AN ASSESSMENT OF IMPACTS OF SOCIO-ECONOMIC ACTIVITIES ON LAND USE AND LAND COVER CHANGES IN NAROK NORTH SUB-COUNTY, KENYA

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DECLARATION

Declaration by the student

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DEDICATION

This research is dedicated to my mother who shaped my life and to my family without whom I would have no purpose in life.

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I sincerely thank a number of people whose support and encouragement made it possible to accomplish this research. First, my gratitude goes to my supervisors, Prof. Simon Ole Seno and Dr. Samson Okong'o Mabwoga for their valuable support, guidance, availability for consultation and great insight during the period. Secondly, many thanks go to my mother for pushing me to achieve more and providing me with support whenever it was needed. Thirdly, I also extend my heartfelt gratitude to my friends, family and all those who were there to encourage and support me throughout this study. Above all to my heavenly father for his blessings and guidance, I give him all the glory, honor and praise.

ABSTRACT

Narok County is positioned in south-western Kenya and covers an area of 17,921km². It is the thirteenth largest county in Kenya. Large tracks of land initially under group ranch tenure system have been converted into freehold tenure. Agriculture and livestock production are the main land use practices followed by wildlife conservation areas. The highland areas of Mau Escarpments provide fertile ground for large scale production of maize, barley and wheat while beans, potatoes and peas are grown in small scale. Wool and dairy farming is practiced in the areas of Melili, Olpusimoru and Olokurto. In the rangelands, livestock production is the main source of livelihood followed by tourism from wildlife conservation. Current understanding of changes in uses of land in Narok County is not adequate. In order to understand the causes of change, it is necessary to carry out studies that explicitly reveal the variations in these changes. This research sought to assess impacts of socio-economic activities on land use and land cover changes in Narok North Sub-County, Kenya. The study objectives were to analyze land use and land cover changes between the year 1986, 2000 and 2019, to determine the main causes of land use and land cover changes and to determine the effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County. For social survey the study employed descriptive research design. The study targeted 59,996 Households out of which 100 households were selected using stratified random and systematic random sampling methods. The study obtained primary data for images for 1986 and 2000 using satellite images from Landsat 5 and 7 satellites whereas for 2019 epoch the study used Sentinel 2B. Sub- County boundary shape file acquired was used to show the extent of the study area. Also, for household survey, primary data was obtained using both open ended and closed questionnaires. Data analysis was conducted using quantitative and qualitative techniques for household survey where inferential statistics was used to test the association between the variables of interest. Images were processed through; resampling, layer stacking, mosaicking, sub-setting Image Classification, normalized deferential vegetation index (NDVI) and finally accuracy assessment. The study revealed there was significant changes in forested area based on the three images analyzed. There was a decrease from 45% in 1986 to 23% in 2019 while settlement and farm land area increased from 25.2% in 1986 to over 40.6% in 2019. The study revealed that among the causes of changes were belief systems, pastoralist lifestyle, urbanization, poverty, human population pressure, politics, weak laws and regulations among other factors. The response was considered very significant following the results obtained from the ANOVA test and the chi square test of association which revealed that the association between drivers and land use and land cover was very significant given ($\chi 2$ calculated of 28.29 > critical value of 2.26; and a P value < 0.05). In regard to the impacts of socio-economic activities on land use and land cover, the study established that there is a significant association between the key variables. The responses were statistically significant as ($\chi 2$ calculated of 14.002 > critical value of 2.02; and a P value < 0.05). This study concluded that there is a remarkable decrease in the area under forest cover with more of the forest land being converted to farm land and settlements. This conversion has affected the land cover in the area. The study also concluded that most of the causes of land use and cover changes are as a result of the socio-economic factors (population, believes, culture, politics, poverty, urbanization among others). Finally, the study concluded that, despite the existing land initiatives and interventions, development control in the land use has been inadequate and ineffective. For instance, the existing framework for land administration and management is highly centralized, complex and exceedingly bureaucratic, consequently leading to corruption and failure to deliver efficiently. The study

recommends that all relevant stakeholders should develop a sustainable land use policy in Narok North Sub-County and zone different areas for different land use practices. The study further suggests that stakeholders should implement existing policies and laws in protection of forested areas as they are ecologically significant areas.

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LIST OF ACRONYMS/ABBREVIATIONS

ASALs	Arid and Semi-Arid Lands
AVHRR	Advanced very high-resolution radiometer
CBOs	Community Based Organizations
CIDP	County Integrated Development Plan
DRSRS	Department of Remote Sensing and Resource Surveys
ENSDA	Ewaso Ng'iro South Development Authority
ESMAP	Energy Sector Management Assistance Program
ETM+)	Enhanced Thematic Mapper Plus
FAO	Food and Agriculture Organization of United Nations
FGD	Focused Group Discussion
GIS	Geographic Information Systems
GoK	Government of Kenya
ICRAF	International Centre for Research in Agro Forestry
KEFRI	Kenya Forest Research Institute
KFS	Kenya Forest Services
KIHBS	Kenya Integrated Household Budget Survey
KIPPRA	Kenya Institute for Public Policy Research and Analysis
KMO	Kaiser-Meyer-Olkin Measure of Sampling Adequacy
KNBS	Kenya National Bureau of Statistics
LULC	Land Use Land Cover
LULCC	Land Use and Land Cover Change
MAGI	Maryland Geographic Information
NDVI	Normalized difference in vegetation index
NEMA	National Environment Management Authority
NGOs,	Non-Governmental Organizations
NOAA	National Oceanic and Atmospheric Administration
PPES	Probability Proportionate to Estimated Sample
PSUs	Primary Sampling Units
SID	Society for International Development
SLM	Sustainable Land Management
SPSS	Statistical Package for Social Sciences Software
SRS	Simple Random Samples
UNDP	United Nations Development Programme

UNEP	United Nations Environment Programme
USUs	Ultimate Sampling Units

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Changes in land use can be depicted by the unpredictable connection of basic and conduct factors (Gessesse et al., 2015). Land use is rarely static but constantly changes in light of the dynamic connection between the basic drivers and causes (Alvarez Martinez et al., 2011). The reasonable comprehension of causes has an essential significance to recognizing the reasons for Land Use and Land Cover Changes (Greene et al., 2015).

According to Sustainable Development Goal No. 15, human life depends on the earth as much as the ocean for sustenance and livelihoods. Plant life provides 80 percent of the human diet, and we rely on agriculture as an important economic resource. Forests cover 30 percent of the earth's surface, provide vital habitats for millions of species, and important sources for clean air and water, as well as being crucial for combating climate change. Every year, 13 million hectares of forests are lost, while the persistent degradation of drylands has led to the desertification of 3.6 billion hectares, disproportionately affecting poor communities. While 15 percent of land is protected, biodiversity is still at risk. Nearly 7,000 species of animals and plants have been illegally traded. Wildlife trafficking not only erodes biodiversity, but creates insecurity, fuels conflict, and feeds corruption. Urgent action must be taken to reduce the loss of natural habitats and biodiversity which are part of our common heritage and support global food and water security, climate change mitigation and adaptation, and peace and security.

As global population increases, pressure is exerted on the land resulting to a tenuous cohesion between environmental variables (Akinyemi, 2017). The rapid changes of land uses and land cover particularly in developing countries are often associated with rampant urban sprawl (Bajocco et al., 2012) and land degradation by agricultural development and tourism industry (Melesse & Abtew, 2015), resulting to an enormous cost on the environment (Souza et al., 2015). This sort of changes significantly influences nearby territorial climate and the worldwide climate. Anthropogenic changes in land cover for example, impact the worldwide carbon cycle and add to the expansion in greenhouse gas emissions (Bailis, 2010).

In Malaysia, a study by Mahamud et al., (2019) sought to establish the prediction of future changes in land use practices and land cover of Kelantan. According to the study activities carried out on land had undergone many changes particularly since Malaysia got its independence.

In the African Continent many studies have discussed LULCC in arid and semi-arid lands (ASALs) and agricultural productive lands (Dale et al., 2011). Yoshikawa & Sanga-Ngoie (2011) utilized 10 years of National Oceanic and Atmospheric Administration- Advanced Very High-Resolution Radiometer (NOAA-AVHRR) information to break down land cover changes in Sub-Saharan Africa and their investigation demonstrated that ceaseless unidirectional change measure influenced under 4 percent of Sub-Saharan areas.

Terefe, Feyera, Moges (2017) studied the impact of land use/land cover change on ecosystem services in the central highlands of Ethiopia. The study indicated that between 1973 and 2015 the value of the forest cover change that was lost due to the land use was estimated at US$ 3.69 million. The major ecosystem services reduced included: nutrient cycling, provision of raw material and erosion control. In order to

effectively track the past environmental changes through research the use of LU/LC data together with global Ecosystem Service Values (ESV) was considered appropriate in providing reliable data.

Tahir & Hussain (2013) conducted a study in Ethiopia and focused on major land uses which include agriculture, forest, shrub land / grassland and settlements. The findings showed that land use practices and land cover trajectory was different with the forest cover reducing as a result of encroachment by carrying out agricultural practices

In a study by Moodey et al (2009) there are many natural and anthropogenic stressors to the ecosystems and Biodiversity. They indicated that any activity or phenomenon that induces an effect and eventually leads to degradation of land and changes the viability of the natural system is referred to as a stressor. These stressors have been categorized into four groups: land-use and land-cover change [LULCC], including habitat fragmentation and degradation, urbanization, and infrastructure development), biological disruptions for instance introduction of non-native invasive species, diseases, and pests, extractive activities such as fishing, forestry, and water withdrawals, and pollution which includes chemicals, heavy metals, and nutrients. The combined impacts of these stressors are estimated to have altered more than 75% of Earth's ice-free land.

Musa Kiio and Odera (2015) analyzed the effects of LULC change on agricultural land in Kiambu County and determined the main drivers of LULC changes using geospatial technologies. Landsat Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM+) satellite images together with other data-sets were used. The classes mapped were agricultural land, forests, built-area/urban, water body, wet land, grassland and bare land/rock area. The results obtained showed that Agricultural land reduced over the whole period of study from 39.7% to 15.8% which is an indication that the County

is food insecure considering that the population also grew at similar rates. It was also evident that the built-area/urban increased tremendously over the same period, from 1.9% to 33.5%, showing a high demand for houses. A decrease in grassland, Forest, water body and Bare-land/Rocky areas was also observed. The application of geospatial technologies to analyze LULC and related effects was clearly demonstrated.

Mbau (2013) investigated trends in both land use and land cover changes in Taita Taveta County. Remote Sensing imageries were analyzed for the years 1987, 2001, and 2011. Percentage changes in land use and land cover types for the years 1987 to 2001, 2001 to 2011 and 1987 to 2011 were determined. Between 1987 and 2011, significant changes occurred in woodlands, sisal plantations, rainfed and irrigated agricultural areas. Shrublands, forests and water bodies showed no significant changes. Wildlife habitats were expected to further decrease significantly due to agricultural expansion. Land use and cover changes resulted from agricultural expansion and human population growth. The study concluded that proper land use planning and community awareness of the implications of these land use and land cover changes were necessary.

Narok County has numerous uses of land which are open to landowners namely agriculture, livestock production and wildlife protection areas (Narok CIDP, 2013). The most common type of land use in Narok County is mixed farming units, with section of the farm allocated to fruit trees, cash crops and vegetables, while fallow land is used for livestock grazing with rotational grazing being common. There is great potential for alternative sources of livelihood such as Eco-tourism and hay production. In 1992, two former group ranches, Sekenani and Musiara group ranch totaling 1,000Km^2 were converted into game reserves and this has significantly restored biodiversity in the area (Narok ADP, 2013). It is worth noting that Narok County has

been marred by conflict as a result of competing land use systems. There are cases of inter-ethnic conflicts mostly among the Maasai and the Kipsigis community in the northern parts of the county as one community predominantly practices agriculture while the other one practices pastoralism.

In the Southern parts of the County there are instances of human-wildlife conflict mostly over water and pasture. Land is either privately owned in high potential areas or communally owned in low potential areas. The adjudication process (conversion of communal land to private ownership) has been quite successfully and there has been a steady issuance of title deeds. Thus far roughly 46 percent of the ranchers hold title deeds however the district has some landless individuals particularly Mau woods evictees found in Olmekenyu in Oloolulunga division. Others are found in exchanging and metropolitan focuses; these are predominantly work searchers from the neighboring provinces who end up jobless. The decreased infiltration in the increasing areas of degraded land (mainly agriculture and range land) and increase in built-up area in Narok town are the possible causes of the increased flood risk in Narok town.

In reference to the Narok County Integrated Development Plan (CIDP) 2018-2022, human settlement pattern in the county is influenced by among other things; agricultural land potential, development, land ownership tenure and the ecosystem. Areas with high agricultural potential like the Mau and parts of Trans Mara have high concentration of human settlements. These are sometimes associated with informal settlements due to agricultural activities.

Nzitonda (2019) assessed the impact of land use/land cover change on the hydrology of Kakia and Esamburmbur sub-watersheds in Narok Town. The study showed that land use has a major impact on soil hydrological properties and implied that the

observed land use changes negatively affected the soil hydrological properties of the watershed.

1.2 Statement of the Problem

Narok North Sub-County which is one the six Sub-Counties in Narok County, has the highest growth rate in the county (Narok CIDP, 2013). The Sub-County's population has had a 43% increase from 175,588 in 2012 (KNBS, 2012) to 251,862 individuals in 2019 (KNBS, 2019).

With such a population growth rate, built-up areas are rapidly increasing and thus leading to various environmental consequences. Further, there is growing socio-economic disparity within the different segments of society at various levels (rural-rural, urban -rural, nomadic-sedentary). Continued deforestation is leading to drying up of water catchment areas in that, perennial rivers are becoming seasonal, and in some places, aquifers have dropped by 100 meters while wells and springs are drying up (Department of Water Annual Report, 2017). Areas which were under forest cover are now exposed to heavy soil erosion resulting into a massive land degradation such as formation of deep gullies. This has posed serious threat to sustainable agriculture and human health. Loss of vegetation cover has resulted in flash floods in Narok Town that have caused massive destruction of property and loss of lives.

The Mau Forest complex which is situated in the south western part of Kenya and found in the Great Rift Valley. The forest lies between latitudes 00 19'N and 00 93'S and longitudes 350 29' and 360 10' East. The forest covers approximately 416,542 hectares and it was the largest closed canopy forest in East Africa. According to Kenya Forest Service (2010) Mau Forest Complex was larger than Mt. Kenya and the Aberdare forests combined. The forest spreads in seven counties including Nakuru, Kericho, Bomet, Narok, Baringo Uasin Gishu and Nandi. Though studies have highlighted

important issues in regard to LULC in the Mau Forest Complex they have not covered the Maasai Mau Forest which is not part of the complex but it is still in the Mau catchment. Maasai Mau Forest, located in a community land in Narok North Sub-County is not yet gazzeted and is therefore held in trust by Narok County Government.

The loss in tree cover in the forest has transformed the rivers that originate from the forest into being seasonal. The degradation of the forest has diminished other benefits of the ecosystem to the surrounding communities. The current status of the Maasai Mau Forest depicts high rates of failure in the restoration activities evidenced by the reduction in the wild animals in the areas including the Maasai Mara due to the changes that are occurring in the climatical patterns. Because the forest is located in Narok North Sub-County, it becomes the appropriate study location by the researcher in order to assess the association between the socio- economic activities and land use and land cover changes in the area.

From the foregoing, though the issues articulated are critical, the current understanding of historic LULCC in Narok North Sub-County is not adequate. Future understanding of LULLC will need to be greatly improved with systematic research methods and designs. In order to understand the drivers of change, it will be necessary to conduct studies that explicitly reveal the variations in change characteristic. Therefore, this research will address relevant issues in LULCC in relation to the socio-economic setup of the study area and try to provide recommendations which may contribute to the sustainability in the management of the environment and therefore lead to the improvement of the wellbeing of the communities within and those contiguous to the study area. There is also scanty information on social economic factors that lead to LULCC hence this study sought to assess the impacts of socio-economic activities on land use and land cover changes in Narok North Sub-County.

1.3 General Objective

The main objective of this study was to assess the impacts of socio-economic activities on Land Use and Land Cover Changes in Narok North Sub-County, Kenya.

1.3.1 Specific Objectives

This study was guided by the following specific objectives:

i. To analyze Land Use and Land Cover Changes between the year 1986, 2000 and 2019 in Narok North Sub-County
ii. To identify the main causes of Land Use and Land Cover Changes in Narok North Sub-County
iii. To determine the effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County

1.4 Research Questions

The study sought to answer the following research questions;

i. What changes have there been in land use and land cover from 1986, 2000 and 2019 in Narok North Sub-County?
ii. What are the main causes of Land Use and Land Cover Changes in Narok North Sub-County?
iii. What initiatives and interventions have been put in place for sound land use practices in Narok North Sub-County?

1.4.1 Research hypothesis

The study sought to test the hypothesis that;

H_O; *there is no association between socio- economic activities and Land Use and Land Cover Changes in Narok North Sub-County*.

1.5 Research Premise

Changes have there been in land use and land cover from 1986, 2000 and 2019 in Narok North Sub-County. Main causes of Land Use and Land Cover Changes in Narok North Sub-County. Initiatives and interventions have been put in place for sound land use practices in Narok North Sub-County.

1.6 Justification of the study

Though studies have highlighted important issues in regard to LULC in the Mau Forest Complex they have not covered the Maasai Mau Forest which is not part of the complex but it is still in the Mau catchment. Maasai Mau Forest is not yet gazzeted and is therefore managed by Narok County Government This study therefore sought to shed light into understanding the LULCC in the Maasai Mau forest. The age of the respondents was therefore very important as the respondents need to be at least 30 years.

1.7 Significance of the Study

The study is expected to play a major role in informing various stakeholders such as: The National Government, the County Government of Narok, Water Resource Users Association, farmers, Community Forest Associations, pastoralist, real estate developers and non-governmental organizations on the various land use practices and their effects on socio-economic variables. This study will also inform existing policy documents including the Narok County Environment Management Act of 2017, The Narok County Climate Change Policy of 2021 and the Livestock Policy It is through this information that the relevant agencies will come up with specific intervention measures such as formulation of policy that regulates land use in this area. Also, this study will be an important input to the Draft Narok County Spatial Plan (2021-2031) , the Draft Maasai Mau Management Plan which are currently being developed and the

third generation County Integrated Development Plan for 2023-2027 whose development has already begun.

1.8 Limitations of the Study and Assumptions

There were quite a number of methodological issues that the researcher faced that might have limited the effectiveness of the results of this study. The use of the descriptive research design which relies on the opinion and views of the respondents limited the effectiveness of the study results in comparing the changes in the study window. The study used sampling where a sample size was selected from the population and this could have been affected by the sampling errors that might have occurred in the process of selecting the sample. The use of questionnaire as the only instrument of data collection also limited the study in the sense that it is not easy for the researcher to control the responses since the respondent has the freedom to give the answer, he/she feels right depending on how he /she has understood the question statement. Despite these limitations the study still considered the results appropriate for making appropriate deductions for answering the study questions. The researcher delimited the study by ensuring that a pilot study helped to refocus the statements on the questionnaire so that there was consistency and validity of the data. Face and content validity was ensured on the questionnaire to ensure that the respondents have an easy time to respond to the question statements. The researcher made follow up on some respondents to ensure that the response rate was effectively achieved. The research assistants helped to ensure that follow up on the questionnaire was achieved. The imagery data helped to justify some of the responses from the questionnaire. Besides literature reviewed helped to gather secondary data that was also very important in enhancing the findings of the result.

1.9 Scope of the Study

The study was carried out in Narok North Sub-County which has an area of 2,603 Km^2 with a population of 251,862 (KNBS, 2019). The study mainly focused on changes in uses of land and land cover that have occurred in Narok North Sub-County in the three epochs 1986, 2000, 2019 and its impact on the socio-economic development. To determine the types of land use and land cover change, the study analyzed satellite images of the study area to estimate the extent of land use changes. The information from the study was used to suggest approaches to minimize the negative impacts of land use change. The rationale behind the 33 years period under study from 1986, 2000 to 2019 is because some land use changes activities take a long period of time before their impacts are seen.

1.10 Operational Definition of Terms

Land use refers to the various ways in which the available land is used for performing human activities over a specific period of time. Such activities entail agricultural activities, infrastructural development, recreation area and wildlife conservation area (Gajbhiye & Sharma, 2012). According to this study land use was considered as the different ways in which land in the Maasai Mau was used leading to the degradation of the forest and hence effect on the environment.

Land cover refers to the natural vegetation, water bodies, rock or soil, grassland, forest, artificial cover and other features noticed on the land (Turner, 2011). According to this study land cover will entails the natural and artificial vegetation, grass land and forests area in the Maasai Mau forest in Narok County.

Land Use and Land Cover Change (LULCC) this refers to the various noticeable adjustments on the land surface of the earth. This change can be accounted for in over a given period of time given that the effect is not immediate (Brown, 2017). For this study LULCC is considered as the noticeable change in the land surface of the earth in Maasai Mau forest in Narok County

Mosaicking This is the process of merging satellite imageries that overlap to produce one large imagery. This was used in this study to get a clear picture of the land changes that have taken place over time in the Maasai Mau Forest.

Remote sensing this refers to as a process whereby information is gathered about an object, area or phenomenon without being in contact with it. It uses the electromagnetic energy to gauge the interaction between earth surface

materials. For this study it is considered as a science of acquiring, processing and analyzing information about the land use and land cover in the Maasai Mau Forest.

Geographic Information system refers to a computer assisted system for the acquisition, storage, analysis and display of geographic data.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

In this chapter, discussion is focused on literature that is available on LULCC detection using time series remotely sensed data and the causes of such changes as well as the effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County. LULCC especially in terms of changes from forest cover to other land use practices, is one of the important factors on research in land use change. The conceptual framework is presented at the end of the chapter to summarize the relationship between the variables.

2.2 Changes in Land Use and Land Cover

Anthropogenic reasons for LULCC are as old as humanity itself (Martinez et al., 2011). Lambin reaffirms this when he says that the change of the world's territory surface because of human activity is exceptional (Lambin and Meyfroidt, 2011). Turner and Meyer (1994) proceeded to state that adjustments in land use and land cover are among the main human incited activities to be considered for the comprehension of the rate, greatness, and spatial reach of changes on the world's surface. Lambin and Meyfroidt (2011) in their investigation on Global Land Use and Land Cover Changes for the Global News Letter express that land cover changes are not basic cycles since there is a practical and basic contrast between sorts of land cover change, both in existence.

Land cover change can be showed in terms of transformation or alteration as indicated by Bajocco et al., (2012). It was set up in the investigation by Turner and Meyer (1994) that land use change prompts change in land cover while land cover may change without the adjustment of land use. Accordingly, straightforward land cover groupings are not

adequate for change discovery (Lambin and Meyfroidt, 2011). Land use impacts can possibly significantly influence the manageability of agrarian and forested biological systems (Lambin and Meyfroidt, 2011). Land use and land cover are constantly changing and this affected by anthropogenic exercises bringing about different sorts of consequences for the environment. The Kenyan scenario is no different, with Land uses and land cover changes being widespread (Boitt, 2016).

With a focus on economic growth and a burgeoning population, changes in LULC in Kenya has been an ever-present phenomenon with a higher than national average land holding size of 16.2 Hectares (Narok CIDP, 2018). Narok County has numerous uses of land which are open to landowners namely agriculture, livestock production and wildlife protection areas (Narok CIDP, 2013). The most common type of land use in Narok County is mixed farming units, with section of the farm allocated to fruit trees, cash crops and vegetables, while fallow land is used for livestock grazing with rotational grazing being common. There is great potential for alternative sources of livelihood such as Eco-tourism and hay production. In 1992, two former group ranches, Sekenani and Musiara group ranch totaling 1,000Km^2 were converted into game reserves and this has significantly restored biodiversity in the area. (Narok ADP, 2013).

It is worth noting that Narok County has been marred by conflict as a result of competing land use systems. There are cases of inter-ethnic conflicts mostly among the Maasai and the Kipsigis community in the northern parts of the county as one community predominantly practices agriculture while the other one practices pastoralism. In the Southern parts of the County there are instances of human-wildlife conflict mostly over water and pasture. Land is either privately owned in high potential areas or communally owned in low potential areas. The adjudication process

(conversion of communal land to private ownership) has been quite successful and there has been a steady issuance of title deeds. Thus far roughly 46 percent of the ranchers hold title deeds. However, the county has some landless individuals particularly Mau Forest evictees found in Olmekenyu in Oloolulunga division.

2.3 Remote Sensing in Land Use/ Land Cover Change Detection

Computerized Land Use and Land Cover Change Detection is the way toward deciding and additionally portraying changes in land-cover and land-use properties dependent on co-enrolled multi-transient far off detecting information. The fundamental reason in utilizing distant detecting information for change recognition is that the cycle can distinguish change between (at least two) dates that is unique of typical variety. To be successful, change identification approaches must expand between date fluctuation in both ghastly and spatial areas (for example utilizing vegetation files and surface factors).

Various analysts have tended to the issue of precisely checking land-cover and land-use change in a wide assortment of conditions with a serious level of achievement (Akinyemi, 2017). Land cover as characterized by Gómez et al., (2016) is "the actual materials on the outside of a given bundle of land (for example grass, soil, landing area, water)," and land use as "the human movement that happens on, or utilizes that land (for example private, business, mechanical)". Land use can comprise of shifted land covers such as a mosaic of bio geophysical materials found on the land surface . For example, a solitary family neighborhood comprises of an example of land-cover materials (for example grass, asphalt, shingled housetops, trees, and so on) the total of these surfaces and their endorsed assignments (for example parks) decides land-use (Anderson et al., 1976).

Land-use is a theoretical idea, establishing a blend of social, financial and strategy factors, which have minimal actual significance as for reflectance properties, and consequently has a restricted relationship to distant detecting. Far off detecting information record the ghostly properties of surface materials, and henceforth, are all the more firmly identified with land-cover. To put it plainly, land use can't be estimated legitimately by far off detecting, but instead requires visual understanding or refined picture handling and spatial example examinations to get land use from total land-cover data and other auxiliary information Integrated investigations inside a spatial data set system (for example GIS) are regularly needed to relegate land cover to suitable land-use assignments. Achievement in land-cover and land-use change examination utilizing multi-transient far off detecting information is subject to precise radiometric and mathematical amendment (Loannis and Meliadis, 2011).

According to Loannis and Meliadis, (2011) the planning and management tasks of the environment are troubled due to insufficient information on rates of land cover/land use changes. The study noted that land cover changes occur naturally in a progressive and gradual way, however, sometimes it may be rapid and sudden due to anthropogenic activities. They noted that among the most prominent form of global environmental changes occurring is the Land use land cover (LULC) which indicates the spatial and temporal scales. Changes occurring among the urban areas is caused by activities of urbanization. The process of urbanization often leads to haphazard growth in metropolitan cities, deterioration in living conditions and worsening of environmental scenario having detrimental impacts on human health.

