THE ROLE OF FOREST COVER IN LANDSLIDE RISK REDUCTION IN MARAKWET EAST ESCARPMENT, ELGEYO-MARAKWET COUNTY, KENYA.

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DECLARATION

This project is my original work and has not been presented to any other institution.

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DEDICATION

To my parents-Mr. and Mrs. Cherop, my sisters -Gloria and Abigail, and my brothers- Kelvin and Victor.

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ABSTRACT

This research was conducted in Marakwet East Escarpment, Elgeyo-Marakwet County, which extends across Tirap and Tot divisions in Marakwet East sub-county. The frequency and magnitude of landslides in this area are responsible for various adverse social, economic, and environmental impacts including loss of human life, loss of property, and destruction of infrastructure.

The main goal of this study was to analyze the role of forest cover in Landslide Risk Reduction in the region. The study addresses four specific objectives: To determine the trend of forest cover change in the past 20 years (2000-2020), to determine the frequency of landslide incidences in the past 20 years (2000-2020), to assess the extent to which the local community is aware on the role of forest cover in landslide risk reduction and, to analyze the perception of the local community on forest cover support to landslide risk reduction.

The study employed the use of questionnaires, interviews, and field observation methods to collect data from a random sample of 385 residents, which were analyzed by use of texts and statistical methods. Quantitative data were analyzed using descriptive statistics with the aid of SPSS and Microsoft excel, while qualitative data were analyzed using themes based on similarities and differences. Hypothesis testing was done using simple linear regression.

Results and findings show that the Marakwet East Escarpment lost 390.53 ha of forest cover between 2000 and 2020, translating into a loss of 19.53 ha per year. In the same period (2000-2020), landslide frequencies increased from zero landslides per year between the years 2000 and 2009 to at least one landslide event per year except for years 2012, 2015,2016 2017, and 2018 between 2010 and 2020. The area residents are aware and optimistic of the role of forest cover in landslide risk reduction with 62.50% being confidently aware and 64.29% perceiving it to be very important.

This study concluded that forest cover loss has played a major role in increasing the frequencies of landslide occurrence. Besides the community is aware and positive of the role of forest cover in landslide risk reduction though poverty levels push them to deforestation. The study recommends the development of policies, programs, and institutions on forest protection, conservation, restoration and management, forestry to be made one of the land-uses in the area, and research on sustainable management of forests.

ABBREVIATIONS AND ACRONYMS

DRR - Disaster Risk Reduction

FAO - Food and Agriculture Organization

GDP - Gross Domestic Product

IPCC - Intergovernmental Panel on Climate Change

KFS - Kenya Forest Service

LRR - Landslide Risk Reduction

LUP - Land Use Planning

MEA - Millennium Ecosystem Assessment

NGOs - Non-Governmental organizations

SDG - Sustainable Development Goal

SPSS - Statistical Package for Social Science

UNEP - United Nations Environment Program

UNFCCC - United Nations Framework Convention on Climate Change

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CHAPTER ONE: INTRODUCTION

1.1 Background

Landslide is a type of mass wasting that involves a mass movement of earth, rock, or debris down a slope due to a direct influence of the force of gravity (Cruden, 1991). They mainly occur in mountainous and hilly slopes where human activities such as deforestation have escalated, making them vulnerable to landslides (Forbes and Broadhead, 2011). During landslides, materials move downslope either by falling, sliding, toppling, or flowing, which translates to their varied effect and impacts (Kappers et al, 2012). In Kenya, major landslides have been reported in counties such as Kakamega, Murangá, Nyandarua, West Pokot, and Taita Taveta. According to (GOK, 2019), recent (especially from the year 2018 to the year 2020) landslides were triggered by prolonged and intense rainfall, driven by the phenomenon known as the Indian Ocean Dipole.

The root causes of landslides lie in both changes in natural and anthropogenic (human-induced) activities that alter topography, geology, and climatic conditions. Human-induced factors contributing to landslides include increasing urbanization, environmental degradation, and population growth (Schuster and Highland, 2001; Forbes and Broadhead, 2011; Petley et al.2005a). Landslides are usually triggered by factors such as heavy and long durations of rainfall (Central Weather Bureau, 2004) or even seismic waves (Keefer, 1984). They are made worse, especially in steep slopes with human activities such as settlement, farming activities, and deforestation, which jeopardize the stability of the slope hence making it susceptible to landslides (Weatherly, 2004; Temple and Rapp, 1972).

The frequency of landslides and their impacts have been growing worldwide, especially in developing countries, attributed to accelerating development (Geest and Schindler, 2016). Additionally, the developing world has large proportions of populations that are poor and depend on the exploitation of natural resources for their livelihoods. Resources are often overexploited to sustain the rapidly growing population (Forbes and Broadhead, 2011; Msilimba, 2012)

Landslides are one of the most acute hazards, although their impacts are usually under-represented (Hewitt 1997). They have been ranked as the 7th most deadly hazard (Petley, 2012), and a threat to the achievement of Sustainable Development in many countries around the world. The social, economic, and environmental costs of landslides run into hundreds of millions of dollars every year (Knapen et al. 2006). An example of this is that landslides have contributed to reduced Gross

Domestic Product (GDP) and triggered an economic decline in Rwanda, Kenya, Cameroon, Ethiopia, Ethiopia, and Tanzania in Africa (Muwanga et al., 2001; Knapen et al. 2006; Westerberg and Christianson, 1998; Toya and Skidmore 2007). Loss of lives is one of the significant impacts of landslides (Ngecu and Ichangi, 1999). After landslides, there is a displacement of people where they will find starting life in a new area much complex hence taking long to realize economic development and adaptation to the new environment (Geest and Schindler, 2016). Other impacts of landslides include: the destruction of infrastructure such as housing, roads, bridges, railway lines, and electric lines (Geest and Schindler, 2016; Gori et al. 2003), destruction of worship sites (Pethey, 2018; Geest and Schindler, 2016), burial grounds, schools, water supplies (Standard Media, 2012); and loss and damage of land as fertile soil is moved away leaving the land barren as well as crop destruction (Geest and Schindler 2016; Govt of Nepal set al. 2008).

Managing landslides draws from approaches that either see solutions in technology or nature itself. Landslide risk reduction emphasizes community actions, improved governance, reducing external dependence, enhancing preparedness and self-reliance (Rawat et al., 2012). Technology-based approaches use engineering-based solutions such as the construction of barriers to help control the downslope movement of slope materials in Landslide-prone areas. These approaches are in most cases, short-term solutions, hence requiring ecosystems to reinforce them (Rawat et al. 2012, Murti and Renaud 2013). Ecosystem management is usually multi-dimensional hence requires an inter-disciplinary approach. A nature-based system is most suitable as it includes the development of principles, tools, and strategies that enhance ecosystem services thus reducing the susceptibility of the area to Landslide. Forest management helps in the control of Landslides since it is capable of reducing physical exposure by acting as a natural barrier, and their roots hold soil particles, making a slope less susceptible to landslides. These ecosystems, especially the natural ones, are the most reliable in the reduction of probabilities of landslide occurrence (Dolidon et al. 2009). These ecosystems also help in reducing the social and economic impacts associated with landslides hence sustaining human livelihoods.

Well-managed forests make communities more resilient to landslide and their impacts because they can quickly recover from this hazard when compared to those in degraded sites. They help in the recovery process from disasters as they provide goods and services required during recovery periods such as food, fuel, and even pasture (UNEP,2010; MEA, 2005). Forest diversity affects their performance, which determines the intensity and frequency of the disaster (IPCC, 2007).

1.2 Statement of the research problem

Landslides in the Marakwet East Escarpment have adversely impacted people, the economy, and the environment with far-reaching consequences. They have stagnated, retarded, or erased many years of development even as no approach seems to have brought a lasting solution. The landslide problem has been attributed to factors such as the steep sloppy terrain of the Marakwet East Escarpment, a fast-growing human population, a significantly high amount of rainfall, declining land cover, and unsustainable farm practices (Kilimo, 2014). In particular, human encroachment on forests has been cited as the most important influencer of landslide incidences.

Landslides have caused untold loss to residents of the Marakwet East Escarpment. For example, in the year 2020, landslides events alone killed more than 15 people in the escarpment besides causing property loss worth millions of Kenyan Shillings. Apart from the loss of lives, other losses have included displacement of people, missing persons (often presumed dead), physical injuries, mental trauma, loss of crops, and damage of social and transport infrastructure (Kipkura and Kakai, 2020). A major landslide can mean wiping out many years of development leaving the affected community in dire need of the aid of reconstruction and recovery.

Although landslide risk reduction measures such as the construction of retaining walls have been used before, these have been generally short-term solutions. Experiences from other parts of the world have confirmed that sustainable solutions to landslides lie not in technology but in nature itself (Rawat et al. 2012). Hence, nature-based solutions are currently gaining much traction among scientists, policy makers, and practitioners around the world. Nature-based approaches to landslide risk reduction require the use of natural infrastructure to address natural hazards. For example, vegetation such as forests can help in binding the soil particles hence making slopes less prone to natural forces that trigger landslides (Choi and Cheung 2013). This study investigated the role of forest cover in providing a lasting solution to landslides in the Marakwet East escarpment. The study argues that sound management of forests compelled with the right actions from the local communities can be the much-sought-after solution for the landslides of the Marakwet East Escarpment. The findings of the study should not only be useful to the county government of Egeyo-Marakwet but also as a trigger of new lines of discourse in landslide management in Kenya. The study also contributes to the aspiration of Kenya's Vision 2030, Big Four Agenda, and SDG (Sustainable Development Goal) 11.

1.3 Research questions

The study set out to answer four questions for Marakwet East Escarpment

i. What has been the trend of forest cover change in the past 20 years (2000-2020)?
ii. What has been the frequency of landslide incidences in the past 20years 2000-2020)?
iii. How is the local community aware of the role of forest cover in Landslide Risk Reduction?
iv. What is the perception of the local community about the role of forest cover in Landslide Risk Reduction?

1.4 Study objectives and hypotheses

The general objective of the study was to analyze the role of forest cover in landslide risk reduction in the Marakwet East Escarpment region.

The specific objectives of the study were:

i. To establish the trend of forest cover change in the past 20 years (2000-2020);
ii. To determine the frequency of landslide incidences in the past 20 years (2000-2020);
iii. To assess local community awareness on the role of forest cover in Landslide Risk Reduction, and;
iv. To analyze the local community perception of the role of forest cover in Landslide.

The study tested the following hypothesis;

H_0: There is no relationship between forest cover change and landslide occurrence in the Marakwet East Escarpment.

1.5 Significance and justification of the study

Marakwet East Escarpment is a mountainous region that experiences torrential rainfall, making it vulnerable to landslides. Human population pressure on the environment has been increasing due to climate change and rising population, a situation that is also widely believed to significantly contribute to landslide phenomena in the region. Also with the increasing population, people have been settling on the more ecologically vulnerable areas, which has raised the probability of more landslides in the future.

