UNIVERSITY OF NAIROBI

CLIMATE CHANGE AND GENDER VULNERABILITY OF BUYANGU FOREST-DEPENDENT COMMUNITY IN KAKAMEGA COUNTY, KENYA

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DECLARATION

I declare that this is my original work and has not been submitted to any other university for the award of a degree or diploma. Where other people's work has been used, this has been properly acknowledged and referenced in accordance with the University of Nairobi requirements.

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DEDICATION

This work is dedicated to my adorable sons, Ivan Sekani and Nevin Saalu.

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ABSTRACT

Climate change poses a great challenge to the livelihoods of Buyangu-forest dependent community in Kakamega County. The effects cut across both gender groups thereby exacerbating the vulnerability of men and women in Buyangu. However, despite the challenges, men and women are expected to adapt but various factors hinder their processes. This study was therefore conducted to determine the levels of vulnerability to climate change among men and women dependent on forest resources for their livelihoods in Buyangu village adjacent to Kakamega Forest. The study adopted a transdisplinary approach through engagement of all stakeholders in assessing the complexities of climate change and the solutions to enhance future resilience in the community. Primary data were obtained through household surveys, focus group discussions, key informant interviews and field observations. Household survey questionnaire was employed to collect data from 203 households living within six kilometres from the forest edge. Climate data on temperature and rainfall were sourced from the Kakamega Meteorological Station, and were analysed to establish the historical trends. Mann Kendall tests and Sen's Slope Estimator were used to establish long term rainfall (1923-2015) and temperature (1980-2015) variations. Findings revealed a warming trend on both mean annual maximum temperatures and mean annual minimum temperatures by 0.04 ^{o}C/year and 0.02 ^{o}C/year, respectively. Moreover, analysis on annual precipitation (1923 – 2015) indicated an increase of 0.068mm/year, however, mean monthly rainfall showed a decreasing trend. As a result, crop production is affected with reduced yields in maize, sugarcane and vegetables. Livestock production is also impacted and respondents reported milk declines, low livestock market values and herd size reduction. While both gender groups are affected by climate change, women bear the most brunt due to their high dependence on natural resources. Nevertheless, both gender groups are struggling to cope with climate change and variability. The study generated useful knowledge that will inform local policy makers in the formulating relevant adaptation strategies that will enhance resilience of forest-dependent community. Specifically, Buyangu community needs to practice agroforestry, intercropping and rain water harvesting that have capacities of improving agricultural yields while maintaining environmental services such as climate change mitigation, watershed protection and biodiversity conservation. The study recommends the integration of all local and national players in formulating adaptation strategies to address the effects of climate change on the community.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

DEFINITION OF KEY TERMS

***Chama groups* –** refers to a self-help group of people used to invest in savings.

Climate change – refers to a change in the state of climate that can be identified (e.g. by using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer.

Climate variability – variations in the mean state and other statistics (such as standard deviations, occurrence of extremes etc.) of the climate on all spatial and temporal scales beyond that of individual weather events**.**

Coping mechanisms – actions taken by an individual in responding to unexpected climatic events such as droughts or floods.

Forest dependent people – in this study, it's defined as the human populations in the rural areas who use forest products substantially for their livelihoods.

Gender – the state of being male or female in relation to social and cultural roles

Household – consists of one (or more) people living in the same dwelling and share meals.

Livelihood – the capabilities, assets and activities required for a means of living.

Vulnerability – refers to the propensity or predisposition to be adversely affected.

LIST OF ACRONYMS AND ABBREVIATIONS

CBOs	-	Community-Based Organizations
DAP	-	Di-ammonium phosphate
ETFRN	-	European Tropical Forest Research Network
FAO	-	Food and Agriculture Organization of the United Nations
FGDs	-	Focused Group Discussions
FIDA	-	International Federation of Women Lawyers
GOK	-	Government of Kenya
HH	-	Household head
IGA	-	Income Generating Activities
IPCC	-	Intergovernmental Panel on Climate Change
KFEMP	-	Kakamega Forest Ecosystem Management Plan
KFS	-	Kenya Forest Service
KII	-	Key Informant Interviews
KNBS	-	Kenya National Bureau of Statistics
KWS	-	Kenya Wildlife Service
MK	-	Mann – Kendall
MOEF	-	Ministry of Environment and Forestry
NGOs	-	Non-Governmental Organizations
NSSF	-	National Social Security Fund
NCPD		National Council for population and Development
NTFPs	-	Non-Timber Forests Products
PFM	-	Participatory Forest Management
SDGs	-	Sustainable Development Goals
SPSS	-	Statistical Package for Social Science
SSA	-	Sub – Saharan Africa

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter presents the background of the research study by documenting the problem at global, regional, national and sub-national scales. It identifies and quantifies the research problem, research questions, study objectives, justification and significance of the study, scope and methodological overview for the study.

1.1 Background to the study

Africa is one of the highly exposed continents to changes in weather and climate patterns ostensibly due to its weak infrastructure and low adaptive capacity (IPCC, 2014). The key sectors of economy in Africa such as agriculture, health, transport, forestry and energy are highly susceptible to climate change and variability. Precisely, rain-fed farming in third world countries is the most affected through unpredictable rainfall patterns, prolonged droughts and intermittent floods resulting in significant declines in crop yields (Maraseni, 2012). Equally, changes in climate have a series of effects on physical and mental health thereby exposing more people to health risks which the public health sector is unable to manage. All these climate change impacts affect the economy as a whole as funds meant for other development activities are diverted to address disasters arising from climate change and variability (ETFRN, 2009).

Recently, various global assessment reports emphasized the vulnerability of Sub-Saharan Africa (SSA) to climate change effects and its inability to cope with changes in climate and variability (IPCC, 2014; Stern, 2007). A host of factors emphasize exposure, adaptability and sensitivity of a system to impacts of a changing climate. One outstanding feature is the wellbeing of rural people whose lives rely on natural ecosystem services for livelihood, but which are highly affected by changes in weather and climate patterns. Moreover, people's vulnerability is exacerbated by low levels of development and limited potentials to adapt (FAO, 2009).

Kenya, like many other developing countries, experiences unfavorable climate change impacts on livelihoods attached on tree resources (Dunemu and Obeng 2016; Ofoegbu *et al.*, 2016). The effects could vary across different gender groups. In Kenya, men and women living adjacent to

Kakamega tropical rain-forest derive their livelihoods through various means which are presently vulnerable to climate change and variability. Majority of the rural forest community have low capabilities to recuperate from harsh climatic conditions. However, as much as this community is expected to adapt, various factors may hinder processes of effective adaptation amongst different gender groups, hence compromising their resilience to climate change. To this effect, analysing climate variability and gender vulnerabilities of the forest dependent people in Kakamega County is necessary in understanding and supporting their coping strategies for planned future adaptations.

1.2 Problem statement

Forests and trees supply hundreds of millions of people with food, energy and income as well as acting as important safety nets during harsh economic times. But the manner in which people use and manage forests and trees will determine future resilience in the wake of climate change (FAO, 2018). Climate change is expected to potentially disrupt the important forest ecosystems thereby reducing the supply of forests resources such as food, fuel wood, medicinal herbs and other NTFPs. In the long run, this will impose additional stress on the livelihoods of mostly poor and forest-dependent people. With increased vulnerability of forest dependent people, adequate data on the impacts of climate change on livelihoods and vulnerabilities is still lacking. Understanding the vulnerability of forest dependent community and their coping strategies is essential today in order to design any feasible local adaptation strategy.

According to Barasa *et al.,* (2015), climate change has created high vulnerabilities for rural farmers in Kakamega County through unfavourable weather conditions that greatly affect crop farming and livestock rearing. Buyangu forest-dependent community being part of the larger community are widely exposed to the negative climate change impacts which are compounded by other economic and social constraints. To the local community, the forest has not only been an important source of firewood and animal pastures but also a source of medicinal herbs for curing various ailments affecting both humans and livestock (Mitchell, 2004; Keifer and Bussman 2008). Added to the low adaptive capacities of the rural population, climate change impacts on forests and other forms of livelihood will exacerbate the vulnerability of any forest-dependent community and the Buyangu community is no exception (Davisdon *et al.,* 2004; Okali, 2011). The long term effects of climate change cut across both gender groups like any other community resulting to differentiated gender vulnerabilities and corresponding adaptation mechanisms. However, as

much as Buyangu forest-dependent men and women have been observed to take up a wide range of coping strategies, a number of constraints still hinder their adaptation, thereby compromising future resilience. With this background, there is need to study this community to gather insights on gender and vulnerability and coping mechanisms to climate change.

1.3 Research questions:

This study was guided by the following research questions:

(i) What are the impacts of climate change on sources of livelihood of community living adjacent to Kakamega Rain-forest?

(ii) What are the vulnerability levels of men and women dependent on Kakamega Rain-forest and tree resources?

(iii) What are the adaptation strategies for different genders who depend on Kakamega Rain-forest and tree resources in response to climate change?

1.4 Objectives of this study

The general objective of this study was to determine the levels of vulnerability to climate change of men and women dependent on Kakamega Rain-forest resources and trees for their livelihood.

Specifically, this study sought to:

(i) Analyze the climate trends and determine their impacts on sources of livelihoods of Buyangu community living adjacent to Kakamega tropical rainforest;

(ii) Determine vulnerability levels of men and women dependent on Kakamega rainforest resources and trees under climate change, and

(iii) Evaluate gender based coping mechanisms employed by community adjacent to Kakamega Rainforest that depends on forest and tree resources for climate change and variability adaptation.

1.5 Justification and significance of the study

Gender inclination on natural resource use is important in environment and development agenda. While there is data on the determinants of adaptive capacity for any rural community, gender vulnerability assessments on forest dependent communities and their coping strategies is still

inadequate. Therefore, this study generated knowledge on the vulnerability of men and women who depend on forest and tree resources and their adaptation to climate change.

This study is significant as it contributes to current research discourse by providing more insights on the livelihoods of forest-dependent communities in regard to climate change. The assessment of climate change and vulnerability of men and women in Buyangu enables a nuanced understanding of gendered behaviors of such communities especially as regards to actions taken for community survival. Information gathered here is critical to policy makers in establishing relevant policies and interventions at micro level. Specifically, the findings of this study will assist policy makers at the county level to understand gender differentiation in forest resource use and vulnerability to climate change and variability. This will ensure that Buyangu community adaptations are effective in building resilience. In addition, this study is beneficial in academic discourse to provide more insights on the livelihoods of forest-dependent people.

1.6 Scope of the research

The study was conducted in Kakamega County specifically targeting communities living adjacent to Kakamega Tropical Rainforest. The study was confined to Buyangu Sub-location situated on the northeast of Kakamega forest as the people around that part have high dependency on forest resources despite the area being under protection of KWS where people are not allowed to access any forest products. The targeted populations were those living at a distance of six kilometers from the forest edge as they are the majority who have total dependency on forest resources (Müller and Mburu, 2009).

Limitations in this study were inevitable. For instance, finding male household heads during the research period was difficult as many left their homes early in search of casual work. Where the researcher could not find the male household heads, efforts were made to reach them over the weekends to ensure adequate male representation in the sample.

1.7 Overview of the methodological approach

The study employed a transdisplinary mixed methods approach that involves collaboration and engagement of all stakeholders, both in the academic and non-academic circles to assess the complex societal challenges like climate change (Balsiger, 2004; Ramadier 2004) to generate qualitative and quantitative information relevant to address all research questions.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents the theoretical review of literature on climate change and forest communities in relation to gendered vulnerability and climate change adaptation among forest-dependent communities. The chapter is divided into four sections, where the background on forests in relation to climate change is initially discussed, followed by gender vulnerability to change in climate. The third section discusses gender based coping strategies while the subsequent two sections cover gendered access to resources and policy development in Kenya. The last section identifies the knowledge gaps arising out of past studies in the same or related topics.

2.1 Forests and climate change

2.1.1 Kenya forest cover

In East Africa, Kenya has a variety of forests spanning the indigenous and exotic species. The different kinds of forests in Kenya comprise of coastal forests, riverine forests, volcanic mountain forests and the western plateau forests. An example of forests with high diversification are found in the western plateau; Kakamega forest, and the coastal areas; Arabuko Sokoke, Mangrove and Kaya forests (Sayer *et al*., 1992). Kenya's forest cover is about 7.4% of the total area which is below the global recommendation of 10% (MOEF, 2018). Kenya's canopy forests are declining because of deforestation for timber products and other human actions such as illegal logging for charcoal production, fuelwood and construction materials (Lambrechts *et al.,* 2015; Ongong'a and Sweta, 2014) resulting to degradation of forests.

Kakamega tropical rainforest is no exception as it has suffered a major setback of overexploitation of its resources from the rapidly growing human population who are exerting intense pressures on the diminishing resources (Müller and Mburu, 2009). Nearly half of the Kakamega forest has been lost in the past 40 years owing to human encroachment with only about 230km^2 of it remaining (KFEMP, 2012). The past four decades showed an increasing demand for forest products amongst the adjacent communities and a reduction in the supply of same resources (Mbuvi *et al.,* 2009). This raises a lot of concern to the wellbeing of the poor people living near forests and who basically

survive on forest resources which are now endangered by long term repercussions of a changing climate.

The alarming rate of deforestation in Kenya prompted the formulation of institutions and policy reforms that would aid the rebuilding of forest cover. Such measures included the introduction of Participatory Forest Management (PFM) approach that facilitated the formulation of the Kenya Forest Service (KFS), a state corporation that is mandated to protect and manage all public forests in accordance with the Forest Act, 2005. However, despite measures being put in place to preserve natural forests in the country, many people with vested interests in forest resources are still adamant to and are unwilling to comply with forest rules (Mutimba *et al*., 2010).

2.1.2 Forests and climate

Forests and climate are intrinsically related such that they tend to influence both local weather and climate through a number of ways (Betts, 2008). One of the strategies through which forests influence climate is through the albedo effect. Forests have low albedo meaning they ingest a large portion of the approaching sun based radiations, hence warming the air around and changing temperatures. Forests additionally retain water from the soils through tree roots and discharge it to the environment by a process called evapotranspiration, which affects weather and climate (von Randow *et al.,* 2004). Removal of forest cover by logging of trees and any other form of reduction of vegetative cover will definitely affect climate of the deforested zone. This happens since the decreased forest cover expands dissipation, which means a lot of energy emissions from the ground having a heating effect on the earth's surface (Sanderson *et al.,* 2012).

According to IPCC (2007), expansive forest cover aids in the uptake of carbon dioxide from the atmosphere and maintains cooling effect. On the contrary, deforestation results in carbon dioxide being absorbed back to the environment thereby warming land temperatures. The effects of losing forest carbon sinks are long-term as trees take equally longer periods to mature (Sanderson *et al.,* 2012). It is widely known that tropical forests lose moisture through evapotranspiration while at the same time acting as CO_2 reservoirs. This explains why the human race is more disadvantaged by logging of trees as the repercussions are likely to linger on for many years.

2.1.3 Forest use and dependence

In Africa, more than 75% of the people's lives rely on the resources harvested from forests for their upkeep (World Bank, 2004). Forests provide a number of products that underpin the living strategies of many people located in rural setups. The products obtained from forests includes fuel wood, animal fodder, construction materials, medicinal herbs and food. These products act as important safety nets for forest-based communities and form part of IGAs impacted by the effects of climate change (Shackleton and Shackleton, 2004). However, a high dependence on forest products to a group of people can be a form of vulnerability when the resource is overharvested more than forests' rejuvenating capacity. While populations rise, the increasing demands of forest resources will eventually outweigh its supply. Fisher *et al.,* (2010) highlights that interrelation between climate change and other non-climatic factors will speed up forest degradation process leading to scarcity of forest goods. These observations coupled with the high dependence of communities on climate sensitive forest resources makes them susceptible to variations in climate.

Apart from the forest resources, many other rural communities also obtain their livelihoods support from trees outside forests. The presence of trees outside the forests, also known as farm forestry in the rural setup is either because of encroachment into forests resulting to forest fragmentations or the intentional planting of trees or individual trees on a given parcel of land (FAO, 2013). In most rural communities, introduction of trees on horticultural grounds is seen as a system to anchor property rights transferable to people for income diversification. The FAO (2013) report indicates that over a billion of the poorest individuals in the world rely on agriculture forestry for wood fuel and food availability to enhance their climate change coping strategies.

2.2 Gender and vulnerability to climate change

Gender means socially built tasks and expectations of being a man or woman. The concept acknowledges that both genders often display different routine tasks within a family. The IPCC (2007) in its 4th Assessment report recognized that long term changes in weather patterns impact people differently in relation to gender, showcasing that the impacts are not gender neutral. In reality, gender is a crucial but never the only factor in a person's vulnerability to change in climate or other risks. The construed gender roles and responsibilities are subject to change over time thus a holistic perspective is required (Mujere, 2015). Societal culture of unequal gender roles limiting accessibility of certain livelihood properties showcases the likelihood of a gender group being

unable to adjust to climate variability and change. Even with this connotation, gender aspects have been disregarded in climate conversations with little interest given to the groups despite their gender disparities (Assan, 2015). However, in recent times, gender dynamics are gaining much attention from scholars and practitioners across the board.

