliaceae	*Schefflera volkensii*	1	3.9	20	1	28.7	2	31
3	Moraceae	*Ficus sur*	3	2.3	60	2	17	5	24
4	Moraceae	*Trilepisium madagascariense*	8	1.7	40	6	12.4	3	21
5	Euphorbiaceae	*Croton megalocarpus*	8	1	80	6	7.6	6	20
6	Monimiaceae	*Xymalos monospora*	9	0.1	100	7	0.8	8	15
7	Rubiaceae	*Oxyanthus speciosus*	9	0	80	7	0.3	6	13
8	Flacourtiaceae	*Casearia battiscombei*	7	0.2	80	5	1.6	6	13
9	Solanaceae	*Solanum mauritianum*	9	0	60	7	0.1	5	11
10	Euphorbiaceae	*Macaranga kilimandscharica*	4	0.7	40	3	5	3	11
11	Euphorbiaceae	*Erythrococca bongensis*	4	0	60	3	0.1	5	8
12	Meliaceae	*Lepidotrichilia volkensii*	6	0	40	4	0.1	3	8
13	Araliaceae	*Polyscias fulva*	2	0.4	40	1	2.7	3	7
14	Ulmaceae	*Celtis mildbraedii*	2	0.1	40	1	0.5	3	5
15		*Unknown*	2	0.1	40	1	0.5	3	5
16	Olacaceae	*Strombosia scheffleri*	2	0	40	1	0	3	5
17	Rasaceae	*Prunus africana*	1	0.3	20	1	2.2	2	4
18	Meliaceae	*Turraea holstii*	3	0	20	2	0	2	4
19	Rutaceae	*Teclea nobilis*	2	0	20	1	0	2	3
20	Achariaceae	*Rawsonia lucida*	2	0	20	1	0	2	3
21	Compositae	*Vernonia auriculifera*	2	0	20	1	0	2	3
22	Sapindaceae	*Allophyllus sp.*	1	0.1	20	1	0.5	2	3
23	Euphorbiaceae	*Drypetes gerrardii*	1	0	20	1	0.4	2	3
24		*Kipkompotiet*	1	0	20	1	0.1	2	2
25	Ulmaceae	*Celtis africana*	1	0	20	1	0	2	2
26	Boraginaceae	*Ehretia cymosa*	1	0	20	1	0	2	2
27	Melianthaceae	*Bersama abyssinica*	1	0	20	1	0	2	2
28	Rutaceae	*Clausena anisata*	1	0	20	1	0	2	2
29	Rubiaceae	*Paveta sp.*	1	0	20	1	0	2	2
30	Myrtaceae	*Syzygium guineense*	1	0	20	1	0	2	2
31	Oleaceae	*Olea capensis*	1	0	20	1	0	2	2
32	Rubiaceae	*Rytigynia bugoyensis*	1	0	20	1	0	2	2
33	Flacourtiaceae	*Dovyalis macrocalyx*	1	0	20	1	0	2	2
34	Ebenaceae	*Diospyros abyssinica*	1	0	20	1	0	2	2
35	Salicaceae	*Casearia battiscombei*	1	0	20	1	0	2	2
36	Bignoniaceae	*Markhamia lutea*	1	0	20	1	0	2	2
37	Rubiaceae	*Vangueria ruwensoris*	1	0	20	1	0	2	2
		Total	136	13.6	1320	100	100	100	300

Key:

BA= Basal Area; No. =Number of individuals; Freq= frequency; RD1 =Relative density;R.D. =Relative dominance; R.F=Relative frequency; IVI =Importance value index

Appendix 11: Determination of Relative density, Dominance, Frequency and Importance Value Index (IVI) in Ngerek area