Kundu and Olang (2011) conducted a study to investigate the impacts of historical land cover changes witnessed between 1973 and 2000 on the hydrologic response of the

Nyando River Basin. The study used Landsat satellite images to assess the land cover changes in the area and determine how it affects the runoff peak discharges and volumes. The hydrologic models were subsequently used to assess the effect of runoff generation and routing available. Authentic changes in the condition of land cover were inferred by preparing multi-fleeting Landsat pictures. The distinguished changes, along with other spatial datasets were consequently used to gauge the genuinely based catchment and hydrologic model boundaries for overflow age and change, and for channel stream steering. The outcomes acquired showed that the basin experienced huge expansions in top release esteems, particularly in the upstream regions where higher paces of deforestation were recognized. Over the investigation time frame, the pinnacle releases expanded by 16% in the entirety of the 14 sub-catchments in the basin. Reenacted flood volumes in the basin additionally expanded by 10% over a similar period. In light of the outcomes got, the investigation illustrated the results of land use change for flood functions in the basin.

Ayuyo et al (2014) assessed land use and cover changes of the Mau Forest Complex in Kenya from 1973 to year 2010 through formation of geospatial instrument for change detection. The study sought to investigate the pattern of change that had taken place over the defined period with a focus on distinguishing human activities that are liable for the changes. Regulated arrangement were then applied to the Landsat images of 1973, 1986, 2000 and 2010 with grouping plan of three principal classes to be specific - forestland, other vegetation, and non-vegetated land. Post characterization of both visual and territory correlations were done to get data on the patterns, rates and extent of Land Use and Land Cover Changes in the Mau Forest Complex over the long run.

A variety in the greenness of the vegetation present in the pixel over the long run was done through standardized distinction in vegetation record (NDVI) with thickness cuts going from 0.25 μm to 1.00 μm (scope of vegetation cover). The consequences of the examination indicated that adjustments in land use and land cover had happened in all the 22 squares of Mau backwoods complex and brought about the decrease of timberland cover. It was additionally uncovered that there was connection between increment in populace and abatement in timberland cover and that, precarious slants were freed from their backwoods as land utilize changed and resulting loss of biodiversity and mostly prompted decrease in precipitation and ensuing lessening in stream release.

2.4 Land Use and Land Cover Classification

A study by Kundu and Olang, (2011) noted that diverse land cover types in an image can be separated using an image order calculation utilizing unearthly highlights, that is, the splendor data contained in every pixel. In the classification of features in an image different element of visual interpretation are used to identify homogeneous groups of pixels in an area of interest. Srivastava et al., (2012) in their study on LULC features in Kanyakumari district in India, established that among the activities that have led to land use and land cover classification are agriculture expansion, ground water depletion and urbanization. The study focused on the three different classifiers namely Mahalanobis Distance Classifier, Neural Net Classifier (NN) and Adaptive Coherence Estimator in ENVI 5.1 for LULC classification from Landsat images, to select the best suitable method of classifier for the different features. The study categorized the LULC features as built-up areas, water bodies, agriculture land, hilly areas, forest and bare land. The results revealed that Adaptive Coherence Estimator gave more precise view of the classification as compared to the other methods of classification.

Ioannis and Meliadis (2011) sought to assess the characteristics of land-cover types to be indicated as classes in the analysis of land use and land cover in Delhi India. With the rapid population growth in the area there has been a rapid transformation of its LULC pattern. The study sought to assess the effect of LULC between the years 1990–2018 as well as the growth and pattern of built-up surfaces in relation to the population growth and migration in the suburbs. The study used data from the Landsat 5 (TM) and Landsat 8 (OLI/TIRS) to classify the activities in the study area. Using the K means clustering techniques on the Landsat data for the LULC classification, the change detention method was used to qualify the change in the LULC in the study area Srivastava et al., (2012). In supervised classification the image analyst identifies different features or land cover in an image that are known. These known areas are referred to as training sites in which the group of pixels is a good representation of the land cover or the surface phenomena (Ioannis & Meliadis, 2011).

With the use of the pixel information the computer algorithm then looks other areas that have the same grouping and pixel values. The analyst decides the training areas thus supervises the classification. The expert endeavors to find explicit destinations in the distantly detected information that speak to homogeneous instances of these known land-cover types, These regions are normally alluded to as preparing locales in light of the fact that the ghastly qualities of these realized regions are utilized to prepare the arrangement calculation for possible land-cover planning of the rest of the picture, Training locales order a mathematical "understanding key" that depicts the unearthly credits for each component kind of interest (Srivastava et al., 2012).

2.5 Accuracy assessment

Land use land cover analysis can be done from processed aerial photographs, Satellite images (Landsat image, Quick bird image) and Google Earth (Dash, 2005). Since remote sensed data from the earth orbit can be obtained repeatedly over the same area, they have been very useful to monitor and analyze LUCC in various regions of the earth and greatly contribute to planning and management of available resources, especially in the developing countries where other kinds of background data are often lacking (Dash, 2005; Fakeye et al, 2015). After doing of land use land cover classification, the accuracy of special data should be defined. Accuracy assessment or validation is an important step in the processing of remote sensing data which determines the information value of the resulting data to a user (Abubaker et al. 2013)

Fakeye et al., (2015) noted that land use land cover analysis can be done from processed aerial photographs, satellite images and google earth. They indicated that since remotely sensed data from the earth orbit can be obtained repeatedly over the same area, they have been very useful to monitor and analyze LUCC in various regions of the earth and greatly contribute to planning and management of available resources, especially in the developing countries where other kinds of background data are often lacking. Abubaker et al., (2013) on the other hand indicated that after effective classification of the land use land cover, there is need to assess the accuracy of the data in the processing of the remote sensing data. Which determines the information value of the resulting data to a user.

Rodriguez-Galiano et al., (2012), states that the precision files used to assess and survey exactness of the order cycle are: Producer's precision which alludes to the quantity of

accurately distinguished and marked examples for a given class concerning the complete number of reference tests for that classification. It gives a sign of the mistake of oversight; User's precision is a proportion of the blunder of commission. It is essentially the quantity of accurately distinguished and named tests for a given class regarding the quantity of tests deciphered as having a place with that class; Overall precision is a proportion of the complete effectively deciphered examples regarding the whole number of tests; Average exactness is the normal of the individual classifications which could be the maker's or client's precision; Combined exactness is the normal between the generally speaking and normal precision. The general exactness will in general be one-sided for classes with enormous number of tests while the other way around is valid for the normal precision; The kappa list (K) is a proportion of the arrangement between the deciphered picture and the reference information;

$$K = \frac{\text{Observed Accuracy - Chance Agreement}}{\text{1-Chance Agreement}}$$

Where: Observed accuracy is the measure of the agreement between the reference data and the automatic classifier whereas Chance agreement is a measure of the agreement between the reference data and the random classifier; Error of omission refers to those sample points that are omitted in the interpretation result.

According to Abubaker et al., (2013) it is noted that the accuracy of the classification data will determine it’s useful in detecting any changes in the analysis. In order to effectively study and analyze image classification and thus LULCC detection, there is need to have accuracy assessment in the studying and understanding the changes accurately. Effective classification helps to reveal the extent of correspondence between what is on the ground and the classification results. The study also noted that the

importance of having accurate results helps to ensure that the resulting data from the classification are useful is important to be able to derive accuracy for individual classification if the resulting data are to be used in the detection of the change analysis. In this study, accuracy assessment was done for the Landsat 7 ETM+ 2016 satellite image, for which the ground truth data likely equates. An overall accuracy was calculated by dividing the sum of the correctly classified sample units by the total number of sample units.

It is worth noting that image classification forms a major part of the change detection process, there is however need to assess the level of accuracy in order to evaluate the degree of acceptability of the Classification process. In order to evaluate the level of accuracy there is need to have a standard accuracy assessment procedure for conducting a baseline land cover such as the error matrix. Although it is also noted that this procedure is not easy to apply for multi temporal change analysis. Accordingly, accuracy assessments are usually limited to the very recent image that serves as a reference using ground control points (GCPs) collected as part of the data required for the change analysis.

2.6 Image interpretation

Extraction of information from remotely sensed data can be categorized into: Visual Image analysis and interpretation; Automatic Processing and Semi-Automatic Processing (Ioannis & Meliadis, 2011). In visual Image Analysis and Interpretation, Visual Image Interpretation makes utilization of the capacity of the human brain to subjectively assess spatial examples in a scene. Human vision manages the capacity of an individual to reach inferences dependent on visual perceptions.

In breaking down an image, the researcher is somewhere close to two circumstances: direct unconstrained end or utilizing a few pieces of information to reach determinations by thinking measure (coherent deduction); unconstrained acknowledgment-identify features at a first glance; Relies on prior knowledge about area of study and Logical Inference-The interpreter applies reasoning and uses professional knowledge and experience. This might not be enough and ground truthing in most cases is necessary (Ayuyo et al., 2014). A far-off detecting gadget records reaction which depends on numerous attributes of the land surface, including characteristic and land cover. A translator utilizes the component of tone, surface, design, shape, size, shadow, site and relationship to infer data about land cover (Zubair, 2006).

In automatic processing and semi-Automatic processing, semi-automatic/automatic processing uses image classification operation to supplant visual examination of the picture with quantitative methods for mechanizing the highlights in a scene. This includes the investigation of multi-phantom information and the use of factually based choice principles for deciding the land cover personality of every one of pixel in an image (Lille sand and Kiefer, 2000). These include; Spectral pattern recognition, classification process where decision is solely based on the spectral radiance observed in the data, Spatial pattern recognition: decision rule classification is based on the geometric shape, size and pattern present in the image and the intent of image classification process is to categorize all pixels in the digital image into one of the several land cover classes (Konana, et al., 2017).

2.7 Change Detection and Land Cover Analysis

The integration of Remote Sensing and GIS in carrying out monitoring, detection analysis and evaluation of changes has achieved a lot of success in the recent decades. The USA's National Oceanic and Atmospheric Administration (NOAA) satellites have been used by scientists in the preparation of maps and analysis of continental and global scale vegetation cover and vegetation cover change. Hussain et al., (2013), used image datasets prepared by NOAA to compute global vegetation index to analyze the global area coverage. Matikainen et al., (2016) researched the benefits of distant detecting methods according to handle studies in giving a provincial portrayal of vegetation cover. The consequences of their examination were utilized to deliver four vegetation cover maps that gave new data on spatial and transient disseminations of vegetation and permitted local quantitative appraisal of the vegetation cover.

Bengal (2014), completed an examination of land use and land cover planning of Panchkula, Ambala and Yamunanger Districts, Hangana State in India. He noted that the heterogeneous atmosphere and physiographic conditions in these locales have brought about the advancement of various land use and land cover in these regions, an assessment by computerized investigation of satellite information demonstrates that dominant part of zones in these areas are utilized for farming reason. The sloping areas display reasonable advancement of held woodlands. It is deduced that land use and land cover design in the zone are commonly constrained by agro-climatic conditions, ground water potential and a large group of different elements. It has been noted over the long haul through arrangement of studies that Landsat Thematic Mapper is sufficient for general broad succinct inclusion of enormous regions (Ioannis and Meliadis, 2011). Subsequently, this diminishes the requirement for costly and tedious ground reviews led for approval of information. For the most part, satellite symbolism can give more

incessant information assortment consistently not at all like ethereal photos which in spite of the fact that may give all the more mathematically precise guides, is restricted in regard to its degree of inclusion and cost; which implies, it is a rare occurrence utilized (Bengal, 2014). In 1985, the U.S Geological Survey completed an examination program to deliver 1: 250,000 Scale land cover maps for Alaska utilizing Landsat MSS information (Bengal, 2014).

The State of Maryland Health Resources Planning Commission likewise utilized Landsat TM information to make a land cover informational collection for consideration in their Maryland Geographic Information (MAGI) information base. To determine forest cover changes in five water towers in Kenya namely Cherengani, Aberdare, Mau, Mount Elgon and Mount Kenya, an assessment was undertaken by DRSRS, UNEP and KFS between the years 2000-2002 where Landsat TM imageries of 1987, 1995, 2000 and 2002 were used. Interpretation of the imageries were based on “true color" composition of bands 1 (blue), 2(green) and 3(red), and “aerial trudging" was done by low flying to validate results of the satellite imageries. Areas of various cover classes were compared to monitor the cover change, thus achieving its main objective. It finally recommended the use of Geographic Information Systems (GIS) for effective monitoring of changes in ecosystem, using among others aerial survey and satellite imagery (Nagendra et al., 2012).

Houet et al., (2010) undertook a project to map LULCC in Kakamega Forest between 1975 and 2005 being necessitated by changes that had occurred in the forest due to several factors such as illegal excision, selective cutting of commercially viable trees, unauthorized settlement and uncontrolled grazing, like in many other forests in the country. They were to provide information on status and to generate database on

Kakamega Forest resources and its ecological changes to facilitate sustainable management geared towards conservation. The objectives were achieved but the database provided was not complete in that, it was composed of time series land cover types only. A more vibrant geo-database was required in such a case and this was has achieved using such variables like population dynamics, slopes and soil data.

Akotsi and Gachanja (2004) efforts to examine changes in the five water towers in Kenya utilized image differencing and Normalized Difference Vegetation Index techniques with Landsat imageries to highlight areas where forest cover had been depleted. The study achieved its objective of mapping and showing clearly, the changes in forest cover in the catchments. Forest cover mapping of Mau Forest Complex was undertaken by DRSRS in the year 2003, as a priority following the controversial illegal settlements. Being a very important catchment area, and source of rivers such as Mara River and Ongata Rongai River, it was a matter of paramount importance to map this forest.

The method involved digitizing Landsat satellite imagery of 2003, which had prior been composite using spectral bands 3, 2, and 1 for Red, Green and Blue respectively before performing unsupervised classification. The classification was aided by data from field sample points and aerial photography. The gazzeted forest land boundary was overlaid on classified image to clip the area under study. The whole of Molo Forest was found to be under cultivation. However, the most intact of the 22 gazzeted forest blocks in this complex was Chemogorok which had only 0.35% of its original coverage cleared. Through the use of remotely sensed data the objectives of mapping the forest complex, assessing the status and quantifying the area under different classes in each forest blocks were achieved.

Landsat imageries were used to assess the forest cover change in the Mau Forest Complex between 1986 and 2000 to illustrate the potential use of high-resolution Landsat imageries in vegetation cover analysis. The results gave a good discrimination of changes in cover types, and also showed areas prone to landslides. Though these studies have highlighted important issues in regard to LULC in the Mau Forest Complex it did not cover the Maasai Mau Forest which is not part of the complex but it is still in the Mau catchment. This study therefore sought to shed light into understanding the LULCC in the Maasai Mau forest.

The reviewed studies have indicated that there has been a lot of research focusing on the Mau Forest in the previous past. Although all these studies have purported to have covered all the forest blocks of the Mau Complex, it is evident that little has been done in the Maasai Mau partly because it is not been gazetted and it's still under the management of Narok County Government. It is therefore the purpose of this present study to consider the land use and land cover changes in this block and hence provide literature to fill the gap by incorporating the Maasai Mau Forest. This study also sought to bring to an understanding the role of socio-economic factors in the LULC in the forest and the surrounding environment. Unlike the previous studies which have concentrated on the understanding the various aspects of land use and land cover from a geo spatial perspective using satellite images only. These studies did not use field studies were the people living in the forest areas were in0volved in the study. The involvement of the local households in the study was considered very important in the current study as it helped to bring out the views and perception of the residents in regard to the effect of the LULCC in the Maasai Mau forest.

The use of interviews and questionnaires helped to assess the understanding of the community living around the forest of the impact that changes in land use and land

cover have had on their activities. Change detection using remote sensing can be useful in many ways including Forest cover monitoring and analysis, Land cover change analysis, Disaster management, Urban monitoring (Ayuyo et al., 2014). The application of change detection of concern here is the change detection analysis of LULC of Maasai Mau Forest.

2.8 Causes of Land Use and Land Cover Change

Land use is rarely static however continually changes in light of the dynamic collaboration between fundamental drivers and proximate causes (Lambin and Meyfroidt, 2011). The calculated comprehension of proximate causes and hidden powers has a significant significance to distinguishing the reasons for LULC (Brown et al. 2012). Proximate causes incorporate horticultural extension, wood extraction, infrastructural development and others that change the actual condition of land cover (Alvarez Martinez *et al*., 2011). At the proximate level, LULC changes might be clarified by different factors as opposed to a solitary variable (Lambin and Meyfroidt, 2011).

Fundamental main impetuses, for example, segment pressure, financial status, innovative and institutional components impact land use and land cover changes. Land use changes were driven by various financial, socio-political and biophysical factors. In the course of the most recent twenty years, the development of land utilizes got intense in the metropolitan and country regions. Particularly, more land territories have been dislodged or changed over to non-agrarian exercises especially for industry, lodging and business exercises (Munteanu *et al*., 2014). Proximate causes work at the neighborhood level (singular homesteads, family units, or networks) while hidden causes are at local and public levels, for example, regions, areas or nations.

Fundamental causes are frequently outside and outside the ability to control of nearby networks (Akotsi and Gachanja, 2014).

2.8.1 Population Growth and Land Use and Land Cover Change

Verifiably, populace was viewed as the most significant and the main thrust behind worldwide land use and land cover change. Notwithstanding, right now it is perceived that Land Use and Land Cover Changes have many main impetuses that are firmly interrelated, populace being just one of them (Jiyuan et al., 2014).

Studies led at longer time scales show that land cover change had and still has hugely been impacted by both the expansion and diminishing of a given populace. The point of concern was, to examine how social economic factors play an influence the land use and land cover in developing countries such as Kenya. In 2003 to 2004 a study was conducted in East Germany to determine the correlation between population and the land use land cover change (Srivastava et al., 2012). The study found out that there was a correlation between natural population growth and immigration and the shift in land uses within the east of Germany. Lambin & Meyfroidt (2011) in contrast, argued that populace development, destitution, and framework are bad markers of the status of land cover changes. All things considered, reactions from individual and networks to changing financial conditions and institutional factors regularly influence land use and land cover change. In most non-industrial nations' populace development has been a predominant reason for Land Use and Land Cover Change than different powers (Belal, 2011). Although this study considered factors in the social economic front but its location was in developed nations and hence an understanding of how the factors play a role in the land use and land cover in developing countries is a point of interest hence the need for this current study.

Drummond and Loveland (2010) asserted that there is a huge factual relationship between populace development and land cover change in the majority of Asian, and Latin American African nation. The study further noted that the Republic of South Africa, has been also experienced these significant changes in land cover land use as in from the year 1961 to 2006. This change in South Africa could be as a result of trends like agricultural modernization as well as a steep growth in population which has resulted in a great land use change within the region in terms of settlement, urban growth and agricultural diversification (FAO, 2010). This study was conducted in South Africa and only covered a period of 45 years. According to the study the cause of land use and land cover changes were as result of agricultural activities and population growth. This current study seeks to expound on these factors but moves its focus to the Mau Forest in Kenya. The study aims at not just focusing on agricultural activities but it will consider the social economic factors in general as a way off adding new knowledge to the existing one.

Likewise, in Kenya populace burden has been found to have had undesirable effects on forests, especially the Mau (Sayyid et al., 2011). Boitt (2016), in her study of natural forest cover in the five water towers in Kenya concluded that population growth really degraded the forests. Unlike these studies, Balcombe & Tiffin (2012) argued that in Machakos, populace development was found to have a confident impact on forest cover. They state that, areas occupied by people were found out to have more forest cover than areas with sparse or no population. The conclusions by the above studies were not based on spatial analysis between population growth on one hand and LULCC on the other. This study closed the gap by comparing time series population density maps with time series land cover changes to ascertain the relationship and therefore did

not act on mere increase in population over time. This study is in agreement with the various studies that concluded that increase in population resulted in deforestation and general forest degradation.

2.8.2 Population and Environment

The issues on the speculations with respect to the effect of populace on climate and monetary advancement have been bantered between two ways of thinking set forward by Thomas Malthus and Ester Boserup (Rahman, 2019). Neo-Malthusians accept that populace development negatively affects financial turn of events and ecological upgrade. As per this view, populace development has a more noteworthy force than that in the land itself, to impact food creation, and this is on the grounds that populace increments mathematically though food creation increments numerically (Hooke, et al., 2012). India as is one of the countries that has suffered this consequence of increased population as it has resulted into reduced and for agriculture, degraded land and also increased pollution due to vegetation loss (Song & Liu, 2014). In another study Hofmann [2013] that reviewed the suggestion of a Neo-Malthusians, a report of the World Bank between 1968-1981, indicated that 'populace development is the best single mindful factor for low financial turn of events and low quality of climate in agricultural nations.

According to the report population plays a critical role in understanding the effect of land use and land cover in a country. The surface cover has been left uncovered and the cropland expanded. For example, in Ecuador populace development with high thickness brought about the extension of provincial settlement, afforestation with eucalyptus tree and a quickened deforestation (Song and Liu, 2014).

Not at all like Neo-Malthusian perspectives, the individuals who uphold Boserup's thoughts have a hopeful vision with respect to the connection between populace development and food creation just as the nature of the climate (March, 2017). As per this way of thinking, quick populace development assists with growing great proficiency and mechanical advancement as opposed to blocking the expectations for everyday comforts of the individuals. Martinez et al., (2011) noted in his study in Machakos, that the effect of populace development on the climate and neediness isn't straightforward and one directional according to the study fast populace development influences the nature of the climate and expectations for everyday comfort of individuals and the opposite is genuine where populace develops at a slower movement. Though this study was conducted in a Kenya set up it did not bring out the actual influence of populace growth on the land use and land cover and how it influences the climate changes in the area. By considering population in the context of social economic factors the current study sought to shade lighter and insights in the understanding of effect of various social economic factors on the land use and land cover changes in the Mau Forest which is one of the expansive forests in East Africa that is at the brick of depletion because of human activities.

Bajocco et al., (2012) noted that, Land Use and Land Cover Changes has a relationship with social-financial elements. According to this study social- financial elements of which population is one of them puts much pressure on need for more land for development , fuel wood and more land for settlement territories. All these put together, leads to degraded landscape. This study did not Land degradation is hence an interactive process involving multiple causal factors, among which climate variability, soil quality, and land management play a significant role

2.8.3 Institutional Factors

Lambin & Meyfroidt (2011), state that, the comprehension of institutional elements (for example political, lawful, monetary and social) and their association with singular dynamic are significant in clarifying area use changes. Institutional variables should be considered at both miniature and large-scale levels in light of the fact that the execution of large-scale arrangements is polished at the neighborhood level. Land Use and Land Cover Changes are impacted fundamentally when large scale strategies sabotage miniature (nearby) approaches. The structure of neighborhood and public strategies may decide nearby individuals' admittance to land, capital-innovation, and data. In this study it was noted that the absence of all around characterized approaches and frail institutional requirement may encourage changes of land use. It is further noted that, limitation of land utilize is conceivable if there are proper land use arrangements set up. Bajocco et al (2011) inn their study on the Impact of Land Use/Land Cover Changes on Land Degradation Dynamics conducted in the Mediterranean examine various factors that lead to land degradation occurring not only in semi-natural areas, but also in agricultural and peri-urban lands.

According to the study the factors considered were soil erosion, soil sealing, and compaction mainly due to agricultural intensification, salinization, and contamination due to industrial activities. The current study will besides considering these factors us the land cover images to enhance the understanding of the effect of various factors on the LULC changes in the Maasai Mau forest.

In most non-industrial nations, mutual (customary) land holding frameworks have been moved to a formal (state) holding framework (Lambin and Meyfroidt, 2011).

Approaches on value control on horticultural sources of info and yields and accentuation on independence in food creation have all impacted land use changes (Bajocco et al., 2012). The nonattendance of pertinent timberland strategy is referred to as a contributing element for deforestation in various pieces of the World. In Brazil, for instance, public arrangements focused on the change of farming base and building up the Amazon economically have caused the deforestation of 1.1-2.1 million hectares yearly (Bajocco et al., 2012). In the present study, land degradation is considered as a process occurring not only in semi-natural areas, but also in agricultural and peri-urban lands (Bajocco and others 2011). For instance, besides soil erosion, the major land degradation processes in the Mediterranean basin are soil sealing, compaction mainly due to agricultural intensification, salinization, and contamination due to industrial activities (Montanarella 2007)

Srivastava et al., (2012) In their study in India which was based on utilization of Earth observation datasets over the highly urbanized Allahabad district. The study noted that the LULC pattern maps, achieved through classification of multi-temporal satellite datasets, indicated that the socio-economic and biophysical factors have greatly influenced the growth of agricultural lands and settlements in the area. The study was conducted between the periods of 1990–2000–2010. The integrated approach was applied to analyze the temporal and spatial changes in the study area. This study was conducted in an area outside Kenya and hence results might have reflected a different view as compared to the Kenyan perspective. The current study focused on the Kenyan perspective and specifically sought to find out how the integration of the satellite data and social economic data collected from the residents. This study therefore offered an opportunity to fill the existing gap in the literature relating to LULC in Maasai Mau forest.

2.9 Consequences of Land Use and Land Cover Change

This section seeks to discuss the literature related to the consequences of land use and land cover change in the study area. The researcher sought to assess the consequences of LU on the LC changes in the forest area of Maasai Mau in Narok County.

2.9.1 Forest Status

Worldwide, around 29 percent of the land surface was initially under backwoods cover. By and by, in any case, it is just a fifth of this unique woods cover which stays undisturbed (Ajani et al., 2019). It is estimated that in Kenya, 2.5 per cent of the country was covered with closed forest in 1995. High-goal aeronautical overviews of chose woodlands in the Aberdare, Mt. Kenya, Mt. Elgon, and the Mau complex uncovered that deforestation and general debasement was occurring on a more neighborhood scale altogether because of spontaneous timberland abuse (Olang & Kundu, 2011). A part from forest clearance due to man's needs and wants, some forests have largely been destroyed by fires. During the year 2000, fires destroyed about 2978 hectares of forest in Kenya.

Most of these fires were experienced within Mau and Mt. Kenya areas (Olang & Kundu, 2011). A study on the changes of forest cover on the five water towers of Kenya (Ongong, 2012) observed that, a total of 8,266 hectares was destroyed in the Mau, Cherengani and Mt. Elgon forests in 2003 alone. The most affected was Mau with 7,084 hectares lost. About 40,000 hectares of land in the heart of Kenyan forests had been excised by 2001 with Mau being most affected. Although these studies provide a good insight in understanding the consequences of land use on the land cover but none of the studies have considered the Maasai Mau which is not part of the blocks of the Mau Forest. This current study therefore sought to bridge this gap by considering the consequences of land use on the land cover in the Maasai Mau forest, in Narok County.

Keenan et al., (2015) reviewed the Mau Rehabilitation Secretariat Report, which was aimed at managing the Mau forest Complex and bringing it back to its glory. The report also sought to assess the extent to which; change of forestland into settlements; botch of mechanical timberland estates; unlawful woodland asset extraction; fires and overgrazing led to a change in the land cover in the forest. According to the report the northern squares of the Mau Forest Complex have broad mechanical backwoods which have supplemented indigenous woods. These findings clearly show that there has been vast consequences on the forest cover in the Maasai Mau complex because of the varied land use activities that have been performance on the land cover a long time. The current study therefore sought to add to this literature by considering the effect of land use on land cover in the Maasai Mau forest of Narok North sub county.