Gender differentiated effects of climate change are interconnected to gender vulnerabilities (Dube *et al.,* 2017). The IPCC (2014) describes vulnerability as the manner in which a functional unit is unable to recoup from extreme effects of varying climatic conditions. Vulnerability encompasses the three components; exposure, sensitivity and adaptability. Echoing this, gender vulnerability implies examination of people's exposure to climate change, their sensitivity to sudden impacts and their levels of adaptation to such situations based on their gender disposition (Babugura, 2010). This informs that vulnerabilities will be determined by people's ability to recuperate from unfavorable weather conditions.

Further literature unveils that rural women will be more helpless to the impacts of changing climates considering that their wellbeing clearly depends on natural resources, social and cultural circumstances that determine accessibility to resources and opportunities of engaging in IGAs (Denton, 2002; Numayer and Plümper, 2007). Whilst women have been singled out as victims of a changing climate, the paradox fails to confine the variety of intricacies and dynamics of susceptibility. For instance, all women are projected to be alike across the board ignoring other variables like age differences as well as ethnicity that often encircles susceptibility (Resurrección, 2013; Djoudi and Brochhaus, 2011).

Vulnerability is dynamic, locally specific and manifested along gender lines (Nelson et al., 2002). Several studies analyze vulnerabilities at the local levels using the proportions of family units led by men compared to those led by women (Djoudi *et al.,* 2016). A few studies have demonstrated higher vulnerability on female headed households and attributing various factors to the same (Maponya and Mpandeli, 2013). For instance, lack of formal education has been highlighted as a determinant to gender vulnerability. Many people in rural homes cannot pursue higher levels of education due to high poverty rates cutting across most families. Inadequate education lowers the status quo of most families as they have limited options of accessing credit and other assets required to adapt. In other studies, lack of reliable non-farm income amongst female-headed

households as compared to the male-household heads, has been cited as a factor leading to higher vulnerability (Antwi-Agyei *et al.*, 2012).

However, some scholars argue differently as pertains to gender vulnerability. Djoudi *et al.*, (2016) claim that previous evidence provided by other scholars concerning weak points of households headed by either male or female is still insufficient to deduce that a particular gender is better placed or worse off than the other. They emphasize that vulnerability context considered in many studies is not based on own data evidence but on theoretical backgrounds and analysis. According to Djoudi *et al.*, (2016), vulnerability analysis needs to go beyond the comparisons of households headed by men/women in addressing structural grounds of weakness. This implies that there is still inadequate knowledge on gender dynamics and vulnerability to change in climate at local levels calling for more research on the notion.

2.3 Gender based coping mechanisms

With regard to variations in climate, adaptation covers the long term measures moderating effects of climate change while coping mechanisms alludes to the coping strategies presented in the short term (IPCC, 2014). Various researchers are of the view that various elements that shape adaptability are still unexplored (Carr and Thompson, 2014; Kaijser and Kronsell, 2014). The latest developments in observing complex dimensions taken as long term survival tactics on climate change menace is through the lens of intersectionality. This new approach explains that multiple determinants such as the social, economic, cultural, institutional and power relations interact with gender influencing vulnerability and the different behaviors of people in coping with change in climate (Ravera *et al.*, 2016). However, a noteworthy body of literature still recognizes that gender has a crucial task in the adaptation process (Nellemann *et al.*, 2011; Kangas *et al.*, 2014; WEDO-IUCN, 2014).

Men and women preferences on forest resources vary depending on their gender construed roles thereby influencing gender differentiated responses to climate change. Omari (2010) explains that adaptation responses are gender focused and have been disregarded in the global discussions and policy forums. Past publications have demonstrated that people will not always remain as casualties of a changing climate regardless of their gender disposition, but would rather embrace different tactics for survival (Kangas, 2014; Dankelman, 2010). Similarly, forest communities whose livelihoods are pegged on the forest resources are likely to display gendered coping

strategies. But often, strategies adopted are allied to the differences in having resources and their usage together with social norms accompanying both gender in any given society (Kumar and Quisumbing, 2014; Villamor *et al.,* 2015).

However, on-farm tree planting and farming of NTFPs as an adaptation strategy amongst forest dependent communities is taken up to supplement incomes and minimize hazards under climate variability (Verchot *et al.,* 2007). In rural communities, women are using energy efficient technologies such as fuel saving cook stoves and usage of wonder baskets in warming food (Chitiga and Nemarundwe, 2003). This usually works in cases of reduced firewood resources and lack of alternative sources of firewood. For a long time, women are believed to be active agents of adaptation as they have been at the forefront in initiating tree nurseries and tree planting activities around their homes to restore tree cover. This corresponds with Mujere (2015) who affirmed that women are likely to form a new pattern of adaptation given new information.

In the same vein, men have not been left behind as they opt to plant trees on their farms as an adaption strategy. This would cater for their domestic household demands on firewood supply as well as in the production of timber/poles or charcoal for commercial purposes (Balama *et al.,* 2016). Although men also share in the tasks of providing household fuel energy supplies, in many rural communities it remains a woman's household responsibility to ensure there is adequate fuel wood supply for subsistence use. In addition to other adaptation strategies, men are gathering NTFPs such as mushrooms, medicinal plants, honey and bush meat for sale (Msaliwa *et al.,* 2013). Others have opted for urban migration in such of employment as a response to harsh climatic events. Unlike women, mobility of men into towns and cities hunting for job opportunities works well because of their limited household responsibilities (Augustino *et al.,* 2012).

To this end, more debates are now focusing on constraints to adaptation (Biesbroek *et al.,* 2013) under which it is becoming extremely difficult to cope with changing weather patterns. Djoudi et al. (2016) articulate that men and women face different constraints to adaptation and as much as it is important to summarize their differences, it will be difficult if comparisons are made in the absence of a gender framework. In view of all these, examination of various components will improve the understanding of the core issues of vulnerability and adaptability adding more efforts in addressing gender imbalance.

2.4 Gendered access to resources in Kenya

The conviction that change in climate has gender-inclined ramifications both as far as vulnerability and adaptability is concerned is true. However, both men and women play huge roles in determining their future resilience. The diverse ethnicity in Kenya share a common patriarchal culture where males are the primary persons in control and ownership of key productive assets while females are matriarchal (International Federation of Women Lawyers FIDA, 2013). Men inherit property while women's inheritance to the same is determined by their mutual relationship as either her husband, father, brother or brother-in-laws. But such situations are not static as they change over time depending on the circumstances in place especially at local levels (Dankelman, 2010). Amongst the Abaluhya community in Western Kenya, land ownership is by senior male clan members. Thus, women in Western Kenya have been confined into harvesting of tree branches for firewood purposes which are considered to be of low economic returns while men have the rights to fell down trees for commercial purposes (Kiptot and Franzel, 2011).

Despite the de jure specifications of equal access to property amongst women, the customary laws still predominate and their interpretations hinder women from enjoying land tenure rights as compared to their male counterparts (Ifejika- Speranza, 2006). How both gender utilize resources in most communities reflects the gendered access to these resources. The implications of women's restricted access to productive resources under changing climate is strongly influenced by their adaptation options thereby exacerbating vulnerability. However, insecure land tenure rights affecting both men and women reduces incentives to engage in climate smart-agricultural practices. Lack of secure land rights in form of possessions of title deeds inhibits access of credit on both gender groups limiting investments opportunities on natural resource conservation practices (CIFOR, 2013).

2.5 Development of gender policies in Kenya

Kenya has been ranked highly on a score of 0.7258 with 0 being inequality and 1 being equality (Global Gender Gap Report, 2014). This ranking is highly attributed to the formulation of legal and environment policies that supports gender concerns across the country. For instance, the current Constitution of Kenya (2010) recognizes gender equality as a driving factor for national prosperity. In addition, the Kenyan National Policy on Gender and Development (2000) strives to mainstream and uphold the interests of both gender groups in the country (GOK, 2000). Kenya's

vision 2030 sets one of its primary goals on women's initiatives for sustainable and equitable policy, practice and livelihood security.

However, despite the well advanced gender mainstreaming policies in Kenya, implementation of the same is still a mirage in many organizations. Fewer policies have focused on climate change and its influence on gender matters (Ifejika - Speranza, 2011). For example, cultural attitudes and societal perceptions on gender matters being expressed as woman's subject, are a hindrance in policy integration and development. In Kenya, under Article 60 of the Constitution; the law talks of fostering gender equality by avoiding favoritism within a particular gender as regards to land use and all other practices associated with it. But despite these, women's social and economic class persists to be largely defined by cultural laws that are ingrained in the diverse societies in the country (International Federation of Women Lawyers FIDA, 2013). Lack of ownership of properties such as land inheritance amongst women denies them collateral to borrow money thereby impoverishing them even further. Where cultural laws deny a particular gender equal rights to land and utilization of its resources, these coupled with ferocities of climate variability exacerbates vulnerabilities (Kakota *et al.,* 2011).

Much as national frameworks on gender mainstreaming are available, formulation of guidelines that would synchronize both climate change and gender matters both at local and national arena are still lacking. Fundamentally, survival tactics that are gender oriented are scanty and inadequate. There is need for mainstreaming both components - gender and climate change - in development programmes so as to address the underlying issues of adaptation while improving forest resource use efficiency (Ifejika - Speranza, 2011). In addition, more attention needs to be directed to the promotion of institutional capacities for mainstreaming gender in climate change.

2.6 Overview of knowledge gap from reviewed studies

Research studies indicate that changing weather patterns will have unfavorable effects on the lives of those who depend on forests and tree resources. This is expected to have widespread effects for tropical rainforests and which will eventually affect rural livelihoods of communities living adjacent to such forests in Africa (James *et al.,* 2013). Various attempts of research have been undertaken in spelling out the impacts of climate change on forest dependent communities in the tropical forests of Central and West Africa while some have defined their vulnerability (Onyekuru and Marchant, 2014; Brown, 2011). However, the only remnant of the Equatorial forest in Eastern

Africa - Kakamega tropical rainforest - has been overlooked. Some of the related studies carried out in this county have generally focused on fluctuating weather patterns and its impacts on farming, perceptions of farmers regarding climate change and farmers' adaptation strategies (Mulinya, 2017; Barasa *et al.,* 2015; Ochenje, 2016).

Mulinya (2017) analyzed the adaptation approaches of smallholder farmers in Kakamega County. The analyses sheds light on how farmers understand climate change and actions taken in adjusting to the changing climate. The interpretation of the results mentioned planting of drought enduring crops as the main adjustment approach in the cropping systems. Nonetheless, lack of financial resources, lack of farmyard manpower and ignorance were featured by the respondents as significant setbacks to adaptation. Barasa *et al.,* (2015) also studied the livelihoods of agricultural farmers in Kakamega County as regards to climate change. The outcomes demonstrated that changing weather patterns triggered both low crop harvests and inadequate animal forage.

In relation to forest dependent people, there is scanty literature as a handful of researchers have examined the dynamics of weather patterns and its impacts on communities around Kakamega forest. For instance, Kanyiri (2014) examined how different institutions work towards mitigating change in climate through decentralization of forest resources in Kakamega County. The study reported that government institutions enhance local communities' adaptation strategies by providing techniques and expertise than enhance future resilience.

With all these studies, it is evident that very little, if at all, no feasibility studies bespeak of the effects of climate variability on forest dependent people living adjacent to Kakamega forest. In addition, the extent to which different gender groups are susceptible to changing weather patterns and their actions to overcome the effects of climate change is still lacking. Lack of information on these aspects impedes proper planning and establishment of strategies that enhance adaptive capacity across different gender groups.

Given this inadequate data, planning for climate related responses among forest dependent communities becomes very challenging and yet it is fundamentally required. Hence, this study analysed the levels of vulnerability related to climate variability and the corresponding adaptation practices of communities living adjacent to the forest with specific regard to men and women in Buyangu. This generates evidence which can be used as a basis for supporting such communities to adapt effectively against the effects of change in climate.

CHAPTER THREE

STUDY AREA AND METHODS

3.0 Introduction

This chapter describes the study area and the conceptual framework adopted for the study. The methodological approach, data sources, sampling procedures, data collection methods and analysis techniques used in the study are discussed.

3.1 Study area

Kakamega Forest, within Kakamega County, falls between latitudes 00°10'N and 00°21'N and longitudes 34°47'E and 34°58'E. The northern section of the forest was established as a Kakamega National Reserve under KWS. The study was confined in Buyangu village and targeted households living at a distance of six kilometers from the forest margin. These are the households who cannot dissociate themselves from the forest as they fully rely on forest materials (Müller and Mburu, 2009). The region is densely populated with a high demand for forest products from Kakamega tropical rainforest and whose supply is limited due to heavy patrols by KWS warders (Mbuvi *et al.,* 2009). This provided a suitable opportunity for investigating effects of climate variability on men and women dependent on forest resources together with their coping strategies. The findings of this study will provide the needed knowledge towards building resilience of forest-dependent communities against changing climatic conditions.

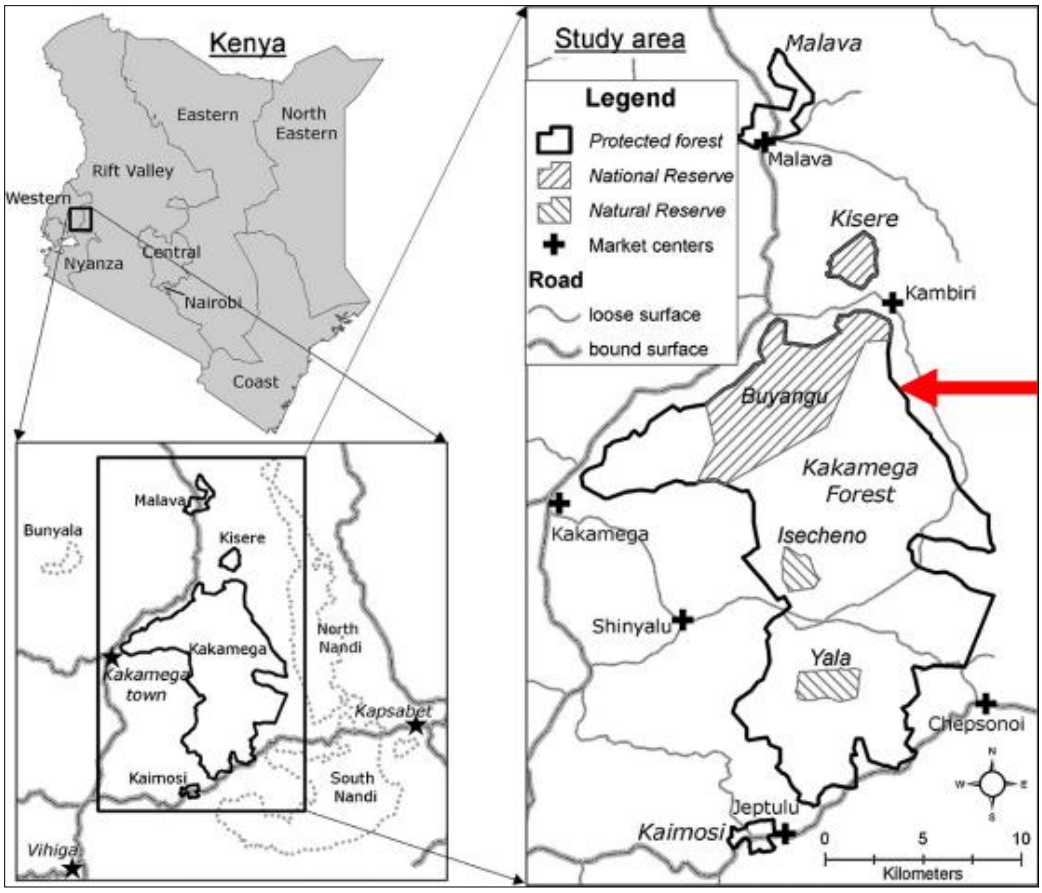

Figure 3.1; Location of Buyangu Source; Müller and Mburu, (2009)

3.1.1 Climatic conditions

The annual precipitation in Kakamega County ranges from 1280.1mm to 2214.1 mm. Rainfalls are generally uniform across the entire year with March and July getting overwhelming downpours while December and February receive lighter rains. Temperatures in this region range from 18 ^{0}C to 29^0 C. The months of January, February and March are the hottest while the rest of the months have warmer temperatures except for July and August which are moderately cool. Humidity level is at an average of 67 % (GOK, 2013; NCPD, 2017).