No.		Species	No.	BA	Freq	RD1	R.D.	R.F.	IVI
1	Solanaceae	*Solanum mauritianum*	62	0.2	100	36.9	3.7	7.8	48.4
2	Euphorbiaceae	*Macaranga kilimandscharica*	22	1	80	13.1	21	6.3	40.3
3	Olacaceae	*Strombosia scheffleri*	4	0.6	80	2.4	12.3	6.3	20.9
4	Euphorbiaceae	*Drypetes gerrardii*	4	0.4	40	2.4	9	3.1	14.5
5	Apocynaceae	*Tabernaemontana stapfiana*	7	0.2	80	4.2	3.7	6.3	14.1
6	Euphorbiaceae	*Croton megalocarpus*	5	0.2	60	3	4.6	4.7	12.2
7	Oleaceae	*Olea capensis*	1	0.5	20	0.6	10	1.6	12.1
8	Araliaceae	*Polyscias fulva*	5	0.3	40	3	5.7	3.1	11.8
9	Sapotaceae	*Aningeria altissima*	1	0.3	20	0.6	7	1.6	9.1
10	Phyllanthaceae	*Bridellia micrantha*	1	0.3	20	0.6	7	1.6	9.1
11	Ebenaceae	*Diospyros abyssinica*	2	0.2	40	1.2	4	3.1	8.3
12	Ulmaceae	*Celtis mildbraedii*	4	0	60	2.4	0.8	4.7	7.8
13	Sapindaceae	*Deinbollia kilimandscharica*	4	0	60	2.4	0.1	4.7	7.2
14	Monimiaceae	*Xymalos monospora*	3	0.1	40	1.8	1.7	3.1	6.6
15	Sapindaceae	*Allophyllus abyssinicus*	3	0.1	40	1.8	1.5	3.1	6.4
16	Euphorbiaceae	*Alchornea laxiflora*	6	0	20	3.6	0.1	1.6	5.3
17	Celastraceae	*Hippocratea africana*	3	0	40	1.8	0.1	3.1	5
18	Compositae	*Vernonia auriculifera*	3	0	40	1.8	0	3.1	5
19	Compositae	*Solanecio mannii*	2	0	40	1.2	0.4	3.1	4.8
20	Ulmaceae	*Celtis gamphophylla*	3	0.1	20	1.8	1.4	1.6	4.8
21	Euphorbiaceae	*Neoboutonia macrocalyx*	2	0	40	1.2	0.2	3.1	4.5
22	Salicaceae	*Casearia battiscombei*	1	0.1	20	0.6	2.1	1.6	4.2
23	Rubiaceae	*Oxyanthus speciosus*	4	0	20	2.4	0.2	1.6	4.2
24	Euphorbiaceae	*Croton macrostachyus*	1	0.1	20	0.6	1.2	1.6	3.4
25	Bignoniaceae	*Markhamia lutea*	1	0.1	20	0.6	1.2	1.6	3.3
26	Hamamelidaceae	*Trichocladus ellipticus*	2	0	20	1.2	0.3	1.6	3.1
27	Ulmaceae	*Celtis africana*	2	0	20	1.2	0.1	1.6	2.8
28	Rutaceae	*Teclea nobilis*	2	0	20	1.2	0	1.6	2.8
29	Melianthaceae	*Bersama abyssinica*	1	0	20	0.6	0.3	1.6	2.5
30	Bignoniaceae	*Kigelia africana*	1	0	20	0.6	0.1	1.6	2.3
31	Boraginaceae	*Ehretia cymosa*	1	0	20	0.6	0.1	1.6	2.3
32	Meliaceae	*Lepidotrichilia volkensii*	1	0	20	0.6	0.1	1.6	2.2
33	Myrtaceae	*Syzygium guineense*	1	0	20	0.6	0	1.6	2.2
34	Rubiaceae	*Vangueria madagascariensis*	1	0	20	0.6	0	1.6	2.2
35	Euphorbiaceae	*Erythrococca bongensis*	1	0	20	0.6	0	1.6	2.2
36	Lamiaceae	*Clerodendrum volkensii*	1	0	20	0.6	0	1.6	2.2
		Total	168	4.6	1280	100	100	100	300

Key:

BA= Basal Area; No. =Number of individuals; Freq= frequency; RD1 =Relative density;R.D. =Relative dominance; R.F=Relative frequency; IVI =Importance value index

Appendix 12: Determination of Relative density, Dominance, Frequency and Importance Value Index (IVI) in Chebilat area

No.	**Family**	**Species**	No.	BA	Freq	RD1	R.D.	R.F.	**IVI**
1	Araliaceae	*Polyscias fulva*	6	1.6	80	4.7	26	8.5	39.2
2	Rhamnaceae	*Maesopsis arborescens*	29	0.1	60	22.7	1.4	6.4	30.5
3	Apocynaceae	*Tabanaemantana stapfiana*	8	0.8	40	6.3	13.8	4.3	24.3
4	Flacourtiaceae	*Casearia battiscombei*	10	0.3	80	7.8	5.7	8.5	22
5	Myrsinaceae	*Measa lanceolata*	6	0.6	60	4.7	10.3	6.4	21.4
6	Ulmaceae	*Celtis mildbraedii*	10	0.2	80	7.8	3.2	8.5	19.6
7	Euphorbiaceae	*Croton megalocarpus*	4	0.5	60	3.1	9.2	6.4	18.7
8	Moraceae	*Ficus sur*	1	0.9	20	0.8	15.3	2.1	18.2
9	Olacaceae	*Strombosia scheffleri*	9	0.3	40	7	5.3	4.3	16.6
10	Solanaceae	*Solanum mauritanum*	11	0.1	60	8.6	0.8	6.4	15.8
11	Euphorbiaceae	*Macaranga kilimandscharica*	5	0.2	20	3.9	3.7	2.1	9.8
12	Stericuliaceae	*Dombeya torrida*	3	0	40	2.3	0.5	4.3	7.1
13	Sapindaceae	*Deinbollia pinnata*	6	0	20	4.7	0.1	2.1	6.9
14	Apocynaceae	*Thevetia thevetioides*	4	0.1	20	3.1	1	2.1	6.3
15	Euphorbiaceae	*Erythrococa fischeri*	3	0	20	2.3	0.1	2.1	4.6
16	Compositae	*Solanecio mannii*	2	0	20	1.6	0.6	2.1	4.3
17	Sapindaceae	*Allophylus abyssinicus*	1	0.1	20	0.8	0.9	2.1	3.8
18	Guttiferae	*Harungana madagascariensis*	1	0	20	0.8	0.7	2.1	3.6
19	Bignoniaceae	*Markhamia lutea*	1	0	20	0.8	0.6	2.1	3.5
20	Celastraceae	*Hippocratea africana*	1	0	20	0.8	0.4	2.1	3.4
21	Euphorbiaceae	*Neoboutonia macrocalyx*	1	0	20	0.8	0.2	2.1	3.1
22	Rutaceae	*Zanthoxylum gilleti*	1	0	20	0.8	0.1	2.1	3
23	Asteraceae	*Vernonia amygdalina*	1	0	20	0.8	0	2.1	2.9
24	Flacourtiaceae	*Dovyalis macrocalyx*	1	0	20	0.8	0	2.1	2.9
25	Ulmaceae	*Celtis africana*	1	0	20	0.8	0	2.1	2.9
26	Euphorbiaceae	*Croton macrostachyus*	1	0	20	0.8	0	2.1	2.9
27	Rubiaceae	*Heinsenia diervilleoides*	1	0	20	0.8	0	2.1	2.9
		Total	128	6	940	100	100.2	100	300.2

Key:

BA= Basal Area; No. =Number of individuals; Freq= frequency; RD1 =Relative density;R.D. =Relative dominance; R.F=Relative frequency; IVI =Importance value index

Appendix 13: Determination of Relative density, Dominance, Frequency and Importance Value Index (IVI) in Morongiot area

