EFFECTS OF CLIMATE CHANGE ON THE AVAILABILITY OF NON-TIMBER FOREST PRODUCTS (NTFPs) IN THE KAVONGE AND MUSEVE HILLTOP FORESTS IN KITUI COUNTY, KENYA

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DECLARATION

I understand plagiarism is an offense and therefore declared that this thesis is my original work and has not been presented for any academic award at any institution of higher learning.

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DEDICATION

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LIST OF ABBREVIATIONS AND ACRONYMS

AEO	**:**	Agricultural Extension Officer
CFA	**:**	Community Forest Association
FAO	**:**	Food and Agriculture Organization
FGD	**:**	Focus Group Discussion
IFPRI	**:**	International Food Policy Research Institute
IPCC	**:**	Inter-governmental Panel on Climate Change
KE	**:**	Knowledgeable Elders
KEFRI	**:**	Kenya Forest Research Institute
KFS	**:**	Kenya Forest Service
MENR	**:**	Ministry of the Environment and Natural Resources
MoA	**:**	Ministry of Agriculture
NGO	**:**	Non-Governmental Organization
NTFPs	**:**	Non-Timber Forest Products
USAID	**:**	United States Agency for International Development
WGL	**:**	Women Group Leader
WBG	**:**	World Bank Group

DEFINITION OF TERMS

Non-Timber Forest Products: Refers to all biological materials other than timber extracted from the forest for human use, e.g., fruits, wild vegetables, fodder, fuel wood, medicinal plants, wooden utensils, fish, resins, bush meat, etc. (FAO, 2005**).**

Climate Extreme Events: Refer to the unexpected, unusual, unpredictable, severe, and unseasonal weather events observed over the years at the extremes of the historical distribution.

Climate Change Adaptation: Consists of initiatives and measures to reduce the vulnerability of natural and human systems to actual or expected climate change effects (Regmi *et al*., 2010).

Distance to the Forest: Refers to the walking distance measured in kilometers between the household head home and the forest (Suleiman *et al*., 2017).

Wild Forest Plants: These plants are used by many members of forest-dependent cultures to eat a large percentage of their daily diet (Shillington, 2002).

ABSTRACT

A study to evaluate the effects of climate change on the availability of Non-Timber Forest Products (NTFPs) was conducted in forest-dependent communities around Kavonge and Museve hilltop forests in Kitui County, Kenya. The specific study objectives were: (1) to assess local community perception of rainfall and temperature patterns on NTFPs availability in Kavonge and Museve hilltop forests, (2) to examine the rainfall and temperature trends around the Kavonge and Museve hilltop forests from 1993 to 2023, (3) to establish a relationship between the availability of NTFPs and distance to the forest edge from the household, and (4) to identify the coping measures adopted by communities in response to the effect of climate change on NTFPs. Two villages were purposively selected based on their closeness to the forests. Data was collected using structured questionnaires, key informant interviews, and focus group discussions. Primary data was collected from individual households through a systematic sampling method. Secondary data collected over 30 years was obtained from the Kitui County weather station for rainfall and temperature. The data was analyzed using descriptive statistics (frequencies, percentages, bar charts), logistic regression, linear regression, correlation, and trend analysis using the Mann-Kendall test and Sen’s slope estimator. A sample size of 120 respondents was selected for the study. Logistic regression model results revealed that age, education, occupation, and resident duration significantly ($p < 0.05$) influence community perception of climate change patterns on NTFPs availability in the area. The perception results reported that most respondents perceived variations with a 96% increase in temperature and a 100% decrease in rainfall in the study area. The Mann-Kendall and Sen’s Slope results showed that there had been an increase in temperature trend in the past 30 years (Kendall Tau 0.820, $p< 0.05$, and Sen’s Slope 0.015) and a decrease in rainfall (Kendall Tau -0.672, $p< 0.05$ and Sen’s Slope -0.022). This was also in line with the people's perception of the temperature and rainfall patterns of the study area. The linear regression results showed a positive relationship between the amount of NTFPs collected and the distance covered to the forest with significance ($p<0.000$, $R^2= 0.797$ and β -893). Also, the study reported that the respondents in Kavonge and Museve use different types of coping and adaptation measures, which include diversification of crops, livestock keeping, late planting, petty trading, use of NTFPs, tree planting, and use of fertilizer to cope with adverse effects of climate change and variability on NTFPs. It was confirmed by the findings that Kavonge and Museve forests edge communities still rely on the available NTFPs as a safety net when faced with unfavorable circumstances, such as crop failure due to climate change. However, it was reported that the available quantities of NTFP are declining due to climate change. The study concludes that available NTFPs will continue to decrease if stringent sustainable utilization and management measures are not implemented. The Community Forest Association (Musekavo) is recommended to continue training the forest communities in the study area on sustainable utilization and management of Non-Timber Forest Products.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the study

The availability of Non-Timber Forest Products (NTFPs) is crucial for the livelihoods and sustenance of rural communities worldwide, particularly in developing countries (Sinha *et al*., 2013). However, climate change poses a significant threat to the sustainability and accessibility of NTFPs (Harris, 2018). Researchers (Forner & Robled, 2005; Parmesan & Yohe, 2003) define climate change as the long-term changes in the distribution of weather patterns from decades to millions of years. FAO (2008b) reported that the global increase in temperature, atmospheric carbon dioxide and rainfall variation, frequency, and severity of extreme climatic events are caused by climate change. These notable changes have several impacts on global forest ecosystems through the extinction of species (including plants and animals), erratic rainfall seasons, and prolonged droughts leading to increased forest fires (FAO, 2008b). The change in the climatic system negatively impacts natural and artificial forests designed for carbon sequestration and other forest resources (NTFPs). FAO (2020) estimated that 294 million ha is 7 % of world forest areas, and natural regenerating forests account for 93% of the world forest area. Extreme weather and climate conditions affect forestry and agriculture productivity and increase food shortages (Malhi *et al*., 2020).

Developing countries, mainly agriculture-dependent, are the most vulnerable to climate change consequences. These countries cannot prevent and respond to the impacts of climate change due to inadequate knowledge of policy formulation and funding for mitigating its effects (FAO, 2001). The disastrous impacts on communities and the rise of vulnerable groups increase seasonally and periodically. According to Kremen *et al.* (2000), the increasing effects of climate change on the impoverished population will cause a rise in death rate, malnutrition, tropical diseases, and urban heat stress by 2030.

Malhi *et al*. (2020) found that shifts in climate patterns lead to changes in species populations and ecosystems, impacting the availability and supply of ecosystem services, including provisioning, regulating, supporting, and cultural functions. Forest ecosystems provide forest produce known as NTFPs, which includes fruits, nuts, vegetables, fish, medicinal plants, and a range of barks and fibers (bamboo, rattans), palms, and grasses that have all been affected by climate change (De La O Campos *et al*., 2018). Estimates suggest that NTFPs provide a living for almost 80% of people living in developing countries (FAO, 2016 & Newton *et al*., 2016).

Non-timber forest products (NTFPs) are essential components of the forest ecosystem, supporting landscape, habitat, and wildlife conservation, as well as the maintenance of macro-climate and soil conservation (Gurung et al., 2021; Talukdar et al., 2021). As researchers Magry et al. (2022) and Yadav et al. (2022) noted, NTFPs also play a critical role in supporting livelihoods and providing socioeconomic security to communities living near forests during agricultural system changes. FAO (2008a) and Dore (2005) predicted severe impacts of increased temperature and low rainfall on the forest ecosystem, productivity, and species distribution, resulting in a decline in NTFPs across forest edge communities.

The reality of climate change threatens the goals and aspirations of the African continent for sustainable development (Gourdji *et al*., 2013). Climate change can reverse decades of African development (Kotir, 2011). Climate change considers global warming and other variations in precipitation patterns and the frequency and intensity of extreme occurrences. These include increased droughts and floods across forest edge communities depending on NTFPs. Along with the effects of unexpected weather occurrences, there is also the chance of climate change accumulations until specific points are reached, which might lead to the collapse of forest communities dealing with NTFPs (Nyong, 2015).

Lack of mitigation on climate variability has resulted in declining production of NTFPs across forest edge communities in Africa (Kashaigili, 2014). Most people in Africa are pastoralists and subsistence farmers who rely on extractive industries like agriculture and forestry, which are directly impacted by climate change and disrupt their livelihoods (Seppelt *et al*., 2011). Ecosystems help to regulate climate and provide food, medicines, biomass, water, habitats, forest species, and pollination (Geijzendorffer *et al*., 2017). The disappearance of NTFP species is accentuated in high-temperature conditions and deforestation. Endemic and indigenous beneficial forest species may become extinct, and opportunistic invasive species can colonize new species in thermo-induced changes (Parmesan & Yohe, 2003). NTFP tree species growth, density, and distribution change in changing climate (Camarero, 2004). In these regards, monitoring and modeling the tree lines and their vegetation regeneration was geared toward sustainable management in response to changing climate (Dullinger *et al.*, 2004). In the proper functioning of ecosystems, adequate conservation measures are required to enhance species diversity, composition, and richness (Mutiso *et al.,* 2013).

Due to inconsistencies, uncertainty, and periodic changes related to climate change, little is known about how variations in regional climate patterns affect NTFPs. Chia *et al.* (2013) and Mohanasundaram *et al.* (2014) carried out studies on NTFPs in Jharkhand State, India, from 1984 to 2014 and reported a drastic decline of NTFPS, approximately 150 tons per annum per ha. Studies by Nayak and Sahoo (2021) also reported changing climatic conditions influencing NTFP species annual yield phenology. Variations in temperature and rainfall are reliable indicators of climate change (Ankrah *et al.*, 2023).

In Kenya, diverse topography produces a wide range of climates, with the inland areas being more relaxed and less humid and the coastal area being hot and humid. Although temperatures vary throughout the nation, there has been a noticeable warming trend since the 1960s, with the annual mean temperature rising by about 1^{0}C with an estimated rate of 0.21^{0}C per decade (MENR, 2016). This trend is expected to continue, with a temperature increment of 1.70C by the 2050s and about 3.5^{0}C at the end of the century. The number of hot days and nights is anticipated to rise faster than cold days and nights (NEMA, 2015). Since the 1960s, the country's reported rainfall trends have shown a considerable geographic variation, with the northern regions growing drier and the southern regions getting wetter but with high levels of variability (World Bank Group, 2021).

Although average rainfall, particularly during the short rains, is predicted to increase by the middle of the century, it is predicted that these rainfall patterns will remain extremely erratic and uncertain. Rainfall in arid zones is anticipated to decline (WBG, 2020). According to Muzari *et al.* (2014) & Martinez *et al. (*2018), understanding local stakeholders' attitudes and perspectives on climate change is vital since their ability to adapt and have the incentive to do so effectively depends on their ability to perceive and understand the phenomenon.

The effects of climate change on forest resources have led to the limited availability of NTFP in forest-dependent communities (Harris,2018). The main challenges facing smallholder farmers in the hilltop areas of Kitui County, Kenya, are the unpredictable rainfall and rising temperature patterns that affect crop productivity (Mutunga *et al.,* 2017). The present thesis aimed to evaluate the effects of climate change on the availability of Non-Timber Forest Products (NTFPs) in the Kavonge and Museve hilltop forests area in Kitui County using the area's long-time rainfall and temperature patterns as climate change indicators.

1.2 Statement of the problem

According to Easterling *et al.* (2007), there is a need for the research community to focus more on how climate change affects Non-Timber Forest Products, leading to the shortage of these resources as livelihood safety for forest communities. The site-specific nature of climate change and the provision of NTFP services complicate understanding climate change impacts on these resources (Irland *et al.,* 2001). Due to the high degree of uncertainty surrounding the ecological effects of climate change and the lack of complete data on the present and anticipated future demand for these products at the national, regional, and worldwide levels, it is generally more challenging to assess the effects of climate change on NTFPs resources (FAO, 2005 & Easterling *et al.*, 2007)

Forests in Kenya, just like other forests in Africa, are facing climate change-related challenges, leading to a reduction in available NTFPs. These climatic changes also impact Kavonge and Museve hilltop forests in Kitui County. Despite the multiple benefits NTFPs provide, climate change's effects on NTFPs and their availability have not been investigated in the Kavonge and Museve hilltop forests area. Previous studies in the two forests focused on anthropogenic activities on tree species composition and diversity in Kavonge and Museve hilltop forests (Musau, 2021). The current study provides an understanding of how Kavonge and Museve hilltop forests in adjacent communities perceive the availability of NTFPs as influenced by rainfall and temperature patterns.

1.3 Objectives of the study

The following objectives guided the study:

1.3.1 Main objective of the study

The study's main objective was to evaluate the effects of climate change on the availability of Non-Timber Forest Products (NTFPs) in the Kavonge and Museve hilltop forests in Kitui County, Kenya.

1.3.2 Specific objectives:

i. To assess the local community perception of local rainfall and temperature patterns on the availability of NTFPs in Kavonge and Museve hilltop forest areas
ii. To examine the rainfall and temperature trends around the study area from 1993 to 2023.
iii. To establish a relationship between the availability of NTFPs and the distance to the forest edge from the household.
iv. To identify coping measures adopted by Kavonge and Museve communities cope with climate change effects on the availability of NTFPs.

1.4 Research questions

i. How do the community perceptions of local rainfall and temperature patterns explain the NTFPs availability?
ii. What are the rainfall and temperature trends around the Kavonge and Museve hilltop forests?

iii. What is the relationship between the availability of NTFPs and distance from the forest edge?

iv. What coping measures have the Kavonge and Museve communities implemented due to climate change effects on NTFPs?

1.5 Justification of the study

The study's justification lies in the increasing significance of Non-Timber Forest Products (NTFPs) as a source of income, food, and medicine for forest edge communities worldwide. In many developing countries, including Kenya, NTFPs support livelihoods and provide essential resources. However, climate change poses a significant threat to the availability and sustainability of NTFPs (Malhi *et al*., 2020; Harris, 2018).

According to a study by Mutunga et al. (2017), Kitui County is currently experiencing climate changes affecting local ecosystems and natural resources. It is essential to study how these shifts impact NTFP availability in the Kavonge and Museve hilltop forests. Understanding these effects is critical for informing sustainable resource management strategies to help mitigate adverse impacts on local communities' dependent on these forest resources around the study area.

Furthermore, investigating how climate change affects NTFP availability in Kitui County will contribute valuable insights to broader discussions on climate resilience and adaptation strategies at both local and global levels. The findings from this study could potentially inform policy development aimed at mitigating the impacts of climate change on forest-dependent communities.

By examining the effects of climate change on the availability of NTFPs within Kavonge and Museve hilltop forests in Kitui County, we can gain localized knowledge about how climate change directly impacts NTFPs within these unique ecosystems. This targeted approach will provide detailed insights into the complex relationships between climate factors, forest ecosystems, and community reliance on NTFPs.

In summary, studying the effects of climate change on the availability of Non-Timber Forest Products (NTFPs) in Kavonge and Museve hilltop forests aligns with broader efforts to understand ecosystem vulnerability due to climatic shifts while addressing critical issues related to the sustainability of community livelihoods. This research has clear implications for informing conservation practices that can safeguard vital resources essential for rural populations' well-being amidst changing environmental conditions.

1.6 Scope of the study

The study focused on forest-dependent communities in Kavonge and Museve hilltop forests in Kitui County, Kenya. It was limited to forest communities adjacent to Kavonge and Museve hilltop forests. This study focused mainly on the effects of temperature changes and rainfall patterns on Non-Timber Forest Products (NTFPs) availability around the Kavonge and Museve hilltop forests. Though there were other villages, the study only considered those villages that are dependent on the forests and live 5 km from the forest boundary to their households.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Perception of local rainfall and temperature patterns on NTFP availability

The perception and experiences of the local community play a vital role in supporting the planning and overall understanding of climate change dynamic in forest edge communities Muzari *et al.* (2014) & Martinez *et al. (*2018). A study by Penuelas *et al.* (2017), based on people's perceptions reported a rising global average temperatures and altered precipitation patterns affecting the productivity of NTFPs and the standard of living for forest edge communities.