2.9.2 Biodiversity Status

A study by Lambin and Meyfroidt, (2011) noted that the most significant effect of land use on the land cover is on soil and biotic assets. The loss of biodiversity because of Land Use and Land Cover Changes happens at numerous levels (scene, biological system and species), and in different measurements (structure and capacity), (Alvarez Martinez et al., 2011). The loss of plant biodiversity may prompt the decrease of environment trustworthiness and loss of plant hereditary assets, which thusly bring about block of logical advancement in agribusiness and pharmaceutics. As indicated by Barbie (2010), 80 percent of the total populace relies upon home grown medication for essential medical care needs. The principal wellspring of these customary drugs is the backwoods environment.

Along these lines, loss of plant biodiversity would have incredible effect on the soundness of poor people who are monetarily compelled and won't have the option to purchase current Medicine. In Kenya, Land Use and Land Cover Change has essentially influenced plant and creature biodiversity. The Mau Forest Complex for instance contains an extraordinary variety of woodland types including the lower Montane which is in its best condition in the South Western Mau Forest Reserve yet vigorously signed in different timberlands where it happens (Intergovernmental Panel on Climate Change and Intergovernmental Panel on Climate Change, 2015). This intergovernmental panel study did not address issues in the Maasai Mau area of the forest since this areas is still under the management of the Narok County and the KWS. This current study therefore sought to add to the literature in understanding how LU affects LC in the Maasai Mau in Narok County.

A study by Stella et al., (2014) sought to analyze the effect of LU and LC in the Mau forest complex. In their study the established that Huge stands of bamboo have been extracted or infringed, Generous pieces of the higher height Juniperus-Podocarpus-Olea backwoods have been infringed and cleared. This has resulted into huge fires which have also added to gigantic loss of both plant and creature species. The Mau Forest Complex along with its assorted creature and vegetation structures is at present under danger (Intergovernmental Panel on Climate Change and Intergovernmental Panel on Climate Change, 2015). Thus, loss of biodiversity in the Mau has affected the Maasai and is equally affecting other communities elsewhere who depend on herbal medicine. It has also affected tourism as a sector of Kenya's economy. The findings of these studies have shown clearly that there is an effect between land use and land cover changes in the Mau Forest complex. This study sought to examine whether the same is

true for the situation in the Maasai Mau forest which is not part of the Mau Forest complex.

2.9.3 The Fate of Hydrological Cycle

Land Use and Land Cover Changes have been known to effect on neighborhood and local atmosphere and hydrological balances (Bajocco et al., 2012). The arrival of carbon dioxide to the climate from the worldwide earthly biosphere has become a significant issue compromising the wellbeing of the climate (Bajocco et al., 2012). As indicated by (Baillis, 2010) in the century we live, deforestation may deliver 5-53 percent of the carbon that would be put away in the worldwide environment.

Land cover changes brought about by both regular and human intercessions contribute towards this environmental change. The effect of Land Use and Land Cover Change on hydrological cycle isn't yet satisfactorily surveyed (Bajocco et al., 2012). A huge expulsion of timberland in the Amazon has prompted a lessening in dissipation and precipitation in the locale.

Land use and land cover changes, particularly vegetation cover, additionally influence water and energy adjusts (Baillis, 2010) Land Use and Land Cover Changes speak to the biggest human wellspring of emanation of nitrogen and carbon dioxide which adds to both nursery driving and air ozone consumption (Dale et al., 2011). The change of various land cover types to cropland has added to the arrival of carbon which is roughly equal to 30 percent of that from non-renewable energy source ignition (Baillis, 2010). The delivered measure of carbon and different gases because of the change of a land cover type into another cover type is mostly subject to the earthbound attributes. For example, woods change into cropland or prairie brings about considerably more carbon in damp regions than equatorial area (Alvarez Martinez et al., 2011).

As indicated by Alvarez Martinez et al., (2011) certain land use types have critical effects past the extent of their spatial degree. The extension of settlement region, for example, to the detriment of other land cover types discharge huge measure of synthetic toxins which might be perilous for safe human residence. In the previous 50 years, the development of dams and supplies has become a significant piece of human incited land cover changes. Effects of land cover changes that happen because of fake water bodies are past their areal extent in degree. To the extent that the hydrological cycle, land cover attributes have numerous linkages. The sort of land cover, clearly, can influence both pace of penetration and overflow sum (Bajocco et al., 2012).

As per (Souza et al., 2015) both surface and ground water streams are fundamentally influenced by sort of land cover. For instance, woods covering and leaf litter assistance to build invasion rate and diminish the erosive activity of downpour drops. Then again, the development of sheet, rivulet or potentially crevasse disintegration are basic in zones where ground cover is deficient. There is proof that convective flows that expansion nearby precipitation are disposed of when broad regions of woodland cover are eliminated (Intergovernmental Panel on Climate Change and Intergovernmental Panel on Climate Change, 2015). Notwithstanding, this doesn't appear to happen for evacuation of little territories, and the size of this impact is hard to set up.

A portion of the impacts of eliminating woods cover are expanded and, now and again, diminished spillover. There is exceptionally solid proof from very much directed, combined catchment contemplates that the net impact is for mean yearly spillover to increment after deforestation, in spite of the fact that the size of the expansion relies upon variables, for example, the yearly precipitation, soil qualities, and sort of substitution vegetation (Gholami, 2013).

Stream streams following moderate to enormous tempests additionally increment in size and flashness in light of the snappier overflow when the backwoods are supplanted with yields and grass. Notwithstanding, expulsion of tree cover has almost no impacts on overflow from extremely enormous tempests (Keenan *et al*., 2015). Enormous enough tempests essentially overpower whatever cover (tree, crops, grass) is available, either in light of the fact that the ground quickly gets immersed or the precipitation is serious to such an extent that it can't invade into the ground rapidly enough and runs off. The reduction in forest cover in the Mau has resulted in reduced river lows and aridity (Olang & Kundu, 2011).

Although the reviewed studies have focused mainly on the other parts of the Mau Forest complex, there is need to also consider the effect of land use on the hydro cycle in the rest of the forest part in this case the Maasai Mau forest area in Narok North Sub County. This study presupposes that forest reduction cover has also led to the creation of similar conditions in the study area.

2.10 Initiatives and interventions for sound land use practices

Land Use decision making is determined by various initiatives and interventions. Olaleye et al. (2013) observes that the analysis of land use and land cover interventions revolves around two questions notably the causes and the impacts of the same. However, determination of land use and land cover initiatives and interventions is not clear as they are debatable but it is agreed that the two main categories of such agents of change are bio-physical and socio-economic (Mengistu and Salami, 2017). The essence of regulations as an initiative is development control and maintenance of acceptable standards of physical development (Oke & Fagbohun, 2013).

Land Use in Kenya is controlled by various instruments but not limited to the following: Physical Planning Act, Cap 286, Local Authorities Zoning Policies, Environmental Management and Coordination Act (EMCA) of 1999 and The Forest Act, Cap 385 of 1996 (revised 2009).

Physical Planning Act, Cap 286 has explicit powers on development control matters in urban areas. It provides for the formulation of National, Regional and Local physical planning guidelines, policies and strategies (Kimani and Musungu, 2010). The physical planning act provides for the preparation and implementation of physical development plans and other connected purposes. Under the Act, Local Authorities are given powers to prohibit or control use and development of land and buildings for orderly development in the following manner: control of sub-division of land, consideration and approval of development proposals, ensuring proper execution and implementation of approved physical development plans, formulation of by-laws to regulate zoning in form of density of development and to preserve and maintain open spaces, parks, urban forest, green belts in accordance with approved physical development plans (Kimani and Musungu, 2010).

In Kenya, county governments regulate and control the type of location of land uses within their borders through zoning (Munroe et al., 2015). Zoning is based on a comprehensive land-use plan, enforced to encourage or regulate development along pre-determined areas or permissible uses in terms of commercial, industrial, residential, and recreational areas. Land use zones separate one set of land uses from another based on the optimum and sustainable use of resources. Theoretically, the primary purpose of zoning is to segregate uses that are thought to be incompatible. In practice,

zoning is used to prevent new development from interfering with existing physical and geological setting. Linked to this is the zoning by-laws or an ordinance defined simply as the statements upholding and supporting the zoning plan (Hodge, 2011). By-laws are the equivalent of local legislation and are enforceable. By-laws can permit or restrict activities across zones; they are not necessarily spatially specific.

They govern how land may be used, where buildings and other structures can be located, the types of buildings that are permitted and how they may be used, the lot sizes and dimensions, parking requirements, building heights and setbacks from the street. Zoning laws are vital in quality of urban environmental since they direct the manner in which important areas are to be utilized and thus have the potential to ensure that resources are sustainably managed. However, zoning is considered as highly political and receive many critics. For instance, regulations fail to care for established neighborhoods' and to prevent sprawl on the fringes of cities, and the administration of regulations is often associated with favouritism and corruption (Listokin, 2014).

As Munroe et al. (2015) argued "zoning plans generally reflect a variety of political interests and stakeholders. Local government also faces a balancing act in attempting to maintain broad political support, keep service costs low, and maximize the residential tax base. In many cases, zoning or re-zoning are strongly influenced by land developers and neighborhood interests are disregarded (Fischel, 2015). Or, the decisions maybe influenced by some home- owning voters, since these small groups of people can sometimes influence the political campaign. Apart from the zoning laws, the forest Act Cap 385 is also important in controlling environmental management. It provides the legal framework for the conservation of forests and under it, the minister responsible for the natural resources is empowered to declare any forest area a nature reserve for the purposes of preserving the natural amenities thereof and the flora and fauna therein.

The Environmental Management and Co-ordination Act (No. 8 of 1999) provides for guidelines for environmentally sustainable development. The Act requires that development plans embrace the preparation of Participatory National Environment Plans that have sectoral coordination and linkages as well as environmental conservation measures. It also requires that environmental impact assessment be carried out for all development projects that are likely to pose negative environmental impacts. For complete projects, the act requires that yearly environmental audits be carried with clear mitigation measures (Kimani & Musungu, 2010). To manage the environment in a holistic manner, the Act establishes two administrative bodies: the National Environment Council (NEC) and the National Environment Management Authority (NEMA).

While NEC has the responsibility of formulating policies, setting national goals, and promoting cooperation among stakeholders, NEMA's role is to supervise and coordinate overall matters relating to the environment. It is instructive to note that the Act creates NEMA (Section 7) as the body charged with implementing the provisions of the Act. The Environmental (Impact Assessment and Audit) Regulations, 2003, stipulate that lead agencies should subject all public policies, plans and programs (PPP) to Strategic Environmental Assessment (SEA). During the SEA process, the likely significant effects of a PPP on the environment shall be identified, described, evaluated, and reported. The full range of potential effects and impacts should be covered, including secondary, cumulative, synergistic, short-, medium- and long-term, permanent, and/or temporary impacts.

The Forest Act, Cap 385 of 1996 (revised 2013) is also one of the statutes that have a bearing on the planning and building sector. The Act provides for the establishment,

control, and regulation of forests in Kenya. It encourages the conservation of all types of vegetation thus contributing to the greening of urban areas immensely (Kimani & Musungu, 2010). The Forest Act is applicable to gazetted forest areas (Forest Reserves) and specifically covers: Gazettement, alteration of boundaries and de- gazettement of Forest Reserves (Section 4); Declaration of Nature Reserves within Forest Reserves and regulation of activities within Nature Reserves (Section 5). Despite these provisions, it's noteworthy that broadly speaking, the declaration of areas as protected forests is an aspect of land use planning which is contained in the Physical planning Act Cap 286. This may cause conflict on which of the laws takes precedence over the other. Additionally, the Act provides for the power of local authorities and the state to regulate the development and use of property (including private property) for the good of the community or country as a whole.

Conversely land use planning provides a guide for integrating different land uses for the benefit of an entire range, especially in ecologically important regions where different property-rights regimes operate. Forest management affect the land use and land cover dynamics within Nairobi as the need to expand built up areas exerts pressure on the forests while endeavoring to ensure that resources are sustainably managed. However, the expansion of the city which may consume any gazette forest would have to go through the procedures of degazettement provided for in the Forests Act.

Apart from state forests, the Act allows for forest officers to make arrests in local authority forests and provisional forests. To ensure strict protection of forests and illegal encroachment to forests, the Act confers prosecution powers to forest officers Further, in the revised Act, the levels of penalties has been raised to ensure deterrence.

National Land Commission Act, 2012 gives effect to the establishment of the National Land Commission as the main regulator of public land. The Act further mandates the Commission to create County Land Management Boards (CLMBs) for purposes of managing public land at the county level. According to the National Land Commission (NLC) progress report of January 2014, the Commission has taken steps and measures to stop encroachment and sale of public land belonging to the county and national governments. NLC has also initiated action to recover encroached public land by supporting court cases filed by resident associations against private developers. It has furhetr advised and notified all Counties to complete their inventories of lands that have encroachments for immediate repossession (NLC, 2014). As most the infill development that affect the environment of the city are done on the enchroached land, the action by the NLC will give planning authorities of the affected areas time to undertake suitability studies for development of those spaces.

Despite the existing land initiatives and interventions, development control in the land use has been inadequate and ineffective. This can be attributed to a number of factors. For instance, the existing framework for land administration and management is highly centralized, complex and exceedingly bureaucratic, consequently leading to corruption and failure to deliver efficiently (Sessional Paper No 3 of 2015). In addition, the existing development institutions and legal framework are weak and lack a comprehensive land use planning policy to guide the way in which land is utilized thus causing disharmony in land utilization (Odhiambo and Nyangito, 2012).

Another challenge relates to laxity in approving plans in that despite the fact that the law requires that all developers must submit their development proposals to local authorities for approval, this has been reported to take unnecessary long period of time

thus delaying developments in most of the local authorities. Developers have had to go ahead with their developments with no regard for submitted plans. Local Authorities have been also slow in making decisions on planning application. This has been attributed to the complicated procedures the applications have to go through; laxity among the officers and the councilors and the over-centralization of decision making (Munroe et al., 2015).

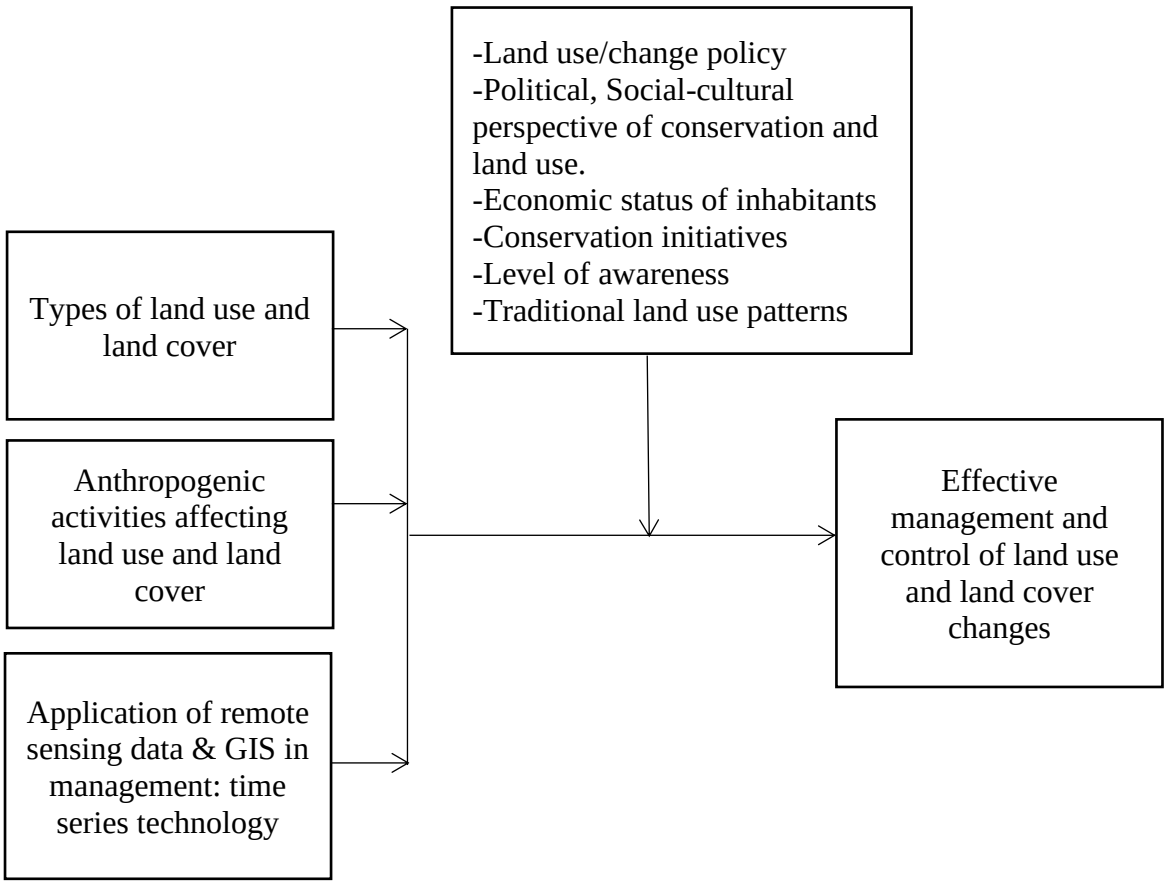
There is also the challenge of multiplicity and incoherent organization of planning institutions. Institutional coordination is handicapped by the fragmented nature of local government and planning institutions inherited from the colonial era. Although there are 100 legislations governing land use and management, there is no concise national policy framework from which holistic and integrated land use strategies and directions can be generated. The multiplicity of laws in these legal entities has also caused various conflicts. There is also lack of a mainstream mechanism for physical development planning thus creating a conflict between the national, regional, and local levels of planning. Whereas the plan formulation/preparation is undertaken by the central Government, plan implementation is the responsibility of the county Government. (Kimani & Musungu., 2013). In addition, there is limited institution coordination of development control agencies especially during development application permission, supervision, and inspection of the projects. Further, some instruments contradict each other and multiplicity of laws domiciled in different institutions is making their implementation uncoordinated.

2.11 Conceptual Framework

A conceptual frame work is a diagrammatical representation of the relationship that is purported to exist between the dependent and the independent variables. It gives the researcher an image of how the variables relate to each other. For this study the

conceptual frame work was developed based on the various aspects of LULCC as reviewed in the literature. The independent variables were the types of land use, the anthropogenic activities and the application of the remote sensing data GIS while the dependent variable was effective management of land use and land cover changes in the Maasai Mau Forest . This is shown in figure 1.

Figure 1: Conceptual Framework



Source: Author 2020

Figure 1 helps to show the relationship that exists between the variables that define the study. It shows that there is a direct effect between the independent variables (types of land use and land cover, the anthropogenic activities affecting land use and land cover

and the application of the remote sensing data in the management of time series technology) and the dependent variables which is the effective management and control of land use and land cover changes. The figure also presents variables that tend to influence the relationship that is the intervening variables.

From figure 1 it is noted that there is a purported effect between the types of land use and land cover in the Narok North Sub-County on the effective management and control of the land cover changes. With an understanding of the various types of land uses it is possible for appropriate strategies to be put in place to enhance effective management of the effect that arise of the different uses.

It is also shown that there is a relationship between anthropogenic (socio economic) activities and how they affect the land use and land cover in the Maasai Mau area. According to the figure understanding the various social economic activities and how they influence the land use and land cover has an influence on the effective management of the land cover changes in the forest area.

There is also a relationship that exists between the understandings of the relationship between applications of the remote sensing data in the management of time series technology. The figure shows that through effective application of remote sensing data in the management of time series technology it is possible to understand effective management of the effects land use and cover change in the forest area in this case the Maasai Mara forest area.

The figure also shows that though there is a purported direct relationship between the variables there are other intervening forces that might influence the relationship. In this case such factors as, **l**and use/change policy, Political, Social-cultural perspective of conservation and land use, Economic status of inhabitants, Conservation initiatives,

Level of awareness and Traditional land use patterns were considered to have an intervening effect on the relationship between the independent and the dependent variables of the study.

CHAPTER THREE

RESEARCH METHODOLOGY

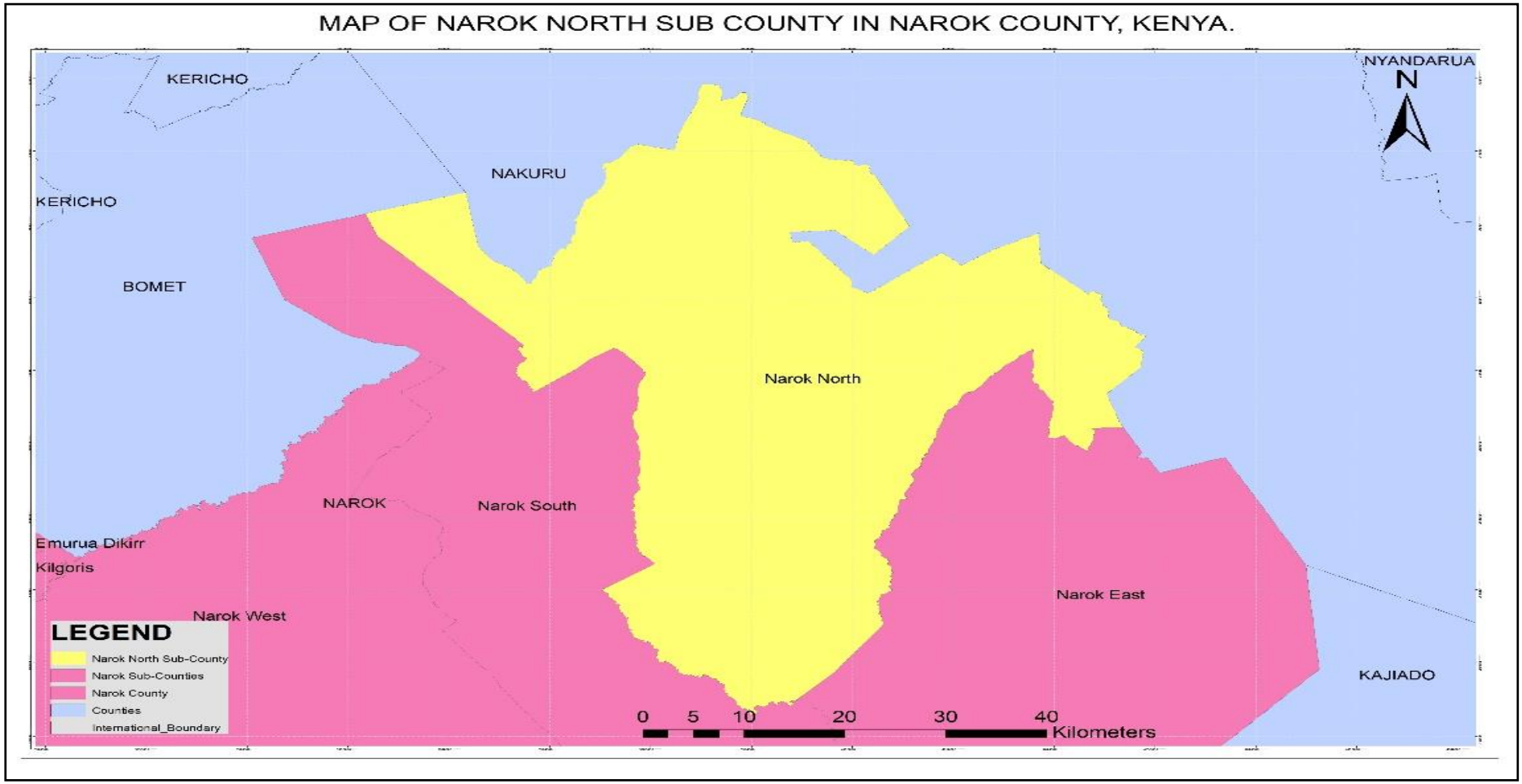
3.1 Introduction

The chapter begins with an introduction of the study area and a study design which provides a concise overview of the study and this is then followed by the categories and foundations of data required for the study, methods and instruments of data collection, spatial data capture and ground truthing. It further describes the data processing techniques used, and data analysis which was confined to the analysis of spatial data using Remote Sensing techniques (Satellite Imagery) and Digital Image processing software (ENVI 5.3) and Geographic Information Systems analysis functions.

3.2 Study Area

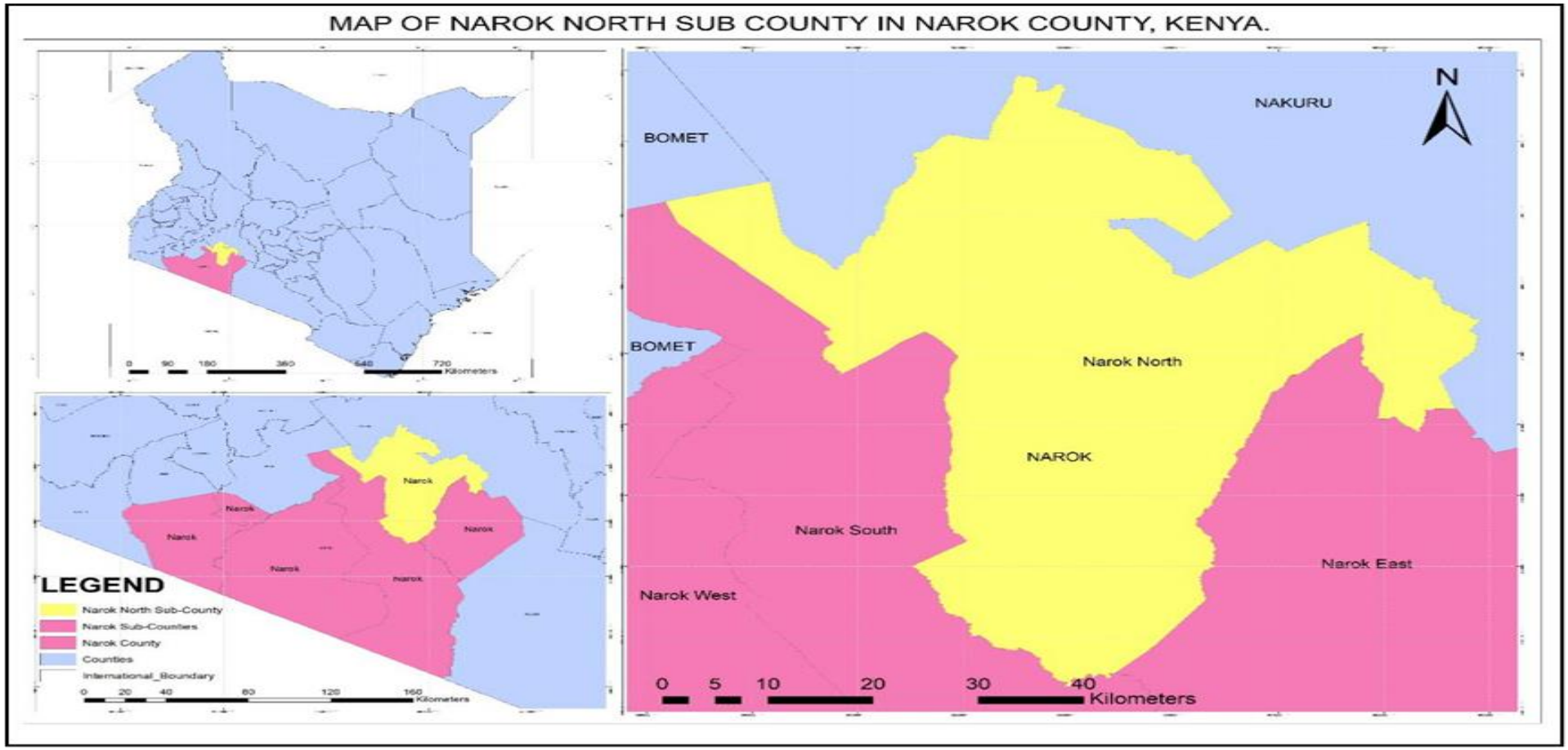
Narok North Sub-County is located in Narok County, Kenya and covers an area of 2,603 km^2. The main economic activities include business activities and agricultural activities (Narok CIDP, 2018).