Landslide hazard has caused many impacts, including loss of lives, destruction, and loss of property, destruction of infrastructure, and loss of fertile soil for agriculture, and damage of housing. These have greatly affected social, political, and economic dimensions of life hence impacting human livelihoods. Landslides have also contributed to increased conflicts, especially as people move to newer places. Recovering from landslide disasters is very expensive as it affects the economy from the household level to the national level hence enhancing poverty.

This study generated empirical evidence on ways that nature-based approaches can contribute to landslide risk reduction. The study was premised on the thinking that nature-based methods can be affordable and easily adoptable by local communities in addressing the landslide problem. The study findings can also be used by authorities (government and non-Government) in shaping policy for mainstreaming Disaster Risk Reduction (DRR) approaches.

1.6 Study limitations

The major limitation that was experienced during data collection was the unwillingness of the residents to take part in the process. Most of the residents especially those who had encroached to the forests were not ready to give information thinking that data was collection was done for them to be chased out of the forests. The researcher had to convince by clearly giving the motive and the objective of the research. The researcher also asked for some assistance from the community leaders who helped in mobilizing the residents.

Besides, some of the areas became insecure due to inter-community conflict between the Pokot and Marakwet communities. The area along the border of the two communities was affected and the researcher has to spend a shorter time than the intended time. This data was complemented by the data that was collected in other parts of the escarpment.

Additionally, most of the areas in the escarpment are inaccessible hence could only be accessed by foot. This prolonged the data collection process and the financial problems to be experienced. The researcher took advantage of gatherings such as churches and schools to collect data. This enables the collection of data from a larger number of people within a short time.

1.7 Scope

This study concentrated on the analysis of the role of forest cover in Landslide Risk Reduction in the Marakwet East Escarpment and analyzing the extent to which forest cover change was related to the occurrence of landslides in the area. Besides landslides, the study did not address other disasters, hence data analyses were limited to the relationship between forest cover and landslide risk reduction.

Geographically, the study was carried out in the Marakwet East Escarpment, which extends across Tirap and Tot Divisions of Marakwet East Sub- County. The study did not cover the wider Elgeyo-Marakwet Escarpment therefore the findings are specific to this study area.

2.0 CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Landslides are caused by natural and anthropogenic activities, environmental degradation, geological conditions, climatic conditions, and population growth. This disaster is common throughout the world. In most cases, it occurs with little or no warnings and is continuously becoming complex, of high magnitude, and also of increased frequency. They pose a lot of impacts, including environmental, social, and economic impacts hence becoming a barrier to the achievement of sustainable development (Toya and Skidmore, 2007). This disaster has been mostly experienced in the developing countries hence lowering their Gross Domestic Product (GDP) (Disaster Management in India, 2011).

On 18th October 2019, an entire family of four lost their lives after they were buried by landslides in the Marakwet East Escarpment (Kipkura, 2019). On 19th April of the following year 2020, another landslide event caused the deaths of more than 15 people, displaced 4000 people with more than 50 people missing, including police officers, while others were critically injured. Property loss included animals, an entire shopping center destroyed as well as; destruction of an entire school, a police station, crops, houses, and damage of infrastructure (roads, and electric lines) (Kipkura and Kakai, 2020). These events depict a later part of the history of landslide disasters in Marakwet East Escarpment that needs redress.

For the Sendai Framework (2015-2030) Goals to be achieved, multi-hazard and multi-sectorial approaches for Disaster Risk Reductions are required. These approaches will help in enhancing work for reduced exposure and vulnerability to Disasters. Corporation from the local, through regional to global levels, is very vital for the realization of this goal. Effective Disaster Risk Reduction is critical as far as achievement of the Sustainable Development Goals to be achieved.

2.2 Nature-based solutions in Managing Landslides

Managed forests help in the management of landslides in that vegetation cover such as vegetation can help in reducing physical exposure by acting as a barrier, hence minimizing the impacts that could be caused. Ecosystems, especially the natural ones, help in reducing the probability of landslide occurrence (Dolidon et al., 2009). Nature-based Disaster Risk Reduction (DRR) solutions usually complement conventional engineering measures. They help communities to understand their vulnerabilities and seek locally available solutions to them. These techniques help in promoting gender equality and social equity from local to global levels. Besides, nature-based techniques help

communities to prepare for, cope with and recover from Disasters such as landslides and additionally protect these communities from secondary impacts associated with disasters. Additionally, nature-based Disaster Risk Reduction measures generate local employment and hence promote economic opportunities and development.

Livelihoods of people depend on the environment for goods and services though ecosystems are facing pressure due to unsustainable utilization, making them vulnerable to disaster, which hence becomes a barrier to poverty alleviation (Rieux et al). Ecosystems need to be used and managed sustainably for risks and vulnerabilities to be reduced (UNISDR,2005). Ecosystems provide services that include; provisioning, supporting, regulating, and cultural. All these services are essential for our well-being and that of the environment. Regulating services for example plays a critical role in reducing risks to disasters as well as recovery from disasters (MEA,2005). Additionally, conservation, restoration, and management of ecosystems need to be sustainable to help reduce risks to landslide disaster risk occurrence through enhancement of provisioning services hence enhancing livelihood resilience (PEDRR,2010), though they can sometimes be difficult as they should pave the way to infrastructure including settlement (Renaud and Radhika Murti, 2003), especially when population grows.

People tend to move to places with a high population to support their various activities such as agriculture, which tend to exert pressure on the environment because of the need for food and other services hence contributing to environmental degradation, which makes the land much susceptible to landslides (Rop, 2011). Deforestation has been done to provide more land for settlement and also for carrying other activities such as agriculture to feed the growing population. The landless people are forced to seek other alternative sources of livelihood which include harvesting forest products for sale and also firewood (Michael, 2012). With all these pressures on land and natural vegetation, the soil is left denuded and vulnerable to landslides.

While modern-day frequency, magnitude, and severity of landslides have been linked to climatic change phenomena, most suggested solutions are related to strengthening the natural infrastructure (Renaud et al.,2016). The previously used approach to landslide risk reduction is the structural approach has been the use of structures, such as retaining walls are constructed (Japan Landslide Society, 2008; Popescu, 2001; DOE, 1994), which (Choi and Cheung, 2013) argues that they require reinforcement from the ecosystem to make them more effective. The nature-based

approach remains the surest answer to landslides around the world. (Rawat et al. 2012) argues that nature-based approaches are much cost-effective, practicable and are a long-term solution to landslides risk reduction.

Ecosystem management for landslide reduction is faced by limitations which include limited or lack of knowledge such as science and economic valuation as well as best practice and understanding the role of the ecosystem in disaster risk reduction. Additionally, there is a need to understand how better natural and engineered infrastructure works (Renaud and Radhika Murti, 2003).

2.3 The role of forest cover in Landslide Risk Reduction

Forest cover plays a vital role in landslide risk reduction. In the past, people used to clear forests and bushes by burning, where they converted these lands to be pasture lands and lands for cultivation. Forests usually help in holding the soil structures, therefore, protecting the soil from soil erosion at the same time they help in enhancing evapotranspiration. Trees act as a physical barrier hence reducing the possibility of occurrence and in case they occur, their speed and effects will be low (Forbes and Broadhead, 2011, Guthrie et al., 2010).

Due to forest clearing, soil particles are not held together and at the same time, water absorption is reduced, making the soil saturated with water hence reducing their cohesion. This makes the soil loose and can easily be moved downslope by the force of gravity (Crozier, 2005). When forest lands are converted to croplands, the depths of roots are reduced from the usual hence, a longer depth of soil is left loose (Forbes and Broadhead, 2011; Dolidon et al., 2009). Improper vegetation usually worsens the situation of landslides when the natural vegetation is replaced with imported trees such as cypress, willow, and turpentine. These trees do not have roots that retain water and at the same time, they prevent undergrowth hence making the soil much susceptible to landslides (Tariq and Gomes, 2005).

Forests help in improving drainage while at the same time strengthening shallow soils (Sidle et al.,2006), whereby roots penetrate the whole soil mantle hence providing anchorage on the slope. Land uses especially those with little consideration of engineering standards tend to contribute to

slope instability, and the situation is usually made worse when the process involved the clearing of vegetation (Siddle et al 2006).

Most regions are deforested to allow space for agricultural or other activities that have been shown to trigger landslide events (Glade 2003; Marden and Rowan, 1993). Based on various spatial data, more than 60 % of landslides occur in non-forested areas hence supporting the relationship between forest harvesting and landslide occurrence (Sidle, 1992). Landslides are directly related to the size of land deforested (Schmaltz., 2017), supported by Spatio-temporal effects addressed in several studies. Trees help in stabilizing slopes through root anchorage in the underlying soil mantle is mostly dependent on the tree's species, age, and substrate (Ghestem et al., 2011). Additionally, as indicated by areas that lost their canopy coverage, rainwater easily infiltrates and saturates the soil, resulting in decreased cohesion forces of roots leading to reduced slope stability (Sidle and Ochiai., 2006).

2.4 Trends on forest cover and their influence on landslide risk

2.4.1 Global and regional trends on the relationship between forest cover and landslides

Most parts of the world with steep slopes, vulnerable soils, heavy rainfall, and frequent earthquakes experience landslides. These are mainly made worse by the development of infrastructure, population growth, farming activities, deforestation, and settlement. These landslides are primarily occurred as a result of slope instability due to saturation by water, undercutting, and removal of vegetation (Crozier, 2005; Kenvironews, 2007).

Global forests have significantly reduced due to factors such as wildfires, e.g., in Asia and Australia, extreme rainfall events, and climate change. In Asia, deforestation is mainly driven by the need for land for subsistence, commercial and industrial agriculture. This is also a common scenario in Thailand, where forests in sloppy areas are deforested to provide ground for agricultural activities. Deforestation in the Philippines, on the other hand, is driven by illegal logging and land conversion (Forbes and Broadhead, 2013). The worst case is in the African forests where forests are cleared mainly by logging activities, need for land for agriculture, need for wood fuel, and need for land to settle the growing population (FAO, 2017)

Loss of forests, mainly in East Africa, has greatly increased since 1990, where approximately 1.5% of the total forest in the region was lost. An example in the 1990s is Tanzania which lost about 41,2000ha per annum, which is about 1.1% of the whole forest cover in the country (Iddi, 2009; Kisinger et al., 2012; Blomley, 2009). The direct causes of forest loss are booming agricultural activities, wildfires, overgrazing, charcoal making, over-reliance on fuel wood, and lack of land use planning (FAO, 2015, Kisinger et al.,2012). The regional population is significantly increasing at about 2.7% per annum due to low mortality and increased fertility immigration, and extension of markets e.g., in Kenya and Sudan (FAO, 2017). This has led to the need for more resources to sustain them, hence contributing to activities such as forest clearance to give land for farming and settlement.

Other activities that contribute to forest loss include, construction of new settlements, brick making, which requires firewood and livestock grazing, and browsing, which removes seedlings and reduces the capacity of regeneration (FAO, 2018). Additionally, civil unrest (e.g., Burundi in 1993) where both natural and planted forests were destroyed to provide fuelwood for refugees, military, and rebel groups (Hobby and Knausenberger, 2003).