3.1.2 Vegetation

The forest has area coverage of around 230 Km^2 and although this has been an indigenous kind of forest, less than half of it remains untampered. The forest has numerous indigenous tree species such as *Sapium ellypticum, Plectrantus forster, Clematopsis scabiosifolia and Markhamia lutea.*

Other remarkable plant species, for example, *Aningeri altissima*, *Cordia millensii* and *Entandrophragma angolense* that are believed to have comparative attributes with those of Western African Equatorial rainforests are found within (Mitchell, 2004). Ideally, this is one of the forests in Kenya characterized by extremely wet climate and heavy annual rainfalls just like those equatorial forests found in the Congo regions.

3.1.3 Soils and soil fertility

The area is characterized by clay loamy soils that are heavily leached and acidic that have developed out of granite rock materials (Blackett, 1994). This kind of soils are of low fertility rates though some areas have nitosols that are of high fertility rates (Glenday, 2006). Organic materials of the forest cover that fall on the ground are reincorporated back into the soil to maintain its fertility. However, this natural nutrient recycling activity is disrupted when the forest is cleared by human induced factors thereby compromising on soil fertility rates (Musila, 2007). Isiukhu River flows through the northern side of the forest while Yala River transverses the southern parts (GOK, 2013).

3.1.4 Land holding and socioeconomic activities

Residents have an average land size of 0.57 acres with farming being the main economic land use activity. People here are peasant farmers of maize (staple food), beans and sugarcane (Mbuvi et al. 2009). Farm forestry exists whereby farmers have planted trees on their pieces of land as an alternative source of income through the sale of timber, wood fuel, charcoal burning, construction and fencing materials. Honey harvesting is also practiced and a variety of farmers have also planted fruit trees such as avocadoes, guavas, oranges, paw paws, passion and mangoes mostly for subsistence use (GOK,2013; NCPD, 2017).

The county majorly depends on farming and cattle rearing as the area gets enough rain throughout the year. Uncontrolled brick making is also on the rise especially along the road reserves, wetlands and on arable crop land. Burning of bricks requires large amounts of wood fuel and this leads to increased felling of trees in the region. The poverty rate stands at 51.3% and this comes as a result of poor farming methods, over-dependence on one crop such as maize cultivation, poor quality livestock and high population density compared to the small parcels of household lands. The residents grow food crop on a small scale due to the limited availability of agricultural lands (GOK, 2013; KNBS and SID, 2013).

3.2 Conceptual framework

The conceptual framework (figure 1) portrays the interplay of various variables (independent, dependent and intervening variables) that determine households' vulnerability outcomes arising out of exposure to climate change. The framework focusses on sources of livelihoods (forest-based and non-forest-based) for both gender groups constrained by climate change, and not excluding the existence of non-climatic factors. The aptness of any society to deal with variations in climatic conditions depends on the ability to have necessary assets - natural, human, financial, physical and social - within peoples' reach (Jones *et al.,* 2010). The framework considered gender as an intervening factor that determines both men's and women's vulnerability as well as their coping strategies.

Analyzing vulnerability of men and women living adjacent to Kakamega forest in Buyangu requires clear examination of exposure levels as well as sensitivity to climate variability. This varies between gender groups depending on societal roles culminating into differences in vulnerabilities. As a result, this brings into being gender differentiated coping strategies that determine resilience. Basically, a less resilient gender group will become increasingly exposed to effects of climate variability affecting their well-being. This study is framed to understand the local dynamics underlying vulnerabilities and coping strategies of Buyangu forest dependent community. The findings from the study suggested bringing on board stakeholders' participation in building community's resilience. All stakeholders in this study referred to the academia, government, non- governmental organizations and local Buyangu forest dependent community.

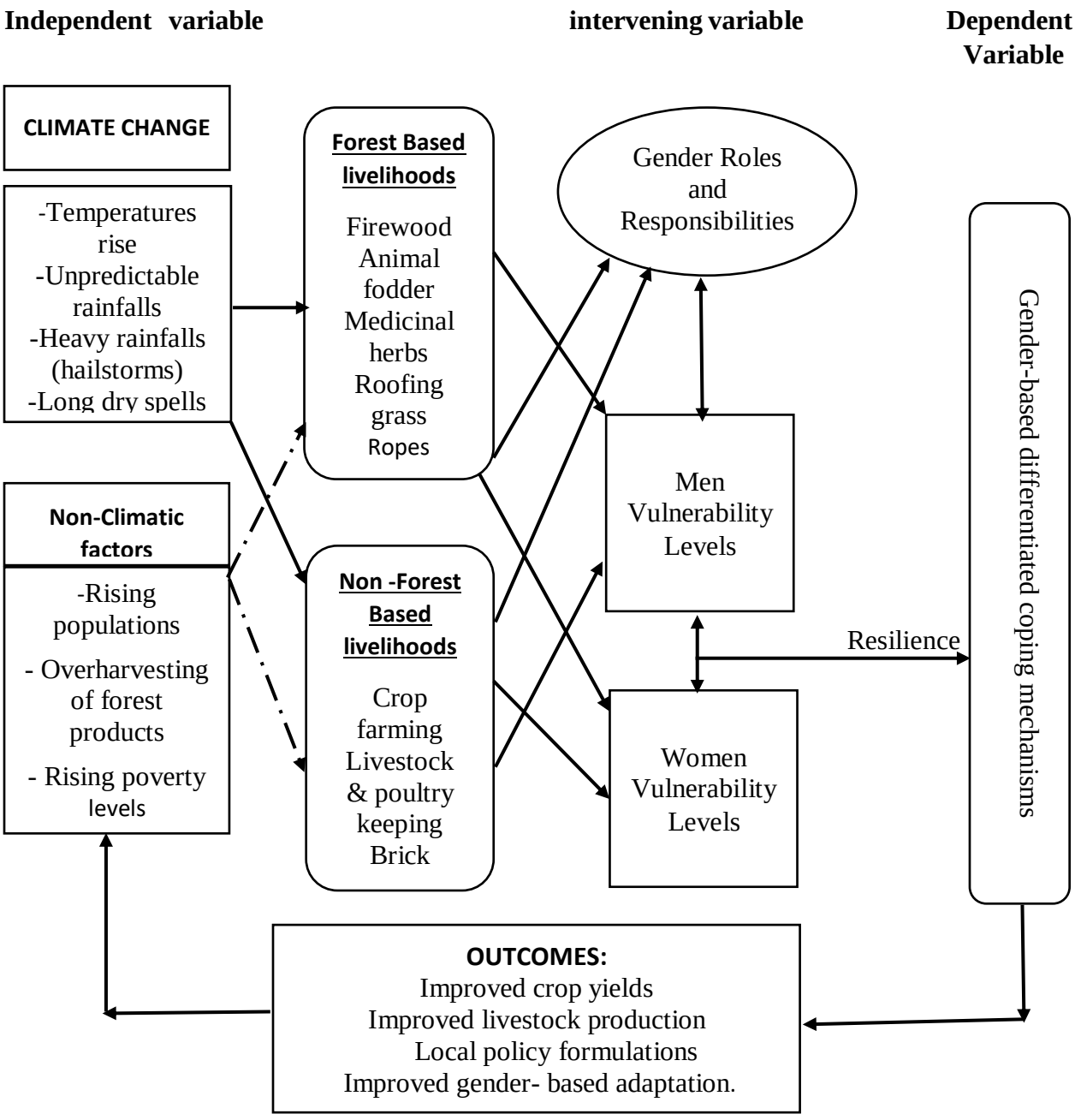

Figure 3.2: Conceptual framework showing factors determining vulnerability of Buyangu forest-dependent community to climate change

3.3 Methods

3.3.1 Research design

This study undertook a transdisciplinary approach that considers collaboration and engagement of all stakeholders in addressing complex challenges such as climate change faced by the society today. A mixed research method comprising of qualitative and quantitative approaches was employed to understand the research problem.

Stratified random sampling was used to categorize households living within six kilometers from the forest margin in order to capture differences in opinions as regards to proximity to from margins. This sampling method was considered ideal as the target population was heterogeneous and not widely spread out geographically. Household units were grouped into three strata according to their distances from the forest edge; 0-2km, 2-4km and 4-6km. Thereafter, household units were randomly selected from each stratum. During the reconnaissance survey, the researcher mapped out all male and female headed household units from each stratum. All female headed households identified in the three strata were purposively sampled while male headed households were selected through simple random sampling. Questionnaires were administered to household heads - 20 years and above - the age bracket used in calculating the sample size of the study. A total 203 sampled households were interviewed between March 2016 and April 2016.

3.3.2 Sample size determination

The population size as at 2016 was obtained as follows:
In 2009, the Buyangu population was 4709 (KNBS, 2010) while the annual growth rate in the County stood at 2.5% (GOK, 2013). The following formulae was used;

$$Pop_{Future} = Pop_{Present} x(1+i)^n \quad \text{..... (1)}$$

Where:

Pop $._{present}$ = Present Population

I = Growth Rate

n = Number of periods (years)

Therefore, in the year **2016**, the population was projected to be;

$$4709 \times (1+2.5\%)^{6} = 5461$$

According to population projections of Kakamega County in the year 2015, the percentage of adults (20 years and above) is 42.21 % of the total population (GOK, 2013).

Working on this assumption, it follows that the same percentage applies to the population in Buyangu. Therefore, the adult population in Buyangu (over 20 years) is 42 .21 % x 5461 = **2305**

According to (GOK, 2013) the average family size in Kakamega County stands at 5.6 members.

The targeted households were calculated as follows:

$$2305/5.6 = 411 \text{ households}$$

Sample size determination was conducted using the *Yamane (1967)* formula;

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

Where n = Sample size

N = Actual population size (411 households)

e = standard error at 0.05 (Confidence level at 95%)

$$n = \frac{411}{1 + 411(0.05)^2}$$

Sample size = 203 households

A household head was used to represent the entire family in answering issues presented in the questionnaire. A household in this study was defined as a family group who have the same cooking arrangement and may cultivate and share the same land resources. Hence, one individual (household head) was interviewed per household. Therefore, the target population for the study was 411 households.

3.3.3 Sources of data

Data for this study was obtained either through primary or secondary sources. Primary data were obtained from the field through household survey questionnaires, Key informant interviews (KII) and non- reactionary observations basically to understand socio - economic activities of Buyangu forest dependent community. Data on temperature and rainfall variables were sourced from Kakamega Meteorological Station. More information on the geographical features and socio-economic activities were sourced from the County Integrated Development Plans.

3.4 Data collection process

3.4.1 Reconnaissance survey

Reconnaissance survey was conducted prior to actual data collection. This was carried out to meet the relevant administrative local leaders, introduce study objectives and seek out permission of conducting the study. The assistant -chief identified two community mobilizers who introduced the researcher to the community. This pre- study was useful as it enabled the researcher familiarize with the local community and gain trust as well as understand the characteristics of the study area. Besides, this activity enabled the researcher to understand the sample size frame considered for the study and how it was to be distributed. Reconnaissance survey was conducted for three consecutive days.

3.4.2 Training of field assistants and pre- testing of instruments

Three local field assistants comprising of two males and one female were engaged in data collection process and were recruited based on their previous work experiences, academic qualifications and their knowledge of the local language. The training was conducted for 2 days and piloted before the actual data collection. This training was conducted to familiarize the field assistants with the study objectives, interpret the questions accurately to avoid partiality of the responses. A pilot test of the questionnaires was conducted with the field assistants in Buyangu and the final amendments were made on the questionnaire accordingly. The pre- test questionnaire was used on 15 households. However, these questionnaires were excluded from data entry and analysis.

3.4.3 Household survey questionnaires

A questionnaire survey was the main source of quantitative data for this study. These were administered to individual household heads. The questionnaire encompassed both Yes/No and expounding questions. Ideally, questionnaire captured opinions of the household heads on issues of weather variations and its impacts on sources of livelihoods, peoples' household dependence on forests and tree based systems, and their actions towards adjusting to changing climate.

The questionnaire was designed in five parts. Section A covered household attributes such marital status, age differences, gender disposition, highest education attainment, duration of living in Buyangu, household size, occupation, main source of cooking fuel and accessibility to electricity. Section B was designed to capture data on the main sources of livelihoods and the challenges faced on each respectively, main types of crops grown and their yields production per season, other sources of household financial support, total land acreage per household, and the main land usage. Section C covered household dependence on forest and tree base systems. In this section, the data concentrated on forest accessibility and the challenges faced - off, resources harvested, supply trends of the resources, forest frequent users, and main type of trees grown on farm, their uses and the preferred tree species. Section D of the questionnaire aimed at gathered information on changing weather patterns and its related impacts on people's sources of livelihoods. Section E of the questionnaire covered the coping strategies adopted by the community in relation to climate variability. Knowledge on existence of forest groups and their services, accessibility of climate information as well as existence of markets for both agricultural and forest products was gathered. Thereafter, the information collected was triangulated with FGDs, KII and observations.

3.4.4 Focused group discussions and key informants

Two different FGDs were conducted each constituting 8 men and 8 women. This was done to cross-check and validate data gathered from the household interviews. Participation in the FGDs was voluntary with much consideration for those who had lived in the village for longer durations. The participants were sampled with the help of community mobilizers. These FGDs created a forum for interaction and discussions on climate variability issues and how it impacts on sources of livelihoods and their vulnerability. Discussions further revealed men and women's coping strategies as well as their dependence on forest resources for livelihoods support. More discussions

were held with key informants who included forest officers (KWS), Agricultural officers, local area chief and village elders in Buyangu.

3.4.5 Rainfall and temperature time series data

The long term series data on rainfall and temperature trends were obtained from Sichirai Meteorological Station in Kakamega situated at N 00^{0} ^{30}', E 034^{0} 8' and approximately 16 kilometres from the study site. Data gathered included average monthly rainfall for the years between 1923 and 2015 alongside minimum and maximum temperatures for the period 1980-2015. Rainfall and temperatures time series analyses were calculated based on 30 year climatological periods as recommended by WMO guideline on trend analysis (Klein *et al.,* 2009). Annual and monthly averages provided values for statistical analysis. In determination of rainfall and temperature climatological trends, this study employed Mann-Kendall statistical test method at 95% confident levels. This method of analysis was chosen as it is not mandatory for data to be normally dispersed (Tabari *et al.,* 2011). Additionally, this method is found suitable for analysing data stretching over prolonged time scales since it is fairly insensitive to sudden breaks caused by heterogeneity of time series. Positive values according to Mann-Kendall Statistic represent rising trends while negative values denote declining trends (Opiyo, 2014).

3.4.6 Field observation

Field observations were part of the study where the researcher sought to understand the area and the activities that were going on. A checklist was used to record land use activities, existence of forest products on site, types of houses, types of livestock breeds reared, types of animal forage on site and the common tree species cultivated. A checklist (Appendix 4) was used to collect this information.

3.5 Data analysis

Analysis of the data integrated both quantitative and qualitative approaches. Previous to analysis, quantitative data collected from the questionnaires were given unique numbers to simplify the process of inputting data in the computer systems. Systematic arrangement of facts was done followed by assignment of numerical codes to each responses. Data was then analyzed through SPSS to get descriptive and inferential statistics. Cross tabulation was also applied in determining

the relationships between gender and other variables. Qualitative data from FGDs w Data was presented using charts and tables.

3.5.1 Trend analysis

Trends for both maximum and minimum temperatures were analysed for the year 1980-2015 while rainfall trend analysis was conducted for the climatological period 1923-2015. For both parameters, Mann-Kendal (MK) test was applied and tested at 95% confidence levels to detect any possible trends over the time scale. This method being a non- parametric statistical test detects non-linear trends but it's limited in showing the magnitudes of significant trends (Barbar and Ramesh, 2013). However, MK is also known to be insensitive to inconsistencies of data, inhomogeneity and irregular sampling intervals of data presented hence doesn't necessarily require the data to be normally dispersed (Karpouzos *et al.*, 2010). The positive and negative values in MK statistic signifies data trends over time. Whereas a positive sign points to an ascending tendency, a negative sign shows a descending tendency.

For this study, an already developed MS Excel template for MK test and Sen's slope estimation (MAKENSENS) was used to detect and estimate magnitude of the trends from the analysed data. MAKENSENS presents its output first as monotonic increase or decreases (Z values) and secondly, it gives a slope of the linear estimate (Q values) through the Sen's method. MK test statistics S, standard test statistic Z's and Var (S) were calculated as follows:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \text{sign}\left(X_j - X_k\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where x_j and x_k = annual values of years, j and k

j>k assuming xj – xk = θ where θ is computed as:

$$\text{Sign}\ \theta = \begin{cases} 1 & \text{if } \theta>0 \\ 0 & \text{if } \theta=0 \\ -1 & \text{if } \theta<0 \end{cases}$$

The variance S in equation 1 above is calculated as below

$$Var\ (S) = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t(t-1)(2t+5)}{18} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (3)$$

n = length of data

t = number of data value

The Z statistic is computed as follows

$$Z = \begin{cases} \frac{S-1}{\sqrt{Var\,(S)}} & S > 0 \\ 0 & S = 0 \\ \frac{S+1}{\sqrt{Var\,(S)}\ S} & S < 0 \end{cases} \quad \text{..... (4)}$$

Where Z values are positive, it depicts an increasing trend and decreasing if negative for the analysed periods at significance level α. This formula is valid for $n \geq 10$.