Yvonne *et al.* (2020) reported a significant increase in temperature trends and a decrease in rainfall, as was perceived by the respondents in the study area over the period 1974–2014. The findings also established that the local community perceived changes in temperature and rainfall patterns, which aligned with conclusions using meteorological records during the study (Yvonne *et al.*, 2020).

Mutunga *et al*. (2017) reported that the people of Kaveta and Mikuyuni perceived changes in the climate system mainly due to temperature increases and average annual decreases in rainfall over the past two decades. Over the past century, analysis of precipitation patterns has gained significant importance since it exposes scientific knowledge about the consequences of global climate change (Mutunga *et al*. 2017). The sustainability and productivity of forestry and agricultural projects are determined by rainfall patterns in a cropping season. One could argue that a minimum standard of living for forest edge communities depends upon the quantity and quality of rainfall and that NTFP availability is anticipated to be significantly impacted by climate change (IPCC, 2007).

Appiagyei *et al.* (2022) summarized a body of perceived knowledge on the implications of climate change on forest ecosystem services by reviewing studies on the impacts of climate change conducted in the Mediterranean forest basin contained in the literature. The review reported that the unpredictable climatic conditions, particularly the increase in climate extremes, are introducing new threats and risks that exacerbate existing pressures. The study further established that a region's average precipitation and temperature determines such areas' sustainability, productivity, and economic growth. Benefits generated from NTFPs greatly rely on the ecosystem preservation and sustainable use of its resources (Appiagyei *et al.*, 2022).

Asamoah *et al*. (2023) conducted a study using a mixed-method approach in Ghana. In recent years, they reported a decrease in NTFP production levels as impacted by climate change, which relates to short rainfall intervals and prolonged droughts on NTFPs. The study also reported that this impact negatively affected food security in rural areas of Ghana, where NTFPs improve the livelihoods of the rural population (Asamoah *et al*., 2023).

Jebiwott *et al.* (2021) conducted a spatial trend analysis of temperature and rainfall and their perceived impacts on ecosystem services in Mau Forest, Kenya, using rainfall and temperature data from 1984 to 2020 and Focus group discussions (FGDs). The findings showed a significant trend in average annual temperature increasing by 2℃ from 1984 to 2020 and a decrease in rainfall. The study further reported that changes in the local climate led to a decline in forest ecosystem services, including agricultural production and water levels in the study area (Jebiwott *et al.*, 2021).

Balama *et al*. (2016) conducted a study in forest-adjacent households on perceptions and adaptation strategies to climate change in Kilombero District, Tanzania, applying quantitative and qualitative methods, Focus Group Discussions (FGDs), and key informant interviews. The findings showed that changes most households perceived emanated from temperature increment, erratic rainfall, flooding, an increase in dry spells across the two seasons, and water scarcity (Balama *et al*., 2016). Furthermore, study conducted by Ibe (2018) reported an increase in both temperature and rainfall, with a decreasing yield of NTFPs in the study area for the last four years.

2.2 Trends in Temperature and Rainfall in Kitui

The IPCC (2007) projected that the regional average temperature would rise more rapidly than the global average. Variations in the climate system are observed globally through temperature measurement at the surface in the middle of the atmosphere, increased sea level, sea surface temperature, ocean heat content, and water vapor in the atmosphere (Princeton & Prathap, 2022). It was assumed that climate change effects would make Africa's current vulnerabilities worse, and this will occur mainly in regions already enduring the effects of water deficit, high temperature and low rainfall, frequent droughts, and food insecurity (Ozor *et al*., 2012; Kabubo-Mariara, 2008; Kotir, 2011).

Muia *et al.* (2024) sought to analyses annual, seasonal, and monthly rainfall and temperature (minimum and maximum) trends in Makueni County from 1991 to 2020 using the Mann–Kendall (MK) trend test and Sen's slope estimator. The findings revealed an upward trend in annual and seasonal minimum and maximum temperatures across the study period. Also, the findings reported a decreasing pattern in annual and seasonal (short and long rain seasons) rainfall in Makueni County. The report also emphasizes the need to develop adaptation techniques to climate change that reduce risks and increase resilience to environmental shocks.

Magry *et al.* (2023) use rainfall and temperature data from 1980 to 2018 to explain climate change trends. Their results showed a general increment in temperature, which reduced lac (*Kerria lacca)* yield by 31.60 tons per year. The changes also affected some amounts of NTFPs on livelihoods, and prices of Lac, Mahua, and Tamarind species declined.

Loh *et al*. (2020) studied NTFPs and climate change adaptation in forest-dependent communities of Bamboko Forest Reserve, in South West Region, Cameroon. They used climate data from 1960 to 2015 and a participatory discussion on precipitation and temperature changes. The findings revealed that 71% of respondents agreed that the temperature has risen for the past 20 years. Using a trend test, the finding also showed annual temperature increases for the past 30 years. About 88% reported rainfall changes for over 25 years. The trend analysis result showed rainfall fluctuation with increased annual rainfall from 1960 to 2015 (Loh *et al*., 2020).

In yet another study by Chitale *et al*. (2018) on the assessment of climate change influence on the distribution of major non-timber forest plants in Chitwan Annapurna Landscape, Nepal, was conducted using ten significant species of NTFPS plants, due to their economic values, ecological importance, and forest dominance. The study applied 19 bio-climatic variables on current and future periods for the year 2050. A digital elevation model (DEM) and Maxent mode were used for analysis. The findings showed that ten NTFP species were distributed across the study area. The projection identified adverse effects on the 10 NTFPs under moderate climate conditions.

Another study by Saalu *et al*. (2020) also determined the variations in climate and its impacts on the livelihoods of the Buyangu Community using interviews, questionnaires, and focus group discussions. Temperature and rainfall data from 1980 - 2015 were also obtained for trend analysis. The findings showed an increasing trend in mean annual maximum and minimum temperatures by 0.04°C and 0.02°C respectively, while annual precipitation increased by 0.068 mm/year in the Buyangu community.

2.3 Relationship Between Availability of NTFPs and Distance to the Forest

Suleiman *et al.* (2017) found that communities close to Forest Game Reserve (FGR) mainly depend on the reserve for firewood, medicinal herbs, fodder, and fruit nuts for household use and sales. A similar study by Hamza *et al.* (2004) attest that distance to the nearest market from the respondent's home influenced the collection of NTFPS, which was primarily gathered for commercial purposes. They also reported that NTFP harvesting can be altered by the distance in kilometers (s) between the household and the forest. The longer the distance from home to the forest, the less likely the NTFPs will be extracted from the reserve. Additionally, Mujawamariya *et al.* (2014), in similar studies, confirmed that communities near the forest typically rely on forest resources more than others at a distance away from the forest reserve and would have more challenges accessing NTFPs due to high transportation costs.

In similar research Rahman *et al*. (2021) reported that distances between home and forest negatively affect income from NTFPs. Further, Zaman *et al*. (2023) revealed that respondents within forest walking distance around the three forest edge communities collected NTFPs due to poverty, income generation, and personal interest in the area. The NTFPs contribute 20-60% of income annually across the three villages. The statistical findings also indicated that the host communities extract products like fruit, mushrooms, vegetables, and medicinal plants from the forests.

Maua (2018b) study assessed socio-economic factors affecting households' reliance on NTFPs and found that 90% of the heads of the household extract NTFPs at a close distance, indicating how important the forest is to the nearest households. Rahman *et al.* (2021 revealed that NTFP income contributes significantly to family or household income. Small-scale businesses earn the relative income derived from NTFPs. The statistical analysis showed negative relationships to forest distance for NTFP collections, while positive relationships exist between the amount of NTFP collected and the time spent on NTFP collection. The moderately higher dependent households collected significantly higher amounts of NTFPs per trip than those moderately dependent and less dependent on NTFPs (Rahman *et al.*, 2021).

2.4 Coping Measures in response to the effects of Climate Change on NTFPs

Global attention to climate change adaptation has grown, involving experts in disaster management and development worldwide (Falzon, 2021 & Roberts *et al.*, 2021). Improving rural communities' capacity to adjust to changing environmental conditions and unpredictability, reducing possible damage, and supporting them through unfavorable outcomes can lessen their susceptibility to changing weather patterns. The continuous change in the climatic systems resulting in ecosystem vulnerability, degradation, depletions, prevalence of species, and food shortages has been a major global challenge for past decades (IPCC, 2007; Sarkodie & Strezov, 2019).

Nyang'au *et al*. (2021) reported coping measures such as diversification of crops, timing of planting, crop rotation, and mixed cropping as climate-smart agricultural practices adopted by farmers in the area. Farmers' views of climate change, household size, monthly income, and loan availability are strongly linked with using climate-smart coping strategies. A similar study by Basu (2018) found that factors such as the age of the household head, income from non-timber forest products (NTFP), farm income, and family size impacted adaptation strategies. The study revealed community adaptation response to climate change includes collecting NTFPs, migrating due to distress, and forming self-help groups (SHGs), microfinance programs, and animal husbandry initiatives.

According to Regmi *et al.* (2010), climate change adaptation consists of initiatives and measures to reduce the vulnerability of natural and human systems to actual or expected climate change effects. Therefore, adaptation through reducing vulnerability is one of the approaches considered likely to reduce long-term climate change impacts. Notably, Nkem *et al*. (2010) argue that the sustainable utilization of NTFPs could be among Africa's effective climate change adaptation strategies.

FAO (2005) studies reported that smallholder farmers and pastoralists in developing countries may not cope with climate change effectively due to their reduced adaptive capacity and higher vulnerability. Eastaugh (2008) found that climate change is expected to heavily impact forest-dwelling communities in the developing world, with no other source of sustenance. The lack of supportive infrastructure and an effective governance system can further increase vulnerability (Adger, 1999; Chia *et al.*, 2013).

Haule (2022) determined how well-prepared households were for the consequences of climate variability on the availability of NTFPs in Iringa District, Tanzania, using rainfall and temperature data from 1986 - 2016. In the studies, he used structured questionnaire surveys, focused group discussions, in-depth interviews, and field observation. The findings reported the local people's vulnerability regarding the changing climate in the study area. He also reported that extracted NTFPs serve as a strategy for adaptation. However, findings reported that homes near the forest extracted more forest products than homes away from the forest. Furthermore, 99.4% of the respondents perceived changes in climate change patterns in the last 20 years. The study established that climate variability and anthropogenic activities were responsible for NTFPS reduction in quality, availability, and quantity (Haule 2022)

Mutunga *et al*. (2017) evaluated adaptation in response to changing climate and variability in Kaveta and Mikuyuni communities in Kitui County. Communities used various coping measures in response to the temperature increment and precipitation decrease. They reported that during this period, communities adopted practices such as diversifying crop varieties, planting early maturing crops, changing planting dates, and planting before the onset of rainfall. Use hybrid crop varieties, pesticides, animal manure, soil conservation, mixed crop, and livestock farming to overcome the effect of changing climate on food production.

2.5 Non-Timber Forest Products (NTFPS) and its importance

Biological materials other than timber taken out of the forest for human use are known as NTFPs. Forest-adjacent communities rely heavily on forest products known as NTFPs for household consumption, monetary deposits, and basic needs (Newton et al., 2012; Kimaro, 2013). For instance, most local communities, particularly in developing nations, depend highly on NTFPs, crucial in employment, healthcare, household energy sources, and subsistence needs (Sinha *et al*., 2013). Broadly, NTFPs are any tradable products derived from the forest that do not include commercial timber but are known for having a vital contribution to the economies of the local communities (Debela, 2019; Shackleton & Shackleton, 2004). Household dependence on forest products (NTFPs) was influenced by various socioeconomic characteristics, including income, land tenure, age, and sex (Dewees, 2013; Newton *et al*., 2012; Rahman *et al*., 2021). The availability of labour, proximity to a forest, engagement in non-agricultural pursuits, and market integration are additional variables that impact household dependency (Mcelwee, 2008; Gatiso, 2019; Maua *et al.*, 2018a).

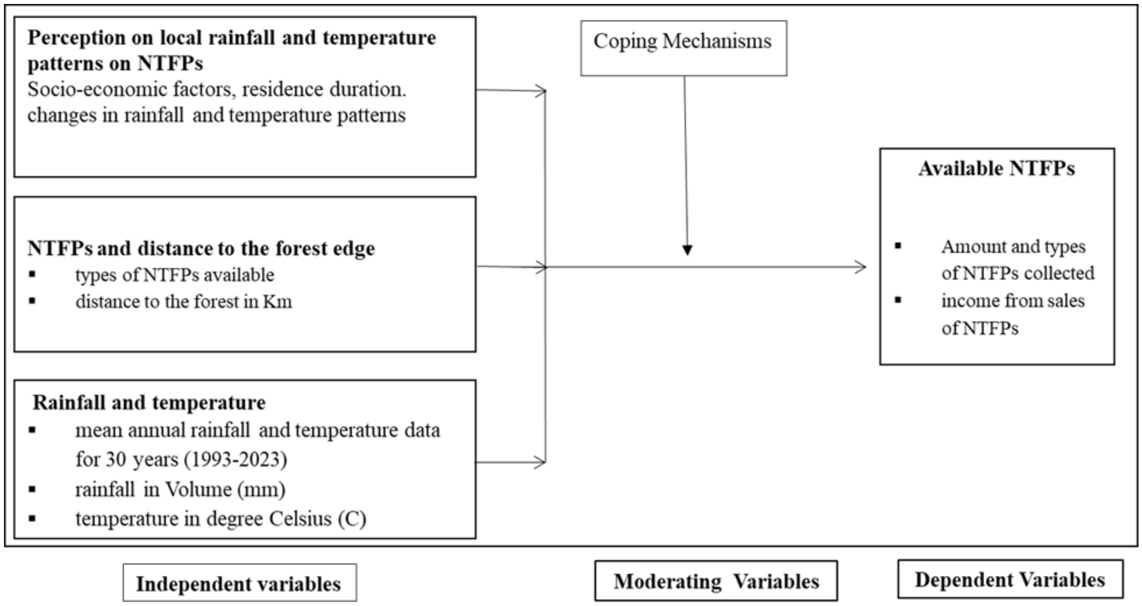
Across the globe, about 1 billion people depend on NTFPs for their livelihoods and food, such as bush meat, insects, honey, fungi, mushrooms, spices, bush pepper, wild vegetables and wild edible fruits., rattan, bamboo, particularly for vulnerable groups such as the poor and undernourished children, wild edibles can offer an open access source of food and revenue (Rahman, 2021). Research by Newton *et al.* (2012), indicates that under some circumstances, the impoverished rely on NTFPs disproportionately. In the review of many researchers on the revenue contributions of NTFPs, rural people mainly depend on NTFPs because they are relatively free, especially in the wild, and the groups mentioned above are more benefited than those with alternative income sources.

2.6 Knowledge Gap

The literature review from previous studies in the Kavonge and Museve hilltop forests focused on anthropogenic activities on tree species composition and diversity (Musau & Mugo, 2021). Also, Mutunga *et al. (2017)* conducted studies on smallholder farmers' perception and adaptation to climate change variability in Kitui County, Kenya, using climate data for 30 years. While these studies advanced knowledge, we still do not know how communities perceive the effects of rainfall and temperature patterns on the availability of NTFPs in Kavonge and Museve hilltop forests in Kitui County. We do not know the relationship between NTFP availability and the distance of households to the forest for NTFP collection and adaptation and copping measures communities counter to the effect of climate change influence on NTFPs.