Besides reducing forest cover, some countries such as Rwanda and Burundi have gained forest cover by planting forests. Rwanda added 1.7% annually since 1990 while on the other hand, Burundi increased 72 ha in 2010 and 23 ha in 2015. This is a great effort as it helps to cushion people and their livelihoods from disasters, including landslides (Rurangwa and Nduwamungu, 2016; FAO, 2015).

2.4.2 Local trends in forest cover change

Forest cover in Kenya has reduced significantly on Kenya's major water towers, including Mt. Kenya, Mau Forest, Aberdare ranges, Mt. Elgon, and Cherangany hills forests. The total loss of forests in Kenya accounts for about 15 % of the whole forest cover in the country. This forest cover loss increased continuously from 1995 (Kenya's Ministry of Environment and Forest, 2018; UNEP,2004). This translates to various hazards such as landslides, that their frequencies and magnitudes are increasing in Kenya.

These losses in forest cover are being driven by population pressure, politics, and failure to implement forest policies (Mugagga et al., 2011). Forests are a source of livelihoods to many Kenyan citizens, either directly or indirectly (Kenya's Ministry of Environment and Forest, 2018). Forest losses have been a result of croplands and grazing to the forest ecosystem, forest fires, need for forest

products such as timber, charcoal, and wood fuel (UNEP, 2008). Degradation of forests alters the soil hydrological conditions of slopes leading to saturation, and hence debris flow and slides are triggered (Mugagga et al., 2011).

Elgeyo-Marakwet county host the second largest (37.6%) forest cover in Kenya. This is majorly constituted by Cherangany hills forest and Kaptagat forest. Embobut forest is one of the forests of Cherangany hills forest. This forest is found in the Marakwet East escarpment. This forest has been greatly deforested since 1979, and approximately 16% of the forest cover here has been lost. Deforestation has greatly been driven by population increase, which has led to the expansion of settlement and roads, crop farming, and livestock keeping (Chebet et al.,2017; Ndegwa and Kilimo 1989)

2.5 Land use activities threatening forests and their influence on increasing landslide occurrence

Land use has been considered a global environmental issue. It is usually driven by the need to provide food, energy, fiber, shelter, and other infrastructure. Although land-use activities vary in different parts of the world, the ultimate result is usually degradation of the environment. The population is the more significant driver of the pressure is put in the biosphere hence jeopardizing the capacity of ecosystems such as forests to sustain its ecosystem's services (Foley et al., 2005). These activities contribute to a reduced carbon sink, which contributes to climate change with conditions such as a change in local meteorological conditions ((Petley et al., .2005a; Foley et al., 2005).

Logging is an activity that is mainly done for commercial purposes and sometimes for subsistence use. Timber from the forests can be sold in the markets or used locally in fences constructions as well as constructions of houses (Foley et al., 2005; Michael, 2012). Forests usually help in holding the soil structures, therefore, protecting the soil from soil erosion, at the same time they help in enhancing evapotranspiration. Trees act as a physical barrier hence reducing the possibility of occurrence and in case they occur, their speed and effects will be low (Forbes and Broadhead, 2011). Due to forest clearing, the soil particles are not held together and at the same time, water absorption is reduced, making the soil saturated with water hence reducing their cohesion. This makes the soil loose and can easily be moved downslope by the force of gravity (Crozier, 2005).

Charcoal burning is happening in most forests especially in developing countries where charcoal is a major source of energy. This activity contributes to cutting down trees for their production. It contributes to the release of greenhouse gases into the atmosphere and can also be a source of human-induced fire, which worsens forest damage (DeLuca and Aplet, 2008; Forbes et al., 2006).

Agricultural activities are putting pressure on forest cover. Large tracts of forests have been cleared to allow space for food production. This was greatly accelerated by the coming up green revolution technologies, which caused damages such as enhanced soil erosion, reduced soil fertility, and overgrazing to the environment (Foley et al 2005). This has been made worse by practices including improper construction of terraces and inappropriate cropping systems (Gurung et al, 2013). Landslides occur when soil pores become saturated with water and slide overpower the vertical component (Ray and De Smedt, 2009; and Ayieko, 2018).

Infrastructure development is another land use activity taking place in the forest cover. Due to population pressure, a lot of housing and roads among other infrastructure are usually required. This is putting pressure on forests because vegetation needs to be cleared (Foley et al., 2005). Some people are also forced to settle in vulnerable areas at steep slopes, which are in most cases not planned (Schuster and Highland, 2001, Foley et al 2005).

Urbanization is a great threat to forest cover, especially in developing countries where most of their urban areas are poorly planned. A lot of urban sprawls and having slums contributes to this as most people settle in fragile places such as the wetlands, forests, and also in marginalized areas such as steep slopes. Most of the vegetation is cleared and converted to the urban built environment, to accommodate the rising population in urban areas and also industrial activities. Due to this, sewages are not planned and can result in saturation of the soil and at the same time, much pressure on the marginalized steep slopes, which make the land vulnerable to landslides. In addition to this, a lot of buildings and many exert pressure on the slopes (Schuster and Highland, 2001).

2.6 Population and its influence on increasing landslide occurrence

According to (UNFPA, 1998), there is an estimation that the global population is increasing by about 300 million people per year, where about 95% of this increase happens in developing countries. Most of the people in these regions of the world depend directly on the environment for food, fuel, timber, and other resources. In addition to this, the levels of affluence lead to higher

demand for the resource causing a lot of pressure on the environment leading to pollution and environmental degradation.

Population increase is a major factor that is speeding up and at the same time worsening the frequencies of landslide occurrence and their impacts (Vernes, 1981). With population growth, the land is usually fragmented into smaller portions that cannot allow people to construct their houses as well as carry out various activities such as crop farming and livestock keeping. They are forced to cultivate their small pieces of land all year round to maximize their yield, which is different from earlier times when there were large pieces of land, and people could practice shifting cultivation. Most of the lands also need to be irrigated because food required by the growing population exceeds food produced by rain-fed farming (Birot, 1960).

People tend to move to places with high rainfall to support their various activities such as agriculture. These activities exert pressure on the environment hence contributing to environmental degradation, which makes the land much susceptible to landslides (Rop, 2011). Deforestation has been done to provide more land for settlement and also for carrying other activities such as agriculture to feed the growing population. The landless people are forced to seek other alternative sources of livelihood which include harvesting forest products for sale and also firewood (Michael, 2012). With all these pressures on land and natural vegetation, the soil is left denuded and vulnerable to landslides. More people are forced to live in vulnerable areas such as fragile ecosystems and the sloppy marginal area and also carry out various activities. This makes more people be at a higher risk of experiencing the impacts caused by landslides (Alexander 2005).

With the growing population, there is a need for a lot of infrastructures; hence, excavation of land for building houses as well as a road (Michael, 2012). This decreases the hill slope stability; hence, when heavy rains occur, the areas become saturated with water, and with the force of gravity, they become vulnerable to landslides. In addition to this, the human population increase has led to increased pollution and release of greenhouse gases, which pollute the atmosphere hence leading to global warming and climate change. This hence worsens the situation of landslides as the patterns of weather are interfered with.

2.7 Significance of local community awareness and perception

When forests are managed, landslide risk is usually reduced in two ways. Firstly, it helps in the mitigation of impacts of landslides, and secondly, it helps in the provision of a productive

ecosystem that is sustainable and enhances the recovery of people after the disaster (Rieux et al) Although dwellers are aware of the disaster, disaster control, adaptation, mitigation, and management are still being less prioritized (Gurung et al 2013). The lack of technical and financial capability to cope with the disaster hence makes life vulnerable. Improved knowledge is key to understanding the causes, frequency, magnitude, and also management skills together with its mitigation (Chalise and Khanal, 2000), for long-term and short-term importance.

Awareness and perception of the local community are vital in landslide risk reduction in various ways. These include: preparing the communities to act on landslides appropriately, helping them understand the risks and vulnerabilities well, highlight roles, procedures, and response to the disaster, understanding the possible causes, early warnings, and remedial options, affect their willingness to participate in the disaster management process, determine community's behaviors, expectations, and activities, and enhance landslide safety in relation to development activities (Parkash, 2013).

According to (Njagi, 2018, Ronan and Johnstone 2003), most communities do not have enough capacity to handle disasters including landslides, hence impairing their management. A lot of capacity building needs to be done in most communities to empower and convince them to manage landslides. Besides, a lot of funds have been allocated to help the communities who have been struck by disasters, but unfortunately, most of them have not benefited.

For disaster risk reduction to be achieved, community action, improved governance, and reduction of external reliance are very important. Communities should be prepared enough and be self-reliant to handle disasters (Rawat et al, 2012). Limitations of knowledge, including economic valuation, best practices, science, and understanding of the importance of ecosystems in disaster risk reduction need to be worked on (Renaud, Rhadhika Murti,2013).

2.8 Research gaps

A lot of research works such as Crozier (2005) and Ayieko (2018) concerning landslides have been done, including causes and impacts of landslides. Little research such as the work of Forbes and Broadhead (2011) on forests and landslides has been done, and there is none done in Marakwet East Escarpment. Identification of forest ecosystem services, their relationship with landslides occurrence,

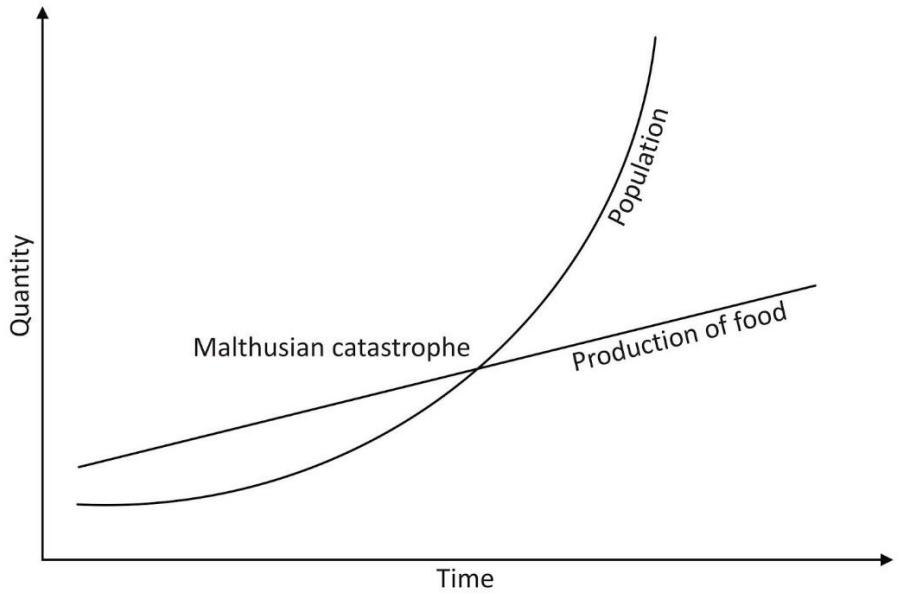
and landslide control have not been done. Besides, ecosystem services especially regulatory and supporting services are still not well understood and valued, since little research concerning these services has been done. Additionally, according to the Sendai Framework (2015-2030), multi-hazard and multi-sectoral approaches for managing and reducing disaster risks are required, hence this is one of those approaches. Therefore, this research analyzed the role of forest cover in Landslide Risk Reduction to help provide knowledge that helps fill the gaps identified.