Sens slope estimation

As described above in this document, Sen's slope is also a tests that does not rely on assertions in determining magnitudes of a climatic trend. It is derived from the following formula

$$Q = \begin{cases} T\frac{N11}{2} & N\ is\ odd \\ \frac{1}{2}(T\frac{N}{2} + T\frac{N+1}{2} & N\ is\ even \end{cases} \quad \text{..... (5)}$$

The increasing or decreasing trend is indicated by the positive and negative Q values.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0 Introduction

This chapter presents the results and discussions of the findings. Data were analyzed to show climate trends and its impacts on the livelihoods of Buyangu forest dependent community. Gender vulnerability assessment was determined and lastly, an evaluation of gender based coping strategies was carried out.

4.1 Socio - demographic characteristics of respondents

The study endeavored to capture respondents' backgrounds through their ages, gender and marital status, education levels, household sizes and occupations. This was important to understand and describe the community.

4.1.1 Gender of respondents

Approximately 58% and 42% of female and male gender participated in the study, respectively (Figure 3). The female gender domination was consistent with Kenya National Bureau of Statistics indicating that 52% of Kakamega County population were women as compared to 48% men (KNBS, 2009). The incorporation of both gender groups as respondents was made in a bid to make comparative assessments and conclusions on specific issues.

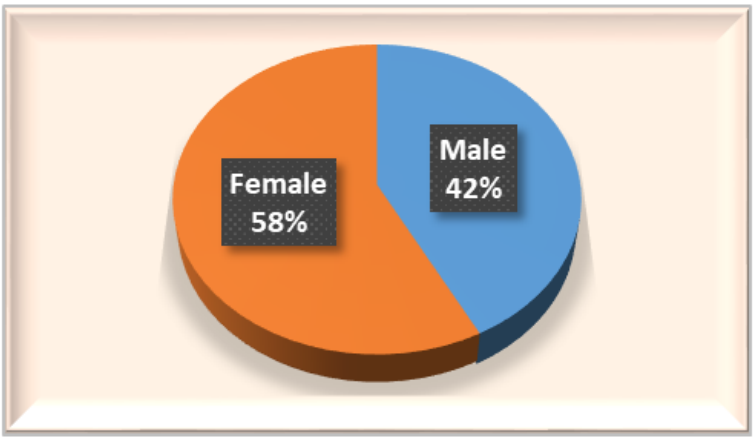

Figure 4.1: Gender of respondents

4.1.2 Age

Majority of respondents (54%) were aged between 31 -50 years followed by those aged above 50 years (Figure 4.1). This age bracket falls under the most active age group in Kenya according to the Kenyan labour force. Thus, their responses in the research findings played an invaluable role for generalization across the county.

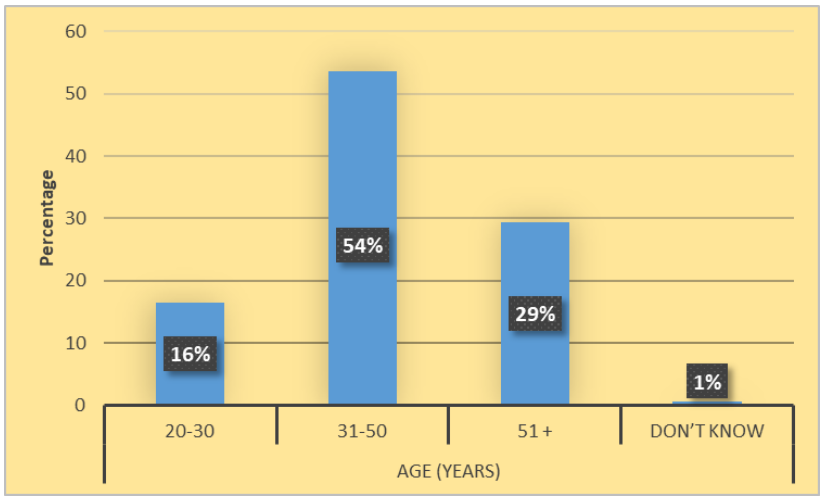

Figure 4.2: Age distribution

4.1.3 Marital status

A significant proportion (80%) described themselves as married while a few (16%) were widowed (Figure 4.3).

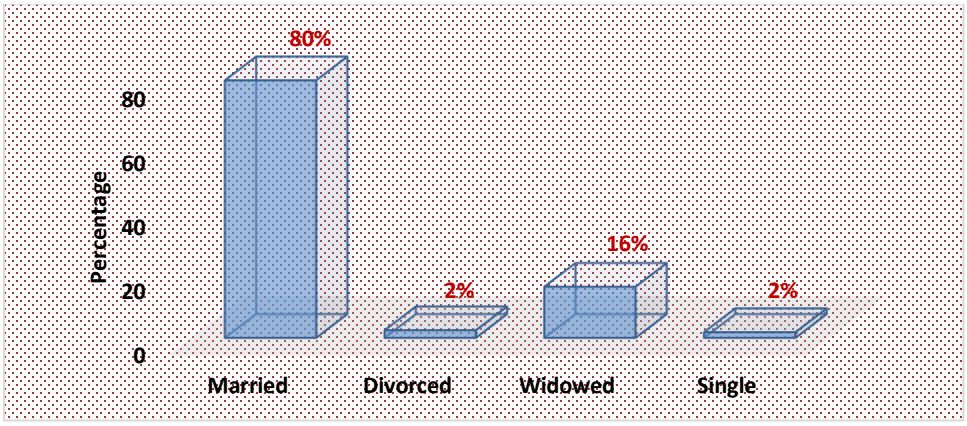

Figure 4.3: Marital status

The study area had high proportions of male household heads and obtaining sufficient number of female headed households was difficult as they were very few. However, during selection of

sample respondents, it was important to categorize households as either female- headed or male-headed households for gender representation on differences of opinions.

4.1.4 Educational level

In terms of education almost all respondents interviewed had attained primary education (Table 4.1). Attainment of primary level education provides a foundation for building an educated society (State of education in Africa report, 2015). But with only 3.5% of the respondents with college education, literacy levels in the region is still very low which prompted the researcher to explain the questions clearly to the respondents for a successful research. This finding concurs with Fisher *et al.,* (2010) who stated that households proximal to forests are less educated, highly reliant on forest resources and are most exposed to change in climate risks.

Table 4.1: Level of Education

Education levels	Frequency	Percent
No formal education	32	15.9
Primary	115	56.5
Secondary	49	24.1
College	7	3.5
Total	**203**	**100**

4.1.5 Household size

Majority (74.7%) had up to 9 members per household (Figure 4.4). This finding collaborates with the last national population census conducted in Kenya where the mean household size in Kakamega County is approximately 6 persons (KNBS, 2010).

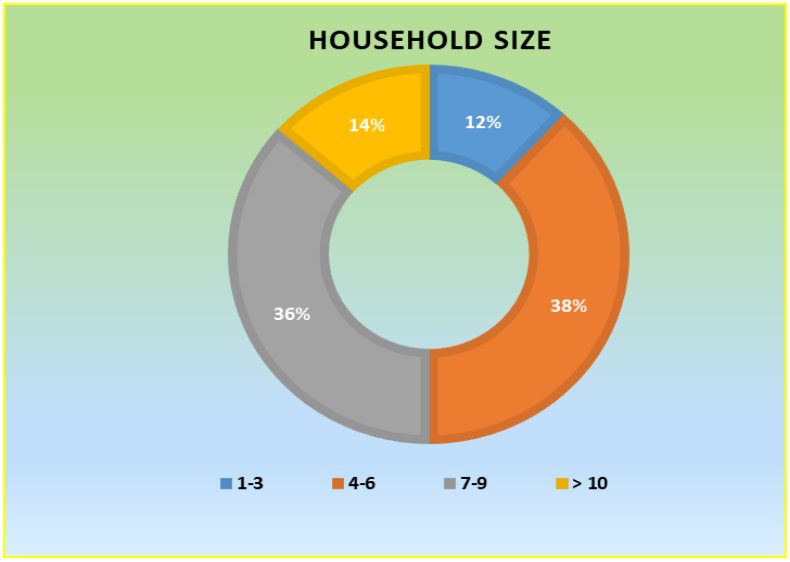

Figure: 4.4: Size of household

Households are coming to terms with the ramifications of large family sizes straining family resources and income, which might slow down the process of adaptation. According to Suleiman et al. (2017), households living closer to forests and with larger families are prone to frequently collect forest resources due to easy divisibility of labour. Relatedly, past studies have justified the probability of adaptation decreasing as family sizes enlarge (Deressa *et al.*, 2008; Mignouna *et al.*, 2011).

4.1.6 Occupation

Of the household heads, about 75% were small scale farmers while 11.8% were involved as casual workers on seasonal basis (Table 4.2). This is a typical representation of a rural community where majority of the communities are farmers. The household heads who had secured formal employment (8%) play a crucial role in contributing towards households' wellbeing. According to Daneji and Suleiman (2011) households occupied with different activities such as small scale businesses and casual employment are less to do with forest resources.

Table 4.2: Main occupation

	Frequency	Percent
Farmer	152	74.7
Salaried/fixed employment	8	4.1
Salaried/contractual	7	3.5
Casual	24	11.8
Small scale businesses	12	5.9
Total	**203**	**100**

4.1.7 Land sizes

Majority of the households (54.7%) own farm plots ranging from 1-3 acres (Table 4.3).

Table 4.3: Land sizes

Land size	Frequency	Percent
< 1 acre	72	35.3
1-3 acres	111	54.7
4-5 acres	13	6.5
6-10 acres	5	2.4
> 10 acres	2	1.2
Total	**203**	**100**

Farm size plays an important role in any agricultural activity including crop farming, livestock keeping and tree farming. Households with small land sizes are constrained into exploring available climate smart ventures such as agroforestry due to competing needs of ensuring food security as well as planting trees on farms (Manjunatha *et al.*, 2013). Divisions of land into smaller units in this county is associated with land inheritance and with poor management, results to agricultural inefficiency. Furthermore, households with small land holdings will fail to create food baskets for their families thus, many will hang on forest resources as their safety nets (Suleiman *et al.*, 2017).

4.2 Analysis of climate trends and its impacts on sources of livelihoods

To achieve this objective, analysis on both rainfall and temperature variability were initially made. This was followed by analysis on community's awareness of climate variability and accessibility to climate information. Analysing effects of changing weather patterns on the livelihoods of Buyangu community necessitated the need to first understand the nature of the community as pertains to crop production and livestock keeping.

4.2.1 Average monthly rainfall variability

Average monthly rainfall data for Kakamega between 1923 and 2015 was analysed for variations and distribution (Figure 4.5). From the results, the highest mean precipitation was documented in the months of April (255mm) and May (257mm) which is also marked as rainy seasons in the region. Precipitation then slightly subsides in June before increasing again in July with August registering higher amounts (222mm) in the short rainy periods. However, the months of December, January and February recorded least quantities of rainfalls at 91mm, 68mm and 92mm respectively.

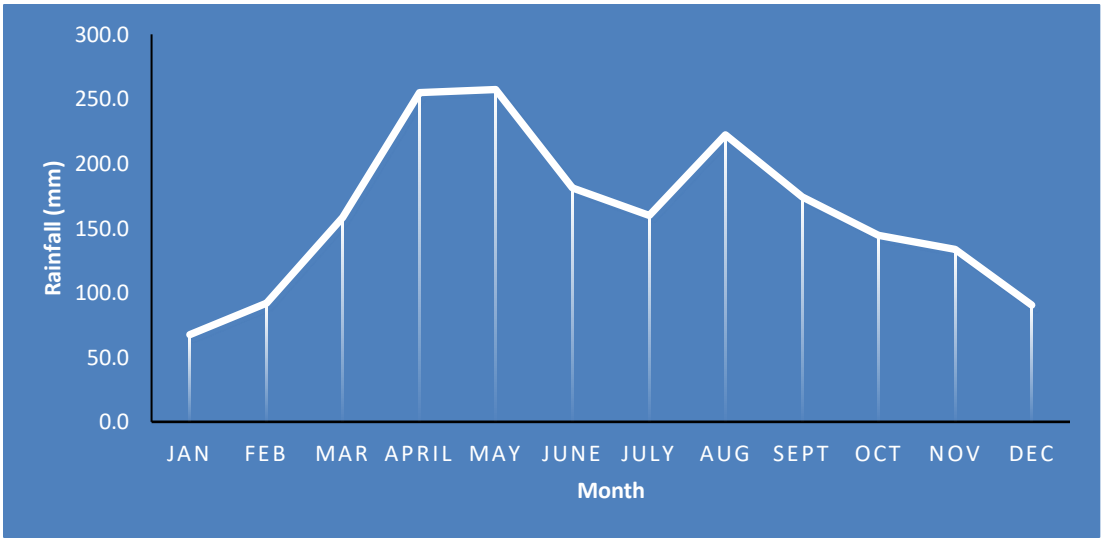

Figure 4.5: Mean monthly rainfall in Kakamega (1923 – 2015)

MK tests for mean monthly rainfalls (Table 4.4) suggests positive rainfall trends in January, March, April, September, October, November and December. These rainfall trends were not very significant at 95% confidence levels.

Table 4.4: Rainfall MK test

	Jan	*Feb*	*Mar*	*Apr*	*May*	*June*	*July*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*ANNUAL*
MK Test (Z)	1	-1.77+	1.88+	0.3	-1.78+	-1.23	-2.2*	-0.77	0.93	2.79**	3.04**	1.15	0.97
Sen's slope (Q)	0.181	-0.38	0.596	0.104	-0.543	-0.265	-0.518	-0.234	0.262	0.619	0.761	0.237	0.068

*** trend at $\alpha = 0.001$ ** trend at $\alpha = 0.01$ * trend at $\alpha = 0.05$ + trend at $\alpha = 0.1$

Increase of rainfalls in October and November were found to be significant at $\alpha = 0.01$. The remaining calendar months displayed downward trends that were not significant except for July which was significant at 95% confidence level. Sen's slope being an indicator for magnitude of change was found to range between -0.543 and 0.761 during this climatological period. Precisely, magnitude of change was highly negative in May indicating a decline in rainfalls by 0.543mm/ year whereas in November, this change was highly positive implying an increased precipitation by 0.0761mm/year. This trend is likely to recur in the coming years. Annual precipitation was found to increase by 0.068mm per year, possibly because of frequent occurrences of hailstorms in the region.

4.2.2 Mean annual rainfall variability

Mean annual rainfalls for climatological period (1923- 2015) indicates highest precipitation between 1963 and 1983 (figure 4.6). On the other hand, a major drop of precipitation occurred between 1988 and 2012. While coefficient of rainfall variation (R^2 linear = 0.193) was weak and insignificant, that the cumulative effects of rainfall variability are expected to continue in the coming years and with less predictability.