2.7 Conceptual Framework

The study's conceptual framework is shown in Figure 2.1. There are moderating, dependent, and independent variables in this study. The independent variables are socio-economic factors such as age, gender, education, marital status, occupation, residence, changes in rainfall and temperature patterns, trends in rainfall and temperature data, NTFPs collection, and distance to the forest. The dependent variable is the available NTFPs, and the moderating variables are represented by coping mechanisms such as the timing of planting, crop diversification, crop rotation, and NTFPs utilisation.



Source: (Author's compilation, 2024)

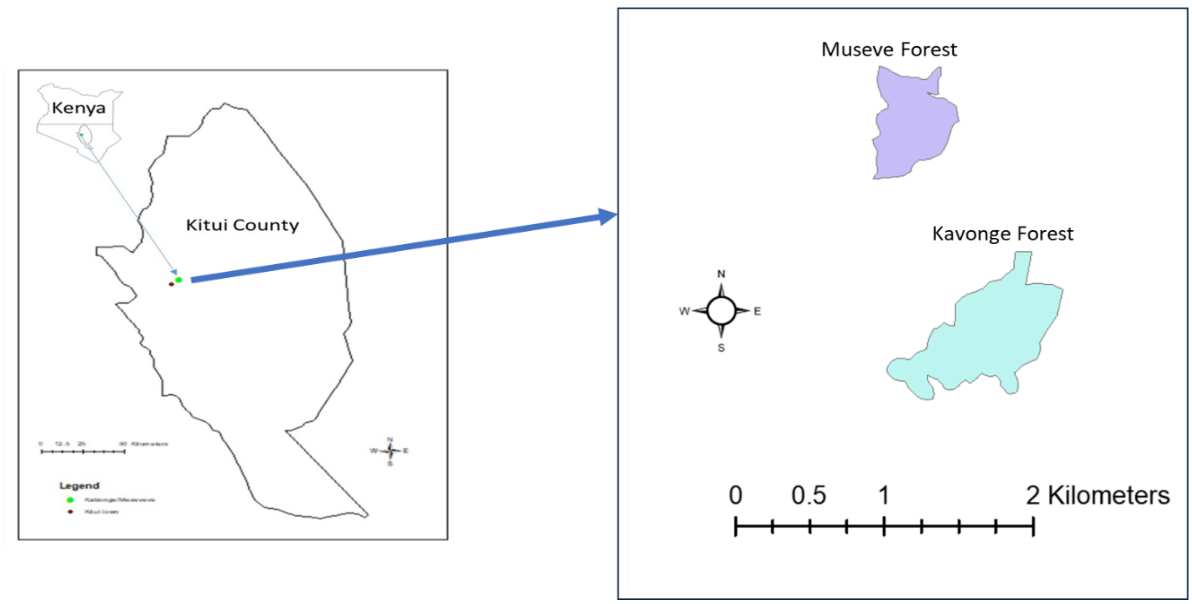
Figure 2.1: Conceptual Framework

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Study area

The study was conducted in the local community living around Kavonge and Museve hilltop forests in Kitui County. Kavonge and Museve hilltop forests are fragments between latitude 1°19'20" S and 1°20'45"S and longitude 38°03'36" E and 38°03'47" E (Vandi *et al*., 2024). The hilltops are dryland forests that cover an area of 436 ha (KFS, 2013). The state owns the two forest fragments, which were formerly under the ownership of local communities prior to the colonial era (Mbuvi *et al.*, 2010). `The two forests' location is shown in Figure 3.1 below.



Vandi *et al.* (2024)

Figure 3.1: Location of the Kavonge and Museve hilltop forests within Kitui County in Kenya

3.2 Topography and Drainage

Kavonge and Museve hilltop forests are rock outcrops that rise above the sedimentary plains, typically low in elevation. The Kalundu and Nzeeu Rivers and their main tributaries form the central drainage system for these forests (MENR, 1994; Ministry of Agriculture (MoA, 1983).

3.2.1 Rainfall and Temperature

The area around Kavonge and Museve hilltop forests is generally hot and dry. There are two distinct rainy seasons each year: the long and the short rainy seasons. The short rainy season begins at the end of October and lasts until December, whereas the long rainy season begins at the end of March and lasts until May, with an average annual rainfall of 750 mm to 1,150 mm. There is a minimum temperature of 15.70 C and a maximum temperature of 27.1^0 C. The coldest month is July, while October and March are the hottest (Jaetzold *et al.*, 2006; Corbett, 1998).

3.2.2 Socio-Economic Activities

The main economic activities around Museve and Kavonge forests include raising livestock and cultivating crops, hunting, trading on traditional medicine, timber, firewood, building poles, and charcoal burning (Sumbi, 2004). The wetland area on the valley separating the Kavonge and Museve hilltops forests is extensively used for crop growing. Crops grown include maize, potatoes, tomatoes, legumes, soya, sugarcane, cassava, and bananas. Wild animals are hunted for bush meat consumption, while domestic livestock such as cattle, goats, poultry, rabbits, sheep, and pigs are mainly used for income generation. The interactions between the people and NTFPs occur daily due to the closeness of the two forests in the Kavonge and Museve communities. The importance of ecosystem services to various livelihood actions changes due to climate variability and social and environmental factors (Piya *et al.*, 2019).

3.3 Data Collection

Primary and secondary data collection was done. Primary data was gathered using direct field observations and household interviews. Secondary data collection entailed reading pertinent books, journals, and papers and using rainfall and temperature records, among other sources. Secondary data is intended to uncover research gaps and evaluate previous work on the study's focus. Kitui County weather station was used to obtain the research site's temperature and rainfall data for 30 years (1993–2023).

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3.3.1 Reconnaissance survey

Before data collection, a pre-field survey was carried out to obtain a fundamental understanding of the research field. This survey involved testing the research instruments, familiarizing with the area, and identifying key stakeholders surrounding the Kavonge and Museve hilltop forests. The pre-field aimed to give the researcher a clear general picture of the socio-economic activities, ethnicity, population size, and settlement patterns in the Kavonge and Museve hilltop forests. The primary sources of general information regarding the research area were acquired from forest officers, chiefs, village leaders, and the Community Forest Association (CFA) members.

3.3.2 Sampling Procedures

Two villages, Kavonge and Museve, surrounding the Kavonge and Museve hilltop forests were purposively selected. The proximity to the hilltop forests served as the selection factor for the research villages. Even though there were other villages around the hilltop forests, only areas within the 5 km radius of the forest boundary were considered in this study. This was considered the maximum distance from the forest edge, where one can travel to the forest to collect NTFPs (Vandi *et al*., 2024).

3.3.3 Sampling size

For the recent Kenya population and housing census (2009), the household lists for each village were collected from village chiefs. The total number of households (N) was used to determine a representative sample size using the Yamane formula (1967) as shown below: A sample size of 120 households was calculated from a total of 172 households in the study area living within the 5 km radius distance from the forest boundary to the households. This was calculated as follows:

$$one = \frac{N}{1+N(e)^2}$$

Where n = sample size

N = Population (Households) size

e= sampling error which is ±5%

Population (Total number of households) size (N) =172 hence,

$n = \frac{172}{1+172(0.05)^2}$

$n = \frac{172}{1+172(0.0025)}$

$n = \frac{172}{1+0.43}$

n =120 sample size for re

3.3.4 Research Design and Sampling Techniques

The study adopted a descriptive survey design. This was done to explore more information from respondents on their perceptions of changes in temperature and rainfall patterns and interactions with the Kavonge and Museve hilltop forests for NTFPs collection. The target population for this study was households within 5 km of the forest boundary. The unit of study was the household, and the head of the household was the respondent.

Purposive sampling was used to select the villages, while systematic sampling was used to select households for data collection. A systematic sampling of households was done to cover all the villages. Regularly spaced parallel transects were made from the forest edge to the outer reaches of the villages (or 5 km from the forest boundary). Starting from the outer reaches of the village at the beginning of the transect, a household was sampled every 1 km (or any nearest distance) so that all the villages were covered. This allowed the researcher to see the available NTFPs at various points and determine the correlation between NTFPs availability and forest distance. This is further explained in (Figure 3.2) below.

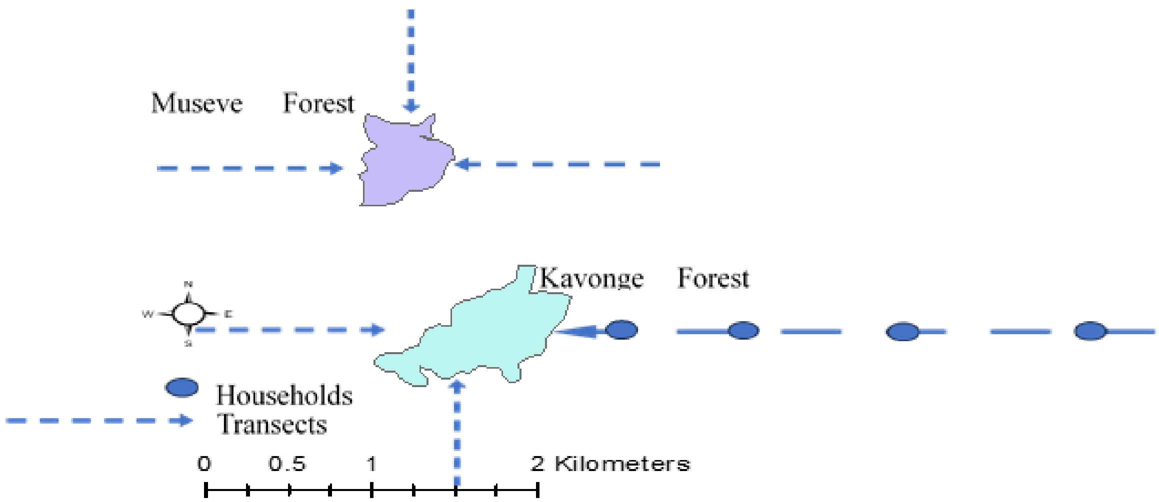

Figure 3.2: Household data collection point using 1 km by 1 km distance

3.3.5 Household survey

An interview schedule comprising closed and open-ended questions was used to obtain household information through quantitative and qualitative data. Important socio-economic data in the questionnaire included gender, marital status, household size, occupation, income, age, and length of residence. Data on people's perceptions of local temperature and rainfall patterns were also gathered using Likert scales to capture long-time climate variations. The Likert scales on rainfall and temperature change patterns on NTFPs availability were collected from respondents using blocked periods of 1993 -1997, 1998-2002, 2003-2007, 2008-2012, 2013-2017, and 2018- 2023. The years were blocked into periods to make it easier for people to remember periods rather than individual years. The data on NTFP types and quantities collected in the Kavonge and Museve hilltop forests area were also included in the data collection. The link between NTFPs availability and distance to the forest edge, as well as coping strategies or measures, were all included in the interview data. Before the field interview, the interview questions were tested on a pilot basis with ten households. This was done to test the data collection tools and the kind of data they were likely to generate.

3.3.6 Interview on Key Informants

The key informants were selected through a purposive sampling method based on their knowledge of the effects of climate change on the use of forest resources (NTFPs) over 30-year period. Key informant interviews help to provide detailed information on local practices and significant knowledge about specific and relevant issues in the related study. In this study, selected institutions like the Kenya Forest Service (KFS), Community Forest Association members, women group leaders (WGL), the chiefs, staff of Non-Governmental Organisations (NGO), and knowledgeable elders (KE) in the village were the key informants interviewed in the study area. Five (5) Key informants were interviewed, and one from each organisation was selected for this study. Their responses were analysed through transcription of data, categorising, and presented in a summarised form to facilitate meaningful discussions.

3.3.7 Focus group discussions

Data from Focus group discussions (FGD) were used to triangulate the accuracy of the responses from the household's interviews. Two focus group meetings were held to encourage individual expression on the changing climate perspective on the availability of NTFPs. The group discussions included four men and five women over 40 years who have lived in the area since 1993 and have local knowledge and experience on the changing weather patterns and environmental impacts. The focus groups were purposively selected based on their involvement in forest utilisation concerning changing climate through the help of the local chiefs. The information obtained from the focus group discussion was used to understand the consequences of the changing climate on livelihood, vulnerability, coping strategies, and the relationship between the availability of NTFPs and the distance to the forest edge. A discussion guide was used to direct the focus group discussion and to avoid wandering to irrelevant topics.

3.4 Data Analysis

3.4.1 Perceptions of local rainfall and temperature effects on NTFP availability

Percentages were used to analyse perception, and bar charts were used to represent the same. People's perceptions of rainfall and temperature changes were plotted on an Excel graph with the recorded period for rainfall and temperature. The differences in perception between the socio-economic characteristics such as age, educational level, occupation, and resident duration of Museve and Kavonge hilltop forests communities were analysed using logistic regression.

3.4.2 Rainfall and temperature trends around Kavonge and Museve hilltop forests

Trends in rainfall and temperature were analysed using the Mann-Kendall test and Sen's slope estimator.

3.4.3 Test of Mann-Kendall Trend

Mann-Kendall model is a non-parametric test used for the normal distribution of data time series and outliers (Kendall, 1975; Mann, 1945). It was statistically used to test the patterns or trends in meteorological data obtained. The formulae for the Mann-Kendall test (S) are given below:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(X_j - X_i)$$

Where:

n: numbers of data points

Xj and Xi are annual values in year j and i, j > 1

Moreover, Sign (Xj – Xi) calculated using the equation:

$$Sign(X_j - X_i) = \begin{cases} -1 \; for \, (X_j - X_i) < 0 \\ 0 \; for \, (X_j - X_i) = 0 \\ +1 \; for \, (X_j - X_i) > 0 \end{cases}$$

3.4.4 Test using Sen's Slope Estimation

Sen initially developed this performance test to check the statistical linear relationships (Agarwal *et al.*, 2021). This study applied Sen's slope to calculate the magnitude of temperature and rainfall trends. The following equation was used to estimate each slope (Q_i):

$$Q_i = \frac{Y_j - Y_i}{j - 1}$$

Where i = 1 to $n - 1$, j = 2 to n, Y_j and Y_i are data values at time j and i ($j > i$), respectively. If, in the time series, there are n values of Y_j, estimates of the slope will be $N = n\,(n - 2)/2$. The slope of Sen's estimator is the mean slope of such slopes' N values. The Sen's slope is:

$$Q_{ij} = \begin{cases} \dfrac{Y_j - Y_i}{j - 1} & \text{if } n \text{ is odd} \\ \dfrac{1}{2}\left(Q\dfrac{N}{2} + Q\left[\dfrac{N+2}{2}\right]\right) & \text{if } n \text{ is even} \end{cases}$$

The positive (Q_i) values indicate an increasing trend, while the negative Q_i values tell us a decreasing trend in the temporal data. Sen's slope (Qi) unit is the slope magnitude per year.

3.4.5 Logistic Regression Analysis

The study applied a logistic regression model to identify the factors determining the perception and collection of NTFPs in the forest edge communities of Museve and Kavonge hilltop forests.

The model specification outlined by Gujarati (2004) and applied by Ndung'u and Bhardwaj (2015) is presented below.