2.9.0 Theoretical framework

2.9.1 Malthusian theory

The Malthusian Theory (Lin, 2010) explaining the critical role of population growth in the determination of the demand and use of natural resources, illustrates the relationship between population and food and any basic need that man requires for his/her well-being. When the population grows, more resources from the environment are required for their satisfaction, which includes; fuel, food, timber, land for settlement, minerals, and infrastructure. These requirements put pressure on the environment because the human population grows in a geometric progression as compared to resource production, which increases in an arithmetic progression; hence, population increase is faster than resource increase. The shortage leads to pressure (Malthusian catastrophe) being exerted on the environment through various activities such as clearance of forests for settlement and also for carrying out agricultural activities to enable feeding of the growing population. These activities weaken the shear strength of slopes hence making them susceptible to landslides.

Figure 1: Malthus Basic Theory



Source: study probe. Live, 2020.

Population growth can be controlled using preventive checks, which include family planning techniques hence reducing the pressure of the population on the environment. When the population is not controlled using the preventive checks, nature can take its cause were catastrophes, which include landslides happen hence causing deaths and many other effects on the environment as well as on human livelihoods.

With all the critics of the Malthus theory, positive checks are taking place in most parts of the world, and a lot of disasters including Landslide are becoming a threat. Besides, many people have low living standards as a result of these disasters. This theory was relevant to this study since it helped in bringing out a clear picture of how human beings interact with the environment, their needs, the ecosystem's carrying capacity, and the consequences of exceeding the carrying capacity. This was hence critical as far as landslide disaster management is concerned since the genesis of the disasters and its relationship with ecosystems were well explained. Additionally, it helped in the development

of interventions such as development planning, population control, resource conservation, and sustainable use of resources for long-term Landslide Risk Reduction.

2. 9.2 Land use planning theory

According to (NOJOVAN 1 et al., 2012), this theory is applied in Land Use Planning (LUP) for disaster risk management. Land Use Planning is a potentially powerful hazard mitigation tool as it seeks to mitigate its risks and vulnerability. Land-use Planning is systematic, future-oriented, and proactive. It enhances sustainable use of and development of land to reduce the vulnerability of people to disasters such as landslides. It aims at reducing the risk associated with people exposed to disasters besides the identification of risk sites and determining normative rules concerning tenure rights.

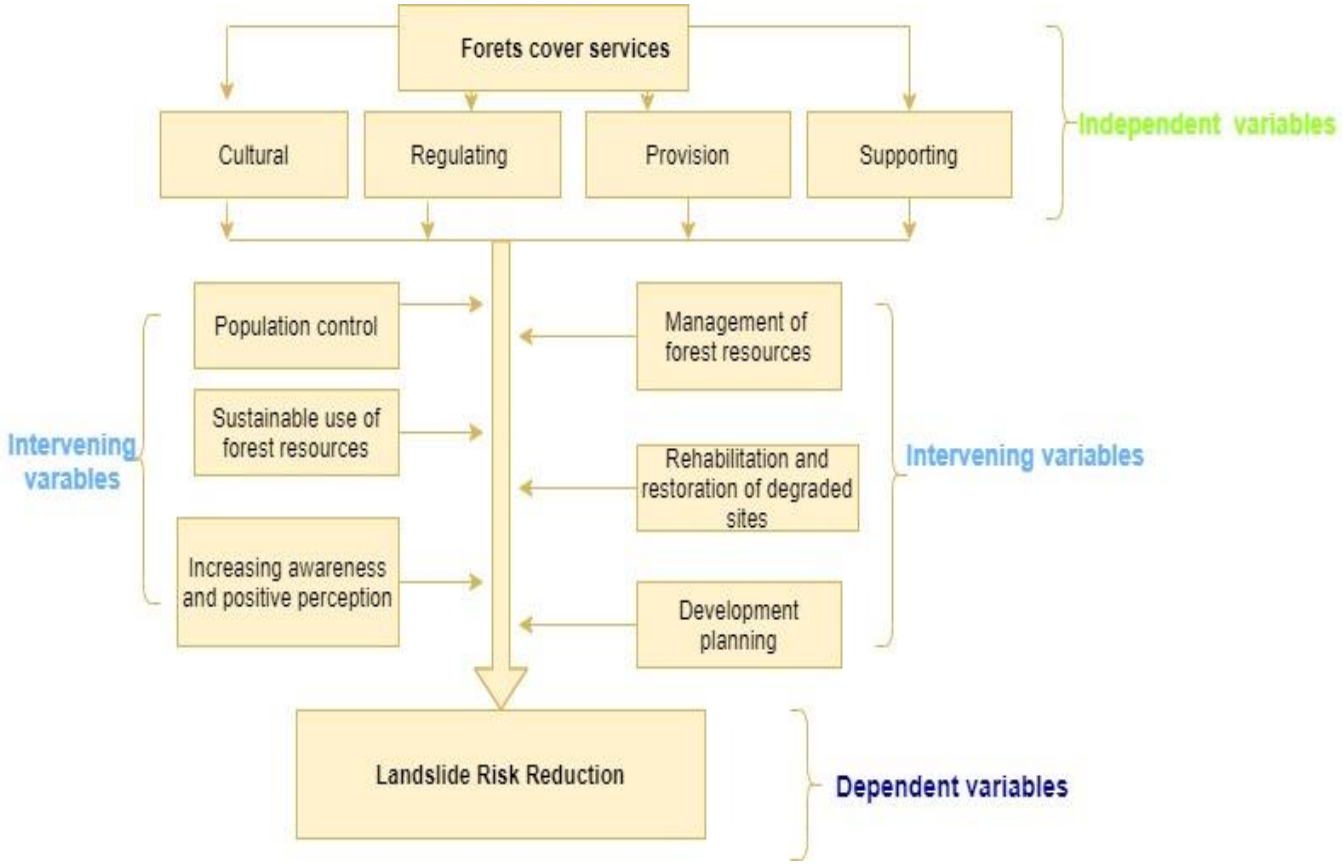
Land Use Planning help in making informed pre-event decisions on where to locate infrastructure, buildings, physical development among other projects. Through LUP, a procedure for pre-disaster prevention, mitigation, and preparedness for possible disasters, organization of emergency measures, enhanced coordination, and recovery, as well as reduced population displacement, is developed. This theory stresses the characterization of potential hazards in an area, based on the level of risk (no risk, low risk, Moderate Risk, and High risk) that is likely to be encountered. This hence guides activities that can be carried out (Glavovic, 2010)

This theory was very relevant to Landslide Risk Reduction since it allows comfort and welfare of the inhabitants together with minimization of fatalities and economic damage. In addition, this theory puts into consideration a lot of aspects including social, economic, cultural, geographic, and economic factors, before a project is done.

2.10 Conceptual framework

Based on the framework (Figure 2) below, a connection between variables is shown for the achievement of Landslide Risk Reduction is shown. Forest cover services include the provisioning, cultural, supporting, and regulatory services. These services play a key role in enhancing environmental balance and human well-being. When forests are exploited beyond their carrying capacity, a crisis occurs, hence; sustainable utilization of forest resources, population control, increased awareness and positive perception, development planning, management of forest resources, rehabilitation and restoration of degraded sites, and development planning should be embraced. When all this is done, Landslide Risk Reduction (LRR) will be realized.

Figure 2: Conceptual framework



Source: Author, 2020.

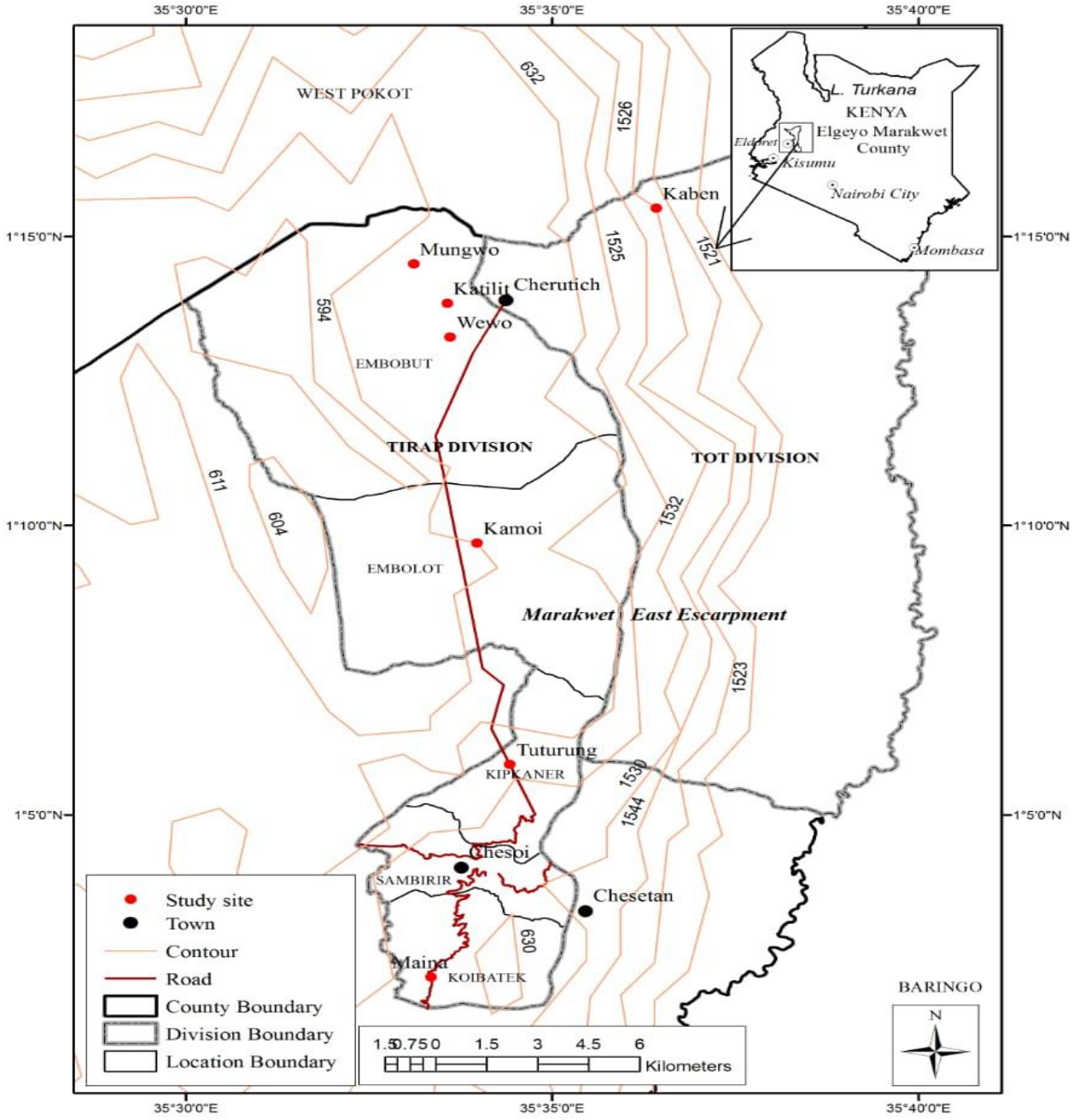
3.0 CHAPTER THREE: METHODOLOGY

3.1. Study area

3.1.1 Location and setting

The study area was the Marakwet East escarpment in Elgeyo-Marakwet County, which borders Baringo County to the East, West Pokot County to the North, Tran Zoia County to the west, and Uasin Gishu county to its southwest direction. The Marakwet East escarpment is a section of the larger Elgeyo-Marakwet Escarpment/ Kerio Escarpment (Kipkiror et al., 2019), and it extends across Tirap and Tot divisions of Marakwet East sub-county.