Figure 2: Inset Map of Narok North Sub-County



Source: Narok County Lands and Physical Planning Database, 2020

Figure 3: Map of Narok North Sub-County in Narok County, Kenya



Source: Narok County Lands and Physical Planning Database, 2020

3.2.1 Baseline Information

This section describes the various steps taken to map the base line for the study

3.2.1.1 Biological Diversity

The Northern parts of Narok North Sub-County comprises of the highland areas of Mau Escarpments which provide fertile ground for production of wheat barley, maize, beans, potatoes and peas as well as wool and dairy farming. (Narok CIDP 2013-2017). The southern parts, which is Limanet area consists of arid and semi-arid areas with scattered acacia species (*Acacia Xathophhlea, Acacia drepanalobium, Acacia Abyssinia, acacia tortilis and acacia geradii*), *Balanites aegyptiacae* and *Opuntia spps*. Besides that, there is elephant grass with other weed varieties whose inventory could not be quantified. Narok North Sub-County has a diverse biodiversity of flora and fauna. The flora is dominated by the *tarchonathus cormphoratus* (Leleshwa). There are also other woody and herbaceous plants such as *Olea africana, rhus natalensis*, *Osyris lanceolata* (Saddle wood) and grasses in the low land areas with trees and shrubs as shown below.

Vegetation in Limanet area in Narok North Sub-County

Source: Researcher, 2020

There are varieties of insects in the grass (ants, flies and butterflies), while pests seen included, caterpillars, whiteflies and aphids. The most common animals found in the area are the wild animals and also some domestic animals mainly cattle. Trees are found to harbor a variety of birds. There are also Zebras, Tortoise, Hyenas, Leopards, Wild dogs, Mountain Reedbucks, Baboons, Dick dicks, Rock hyraxes, Antelopes, Gazelles, Elands, Hares, Bats and Snakes. This area experiences severe erosion caused by wind, water, agricultural activities and overgrazing by livestock and wildlife

3.2.3 Geology, Topography and Soils

Geologically, the area around the area comprises of clay loam soil in types characterized by sand and with high swelling capacity and water retention capacity. The soil swells very fast and becomes sticky once it rains and shrinks very fast when there is water stress. In general, the soil is acidic in nature

The area is characterized by gentle slopes at the low lands. The gradient increases as one moves to the highlands. The low-lying areas has a lot of gullies caused by water runoff and livestock pathways.

The Area is covered by brown Calcerous loams. The soils are developed on undifferentiated volcanic rocks (mainly basalts). The soils are well drained, moderately deep to very deep dusky red to very dark greyish brown, friable to firm, clay loam to clay in many places stony and boulder and/or with severe gulley erosion and rock, outcrops in major upland areas, boulder phase, vertisols and rock outcrops

Narok County Soil Profile

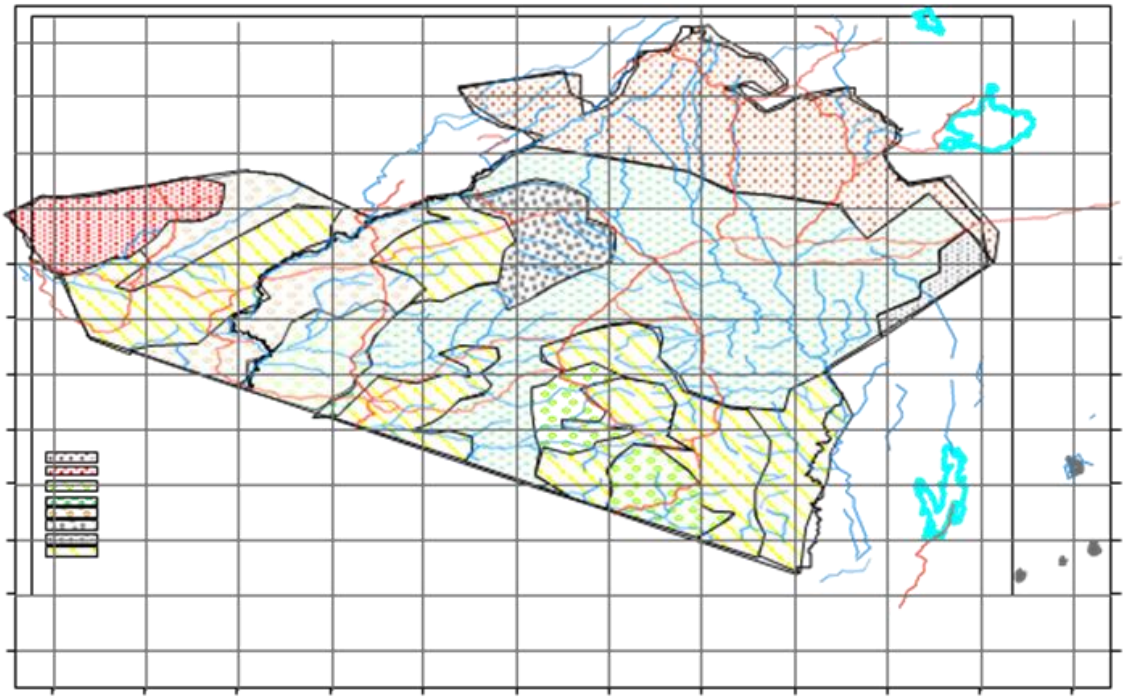


Figure 4: Narok county soil profile
Source: CIDP (2013)

3.2.4 Infrastructure

Narok North Sub-County is home to Narok Town which is the Head Quarter of Narok County. Narok Town lie along the Narok Mai-Mahiu road Highway. There are other several market centers in the sub-county. The Sub-County is served with electricity from the national grid network. Institutions found in the region include Narok County Government Headquarters, Maasai Mara University, Narok Teaching and Referral Hospital, several high schools and primary schools.

Figure 5. Narok- Nairobi Highway

Source: Researcher, 2020

3.2.5 Demography

Narok North Sub-County is dominated by Maasai ethnic community who live in both rural and urban areas. Other communities in the region include the Kisii, Kikuyu, Kalenjin, Kamba, Turkana, Luyha, Luo and Borana mainly found in urban areas.

Table: Distribution of Population by Sex in Narok North Sub-County

Sub-County	Male	Female	Intersex	Total
Narok North Sub-County	128,024	123,829	9	251,862

Source: KPHC 2019, Vol. 1

3.3 Research Design

The study adopted a descriptive survey research design. Descriptive research was used to obtain information concerning the current status of the phenomena and to

describe "what exists" with respect to variables or conditions in the situation at hand and providing data that was used to test the relationships between the variables. Descriptive research designs enable the researcher to seek answers to the following questions: why, what, where, when, who and how in order to establish the reasons for the changes that have occurred as a result of the land use and land cover (Singleton and Strants, 2005; Babbie, 2010). It also helps to assess the responses based on the opinion and experience of the respondents. In addition, the study used both quantitative and qualitative data to enhance the analysis.

3.4 Project Data Types and Their Sources

For this study, Landsat satellite images covering Narok North Sub-County were acquired for two epochs; 1986 and 2000. The selection of the study period was guided by the fact that most studies conducted in the Maasai Mau Complex have covered periods before 2000. By considering this time window was important in ensuring that new data is collected up to the period of 2000. Besides this is the period when there has been a lot of human activities influencing the land use hence land cover. It was therefore necessary to consider this time period to assess the changes that have taken place in the study area.

The satellite images were acquired from Landsat 5 and 7 satellites which carries the Thematic Mapper and the Enhanced Thematic Mapper Plus (ETM+) sensor for1986 and 2000 epoch and Sentinel 2B which carries Multi Spectral Instrument 2019 epoch. LANDSAT 5 has 7 bands that is; band 1-5and 7 with 30M spatial resolution and band 8 (panchromatic band) with a spatial resolution of 15M.

Sentinel 2B has 13 bands with a spatial resolution of 10M except for band 8 which has 5M spatial resolution which is used to enhance the image because of its better

resolution. All the satellite images were in WGS 84 coordinate system and were transformed to UTM coordinate system zone 36 S, WGS 1984 datum. The bands used had a spatial resolution of 30M pixels. For Landsat 5 (TM) and 7 ETM+, band 6 was acquired at 60M resolution and resampled to 30M pixels. Band 8 of the Landsat 7 imagery is used for pan sharpening i.e., enhancing the image because of its higher resolution. For Sentinel 2B MSI bands were acquired at 10M resolution but was re-sampled it to 30M to have a consistency in the imagery resolution. The Landsat and Sentinel imageries were acquired from USGS Earth Explorer website. Sub-county boundaries shape files acquired were used to show the extent of the study area. GPS points that were to be used for ground truthing during the accuracy assessment were collected from the field during a visit in the area. These points were well distributed in the area of study.

3.4.1 Equipment used in the study

Hardware

- Laptop computer with the following specification. HP Intel (R) core TM 15 CPU M520@ 2.40 GHZ, Ram 6GB (5.76 usable), Windows 10 64-bit operating system.

Software's

- Microsoft office 2016 word was used in the typing and presentation of the project.
- ArcGIS10.6 was used to compliment the display and processing of data. As well as making maps of the area of study and change detection maps at different epochs.
- SNAP for editing and rectifying the Sentinel Imageries.

- ENVI 5.3 software was used in the processing of the images, development of land cover land use classes and for Change detection analysis of the study area.

3.5 Digital Image Processing

This section describes the process through which the digital image processing was done.

3.5.1 Resampling

Resampling is the technique of manipulating a digital image and transforming it into another form. This manipulation could be for various reasons - change of resolution or change of orientation. This is because the image as it is captured will have limitations imposed by the imaging geometry or camera in this case the difference in spatial resolution between the Sentinel Imageries and the Landsat Images. The Landsat 4-5 and 7 images are readily resampled and accessed at a resolution of 30M while Sentinel Images are acquired at 10M resolution a higher resolution than the Landsat Images. However, for this analysis, all the images were considered in a standard image resolution for easy readability and comparison. Converting the Landsat Imagery from 30M resolution to 10M resolution results to higher file size hence occupies much the disk space and also takes time to process since the process is heavy on processing. Therefore, the researcher decided to reduce the Sentinel Image resolution of 10M to 30M. The end output result was smaller in size and was easily processed. This technique, was used to ensure that the expected results could be achieved from the imaging process. In ENVI this is done in layer stacking parameters by adjusting the X-pixel size and the Y-pixel size and used the bilinear resampling algorithm to resample the Sentinel Image from 10M resolution to 30M resolution (Wo and Cho 2011).

3.5.2 Layer Stacking

Liu and Mason (2013) noted that layer stacking is the process merging two or more bands that are registered in order to enhance the details contained across multiple exposure of the same scene. Images from Landsat satellite were captured or acquired through bands. Each sensor has several bands which needs to be merged to form a scene image. Layer stacking brings together all band for band operations. Selected bands were stacked before carrying out further processing. Bands 4, 3, 2 were used for layer stacking of Landsat 4-5 and Landsat 7 images of 1986 and 2000 respectively using bands 4, 3, 2 for the false color combination were stacked for the imageries.

3.5.3 Mosaicking

This is the process of merging satellite imageries that overlap to produce one large imagery. Since the area of study lies between two rows 060 and 061 for Landsat imageries and lies between 4 Sentinel imagery blocks namelyT36MZE, T36MZD, T36MYD and TDMYE.

Both the Landsat and Sentinel imagery cut through a section of the Narok North Sub-County. The Narok North Sub-County is captured mostly on the 169-path row 061 while a small section overlaps with row 060. In the Sentinel Imagery, sections of the Narok North Sub-County are captured in the T36MYE, T36MZE, T36MZD, and T36MYD. The Mosaicking process was conducted using the Seamless Mosaicking functionality located in the toolbox in ENVI 5.3. The Land sat Images overlap vertically while the Sentinel imagery overlap both horizontally and vertically. For the Sentinel Imageries, the four-layer stacked image files of four blocks capturing the Narok North Sub-County were loaded. Seam lines were generated to avoid data masking of some regions in the overlap area. After generation of seam lines seamless feathering was applied then Exported to the project folder in .DAT file extension.

3.5.4 Sub setting using Narok North Sub-County shape file

Both sentinel and Landsat images cover a large area than is required. The swath width of a Landsat satellite is 180m, and covers a larger area compared to the Sentinel Imageries. To save on the time needed to process the image it is usually efficient to subset the image. Sub setting means clipping or extracting only the required part in the image. It saves on the storage space and time needed to process the image since Landsat images are bulky. The images covered a large expanse that was not required for this study. A shape file of the Narok North Sub-County was used to subset the images of the three epochs. The image was subset based on the Narok North Sub-County boundary. The Narok North Sub-County region was clipped from the full mosaic images of both the Landsat images and the 2019 Sentinel Mosaic image. The shape file was acquired from Kenya Roads Board shape file datasets repository in the sub-county shape file, where the area of interest is exported for purposes of clipping.

3.5.5 Development of Image Classification Scheme

Image classification is the process of categorizing all pixels in an image/ raw remotely sensed data so as to obtain a given set of land cover themes (Liu & Mason, 2013). The main aim of image classification is to automatically categorize all pixels in an image into a finite number of individual classes. Supervised classification was done using 90 training datasets for each cover class that was developed in this study (Planted farmlands and other vegetation, Forest land cover area and Settlement and Bare Land).

Maasai Mau Forest Area consisting of dense forested regions of the Narok North Sub-County based on the Google Earth Pro ground truthing vectors. The Planted farmlands and other vegetation area class consisted mainly of planted croplands and shrub lands where a small amount of spectral signature of chlorophyll was used to come up with the class values. The Settlement and Bare Land areas included cleared farms prepared

for planting; human settlements and existing bare-land were used to come up with training data for this class. Supervised and Unsupervised classification was used in this project where the areas where a particular type of land cover is present in the sub-county between different epochs was determined then the algorithm computes the spectral reflectance. The algorithm used Maximum likelihood algorithm for classification purposes. The areas with known land cover are digitized, then the image processing software that is ENVI 5.3 computed the spectral reflectance of the land cover types. Training sites were developed for the three-land use/ land cover classes based on Google earth and familiarity with the study area. The classes include Planted farmlands and other vegetation, Maasai Mau Forest Area and Settlement and Bare Land.

3.5.6 Normalized Deferential Vegetation Index (NDVI)

Normalized Deferential Vegetation Index quantifies vegetation by measuring the difference between near infra-red, where vegetation strongly reflects and the red light which vegetation absorbs. The generation of the NDVI was generated by running the NDVI generation functionality in the Toolbox in ENVI. It prompts one to select the Near Infra-red band together with the red band as variable inputs to compute the NDVI by outputting the values between -1 and 1. The Near Infra-red band in Landsat 4-5 TM and Landsat 7 ETM+ is band 4 and band 8 for the Sentinel 2B image package (Liu & Mason, 2013). The Red band is band 3 in Landsat 5 and 7 and band 4 for the Sentinel image package. The NDVI was generated for each year and the +1 and -1 values were represented in grayscale as shown below in Figure 3.

3.5.7 Accuracy assessment

Accuracy assessment is a crucial stage in the process of analyzing remotely sensed data. Classification is only complete after the accuracy has been validated. Accuracy

measures the agreement between the standard assumed to be correct and a classified image of unknown quality. It determines the value of the resulting data to a particular user (Clinton et al., 2010).

Users with a variety of applications should be able to evaluate whether the accuracy of the map suits their objectives or not. There are different ways of accuracy assessment; confusion matrix or error matrix is the most common means of expressing classification accuracy.

In this project confusion matrix was used. It compares, on a category-by-category basis, the relationship between known reference data and the corresponding results of an automated classification. Ground truthing points were collected in the area of study using Google Earth Pro timeline platform. The points were evenly distributed in the area of study (Westrope et al., 2014). These points were used to validate the accuracy of classified image for the year 2019. The land cover found at the date of the image acquisition was then compared to the mapped supervised classified image for the same location. In ENVI the accuracy assessment was conducted using the Confusion Matrix using Ground truth ROI and selected vector shape files of the ground truthing points were used against the Supervised Classification images of all the three different epochs.

3.6 Household Survey

Proportionate stratified multistage clustered sampling was appropriately used because it allows the researcher to divide the population into homogeneous groups known as strata and then draw simple random samples (SRS) from within each stratum (group). This study explicitly used administrative locations as the first strata. The locations were then implicitly stratified to establish villages as the primary sampling units (PSUs). Households were then listed within each PSU to determine the sample frame and the

number of persons within each household recorded according to the latest enumeration report for the area. The number of households or persons within each household was treated as the target population size. The persons within each household became the ultimate sampling units (USUs) and the final stratification stage.

The samples were drawn from each PSU with probability proportionate to estimated sample size (PPES) by randomly selecting the number of households at a fixed rate. Opinion leaders and key informants were also interviewed to gain more insight in the study. They included community leaders, rainmakers, traditional medicine men, spiritual leaders, local NGOs and government officials with specific information or had vast knowledge in the study subject.

The key informants were purposively sampled to identify the first respondent to be interviewed and then snowballing sampling procedure was adopted to get the subsequent respondents. Structured and un-structured questionnaires were used to gather the information from the sample respondents.

3.6.1 Target Population

A population is the group of interest to the researcher, the group to which the researcher would like to generalize the results of the study (Ayala & Elder, 2011). In this study the population involved all the residents of Narok North Sub-County. The target population in this case was 59,996 household as per the census in the year 2019 by (KPHC, 2019). The unit of analysis will be the individual male or female head of the household. The study will only target these two because they are the main decision makers and they have the required information for the study. Besides the study will also seek the opinion of the village elders, environment officers and forest officers (KWS).

3.7 Sample design

Sampling is the process by which a researcher selects a sample of participants for a study from the population of interest (Etikan, 2016). Ayala & Elder (2011) defines sampling as process of choosing a small group of people or things from the population. For objective one and two the research design involved selecting the sample size and sampling procedures.

3.7.1 Sample Size determination

Considering that the population for the study is large, a little smaller sample size was selected. Sample size determination is usually undertaken because resources do not permit researchers to study all members of the target population (Ayala & Elder, 2011).There are various techniques of selecting sample size for the study. From (Gatotoh et al., 2011), he recommended the following formula;

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

Where n= sample size

N=population

Cv= Coefficient of variation (take 0.5)

e=Tolerance of desired level of confidence taken as 0.05 % at 95 % confidence level Since Narok North Sub-County has 59,996 Households (KPHC, 2019), the formula was applied as follows;

$$n = \frac{59{,}996\ (0.5)^2}{0.5^2 + (59{,}996-1) \times 0.05^2}$$

n 99.8 that is approximately 100 respondents who were the household head either the father or the mother or in special cases a responsible person who was available and was willing to participate in the study.

3.7.2 Sampling procedure

This study adopted systematic random sampling method to select the sample from among the households in the six county representative wards in Narok North Sub-County. The wards therefore formed the study strata. Systematic random sampling applied within these strata in order to identify respondents. This sampling methods were appropriately used because they allow the researcher to divide the population into homogeneous groups known as strata and then draw simple random samples (SRS) from within each stratum (group). This study explicitly used administrative locations as the first strata. The locations were then implicitly stratified to establish villages as the primary sampling units (PSUs).

Households were then listed within each PSU to determine the sample frame and the number of persons within each household recorded according to the latest enumeration report for the area. The number of households or persons within each household was treated as the target population size. The persons within each household became the ultimate sampling units (USUs) and the final stratification stage. The samples were drawn from each PSU with probability proportionate to estimated sample size (PPES) by randomly selecting the number of households at a fixed rate. To distribute the number of respondents across the six wards the study used the following proportional formula;

$$\frac{\text{Number of households in the ward}}{\text{Total population}} \times 100.$$

The study also used purposive sampling technique which allows the researcher to rely on his/her expert judgment to determine representative units for specific data that require specific people to respond (key informants and opinion leaders). Opinion leaders and key informants were interviewed to gain more insight in the study.

They included community leaders, spiritual leaders, local NGOs and government officials with specific information or had vast knowledge in the study subject. The key informants were purposively sampled to identify the first respondent to be interviewed and then snowballing sampling procedure was adopted to get the subsequent respondents. Structured and un-structured questionnaires were used to gather the information from the sample respondents.

3.8 Data Collection

This involves the process of designing instruments to be used in collecting data for the study. The focus of data collection was on data collection instruments, the validity and reliability of the instrument and the administration of the same.

3.8.1 Data Collection Instruments

Both primary and secondary data were collected for the purpose of addressing the study objectives. For primary data the study used a structured household questionnaire and a key informant's interview guide. For secondary data the study will rely on information from reports and related literature to capture the statistics of the change. Besides the use of the satellite images will help to determine the actual change that has occurred in the study area. The study used questionnaires for individual households and interviews for the village elders, forest officers, environmental officers and other opinion leaders in the ward.

3.8.1.1 Household Questionnaires

A questionnaire was used because it is a method through which responses are gathered in a standardized way, hence more objective. Questionnaires are also relatively quick to collect information. The household questionnaires was divided into five sections. Section A consisted of items that were used to gather household background

information including demographic and other information such sex, age, academic qualifications, household head and household information. Section B consisted of question statements about the objectives of the study Section c, constituted question statements on the dependent variable. Elsewhere, the household heads were required to indicate their levels of agreement or disagreement on whether the land use activities have resulted into land changes between the study periods. They will be expected to indicate whether they strongly agree, agree, moderately agree, disagree or strongly disagree.

3.8.1.2 Key Informant Interview

In order to increase the scope or range of the data, Key informants were purposively selected and the focus was on informants with rich information about the land use and land cover changes in the area and were very much willing to share their experiences. The question items were derived from the study objectives.

3.8.2 Validity and Reliability of the Research Instrument

Validity is the appropriateness, correctness and meaningfulness of the specific references which are selected on research results (Heale & Twycross, 2015). It is the degree to which results obtained from the data analysis actually represents the phenomenon under study. To ascertain validity of the instrument, the researcher used The Kaiser-Meyer-Olkin Measure of Sampling Adequacy computed from the factor analysis test as suggested by (Field 2009). This measure was applied to test the validity of the questionnaire. According to Field [2009] a KMO value of 0.4 and above is appropriate for the instrument to be considered reliable. Richardson *et al*. (2015) also recommended an absolute value greater than 0.4 for the study instrument to be considered valid. Table 1 shows the validity of the instrument.

Table 1: KMO and Bartlett's Test

Description		Value
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.548
Bartlett's Test of Sphericity	Approx. Chi-Square	1668.005
	df	496
	Sig.	.000

Source: Researcher data (2020)

The results on Table 1 show that the KMO measure of sampling adequacy was 0.548 indicating that the instrument was valid and hence appropriate for use in the study. The chi square value of association is very significant at a p vale of less than 0.05 indicating that the sample was adequate and the responses were valid in regard to representing what they were expected to represent. According to Richardson et al. (2015) reliability is a measure of the degree to which a research instrument yields consistent results of data after repeated trials. Reliability of the questionnaire was determined using the internal consistency value determined using SPSS version 23.

The acceptable range for alpha internal consistency value (r) is 0.70 and above (Ayala & Elder, 2011). The results are presented on Table 2.

Table 2: Reliability Coefficient

Items	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Overall reliability	.740	.723	32
Drivers of land use and land cover changes	.787	.773	12
Socio-Economic impacts of land use land cover change	.726	.696	14
Land Use and Land Cover changes	.788	.793	6

Source: Researcher (2020)

The study established the reliability values for the objectives that were tested by a structured 5 scale Likert questionnaire. The result shave shown that the overall reliability for all the 32 structured items was 0.740 standardized to 0.723, the reliability related to the objectives; drivers of land use and land cover changes, Socio-Economic impacts of land use land cover change and Land Use and Land Cover Changes were 0.787, 0.726 and 0.788 respectively. This implies that the questionnaire was suitable for use in the analysis as it met the required reliability threshold of 0.7 and above according to Ayala & Elder, (2011). The kappa coefficient was used to assess the accuracy of precision in the various images and it was established that all the values indicated substantial strength of precision which fell within the category of 0.6 -0.8 according to Landis and Koch (1977).

3.8.3 Administration of the Instruments

A questionnaire was used to collect information on anthropogenic activities related to land use and land cover and their effects on socio-economic activities. The questionnaires were administered on a sample of 100 households. The questionnaires were developed and tested before they were administered to the respondents in the field. Field research assistants were inducted on how to administer and collect back the questionnaires ensure effective return rate. The questionnaires were dropped at the households and where the there was no responsible person the questionnaire was left to be collected later. Face to face interviews were also administered to informants, departmental heads for natural resources management, NGOs, CBOs and other relevant stakeholders.

3.9 Data Analysis and Presentation Procedure

The statistical analysis was carried out on the impacts of land use/ land cover change. Several land types and land use of the study area were computed for analysis.

Descriptive statistics including frequency giving a general tendency of land use and land cover change. Microsoft Excel was used together with the statistical package for the social sciences version 23. The data was coded and input into the SPSS system where various quantities were computed and presented in form of tables, figures and charts. In order to assess whether there was any association between the test variables the chi square test was computed at a significant level of 5% and analysis of variance was used to test whether there was any mean differences between the variables under test that is social economic drivers and the land use and land cover in the study area.

3.10 Ethical Considerations

Research ethics allude to the propriety of analyst's conduct corresponding to the privileges of the individuals who become the subjects (or witnesses) of the examination work, or are influenced by it (Ponterotto, 2010). Ethical considerations in an important aspect of research as it indicates adherence to legal and moral standards.

In this study, research ethics was ensured by adhering to the best practices in research. Before the research activities commence, an introductory letter was obtained from the University. Permission was also sought from the National Commission for Science, Technology and Innovation and the county environmental office at Narok County.

Ethical consideration was also ensured through voluntary participation, anonymity and confidentiality of the respondents. In this study, the participants in research were informed about the purpose of the study for them to be able to make their own judgment on whether to participate or not. This was to ensure that the principle of voluntary participation (informed consent) is adhered to (Trochima, 2012). Another ethical consideration element is that of anonymity and confidentiality. Anonymity requires that one does not know who the participants are. On the other hand, confidentiality means that one knows who the participants are, but that their identity was not to be revealed

in any way in the resulting report. In this study, the researcher ensured that the identities of participants are protected. In case there is need to disclose their identities, the researcher will make a request for their written consent (Brizee and Driscoll, 2012).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results of the analysis of Land Use and Land Cover Changes in the Narok North Sub-County in 1986, 2000 and 2019. The results are discussed in three sections; Section one discusses the demographic variables of the respondents, section two presents the post classification visual comparison, post classification area comparison, trend, magnitude and rates of change, overlay and NDVI results. While section three presents the descriptive results of socio-economic activities and the impacts on Land Use and Land Cover in Narok North Sub-County.