Y1 = α + β1X1 + β2X2 + β2X2 + β3X3 + B4X4 + β5X5 + β6X6 + β7X7 + β8X8 …… (1)

Where Y_i is a dichotomous dependent variable (Access to forest or not, specified as yes = 1, no =2. A is the Y-intercept whereas $\beta_1 - \beta_8$ is a set of co-efficient to be estimated X1-X8 are explanatory variables factors (Table 3.1) hypothesized based on theory and related work, to influence climate change effects on NTFPS in Museve and Kavonge hilltop forests, Kitui County. Equation (1) can be rewritten as;

Logit (p) = log (p/ 1-p) = $\alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8$ ········2)

Where p is probability that Y = 1 i.e. p = probability (Y =1). In terms of probability, equation (2) can be expressed as:

P = exp ($\alpha + \beta 1X_1 + \ldots + \beta 10X_{10}$)/1 + exp $\alpha + \beta 1X_1 + \ldots + \beta 8X_8$…………………… (3)

Table 3.1: Variables explaining perceptions of local rainfall and temperature

Variable	Description
X_1	Occupational (1 = employed; 2= farmer: 3=business: 4 others)
X_2	Gender of household head (1 = male; 2 = female)
X_3	Age (Age of household head in years)
X_4	Household size (number of family members in household)
X_5	Marital status (1= single; 2 = married;3=widowed)
X_6	Education level (1 = educated; 2 = no formal education
X_7	Average monthly income in Ksh
X8	Residence duration (number of years)

A trend line for NTFP availability for the years 1993 -1997, 1998-2002, 2003-2007, 2008-2012, 2013-2017, and 2018-2023 was plotted and compared with trend lines of NTFPS availability and climate factors (rainfall and temperature) from recorded rainfall and temperature data for correlation.

3.4.6 Correlation

The Kendall's tau b correlation coefficient was used to determine the trends of NTFP availability around the Kavonge and Museve hilltops forests for the past 30 years (1993-2023). The correlation coefficient ranges from -1 to +1, which is a numerical measure of this correlation between the variables. A coefficient value ± 1 for correlation indicates a good match. A value close to zero implies that the two variables have a random, non-linear relation. This is possible with the scatter plot. The linear regression model is useless if there is no relationship between the two variables. A line graph showing the amount of NTFPs perceived to be collected in kilograms and the number of years was plotted and compared from the correlation to predict the trend of NTFPs available in Kavonge and Museve hilltop forests over the past three decades.

3.4.7 Linear regression analysis

Linear regression analysis is a parametric model and one of the most common methods to detect a pattern in a data series. By fitting a linear equation to the observed data, this model establishes a relationship between two variables (dependent and independent).

The following equation generally describes the linear regression model:

$$Y = m^* X + C$$

Where Y and X are the dependent variable (rainfall) and the independent variable (time in months or years), respectively, m is the line slope (mm/year), and C is the intercept constant coefficient. The model's coefficients (m and C) were determined using the most commonly used Least Squares method. The slope sign defines the trend variable direction; it increases if the sign is positive and decreases if it is negative.

Linear regression analysis was used to explain the monthly and annual rainfall trends and temperature data using Sen's slope estimator and Mann—Kendall for Museve and Kavonge hilltop forests. Regression analysis was also used to establish the relationship between the amount of NTFPs and the distance to the forest.

3.4.8 Relationship between NTFP availability and forest edge distance

Data on the types of NTFPs collected were analysed using frequency tables. NTFP species names were identified in scientific and local names used in the Kavonge and Museve hilltop forests. Interview data on the number of NTFPs collected and the distance from the forest were compared using linear regression to determine if there were positive relationships. In the analysis, the dependent variable was the amount of NTFPs, while the explanatory variable (independent variable) was the distance to the forest edge for NTFP collection.

3.4.9 Community coping measures for climate change effects on NTFPs

The coping measures were listed and consolidated into similar groups and analysed in terms of frequencies and percentages. The coping measures adopted by household heads emphasized the importance of coping strategies.

3.4.10 Focus Group Discussion

Responses from the Focus Group Discussions were listed, sorted, and consolidated into similar responses, then presented in tabular form to make a meaningful interpretation. The template below was used to present the FGD responses.

S/N	Comments	Interpretation/outcome

3.5 Summary of data required, research instruments, and data analysis methods

The required data, instruments, and analysis methods for each objective are shown in Table 3.1 below.

Table 3.2: Data requirements based on objectives, instruments, and analysis methods

Objective	Required Data	Research Instrument	Method of Data Analysis	OUTPUT
(1) To assess community perception of local rainfall and temperature patterns on NTFPs availability.	Socioeconomic characteristics (age, gender, education, marital status, occupation, household size, sources of income, residence, etc.), and changes in rainfall and temperature.	Household interviews, critical informant interviews, and Focus group discussions.	Descriptive statistics (frequencies, percentages, tables, charts, etc.), The chi-square test of independence logistic regression analysis	Bar graph showing people's perception of local rainfall and temperature. Significance factors affecting the availability of NTFPs
(2) To examine the rainfall and temperature trends around Kavonge and Museve hilltop forests from 1993 to 2023	Climatic data, mainly rainfall and temperature, for 30 years (1993-2023) were obtained from Kitui County weather station.	Meteorological data	Trend analysis: Mann Kendall test and Sen's slope estimator.	Values showing a decreases or increases in both rainfall and temperature
(3) To establish a relationship between the availability of NTFPs and distance to the forest edge.	Types of NTFPs collected by households. Quantity of NTFPs collected, distance to the forest boundary from households	Household interviews.	Correlation (Kendall tau-b) coefficient and Linear regression analysis and line graph	Different types and quantities of NTFPs Significance of forest distance on their quantity
(4) To identify the coping measures that communities adopt in response to the effect of rainfall and temperature.	Coping measures in response to the effect of rainfall and temperature on NTFPs	Household interviews. Critical informant interview and Focus group discussion.	Descriptive statistics (using Percentages.)	Nine different coping practices were adopted and used.

3.6 Operationalization of variables

The study objectives had dependent, independent, and moderating variables. Table 3.3 below summarised the key variables that guided the study and how each variable was measured to achieve the study objectives.

Table 3.3: Operationalization of variables.

Objectives	**Variables**	**Indicators**	**Measurement**	**Data Analysis**
(1) To assess community perception of local rainfall and temperature patterns on NTFPs availability.	Dependent variable amount of NTFPs Independent variable Socioeconomic factors climate change effect on NTFPs	Time, distance and Amount of NTFPs	Likert scale	Descriptive statistics (frequencies, percentages tables, bar charts, graphs, etc.), logistic regression analysis.
(2) To examine the rainfall and temperature trends around Kavonge and Museve hilltop forests from 1993 to 2023.	Dependent variable climate change Independent variable rainfall and temperature	Trend measurement	Ratio scale	Trend analysis, Mann-Kendall test, and Sen's slope estimator.
(3) To establish a relationship between the availability of NTFPs and distance to the forest edge	Dependent variable: NTFPs availability Independent variable: household distance to the forest	Proximity effect	Ratio scale	Correlation (Kendall tau-b) coefficient and Linear regression analysis
(4) To identify the coping measures that communities adopt in response to the effect of rainfall and temperature.	Moderating variables Coping mechanisms/strategies	Socio-economic diversification	Nominal	Descriptive statistics (frequencies and percentages),

CHAPTER FOUR

4.0 RESULTS

4.1 Socio-economic characteristics of the respondents

This section presents the characteristics of the respondents, including gender, age, marital status, educational level, occupation of the household heads, respondent's household size, monthly income, and residence duration. In total, 120 household heads were interviewed. There were more male respondents, 55.8%, than female respondents, 44.2%, as shown in Table 4.1 below. The respondent's marital status indicated that 60.8% were married, 27.5% single, and 11.7% widowed, as shown in Table 4.1 below. The study indicated that the age range of 31 to over 50 constituted 54.2 0% of the household heads. Conversely, the age bracket of 20 to 30 years represents 45.8% of the household heads, as shown in Table 4.1 below.

A large number of household heads had some form of formal education. The result found that 43.3% of the respondents had secondary education, while 35.0% had completed primary education. Additionally, 12.5% of household heads acquired tertiary education qualifications, and finally, 9.2% of the respondents had no formal learning (Table 4.1). Farmers constituted a significant portion of the household heads, with 55.0% of the respondents engaged in agricultural activities. Business-related occupations are the second most prevalent at 25.8%. Additionally, 15.2% of participants are employees in various sectors. A smaller portion (4%) comprises NTFP collectors, as shown in (Table 4.1).

The most common household size was one to three people (51.3%). It was followed by those with four to six members (27.0%). The least number of households are those above six members, accounting for (21.7%) as shown in Table 4.1 below. Annual household earnings in the study area range from below Ksh 25,000 to above Ksh 100,000. From the results, 43.3% of the respondents earned between Ksh 25,000 and 50,000, the most significant proportion, while 23.3% earned above Ksh 100,000. A proportion (20.9%) of the respondents earned below Ksh 25,000. Conversely, 12.5% of the respondents earned between Ksh 51,000 and Ksh100,000 (Table 4.1). The results found that 55% of the respondents had a residency period over a decade, while 45% had a residency period between 1-10 years, as shown in Table 4.1. Lastly, this study revealed that 95% of the respondents accessed forest resources, while a paltry 5% had no access to forest resources (Table 4.1).

Table 4.1: Socio-economic characteristics of the respondents

Variable	Respondents (%)	Frequency
Gender		
Female	44.2	53
Male	55.8	67
Marital status		
Married	60.8	73
Single	27.5	33
Widow	11.7	14
Age group		
20-30	45.8	55
31-40	15.2	18
41-50	30	36
Above 50	9	11
Educational level		
No formal	9.2	11
Primary	35	42
Secondary	43.3	52
Tertiary	12.5	15
Occupational level		
Farmer	55	66
Business	25.8	31
Employed	15.2	18
NTFPs collector	4	5
Household size		
1-3	51.3	62
4-6	27	33
7-9	21.7	26
Households income		
Below 25000	20.9	25
25000-50000	43.3	52
51000-100000	12.5	15
Above 100000	23.3	28
Residence duration		
1-5	25	30
6-10	20	24
11-15	11	14
16-20	23.3	28
Over 20	20.7	25
Access		
Yes	95	114
No	5	6

4.2 Perceptions of climate change impacts on NTFPs

4.2.1 People's general perception of climate change

A majority (83.0%) of the respondents strongly agreed that the climatic conditions of their area have changed. Only 1.5% of respondents were unsure about the climate change (Figure 4.1).

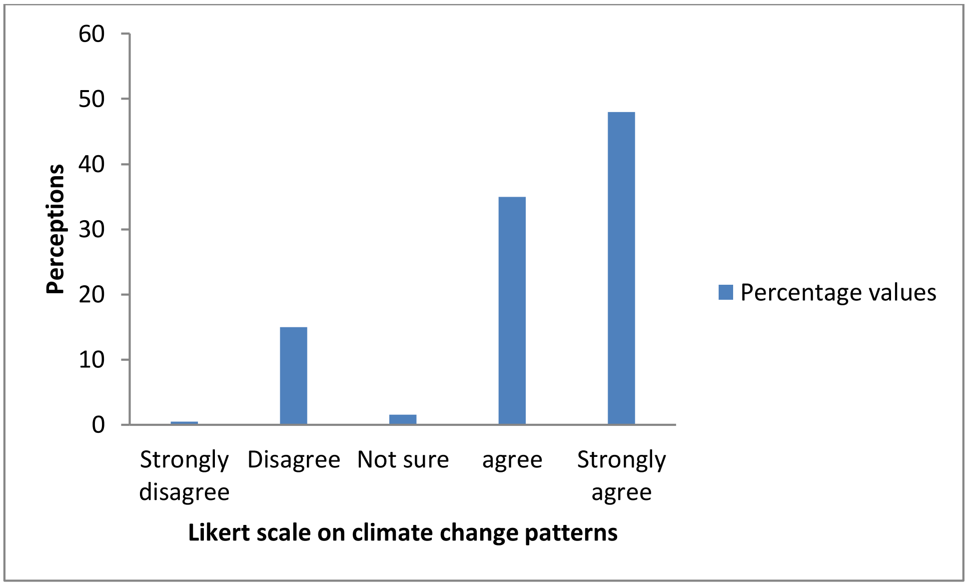

Figure 4.1: People's general perception of climate change

4.2.2 People's perception of changes in temperature patterns

A significant proportion (96%) of the respondents perceived an increase in temperature patterns during this recent period of 2018-2023, while 4% reported no change in temperature pattern. In 2013-2017, 98% of the respondents perceived an increase in temperature patterns, while only 2% reported a decrease in temperature.

In the period of 2008 to 2012, 80% of the respondents reported an increase in temperature patterns, 12% perceived decrease in temperature patterns, and 8% reported no change in temperature patterns. Additionally, from 2003 to 2007, 75% of the respondents perceived an increase in temperature patterns, while 20% perceived decreased in temperature. Furthermore, the respondents' local perceptions in 1998-2002 revealed a mixed pattern, in which 46% reported a significantly decreased in temperature, while 45% perceived an increase in temperature. Lastly, during the 1993-1997 period, 78% perceived a significant decrease in temperature, and 22% perceived an increase in temperature (Figure 4.2).

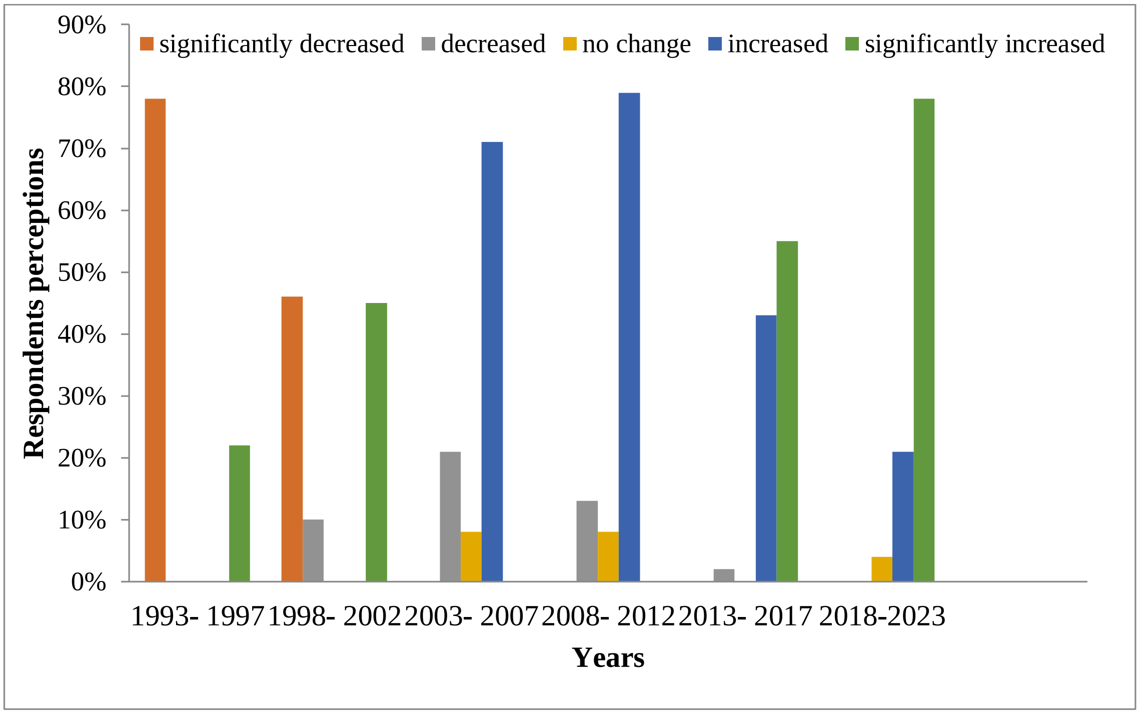

Figure 4.2: Respondents perceptions of changes in temperature patterns

4.2.3 People's perception of rainfall change patterns on NTFPs

All respondents perceived a decrease in rainfall patterns during this recent period of 2018-2023. In 2013-2017, 94% of the respondents perceived a decrease in rainfall, while only 6% perceived no change in rainfall. In contrast, from 2008 to 2012, the results revealed that 95% of the respondents perceived an increase in rainfall.