Figure 3: Study Area Map



Source: Author, 2021.

3.1.2 Climatic conditions

Temperatures in the area range from a minimum of 14^0c to a maximum of 24^0c, while rainfall on the other hand ranges from 1000mm to 1400 mm per annum (Kilimo, 2014). This warm temperature is contributing to fast population growth. This temperature contributes to a lot of evapotranspiration and hence rainfall. This rainfall is mostly erratic hence affecting people's preparedness for landslides and planning of their activities (Chebet, 2017). This hence contributes to a lot of very acute impacts. Additionally, climatic variability in most cases contributes to vegetation loss and hence the bareness of land.

3.1.3 Physiography and topography

The Marakwet East escarpment is bounded by the Kerio River to the East at 1000m above sea level and Cherangani hills to the west which rises to 3300 m above sea level (Chebet, 2017). This region rises to towards the west. It conspicuously separates the highlands and Kerio Valley regions of Marakwet East. The area is characterized by arid and semi-arid conditions together with a fast-growing population because of the warm conditions. The steep slopes in the area make them much vulnerable to landslide disasters, especially during heavy rains. The arid and semi-arid vegetation in the area do not provide an excellent ground cover, hence increased susceptibility to landslides. Recently, this cover has been replaced by human activities including tree crops such as mango, avocado, lemon, banana, and pawpaw among other crops such as maize, beans, millet, and sorghum. Demand for more land for agriculture has receded the Embobut forest (Murkomen, 2019). Additionally, the growing population is worsening the situation through carrying out various human activities, such as farming, overgrazing, and settlement in an already fragile environment.

3.1.4 Geology and soils

The Marakwet East Escarpment area consists of sedimentary rocks particularly hornblende, gneisses, and crystalline limestone together with minor amounts of quartzite and biotite gneisses. Most parts have lateritic soils and alluvium in the river valley. These rocks are highly eroded hence are very vulnerable to landslides (Murkomen, 2019). The rocky conditions worsen the level of impacts since when the shear strength of the slope is jeopardized, a combination of mudslides and rock slides/falls take place.

3.1.5 Drainage

The area has a major drainage basin, which is the Kerio river catchment area. The rivers originate from the Embobut forest and the major rivers in this catchment area include *Chesegon, Embobut, and Embomon* (Kilimo, 2014). Besides, the area has a sophisticated furrow system that helps in cultivation along the Kerio valley. During heavy rainfall, these rivers and furrows burst their banks and affect the nearby villages. When it flows along bare grounds especially areas cleared and land-use changes have been done, landslides happen.

3.1.6 Socio-economic activities

The area is inhabited by Marakwet people (one of the groups of the Kalenjin community), which speak the *Markweta* language. The population is growing is not controlled, hence greatly increasing. They've been having a long history of disputes with the Pokot people who border them to the North. The inhabitants lead a simple rural life characterized by mixed small-scale farming. They keep goats and zebu cows besides growing millet, sorghum, vegetables, and fruits which include mangoes and oranges. Overstocking and overgrazing are common in the area (Kilimo,2014). Vegetation is also cleared for farming activities to be carried out. A lot of furrows are then dug on the steep slopes. These activities increase the vulnerability of the area to landslides.

3.1.7 Population dynamics

The area has a population of 32347 people comprised of 16323 females and 16024 males (Kenya Bureau of Statistics, 2019). The area is characterized by a fast-growing population with most of the people in the area are also residents of Trans-Nzoia and Uasin Gishu counties, among other towns in the country. Most (57%) of the people in the Marakwet East Escarpment are poor and food poverty is the most experienced type of poverty. This is because most of their farming activities and dependent on climatic conditions (Murkomen, 2019).

There are higher concentrations of settlements near forests and markets in the escarpment. Most of their settlements are usually determined by climatic conditions, economic activities, and also security. The people of this area live in the form of clans and land is communally owned, with boundaries of clans made by physical features such as rivers and hills.

3.2 Research design

This research employed a mixed research design which combines both the use of quantitative and qualitative methods (Shcooneboom and Johnson, 2017). This design enables the gathering of data that enables holistic interpretation of framework that enables generation of possible solutions to the problem and also enables a new understanding of the problem. According to (Kombo and Tromp, 2006), this type of research design is very convenient and enhances the collection of enough data from respondents within a shorter time and it is cheaper.

Data collection was done using questionnaires, interviews, and observation methods. Quantitative data was analyses texts and descriptive methods, while quantitative data were categorized and analyzed based on similarities and differences. These techniques worked together to enable the development of strong evidence and conclusion to the study.

3.3 Study population

This study targeted the collection of information from the residents of the Marakwet East escarpment. Data was collected from people who live in the Marakwet Escarpment region, of the Marakwet East constituency, Elgeyo-Marakwet County. Data was collected in this area because the escarpment covers three-quarters of this Region. According to (KNBS, 2019) data, the area has a total population of 32,347 people.

3.4 Sampling design

Determination of sample size

This study employed Cochran's Formula to determine the sample size. This formula was appropriate because the population was large, and at the same time, it allows the calculation of absolute sample size when the estimated population, desired degree of freedom, and preferred level of precision are given.

The formula is $n_o = \frac{Z^2 p q}{e^2}$

Where: n_o = Sample size

Z= found in Z table

p=estimated portion of the population which has the attribute in question

q=1-p

e= the desired level of precision

Z= 1.96 at 95% confidence level

p= .50

q= 1- .50= .50

e=0.05

Therefore, no=$\frac{\mathbf{1.96^2 * .50 * .50}}{\mathbf{0.05^2}}$

=**384.32**

From this formula, a sample size of 385 individuals was used.

Determination of sample size together with the use of an appropriate sampling technique and data collection method helped in the achievement of scientifically sound results. This method helped in the determination of an adequate sample that enabled the generalization of the whole population.

Selecting samples from the target population

a) **Questionnaire sample**

A questionnaire sample is a group of people who are chosen to represent the total population in filling the questionnaires for the study. Cluster sampling was employed in this study to identify the individuals to who questionnaires were administered, for data collection. This sampling technique was very efficient, hence cheap and data was collected within a very short time.

b) **Key interviews sample**

A key interview sample is a group of key informants to the study, who are interviewed. This sample was determined through a purposive sampling technique that involved selecting individuals that were useful and had adequate information for the study. These individuals included; some affected community residents, area chief and assistant chiefs, Kenya Forest Service (KFS) officers, and county Disaster Management Department officers. This method of data collection was less time-consuming and enabled the collection of detailed information about the study.

c) Field observation sample

A field observation sample is a group of areas that represent the whole area under study. Purposive sampling was used in determining the field observation sample. Some areas have experienced high magnitude and frequent landslides than others, hence selection was done. This enhanced collection of adequate information concerning issues such as economic, social, and environmental impacts caused by landslides. It also enhanced the collection of data on the human activities carried out in the area, population distribution, and level of forest degradation.

3.5 Sources of data

Data collection sources were secondary and primary sources. The secondary sources aided in identifying information such as the type of climatic conditions in the area of study, type of geology, and the area covered by the county. Secondary data also helped in finding out related researches which have been done. Primary sources aided in the identification of most of the factors that were under studies such as human activities and the effects caused by landslides.

3.6 Methods of data collection

Data was collected using the following methods:

a) Questionnaires

According to (Kontari et al.,2011), questionnaires include both closed-ended and open-ended questions, which are based on the variables that help in the achievement of research objectives and testing the research hypothesis. The questionnaires were administered and collected after one week. This method was important in that it was an affordable method of data collection, practical, data was

collected within a very short period, enabled data collection from a larger audience, it was easy to do a comparison of data, allowed easy analysis and visualization, covered a lot of aspects of the topic and enhanced respondent's anonymity. This technique of data collection was likely to experience some limitations which include receiving dishonest answers, differences in understanding and interpretation of questions. These limitations were eliminated in the following ways; assuring respondents of their privacy, creation of simple questions, using the Likert scale to convey feelings and emotions, and making sure that were the questions were short and clear.

a) **Interviews**

This section describes two approaches to interviewing used by the study to capture data from respondents.

i. Key informants' interview

This was a very important technique for data collection since it allowed the collection of in-depth qualitative data about the nature and the underlying information about the problem at hand. Reliable data was collected through this method at an affordable cost and using a shorter time. The individuals interviewed using this method included community leaders, community residents, and experts. Key informants were of diverse representation hence enhancing a wide range of perspectives of information to be collected. This was a key method because it gave a chance for a free exchange of ideas, getting information on complex issues about the problem, and getting detailed responses. Interview guide having open-ended questions was important and the purpose and importance of the interview were clarified to the respondents. The recording was done using note-taking.

After the interview, time was created to organize the findings and write additional notes. The main limitation to this method of data collection was the scheduling of interviews with busy or hard-to-reach respondents. A situational analysis to understand the respondents and their schedules was done and arrangements and booking of appointments were also done as early as possible.

ii. Focus group interview

Both open-ended questions and closed-ended questions were asked based on the objectives from any angle. The purpose and importance of the data were clarified and confidentiality of provided

information was assured. This was an important method of data collection because it favored the illiterate respondents, ensured that verbal and non-verbal cues were collected, and allowed the collection of quality data. Additionally, through face-to-face interviews, we were able to make conclusions as the accurate screening was easily made. Situational analysis of the community was done to understand various aspects of the community that could limit effective data collection. This also helped in scheduling interviews.

b) **Field observation**

This method allowed having data on the general picture of the area under study. This method clarified the data collected using other methods. It complimented questionnaire and interviews methods of data collection. It was a very simple and very useful in framing hypothesis, more accurate, universal method as far as the data collected is concerned, and it was very independent of peoples' willingness to give information.

3.7 Methods of data analysis

Analytical techniques were used in analyzing the qualitative and quantitative data collected. Data were analyzed using texts and descriptive methods. Quantitative data was analyzed in, descriptive and inferential methods with the aid of SPSS, while the qualitative data was analyzed using theme categories based on the similarities and differences. Hypothesis testing was done using simple linear regression. Simple linear regression was easy to interpret and less time-consuming.

Table 1: variables, level of measurement, indicators of measurement, sources of data, and type of data analysis.