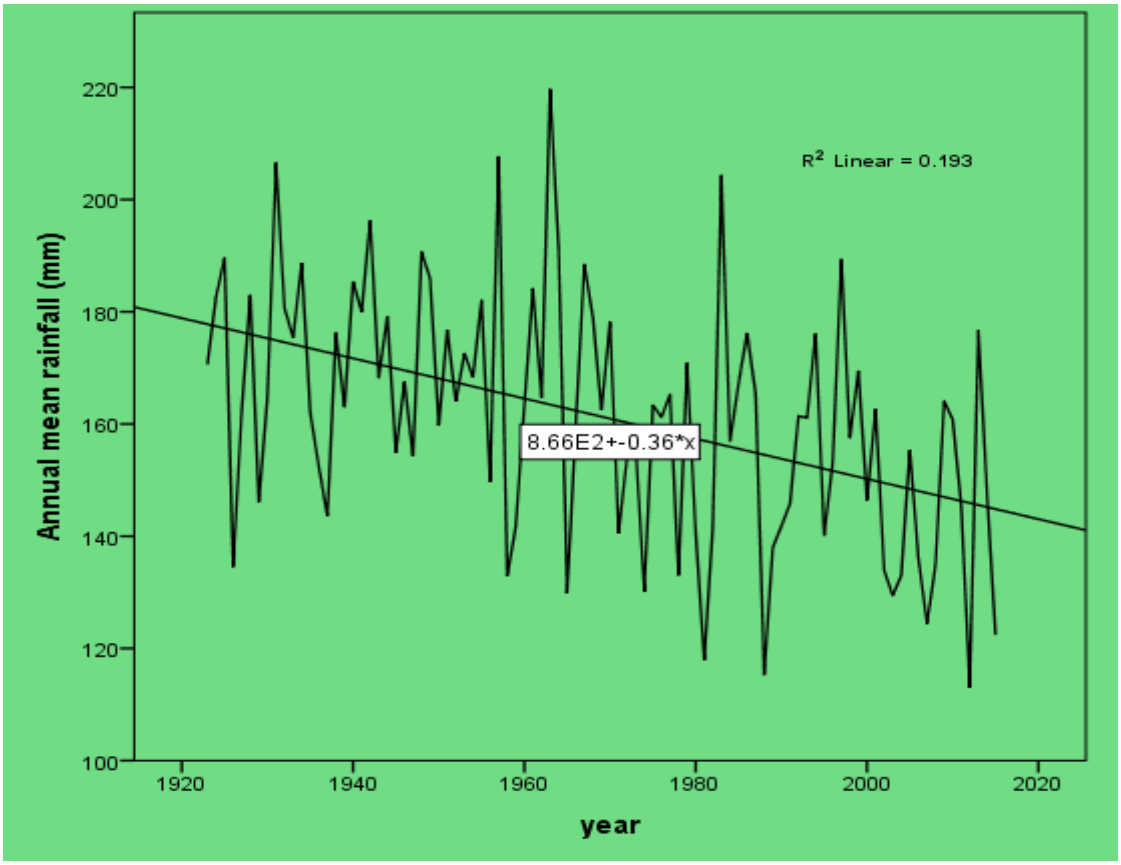

Figure 4.6: Mean annual rainfall in Kakamega (1923 – 2015)

4.2.3 Mean monthly temperature variability

Mean monthly temperature (maximum and minimum) for the climatological period (1980-2015) were investigated for variations and trends. The months of January to March were the hottest with maximum temperatures reaching as high as 30.8 ^{o}C (Figure 4.7). As for temperatures, the months of July, August and September recorded lowest minimum temperatures ranging between 13.8 ^{o}C, 13.7 ^{o}C and 13.6 ^{o}C respectively whereas April had the highest minimum temperature (15.2 ^{o}C). These findings corroborate the earlier observations made by Barasa *et al.,* (2015) on temperature variations in the region. Generally, it can be observed from the graphical presentation that trends for both maximum and minimum temperatures are nearly similar such that both increase and decrease within almost the same time range.

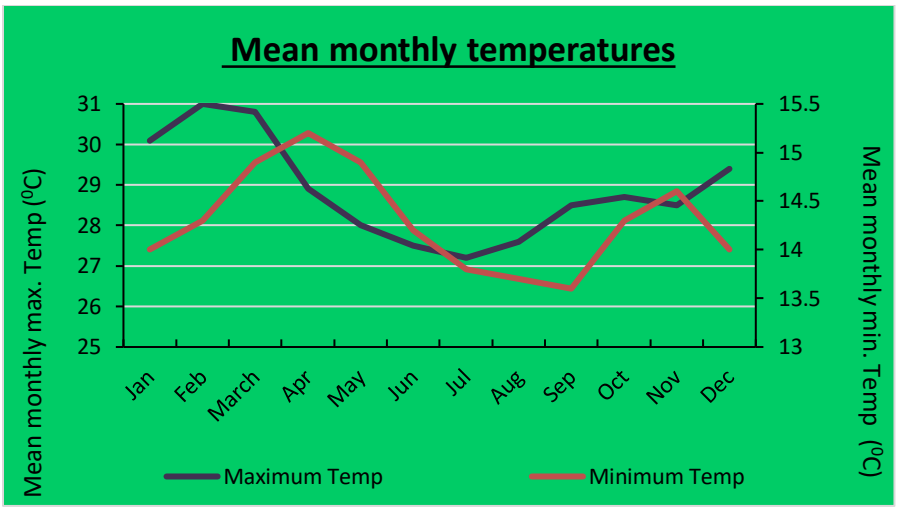

Figure 4.7: Maximum and minimum mean monthly temperature (1980-2015)

4.2.4 Mean annual temperature variability

Figure 4.8 represents mean annual temperature trends for the period (1980-2015). Variability was witnessed in both mean annual maximum and minimum temperatures where 2009 and 2014 had highest values. The lowest mean annual maximum temperatures of 19.9 °C, 20.4 °C and 22.6 °C were recorded in 1999, 1991 and 1994 correspondingly. This is an indication that the years were the coldest during the climatological period with 1999 reporting the lowest values. This sentiment was attested during FGDs where participants mentioned 1999 as the coldest year on record. However, the highest minimum temperatures (15°C) occurred in the year 2010.

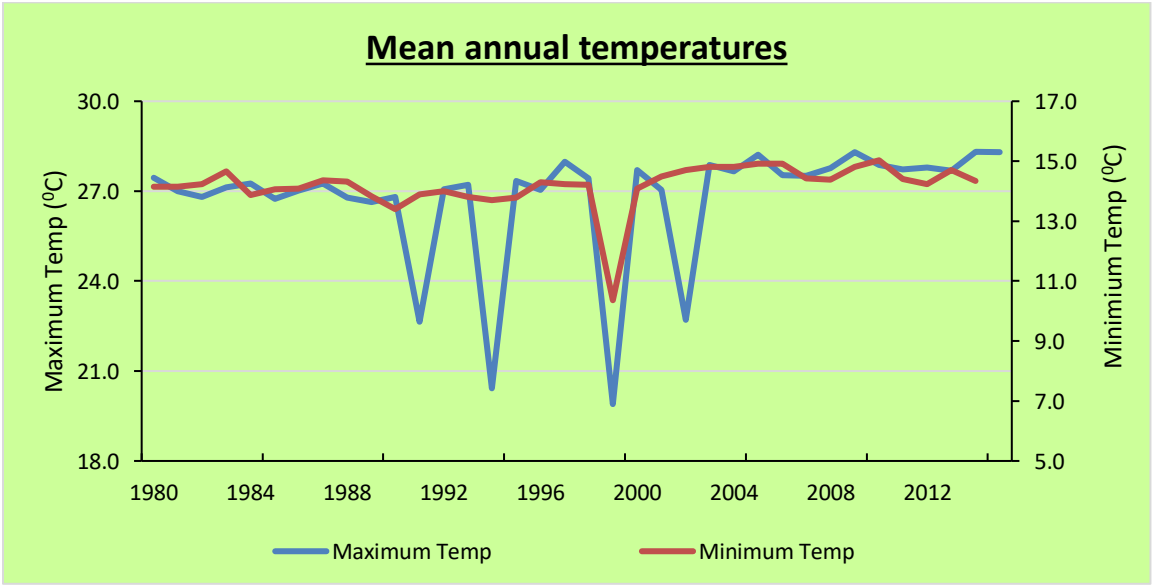

Figure 4.8: Maximum and minimum mean annual temperature (1980 -2015).

The MK test for maximum and minimum temperatures in table 4.5 below shows positive trends giving an indication that temperatures are rising with time. As regards to maximum temperatures, increase was found to be significant ($\alpha = 0.05$) in January, February, September, November and December. The magnitude of the change as presented by Sen's slope estimator was 0.019 ^{o}C for minimum temperature and 0.037 ^{o}C for maximum temperature. The findings give an indication that global warming effect is being felt in this region and these findings are in consistent with preceding studies done on temperature variability and trend analysis (Mulinya *et. al.*, 2016).

Table 4.5: Mann-Kendall test and Sen's slope for max and min temperatures

Variable	Z test		Sen's slope	
	Max temp	Min temp	Max temp	Min temp
January	2.32*	1.38	0.054	0.016
February	2.11*	0.79	0.058	0.009
March	1.91+	0.93	0.047	0.005
April	3.39***	0.35	0.066	0.003
May	4.92***	0.78	0.049	0.007
June	4.02***	2.22	0.039	0.016
July	4.43***	3.56	0.059	0.024
August	3.26**	2.87	0.033	0.024
September	1.99*	2.93	0.018	0.029
October	1.17	2.85**	0.014	0.025
November	2.19*	1.81+	0.027	0.019
December	1.96*	1.59	0.032	0.015
ANNUAL	4.78***	3.06**	0.037	0.019

*** trend at $\alpha = 0.001$ ** trend at $\alpha = 0.01$ * trend at $\alpha = 0.05$ + trend at $\alpha = 0.1$

4.2.5 Perceptions on climate change

Many of respondents observed delayed rainfalls and prolonged dry spells for the last 20 years (Table 4.6). Generally, the perceptions of the respondents on climate change concurs with meteorological data presented on rising temperatures and declines in rainfall. The findings implied that farmers fairly understood the unpredictability of weather patterns which affects their modes of earning a living.

Table 4.6: Respondents' perceptions on climate change

Observations	Frequency	Percent
Weather changes experienced		
Delayed rainfalls	91	44.7
Long dry spells	74	36.5
Heavy rainfalls(hailstorms)	9	4.7
Rising temperatures	29	14.1
Total	**203**	**100**
Rainfall trends		
Increasing	17	8.2
Decreasing	153	75.3
Unpredictable	33	16.5
Total	**203**	**100**
Temperature trends		
Increasing	193	95.3
Decreasing	10	4.7
Total	**203**	**100**

4.2.6 Access to climate information

A larger population (81.2%) receive weather forecast information through their own radios in the houses (Table 4.7).

Table 4.7: Access to weather information

Do you have access to climate information/rainfall forecasts?		
	Frequency	**Percent**
Yes	165	81.2
No	38	18.8
Total	203	100.0
If yes, from what source do you get weather information?		
Radio	177	87
Community meetings/barazas	16	8
Indigenous knowledge	10	5
Total	203	100.0
Is the information helpful to you in planning your agricultural activities?		
Yes	163	80.3
No	40	19.7
Total	203	100

Almost all respondents who acknowledged receiving weather forecasts through radios explained that much of the information gathered was resourceful. Whilst farmers in Kenya rely on rain fed agriculture, accessibility to climate information improves farmers' activities thereby promoting productivity (Biazin, 2012). Radio is the most effective medium of communication in the region where majority can access weather forecasts information. This implies that for policy makers and stakeholders to improve on weather forecasting, there is need to maximize on the usage of radios to disseminate real time climate information to rural communities for efficient and effective adaptation (Wiid and Ziervogel, 2012).

4.3 The nature of livelihoods in relation to climate change.

Crop production (35%) and livestock farming (31%) were the main livelihoods activities in Buyangu. (Figure 4.9).

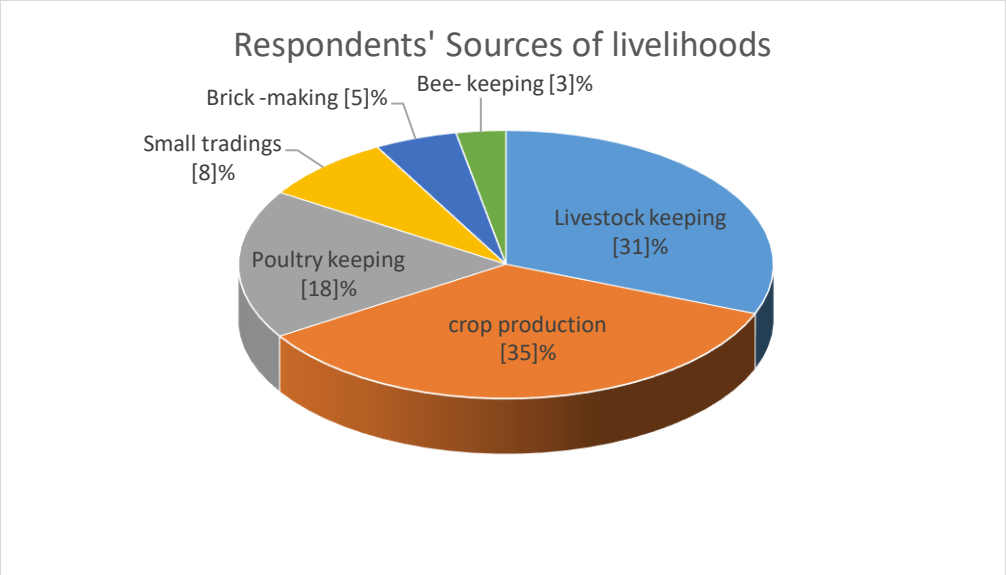

Figure 4.9: Main sources of livelihoods in Buyangu

The results are true for most forest based rural communities where livelihoods are characterized by agricultural production for sustainability (Gross -Camp *et al.,* 2015). Poultry keeping was practiced on a lower scale (18%) due high prevalence fowl diseases and the frequent predatory attacks of baboons from the forest. On the other hand, bee keeping which would otherwise be thought to be highly practiced in the forested area was on the lower side (3%). This low percentage on bee keeping may be attributed by the fact that Kakamega forest is a government protected zone and while entry is highly restricted, there are inadequate nesting places of beehives in people's homesteads to due limited land sizes.

4.3.1 Crop production

To understand the nature of crop farming the study participants engaged in, they were asked to specify four common types of crops growing in their farms. The findings are shown below (Table 4.8).

Table 4.8: Distribution and performance of crops cultivated

Crop	Distributions (Percent)	Yield harvested as a percentage of all crops yields (Percent)
Maize	36	57.1
Vegetables	14	4.7
Sugarcane	22	32.9
Sweet potatoes	13	5.3

The results indicate that maize, being the most generally consumed food crop in the country was highly cultivated (36%) followed by sugarcane (22%) which is also a common cash crop in the western region Kenya. In Kenya, maize is a staple food and sustains 96% of the human populace and provides 40% of the calories needed in the body (Omoyo et al., 2015). In terms of crops performance, maize was also found to be doing well (57.1%) compared to sugarcane (32.9%), sweet potatoes (5.3%) and vegetables (4.7%) respectively. Most of the households are engaged in multiple cropping systems to enhance food security. In this study, performance of crops was based on the cost of production and harvest output on farmers. Other crops mentioned in the study as being cultivated included beans, groundnuts, bananas and arrowroots.

4.3.2 Crop surplus and their uses

The study sought to establish the possibilities of crop surplus from farm fields and its uses especially during hard times brought about by climate variability. The responses gathered are summarized in the figure 4.10 below.

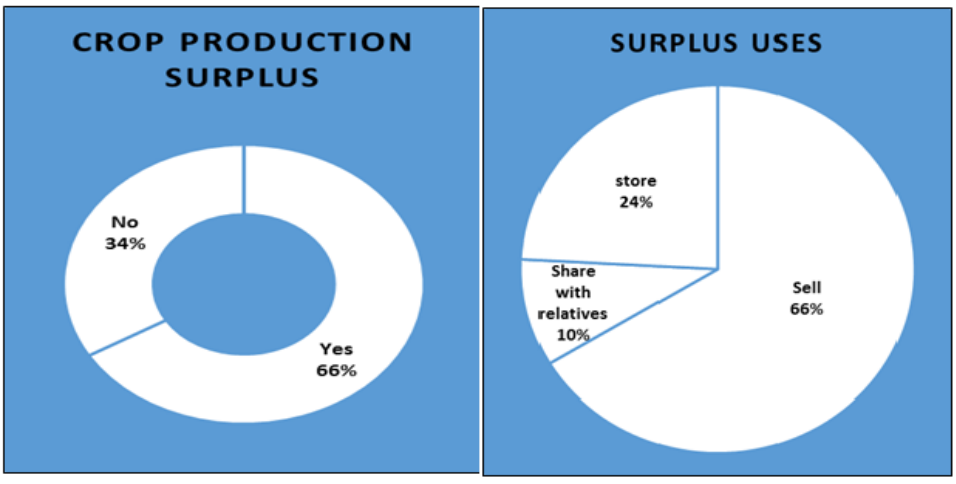

Figure 4.10: Crop surplus and their uses

From the findings, 66% responded to the affirmative out of which the majority (66%) sell their surpluses. This means that while farmers are able to produce surplus yields, a smaller group (24%) can afford storage of the same. According to Crespo *et al.,* (2011), changes in agricultural yields due to unpredictability of weather conditions, and the ways farmers store their harvests may project future status of our food basket. The respondents in Buyangu cited lack of proper storage facilities in their homesteads prompting them to sell crop produce rather than store to avoid post-harvest losses. Market distance for most household groups falls between 1-2Km from their homesteads indicating an easy access thus better opportunities to engage in IGAs (Saha and Sundriyal, 2012).

4.3.3 Effects of climate change on crops.

Amongst those who opined that the climate is now dynamic, 52% highly attributed their reduced farm yields to unpredictability, excessive or inadequate rainfalls (Table 4.9).