Additionally, from 2003 to 2007, 80% perceived an increase in rainfall patterns, while the respondent's local perceptions in the 1998-2002 periods revealed that 98% of the respondents reported to have experienced an increment in rainfall at that time.

Lastly, during the period of 1993-1997, 97% of the respondents attested significant increment in annual rainfall (figure 4.3).

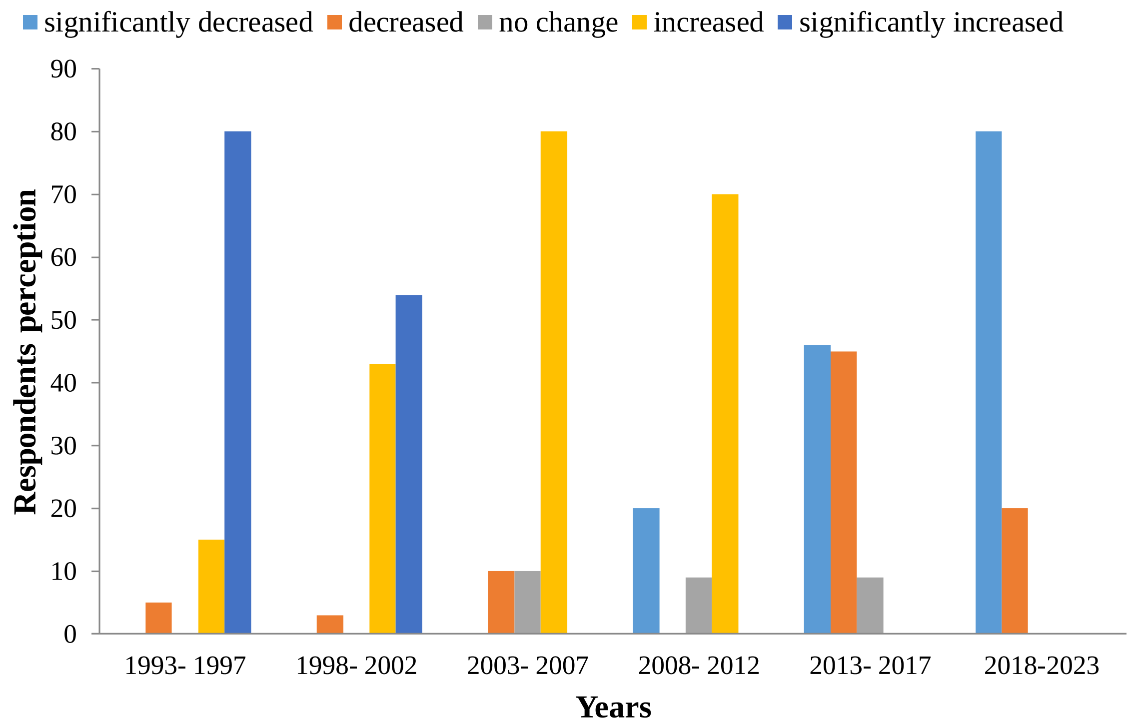

Figure 4.3: Respondents perception of changes in rainfall patterns

4.2.4 Socio-economic characteristics influencing climate change perceptions

Logistic regression analysis showed how individuals perceived climate change using socio-economic factors (Table 4.2). The analysis showed significant differences in respondents' perceptions due to age, education, occupation, and residence time ($p<0.05$). The result employed that respondents' perceptions of climate change were influenced by their age, educational attainment, occupation, and length of stay.

Table 4.2: Logistic regression model on people's perceptions of climate change

Factor	X^2	df	`p-value	Odds Ratio
Gender	0.355	1	0.552	0.361
Marital status	1.502	2	0.682	0.493
Age	0.400	3	0.001*	0.971
Education	15.426	3	0.01*	0.270
Occupation	11.675	3	0.003*	0.241
Household size	7.447	2	0.059	0.530
Income	0.153	3	0.362	0.540
Residence	5.871	4	0.046*	0.243

4.3 Temperature and rainfall trends around Kavonge and Museve hilltop forests

4.3.1 Temperature trend around Kavonge and Museve hilltop forests from 1993 to 2023

The results from the trend line graph showed a steady rate of increase in the study site's temperature, while the linear regression equation reported a positive slope value (0.025) and R^2=0.0599, as shown in Figure 4.4.

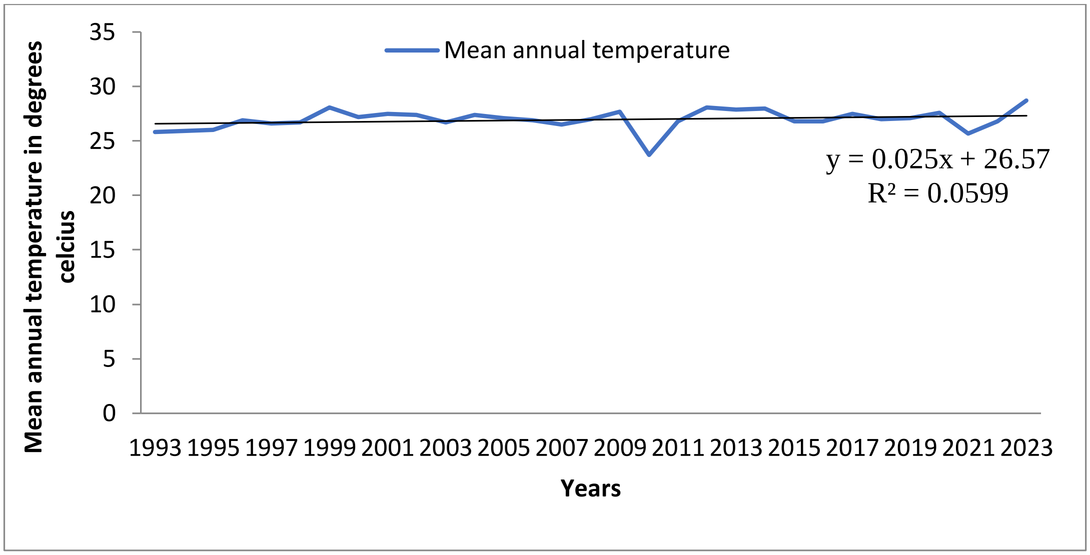

Figure 4.4: Trends in temperature around the Kavonge and Museve hilltop forests for the past 30 years

4.3.2 Rainfall trend around the Kavonge and Museve hilltop forests from 1993 to 2023

The results revealed a gradual decrease in rainfall at the study site, while the linear regression equation reported a negative slope value (-44.36) and the R^2=0.794 as shown in Figure 4.5 below.

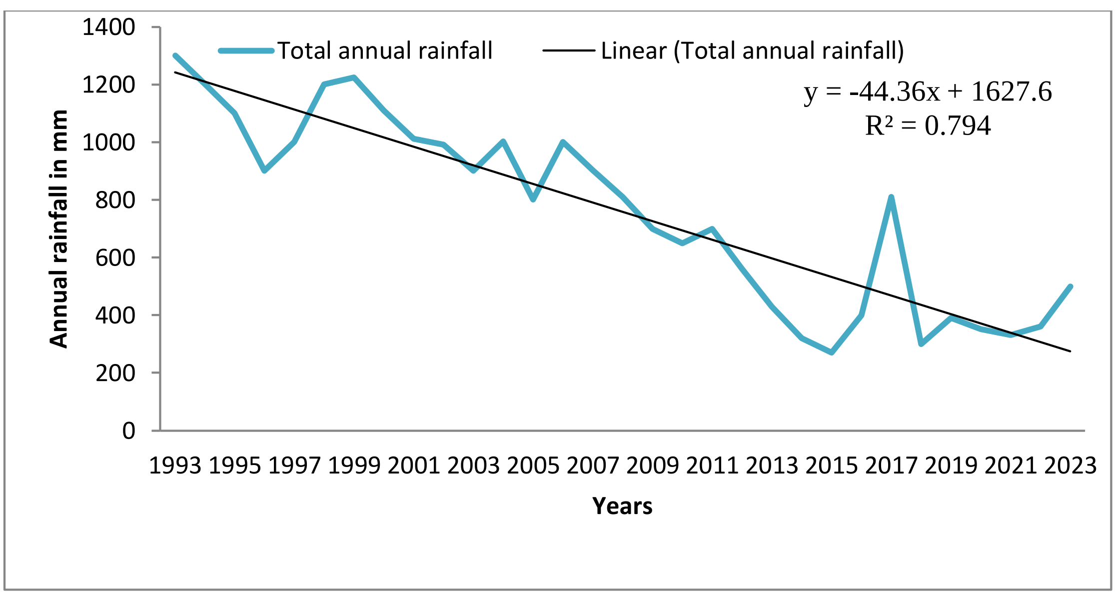

Figure 4.5: Trends in rainfall patterns around Kavonge and Museve hilltop forests for the past 30 years

4.3.3 The Mann- Kendall test results

The Mann-Kendal test for temperature showed a robust positive correlation (Kendall's Tau = 0.820, p= 0.0001) and a Sen's slope value of 0.015. In contrast, rainfall exhibited a strong negative correlation (Kendall's Tau = -0.672, p=0.0023) and a negative Sen's slope value of -0.022, as shown in Table 4.3 below.

Table 4.3: Mann Kendall's test and Sen's slope for climate trends

Series	Kendall's tau	p-value	Sen's slope
Temperature	0.820	0.0001	0.015
Rainfall	-0.672	0.0023	-0.022

Significance level 0.05%

4.4 Types and amounts of NTFPs and their relationship to the distance from the forest edge

4.4.1 Types of NTFPS collected and utilized from Kavonge and Museve hilltop forests

The study reported different categories of NTFPs harvested from the Kavonge and Museve hilltop forests. These included wild fruits, vegetables, medicinal plants, mushrooms, fuel wood, and charcoal. Some of these NTFPs were abundant during both dry and wet seasons. The study results found that the respondents from the Kavonge and Museve hilltop forests gathered 42 distinct species of Non-Timber Forest Products, as identified in (Table 4.4).

Most respondents (66.7%) harvested seven wild fruits from the Kavonge and Museve hilltop forests (Table 4.4 and 4.5). Results indicate that 51.7% of respondents around Kavonge and Museve hilltop forests harvested and used different types of wild vegetables. The study found that wild vegetables harvested were used either fresh or dried for future consumption. According to the respondents, wild vegetables were mainly available and utilised during the dry season when plants sprouted and produced tender leaves (Table 4.4 and 4.6). The study identified different plant species used for medicinal purposes, including trees, shrubs, and grasses. A significant proportion (62%) of the respondents used medicinal herbs to treat their sickness, as shown in (Tables 4.4 and 4.7).

Various mushrooms are collected and consumed from Kavonge and Museve hilltop forests during the wet season, as shown in Tables 4.4 and 4.8 below. Most respondents (80%) collected, dried, and preserved mushrooms for consumption, especially in the dry seasons. Different tree species used for firewood are found in Kavonge and Museve hilltop forests (Table 4.4 and 4.9). A significant percentage (64%) of the respondents source their fuelwood from the Kavonge and Museve hilltop forests. The study identified different tree species used for charcoal production around Kavonge and Museve hilltop forests (Table 4.4 and 4.10). A substantial percentage, 77% of the respondents, were engaged in producing and using charcoal as a source of income (Table 4.4 and 4.11).

Table 4.4: Types of NTFPS collected from Kavonge and Museve hilltop forests.

Types of NTFPs collected	**% Response**	**Number of species identified**
Wild fruits	66.7	7
Wild vegetables	51.7	5
Medicinal plants	62	9
Wild mushrooms	80	6
Fuelwood	64	8
Charcoal	77	7

Table 4.5: Identified wild fruits harvested from Kavonge and Museve hilltop forests

Kamba name	Scientific name	Growth habit	Availability
Mutomoko	*Annona murikata*	Tree	Dry season
Mukolya	*Lannea alata*	Tree	Dry season
Muasi	*Lannea schweinfurthii*	Tree	Dry season
Muthaalwa	*Lannea triphylla*	Shrub	Dry season
Kitheu	*Searsia tenuinerris*	Shrub	Whole year
Muua	*Sclerocarya birrea*	Tree	Dry season
Musuala	*Pannari excels*	Tree	Dry season

Table 4.6: List of identified wild vegetables harvested from Kavonge and Museve hilltop forests

Kamba name	Scientific name	Growth habit	Availability
Telele	*Amaranthus dubias*	Herb	Wet season
Walange	*Digera murikata*	Herb	Dry season
Ndungu	*Lannea alata*	Shrub	Dry season
W'oa	*Amaranthus graezizans*	Herb	Dry season
Telele	*Amaranthus spinosus*	Herb	Dry season

Table 4.7: List of medicinal plants harvested from Kavonge and Museve hilltop forests

Kamba name	**Scientific name**	**Growth habit**	**Part used**
Uthekethe	*Achyranthus aspera*	Herbaceous	Whole plant
Mukukuma	*Uvaria acuminata*	Shrub	Roots
Mungendya	*Kleina squarrosa*	Shrub	Leaves
Uthunga	*Launaea cornuta*	Liana	Leaves
Mwenzene	*Boscia salieifolia*	Tree	Barks, stems
Muuku	*Terminalia brownii*	Tree	Bark, leaves
Kiana	*Combretum molle*	Tree	Bark, leaves
Musemei	*Acacia nilotica*	Tree	Roots, leaves
Mukau	*Melia azadirach*	T	Leaves, roots

Table 4.8: List of wild mushrooms harvested from Kavonge and Museve hilltop forests

English name	**Scientific name**	**Availability**
Tremella	*Tremella fuciformis*	Wet season
Reish	*Ganoderma lucidum*	Wet season
Meshima	*Phellinus linteus*	Dry season
Maitake	*Grifola frodosa*	Wet season
Chaga	*Inonotus obliquus*	Wet season
Cordyceps	*Cordyceps militaris*	Wet season

Table 4.9: List of fuelwood tree species harvested from Kavonge and Museve hilltop forests

Kamba name	Scientific name	Growth habit	Part used
Kivovoa	*Falcon's acacia*	Tree	Stems
Mukala	*Antidesma venosum*	Tree	Branches
Kyoa	*Albezia glaberrima*	Tree	Branches
Mwowa	*Albezia anthelmintica*	Tree	Stems
Musemei	*Acacia nilotica*	Tree	Stems/branches
Musewa	*Acacia polyacantha*	Tree	Stems/branches
Muthii	*Acacia gerardi*	Tree	Stems andbranches

Table 4.10: List of tree species harvested for charcoal production from Kavonge and Museve hilltop forests

Kamba name	Species
Mweeya	*Acacia tortilis*
Muuku	*Terminalia brownie*
Kiundwa	*Albizia amara*
Mweya	*Acacia Seyal*
Kimweya	*Acacia xanthrophloea*
Kivai	*Acokanthea schimperi*
Musewa	*Acacia polyacantha*

4.4.2 NTFP trends in Kavonge and Museve hilltop forests over the past 30 years

The Kendall tau b correlation results indicate an inversely strong negative correlation between the amount of NTFPs and time tau b -0.709, p=0.000 (Table 4.11 and Figure 4.6). The negative value of tau b indicates a downward trend, signifying a consistent decrease in the amount of NTFPs collected over the years.