No.	Family	Species	No.	BA	Freq	RD1	R.D.	R.F.	IVI
1	Araliaceae	*Polyscias fulva*	9	3.9	80	5.4	49	7.3	61.6
2	Rhamnaceae	*Maesopsis eminii*	53	0.1	80	31.7	0.8	7.3	39.8
3	Solanaceae	*Solanum mauritianum*	37	0.2	100	22.2	2	9.1	33.2
4	Moraceae	*Ficus sur*	6	1.4	60	3.6	17.1	5.5	26.2
6	Ulmaceae	*Celtis mildbraedii*	10	0.7	100	6	9.4	9.1	24.5
7	Flacourtiaceae	*Casearia battiscombei*	4	0.2	60	2.4	2.8	5.5	10.7
8	Apocynaceae	*Tabernaemontana stapfina*	4	0.3	40	2.4	3.7	3.6	9.7
9	Rosaceae	*Prunus africana*	2	0.2	40	1.2	2.5	3.6	7.4
10	Olacaceae	*Strombosia scheffleri*	3	0.1	40	1.8	1.9	3.6	7.3
11	Euphorbiaceae	*Neubotonia macrocalyx*	2	0.2	40	1.2	2.4	3.6	7.2
12	Rutaceae	*Zanthophylum gilletii*	4	0	40	2.4	0.2	3.6	6.2
13	Euphorbiaceae	*Drypetes gerrardii*	2	0.1	40	1.2	0.8	3.6	5.7
14	Boraginaceae	*Erhetia cymosa*	2	0	40	1.2	0.5	3.6	5.3
15	Bignoniaceae	*Spathodea campanulata*	1	0.2	20	0.6	2.5	1.8	4.9
16	Euphorbiaceae	*Erythrococca fischeri*	4	0	20	2.4	0.1	1.8	4.3
17	Compositae	*Solanecio mannii*	3	0	20	1.8	0.5	1.8	4.1
18	Euphorbiaceae	*Macaranga kilimandscharica*	2	0.1	20	1.2	0.8	1.8	3.8
19	Rhizophoraceae	*Cassipourea malosana*	3	0	20	1.8	0.1	1.8	3.7
20	Salicaceae	*Dovyalis africana*	3	0	20	1.8	0	1.8	3.7
21	Sapindaceae	*Deinbollia kilimandscharica*	3	0	20	1.8	0	1.8	3.6
23	Myrsinaceae	*Maesa lanceolata*	1	0.1	20	0.6	1.2	1.8	3.6
24	Myrsinaceae	*Maesa mildebradii*	1	0	20	0.6	0.6	1.8	3
25	Sapindaceae	*Allophyllus abyssinica*	1	0	20	0.6	0.5	1.8	2.9
26	Meliaceae	*Trichilia emetica*	1	0	20	0.6	0.4	1.8	2.8
27	Melianthaceae	*Bersama abyssinica*	1	0	20	0.6	0.2	1.8	2.6
28	Rutaceae	*Fagaropsis angolensis*	1	0	20	0.6	0.1	1.8	2.5
29	Euphorbiaceae	*Croton megalocarpus*	1	0	20	0.6	0	1.8	2.5
30		*Unknown (Climber)*	1	0	20	0.6	0	1.8	2.4
31	Menispermaceae	*Tiliacora funifera*	1	0	20	0.6	0	1.8	2.4
32	Melianthaceae	*Bersama abyssinica*	1	0	20	0.6	0	1.8	2.4
		Total	167	7.9	1100	100	100	100	300

Key:

BA= Basal Area; No. =Number of individuals; Freq= frequency; RD1 =Relative density;R.D. =Relative dominance; R.F=Relative frequency; IVI =Importance value index

Appendix 14: Regeneration status of woody plants: number of seedlings, saplings and adults per hectare in the South Nandi Forest (Regeneration status: 1= None; 2= Poor; 3= Fair; 4= Good; and 5=New).