Variables	Level of measurement	Indicators of measurement of variables	Source of data	Type of data analysis and hypothesis testing
Landslide incidences and frequency	Nominal/ ratio	• Places where landslides took place • When landslides incidences were experienced	Secondary sources, questionnaires, key informants	Descriptive and Text • Simple linear regression used to test the hypothesis
Forest cover and history	Nominal/ ratio	• Forest cover loss	Secondary sources, key informants, questionnaire, observation	
Community awareness	Nominal/Ordinal	• knowledge levels	Questionnaires and interviews	Text, descriptive
Community perceptions	Nominal/ Ordinal	• opinions, views, believes, and feelings	Questionnaires and interviews	Text, descriptive

Source: Author, 2020.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Respondents' characteristics

Table 2 shows the respondents' characteristics, which include sex, lengths of residence, sources of livelihood, and level of education. Slightly more women (51%) than men (49%) took place in the process, indicating greater availability of women to participate in the study than men. This was because, most of the household heads were absent from their homes during the process, and the wife or (one of the wives) was interviewed. About 79.6% of the respondents were people who had stayed in the escarpment area for more than ten years, which meant they had experience or had knowledge of several landslides in the period considered by the study (i.e., 2000-2020). The majority of the household derived their livelihoods from crop cultivation and keeping of livestock (39% and 36.8% respectively), which implied that land was an important requirement for the local economic prosperity. Economic activities have an important bearing on land cover, land use, and vegetation degradation. That most household respondents had either a tertiary or high school education (37.6% and 50.1% respectively) speaks of a fairly literate and supposedly knowledgeable population that the study was endowed to. Literacy would also play a key role in a person's awareness levels and perspectives on local issues.

Table 2: Respondents' characteristics

Variable	**% Of Respondents**
Gender	
Female	51.0.
Male	49.0
Length of residence	
2 years and below	12.2
2-5 years	4.1
5-10 years	4.1
above 10 years	79.6
Source of livelihood	

Pastoralism	36.8
crop farming	39.5
Business	3.5
salary and wages	8.6
Others	11.6
Level of education	
no formal education	1.8
primary level	10.5
secondary level	50.1
tertiary level	37.6

Source: Field data, 2020.

Trends of forest cover change in Marakwet east escarpment from 2000-2020

Table 3 below show forest cover loss in the Marakwet East Escarpment from the year 2000 to the year 2020. There was a total loss of 390.53 Ha of forest cover between 2000 and 2020. The annual forest cover loss was 19.53 Ha, which translated to 19.53% loss per year. Most forest cover loss took place between the years 2005 and 2008, where there was a loss of 20.58 Ha of forest cover.

Table 3: Forest cover loss

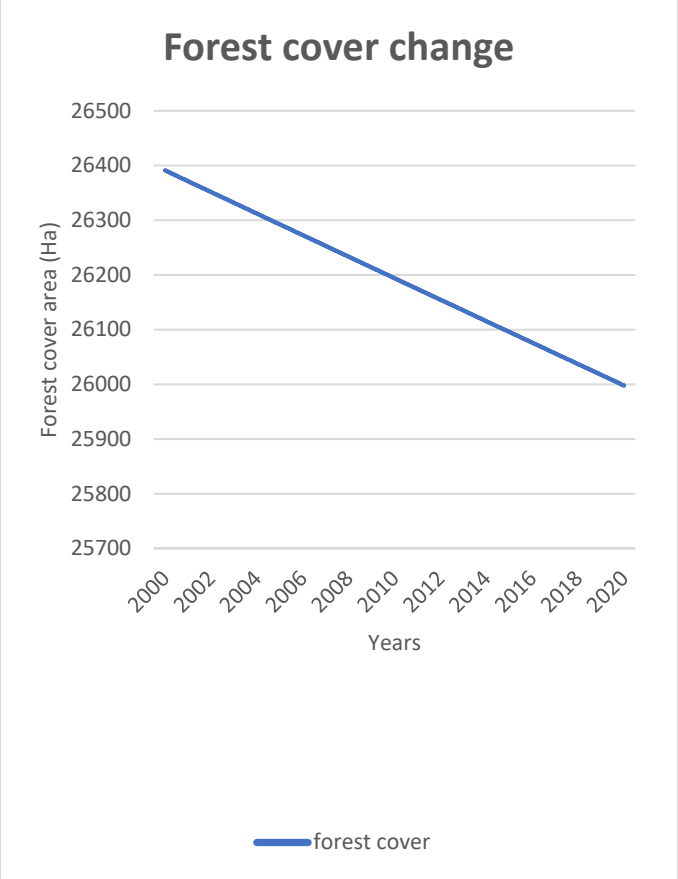
Period	Forests cover area (Ha) in the start year	Forest cover (Ha) in the end year	Total forest loss (in Ha)	Annual forest loss (in Ha)	% Of the total forest loss
2000-2004	26392.70	26312.60	80.10	20.03	20.50
2005-2008	26312.60	26230.30	82.30	20.58	21.07
2009-2012	26230.30	26152.80	77.50	19.38	19.84
2013-2016	26152.80	26076.40	76.40	19.10	19.56

2017-2020	26076.40	26000.80	75.60	18.90	19.36
2000-2020	2632.70	26000.80	390.53	19.53	19.53

Source: KFS data, 2020.

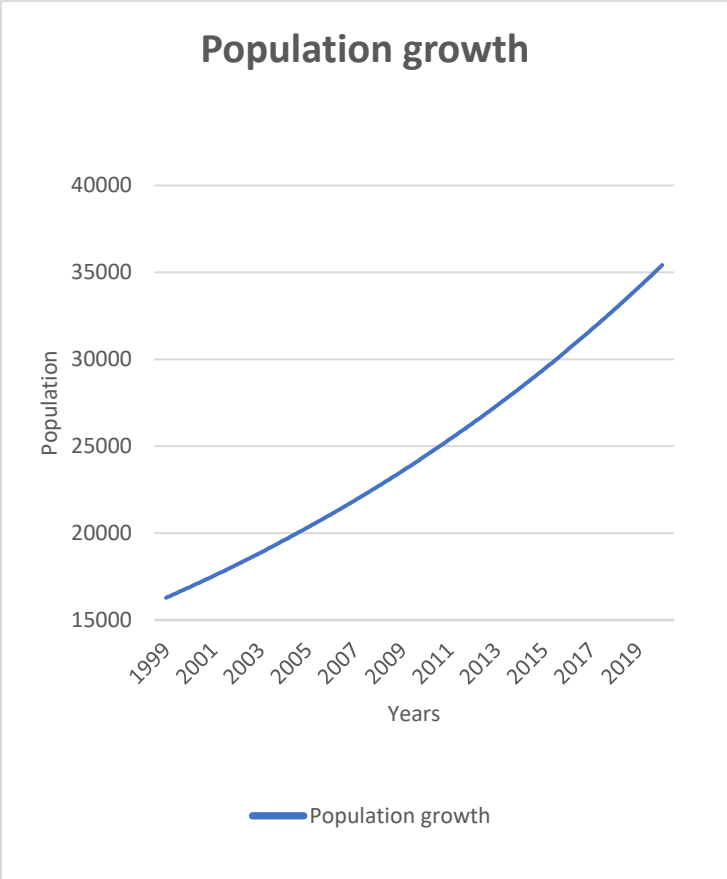
Figure 4 shows trends in forest cover between the years 2000 and 2020 in the Marakwet East escarpment. On the other hand, Figure 5 shows population growth trends between 1999 and 2019.

Figure 4: forest cover change



Source: KFS data, 2020.

Figure 5: Population growth



Source: KNBS data, 2020.

In general, there is a sustained, decline in forest cover over the Marakwet East Escarpment over the years (2000-2020) in consideration. Over the same period, no incidence of landslides was recorded between 2000 and 2009 but thereafter, at least one incidence was recorded every year between the years 2010 and 2014 except in the year 2012. Every location where the landslide was recorded had some of the lowest forest covers on the escarpment. For example, the areas around Kaben, Kittony, and Kamoi had completely lost their forest cover, while the area around Katilit, Wewo had only Scanty tree cover. Also, views from members of the local community held that the occurrence of each of the landslides was preceded by heavy rainfall: "All the landslides were triggered by heavy rains".

All other factors held constant, the result shows that areas that had low forest cover were more prone to landslide incidence than areas endowed with better forest cover. The result, therefore, seems to point to the loss of forest cover as a major influencing factor to the incidence of landslides in the Marakwet East escarpment. Most respondents (62.50%) attributed the decline in forest cover to the fast-growing population and increased demand for land for crop cultivation. One respondent said, "Forest cover loss has been as a result of population growth, which makes people need more land for cultivation. As a result, people clear forest cover to create room for cultivation". Population in the area greatly increased from 15430 in the year 1999 to 26255 in the year 2009, and to 32347 in the year 2019. This was an increase of 109.6% between the year 1999 and the year 2019.

The findings were consistent with the work of (Foley et al., 2005 and Gurung et al.,2013), who argue that agricultural activities highly contribute to forest cover loss, which in turn trigger landslide incidences. This study in particular bears great consistency with the work of (Crozier, 2005) who argued that when forest cover is cleared, soil particles are not held together and water absorption is reduced. This makes soil saturated with water when there are rains and cohesion is reduced hence sliding downslope.

4.3 Incidences of landslides from 2000-2020

Table 4 shows that all the landslide incidences recorded in the period under consideration (2000-2020) occurred between 2010 and 2020. This means that for ten years (2000 and 2009), Marakwet East Escarpment did not record any landslides. It was therefore a matter of curiosity as to why landslides started to happen more frequently in the years following 2009. Could this be attributed to factors such as increased rainfall, increased deforestation, or any other?

Table 4: Landslide incidences

Year of occurrence	Location	Triggering factor	Number of landslide events	Approximate time (year) lapse from the previous event to the next event
2000-2009	**No landslides events reported**			
2010	**Kaben, kittony and Kamoi**	**Heavy rainfall (overnight).**	**3**	
2011	**Katilit**	**Heavy rainfall (overnight).**	**1**	**1**
2013	**Wewo**	**Heavy rainfall**	**1**	**2**
2014	**Kitony**	**Heavy rainfall**	**1**	**1**
2019 (October)	**Tuturung**	**Heavy rainfall**	**1**	**5**
2020 (April)	**Elgeyo Marakwet/West Pokot border**	**Heavy rainfall**	**1**	**1**

Source: Directorate of Disaster Management data, 2020.

While most (75.1%) questionnaires feedback linked this observation to the loss of forest cover that persisted over a long time, there was a dominant view among interviewees that heavy rains were only a trigger to an already vulnerable situation: “The escarpment is vulnerable to landslides, it is only made evident when rains occur.” “Some parts are naturally fragile while most parts have been made vulnerable as a result of vegetation clearing.”