4.1.1 Respondents Response Rate

The study targeted a total of 100 households residing in the study areas. The researcher collected back a total of 93 questionnaires. The other seven respondents were unreachable at the time of collecting back the questionnaires. Out of the 93 only 87 were suitable for use in the analysis as the other 6 questionnaires were incomplete and hence were discarded. The 87 questionnaires represented a response rate of 85.3 Percent of the questionnaires distributed and hence were considered appropriate for use in the analysis. This is supported by Mugenda and Mugenda (2008) and Babbie (2010) who recommended a response rate above 70% as suitable for data analysis.

4.2 Socio-Economic Characteristics of Households

The study sought to analyze the background information about the respondents to assess whether they were a representative sample or not. Data was collected and analyzed based on the gender, the age bracket, marital status, whether resident of the area or not, years stayed in the study area, education and occupation, level of income and sources of income. The findings are presented as follows.

Pictorials of House hold Surveys




Source: Researcher, 2020

4.2.1 Gender of the respondents

Gender is an important social factor as it helps to assess perception and opinion from both male and female respondents. The distribution is presented in figure 6.

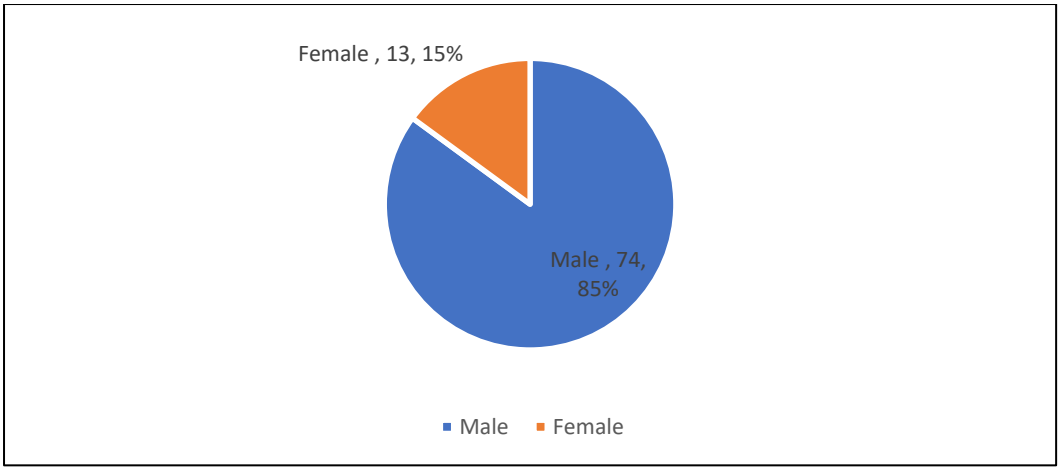


Figure 6: Gender distribution

Source: Research Data, 2020

From most house holds the majority of the respondents 74 (85%) were male with only 13(15%) being female. This implies that majority of the participants in the study were male who are the head of the household and land owners.

4.2.2. Age distribution of the respondents

This study was a longitudinal study covering a period of about 30 years, 1988 to date. The age of the respondents was therefore very important as the respondents need to be at least 30 years and above to provide appropriate data. The distribution by age is presented in figure 7.

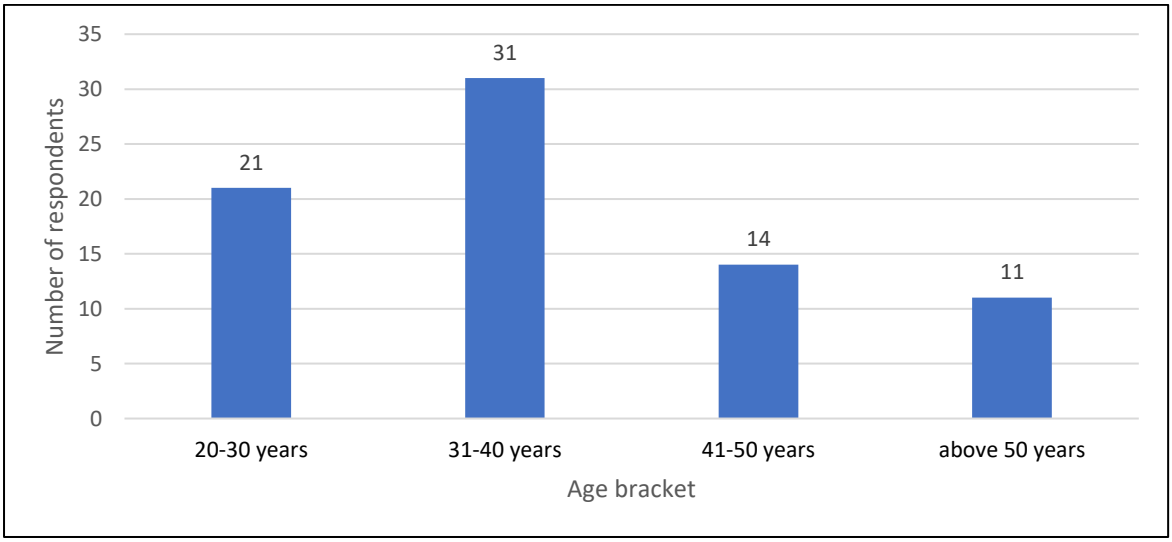


Figure 7: Age distribution of the respondents

Source: Research Data, 2020

The results show that most of the respondents (40%) were in the age bracket 31-40 years, followed by (27%) in the age bracket of 20-30 years, (18%) in the age bracket of 41-50 years and 11(15%) in the age bracket of above 50 years. This shows a well-represented sample with 55% of the respondents being above 30 years. This implies they have a good understanding of the previous and current situation in terms of land use and environmental changes.

4.2.3 Years lived in the area

The study also sought to find out the years that the respondents had lived in the area. This was important because it determines the whether the respondents understand the changes that have taken place if any. The results are presented in figure 8.

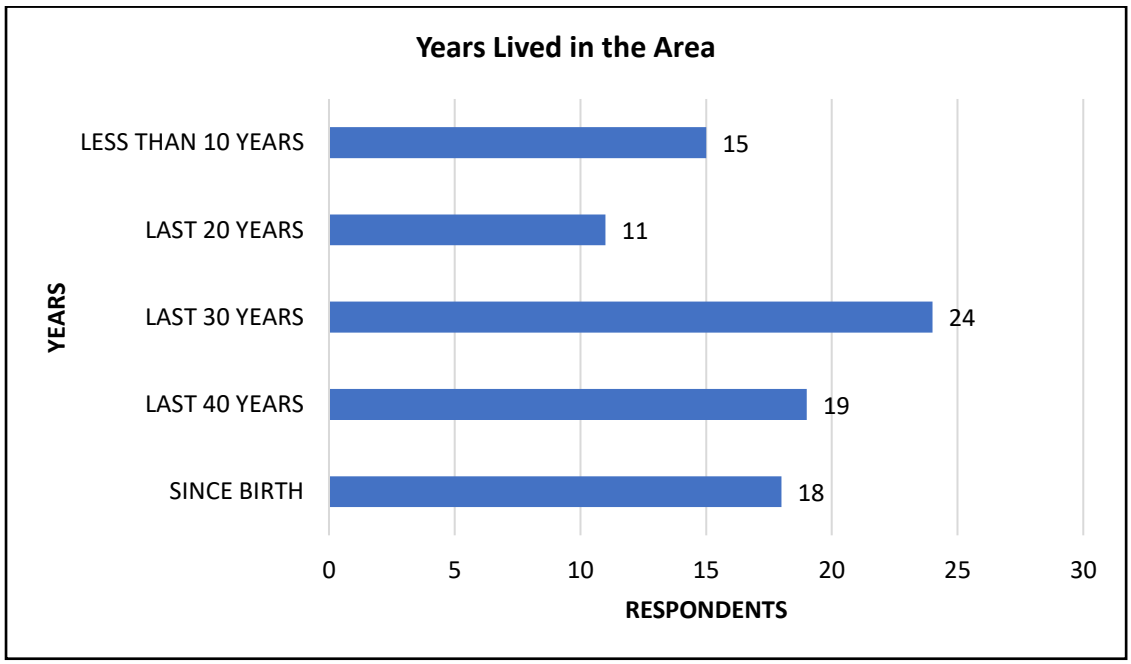


Figure 8: Years lived in the Maasai Mau Area

Source: Research Data, 2020

The results show that most of the respondents (24%) have lived in the area for the last 30 years 19% have lived in the area for the last 40 years, 18% have lived since birth while 15% have less than 10 years and only 11% have lived in the area for less than 20

years. This implies that majority of the respondents have been in the area for 30 years and above. Hence, they have appropriate knowledge and understanding of the environmental changes that have taken place since the 1988.

4.2.4 Level of Education

It was important to assess the level of education attained by the respondents as it was considered a social factor that influences the decision to use land and hence bring about the changes that have taken place in the study area. The response was presented in Table 3.

Table 3: Level of education

Level	Percent
Primary	29
Secondary	33
Post-secondary training	28
University	10
Total	**100.0**

Source: Research Data, 2020

The results shows that most of the respondents (33%) had attained secondary education, 10% had attained university education, 28% had attained post-secondary training, while 29% had attained primary education. This implies that the respondents were distributed across all the education levels and hence the results were representative of the population.

4.2.5 Occupation of the respondents

The study sought to find out the occupation of the respondents as it has a direct relationship with the income level of the respondents. This was also important because

it helped to establish whether one's occupation had any influence on LULCC as presented in Figure 9.

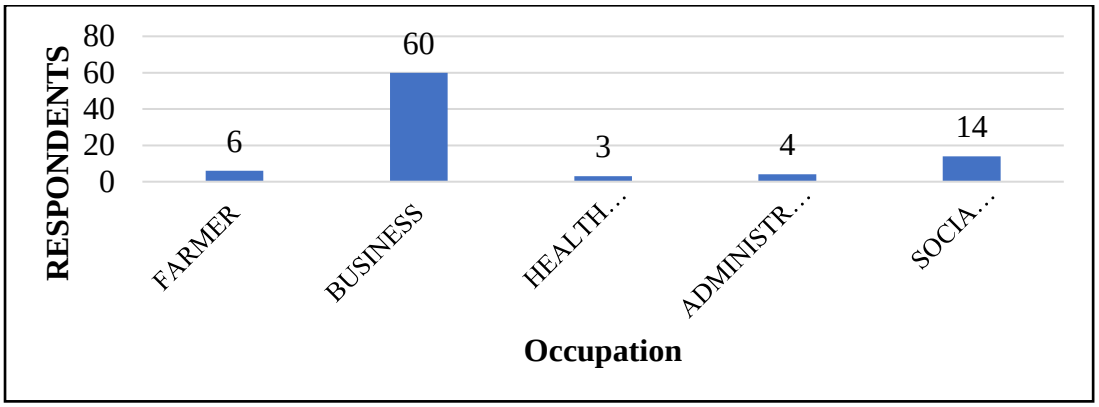


Figure 9: Occupation of the respondents

Source: Research Data, 2020

The results show that most of the respondents 69% were business people, 16% were social workers, 7% were farmers 5% were administrators and 3% were health workers. This implies that majority of the respondents were doing business in the area of study. Businesses have had a major contribution on the use of land and the changes that have taken place in the study area.

4.2.6 The average income per months among the residents in the area

Income has a direct relationship with the livelihood of people in an area. The study sought to assess the influence of income as a socio-economic factor on land use and land cover change. In an environment where there are many people with low-income levels the land is also poorly managed and activities like leasing, selling and charcoal burning is predominant. The results were presented in figure 10.

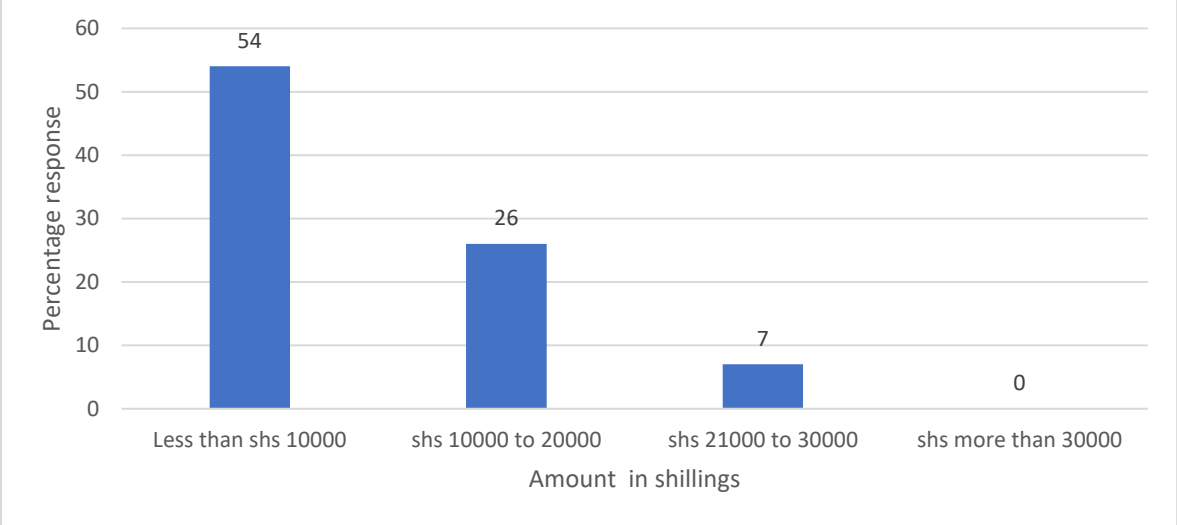


Figure 10: Income of the respondents

Source: Research Data, 2020

The results show that 54% of the respondents earned an income of less than Kshs 10,000.00 per month from their occupation, 26% earned an income of between Kshs 10,000.00 to 20,000.00 and only 7% earned an income of between Kshs 21,000.00 and 30,000.00. This indicates that the people in the study area earn on average less than Kshs 10,000.00. This pushes them to engage in other activities aimed at generating more income. These activities usually involve the use of land and hence increased level of degradation which leads to environmental change. The results further indicated that majority of the respondents 43.7% earned their income from off farm activities, another 43.7% earned their income from on farm activities and the rest indicated that they earned their income from both off farm and on farm activities.

4.2.7 Effect of household income on land use in the study area

The study sought to examine the effect of income on land use. The results are presented in Table 4.

Table 4: Effect of Income on Land Use

Items	Percent
No Effect	1
Little Effect	3
Moderate	55
Great Extent	35
Very Great Extent	6
Total	**100.0**

Source: Research Data 2020

The results show that most of the respondents 55% indicated that income had a moderate effect on land use, 35% indicated that income had a great effect on land use, 6% indicated that income had a very great effect on land use and only 1% and 3% indicated that income had no effect little effect on LULLC respectively. The results show that most of the respondents (over 86%) indicated that income of the respondents had an effect on LULCC in the study area.

4.2.8 Respondents Perception of Rainfall availability between 1980 to present

On whether the respondents understood the frequency of rainfall between 1980 to present. The study sought to establish whether the respondents have an understanding of the rainfall pattern of study for the time they have lived in the area of study. The results are presented in figure 11.

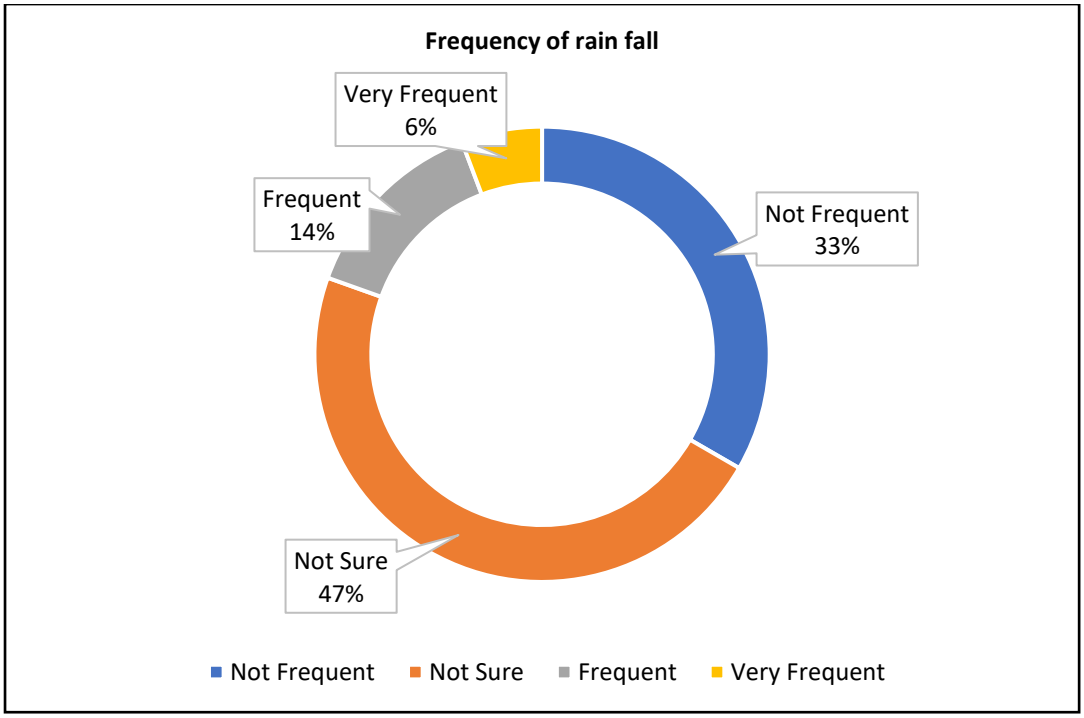


Figure 11: Frequency of Rainfall in the Maasai Mau Area since 1980s
Source: Research Data 2020

The results show that most respondents (47%) were not sure of the changes in the rainfall pattern in the area since the 1980s. Only 33% said it was not frequent, 14% said it was frequent and 6 % said the rainfall was very frequent. This implies that most respondents were not in a position to recall how the rainfall patterns have changed in the study area.

4.3 LULC Change Detection from 1986, 2000 and 2019 in Narok North Sub-County

This section presents the satellite images as captured on the Digital Image Processing

4.3.1 Post Classification Visual Comparison

Figures 12a, 12b and 12c are thematic cover classes for 1986, 2000 and 2019 Landsat imageries. From the 1986 thematic map (figure 12a), the area under Maasai Mau forest cover was intact with most of the forested area being under closed canopy and a small portion under Planted farmlands and other vegetation with even a smaller part under

Settlement and Bare Land. Settlements and Bare Land areas included built up areas, bare land and even newly prepared farms.

The Supervised Classification results of the year 2000 showed a decrease in coverage of the areas under the Maasai Mau forest and Planted farmlands and other vegetation classification class while areas under cover class Settlement and Bare land increased (figure 12b).

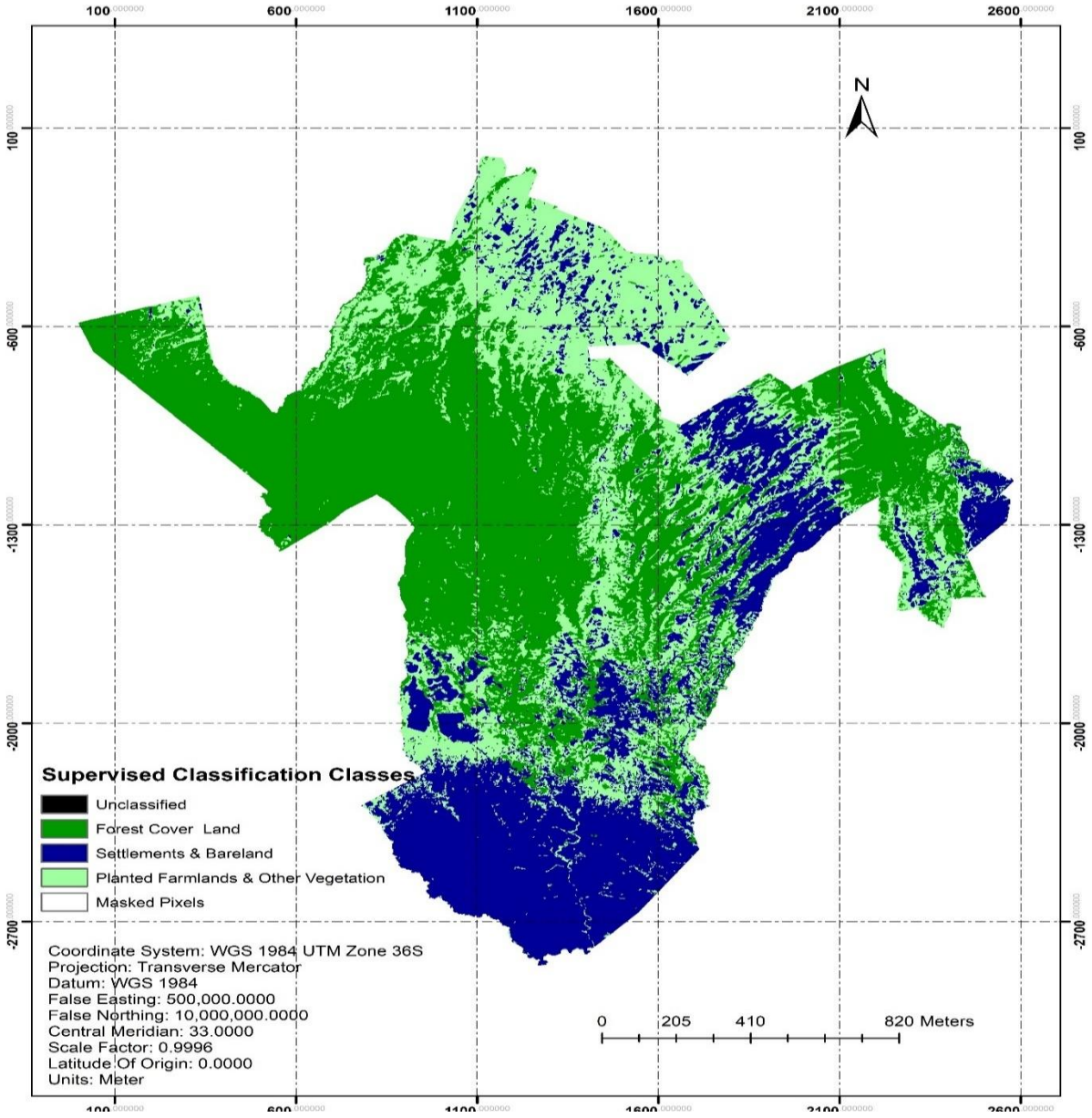


Figure 12.a: Land Use and Land Cover Map of Narok North Sub-County (1986)
Source: Research Data 2020

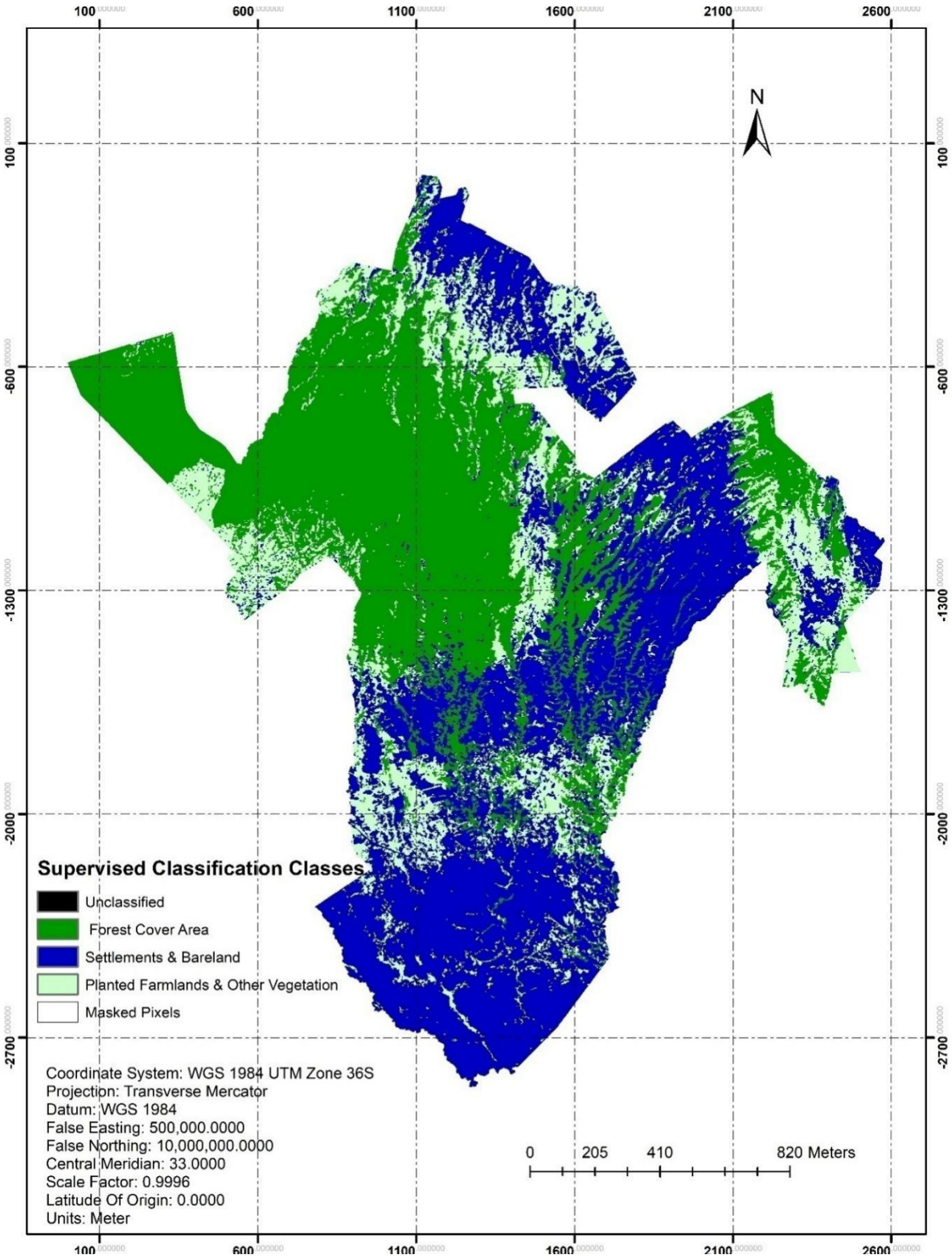


Figure 12.b: Land Use and Land Cover Map of Narok North Sub-County (2000)

Source: Research Data, 2020

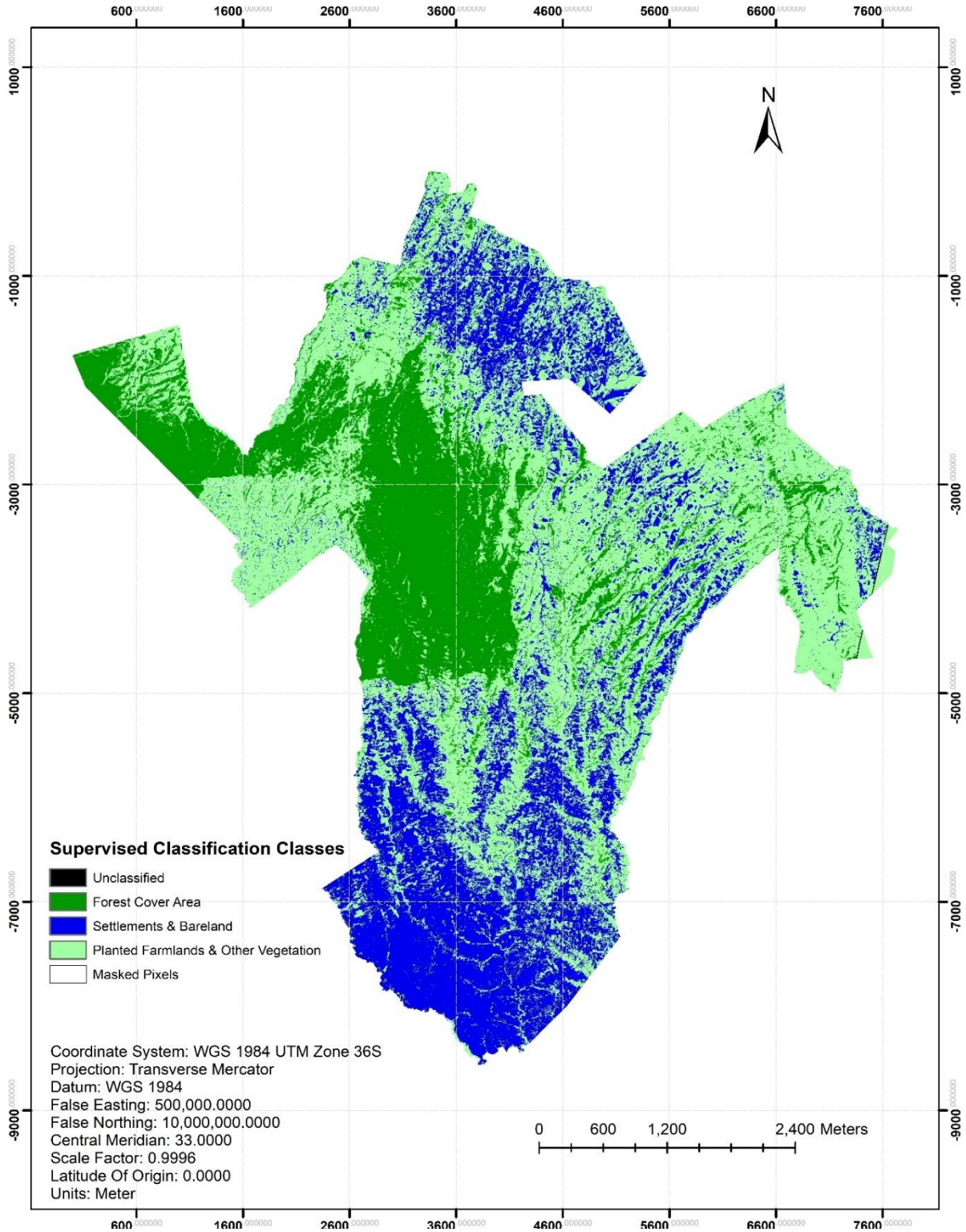


Figure 12.c: Land Use and Land Cover Map of Narok North Sub-County (2019)

Source: Research Data, 2020

When the three maps are compared it is very clear that there has been a gradual change in the physical feature of the area which is an indication that the land use and cover has been changing over the time.