Table 4.11: Kendall tau b correlation on the trends of the amount of NTFPs collected (kgs) for the past 30 years

Correlations

		Year	amount of NTFPs
Kendall's tau-b			-.709**
	Sig. (1-tailed)	.	.000
	N	30	30

****. Correlation is significant at the 0.05% level (1-tailed).**

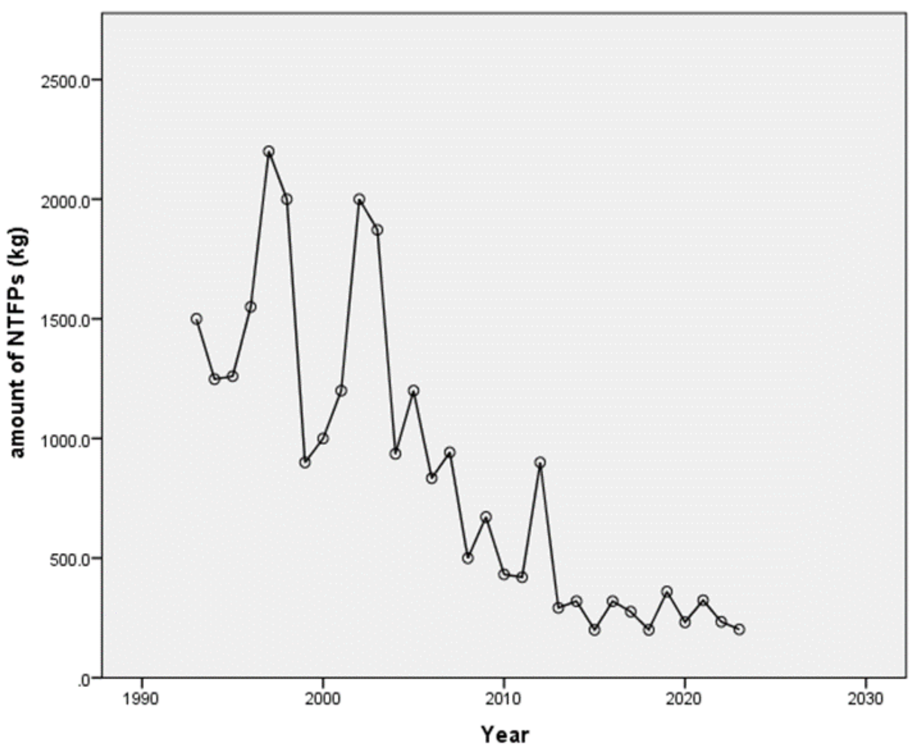

Figure 4.6: Trends of the amount of NTFPs collected from Kavonge and Museve hilltops forests for the past 30 years

4.4.3 The relationship between the availability of NTFPs and the distance to the forest edge

The results in (Table 4.12 and Figure 4.7) found that there was a significant relationship (p=0.000, R^2 0.797, β=-893) between the distance covered to the forest edge and the amount of NTFPs collected from Kavonge and Museve hilltop forests.

Table 4.12: Linear regression analysis on availability of NTFPs and distance to the forest edge

Co-efficient

Model		Unstandardised Coefficients		Standardised Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	4.956	.232		21.367	.000
	Distance km	-.004	.000	-.893	-9.293	.000

a. Dependent Variable: Amount of NTFPs

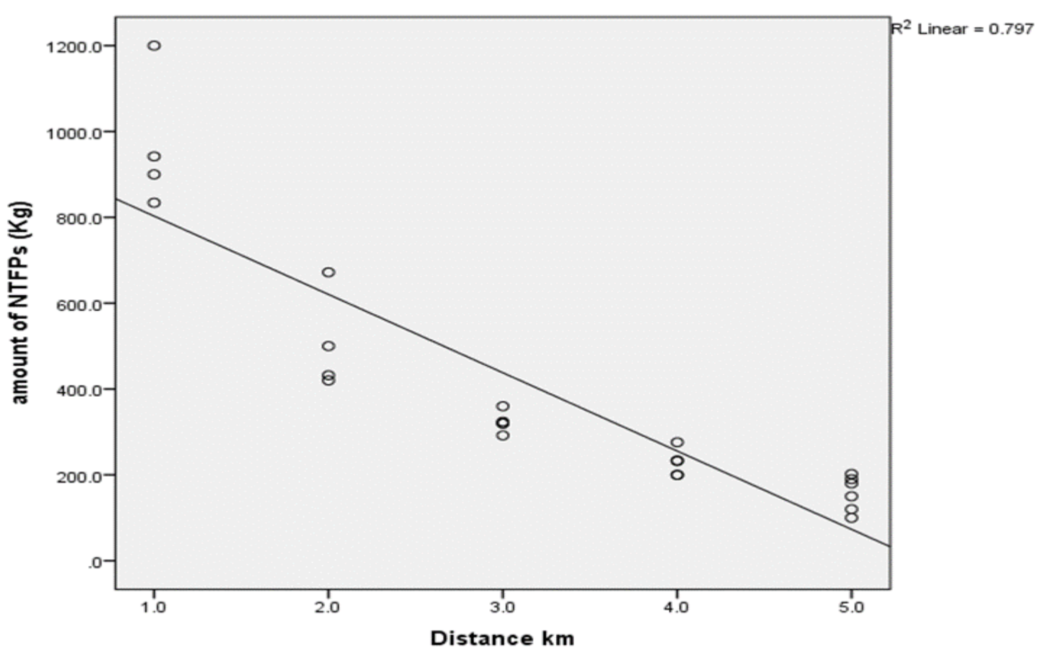

Figure 4.7: The relationship between the amount of NTFPs and the distance to the forest edge

4.5 Coping and Adaptations to Changing NTFP Availability

4.5.1 Measures adopted by the community near Kavonge and Museve hilltop forests

The study revealed that 90% of respondents adopted agricultural crop diversification as a preferred coping strategy for climate change and variability (Table 4.13). The results showed that 87% of respondents reported rearing livestock, while 75% were involved in delayed planting. The last 26% were involved in using fertilizers for crop growing.

Table 4.13: Response to various adaptations as coping strategies to climate change

Adaptation strategy	% response (n)
Crops diversification	90
Rearing of livestock	87
Late planting	75
Conducting petty business	60
Selling of timber from the owned farm	45
Utilisation of NTFPs	42
Tree plantation	35
Use of fertilizer	26

4.5.2 NTFPs utilised by households to cope with climate change and variability

At least 76% of the respondents reported consuming wild vegetables as the most popular coping mechanism associated with NTFPs, while 68% attested to fodder as livestock feed (Table 4.14). Additionally, 62% of the respondents reported using fuelwood as a coping mechanism, while 55% used dry mushrooms as coping measures during hard times.

Table 4.14: NTFPs utilised to cope with climate change and variability

Existing NTFPs	% response (n)
Wild vegetable	76
Fodder	68
Fuelwood	62
Mushrooms	55

4.5.3 Organisations that aided climate change adaptation in the study area

The Organisations that assisted the local people to adapt to climate change are presented in Figure 4.8 below. From the figure, 50% of the respondents indicated they had received training on adaptation strategies from MUSEKAVO Community Forest Association (CFA) officials in the study area. In comparison, 30% and 15% of respondents indicated that they were trained by KEFRI and KFS, respectively. A paltry of 5% of the respondents attested that they were unaware of organizations/institutions in the study area that trained locals to adapt to climate change.

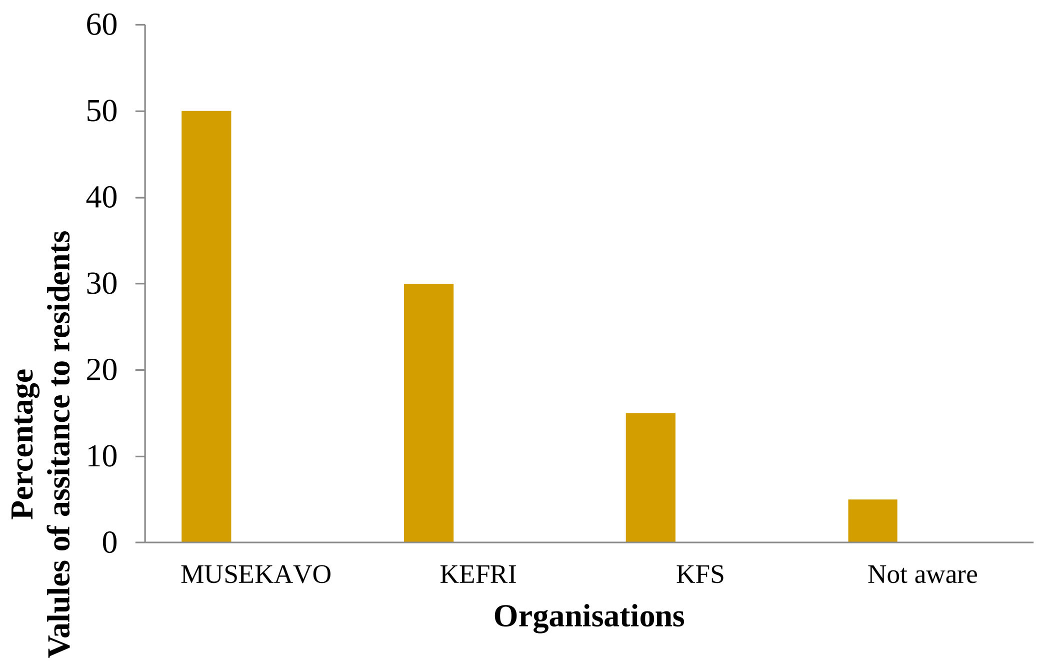

Figure 4.8: Organisations that assisted the Kavonge and Museve residents in coping with the climate change and variability

4.5.4 Comments and Outcomes on Focus Group Discussions

A discussion with Focus Group revealed the following comments and outcomes of climate change, as shown in Table 4.15.

Table 4.15: Major responses indicated by the farmers related to the current climate variability during FGD

S/N	Comments	Outcome/interpretation
1	Unable to work on the field continuously for more extended hours due to high intensity of heat	Low human labor due to extreme tiredness from the excessive heat.
2	'Insufficient groundwater is due to low rainfall.'	No off-season irrigation practice
3	'It was a disappointing season'	Crop farming is ultimately affected
4	'Increases in pest attack and incidence of diseases'	Crop failure, decreasing yield
5	'Lack of knowledge on the type of soil we are farming on'	Crop failure due to no idea of the type of soil used for farming on hilltops
6	'Delay rain during the expected rainy time'	Most farmers had to postpone their farming to the next rainy season
7	'Declining water level'	Deficiency in water supply from the source
8	'Lowering the soil moisture' soils are dry.'	Plants wither and wilt
9	'Our area has a saltwater problem; we cannot use it for cultivation.'	Potential areas along the hilltops stretch have become non-productive
10	'Distractions of our crops by the monkeys'	Low production
11	'Loss of valuable NTFPs'	Limited NTFPs species

CHAPTER FIVE

5.0 DISCUSSIONS

5.1 Perceptions of how local rainfall and temperature impact NTFP availability

Understanding the dynamic relationship between the effects of climate change and the availability of Non-Timber Forest Products (NTFPs) requires evaluating people's local viewpoints on climate change as represented by prevailing rainfall and temperature patterns and their socio-economic parameters. Age, education, occupation, and length of residency were shown to be statistically significant based on respondents' perceptions of changes in temperature and rainfall patterns. This result implies that having more life experience with age means having a greater chance of observing changes related to the weather. An older adult is more reliable in recording history than a young person and has accumulated more experience in the changing climate patterns in the study area. The findings are comparable to those of Suleiman *et al.* (2017), who found that older adults have more experience than young people living in forest areas.

The results indicate that education is statistically significant, suggesting that educated individuals are more likely to accurately perceive rainfall and temperature change patterns for a longer time than those without education. Educated people are also more inclined to adopt new technologies to combat climate change. Education enhances productivity and work efficiency, meaning that households with more educated members tend to benefit more from NTFP revenue production. These findings are consistent with Shemnga (2015), who noted that local knowledge can provide a comprehensive understanding of the localised effects of climate variability on NTFP availability and its impact on communities facing changing climate conditions.

The statistically significant impact of occupation highlights its role as a livelihood strategy, with farmers who depend on farming being more attuned to changes in temperature and rainfall patterns compared to those in other economic activities. Additionally, the duration of residence reflects the respondents' lifetime experience, indicating that individuals who have lived in the Kavonge and Museve hilltop forests for many years possess extensive knowledge and experience regarding climate change issues in the area. The results agreed with Muzari *et al.* (2014) & Martinez *et al. (*2018), who reported that the local community's perspectives and experiences are vital in supporting the overall planning of adaptation measures.

Throughout the study period, local perceptions of temperature changes reported a steady increase in temperature patterns in 2018–2023. This was closely attributed to the global conversation on climate change and the observed warming trends worldwide. The results are in line with Liu *et al*. (2006); Maroschek *et al.* (2009); Chakraborty *et al*. (2018), who reported that changing precipitation patterns and increments in global average temperatures affect the availability of NTFPs. The high percentages of perception of the changes in temperature and rainfall patterns imply the consistency of their local views with recognised scientific discoveries. This emphasises the importance and integrity of these local observations of rainfall and temperature patterns in the study area. This phenomenon agreed with research by Smith *et al.* (2017); Brown & Adams (2019), who highlighted the need to use local knowledge to supplement and validate climate information gathered using conventional scientific techniques.

The study findings reported that, higher percentage of the locals in the Kavonge and Museve hilltop forests area strongly agreed that climate change is happening in the study area. This provides a crucial context to the larger climate change narrative on the decreased in available NTFPs. These impressions act as an early warning system and can guide local adaptation plans. In this study, the local population's capacity to identify and describe temperature patterns highlighted their significance as crucial players in measures to manage resources and increase climate resilience. According to Brooks (2019) & Penuelas *et al*. (2017), their perceptions can form the basis for community-driven adaptation initiatives. Adapting agricultural operations, shifting NTFPs harvesting dates, or creating sustainable resource management plans that consider climate change are examples of such strategies of NTFPs and means of subsistence for the inhabitants of mountainous forests. The main climate-related changes enumerated in the Kavonge and Museve area were sure to cause temperature change patterns and unpredictable rainfalls. These have led to a decrease in NTFP availability, dryness of river sources, damage to crops by high-temperature intensity, and pest and disease damage to crop farmers. Additionally, there were variations in the overall quantity of rainfall and the timing, with rain falling either earlier or later than anticipated. The findings were ascertained by Haule (2022), who concluded that climate variability and anthropogenic activities are responsible for NTFPS reductions in quality, availability, and quantity.

The focus group talks also indicated that the research area's rapidly changing rainfall and temperature patterns have contributed to an ongoing decline in NTFP availability. Equally, the decreasing soil moisture, increasing heat intensity, and drought-like situation are some obstacles that farmers must overcome during farming seasons in the study area. Due to the high temperatures and insufficient rain, farmers have also observed a significant drop in the water level. This agrees with Ongoma and Chen (2017), who noted that since 1970, droughts have increased in frequency, particularly in the tropics and subtropics, with severe economic and environmental consequences on crops and forest product availability.

The key informant interviews revealed the different kinds of NTFPs obtained from the hilltop forests of Kavonge and Museve in Kitui County. The NTFPs collected were used for household consumption, income generation, and other basic needs. The Kavonge and Museve hilltop forest edge communities depend highly on these forest resources. The study findings agreed with Newton *et al.* (2012*)* & Kimaro (2013), who reported that forest-adjacent communities rely heavily on NTFPs for household consumption, monetary deposits, and basic needs. Also, other benefits provided by the Kavonge and Museve hilltop forests for communities are (1) provisioning services, e.g., the source of river Kalundu and Nzeeu, (2) providing services such as carbon sequestration and storage, local climate and air quality regulation, and moderation of extremes events (storms, landslides. (3) Housing or supporting services, including hosting species of plants and animals and maintaining genetic diversity of indigenous and exotic species. (4) Recreational and cultural services, e.g., camping, aesthetic appreciation, education, tourism, and spiritual experience/sense of place. The results align with the findings of Himberg *et al.* (2009), who observed that communities residing near forest reserves, engaged in activities related to the forest resource extraction which provide benefits such as habitat for species of plant and animals, maintenance of genetic diversity of both indigenous and exotic species, provision of their river sources and forest regulating services.