Species	Life-form	seedlings	saplings	Adults	Regeneration status
Acanthus eminens	S	1429	0	0	5
Albizia gummifera	T	0	23	1	2
Alchornea hirtella Benth.	T	0	17	0	2
Allophyllus sp	T	2858	6	6	3
Aningeria altissima	T	0	0	1	1
Berarait (Unknown)		357	51	0	5
Bersama abyssinica	T	71	20	3	4
Bridellia micrantha	T	143	9	0	5
Casearia battiscombei	T	286	86	10	4
Cassipourea ruwensorensis	T	429	9	2	4
Celtis africana	T	1643	17	2	4
Celtis gomphophylla	T	0	0	4	1
Celtis mildbraedii	T	143	31	12	4
Clausena anisata	S	71	6	0	5
Clerodendrum johnstonii	T	71	9	0	5
Coffea eugenioides		357	0	0	5
Croton macrostachyus		0	0	1	1
Croton megalocarpus	T	1000	57	15	4
Culcasia falcifolia		8714	0	0	5
Cupressus lusitanica	T	0	0	1	1
Deinbollia kilimandscharica	S/T	1286	31	0	5
Diospyros abyssinica	S	2429	23	3	4
Dombeya torrida	T	1	0	0	5
Dovyalis macrocalyx	S	429	0	0	5
Dracaena laxissima	C	1214	0	1	3
Drypetes gerrardii	T	5786	14	7	4
Ehretia cymosa		0	14	4	2
Erythrococca bongensis	S	1429	46	0	5
Fagaropsis angolensis	T	143	9	0	5
Ficus sur	C	0	3	9	2
Ficus thonningii	T	0	0	1	1
Harungana madagascariensis	T	0	0	1	1
Heinsenia diervilleoides	T	500	37	1	4
Hippocratea africana	T	0	9	1	2
Justicia japonica		3786	0	0	5
Keetia gueinzii	S	500	3	0	5
Kigelia africana	S	0	3	1	2

Lantana camara		286	3	0	5
Lepidotrichilia volkensii	T	0	29	0	5
Lobelia gibberoa	T	0	6	0	5
Macaranga kilimandscharica	T	8857	17	21	3
Maesa lanceolata	T	71	0	6	3
Marattia fraxinea		25	3	0	5
Markhamia lutea	S/T	71	6	1	4
Maesopsis eminii		0	100	0	5
Mimulopsis arborescens	T	0	157	2	2
Neoboutonia macrocalyx	T	0	9	4	2
Nuxia congesta	T	0	6	0	5
Ocinum kilimandscharica	S	357	0	0	5
Olea capensis L.	S	0	3	1	2
Oncoba spinosa	T	0	3	1	2
Oxyanthus speciosus	S	0	34	1	2
Pafornia urens	T	429	0	0	5
Pavetta abyssinica	T	15	5	0	5
Phyllanthus fischeri	S	429	0	0	5
Phytolacca dodecandra	S	143	0	0	5
Piper capense	H/S	5071	0	0	5
Polyscias fulva	T	571	0	16	3
Prunus africana	T	20214	6	0	5
Psidium guajava	T	0	6	0	5
Rawsonia lucida	S	71	9	0	5
Ritchiea albersii	T	0	6	0	5
Rytigynia bugoyensis	T	0	3	0	5
Schefflera volkensii	T	0	0	1	1
Shirakiopsis elliptica	T	0	0	1	1
Solanecio mannii		71	23	4	4
Solanum mauritianum	T	1143	614	24	4
Spathodea campanulata	T	0	0	1	1
Strombosia Scheffleri	T	2286	54	15	4
Syzygium guineense	T	71	9	0	5
Tabernaemontana stapfiana	T	214	49	44	4
Teclea nobilis	T	429	11	0	5
Trichilia emetica	T	286	11	1	4
Trilepisium madagascariense	S/C	8929	31	2	4
Triumfetta brachyceras		286	6	0	5
Turraea holstii	T	0	9	0	5
Vangueria madagascariensis	S	429	9	0	5
Vernonia amygdalina	S	1214	3	0	5
Vernonia auriculifera Hiern		0	34	1	2
Xymalos monospora	S	214	37	3	4