The period 1986 as shown on figure 12a, shows the density populated forest area (green color), Compared to the figure 12.b for year 2000 and figure 12c which shows reduction in the forest density and increase on other vegetation's like farming crops. This implies that the period between 2000 and 2019 showed an increase in the land use and reduction in the land cover by the natural vegetation. Much of the reduction in the land cover by the forests was still perceived in the northern western region of the sub-county. These findings agree with the other previous studies such as Olang & Kundu (2011); Ongong, (2012) and Proposal (2010) who also established that there was a reduction in the land cover by forests in the Mau forest and other forest areas in Kenya due to increased human activities in the forests.

4.3.1 Post Classification Area Comparison

When considering the post classification area, the study used a time series land cover class quantification for the period 1986, 2000 and 2019 imageries. The results were presented in Table 5.

Table 5: Classified Imageries Cover Class Areas of the Maasai Mau Forest 1986, 2000 and 2019

Class Category	1986		2000		2019	
Cover Type (Class)	Area (Ha)	Percentage (%)	Area (Ha)	Percentage (%)	Area (Ha)	Percentage (%)
Narok North Forest Cover area	119,765 ha	44.877%	107,066 ha	40.119%	60,321 ha	22.603%
Settlements & Bare land	67,232 ha	25.192%	108,509 ha	40.660%	71,129 ha	26.653%
Other Vegetation& Planted farmlands	79,873 ha	29.929%	51,294 ha	19.220%	135,333 ha	50.711%

Source: Research Data, 2020

The results show that in 1986, closed canopy forest occupied the highest class with 44.877% of the total classes. The other vegetation occupied about 14.543% of the classes while non-vegetated land was 3%. Clearance of forest land for forest products and other human needs for the forest land were established when Land Use and Land Cover for 1986 and 2000 were compared.

Forest land was 82.912% showing an increase in forest land cover in 1984 while area under other vegetation was 14.440%, a reduction of 1.13% and 11% from the class coverage in 1986. During the same period, non-vegetated land reduced from 3.517% to 2.648%, a reduction of about 1%. The period between 2000 and 2019 the area under close canopy reduced by about 5.317% during these 19 years, the area under other vegetation increased by about 5.039%.

This was mainly due to increased agriculture practice and area under Settlement and Bare land cover slightly increased by about 0.278%. This means that, more clearance

was done in the area under the Maasai Mau forest land and this resulted in the increase in the area under Settlement and Bare land. The results agree with the findings of Tahir & Hussain,(2013) and Boitt (2016) who sought to understand land use and land cover in Ethiopian forest areas and Kenyan forests respectively.

4.3.2 Trend, magnitude and rate of land cover change

In order to assess the trend, magnitude and rate of land cover change, the visual images were analyzed to determine the area under Forest Cover, Settlements & Bare land and Other Vegetation& Planted farmlands the results presented in Table 6.

Table 6: Magnitudes and trends of land cover change in Maasai Mau Forest

Class Category				
Cover Type (Class)	1986 – 2000 Area (Hectares)	Percentage (%)	2000 – 2019 Area (Hectares)	Percentage (%)
Maasai Mau Forest Cover area	-12698.5	-4.75833	-46744.6	-17.515911
Settlements & Bare land	41277.99	15.467495	-37381	-14.007232
Other Vegetation& Planted farmlands	-28579.5	-10.709166	84039.72	31.490966

Source: Research Data, 2020

The results show that between 1986 and 2000, the forest cover area had increased by 495.63 hectares (1.072%), Planted farmlands &other vegetation decreased by 940,500 hectares (-0.203%) while non-vegetated land reduced by 401.58 hectares (-0.8687%). The Settlement & Bare land and land under Planted farmlands &other vegetation was reduced to growth and increase of the forest cover area. Between 2000 and 2019, the

Maasai Mau forest cover area decreased by 3919.10 hectares (1.2%), area under planted farmlands while other vegetation decreased further by 20846.48 hectares (-6.0%) while area under settlement / bare land cover increased by 30745.37 hectares (7.2%). These results again are in line with other studies conducted not only in Kenya but in other African states and use and land cover in forest area such as Tahir and Hussain, (2013) who also established similar trends of replacement of forest land by farming and other human activities such as urbanization.

The study also sought to assess the annual rates of change in land cover category. The results are presented in Table 7.

Table 7: Annual rates of change in land cover category in Maasai Mau Area

Class Category	1986 – 2000		2000 – 2019	
Cover Type (Class)	Area (Hectares)	Percentage (%)	Area (Hectares)	Percentage (%)
Maasai Mau Forest Cover area	-907.035	-0.33988	-2460.24	-0.92189
Settlements & Bare land	2948.428	1.104821	-1967.41	-0.73722
Other Vegetation& Planted farmlands	-2041.39	-0.76494	4423.142	1.657419

Source: Research Data, 2020

The results show that between 1986 and 2000, there was an annual rate of change in forest land of -3571.69 hectares; area under Planted farmlands & other vegetation had an annual rate of change of -1202.92 hectares while the area under non-vegetation changed at an annual rate of 1795.15 hectares. The area under forest experienced an annual rate of change of -3604.4 hectares during the period 2000 to 2019. During the

same period, the area under Planted farmlands & other vegetation changed at the rate of 7796.3 hectares per annum while the area under non-vegetation experienced a rate of change of -5168.99 hectares per annum.

It was also important to assess the level of coverage class changes over the study period 1986 to 2019. The results were presented in figure 13.

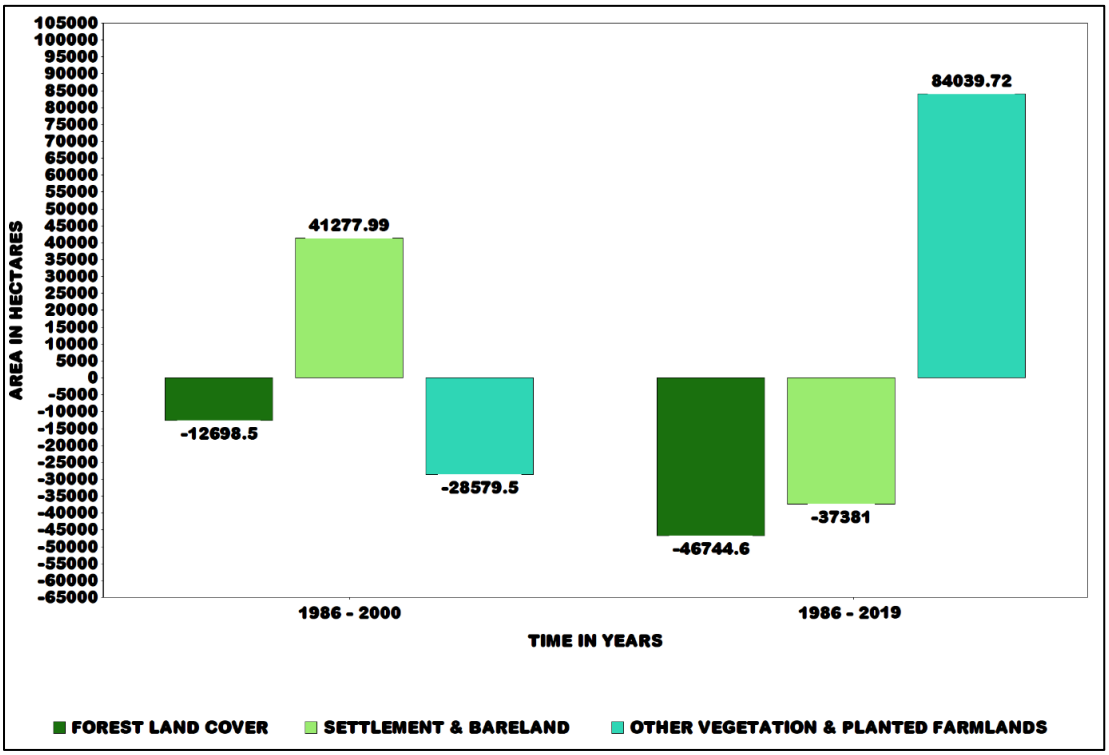


Figure13: Coverage class changes with time in Narok North Sub-County

Source: Research Data, 2020

The results on figure 13 shows changes in cover classes in hectares against time. The values that are above the X- axis represents cover types that had increased while the values that are below the X- axis represents the cover types that decreased over the same period.

4.3.3 Thematic land cover change between the different epochs

These are the changes that occurred between two different epochs and are generated by overlay of an initial image to a final image. The initial image is the first image you would like to compare the cover classes to while the final image is the image of the following epoch of study i.e., the initial image being 1986 for our first comparison of the cover class changes and the final image being 2000 for our first land cover class changes.

4.3.3.1 Thematic land cover change between 1986 and 2000

During the period 1986 to 2019 a slight decrease in the forest cover was experienced while a slight change from Forest land converting to both non vegetated area and other vegetation class. The results are presented in Table 8.

Table 8: Land cover types from1986 to 2000 in the Maasai Mau Forest

1986	2000	Area	Percent
Forest Land	Forest Area	861939	11.693118
Forest Land	Settlements & Bare land	253829	3.44346
Forest Land	Planted Farmlands & Other Vegetation	209549	2.842755
Settlements & Bare land	Forest Area	61700	0.837026
Settlements & Bare land	Settlements & Bare land	558654	7.578735
Settlements & Bare land	Planted Farmlands & Other Vegetation	122273	1.658763
Planted Farmlands & Other Vegetation	Forest Area	260316	3.531463
Planted Farmlands & Other Vegetation	Settlements & Bare land	388827	5.274851
Planted Farmlands & Other Vegetation	Planted Farmlands & Other Vegetation	233208	3.163714

Source: Research Data, 2020

The results show that there was more land converted from forest land to settlement and planted farmland between the period 1986 and 2000. From the table it is noted that a total of 6.28% of forest land was converted to settlement, (3.44%) and planted farm land and other vegetation (2.84%) compared to only 4.48% of land that was converted from settlement and bare land (0.84%) and planted farm land and other vegetation (3.53%) converted to forest land. This implies that there is more forest land being converted to settlement & bare land than or to farm land & other vegetation than that being converted to forest land.

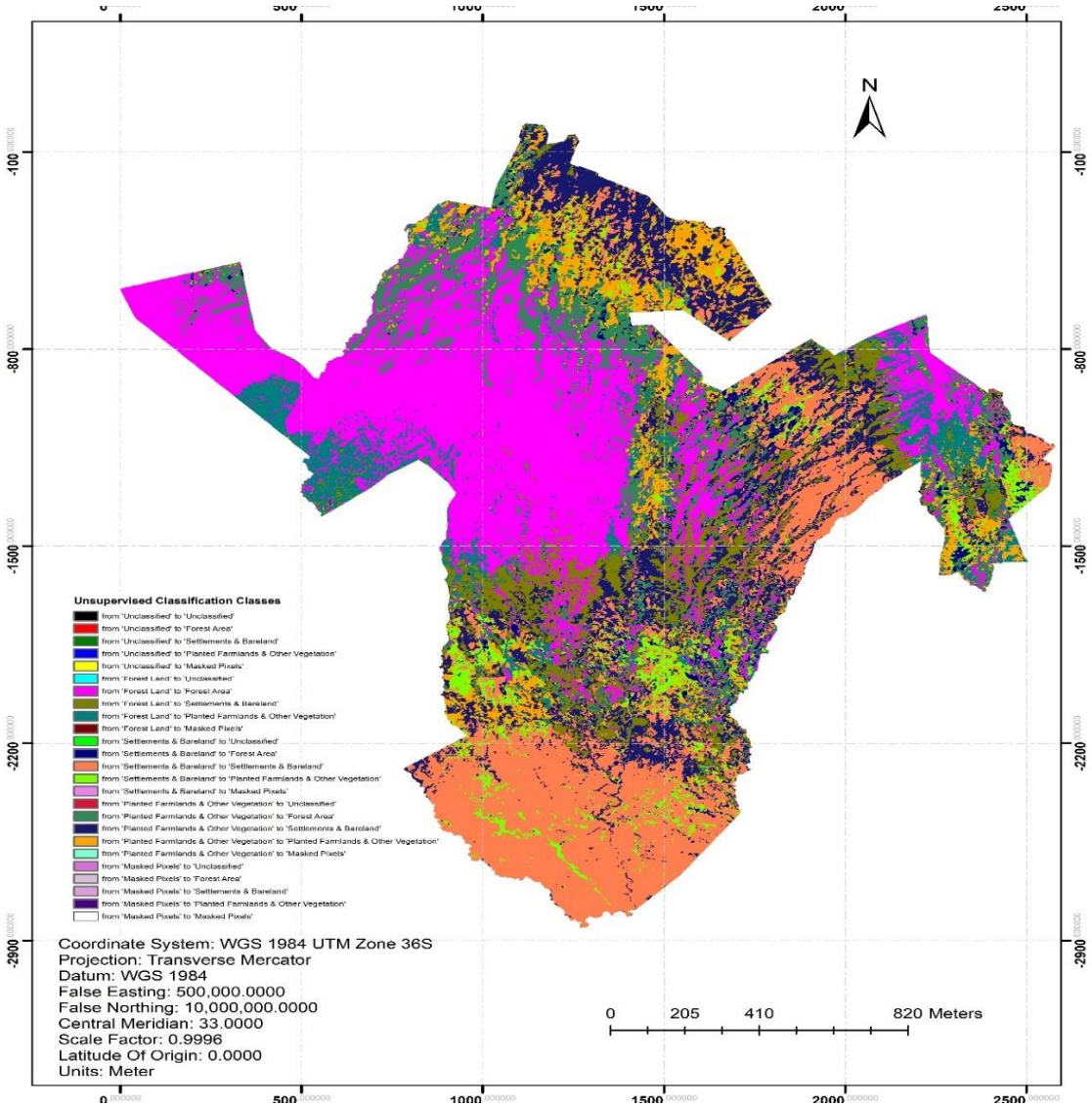


Figure 14: An overlay of 1986 and 2000 images

Source: Research Data, 2020

The pink colour shows the area under forest cover between the year 1986 and 2000. The brown color shows the area under settlement while the green patches show the area that is covered by farm land and other vegetation. The notice of change in figure 7 is used for the comparison.

4.3.3.2 Thematic land Cover change between 2000 and 2019

The changes that took place between the year 2000 and 2019 are presented in table 9.

Table 7: Land cover change types between years 2000-2019

2000	2019	Area	Percent
Forest Area	Forest Area	531654	7.212451
Forest Area	Settlements & Bare land	85432	1.158976
Forest Area	Planted Farmlands & Other Vegetation	566234	7.681565
Settlements & Bare land	Forest Area	66658	0.904287
Settlements & Bare land	Settlements & Bare land	526160	7.137919
Settlements & Bare land	Planted Farmlands & Other Vegetation	607725	8.244435
Planted Farmlands & Other Vegetation	Forest Area	56524	0.766808
Planted Farmlands & Other Vegetation	Settlements & Bare land	164041	2.22539
Planted Farmlands & Other Vegetation	Planted Farmlands & Other Vegetation	343446	4.65921

Source: Research Data, 2020

The results on the table shows that there has been a massive change in land cover during this period between the years 2000 – 2019. A percentage of 14% drop in forest land and an increase in other vegetation an indication of tree cutting to pave way for farming activities in areas that were previously occupied by forest cover. A slight increase in non-vegetation land indicated cleared land for farming practices by the illegal invaders

into the forest area. Most of the cleared forest land was converted to other vegetation land cover class indicating increase in planted crop lands and shrub occupied area. Since the eviction of people who had settled in the forest largely affecting the cover area of the Maasai Mau forest the results indicates that the highest rate of deforestation of all periods occurred during the period of 2000 and 2019 (1986 – 2000 and 2000 – 2019) compared.

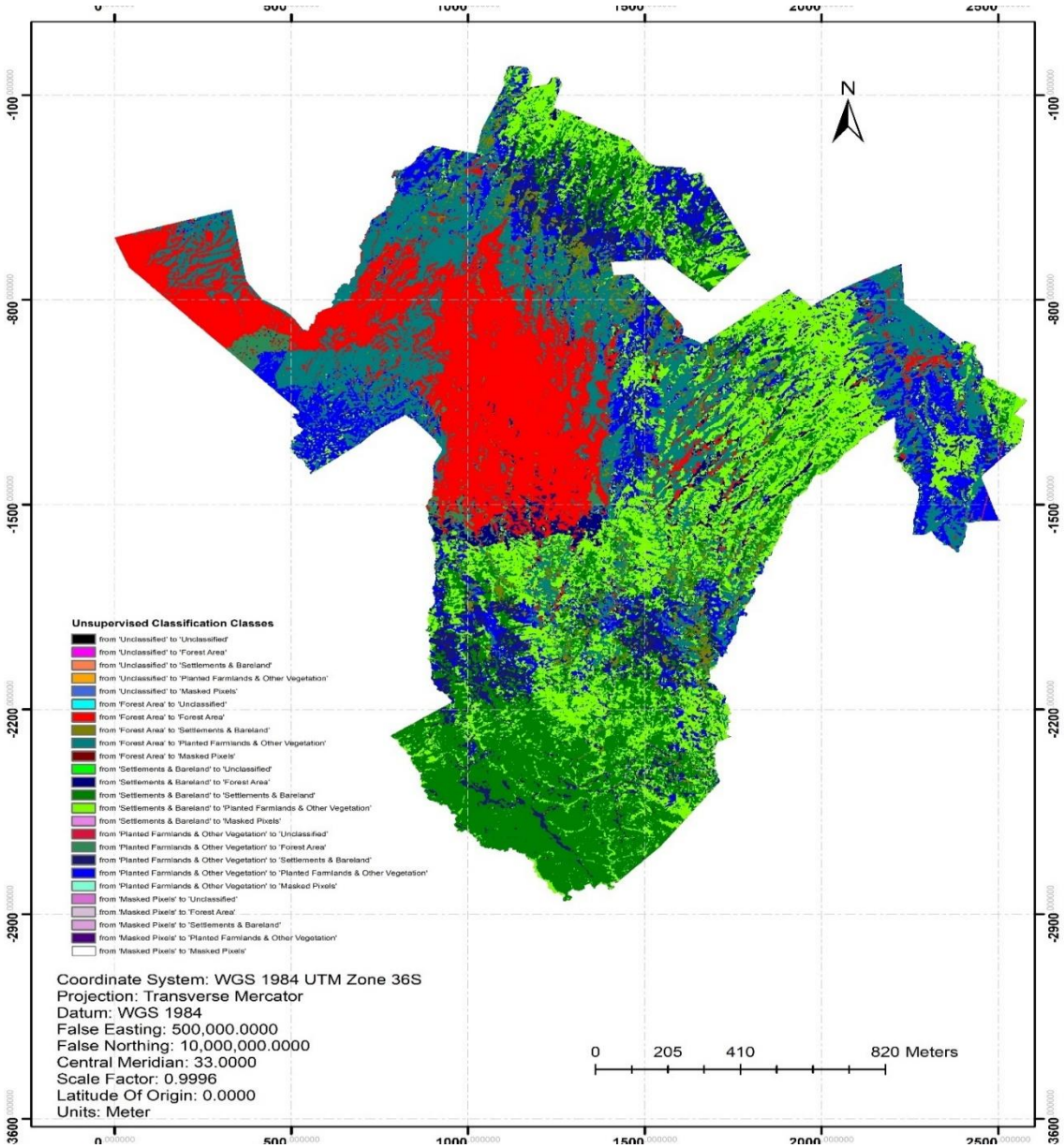


Figure 15: Changes in land use and land cover between 2000 and 2019

Source: Research Data, 2020

The results in figure15 shows that there is a reduction in the forest cover area as shown by the red color compared to the earlier map which showed the forest cover with the pink colour. The area under settlement is shown by the dark green colour while the light green colour shows the area under farmland and other vegetation. This implies that there is sufficient evidence of conversion of forest land to more settlement land and farm land in the Maasai Mau forest.

4.3.3.3 Accuracy Assessment

Accuracy assessment was conducted for each year epoch, 1986, 2000 and 2019. According to Srivastava et al., (2012) there are two common errors that are observed in the interpretation of the spatial imaging pictures used in the assessment of the land use and land cover; the errors of omission and error of commission. Error of omission occurs when a feature is left out of the category being evaluated**,** Error of commission occur when a feature is incorrectly included in the category being evaluated. An error of omission in one category is counted as an error in commission in another category. This is evaluated by computing the level of accuracy and precision on the maps measured by the kappa coefficient where values lying between 0.6 -0.8 indicate substantial strength of precision.

4.3.3.4 Classification 1986

The results of the accuracy for this period were assessment and presented in Table 8.

Table 10: Level of Precision of various classes in the Maasai Mau Forest

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Unclassified	0	0	0/0	0/0
Masked Pixels	0	0	0/4823873	0/4823873
Forest land	0.21	17.45	1021/1183757	617577/1800625
Other Vegetation	57.03	64.14	734480/396480	266202/396480
Settlements	56.64	23.04	527873/1199319	113350/1197489

Source: Research Data, 2020

Overall Accuracy = (996641/1016471) 92.0491%

Kappa Coefficient = 0.88647

According to the table it is noted that the level of precision was very high with only 0.21% error of commission against a 17.45 percent error of omission in the interpretation of the area covered by the forest. The error of commission was more than 50% in estimating both the area under other vegetation and settlements compared to 64.14 % and 23.04% error of omission. The level of accuracy was also confirmed by the overall accuracy score of 92.049% and the Kappa coefficient of 0.88647. This implies that the level of precision in the presentation of the maps was very high hence appropriate for making deduction about the level of land use and land cover in Maasai Mau area between the years 1986 to 2019.

4.3.3.5 Classification 2000

For the year 2000 the results of level of accuracy are presented in Table 9

Table 11: Error of commission and omission committed

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Unclassified	0	0	0/0	0/0
Masked Pixels	0	0	0/4420742	0/4420742
Forest land	0.06	34.3	709/1183757	617577/1800625
Other Vegetation	77.03	67.14	436840/567118	266202/396480
Settlements	46.64	15.04	559580/1199719	113350/753489

Source: Research Data, 2020

Overall Accuracy = (6374207/7371336) 86.4729%)

Kappa Coefficient = 0.7669

The result shows that the error of commission and omission committed in the interpretation of the area under forest land were 0.06 % and 34.3% respectively, while the errors of commission and omission committed in the interpretation of the area under other vegetation was 77.03% and 67.14% respectively. Regarding the area under settlement the study established that the errors of commission and omission committed were 46.64% and 15.04% respectively. This implies that the presentation of the maps was appropriate for use in the analysis as the overall accuracy level was 86.4729% confirmed by the level of kappa coefficient of 0.7669.

The reduction in the level of accuracy can be explained by the density of other vegetation's and farm land crops which made it difficult to accurately map out the area under each category.

4.3.3.6 Classification 2019

The precision for the errors in 2019 was evaluated and presented in Table 11.

Table 11: Level of Precision in Presentation

Class	Commission (Percent)	Omission (Percent)	Commission (Pixels)	Omission (Pixels)
Unclassified	0	0	0/0	0/0
Masked Pixels	0	0	0/4658842	0/4658842
Forest land	0.12	29.93	605/134620	617577/134657
Other Vegetation	64.11	71.08	448740/577603	266202/577618
Settlements	33.64	23.43	527784/1224287	113350/1224319

Source: Research Data, 2020

Overall Accuracy = (986539/1033978) 85.4120%

Kappa Coefficient = 0.8105

The results show that the level of precision improved in the estimation of the land under other vegetation's and settlement. It is noted that the error of commission for forest land was 0.12% compared to the error of omission of 29.93%. For the area under other vegetation the percentage of commission and omission is 64.11 % and 71.08% respectively while for area under settlement the level of accuracy was 33.64% and 23.43% defining the errors of commission and omission respectively. This implies that the results are accurate in assessing the level of land use and land cover in the Maasai Mau forest area. Given that the kappa coefficient values in all the three test periods were all within 0.6 -0.8 range which indicates substantial precision and accuracy.

4.4 Causes of Land Use and Land Cover Change in Narok North Sub-County

This study sought to determine the main causes of Land Use and Land Cover Changes in Narok North Sub-County between the periods 1986, 2000 and 2019. The study sought the opinion of the respondents using a five scale Likert where 5-was 'very great extent', 4- 'great extent', 3- 'moderate extent', 2 'low extent' and 1 – 'not sure', to the

various statement that defined the drivers. The descriptive statistics were computed based on the responses as presented in Table 12.