5.2 Trends in temperature and rainfall around Kavonge and Museve hilltop forests from 1993 to 2023

5.2.1 Temperature trend around the Kavonge and Museve hilltop forests

The study findings revealed a significant increase in temperature trends in the Kavonge and Museve hilltop forest areas over the past 30 years. This gradual temperature rise has impacted the availability of NTFPs by reducing the quantities produced annually. These findings are consistent with Camarero (2004), who noted that the growth, density, and distribution of NTFP tree species are altered by the effects climate change. The increasing trend in average temperatures is a clear indicator of global warming, which furthered explained the impacts on the local environment and reduced the availability of NTFPs in the Kavonge and Museve hilltop forests. The results confirm that climate change is indeed occurring, as evidenced by the changing temperature patterns and their adverse effects on NTFP availability over time. The study's findings align with those of Niang *et al*. (2014), who observed that rising temperatures lead to prolonged hot nights and more frequent heat waves, impacting forest resources availabilty in Africa.

The rising temperature trends indicate high warming and heat stress across the study area, especially during the day and night, even when they lived close to the forest. The findings agree with general scientific opinions that the average temperature has risen in the last few decades (MoALF, 2016) & GoMC, (2022). These changes in temperature patterns have resulted in heat stress, shortened crop cycles, and the introduction of new plant species, pests, and diseases. This suggests that every component has contributed to a decline in agricultural and forestry productivity in the study area, leading to food insecurity, livelihood losses, and higher poverty levels. The findings are consistent with the previous findings by Awuor *et al*. (2008); Bryan *et al.* (2013); Niang *et al*. (2014), who estimated that climate change would result in up to 20% more variability in precipitation and approximately 4°C increase in temperature in Kenya.

The increasing temperature trends implies significant impacts on agricultural productivity, water availability, and access to NTFPs as a critical factor in biological and environmental changes in the forest. Studies by IPCC (2018) & Easterling (2017) highlighted the impacts of rising temperatures influencing ecosystems, changing species ranges, and upsetting traditional livelihood patterns based on natural resources. Temperature changes can have significant effects on NTFPs by influencing the abundance, distribution, and phenology of NTFP-bearing species. For instance, rising temperatures can disrupt plant flowering and fruiting cycles, thereby affecting NTFP productivity in hilltop forests. These results are consistent with findings from the IPCC (2007), which noted that shifts in climate patterns are expected to significantly impact the availability of NTFPs in mountain forest regions, with important implications for regional adaptation strategies.

5.2.2 Rainfall trend around Kavonge and Museve hilltop forests

The rainfall exhibits a moderate negative correlation indicating a statistically significant but more gradual decline in rainfall trends during the last 30 years. The negative Sen's slope value suggests the magnitude at which the rainfall decreased over the last 30 years in the study area. This shows that rainfall patterns have continuously reduced, leading to climate variability in the study area. The results conform with FAO (2008a) & Dore (2005) who found that severe consequences of changing climate on the forest ecosystem, forest productivity, and species diversity result in a decline in NTFPs. The availability of NTFPs depends on the amount of rainfall received during a particular plant flowering season. Thus, the reduction in rainfall amounts has resulted in a declining trend in the harvest of NTFPs in both hilltop forests in the study area. The results agreed with recent findings by Muia *et al*. (2024), who reported a declining trend in annual and seasonal (short and long rain seasons) rainfall in Kenya.

The study observed negative rainfall anomalies in the Kavonge and Museve hilltop forests over the past three decades. Our current study found that rising temperatures and decreasing rainfall patterns characterise climate change in these regions. This decline in rainfall is driven by ongoing global warming, along with other factors such as land use diversity, changes in land cover, over-exploitation, and the utilisation of NTFPs. These findings are consistent with those of Adegbola *et al.* (2013), who reported that farmers in Nigeria have been experiencing decreasing precipitation causing low NTFPs availability. Similarly, Mutunga *et al.* (2017) found comparable results in their trend analysis of rainfall and temperature variability, particularly in the arid and semi-arid regions of Kitui, Kenya. However, in contrast to our findings, Loh *et al*. (2020) observed a trend of increasing annual rainfall between 1960 and 2015 causing decrease in NTFPs availability in the Bamboko Forest Reserve, South West Region, in Cameroon.

5.3 Relationship between NTFPs availability and distance to the forest edge

The results signify that the distance to the forest edge is inversely proportional to the amount of available NTFPs collected by the household heads. The negative slope means an increase in distance by 1 km leads to a decrease in the amount of NTFPs in the Kavonge and Museve hilltop forests area. The findings indicated that variations occur in quantities of NTFPs collected between household heads living within a distance of 1 km - 3km and those living within a distance of 4 to 5 km away from the forest boundary. Our results were compared to Suleiman *et al*. (2017), who stated that the distance expressed in kilometers, between the residence and the forest is anticipated to impact the quantity of NTFPs gathered. This suggests there is less chance of NTFPs being collected from the forest by households living farther from the forest than those nearby.

The results of this study clearly showed an inverse relationship between NTFP availability and families' distance from the forest edge. Particularly, those who lived closer to the forest border discovered that NTFPs were noticeably more readily available and collected many times than those far from the forest. This is consistent with research conducted by Mujawamariya *et al.* (2014), who observed that individuals who lived nearer to the forest were more reliant on its supplies of resources than those who lived farther away. Elsewhere, Rahman *et al.* (2021) found that the growing distance between the household and the forest negatively influenced the household income from NTFPs collections.

The relationship between the availability of NTFPs and the distance from the forest border significantly correlated. The outcome is inconsistent with Maua (2018b), who reported that

90% of the heads of the household extract NTFPs at a close distance, indicating how vital the forest is to the nearest households. Also, the results agree with the widely accepted ecological premise that gradients in environmental variables, including distance from forest borders, frequently alter the ecological composition of forests, including the abundance of various NTFP-bearing species (Turner, 2015). The existing relationship describes how the local communities rely on these resources, the quantity distribution of NTFPs collected per households, as modified by the distance to the forest edge. The relationship between the amount of NTFP collected and distance to the forest boundary from households attest that NTFPs are more accessible for those who live closer to the forest border and provide dependable sources of food security, livelihood, and income for them. Our result agreed with Rahman *et al*. (2021) who reported that distances between home and forest negatively affect income from NTFPs.

The Kendall tau b correlation coefficient shows that the amount of NTFPs has gradually decreased in the last 30 years in the Kavonge and Museve hilltop forest areas. The continuous decrease in NTFP availability is probably caused by unpredictable rainfall and high-temperature intensity during the flowering seasons of NTFP species. Other factors causing the decline in NTFPs are population increase and their use of limited NTFP resources, increase in commercialisation of NTFPs, and increased knowledge on the value of NTFPs in present days compared to the past decades. These results follow the outcomes of Shackleton and Shackleton (2004), who found out that there is now a high recognition of the value of NTFPs in people's livelihoods. For instance, wild foods significantly boost food security and nutrition, especially for the impoverished in rural areas. Elsewhere, Hamza *et al.* (2004) found that 80% of local communities living adjacent to Migori Forest Reserve acquired wild fruits, vegetables, and honey from the forest, which helped improve their nutritional needs.

5.3.1 Types of NTFPs Collected in Kavonge and Museve hilltop forests

The Kavonge and Museve hilltop forest edge communities rely on Non-Timber Forest Products (NTFPs) as essential resources, offering various benefits such as food, medicine, and energy. Utilising NTFPs like wild fruits, wild vegetables, medicinal plants, wild mushrooms, fuel wood, and charcoal plays an essential function in the traditions and livelihoods of these communities. The results were comparable to Sinha *et al*. (2013) who reported that local communities in developing nations depend highly on NTFPs for employment, healthcare, household energy sources, and subsistence needs.

The results explore high percentages of collection and usage of NTFPs in the study area and also highlight its significance to their livelihoods. The respondents from the hilltop forests of Kavonge and Museve gathered six distinct types of non-timber Forest Products (NTFPs) from which 42 different species of non-timber forest products (NTFPs) were identified and collected from the hilltop forests of Kavonge and Museve. Among the NTFPS were charcoal, mushrooms, wild fruits, wild vegetables, fuel wood, and medicinal plants which also helped produce income in addition to being consumed. Similar research by Newton *et al*. (2012), indicates that under some circumstances, the impoverished rely on NTFPs disproportionately for consumption and income generations.

Wild fruits are a vital nutrition and food security source for forest-edge communities. The relatively high percentage indicates a firm reliance on wild fruits as part of the local diet. The collection of wild fruits helps diversify food sources and contributes to dietary health. It also offers potential economic benefits if surplus fruits are sold in local markets. The high percentage may be due to various fruit species in the forest, the traditional understanding of fruit collection, and the seasonal abundance, all of which could contribute to the high collection rate. Ruffo *et al.* (2002) found out that wild fruits of *Adansonia digitata* and *Ximenia caffra* contain higher vitamin C content than mango (*Mangifera indica*) or orange (*Citrus sinensis*).

Wild vegetables are another critical food source, providing essential vitamins and minerals. The percentage in reflects a moderate reliance on these resources. Its reliance supports food diversity and nutrition. However, it also indicates the need for sustainable harvesting practices to avoid overexploitation. The potential reasons for harvesting are the seasonal availability of vegetables, cultural preferences, and the presence of specific edible plant species that influence the collection rate. The study findings are compared to Mvungi *et al.*

(2001) who reported that wild vegetables save the lives of thousands of impoverished people who reside in forest edge communities of Iringa, Dodoma, Singida, and Morogoro in Tanzania.

The medicinal plants are crucial in primary healthcare for forest edge communities. The high percentage highlights the importance of traditional medicine to forest edge communities of Kavonge and Museve hilltop forest areas. The use of medicinal plants underscores the need for conservation efforts to ensure these resources remain available. It also suggests the potential for developing sustainable medicinal plant markets. The rich traditional knowledge of herbal medicine, limited resources for modern healthcare, and the availability of diverse medicinal species in the forest contribute to its high usage in the study area. Mann *et al*. (2008) reported that traditional medicines will continue to be a significant source of healthcare for most rural communities in developing countries.

Wild mushrooms are the most frequently harvested NTFPs in the Kavonge and Museve hilltop forests, highly valued for their nutritional and culinary properties. The high collection rate reflects the locals' significant reliance on this resource, driven by abundant mushroom species, favorable climatic conditions, and cultural preferences for mushroom consumption. This intensive usage underscores the need for sustainable management to prevent the depletion of mushroom species.

Similar findings were reported by Nandi *et al.* (2009) in Western Kenya, where wild mushrooms are frequently used for nutritional, therapeutic purposes, and as a food source to adapt to changing climates. This study's outcomes also align with Shillington (2002), who noted that many forest food products are gathered annually for home consumption and sale, particularly during the dry season, to shield families from harsh weather conditions. Equally, the results support those of Falconer (1992), who found that around 1,500 species of wild plants are collected for consumption in central and West Africa.

Fuelwood is a primary energy source for cooking and heating in the forest-edge communities of the Kavonge and Museve hilltop forests. The high usage percentage reflects the substantial dependence of households on this resource, which in turn contributes significantly to forest reliance in the study area. However, this heavy reliance on traditional fuelwood poses challenges for forest conservation, as unsustainable collection practices can lead to deforestation.

The study also found that charcoal is another widely used energy source in these communities. The high rate of charcoal use indicates a strong reliance on its production. The economic benefits of charcoal, including its high energy efficiency, income generation from sales, and cultural significance, further contribute to its widespread use.

This finding suggests that the extensive use of charcoal raises significant concerns about forest degradation and carbon emissions, emphasising the need for sustainable charcoal production methods and alternative energy sources for households in these forested areas. The study's results are consistent with those of Mary *et al.* (2013), who found that 72% of urban and 98% of rural families in sub-Saharan Africa rely on fuelwood for energy. They also reported a 64% increase in charcoal dependence among Kenyans living in urban areas over the past two decades.

Regarding NTFP use in coping with climate change, wild vegetables were the most frequently harvested, serving as both a food source and a means of income, followed by fodder, which is used as livestock feed during the dry season. These findings align with those of FAO (1992), which highlighted the importance of fodder plants in animal nutrition, particularly during dry seasons when they provide essential proteins and supplementation.

5.4 Coping Measures in Response to Climate Change Impacts

This study reveals that communities in the Kavonge and Museve forest areas employ a range of coping strategies during the impacts of climate change on non-timber forest products (NTFPs). A prominent approach is the diversification of agricultural practices, including the cultivation of climate-resistant crop varieties. This method helps to buffer against unpredictable weather patterns and enhance food production. By adapting their crop choices to current climatic conditions, these communities improve their resilience to climate change. This finding aligns with the adaptive management strategies proposed by Thornton et al. (2018), which underscore the importance of diversified agriculture in fostering climate-resilient food systems among farmers in Kenya's forest edge communities. Additionally, the use of fertilizers has gained popularity as a response to the challenges of erratic rainfall, a trend supported by Deryng (2016), who noted that fertilizers enhance soil fertility and boost crop yields.

In our study, a sizeable percentage of respondents kept livestock as a way of coping and adaptation strategy due climate change. Livestock offers a means of generating revenue and ensuring food security to address climate-related concerns. A similar study by Herrero *et al.* (2013) highlighted the many advantages of livestock in adapting to the changing climate, including the significance of livestock in strengthening resilience.

Small enterprises and other small-scale entrepreneurial endeavors have also become a significant coping measure in the study area. These small enterprises provide households with varied revenue streams that assist them in coping with the financial effects of climate change. The result agrees with Jabbar *et al*. (2023), who reported that Non-farm income diversification is a vital livelihood strategy that endorses sustainable agriculture and alleviates poverty.

These coping strategies highlight the adaptability and resilience of local populations in response to changing environmental conditions. They reflect the community's capacity to manage climate-related challenges using their resources and traditional knowledge. Regmi *et al*. (2010) support this view, noting that effective climate adaptation requires context-specific and flexible solutions.

Identifying these coping methods, especially the collection of NTFPs, underscores how important it is for communities to build resilience. Understanding and supporting these initiatives can increase food security, enable more successful climate adaptation efforts, and help manage NTFPs sustainably in the face of climate change. The study identified four key NTFPs: wild vegetables, animal fodder, fuelwood, and mushrooms—that communities use to address food insecurity during droughts. This aligns with findings from Bahl (1994), who emphasises the nutritional value of mushrooms, and Schippers (1997), who highlighted the crucial role of native African forest food in ensuring food security for both urban and rural populations.

The study findings indicate that the Kenya Forest Research Institute (KEFRI), Kenya Forest Service (KFS), and MUSEKAVO Community Forest Association (CFA) were the primary organisations that offered training for residents in Kavonge and Museve on climate change coping and adaptation strategies. Among these, MUSEKAVO CFA was the most proactive, providing the most extensive training on these mechanisms, KEFRI followed as the second organisation to implement such training, while KFS was the third to offer such education.

These training programs significantly increased respondents' awareness of various coping strategies, including diversified crop-growing, livestock farming, and tree planting. However, a small group of respondents were unaware of organisations providing such training, likely representing individuals not involved in joint forest management. It is important to note that the Kavonge and Museve hilltop forests are regulated under rules and regulations set by KFS.