Table 4.9: Effects of climate change on crops

	Percentage
Impacts of climate variability on crops	
Reduced yields on common crops	52
Increased soil infertility from erosion and floods	32
Increased Pests and disease attacks	16
Total	**100**
The degree of impact of climate change on crop yields	
High	58
moderate	33
Insignificant	9
Total	**100**
Most affected crops	
Maize	62
Sugarcane	34
Vegetables	4
Total	**100**

However, maize is the most affected crop due to its sensitivity to inadequate water supplies especially at crucial moments of flowering and onset of maize- seed filling stage (Slingo *et al.*, 2005). As many generally complained of crop declines arising out of climate variability, one farmer explained as follows:

"We are now harvesting nearly half the yields we used to harvest some years ago from the same piece of land". "We even could plant and harvest maize twice a year because the short rains were sufficient and reliable, but nowadays the short rains are no longer predictable" Added another farmer.

Variations in temperatures and rainfalls have wider repercussions on maize yields subsequently impacting on food reserves in Western Kenya (Omoyo *et al.*, 2015). As well, farmers across the study region elaborated how rainfall onsets which is most occasions is accompanied by hailstorms that destroys germinating crops. They elaborated how sudden heavy hailstorms was on the rise culminating into flooded farms heightening soil unproductivity.

4.4 Livestock production

Livestock keeping was yet another source of livelihood for the community with the majority (73.5%) rearing cattle (Table 4.10). Although a significant number (26.5%) did not keep cattle, more than half of study participants (54.1%) kept between 1 and 2 animals.

Table 4.10: Number of herd size

Number of cows	Frequency	Percent
0	54	26.5
1	60	29.4
2	50	24.7
3	24	11.8
4	10	4.7
5	2	1.2
6	2	1.2
7	1	0.5
Total	**203**	**100**

The option to maintain small number of livestock was attributed little land spaces for each family. A male FGD participant gave the following explanation;

"Some many years back before KWS officers came here to protect the forest, we used to keep large number of animals as we used to graze in the forests. And life was very easy then as we never used to worry about animal pastures. These animals used to help us a lot as we could sell one or two to cater for school fees. But when KWS officers came and took over the forest, it became a national reserve and we were forbidden to enter the forest. We were then forced to sell most of our livestock and remain with a few due to lack of enough pastures in our small pieces of lands"

This outcome resonates with Peters *et al.,* (2012) who also established that 76% of small scale farmers in Kakamega kept between 1 and 3 heads of cattle since the majority are poor and cannot sustain large herds. The community relied on livestock for milk, meat production and as an income sources through sale of animals.

4.4.1 Milk production

Most of the respondents (37.2%) who reared dairy cattle had their animals produce an average of 1-3 litres of milk while 22.1% could afford 4-6 litres per day (Table 4.11).

Table 4.11: Milk production

Litres of milk /per day	Frequency	Percentage
0	57	28.1
1-3	76	37.4
4-6	45	22.2
7-10	18	8.9
> 10	7	3.4
Total	**203**	**100**

As much as respondents in the study considered milk production from their cattle sufficient for family consumption, the optimum milk production is yet to be realized. The study established that lack of adequate pastures and frequency of animal diseases affect milk output. Wanjala and Njehia (2014) also reported that milk production for one animal per day is relatively low in Western Kenya. It has also been argued that lack of forage not only reflects on milk output but also on their

health status. Livestock lacking adequate forage tend to be unhealthy and succumb easily to diseases (Archambault, 2012; KARI, 2013).

4.4.2 Types of cattle breeds reared

A significant number (49%) of farmers engaged in cattle rearing preferred indigenous breeds which were considered to be more drought tolerant, require less feeds and are resistant to diseases. Field observations also revealed Friesian and Guernsey cows as the common indigenous breeds reared in the area (Appendix 3). However, some farmers preferred cross breeds due to high milk and meat productivity when compared to indigenous breeds (Figure 4.11).

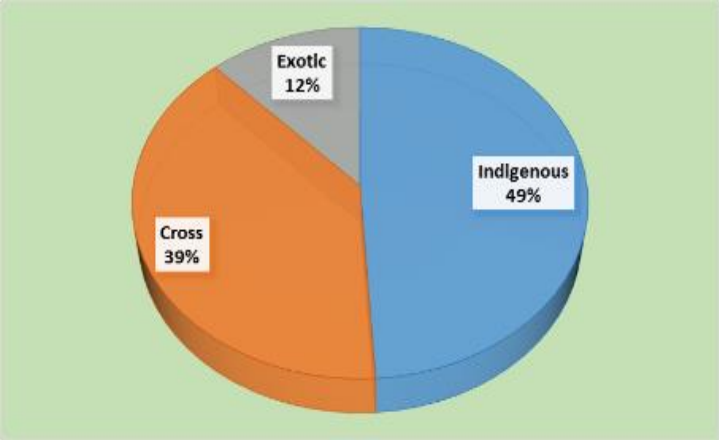

Figure 4.11: Cattle breeds reared

According to Thornton and Herrero (2010), the adoption of cross breeds results to over twice the quantity of meat produced and milk supplied as compared to local breeds. From the results above, it is noticeable that farmers had chosen to keep animals (indigenous and cross breeds) that are disease tolerant, require less feeding and are able to withstand harsh weather conditions. This in a way is a form of dealing with climate inconsistency for farmers in Buyangu.

4.4.3 Effects of climate change on livestock production

The study unveiled that majority of the farmers (87%) had reduced their herd size by selling part of livestock due to limited forage arising out of prolonged drought conditions in the Consequently, milk productions have declined (97%) due to inadequate pastures while livestock market values (65%) have been negatively affected region. (Figure 4.12).

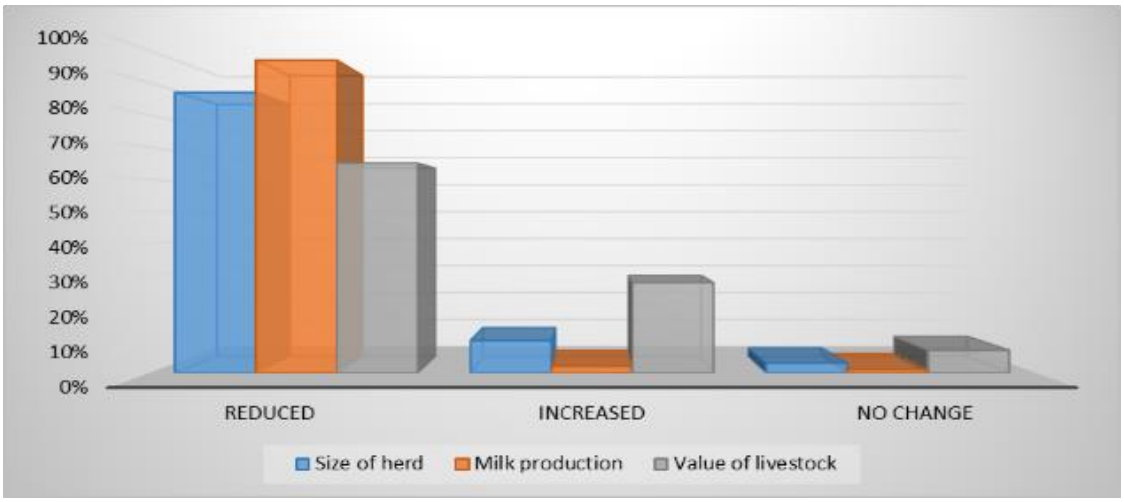

Figure 4.12: Effects of climate change on livestock

Generally, livestock farming depends on innate systems exposed to and sensitive erratic weather conditions characterized by change in temperatures, rainfalls and extremes (Lagat and Nyagena, 2016). High temperatures and long dry spells leads to deterioration of pastures which eventually affects animal's productivity and physical health. Such animals fetch lower prices in the market hence lower livestock net revenues (Lagat and Nyagena, 2016). Moreover, increase in vector borne diseases such as foot and mouth disease amongst livestock was highly attributed to excessive rainfalls in the region. The aforementioned impacts on livestock has widely interfered with households' income as many rely on the net returns to offset children's' school and other family demands. Much as livestock keeping was being practiced in the region, many claimed that the venture had become too expensive. Jaetzold *et al.*, (2011) emphasized that animal grazing grounds including water supplies influence livestock wellbeing of which their inadequacy impacts negatively on the animals. To this effect, where households have been forced to purchase animals feeds instead, many have opted to abandon the venture.

4.5 Alternative sources of income

The findings pointing towards the uncertainties of weather patterns has prompted this community to expand their sources of income. Majority of the respondents have turned to their children (48%) and relatives (26%) for financial assistance (Table 4.12).

Table 4.12: Alternative sources of incomes for households

Financial sources	Percentage
Social protection for elderly	15
Remittance from children	48
Remittance from relatives	26
Remittance from friends	9
CBOs and NGOs	2
Total	**100**

Social protection programmes such as the National Social Security Fund (NSSF) is relied on by the minority (15%) in the region. This is an indication that a larger population in Buyangu are not in any social protection programs. As per World Bank (2013), nations that have social insurance frameworks set up before a calamity hits are positioned better to counter the effects of changing climate. Instruments of social security such as money transfers both in kind and pensions can work be useful to the most vulnerable households especially the elderly group hardest hit by climate-related disasters (Ziegler, 2016).

4.6 Community's forest accessibility

To gauge forest accessibility based on the households' proximity to forest, the respondents estimated their household distances from the forest edge. About 63% of the households were located within 3Km range from the forest edge (Table 4.13). These households are believed to be the frequenters in search of forest products.

Table 4.13: Access to forest

Distance from forest	Frequency	Percent
< 1Km	55	27.0
1-3 Km	72	35.6
4-6Km	76	37.4
Total	**203**	**100%**

Mujawamariya and Karimov (2014) likewise deduced that individuals living closer to forests had a higher tendency of overharvesting resources due to the fact that the natural habitat can be accessed at any time. It has been contended that abuse of forest materials essentially at the forest

edges is subject to human's easy accessibility into the forest (Harper, 2005). However, the presence of KWS officers on this part of Kakamega forest does not deter Buyangu community from getting inside the forest. This clearly signifies the community's total dependence on forest resources for their livelihood support.

4.7 Supply of forest resources in the past years

About 44% of respondents reported decrease in amounts of forest products in the past years while 39% opined that supply of forest products was actually increasing citing the presence of KWS officers protecting the forest as the probable cause (Figure 4.13).

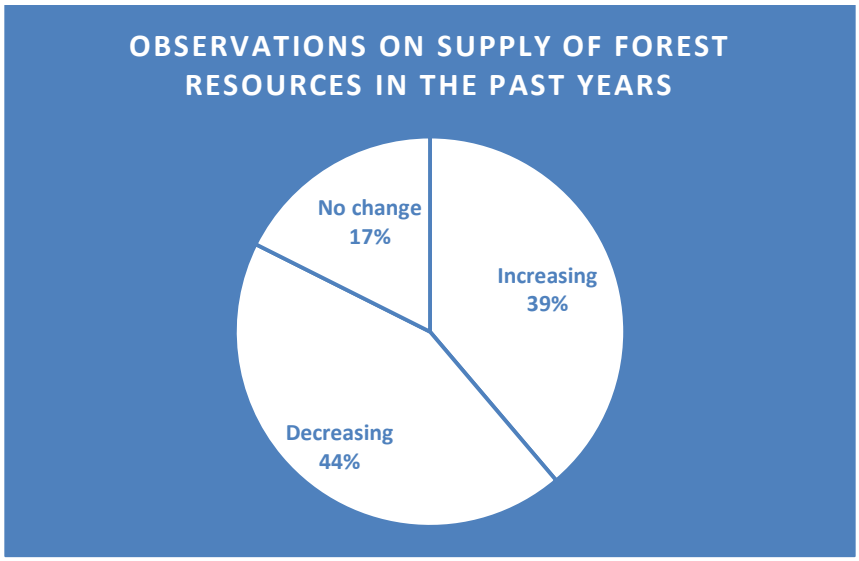

Figure 4.13: Observations on supply of forest resources for past years

Hermans - Neumann *et al.*, (2016) assured that proper forest management always works well in preserving forests and ensuring constant supply of forest resources. However, with respect to decrease in supply of forest resources from Kakamega forest, overharvesting was highly mentioned to have influenced the supply. Similarly, it was also observed that overharvesting was believed by forest communities to be the major contributor to forest resources decline. In respect, most of the respondents in Buyangu could not relate change in climate and its influence on accessibility of forest products. This is contrary to other forest dependent communities in other zones in Africa who understand that change in climate contributes to reduced supply of forest resources especially NTFPs (Onyekuru *et al.*, 2014; Nhemachena *et al.*, 2014). This goes without saying that Buyangu community's ignorance and little knowledge on how change in climate influences the supply of forest resources will impede their adaptation responses.

4.8 Preferred on farm tree species and their uses

Firewood supply (44%) and timber extraction (43%) were major uses of trees in the region (Figure 4.14). From field observations, *Eucalyptus saligna*, *Cupressus lustanica*, *Grevillea robusta*, *Croton macrostachyus* and *Markhamia lutea* were found to be the most common tree species cultivated in the area (Appendix 3). The major reasons cited for these tree species preferences were because of their ability to withstand droughts (54%) and faster growths (35%).

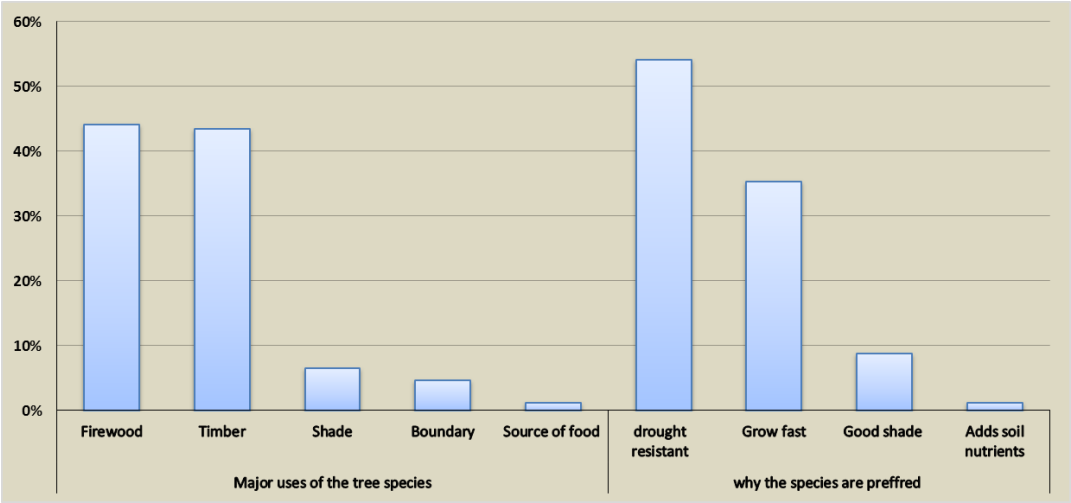

Figure 4.14: Uses and preferences of tree species.

For example, *E. saligna, C. lustanica and G. robusta* are fast growing species targeted for commercial purposes, fuelwood and timber/poles extraction. Other species such as *G. robusta* and *E. saligna* were mainly preferred for boundary reinforcements while *M. Lutea and C.* macrostachyus are preserved for medicinal purposes.

4.9 Community conservation initiatives

Sustainable use and conservation of trees both inside and outside forests is crucial. At this point, this research strived to establish existence of community forest conservation groups. Some of the community forest groups identified in Buyangu included Kakamega Environmental Education Program (K.E.E.P.), Bush community based organization and Kakamega Forest Women Group amongst others. These organisations were mentioned to engage in different conservation practices such as forest conservation awareness, raising tree seedlings, reforestation and distribution of energy saving cook stoves. However, most of these forest conservation associations were deemed to be inactive in the village as a result of poor management and less interest amongst the residents.

As much as high number of households living close to the forests may be perceived as a threat to forests due to overharvesting of the resources, households and forest distances have an influence on communities' joining forest associations (Ogada, 2012). He further explained that chances of community members joining the conservation groups are reduced by 0.6% for every one-minute walking distance farther from the forest.

4.10 Forest resources sought by women

The study found that majority (70%) of the women exclusively search for firewood in the forest (Figure 4.15).