Table 12: Response on causes of LULCC in the Maasai Mau Forest

Sn	Drivers of land use and cover	1	2	3	4	5	Total
B1	Beliefs and practices around property ownership rights	41.4%	8.0%	10.3%	33.3%	6.9%	100.0%
B2	Selling of land as a source of income	3.4%	40.2%	43.7%	6.9%	5.7%	100.0%
B3	Keeping of many livestock	14.9%	18.4%	34.5%	25.3%	6.9%	100.0%
B4	Increased farming activities	11.5%	4.6%	17.2%	48.3%	18.4%	100.0%
B5	Lack of appropriate institutional regulations	1.1%	23.0%	43.7%	19.5%	12.6%	100.0%
B6	Population growth	13.8%	4.6%	9.2%	14.9%	57.5%	100.0%
B7	Political systems in the area	19.5%	10.3%	28.7%	32.2%	9.2%	100.0%
B8	Burning of charcoal as a way of raising income	9.2%	9.2%	10.3%	37.9 %	33.3%	100.0%
B9	Lack of appropriate legislation systems	11.5%	9.2%	17.2%	43.7%	18.4%	100.0%
B10	Urbanization	10.3%	0	0	33.3%	56.3%	100.0%
B11	High economic pressure forcing people to cut down the shrubs	0	2.3%	18.4%	43.7%	35.6%	100.0%
B12	Poverty	0	6.9%	50.6%	27.6%	14.9%	100.0%

N= 87; Grand Mean = 3.22

Source: Research Data, 2020

The results show that most of the respondents 41.4% were not sure of the effect of the beliefs and practices around property ownership rights on the land use and cover in the Maasi Mau Area of Narok County, 33.3% indicated that they impact to a great extent,

10.3% indicated that beliefs impacted moderately on land use and cover while 8.0% and 6.9% indicated that the impact was to a low extent and very great extent on land use and cover in Maasai Mau area of Narok county between the period 1986 to 2019. This implies that most respondents felt that beliefs and practices around property ownership rights did not have a great impact on the land use and cover.

On whether desirability of the selling of land as a source of income has impact on the land use and land cover most of the respondents 43.7% indicated that it had a moderate impact, 40.2% indicated that its effects was at a low extent, the rest 6.9% and 5.7% agreed to a great extent and very great extent respectively, while only 3.4% were not sure of the impact. This implies that the rearing of the local animals had a moderate impact on the land use and cover in Narok County. Similarly, 34.5% of the respondents indicated that keeping of many livestock causes erosion and this impacted on the land use and cover to a moderate extent in the county. The results further indicated that most respondents 32.2% indicated that keeping of many livestock as a way of maintaining social status has had an impact on the land use and land cover in the county to a great extent.

Most of the respondents 48.3% indicated that increased farming activities impacted on the land use and cover to a great extent while 18.4% indicated that it impacted to a very great extent the rest were either not sure or indicated that the effect was moderate or to a low extent. On the other hand, whether lack of appropriate institutional laws and regulations had an impact on the land use land cover most of the respondents 43.7% indicated that the effect was moderate with only 19.5% and 12.6% indicating that it affected land use to a great extent. This implies that both farming activities and pastoralism have had an impact on the land use and cover in the county. The study

also sought to find out whether population growth has had an impact on the land use and cover most of the respondents 43.7% and 18.4% indicated that the practice has had a very great impact on the land use in the county.

The study sought to assess whether socio-political systems affect the land use and land cover in the forest area. The results show that 57.5% of the respondents agreed that it affects to a very large extent, 14.9% indicated that it affects to a large extent while 13.8% were not sure that there was any impact. This implies that among the social economic factors that were noted to have had an effect on the LULCC in the Maasai Mau Forest in Narok North Sub County was political influence.

In regard to economic activities considered for the study such as the burning of charcoal, the study established that most respondents (38% and 33%) indicated that burning of charcoal for raising income had impacted on the land use and cover in the county to very large extent. It was also important to assess whether Selling of land for commercial buildings (urbanization) had an impact on the land use and cover. The results show that 56.3% agreed that the practice has had a great impact on the land use and cover for the period of the study while 33.3% indicated that the practice has had a very great impact on the land use and cover. This implies that urbanization has played a critical role in the degradation of the environment as it has impacted negatively on the land use and land cover. Similarly, the results show that 43.7% and 35.6% of the respondents respectively felt that high urbanization has forced people to cut down the shrubs and expose the soil to erosion as they clear land for settlement. This has had a very serious impact on the land use and cover in the county.

The results also indicted that 50.6% of the respondents felt that the poverty level among most land owners affect their decision making on the land use moderately while 27.6% and 14.9% felt that the practice affects and use and cover to a great extent and very great extent respectively. Based on the overall mean of 3.22 on the Likert scale representing 64.4% response. The results have indicated that socio-economic practices have an impact on the land use and land cover in Maasai Mau forest area of Narok county hence it has affected the environment in the area between 1986 and 2019.

4.4.1 Analysis of variance

Further analysis was done to establish whether there was any statistical significance in the responses hence making it possible to make generalizations, conclusion and recommendation regarding the social economic practices and the effect on land use and cover changes in the Maasai Mau Area. The analysis of variance was computed and used to make these deductions (Table 13).

Table 13: ANOVA to establish the influence of socio-economic activities on land use and land cover changes

		Sum of Squares	Df	Mean Square	F	Sig
Between People		378.416	86	4.400		
Within People	Between Items	291.781	11	26.526	28.296	.000
	Residual	886.803	946	.937		
	Total	1178.583	957	1.232		
Total		1556.999	1043	1.493		

Source: Research Data, 2020

4.5 Effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County

The study further sought to assess the effectiveness of existing initiative and interventions for sound land use practices in the study area. Based on the five Likert scale where 5- strongly agree (SA), 4- agree(A), 3- not sure (NS), 2 disagree (D) and 1 – strongly disagree (SD), the respondents were asked to give their opinion on the statement addressing the actual impact between 1986 to 2019 as presented in Table 14.

Table 14: Effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County

Effectiveness of existing initiative and interventions	SD	D	NS	A	S A	Total
Existing initiatives have led to increased land commercialization	9.2%	12.6%	0	46.0%	32.2%	100.0%
Existing land use initiative and interventions has led to decrease of land degradation	9.2%	16.1%	6.9%	46.0%	21.8%	100.0%
These interventions have led to the increased animal movement	5.7%	4.6%	9.2%	50.6%	29.9%	100.0%
Poverty pushes people to sell land hence affecting the effectiveness of existing land initiative and interventions in the sub-county	2.3%	19.5%	12.6%	41.4%	24.1%	100.0%
Increase in Charcoal burning business affects existing land initiative and interventions in the sub-county	5.7%	6.9%	8.0%	52.9%	26.4%	100.0%
Political systems has impacted negatively existing land initiative and interventions in the sub-county	5.7%	12.6%	12.6%	44.8%	24.1%	100.0%
There is reduced rainfall volume because of the many human activities in the land. This has greatly affected the effectiveness existing land initiative and interventions in the sub-county	10.3%	12.6%	0	48.3%	28.7%	100.0%
Increased demand for land for settlement has led to high level of negligence towards the implementations of existing land initiative and interventions	9.2%	13.8%	17.2%	47.1%	12.6%	100.0%
Increased conversion of forest land to more farm land for settlement is another threat to the existing land initiative and interventions in the sub-county	14.9%	4.6%	0	57.5%	23.0%	100.0%
Existing land initiative and interventions in the sub-county has been greatly affected by an intensive farming and deforestation which in return has led to soil degradation	0	0	0	44.8%	55.2%	100.0%
Poor legislation procedures lead to poor implementation of land initiative and interventions in the sub-county	0	0	1.1%	52.9%	46.0%	100.0%
Urbanization has led to pollution hence land initiative and interventions poor implementation	0	0	0	23.0%	77.0%	100.0%
Urbanization and land use has led to decline in land initiative and interventions in the sub-county	10.3%	1.1%	0	55.2%	33.3%	100.0%

Source: Research Data, 2020

The results show that most respondents 46.0% agreed while 2.2% strongly agreed that existing initiatives have led to increased land commercialization. This implies that existing initiatives have led to increased land commercialization in the study area.

The study also established that most of the respondents 46.0% agreed and 21.8% strongly agreed that existing land use initiative and interventions has led to decrease of land degradation. It was also noted that most respondents 50.6% agreed and 29.9% strongly agreed with the statement that these interventions have led to the increased animal movement in the study area. This implies that interventions have led to the increased animal movement which has impacted negatively on the use of forest land hence affecting the land cover.

On whether poverty pushes people to sell land hence affecting the effectiveness of existing land initiative and interventions in the sub-county, the study established that most respondents 41.4% agreed and 24.1% strongly agreed with the statement. This implies that poverty pushes people to sell land hence affecting the effectiveness of existing land initiative and interventions in the sub-county. A vast majority (80%) where of the opinion that poverty pushes people to sell land hence affecting the effectiveness of existing land initiative and interventions in the sub-county.

It was also noted that increase in Charcoal burning business affects existing land initiative and interventions in the sub-county, majority of the respondents 47.1% agreed with the statement while 17.2% were not sure while 13.8% disagreed with the statement. This implies that increase in Charcoal burning business affects existing land initiative and interventions in the sub-county. In regard to whether political systems has impacted negatively existing land initiative and interventions in the sub-county most of the respondents 57.5% agreed with the statement while 23.0% strongly agreed with the

statement. It was also noted that most respondents 55.2% strongly agreed while 44.8% agreed that there is reduced rainfall volume because of the many human activities in the land. This has greatly affected the effectiveness existing land initiative and interventions in the sub-county. It was also noted that most respondents 52.9% agreed with the statement while 46.0% strongly agreed with the statement, increased demand for land for settlement has led to high level of negligence towards the implementations of existing land initiative and interventions.

This implies that farm related activities have a great impact on the land use and land cover in Narok County and hence this accounts for the changes in whether patterns observed between 1986 to now.

This supports the findings of Souza et al., (2015) who noted that land use impacts have the potential to significantly affect the sustainability of the agricultural and forest systems, because as the rain pattern change the sustainability of agriculture becomes even more difficult.

On whether poor legislation procedures lead to poor implementation of land initiative and interventions in the sub-county, the study established that due to the poor status of land regulation there is increased destruction of forest land which is being converted to other uses that are leading to land cover reduction. This is supported by 44.8% of the respondents who agreed with the statement while 24.1% strongly agreed with the statement. This agreed with the findings of Bajocco et al., (2012) who also established that the nonattendance of appropriate backwoods strategy is referred to as a contributing element for deforestation in various pieces of the World. In Brazil, for instance, public strategies focused on the change of agrarian base and building up the Amazon economically have caused the deforestation of 1.1-2.1 million hectares yearly.

It was further noted that majority or the respondents 77.0% strongly agreed while 23.0% agreed that urbanization has led to pollution hence land initiative and interventions poor implementation. The study revealed that most respondents 55.2% agreed and 33.3% strongly agreed that urbanization and land use has led to decline in land initiative and interventions in the sub-county. This implies that activities of urbanization on land use and cover have had a very large impact on the environment. The increased human wildlife conflict in the Mau area is a clear indication that people have invaded the forest driving the wild animals away and, in the process, there is a lot of conflict which has led to destruction of property, crops and death. This agrees with the findings of Lynch and Carpenter (2003) who noted that as urbanization intensifies, agricultural and nonagricultural land use conflicts become more severe leading to increased environmental degradation.

4.5.1 Analysis of variance

The results further sought to assess whether the socio-economic practices impact on and use and land cover was statistically significant or not at a significant level of 5%. The results were presented on Table 15.

Table 15. ANOVA

		Sum of Squares	df	Mean Square	F	Sig
Between People		229.128	77	2.976		
Within People	Between Items	153.249	13	11.788	14.062	.000
	Residual	839.179	1001	.838		
	Total	992.429	1014	.979		
Total		1221.557	1091	1.120		

Grand Mean = 3.98

Source: Research Data, 2020

From the results it is noted that the impact of socio-economic practices on land use and cover was statistically significant at an F statistic of 14.062 compared to the critical f statistic of 2.02 at (df: 13, 77). This indicates that the model is a suitable predictor of the impact of socio-economic factors on the environmental degradation following the changes in the land use and land cover.

4.6 Estimated percentage of current estimated land cover

The respondents were asked to give their opinion on the level of land cover between 1988 and 2018. On a five scale Likert, where; 1-Less than 10%, 2- between 10 -20%, 3- between 21- 50%, 4 – between 51-70% and 5 more than 70% the results from the respondents were presented in figure 16.

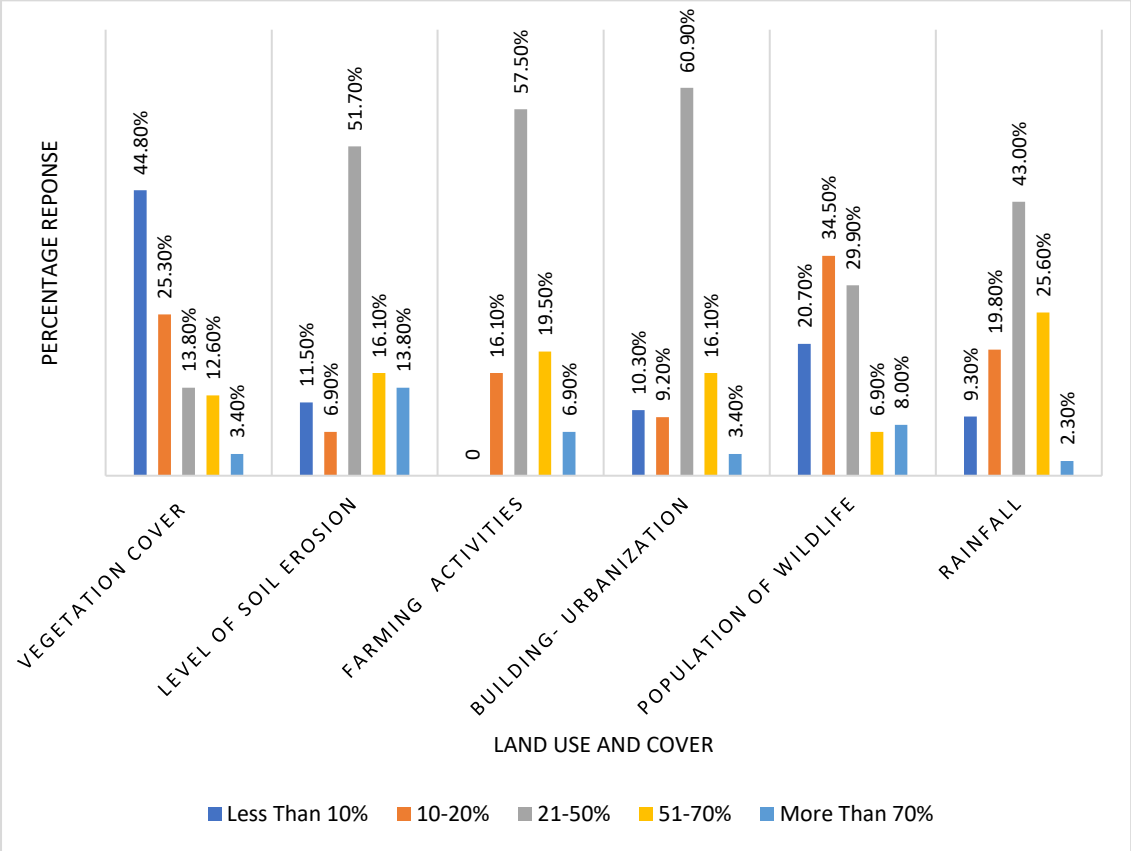


Figure 16: Estimated percentage level of activity in the area

Source: Research Data, 2020

The results on figure 16 show that most of the respondents 44.8% indicated that currently the vegetation cover on land is less than 10%. It can be further noted that 25.3% of the respondents indicated that the vegetation cover currently is between 10-20% with only a total of only 29.8% indicating that the vegetation cover is over 50%. This implies that there are only few areas where the vegetation cover has not changed much but, in most areas, there is a big change in the vegetation cover resulting into environmental degradation. This supports the findings by Intergovernmental Panel on Climate Change and Intergovernmental Panel on Climate Change, (2015) who established that in Kenya, Land Use and Land Cover Change has significantly affected plant biodiversity.

In regard to soil erosion levels, the results indicates that most of the respondents 51.7% indicated that there is increased soil erosion in most parts of the sub-county with only 11.5% of respondents indicating a level of less than 10%, 6.9% indicated a level of 10-20% while 29.9% respondents indicate a n increase of more than 50%. This shows that in most parts of the sub-county there is increased level of soil erosion which could be as a result of reduced level of vegetation cover. This agreed with the argument of Bajocco et al., (2012) and Souza et al., (2015) who indicated that the land and cover changes have affected the rate of infiltration and runoff which causes soil erosion that degrades the land and hence the environment.

In regard to farming activities the results show that most of the respondents 57.5% indicated there is an increase in the level of farming of between 22-50% in the study area, followed by 19.5% who indicated an increase of between 51-70 % while 6.9% indicated an increasing farming activity of more than 70%. This implies that the level of land use and cover has changed due to increased farming activities in the area. This

agrees with the findings of Souza et al., (2015) who noted that land use impacts have the potential to significantly affect the sustainability of the agricultural systems in the future.

Regarding urbanization, the results show that most respondents 60.9% indicated that there is an increase in urbanization of between 22-50%, followed by 16.1% who indicated that there is an increase of 51-70%. This implies that majority of the respondents indicated that there was an increase of more than 22% in the level of buildings and urbanization in the county. This accounted for the environmental degradation in the area. These findings are in line with the concerns of Wu and Cho (2007) who established that Urbanization has presented many new opportunities for farmers forcing them to put more natural and to agricultural use to meet the demands of their emerging new customers. There are more legitimate concerns about the use and condition of rural natural resources, because of the pressure from urbanization.

The population of wildlife was an important indicator of the land use and cover in the area. The study therefore sought to assess the level of wild life population in assessing the level of change in the environment. The results how that most respondents 34.5% felt that the population levels of wildlife were between 10-20%, followed by 29.9% who indicated that it is between 22-50%, while 20.7% indicated that a population of less than 10%. Only 6.9% indicated that the population is more than 51%. This implies that the population wild life has reduced which is an indication of environmental degradation. This agrees with the findings in a study by Lambin & Meyfroidt (2011) and Alvarez Martinez et al, (2011) who indicated that the annual loss of plant species in tropical Africa due to Land Use and Land Cover Change is very high and takes place at multiple levels (landscape, ecosystem and species).

The study also sought to assess the level of rainfall in the area between the study periods. The results revealed that most respondents 43.0% indicated that the amount of rainfall received in the area is less than 10%, followed by 25.6% who indicated that the level is between 22-50% while 19.8% indicated that the eve of rainfall is between 10-20%. Only 9.3% and 2.3 % respectively indicated a rainfall level of between 51-70% and above 71%. It is therefore important to note that the results presented are evident that there is environmental degradation in the study area which is caused by the current land use and cover change in the Maasi Mau Forest.

4.6.1 Analysis of Variance

Further analysis to assess whether the response given had any statistical significance and hence could be relied upon to make any deduction. The study used the analysis of variance to test the differences in the means of the responses. And the results were presented in Table 16.

Table 15: Analysis of Variance.

		Sum of Squares	df	Mean Square	F	Sig
Between People		254.847	85	2.998		
	Between Items	9.498	5	1.900	2.990	.012
Within People	Residual	270.002	425	.635		
	Total	279.500	430	.650		
Total		**534.347**	**515**	**1.038**		

The results show that there is a statistically significant variance between the means of the respondents which indicates that the results can be relied upon to made deduction that there has been a change in the land use and land cover which has had a negative impact on the environment.

The F statistic is 2.99 compared to the tabulated F statistic of.2.444 at a p value of less than 0.05 (0.012). The model is therefore a good predictor of the impact of socio-economic practices on environmental degradation.

4.7 Chi square test of Association (χ^2)

It was important to test the association between the socio-economic practices and the impact they have on the land use and cover hence environmental degradation in Narok County. The chi square test statistic between socio-economic practices and land use and cover changes was computed and presented on table 17.

Table 17: Chi-Square Tests of association between socio-economic practices and land use and cover changes

Items	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	346.161[a]	104	.000
Likelihood Ratio	221.962	104	.000
Linear-by-Linear Association	.033	1	.856
N of Valid Cases	87		

The results show that there is a very strong association between the socio-economic practices and the level of land use and cover in Narok North Sub-County. From the table the calculated chi square is 3.46.161 with a p value of 0.000 indicating very high level of significant association between the variables. This implies that socio-economic practices affect the land use and cover in Narok North Sub-County. This agrees with the findings of Lubowski et al. 2006 who established that socio-economic practices have led to conversion of most land into farming activities and urban settlement. This

exposes the available land to soil erosion, salinization, desertification, and other soil degradations.

The study also sought to assess whether there is an association between the impact of the socio-economic practices and land degradation in Narok County. The results are presented in Table 18.

Table 18: Chi-Square Tests of association between impact of socio-economic practices on land use and cover changes

Items	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	371.448[a]	88	.000
Likelihood Ratio	225.441	88	.000
Linear-by-Linear Association	.056	1	.813
N of Valid Cases	87		

The results show that there is a very strong statistical association between the impacts of the socio-economic practices and use and cover changes in Narok County since chi square value is 371.448 and the p value is 0.000. This implies that the impacts caused by the socio-economic practices have a very significant effect on environmental degradation in the area. The results are in line with the geospatial change detection results presented in the first section of this study which have cleary shown that there is a big change in the land use and land cover in the study area resulting in environmental degradation.

4.8 Chapter Summary

The chapter focused on the data analysis and presentations. It first focused on the response rate from the data collection instruments to determine the appropriateness of the response. The issue of involvement was also considered where the gender

representation was factored. To determine the quality of the respondents, the demographic factors of the respondents were considered. The study sought to establish the relationship that existed between the study variables, this was tested by use of the correlation analysis. The findings of the data analysis were presented in tables, graphs and figures appropriately. Statements of the findings were also clearly presented.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS OF THE STUDY

5.1 Introduction

The purpose of this study was to assess the socio-economic impacts of Land Use and Land Cover Changes in Narok North Sub-County, Kenya. To achieve this the study analyzed the Land Use and Land Cover Changes between the year 1986, 2000 and 2019. This was done using spatial maps that were generated from spatial pictures taken in the study area. A comparison was done between the images for the year 1986, 2000 and 2019. The study also sought to establish the main drivers of change in land use and land cover in the study area. The focus was mainly on the social and economic drivers which were identified from the literature, the impacts of these drivers on Land Use and Land Cover Changes were analyzed and discussed.

5.2 Summary of the findings

5.2.1 Geospatial findings of Land Use and Land Cover Changes

The study analyzed the spatial images taken from the three periods, 1986, 2000 and 2019, it was established that there was a clear line of distinction between the land use and land cover in the Maasai Mau Forest. The image taken in 1986 (Figure 10) showed a very dense forest cover which is shown in dark green colour that we see fading and being replaced gradually by settlements and farm land and other vegetation types. The results further show that much of the reduction in forest cover is found in the north western region of the sub-county.

The study further used time series concept to assess the land cover and classify the level of cover for the period 1986, 2000 and 2019 imageries of the area of study. The results from comparing the three assessment periods show that in 1986, the land cover showed a dense forest canopy which occupied 44.877% of the area. There is clear evidence that

the land use and land cover has changed since 1986 with more human activities taking the center stage and replacing the forest area. The results have also shown that most of the land that was under forest cover in 1986 have been converted either to settlement or farm land. There have been more agricultural activities in the area between 2000 and 2019 compared to the level of activities in 1986 to 2000.

The results established the magnitude and rate of land cover change, in the Maasai Mau Forest Cover area, are attributed to increased Settlements and planting of Other Vegetation and farmlands. There is more acreage of forest being converted to settlement and farm lands hence affecting the actual land cover in the study area. The assessment of the annual rates of change in land cover category between 1986 and 2019, noted a general decline in the forest land changing from -3571.7 hectares to a change of -3604.4 hectares. The other land use and land cover, that is farmlands and other vegetation had an increased annual rate of change replacing the forest land. This implies that the notable changes in the land use and cover are a consequence of increased human activities and thus more land was converted from other vegetation to agriculture, settlement and even clearance to get timber for construction, among others. These processes continued adding to the increase in areas under non-vegetated cover.

The digital images have clearly shown that between 1986 and 2000 a lot of the forest land was converted to farm land and settlement. A good proportion of the forest land was also converted to other vegetation's other than the natural forest over. The pink colour shows the area under forest cover between the year 1986 and 2000. The brown color shows the area under settlement while the green patches show the area that is covered by farm land and other vegetation (Figure 11).

It was established that the level of accuracy in the presentation and interpretation of the maps was defined by the errors of omission and commission. The results have revealed that in all the here incidences the there was a high level of accuracy as al the picture indicated an accuracy of more than 80% and the Kappa coefficient used to determine the presence of the various themes in a test and a coefficient of between 0.6 - 0.8 was considered appropriate. Therefore, all the three maps were considered accurate and precision providing the required information.

5.2.2 Socio-economic practices as drivers of Land Use and Land Cover Change

Regarding the social economic practices as drivers of and use and cover changes. The results indicated that cultural believes and practices pertaining to property ownership rights did not have a great impact on the land use and cover in Narok County. There was increased soil degradation due to increased livestock keeping in the Maasai Mau forest. Similarly, increased farming activities had a significant impact on the current state of Maasai Mau forest.

The study also established that the current state of Maasai Mau forest was influenced by political activities where by the politicians used the forest to advance their political goals. They settled thousands of people in the forest converting it to a settlement and farming activities. The increased farming activities led to planting of commercial crops replacing the natural forest vegetation. Besides politics the study noted that there are generally weak regulations and policy governing protection of forest land, because of this there are many illegal allocations of the forest land to individuals who later sale it to other many people. The increased settlement in the forest area and conversion of the forest land has also led to increased charcoal burning and feeing of trees for use as firewood. There is also increased burning of charcoal as a source of fuel and income

to the poor families living around the forest. Generally speaking, these activities have had a significant impact on the current state of the Maasai Mau forest.

It was also noted that people around the forest are selling land for urbanization and because of that there is also increased demand for food by the business people demand for fuel (charcoal and firewood) is also a key contributor to the increased decrease of forest land. It is therefore noted that majority of the respondents who participated in the study agreed that the social economic practices play a major role in changes in the land use and land cover in the Maasai Mau forest area. The results were established to be very significant hence appropriate in explaining the impact of social economic practices in the land use and land cover in the study area.

The analysis of variance showed that the calculated F statistics is 28.296 (df: 87, 11) was greater than the critical F value tabulated of 2.26. This implies that the model is statistically significant in explaining the impact of socio-economic practices on land use and cover since the p value is less than 0.05.

5.2.3 Effectiveness of existing initiative and interventions for sound land use practices

The results show that most respondents agreed that existing initiatives have led to increased land commercialization. The study also established that most of the respondents agreed. It was also noted that most respondents agreed with the statement that these interventions have led to the increased animal movement in the study area. On whether poverty pushes people to sell land hence affecting the effectiveness of existing land initiative and interventions in the sub-county, the study established that most respondents agreed with the statement.