Delayed planting was also a primary coping strategy. The Farmers' Group Debates (FGDs) showed that farmers do not want to assume the risk of crop failures, given the prolonged droughts they have been having for several years and the resulting agricultural damage. Another cause of delayed planting is that farmers use the seeds they had preserved from their previous crop, so they do not want to risk losing them during prolonged dry spells. Using NTFPs as one of the preferred coping strategies was the best option during crop failures regarding the effects of changing climate and variability. These farmers believe that the rainy season has been decreasing unreasonably and unpredictably from 2008-2023 and that heat is becoming excruciating, as seen in (Figure 4.3). This was also supported by the statement from the FGDs, which stressed that rainfall has been decreasing over the years. This also agreed with a similar scenario reported by Simelton *et al*. (2013).

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary of the findings

In summary, the study found that 96% of respondents observed a steady rise in temperature over recent years, while all noted a decrease in rainfall patterns. This widespread awareness among local people of the changing climate in the Kavonge and Museve hilltop forest areas is linked to reduced non-timber forest product (NTFP) availability, increased drought, and drying river sources.

The local perceptions of temperature and rainfall changes were consistent with meteorological data analysed using the Mann-Kendall and Sen's slope tests. The Mann-Kendall test revealed a significant positive trend in temperature (Kendall's Tau = 0.820, p = 0.0001), with a Sen's slope indicating an average annual increase of 0.015°C. This confirms the observed global warming trend. Conversely, the rainfall data showed a significant negative trend (Kendall's Tau = -0.672, p = 0.0023), with a Sen's slope indicating an average annual decrease of 0.022 mm, suggesting challenges for NTFP species distribution, growth, and crop productivity.

The study identified various NTFPs harvested from the Kavonge and Museve hilltop forests, including wild fruits, vegetables, medicinal plants, mushrooms, fuel wood, and charcoal. Over 30 years, respondents collected 42 distinct NTFP species. Kendall's Tau result (-0.709) indicated a strong negative correlation between NTFP availability and the time of collection, reflecting a significant decline in NTFP availability. Additionally, there was a notable relationship between the distance to the forest edge from households and the quantity of NTFPs collected. All respondents employed coping strategies to enhance resilience against climatic uncertainties in the area.

6.2 Conclusions

(a) Perceptions of local rainfall and temperature patterns on the availability of NTFPs

The high percentages of respondents noting increases in temperature and decreases in rainfall reflect significant community awareness and concern about climate change impacts. The study found that differences in education level, age, occupation, and length of residence influence how people perceive the effects of climate change on non-timber forest products (NTFPs) in the Kavonge and Museve hilltop forests. Long-term experiences with local weather patterns are crucial for understanding the current climate dynamics in the area.

Additionally, the study confirms that local perceptions of decreasing rainfall and increasing temperatures align with scientific findings, reinforcing that both temperature and rainfall trends observed by the community are consistent with the broader scientific conclusions from recorded data for the study area.

(b) Trends in temperature and rainfall around Kavonge and Museve hilltop forests from 1993 to 2023

Over the past 30 years, variability in rainfall and temperature has significantly affected the availability of non-timber forest products (NTFPs) in the Kavonge and Museve hilltop forests. The upward trend in temperatures indicates a consistent increase, which has notably impacted the availability and productivity of NTFPs. According to focus group discussions (FGD), the combination of erratic rainfall and the increase temperatures has led to a marked decline in NTFP availability over the years.

(c)Relationship between NTFPs availability and distance to the forest edge

The high percentages of NTFPs reflect a significant reliance on NTFPs for various needs, highlighting their critical role in the livelihoods of forest-edge communities. The results indicated a statistically significant relationship between the availability of NTFPs and the distance from households to the forest edge. The distance to the forest edge from the household head residence was among the key factors affecting the availability and consumption of NTFPs in the study area. It was concluded that the longer the distance of the household home from the forest, the less NTFPs were collected from the hilltop forests.

(d) Coping measures in response to climate change impacts on NTFPs

The majority of the respondents practised some coping strategies for climate change, including diversification of crops, rearing livestock, delaying planting time for rain, tree planting, and applying fertilizer to achieve good yields. These strategies strengthen resilience against climatic uncertainties and reduce the economic risks caused by decreased NTFP availability.

6.3 Recommendations

The findings of the study established the following recommendations:

1) Local people's knowledge and experience should be relied on more heavily when understanding climate change dynamics, especially rainfall and temperature patterns. This will help researchers better understand the long time effects of climate change scenarios in the study area.
2) Given the decline in non-timber forest product (NTFP) resources, which serve as a crucial food safety net for residents in the Kavonge and Museve hilltop forests, the study recommends that both Central and County governments support residents by providing tree seedlings and promoting the establishment of farm forests. This initiative will help ensure a continuous supply of NTFPs for sustenance and income generation.
3) Central and local governments should create and enforce policies and community bylaws aimed at reducing deforestation, controlling overharvesting, and mitigating climate change impacts on forest ecosystems. These measures should promote responsible collection, management, and preservation of endangered non-timber forest products (NTFPs). These efforts must align with the needs and goals of local communities, involving them in the development and implementation of these policies.
4) Forest managers should support local populations by integrating indigenous knowledge into climate-resilient agricultural practices. This support will help

diversify livelihoods and enhance food security. The introduction of drought-resistant crop varieties is essential for sustainable land management and adapting to changing climatic conditions.

6.4 Recommendations for further studies

Future research projects should prioritise long-term climate modeling to understand better climate change's current and future effects on non-timber forest products (NTFPs) in the Kavonge and Museve Hilltops forest. A thorough approach to climate modelling over several decades may provide priceless insights into the predicted climatic changes, allowing for a more precise evaluation of how NTFP species will likely react and adapt over time. This information will make it easier to create specialised conservation and adaptation plans that can change along with the dynamics of the changing climate.

Creating and assessing community-based adaptation methods tailored to the particular requirements and capacities of communities close to these forest reserves should be the subject of further study. This entails using a participatory approach where community people are actively involved in developing and implementing climate adaptation strategies. Researchers may develop more successful, culturally aware, and community-driven strategies to protect NTFPs and the livelihoods they sustain by emphasising the opinions and expertise of locals.

Additionally, future research should focus on conducting a comprehensive economic impact assessment to understand the full effects of decreased non-timber forest product (NTFP) availability. This assessment should evaluate various factors, including the extent of income loss experienced by local populations, potential changes in subsistence patterns, and the overall economic resilience of affected groups. By measuring these economic impacts, researchers can provide valuable data-driven insights to help organisations and governments implement actions that enhance the economic well-being of communities facing NTFP shortages.

A deeper and more nuanced view of the availability and conservation of NTFP may be provided by a comparative study conducted across several forest reserves or areas with various climate change effects. Researchers may discover patterns and adaptable techniques that may be transferred to other settings by examining NTFP responses in regions with different climatic circumstances. This helps to provide a more thorough knowledge of NTFP dynamics. In-depth cultural effect analyses should be part of future studies to understand the cultural implications of decreased NTFP availability fully. Cultural practices, traditions, and community cohesiveness may be impacted by variations in NTFP availability, which may be made clear by ethnographic and sociological investigations. These realisations, which acknowledge the connectivity of NTFPs with cultural identities, might guide cultural preservation initiatives in addition to conservation.

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APPENDICES

Appendix i: Household Survey Questionnaire

Introduction

My name is Alex Saffa Vandi from SEKU and I am researching for a master's of science degree in climate change and Agroforestry. As part of the research, I am studying the effect of climate change on the availability of NTFPs in Kavonge and Museve hilltop forests. The research intends to identify appropriate livelihood strategies for this area in the face of changing climate, socio-economic, and policy conditions. The research is anonymous, so I will not record your name and all the information provided will be used for research purposes only. I will be very pleased if you answer my questionnaire. Thank you.

Date............/........../...............

County............ Sub-County................... Ward................ Village....

A: Socio Demographic Information.

Please tick the relevant boxes.

1. What is your gender? Male ☐ Female ☐

2. Marital status: 1. Single 2. Married 3. Widowed 4. Divorced

3. What age group do you belong to?

(1) 20-30 years ☐ (2) 31-40years ☐ (3) 41-50 years ☐ (4) Above 50 years ☐

4. What is your level of education? No formal education ☐ Primary Education ☐ Secondary Education ☐ Tertiary Education ☐

5. What is your occupation? Employed ☐ Farmer ☐ Business ☐ Others ☐

6. Household size (number of people in household) ……………

7. What is your annual household income (In Ksh)? below 25,000 ☐ 25,000- 50,000 ☐ 51,000-100,000 ☐ Above 100,000 ☐

8. How long have you been residing here? (1) 1-5 years ☐ (2) 6-10 years ☐ (3) 11-15 years ☐ (4) 16-20 years ☐ (5) Over 20 years ☐

B: NTFPs, Distance and Livelihood Information

9. Does your family have access to forest the Kavonge and Museve forests? Yes ☐ No ☐

10. (a) How far is the Kavonge and Museve forest area from the house? …………….
(km)

b How long do you take to walk to the forest? ………….. (min)?

11. What types of NTFPs do you collect? Tick all that apply.

Fodder☐ Fuelwood ☐Medicinal Plants ☐ Wild Fruits ☐ Wild Vegetables ☐

Charcoal ☐ Mushrooms ☐Others ☐

12.What can you describe as the trend of NTFPs available in the forest area over the last 30 years? Increasing ☐ Decreasing ☐ No change ☐

NTPF collected	Frequency	Amount collected presently	Amounts collected in 2018	Amounts collected in 2013	Amounts collected in 2008	Amounts collected in 2003	Comments E.g. species or anything worth noting
Firewood	Daily						
	Weekly						
	Monthly						
Fodder	Daily						
	Weekly						
	Monthly						
Medicinal Plants	Daily						
	Weekly						
	Monthly						
Wild Fruits	Daily						
	Weekly						
	Monthly						
Wild Vegetables	Daily						
	Weekly						
	Monthly						
Charcoal	Daily						
	Weekly						
	Monthly						
Mushrooms	Daily						
	Weekly						

C: Perception of Climate Change

13. To what extent do you agree with the statement "Climate Change is happening in your area"?

Please tick the response below: 1. Strongly Disagree ☐ 2. Disagree ☐ 3. Not sure ☐ 4. Agree ☐ 5. Strongly Agree ☐

14. How do you compare the recent temperature to the temperature in the past 30 years using the following period of years below? Please tick the relevant box below.

(1-Significantly Decreased, 2-Decreased, 3-No Change, 4-Increased, 5-Significantly Increased)

Year	Rainy season	Dry season	Comments
2023 -2018	Maximum Temp 1,2,3,4,5	Max Temp 1,2,3,4,5	
	Min temp	Min Temp	
2017-2013	Maximum Temp 1,2,3,4,5 Min temp 1,2,3,4,5	Max Temp 1,2,3,4,5 Min Temp	
2012-2008	Maximum Temp 1,2,3,4,5 Min temp 1,2,3,4,5	Max Temp 1,2,3,4,5 Min Temp	
2007-2003	Maximum Temp 1,2,3,4,5 Min temp 1,2,3,4,5	Max Temp 1,2,3,4,5 Min Temp	
2002-1998	Maximum Temp 1,2,3,4,5 Min temp 1,2,3,4,5	Max Temp 1,2,3,4,5 Min Temp	
1997-1993	Maximum Temp 1,2,3,4,5 Min temp 1,2,3,4,5	Max Temp 1,2,3,4,5 Min Temp	

15. How do you compare the recent rainfall to the rainfall in the past 30 years using the following period of years below? Please tick the response below. (1-Significantly Decreased, 2-Decreased, 3-No Change, 4-Increased, 5-Significantly Increased)

Year	Raining season	Dry season	Comments
2023 -2018	Maximum rainfall 1,2,3,4,5	Maximum rainfall 1,2,3,4,5	
	Min Rainfall 1,2,3,4,5	Min Rainfall 1,2,3,4,5	
2017-2013	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	
2012-2008	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	
2007-2003	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	
2002-1998	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	
1997-1993	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	Maximum rainfall 1,2,3,4,5 Min Rainfall 1,2,3,4,5	

16. How do you compare your recent drought experience to the past 30 years using the following period of years below?

Please tick the response below. (1-Significantly Decreased, 2-Decreased, 3-No Change, 4-Increased, 5-Significantly Increased)

Year	Drought experience	Comments
2023 -2018	1,2,3,4,5	
2017-2013	1,2,3,4,5	
2012-2008	1,2,3,4,5	
2007-2003	1,2,3,4,5	
2002-1998	1,2,3,4,5	
1997-1993	1,2,3,4,5	

D. Coping and adaptation to changing NTFP availability

17. How do you cope with changes in NTFP availability? -------------------------

18. Are the existing coping strategies working or effective?

1. Yes, 2. No

19. If, no, what could be done……………………………………………

20. Which existing NTFPs are used or could be used to assist households/communities cope with the current climate change and variability?...

E. Coping and adaptation measures to climate change and variability

21. How does your household cope with the effects of climate change and variability?

………………………………………………………………………………………..

22. Which organisations available in your area have assisted you in coping with the changes occurring? ……………………………………………………………….

Appendix ii: Key Informant Checklist

Checklist for Key Informants

1. What are the main socio-economic activities of communities surrounding the area?

2. What is the average income from each activity?

3. Who has the access to the forest?

4. What kinds of benefits are obtained from the forest?

5. What non-timber forest products are available and used in the village?

6. How is the supply of available NTFPs to the community?

7. Which kind of NTFPs do they preserve and why?

8. Which NTFPs are more vulnerable to climate change and variability?

9) Which social groups are vulnerable to climatic change and variability?

10) Why do you think the social groups above are more vulnerable to climate? Change and variability?

11) How does your community cope with the effects of climate change and variability?

12) Which existing NTFPs are used or could be used to assist households/communities to cope with the current climate change and variability?

13) What organizations/institutions are available in your area to assist you in coping with the changes occurring?

14) What are the barriers to the adaptation /coping measures?

15) Are there any by-laws in your village used to control NTFPs resources?

Appendix iii: Focus Group Checklist

Checklist for Focused Group Discussion

1) What are the livelihood resources of the village?

2) What non-timber forest products are available and used in the village?

3) What does the village face in the previous and current climatic hazards?

4) What are the impacts of the previously mentioned climatic hazard on the livelihood resources?

5) What are the impacts of the previously mentioned climatic hazards on the NTFPS?

6) For each impact, what are the coping strategies?

7) Which existing NTFPs are used or could be used to assist households and communities in coping with current climate change and variability?

8) Which social groups are vulnerable to climate change and variability?

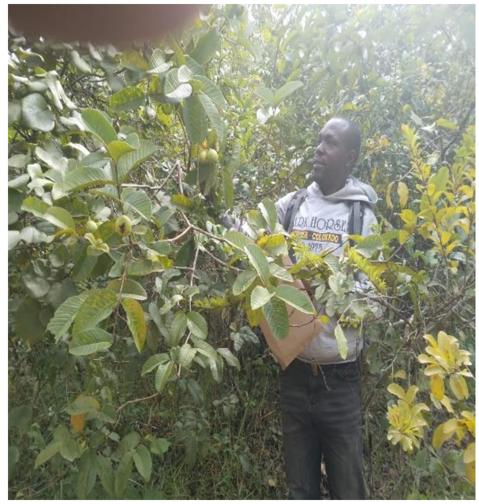
9) Why do you think the above-mentioned social groups are more vulnerable to climate change and variability?

10) How does the community cope with the effects of climate change and variability?

11) What organisations are available in your area that assisted in training you to cope with the changes occurring?

Appendix iv: Research photographs

Focus group discussion photographs. **Wild fruit *Psidium guajava, (*Kivela-local name)**



Wild fruits called Kivela in Kikamba

Taking GPS co-ordinate in Kavonge forest.