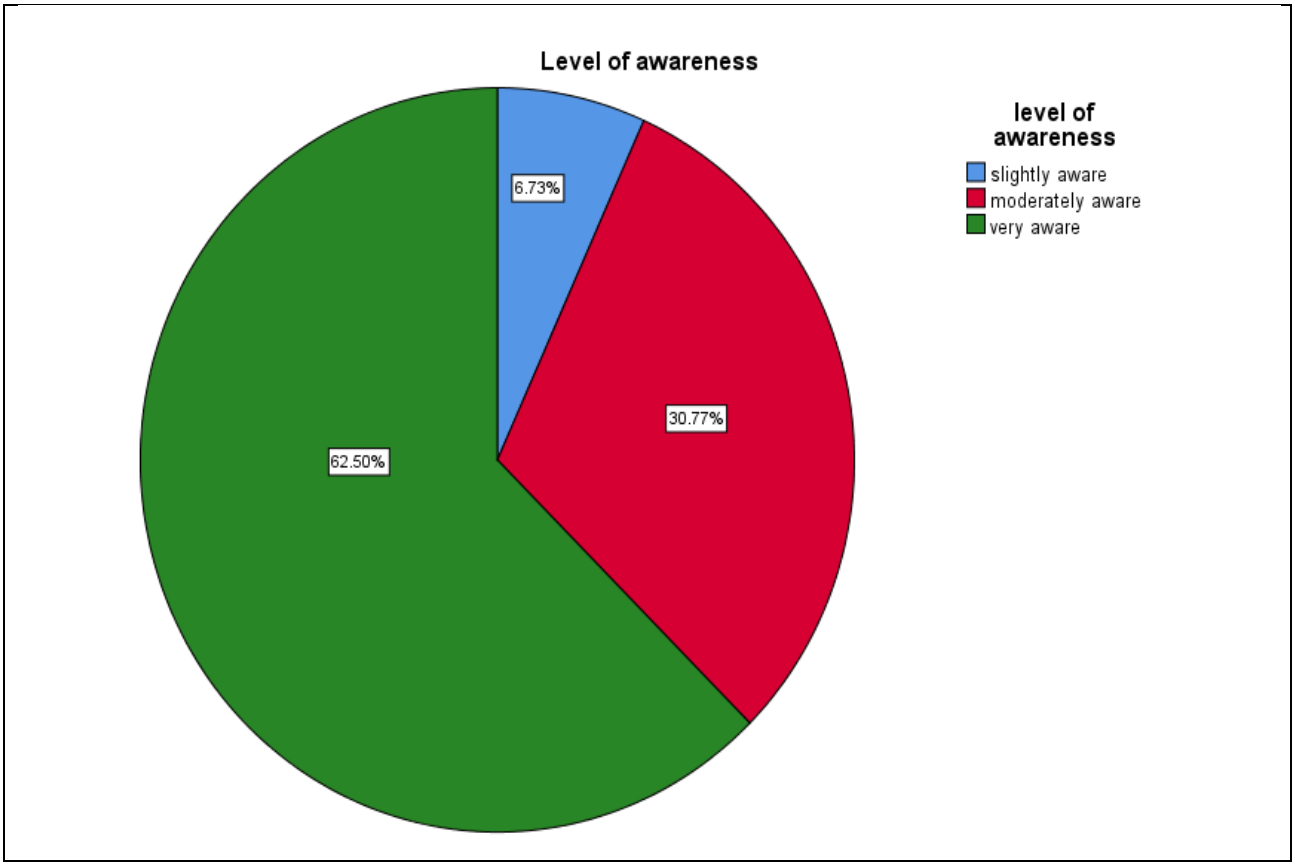
The study, therefore, found that forest cover loss was the primary influence on the observed frequency of landslides but other factors such as rainfall and poor land-use practices were secondary actors or triggers. Any sustainable solutions in the Marakwet East Escarpment therefore ought to primarily consider increased forest cover and forest conservation. This is so even in the light of a fast-growing population.

These findings concur with the work of (Dolidon et al., 2009), which argue that when ecosystems are well conserved and managed, they help in reducing the probability of disasters happening. The finding also supports the research of (Lin, 2010) which argues that whenever a natural ecosystem’s carrying capacity integrity is destroyed by human demands, nature will usually make its case, and disasters such as landslides occur. In simple terms, ecosystems such as forests play a vital role in disaster mitigation, which function can be curtailed by human pressures with serious consequences.

4.4 Community awareness on the important role of forest cover in landslide risk reduction

Figure 5 shows the extent to which respondents were aware of the vital role that forest cover played in landslide risk reduction. Most (62.5%) of the respondents were highly aware of the role of forest cover in landslide risk reduction while 30.8% and 6.7% were moderately aware and slightly aware, respectively. There were no respondents who mentioned that they were not aware of the role of forest cover in landslide risk reduction.

Figure 6: level of awareness



Source: Field data, 2020.

Respondents said that they acquired their awareness from various sources namely; radio and television (40.0%) and county government campaigns (25.0%). Others learned from NGOs (10.0%) and experiences (7.0%), with the rest deriving their awareness from local social groups like CBOs among others.

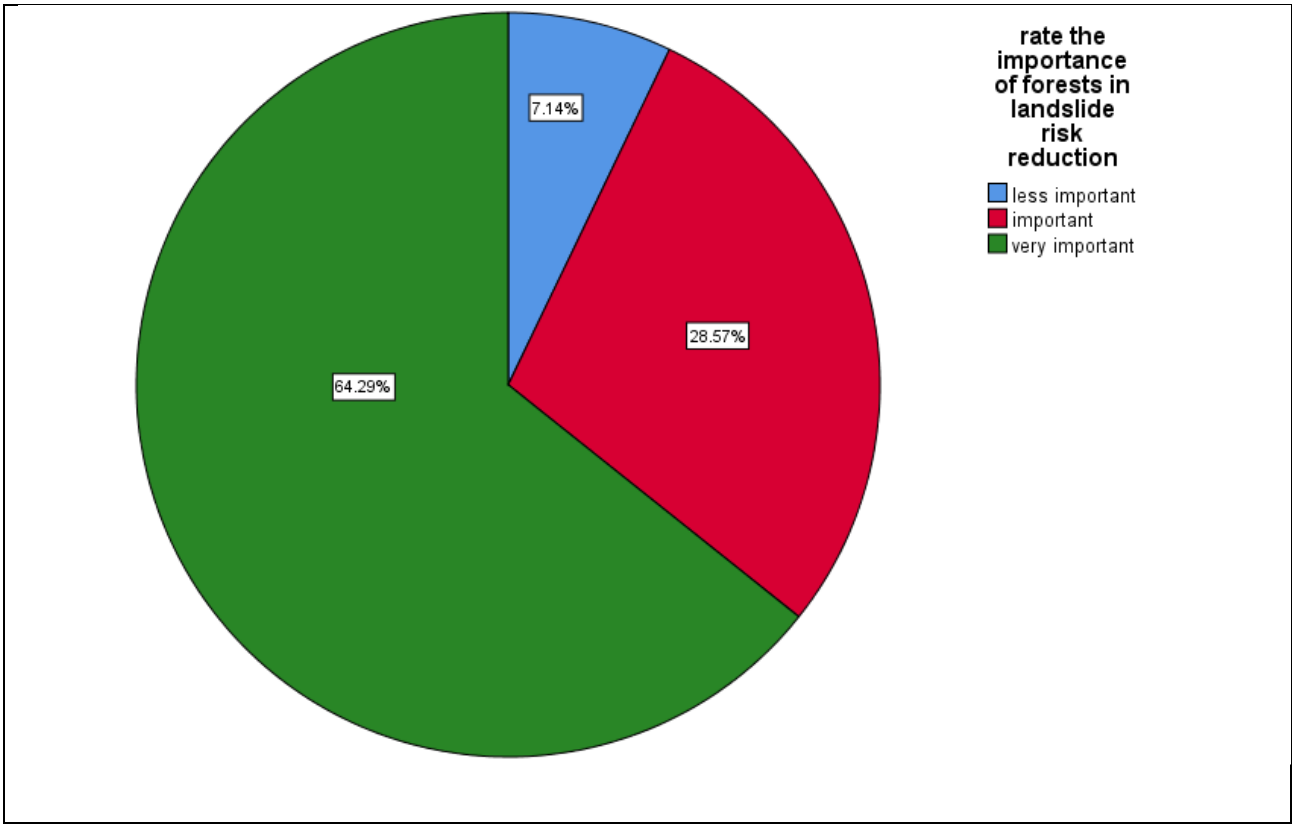
The findings of awareness were similar to the works of (Rawat et al, 2012) and (Chalise and Khanal, 2012), which both found out that capacity building on aspects of disaster Risk Reduction such as ecosystems conservation is essential and should be a compelling part of building disaster resilience in all communities.

4.5 Local Community perceptions on the importance of forest cover in landslide risk reduction

Perception is how something is identified, understood, regarded, and interpreted. This is different from awareness which is having knowledge or consciousness about something. Perception includes, opinions, feelings, thoughts, and/or believes held by people about something (Merikle et al., 2001).

Figure 6 shows the perceived importance that local communities attached to forest cover for landslide risk reduction. Most (64.29% and 28.57% respectively) of the respondents held the view that forest cover is either very important or important in landslide risk reduction. Only (7.14%) of the respondents perceived that forest cover bears little importance to landslide risk reduction. Additionally, no respondent perceived that forest cover was not important at all in landslide risk reduction.

Figure 7: Community perception



Source: Field data, 2020.

From the results above, the community is positive about the important role of forest cover in landslide risk reduction. The enthusiasm may be what is needed to mobilize local community support towards programs geared to nature-based solutions to landslides in Marakwet East Escarpment.

This finding collaborates with a similar study by (Njagi, 2018), which established that positive and optimistic perception is a vital catalyst to action towards empowering themselves to solve their problems. For the Marakwet East Escarpment community, high enthusiasm about forest-based solutions to landslides can be a basis for campaigns to restore and increase forest cover to heal the land from landslides.

4.6 Hypothesis testing.

Hypothesis testing is a key point in research since it helps in the determination of whether there is enough statistical evidence in favor of a certain belief about a parameter. It forms a framework for conclusion and interpretation and also enables a researcher to make a valid and reliable generalization about the population for the sample data.

This research employed simple linear regression to perform the hypothesis testing because it is less time-consuming and easy to interpret. This test enables the study and summarizing of the relationship between two continuous (quantitative) variables (Zou et al., 2003)

H0: There is no relationship between forest cover change and landslide occurrence.

Table 5: Simple linear regression

Model		Unstandardized Coefficients		Standardized Coefficients			95.0% Co
		B	Std. Error	Beta	T	Sig.	B
							Lower Bo
1	(Constant)	.433	.443		.977	.331	-.447
	landslide occurrence	.250	.097	.252	2.579	.011	.058

a. Dependent Variable: forest cover change

Source: Field data, 2020.

From the simple regression test, the **p-value** is **0.011** which is less than the used significance level of **0.05.** This means that there is enough evidence to reject the null hypothesis which states that "There is no relationship between forest cover change and landslide occurrence", and accepts the alternative hypothesis which states that, "There is a relationship between forest cover change and landslide occurrence".

Evidence from the sample shows that there is a relationship between forest cover change and landslide occurrence. This means that forest when forest cover changes, it has an impact on landslides occurrence, i.e., when forest cover is destructed, landslide risk will increase and vice versa, hence when forest cover is well managed, landslide risk reduction will be achieved.