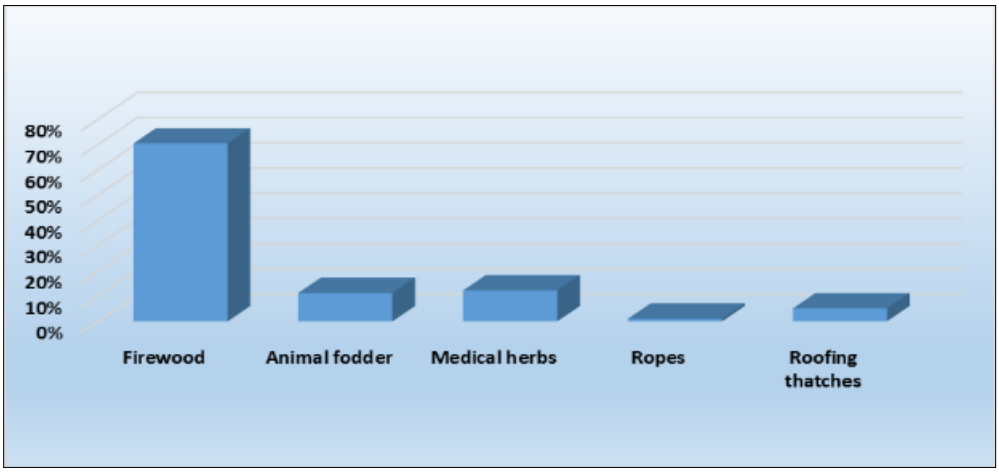

Figure 4.15: Forest resources collected by women

This justified women's societal gender roles of ensuring constant supply of firewood in their respective homes. Women are basically in charge of gathering forest materials for home consumption and this points to items that improve on food security (Burchi *et al.*, 2011). It doesn't work differently in Buyangu as women have to cook for their households prompting them to risk being arrested by KWS when found inside the forest. With their limited options on fuel wood supply, women in Buyangu are forced to sneak in the forest in search of firewood.

4.11 Forest products sought by men

The study found that animal fodder (70%) was the most sought out resource amongst the male gender group with a paltry 20% in search of medicinal herbs (Figure 4.16).

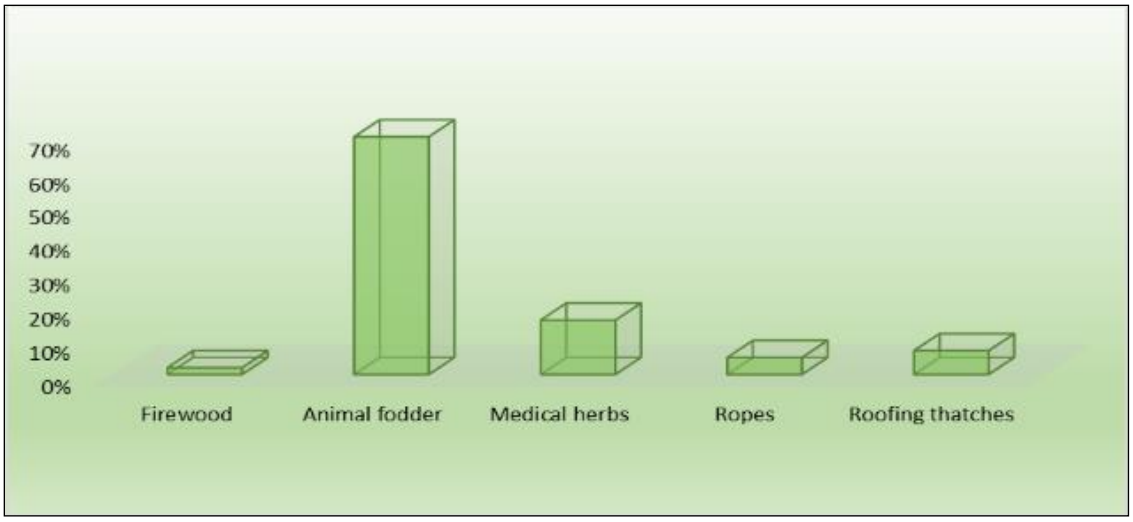

Figure 4.16: Forest resources collected by men

Men are typically reported to collect forest products for commercial purposes (Cavendish, 2000; Shackleton and Shackleton, 2000), contrary to men in Buyangu who collected animal fodder mainly for domestic purposes. This signifies the scarcity and the demand for animal forage in the region. Field observations revealed presence of medicinal herbs (tree barks) gathered for treating both human ailments and livestock diseases (Appendix 3).

4.12 Gender vulnerabilities of Buyangu community under climate change and variability

The gender vulnerability indicators for this study included occupation, literacy, employment status, household size, income diversification opportunities, unawareness concerning risks of climate change on forest resources as well as membership to forest group associations (Table 4.14).

Table 4.14: Indicators of gender vulnerabilities

Vulnerability Indicator	Description of specific Indicator	Impact to social vulnerability	Dimension of vulnerability
Natural resource dependency	Majority of women (80%) farmers dependent on rain fed agriculture; Majority (80%) of women rely on forest firewood.	-Crop declines - Firewood scarcity. - Inadequate animal forage.	**Exposure**
Literacy	HHs with higher education are well informed. -Primary education was highest level attained (56%)	- Limits in resources accessibility and adaptation choices	**Sensitivity**
Employment status	Unemployment rates highest amongst women (only 13.3% in seasonal employment)	Women have fewer adaptation options. - Limited in accessing credit facilities.	
Household size	Majority (74.7%) had up to 9 members per household	Families with more dependents have lower resilience.	
Income diversification opportunities	Lowest amongst female HHs as compared to male HHs	Families with narrow sources of incomes are constrained.	**Adaptability**
Awareness of CC impacts on forest resources	Unawareness of CC impacts on forest resources	Constraints to adaptation	
Membership to forest group associations	Community forest groups are inactive	Non - membership limits adaptation	

Findings show that majority of household depend on natural resources for their wellbeing. Reliance on farming exclusively sustained by rains which have now become so unpromising,

greatly influences gender vulnerabilities. Majority of women (80%) in Buyangu are agricultural farmers with a dependency on firewood as cooking fuel and whose supply is dwindling as a result of changing climate. FAO (2007) affirmed women tend to be dependent on natural resources susceptible to climate changes. The crop declines due to erratic weather patterns and the scarcity of firewood arising out of the forests' inability to regenerate, will heavily impact on women who will not be able to fulfil their gender roles of providing food for their families.

On educational status, majority of households (56%) had obtained primary education which was the highest level attained. The level of schooling for household heads entirely contributes to successfulness of any household which makes it easier in appreciating nature and negative externalities of the same (Newton *et al.,* 2016). Lower educational achievements drive both vulnerability and adaptability of forest communities by constraining engagement in alternative sustainable IGAs that are not forest related (Suleiman *et al.*, 2017).

As regards to employment status, a paltry 13.3% of the female gender group had remunerative jobs which were still not sustainable. The main drawback in the rural areas is the few available job opportunities that are unable to absorb wider populations. This calls for people's engagement on seasonal trading activities mainly on agricultural and forest products (Naidoo *et al.,* 2013). Even though women appear to less popularize sale of forest materials, firewood trade is a thriving business in Buyangu. It worth noting that utilization of forest resources as a counter measure for CC extremes remains a tactical approach for many forest based livelihoods (Pramova *et al.*, 2012).

Family units that are preoccupied on diversified activities such as petty trade and other formal businesses are less likely to harvest forest resources and have wider options of enhancing their adaptability (Jimoh and Azeez, 2002). Whilst agrarian rural economies are not sufficient to furnish resident individuals with enough gainful occupations, men in Buyangu are better placed to access these opportunities more than women. This augments the necessity of creating opportunities to cushion people against harsh realities of changing weather conditions (Turpie and Visser, 2013). Furthermore, unavailability of incomes for women in Buyangu is a setback when it comes to loan requests from financial institutions. Many women cannot get collateral for their loans. A similar observation was made on UNFPA (2009) study where unemployed women had difficulties accessing credit facilities from local financial institutions.

Against the backdrop, even though the effects of change in climate cut across both gender groups, the findings indicate women to be the most vulnerable to changing weather patterns.

4.13 Coping mechanism adopted by men

This study sought to differentiate the coping mechanisms to change in climate and variability in relation to different gender groups (Table 4.15).

Table 4.15: Male gender coping mechanisms

Adaptation /Coping strategy	Frequency	% within male Gender
Reduce livestock	9	10.6
Planted trees on farms	12	14.1
Buy food e.g. maize	6	7.1
search for casual jobs	25	29.4
Planting napier grass	6	7.1
Shifting from maize to sugarcane farming	5	5.8
Remittance from relatives	16	18.8
Cultivating variety short term crops	6	7.1
Total	**85**	**100**

Majority (29.4%) of the men reported to seek casual jobs for payment to supplement family income. According to the respondents, majority of men relied on casual employment such as looking after people's farms which doesn't require much skills. Though getting such casual jobs still proved to be difficult due to the limited available prospects in the rural areas, many were still determined to go out of their homes to seek this kind of employment.

According to Kakota et al. (2011), men have more opportunities than women in dealing with the effects of change in climate. Another significant number (18.8%) seek cash from relatives in the urban areas whereas 14.1 % of the respondents have resorted into planting trees on farm for subsistence and commercial purposes. Lack of adequate pastures emanating from lengthy dry periods has forced male small holder farmers (10.6%) to sell part of their livestock as people are not allowed to graze their animals in the forest. However, those with larger pieces of land have resolved into planting napier grass for the animals while others are feeding their animals with alternative feeds such as sugarcane leaves. Some male farmers (5.8%) are diverting from maize

cultivation to sugarcane which can withstand extreme weather conditions and fetches more revenue. Other group of farmers (7.1 %) are engaging in crop diversification targeting short term crops such as cassava, millet and sorghum which are drought tolerant. Similar coping strategies such as buying livestock feeds supplements, selling livestock, planting and retaining trees on farms have been witnessed in the larger western region (Bryan *et al.*, 2010).

4.14 Coping mechanism adopted by women

Comparably, the study sought to establish the coping mechanisms of the female gender as they are believed to be better agents of change in climate adaptation (Table 4.16).

Table 4.16: Female gender coping mechanisms

	Frequency	**% within female Gender**
Energy efficient cooking stoves	15	12.7
Buying firewood	21	17.8
Use of maize stalks for firewood	9	7.6
Search of casual	10	8.5
Skipping meals/reducing no. of meals	20	16.9
Self-help groups (*Chama*)	12	10.2
Remittance from relatives	15	12.7
cultivating short term variety crops	16	13.6
Total	**118**	**100**

Majority of women (17.8%) are purchasing firewood either from the market place or neighbouring homes as an adjustment to scarcity while (16.9%) women resolved to either skipping meals once or even twice a day depending on availability of income. During women FGDs, these strategies were argued to save on firewood use and to limiting number of forest trips in search of the resource. The use of energy efficient cooking stoves constructed out of local clay was praised for saving on firewood and retaining heat. The cultivation of short term variety crops is a preference for 13.6% of women farmers. Diverting into cultivation of different crops that mature within shortest times is much preferable as it reinforce pliability to effects of climate variability. This finding corroborates other studies indicating cultivation of early maturing crops by rural farmers aids in

coping with the unpredictable rainfalls (Speranza, 2010; Mulinya, 2017). Moreover, 12.7% of women depend on cash remittances from relatives while 10.2% have joined self-help groups otherwise known as *Chama*. Even though microfinance institutions and other lending institutions exist, many women in Buyangu are not able to access credit services due to their limited financial capacities to pay up for loans. Women in Buyangu are better off saving their money through the existing *Chama* groups.

4.15 Gender based constraints in coping with climate change.

This study exhibited that actions taken to outsmart effects of fluctuating weather patterns were met by several hurdles heightening gender vulnerability. Unemployment and lack of farm inputs were the core challenges faced by women in the region (Table 4.17).

Table 4.17: Women's challenges in coping with climate change

Constraints	Frequency	Percent
Lack of time of engaging in IGAs	7	6.0
Illiteracy	15	12.7
lack of farming accessories (e.g. fertilizers)	41	34.7
Unemployment	45	38.1
Lack of forest associations to support adaptation	4	3.4
Limited access to credit facilities	6	5.1
Total	**118**	**100**

The above sentiments were echoed during the FGDs where all the participants unanimously agreed that a larger population of women in Buyangu were and poor and illiterate. One female discussant explained as follows:

"Here the major problem is poverty and many people cannot afford to buy fertilizers. We prefer using Diammonium phosphate (DAP) fertilizer on our maize crops but the buying price of this fertilizer is just too high. It's being sold at Kshs. 4,000 per bag in the private shops which is just too high compared to our little income.

This signifies the government inability to successful ensure subsidized fertilizers and seeds reach farmers in good time thereby affecting crop yields in rural parts of Western Kenya (Chianu *et al.*, 2008). Although, chemical fertilizer enhances crop productivity, its application releases unwanted

gases back into the atmosphere accentuating global warming. As land use is critical issue in change in climate solution, efforts to address soil fertility is necessary with more emphasis put on organic manure. It should be noted that overuse of chemical fertilizers causes soil degradation which worsens change in climate as degraded soils cannot store carbon (Sarker *et al.,* 2012).

Moreover, although women are active agents of adaptation, illiteracy hinders the process as many fail to develop the required skills for effective adaptation. For instance, the few women in Buyangu engaged in small trade face poor markets for their products and with their low illiteracy levels, they are incapable of engaging in viable business investment opportunities. Lusimbo and Muturi (2015) also affirmed that illiteracy was the main driver towards poor performances in small and medium enterprises in Kakamega County. Such limitations hinder both individualized and group adaptation (Adger *et al.,* 2007). However, much women might be engaged in adaptation programmes, they would still find it difficult to implement measures provided due to their illiteracy.

4.16 Men's challenges in coping with climate change

The study showed that lack of financial means amongst men acts as a limitation in devising suitable adaptation practices (Table 4.18).

Table 4.18: Men's challenges in coping with climate change

Crop farming	Frequency	Percent
Financial stringency	46	54.1
Small land acreage	14	16.5
Lack of knowledge on adaptation	15	17.6
Lower returns on sugarcane farming	10	11.8
Total	**85**	**100%**

Financial stringency makes it difficult for the peasant farmers to even arrange for the purchase of modern farm inputs such as use of tractors for tillage. The high labour costs incurred by sugarcane farmers coupled with low producer prices on the cash crop is demotivating especially for farmers who had shifted from maize to sugarcane plantation in the sense that the latter crop can withstand changing weather patterns. In addition, small land acreage in the region limits men's efforts of engaging in sustainable agriculture hence the main reason as to why farming has been left to

women. According to Ali and Erenstein (2017), farmers operating with larger pieces of lands are better placed investing in sustainable agricultural practices. But however much men in Buyangu may be trying to cope, lack of finances and poor knowledge on adaptation is already an impediment to successful adaptation.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter sums up the findings of this study, conclusions spelt out and recommendations outlined based on the study objectives. Thereafter, suggestions for future research have been provided.

5.1 Summary of key findings

Temperature trend analyses revealed a warming trend for both mean annual maximum temperatures and mean annual minimum temperatures. With regard to maximum temperatures, the rise was found to be significant at $\alpha = 0.05$ for January, February, September, November and December. The magnitude of the temperature increase as represented by Sen's slope was 0.019^{o}C/year for minimum temperatures and 0.037^{o}C/year for maximum temperatures.

Mean annual rainfall variability (1923-2015) indicated an increase of 0.068mm/year while mean monthly rainfall displayed a decreasing trend. Notable peaks of rainfalls were experienced between 1963 and 1983, whereas significant dips were emerged in 1988 and 2012. With a low coefficient rainfall variation (R^2 linear = 0.193), the cumulative effects of rainfall variability are expected to continue in future with less predictability.

The study revealed that Buyangu community are aware of climate change and variability with 95% reporting increasing temperatures while 75% have experienced declines in rainfall amounts over the past 30 years. This finding concurred with the meteorological data analysis presented on rising temperatures and declines in rainfalls for this region.

The study also revealed that climate change has considerable effects on the livelihoods of Buyangu forest-dependent community with both crop and livestock production as the most affected. Ideally, reduction in rainfalls and increasing temperatures have suppressed animals' pastures compromising milk output, herd sizes and livestock market values. Moreso, crop production is on the decline with maize, sugarcane and vegetables as the most affected crops. Although 44% of the respondents reported decrease in the quantities of forest products over the past years, many respondents could not relate climate change and its impacts on supply of forest products. Many

respondents were of the opinion that the decline of forest resources was purely as a result of overharvesting rather than manifestation of climate change.

However, the study showed that although both gender groups are exposed to climate change risks, women in Buyangu are the most vulnerable groups because of their high dependency on natural resources and they form a large proportion (80%) of small scale peasant farmers. Other that pointed towards women' vulnerability included illiteracy, high unemployment rates, inactive membership on forest groups and low income diversification opportunities.

Coping mechanism evaluation revealed that both gender groups have developed various strategies in the wake of climate change. While majority of men are searching for casual jobs to supplement family incomes, women have joined *chama* groups to boost their finances especially during low crop yield seasons. However, in coping with climate change, both men and women face a number of challenges which hinder their processes of adaptation. Unemployment and lack of farm inputs amongst were the main factors limiting women's capacities to cope losses induced by climate change. Similarly, financial stringency and lack of knowledge on adaptation practices amongst men is an impediment to successful adaptation.