These findings are consistent with the work of (Forbes and Broadhead, 2011), which established that forest cover change plays a vital role in landslide occurrence, hence sustainable use and management are required for Landslide Risk Reduction (LRR). In this case, all the aspects that contribute to forest cover change should be put into consideration for the goal to be realized.

4.7. Findings and their relationships with the theoretical framework

These findings are consistent with the Malthusian theory stated in the literature review. The findings have shown that when the population grows, pressure is put on the environment since there is a need for more food and other resources to sustain the population. Based on **figure 5**, the population in the Marakwet Escarpment increased by 109.6% between the years 1999 and the year 2019 which led to the need for more land for growing food and also settlement. This forced people to encroach the forest and 390.53 Ha of forest cover was lost between the years 2000 and 2020, as shown in **figure 4**. Due to this, the carrying capacity of the ecosystem was exceeded and nature took its cause (Landslides occur).

On the other hand, these findings deviate from the land use planning theory as stated in the literature review. Pre-event decisions including engineering planning have not been put into considerations when doing land use activities such as the construction of settlements, carrying out agricultural activities among other land uses in the Marakwet East Escarpment. Social, economic, cultural, and geographical aspects are not considered before an activity is carried out. As a result, pre-disaster prevention, mitigation, and preparedness are compromised. This makes the land more vulnerable to landslides.

CHAPTER 5: SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATION

5.0 Summary of findings

The movement of people who were initially intended to live temporarily in the escarpment was not done. This contributed to the conversion of the area into a permanent home for the inhabitant. Various activities including settlement, agricultural activities, development of infrastructure, charcoal burning, and cutting down of trees for timber and other construction materials were carried out. These activities increased over time as the population increased. The land was made more susceptible to landslides than before.

From the results, it is evident that the frequency of Landslide in the Marakwet East Escarpment has increased drastically from zero cases between 2000 and 2010 to 8 cases recorded between 2010 and 2020. The increasing landslide frequency has been contributed majorly by forest cover reduction. Forest cover reduction has been a result of the increasing population in the area, leading to the need for more land for settlement, farming, and livestock keeping. Deforestation is also done to acquire timber and other construction materials and also firewood and charcoal. What worsens the situation is that forest clearing is majorly done by burning it which renders the ground bare, with loose soil, hence susceptible to landslides. Another major reason for this is that most parts of the Marakwet East Escarpment are not fit for human settlement and other human activities, and be protected. Instead, the fragile areas have been accumulated with a lot of human activities hence going beyond carrying capacity.

The study found out that the residents of the Marakwet East Escarpment are aware of the role of forest cover in Landslide Risk Reduction, though little efforts have been put to improve and increase forest cover in the area. Besides population growth, forest degradation has been a result of increased poverty levels in the area. Poverty has forced the residents to depend on forest and forest resources to acquire their livelihoods. Additionally, the study found that most residents of the Marakwet East Escarpment view forest cover as very important to landslide risk reduction. They believe that forests have a larger ability to support soil and fragile grounds hence reducing the possibility of landslide occurrence

Much clarity on the extent to which forest cover can help in enhancing landslide reduction has not been done. Together with this, little support and motivation have not been given to these people,

hence contributing to little effort put into forest conservation and improvement. This has also led to little implementation levels of the measures in place.

5.1 Conclusion

In conclusion, Marakwet East Escarpment is a very fragile ecosystem and human activities in the area are beyond the carrying capacity. Deforestation is a major culprit to the increased landslide cases in the area. Besides population growth, poverty is a contributor to deforestation, as the inhabitants directly depend on the forest and its products for their livelihoods. Landslide frequencies have increased over time and there is still a threat of future cases. The residents are aware, positive, and enthusiastic about the relationship between forest cover and landslides, and the importance of forest cover in landslides risk reduction respectively. The residents are not motivated and supported especially, financially and technologically. Additionally, institutions in the area have not been strengthened, to help in enhancing forest cover conservation, improvement, and management at large.

5.3 Recommendation

To policymakers

The county government should develop policies, programs, and institutions of forest cover protection, conservation, restoration, and management. From the findings, the community is aware, optimistic, and enthusiastic about the vital role of forest cover in landslides risk reduction. This is hence an opportunity for the county government in the process. Besides, empowerment of residents on diversification of income sources needs to be done. Financial capacity should also be enhanced to allow the smooth rollout of the programs. A partnership between the government, private, and NGOs is key in the process.

Forestry needs to be developed as one of the land-uses in the region. From the findings, forest cover is reducing and hypothesis testing has proved that landslides that occurred in the area are greatly dependent on forest cover change. When forestry is made one of land use, the residents will enjoy

products from the forests while at the same time enhancing landslide risk reduction. This can be done majorly in fragile sites, landslide-prone areas, and as a forest cover restoration strategy.

To further studies

It is suggested that further research on the role of policies and proper institutions in landslides risk reduction, in the Marakwet East escarpment needs to be done. This has the potential of providing knowledge that will back up the existing knowledge, in achieving the goal of landslide risk reduction.

Research on sustainable management of forests needs to be done. This will enable the development of strategies for sustainable forest management. This will enhance the enjoyment of forest cover services in the present and also future generations.

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APPENDICES

APPENDIX 1: Questionnaires

Questionnaires for Marakwet East Escarpment residents

(This questionnaire is for research and your honesty will be highly appreciated. Your answer will remain anonymous and in no incidence will your name be mentioned. Your answers will be appreciated). Please tick where appropriate.

1. Gender
   a) Female--------- b) male---------

2. Village of residence
   ----

3. For how long have you been a resident of the area?
   a) 2 years and below----------
   b) 2-5 years----------
   c) 5-10 years ----------
   d) Above 10 years----------
4. i) Have you ever been affected by landslides?
   a) Yes ---------- b) No ----------

   ii) if yes what are the effects of the landslides that you experienced?

   ---

5. i) what do you do for a living? ----------

ii) Do you think what you do is contributing to landslides?

a) yes---------- b) ----------

6. Are there measures in place to improve forests?

---

iii) if yes, to what extent have these guidelines been implemented?

a) Not implemented----------
b) Less implemented----------
c) Most implemented----------

iv) if implemented, to what extent have they worked?

---

iv) if implemented, to what extent have they failed to work?

---

7. i) Forests can play a key role in landslide risk reduction

a) TRUE----------b) FALSE----------

ii) If true, rate its importance

a) less important----------
b) important----------
c) very important

---

8. i)Can you state the years by which landslides took place in the area?

---

ii)Do you think landslide frequency in the area is increasing?

a) Yes ---------- b) No ----------

iii) if yes, what do you think are the causes?

---

9. i) What are the common resources that are obtained from the forest,

---

---

ii) are people competing for these resources?

a) Yes---------- b) ----------

iii) What is the trend of forest cover change in the area?

a) Increasing-------- b) constant---------- c) decreasing----------

iv) State the reason for your answer to question (iii) above

---

b) Yes ---------- b) No ----------

10. i)Is the population increasing in the area?

a) Yes---------- b) No----------

ii) if yes, can it be related to increasing frequencies and magnitude of landslides?

a) Strongly agree----------

b) Agree----------

c) Disagree----------

d) Strongly disagree----------

11. i) Is there any relationship between reduction in forest cover and landslide occurrence?

a) Yes---------- b) N

ii) if yes, how?

---

12. i) Rate your level of awareness on the role of forest cover in landslide risk reduction.

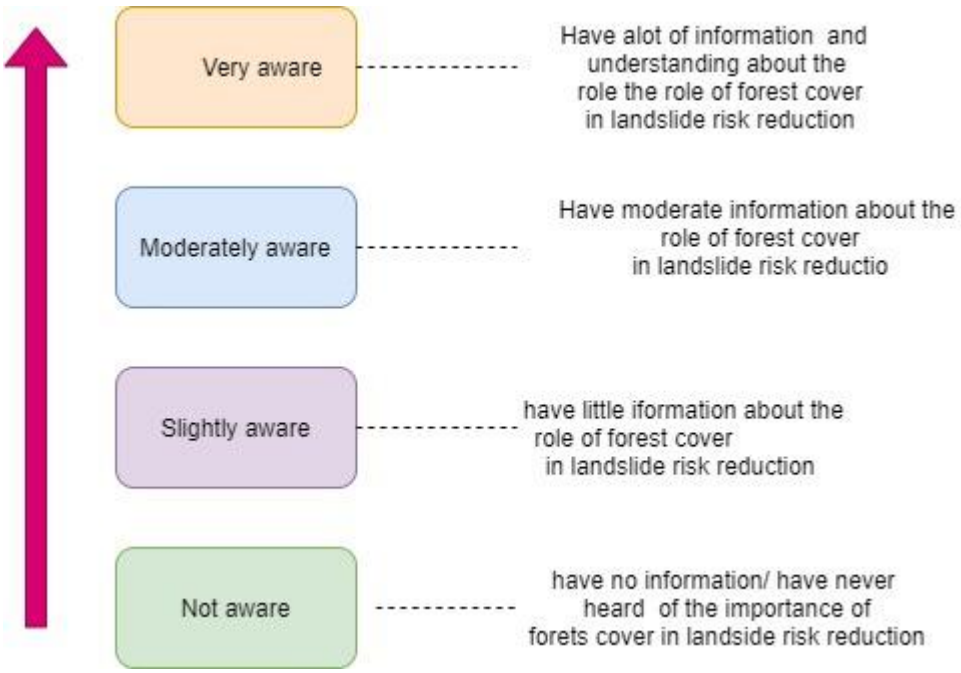
a) Not at all aware----------

b) slightly aware----------

c) Moderately aware----------

d) Very aware----------

AWARENESS SCALE



ii) If aware, what were the sources of your knowledge?

a) Radio/television----------
b) County ministries----------
c) NGOs----------
d) Social groups----------
e) Private sector----------
f) Observation and experience----------
g) Schooling----------
h) Others ----------

Appendix 2: Key Informants Interview Schedule

Type of key informants	Dates of the year 2020.
1. Local community-based key informants e.g., chiefs and assistant chiefs	16th November to 26th, November 2020
2. Constituency officers. These include officers in the departments of forestry and environment and disaster management	28th November to 8th December 2020
3. County-level key informants. They include officers in the ministry of forestry and environment and department of disaster management	10th November to 20th December 2020

Appendix 3: Focus Group Interviews Guide.

1. Respondents to give stories on how forest cover changed over time, especially from 2000 to 2020.
2. Find out data on landslide occurrences and their frequencies
3. Find out the respondent's level of awareness as the role of forest cover in landslide risk reduction is concerned.
4. The respondents' perception of the role of forest cover in landslide risk reduction.

Appendix 4: Field Observation Guide

Topics under observation	What to be done
Forest cover and degradation	• **Go to the site** • **Make notes** • **Take photographs**
Population increases and distribution	
Landslides sites	
Impacts caused by landslides	
Land use activities in the area	
How people utilize forest resources	
Biophysical characteristics, including vegetation type, topography, and drainage	

EVIDENCE OF FIELDWORK

Some of the human activities taking place in the area

This is how hilly the area looks.

Some of the effects caused by landslides in the a

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