5.2 Conclusions

This study looked at the analysis on the variability of temperatures and rainfalls over long periods of time to establish trends. Results revealed a global warming effect in Kakamega County for the period the climatological period 1980-2015. Both mean annual maximum temperatures and mean annual minimum temperatures are increasing by 0.04ºC/year and 0.02ºC/year, respectively. Moreover, analysis of mean annual rainfall (1923–2015) indicated an increase of 0.068mm/year; however, mean monthly rainfall showed a decreasing trend. This is a very important finding which could work in informing policy makers and local county government when planning for adaptation measures for Buyangu forest-dependent community. The study did not establish what is causing an increase in mean annual rainfalls in the area and yet mean monthly rainfalls analysis indicated a declining trend. Thus, the study would recommend further research on this.

The effects of climate change on livelihoods of Buyangu forest-dependent community were examined. The study revealed that both crop production and livestock keeping are affected. With the increasing temperatures, long dry spells and reductions in rainfall amounts, the community will

continue to suffer serious negative consequences on their sources of livelihoods and this means declines in both household food security and other sources of income.

The study also examined gender vulnerability of men and women in Buyangu in regard to climate change and its impacts on their sources of livelihoods. The findings revealed that as much as both gender groups are affected by climate change, women bear the most brunt. The need to address gender differentiated impacts to climate change is inevitable considering that men and women have to fulfill their gender roles of providing for their families.

Local coping strategies for men and women in Buyangu were evaluated. The study revealed that both genders are struggling to cope with climate change. Both men and women have devised coping strategies that are not sustainable in the long run. It is therefore paramount that all stakeholders on the ground collaborate in promoting adaptive measures that will enhance community's resilience.

5.3 Recommendations

This study has demonstrated that Buyangu forest-dependent community has been significantly affected by climate change. A number of recommendations have been suggested. These include:

1. Buyangu community must be involved in decision making processes together with other stakeholders. Incorporating perspectives of both men and women in Buyangu is important in developing appropriate adaptation strategies that will build community's resilience against extreme climatic conditions.
2. There is need to facilitate greater adoption of climate-smart agriculture technologies for Buyangu forest-dependent community for them to realize food security and productivity of incomes, build resilience as well as reducing GHG emissions. Such practices include provision of high-yielding drought tolerant maize seeds, promoting agroforestry and intercropping.
3. Mechanisms must be put in place by the local authorities in Buyangu to ensure successful transition from coping with climate variability to long term adaptation strategies for any forest dependant community.

4. The best adaptation strategies of Buyangu forest-dependent community be documented for wider circulation, demonstration and replication by similar communities in different regions.
5. Finally, creation of water harvesting and water conservation technologies should be enhanced in Buyangu to overcome water shortages especially during dry seasons. The study recommends reviving of the traditional ways of harvesting rainwater through water tanks placed under the roofs of houses.

5.4 Recommendation for Future Research

More research is necessary in widening understanding of climate variability and gender vulnerability assessment of Buyangu forest-dependent community in Kakamega Tropical Rain Forest. The study recommends further research on the relationship between climate change and health of livestock especially on vector borne diseases in Buyangu. This would give insights on what the community believe to be livestock diseases brought about by climate change.

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APPENDICES

Appendix 1: Questionnaire for household head in Buyangu village, Kakamega County

SECTION A; HOUSEHOLD CHARACTERISTICS

1. NAME OF RESPONDENT (optional) ……
   Location……
   Village……

2. Gender of household head ☐Male ☐Female

3. Age of household head ☐20-30years ☐31-50 years ☐51+ years

   ☐Don't know

4. MARITAL STATUS ☐Married ☐Divorced /Separated ☐Widowed

   ☐Single /Never married

5. Level of Education

   ☐No formal education ☐Primary ☐Secondary ☐College

   ☐University

6. For how long have you lived in this village?

   ☐ Less than 5 years

   ☐ 5-10 years

   ☐ 11-15 years

   ☐ Over 16 years

7. How many are you in your household?
……

Specify no of Children _____boys _____ Girls_____ Adults_____

8. How many of the children are in school? _____

9. Are there any of your children who are school going and are not attending school?

☐Yes ☐No

10. If **YES** above, what are the reasons that they are not attending school?

☐Lack of fees

☐Lack of/inadequate schools

☐Refused to go to school

☐Working

☐Others (Specify)…….

11. What is your type of occupation?

☐ Farmer /peasant

☐Salaried/fixed employment

☐Salaried-contractual

☐Casual labour

☐Small scale businessman/woman

☐None of the above (Specify)……..

12. Do you have access to electricity?

☐Yes ☐No

13. What is your most regular form of cooking energy source?

☐ Firewood ☐ LPG Gas ☐Kerosene

☐Charcoal ☐ others (Specify) ……..

14. What is your type of house?

☐Mud walled /Grass thatched

☐Mud walled/Corrugated Iron sheets

☐Semi-Permanent house

☐Stone walled /Permanent house

☐Others (Specify)……..

SECTION B: Sources of livelihoods

15. What are your main sources of livelihoods? ***Tick as appropriate***.

Source of livelihood	**Tick as appropriate**	**Rank as appropriate, 1 being the most/main source of livelihood**
Crop farming		
Livestock farming		
Micro-business/small scale		
Brickmaking		
Charcoal Burning		
Others(Specify)		

16. **If mentioned crop farming**, state what crops you grow on your farm.

Type of crop you grow	**No seasons per year**	**Cost per season (Ksh)**	**Estimated quantity harvested per season**

17. Which kind of crops do well in your farm?

.....

18. Are you left with any surplus from your crop produce?

☐ Yes ☐ No

19.If **YES**, what do you do with the surplus?

☐ Sell

☐ Share with relatives

☐ Store

☐ Others (Specify)……..

20. Have you experienced any challenges in relation to crop farming?

☐ Yes ☐ No

If **YES**, what are the challenges?

……
……
……

21. If mentioned Livestock farming, state type of livestock farming you do, the number you own and value of your livestock

Type of livestock farming	Type of Breed	Total Number	Approximate value (Ksh)
Dairy farming			
Beef farming			
Mixed livestock(goats ,sheep, pigs)			
Poultry farming			
Others ……..			

22. If **mentioned dairy farming**, how many litres of milk do you produce per day?

.....

23. What do you do with the milk you produce?

☐ Consume all of it ☐ partly consume and partly sell

☐ Sell all milk How much per litre?

.....

24. Have you experienced any problem with livestock farming?

☐ Yes ☐ No

25. If **YES**, what are the challenges?

.....

.....

26. If mentioned **small scale business,** how much do you make per day?

.....

27. What do you do with your daily earnings?

.....

.....

28. Do you have any challenges with your small scale business?

☐ Yes ☐ No

29. If **YES**, what are the challenges?

.....

.....
.....

30. If mentioned **brick- making,** how much are your earnings per day?

……
……
……

31. What do you do with your daily earnings?

……
……
……..

32. Do you have any challenges encountered in brick-making?

☐ Yes ☐ No

33. If **YES**, what are the challenges?

……
……
……
……
……

34. If mentioned **charcoal burning**, how much are your earnings per day?

……

35. What do you do with your daily earnings?

……
……
……

36. Do you have any challenges encountered in charcoal burning?

☐ Yes ☐ No

37. If **YES**, what are the challenges?

……
……
……

38. Other than main sources of livelihood and occupation mentioned, what are other sources of your finances? **(Tick as many)**

☐ Social protection for elderly ☐ Remittance from children

☐ Remittance from relatives ☐ Remittance from friends

☐ CBOs and NGOs ☐ Others ((Specify)……..

39. What is the total area of land that this household owns?

☐ Less than one acre ☐ 1-3 acres ☐ 4-5acres ☐ 6-10 acres

☐ over 10 acres

40. What is the main use of land?

☐ Agriculture/crop production

☐ Tree cover

☐ Grazing for livestock

☐ Fallow land

☐ Homestead

SECTION C: Household dependence on forest and tree-base systems

41. Do you have access to the forest? ☐ Yes ☐ No

42. How far is the forest area from the house/measured in terms of distance…….. (Km) measured in terms of time (in minutes walking) …….. (Min)?

43. Which commodities/products do you go to collect from the forest?

Type of forest product collected (*Tick as many)*	**Frequent of collection**	**Quantity collected per specified frequency**
Firewood		
Grass for the animals		
Medicinal Herbs		
Honey		
Mushrooms		
Wild Fruits		
Indigenous Vegetables		
Ropes (tying)		
Roofing grass(Thatch)		
Others(specify)		

44. Who frequently uses the forest resources in your area?

☐ Men ☐ Women ☐ Elderly

☐ (Specify)……..

45. What have you observed in terms of supply of these products over the past years? **(Say 10-20 years ago).**

☐ Increasing

☐ Decreasing

☐ No change

46. If it has **increased**, what could be the causes for these changes?

……
……
……

47. If it has **decreased**, what could be the causes for these changes?

……
……
……
……..

48. Who are most affected with **decrease** of forest resources?

☐ Men ☐ Women ☐ Children ☐ Elderly

49. How do you cope with decrease on forest resources? (e.g. firewood)

……
……
……
……
…….

50. What challenges do you face with regard to access of forest products?

…….
……

51. Which are the main type of trees in your farm?

…….
…….

52. Why do you prefer the tree species mentioned above?

…….
…….

53. What is the major use of trees in your farm?

☐ Firewood

☐ Timber

☐ Shade

☐ Boundary

☐ Others (Specify)……

54. Apart from collection of forest products, are there **any other services** you enjoy from the forest?

☐Yes ☐No

55. If **YES**, which kind of forest services do you enjoy?

☐ Recreation

☐ Prayer and worship

☐ Circumcision rites

☐ Other Services (Specify)……

56. Who frequently uses the services mentioned above?

☐Men ☐Women ☐Youth (Boys &Girls) ☐Both men & women

☐Elderly

SECTION D: Climate change

57. Have you experienced climate change in this region?

☐Yes ☐No

58. If **YES**, explain

……
……
……
……

59. Have you noted any changes in temperature and rainfall in your area?

☐ Yes ☐ No

60. If **YES**, how could you describe the temperature changes?

☐ Increasing

☐ Decreasing

☐ Not Sure

61. If **YES**, how would you describe the rainfall patterns?

☐ Increased ☐ Decreased ☐ Same/unchanged

☐ Unpredictable

62. Have your sources of livelihoods been impacted by changes in weather patterns?

☐ Yes ☐ No

63. If **YES**, state the source of livelihood and explain how it has been affected by climate change impacts.

Source	**Impacts**

Section E: Coping mechanisms

64. What adjustments have you made in your livelihoods to these long shifts in temperatures and unpredictable rainfalls?

.....
.....

65. Are there any social forest groups/associations in your locality that help you in access / use forest resources in a sustainable way ?(e.g. provision of tree seedlings)

☐Yes ☐No

66. If **YES**, name the forest group and state how they assist you?

Type of forest group	**Services offered**

67. Do you have access to climate information/rainfall forecasts?

☐Yes ☐No

68. If **NO,** please, specify the reason……
……..

69. If **YES,** from what source do you get the weather information?

☐Radio

☐Community meetings (Barazas)

☐Community Elders

☐Others (Specify)…….

70. Does the information help you in planning your land use activities?

☐Yes ☐ No

71. If **YES** how and why?

……
……..……
……

72. Do you have access to market for agricultural and forest products?

☐ Yes ☐ No

73. If **YES**, how far is it from your village in _____Km _____ (Minutes taken)

74. Which is your regular means of transport to the market place?

☐ Walking

☐ Motor Bikes (Boda boda)

☐ Matatu

☐ Others (Specify) ……..

75. Finally, are there any other issues you would like to say with regards to forests/ trees and environment in this area?

……
……
……
……

Appendix 2: Focus Group Discussion Guide

1. Please let us discuss the general view of climate change in this area over the past 30 years.
2. How have these climatic changes affected your sources of livelihoods?
3. How has the supply of forest products been over the past years?
4. Which types of forest resources do men and women collect from forests?
5. Who are the most forest frequenters (between men and women) in search of forest resources?
6. What are your major challenges in accessing forest resources?
7. Who are the most vulnerable groups (men or women) to climate variability?
8. What factors make a particular gender group more vulnerable than the other?
9. How are men and women coping with climate variability in this place?
10. What are your major challenges in coping with climate variability?
11. Are men and women working together to address these challenges? If yes, how?
12. Which roles do forest groups/associations play in your area? Are you satisfied with their services?
13. How can you be better equipped to deal with climate variability affecting your sources of livelihoods?

THANK YOU

Appendix 3: Observation checklist

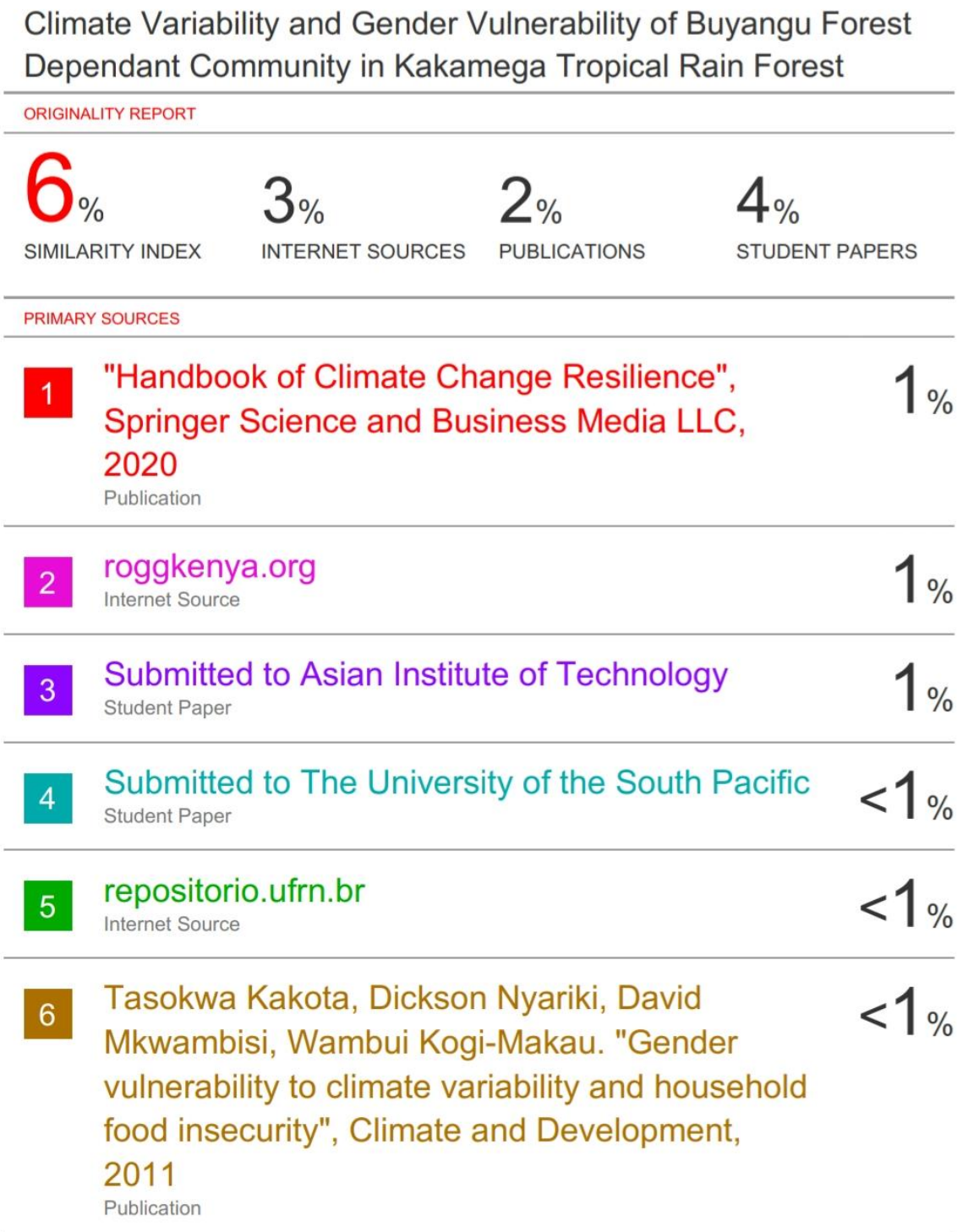
1. Surrounding of Buyangu community
2. Types of socioeconomic activities in the area
3. Types of house lived in
4. Forests products on site
5. Types of forage available
6. Common tree species on homesteads
7. Livestock breeds

Appendix 4: Selected pictures during data collection in Buyangu

Key:

1. A tree felled by heavy rainfall(hail storm)
2. Brick making process
3. Energy saving cook- stoves
4. Houses thatched with grass from the forest
5. Medicinal tree barks harvested from the forest
6. Men's Focus Group Discussion
7. Women's Focus Group Discussion

Appendix 5: Plagiarism checker Report



Climate Variability and Gender Vulnerability of Buyangu Forest Dependant Community in Kakamega Tropical Rain Forest

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