It was also noted that increase in Charcoal burning business affects existing land initiative and interventions in the sub-county, majority of the respondents 47.1% agreed with the statement. This implies that increase in Charcoal burning business affects existing land initiative and interventions in the sub-county. In regard to whether political systems has impacted negatively existing land initiative and interventions in the sub-county most of the respondents 57.5% agreed with the statement. This implies that farm related activities have a great impact on the land use and land cover in Narok County and hence this accounts for the changes in whether patterns observed between 1986 to now.

On whether poor legislation procedures lead to poor implementation of land initiative and interventions in the sub-county, the study established that due to the poor status of land regulation there is increased destruction of forest land which is being converted to other uses that are leading to land cover reduction. This is supported by 44.8% of the respondents who agreed with the statement with the statement. This agreed with the findings of Bajocco et al., (2012) who also established that the nonattendance of appropriate backwoods strategy is referred to as a contributing element for deforestation in various pieces of the World. It was further noted that majority of the respondents strongly agreed that urbanization has led to pollution hence land initiative and interventions poor implementation. The study established that it was important to test the association between the socio-economic practices and the impact on the land use and cover hence environmental degradation in Narok North Sub-County. The results showed a very strong association between the socio-economic practices and the level of land use and cover since the calculated chi square was 3.46.161 with a p value of 0.000 indicating very high level of significant association between the variables. The results further showed that there was a strong association between the test

variables; the impact of the socio-economic practices and land degradation where the chi square value was 371.448 and the p value is 0.000, which implies that the impacts caused by the socio-economic practices have a very significant effect on environmental degradation in the area. The results are in line with the geospatial change detection results presented in the first section of this study which have Cleary shown that there is a big change in the land use and land cover in the study area resulting in environmental degradation.

5.3 Conclusion

This study sought to assess the social economic impact of land use and land cover in Narok North the Sub-County. It evaluated the extent to which the Mau Forest has been degraded by analyzing Geo special maps from pictures that had been taken in from the area in 1986, 2000 and 2019. The study also evaluated various drivers causing the change in land use and land cover. The results have shown that there is a very significant change in the land use and land cover in in Narok North Sub-County.

Based on the findings of the study it is concluded there is evidence of massive Land Use and Land Cover Changes in Narok North Sub-County. With a precision of accuracy of more than 0.6 as defined by the kappa coefficient, it is evident that since 1986 there are a lot of land use changes which have impacted negatively on the land cover. The study also concludes that most of the drivers of land use and cover in the Maasai Mau are social economic with population growth, politics and urbanizations having a very high impact on the land use and cover. It is also concluded that there is massive destruction of the forest to pave way for settlement and farm land between 1986 and 2000.

The results have also indicated that drivers of Land Use and Land Cover Changes such as beliefs and customs, poverty, low-income levels, population growth, government policies and politics have played a major role in the destruction of the forest in Maasai Mau. Their impacts are very evident in the sense majority of the respondents agreed that there has been an increase in the level of destruction as seen by the increase in the land for settlement, farm land and other vegetation cover replacing the natural cover. Therefore, the effective management of land use and land cover highly depend on how the various aspects of the land use and land cover are managed.

5.4 Recommendation

Based on the findings of the study it is recommended that:

First, there is need to put in place measure that will check on the causes of change in land use and land cover in the Maasai Mau forest. There is need to address the various kinds of land use and land cover that are causing the massive changes in the land cover in the Maasai Mau Forest. This requires effective collaboration between the stakeholders who should include the community, the government and its various agencies faced with the challenge of environmental conservation.

Secondly there is need to apply the multiple tools in understanding the various causes of land use and land cover changes in the Maasai Mau Forest area. From this study it has been noted that employing different methods of data collection and analysis provides more comprehensive information in regard to the land use and land cover changes. This study therefore recommends the application of technology in the collection of data, analysis and interpretation for more precise findings.

It is also recommended that research in LULC should involve all stake holders to capture their views fully and hence provide comprehensive information that will lead

to proper understanding of the various aspects of the causes of land use and land con\ver in the forest areas.

5.5 Areas for further study

In line with the study findings, it is noted that there are still gaps that need to be addressed through further research. This study only focused on the households in Narok North Sub-County in collecting data for the questionnaire. The impact of the deforestation could have other effects to other people not living around the forest, for instance issues of hydrological cycle affects other people who rely on the streams for water.

There is therefore need to carry out further study to include other stakeholders in the data collection process in order to collect more comprehensive data.

There is also need to carry out an in-depth study of the drivers of changes in the types of land use practices and land cover instead of just being listed. This will add a lot more information to the understanding of how these drivers actually impact LULCC.

REFERENCES

A, A. E. H. (2010). Land use change in the tropics and its effect on soil fertility. 1990(August), 55–58.

Ajani, I. O., Michael, A. A., & Olusegun, O. A. (2019). Comparative studies on Nutrients need and uptake in Enthandrophragma angolense seedlings. 6(1), 1–7. https://doi.org/10.15580/GJAFH.2019.1.020719027.

Akinyemi, F. O. (2017). Land change in the central Albertine rift: Insights from analysis and mapping of land use-land cover change in north-western Rwanda. Applied Geography, 87, 127–138. https://doi.org/10.1016/j.apgeog.2017.07.016.

Alvarez Martinez, J. M., Suarez-Seoane, S., & De Luis Calabuig, E. (2011). Modelling the risk of land cover change from environmental and socio-economic drivers in heterogeneous and changing landscapes: The role of uncertainty. Landscape and Urban Planning, 101(2), 108–119.https://doi.org/10.1016/j.landurbplan.2011.

Ayala, G. X., & Elder, J. P. (2011). Qualitative methods to ensure acceptability of behavioral and social interventions to the target population. Journal of Public Health Dentistry, 71(SUPPL. 1). https://doi.org/10.1111/j.1752-7325.2011.00241.x

Ayuyo et al., (2014). Land use change in Kenya: Insights from analysis and mapping of land use-land cover change in Mau forest cover. Applied Geography.

Bajocco, S., De Angelis, A., Perini, L., Ferrara, A., & Salvati, L. (2012). The impact of Land Use/Land Cover Changes on land degradation dynamics: A Mediterranean case study. Environmental Management, 49(5), 980–989. https://doi.org/10.1007/s00267-012-9831-8.

Balcombe, K., & Tiffin, R. (2012). Integrating spatial dependence into Stochastic Frontier Analysis. 521–541. https://doi.org/10.1111/j.1467-8489.2012.00597.

Barbier, E. B. (2010). Poverty, development, and environment. 635–660. https://doi.org/10.1017/S1355770X1000032X.

Belal, A. A. (2011). Detecting urban growth using remote sensing and GIS techniques in Al Gharbiya governorate, Egypt. The Egyptian Journal of Remote Sensing and Space Sciences, 14(2), 73–79. https://doi.org/10.1016/j.ejrs.2011.09.001.

Bengal, W. (2014). Monitoring of Landuse and Landcover- A case study of Nonagaon Basin, North. May.

Boitt, M. K. (2016). Impacts of Mau Forest Catchment on the Great Rift Valley Lakes in Kenya. May, 137–145.

Brar, (2013). The land use-climate change-energy nexus. Landscape Ecology, 26(6), 755–773. https://doi.org/10.1007/s10980-011-9606-2.

Brown, D. G., Walker, R., Manson, S., &Seta, K. (2012). Modeling land use and land cover change. In Land change science (pp. 395-409). Springer, Dordrecht.

Clinton, N., Holt, A., Scarborough, J., Yan, L. I., & Gong, P. (2010). Accuracy assessment measures for object-based image segmentation goodness. Photogrammetric Engineering and Remote Sensing, 76(3), 289–299. https://doi.org/10.14358/PERS.76.3.289.

County, N., & Development, I. (2013). County Integrated Development Plan for Narok County 2013 – 2017

County, N., & Development, I. (2018). County Integrated Development Plan for Narok County 2018 - 2022

Dale, V. H., Efroymson, R. A., & Kline, K. L. (2011). The land use-climate change-energy nexus. Landscape Ecology, 26(6), 755–773. https://doi.org/10.1007/s10980-011-9606-2.

District, T. M., Rift, S., & Kipsisei, G. C. (2011). Environmental Degradation and Social Conflict in FTJSIV VL' Y of Nairobi (Op Anthropology).

Drummond, M. A., & Loveland, T. R. (2010). Land-use Pressure and a Transition to Forest-cover Loss in the Eastern United States. 60(4), 286–298. https://doi.org/10.1525/bio.2010.60.4.7

Environmental, A. R. (2010). Spatial patterns and driving forces of land use change in China during the early 21st century. 20(2009), 483–494. https://doi.org/10.1007/s11442-010-0483-4

Etikan, I. (2016). Comparison of Convenience Sampling and Purposive Sampling. American Journal of Theoretical and Applied Statistics, 5(1), 1. https://doi.org/10.11648/j.ajtas.20160501.11.

FAO, I., & Isric, I. (2010). JRC. 2009. Harmonized world soil database (version 1.1). Food and Agriculture Organization, Rome, Italy and International Institute for Applied Systems Analysis, Luxemburg, Austria.

Fischel, W. (2015): The economics of zoning regulations: A property rights approach to American land use regulations. Baltimore: John Hopkins University Press.

Flower, A., McKenna, J. W., Bunuan, R. L., Muething, C. S., & Vega, R. (2014). Effects of the Good Behavior Game on Challenging Behaviors in School Settings. Review of Educational Research, 84(4), 546–571. https://doi.org/10.3102/0034654314536781.

Forum, I. S., Kingdom, U., & Vol, P. (n.d.). 4th International Scientific Forum, ISF 2015, 2-4 September, Oxford, United Kingdom.

Gatotoh, A. M., Omulema, B. E. E., & Nassiuma, D. (2011). Correctional Attitudes: An Impetus for a Paradigm Shift in Inmate Rehabilitation. International Journal of Humanities and Social Science, 1(4), 263–270.

Gessesse, B., Bewket, W., & Bräuning, A. (2015). Model-Based Characterization and Monitoring of Runoff and Soil Erosion in Response to Land Use/land Cover Changes in the Modjo Watershed, Ethiopia. Land Degradation and Development, 26(7), 711–724. https://doi.org/10.1002/ldr.2276.

Gholami, V. (2013). The influence of deforestation on runoff generation and soil erosion (Case study : Kasilian Watershed). 2013(7), 272–278.

Gómez, C., White, J. C., & Wulder, M. A. (2016). Optical remotely sensed time series data for land cover classification: A review. ISPRS Journal of Photogrammetry and Remote Sensing, 116, 55–72. https://doi.org/10.1016/j.isprsjprs.2016.03.008.

Greene, C. M., Blackhart, K., Nohner, J., Candelmo, A., & Nelson, D. M. (2015). A National Assessment of Stressors to Estuarine Fish Habitats in the Contiguous USA. Estuaries and Coasts, 38(3), 782–799. https://doi.org/10.1007/s12237-014-9855-9.

Hagos & Holden, (2006). The Impact of Land Use Change on the Hydrology of the Angereb Watershed, Kenya : International Journal of Water 1 DOI.

Heale, R., & Twycross, A. (2015). Validity and reliability in quantitative studies. Evidence-Based Nursing, 18(3), 66–67. https://doi.org/10.1136/eb-2015-102129

Hodge, G. (2011). Planning canadian communities: An introduction to the principles, practice and participants (2nd ed.) Scarborough: Nelson Canada.

Hofmann, K. (2013). Beyond the principle of population : Malthus's Essay Beyond the principle of population : Malthus's Essay. 2567. https://doi.org/10.1080/09672567.2012.654805

Houet, T., Verburg, P. H., & Loveland, T. R. (2010). Monitoring and modelling landscape dynamics. 163–167. https://doi.org/10.1007/s10980-009-9417-x

Hussain, M., Chen, D., Cheng, A., Wei, H., & Stanley, D. (2013). ISPRS Journal of Photogrammetry and Remote Sensing Change detection from remotely sensed images : From pixel-based to object-based approaches. ISPRS Journal of Photogrammetry and Remote Sensing, 80, 91–106. https://doi.org/10.1016/j.isprsjprs.2013.03.006.

Intergovernmental Panel on Climate Change, & Intergovernmental Panel on Climate Change. (2015). Agriculture, Forestry and Other Land Use (AFOLU). Climate Change 2014 Mitigation of Climate Change, 811–922. https://doi.org/10.1017/cbo9781107415416.017.

Intergovernmental Panel on Climate Change, & Intergovernmental Panel on Climate Change. (2015). Agriculture, Forestry and Other Land Use (AFOLU). Climate Change 2014 Mitigation of Climate Change, 811–922.

Ioannis, M., & Meliadis, M. (2011). Multi-temporal Landsat image classification and change analysis of land cover/use in the Prefecture of Thessaloiniki, Greece. Proceedings of the International Academy of Ecology and Environmental Sciences, 1(1), 15–25.

Jiyuan, L. I. U., Wenhui, K., Zengxiang, Z., & Xinliang, X. U. (2014). Spatiotemporal characteristics, patterns, and causes of land-use changes in China since the late 1980s. 24(2010), 195–210. https://doi.org/10.1007/s11442-014-1082-6

Keenan, R. J., Reams, G. A., Achard, F., Freitas, J. V. De, Grainger, A., & Lindquist, E. (2015). Forest Ecology and Management Dynamics of global forest area : Results from the FAO Global Forest Resources Assessment 2015 q. Forest Ecology and Management, 352, 9–20. https://doi.org/10.1016/j.foreco.2015.06.014.

Kenya National Bureau of Statistics. (2010). The 2009 Kenya population and housing census (Vol. 1). Kenya National Bureau of Statistics.

Kimani, M. & Musungu, T. (2010, September). Reforming and restructuring planning and building laws and regulations in Kenya for sustainable urban development. 46th ISOCARP Congress 2010, Nairobi.

KNBS, K. F. (2009). Figures 2009.

Konana, C., Gachene, C., Mburu, D., Mureithi, S., Gicheru, P., & Khalif, Z. (2017). Land Use and Land Cover Change and its implications on gully erosion in Suswa catchment, Narok County.

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. 108(9). https://doi.org/10.1073/pnas.1100480108.

Listokin, D., (2014). Land use controls: Present problems and future reform. Centre for Urban Policy Research, Rutgers University, New Brunswick, N.J.

Liu, J. G., & Mason, P. J. (2013). Essential image processing and GIS for remote sensing. Essential Image Processing and GIS for Remote Sensing, 1–443. https://doi.org/10.1002/9781118687963.

Mahamud et al., (2019). Dynamics of land-use and land cover change in tropical regions. Annual Review, Environment Resources. 28, 205–241. http://dx.doi.org/

March, P. (2017). Food Production Trend in Nigeria and Malthus Theory of Population : Empirical Evidence from Rice Production. 13(1), 126–132.

Matikainen, L., Lehtomäki, M., Ahokas, E., Hyyppä, J., Karjalainen, M., Jaakkola, A., Kukko, A., & Heinonen, T. (2016). ISPRS Journal of Photogrammetry and Remote Sensing Remote sensing methods for power line corridor surveys. ISPRS Journal of Photogrammetry and Remote Sensing, 119, 10–31. https://doi.org/ 10.1016/j.isprsjprs.2016.04.011.

Melesse, A. M., & Abtew, W. (2015). Landscape Dynamics, Soils and Hydrological Processes in Varied Climates. Landscape Dynamics, Soils and Hydrological Processes in Varied Climates, 1–839. https://doi.org/10.1007/978-3-319-18787-7.

Mengistu, D.A. & Salami, A.T. (2017). Application of remote sensing and GIS inland use and land cover mapping and change detection in a part of South Western Nigeria. African Journal of Environmental Science and Technology, 1 (5), 99-109.

Munroe, D.K., Croissant, C. and York, A.M. (2015), Land use policy and landscape fragmentation in an urbanizing region: Assessing the impact of zoning. Applied Geography, 25, 121–141.

Munteanu, C., Kuemmerle, T., Boltiziar, M., Butsic, V.,., & Radeloff, V. C. (2014). Forest and agricultural land change in the Carpathian region-A meta-analysis of long-term patterns and drivers of change. Land Use Policy, 38, 685–697. https://doi.org/10.1016/j.landusepol.2014.01.012

Nagendra, H., Lucas, R., Pradinho, J., Jongman, R. H. G., Tarantino, C., Adamo, M., & Mairota, P. (2012). Remote sensing for conservation monitoring: Assessing protected areas, habitat extent, habitat condition, species diversity, and threats. Ecological Indicators. https://doi.org/10.1016/j.ecolind.2012.09.014

Ndung'u, N., Thugge, K., & Otieno, O. (2010). Chapter 4 Unlocking the Future Potential for Kenya : The Vision 2030. Kenya: Policies for Prosperity, 4(2), 39–53.

Odhiambo, W. and Nyangito, H. (2012, September). Land Laws and Land Use in Kenya: Implications for Agricultural Development, KIPPRA Discussion Paper 15.

Ogutu, (2015) Impacts of Anthropogenic Activities and Climate on Wetland Ecology:

Case of Sitatunga (*Tragelaphus Spekei*) at Kingwal Wetland, Kenya. 1. 1-8.

Oke J. O. & Fagbohun, P.O. (2013).Urbanization in Lagos: Development or degeneration? A study into Urban Transport Situation along Oshodi-Sango, Nigeria

Olaleye, J, (2013). Optimum software architecture for an analytical photogrammetric workstation and its integration into a spatial information environment. Technical Report No. 162, (pp228). Canada, University of New Brunswick.

Olang, L. O., & Kundu, P. M. (2011). Land Degradation of the Mau Forest Complex in Eastern Africa : A Review for Management and Restoration Planning.

Ponterotto, J. G. (2010). Qualitative research in multicultural psychology: Philosophical underpinnings, popular approaches, and ethical considerations. Cultural Diversity and Ethnic Minority Psychology, 16(4), 581–589. https://doi.org/10.1037/a0012051.

Rahman, M. (2019). Validity of Malthusian Theory of Population in 20th Century in Terms of Using Scientific Technology to the Mahfuzur Rahman To cite this version : HAL Id : hal-02298401 Validity of Malthusian Theory of Population in 20 th Century in Terms of.

Richardson, J., Khan, M. A., Iezzi, A., & Maxwell, A. (2015). Comparing and explaining differences in the magnitude, content, and sensitivity of utilities predicted by the EQ-5D, SF-6D, and HUI 3, 15D, QWB, and AQoL-8 D multiattribute utility instruments. Medical Decision Making, 35(3), 276–291. https://doi.org/10.1177/0272989X14543107.

Robert E. Bailis, J. E. B. (2010). GHG emissions and LUC from Jaropha in Brazil

Rodriguez-Galiano, V. F., Ghimire, B., Rogan, J., Chica-Olmo, M., & Rigol-Sanchez, J. P. (2012). An assessment of the effectiveness of a random forest classifier for land-cover classification. ISPRS Journal of Photogrammetry and Remote Sensing, 67(1), 93–104. https://doi.org/10.1016/j.isprsjprs.2011.11.002.

Song, W., & Liu, M. (2014). Land Use Policy Assessment of decoupling between rural settlement area and rural population in China. Land Use Policy, 39, 331–341. https://doi.org/10.1016/j.landusepol.2014.02.002.

Souza, D. M., Teixeira, R. F. M., & Ostermann, O. P. (2015). Assessing biodiversity loss due to land use with Life Cycle Assessment: Are we there yet? Global Change Biology, 21(1), 32–47. https://doi.org/10.1111/gcb.12709.

Souza, D. M., Teixeira, R. F. M., & Ostermann, O. P. (2015). Assessing biodiversity loss due to land use with Life Cycle Assessment: Are we there yet? Global Change Biology, 21(1), 32–47. https://doi.org/10.1111/gcb.12709.

Srivastava, P. K., Han, D., Rico-Ramirez, M. A., Bray, M., & Islam, T. (2012). Selection of classification techniques for land use/land cover change investigation. Advances in Space Research, 50(9), 1250–1265. https://doi.org/10.1016/j.asr.2012.06.032.

Tahir, M., & Hussain, T. (2013). Evaluation of land use/land cover changes in Mekelle City, Ethiopia using Remote Sensing and GIS. Computational Ecology and Software, 2013(1), 9–16.Urban, I., & Risk, F. (n.d.). A Guide to Integrated Urban.

Tahir, M., & Hussain, T. (2013). Evaluation of land use/land cover changes in Mekelle City, Ethiopia using Remote Sensing and GIS. Computational Ecology and Software, 2013(1), 9–16.

Westrope, C., Banick, R., & Levine, M. (2014). Groundtruthing OpenStreetMap building damage assessment. Procedia Engineering, 78, 29–39. https://doi.org/10.1016/j.proeng.2014.07.035.

Yoshikawa, S., & Sanga-Ngoie, K. (2011). Deforestation dynamics in Mato Grosso in the southern Brazilian Amazon using GIS and NOAA/AVHRR data. International Journal of Remote Sensing, 32(2), 523–544. https://doi.org/10.1080/01431160903475225.

APPENDICES

APPENDIX I: RESPONDENT'S INTRODUCTION LETTER

Dear respondents

Request to Participate in Filling Questionnaire

I am a student at Maasai Mara University taking a degree in Masters in Environmental Studies. I am carrying out a study to assess the socio-economic impacts of Land Use and Land Cover Changes in Narok North Sub-County, Kenya. This is to request for your participation in filling the attached questionnaire to assess the drivers of land use and how it affects land cover and to examine the effect of these activities on the social economic wellbeing of the residents.

I request that you give information to the best of your knowledge that truly reflects the situation in the study area. The information collected will be confidentially handled, and used solely for the purpose of research. Your participation is highly valued.

Thanking you in advance for agreeing to participate.

Ann Nairuko

Masters Student
Maasai Mara University

APPENDIX II: QUESTIONNAIRE

Section A: Background Information

Please respond by ticking the correct option

1. Please indicate your Gender?

Male [ ] Female [ ]

2. Kindly specify your age bracket?

20–30 years [ ] 31–40years [ ] 41–50years [ ] 51 years and above [ ]

3. Kindly indicate your marital status

Single [ ] Married [ ] Separated [ ] Divorced [ ] Widowed [ ]

4. Are you a resident of this area?

Yes [ ] No [ ]

5. If yes; for how long have you lived in the area?

Since birth [ ] Last 40 years [ ] Last 30 years [ ] last 20 years [ ] Less than 10 years [ ]

6. What level of education have you attained?

None [ ] Primary [ ] Secondary [ ] Post-secondary training [ ] University [ ] others (please specify).....

7. What is your occupation?

Farmer [ ] Business Person [ ] Teacher [ ] Health worker [ ] Administration [ ] Social worker [ ]

Any other specify ……..

8. How many years have you served in your occupation?

Less than 5yrs [ ] 6–10yrs [ ] 11– 20yrs [ ] 21–30yrs [ ] More than 30yrs [ ]

9. What is your average income per months?

Less than KShs 10,000 [ ] KShs 11000 – KShs 20000 [ ] KShs 21000- KShs 30000 [ ] KShs more than 30000

10. What is the main source of this income for most residents?

Off-farm income [ ] On farm income [ ] Both farm and off-farm sources of income

11. To what extent does household income affect land use in the study area?

To a very great extent [ ] too a great extent [ ]

To a moderate extent [ ] to a little extent [ ]

To no extent [ ]

12. What is the frequency of rainfall in the area since the late 1980s compared to current situation?

Very Frequent [ ] Frequent [ ] I Am Not Sure [ ] Not Frequent [ ]

13. To what extent do you believe that most social economic activities undertaken impact on the land use and cover?

Very low extent [ ] Low extent [ ] I am not sure [ ] High extent [ ] Very high extent [ ]

Section B: Specific Objectives

Section B1: The effect of social economic practices as drivers to Land Use and Land Cover Changes between the year 1986, 2000 and 2019 in Narok North Sub-County

You are requested to give your opinion based on the given five Likert scale where 5- very great extent, 4- great extent, 3- moderate extent, 2 low extent and 1 – not sure, to the given statement addressing each objective.

To what extent do the following social economic practices act as drivers to land use and cover in Narok North Sub-County from the period **1986 to 2019.**

Sn	**Social economic practices as drivers of land use and cover**	**Very great extent**	**Great extent**	**Moderate extent**	**Low extent**	**Not sure**
B1	Beliefs and practices around property ownership rights					
B2	Selling of land as a source of income					
B3	Keeping of many livestock					
B4	Increased farming activities					
B5	Lack of appropriate institutional regulations					
B6	Population growth					
B7	Political systems in the area					
B8	Burning of charcoal as a way of raising income					
B9	Lack of appropriate legislation systems					
B10	Urbanization					
B11	High economic pressure forcing people to cut down the shrubs					
B12	Poverty among the residents					

In your own opinion what other social economic practices do you think have affected land use and land cover in this area;

……

……...

……

……

B2: Effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County

You are requested to give your opinion based on the given five Likert scale where **5 - strongly agree , 4 - agree, 3- not sure , 2 disagree and 1 – strongly disagree,** to the given statement addressing this objective.

What is the effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County between **1986 to 2019?**

sn	Social economic impact of land use and cover	Strongly agree	Agree	Not sure	Disagree	Strongly disagree
C1	Existing initiatives have led to increased land commercialization					
C2	Existing land use initiative and interventions has led to decrease of land degradation					
C3	These interventions have led to the increased animal movement					
C4	Poverty pushes people to sell land hence affecting the effectiveness of existing land initiative and interventions in the sub-county					
C5	Increase in Charcoal burning business affects existing land initiative and interventions in the sub-county					
C6	Political systems has impacted negatively existing land initiative and interventions in the sub-county					
C7	There is reduced rainfall volume because of the					

	many human activities in the land. This has greatly affected the effectiveness existing land initiative and interventions in the sub-county					
C8	Increased demand for land for settlement has led to high level of negligence towards the implementations of existing land initiative and interventions					
C9	Increased conversion of forest land to more farm land for settlement is another threat to the existing land initiative and interventions in the sub-county					
C10	Existing land initiative and interventions in the sub-county has been greatly affected by an intensive farming and deforestation which in return has led to soil degradation					
C11	Poor legislation procedures lead to poor implementation of land initiative and interventions in the sub-county					
C12	Urbanization has led to pollution hence land initiative and interventions poor implementation					
C13	Urbanization and land use has led to decline in land initiative and interventions in the sub-county					

In your opinion how else can you say about the effectiveness of existing initiative and interventions for sound land use practices in Narok North Sub-County.

……

……

……

……

……

c) In your opinion compare the land use between 1988, 2000 and 2018 by estimating the percentage cover by indicating the number

1- Less than 10%, 2- between 10 -20%, 3- between 21- 50%, 4 – between 51-70% and 5 more than 70%

Activities	1988	2000	2018
Vegetation cover			
Level of soil Erosion			
Farming activities			
Buildings			
Amount of rain fall recorded			
Number of world animals in the area			

Thank you

APPENDIX III: LETTER OF INTRODUCTION FROM SCHOOL

MAASAI MARA UNIVERSITY

SCHOOL OF TOURISM AND NATURAL RESOURCES MAGEMENT

Tel. No. 050-23213
Fax No. 050-22103

P.O BOX, 861-20500
NAROK, KENYA

DATED: 26-05-2016

TO WHOM IT MAY CONCERN

Dear Sir / Madam

REF: MES10/1009/2014 - ANNE NAIRUKO MOOTIAN

Reference is made to the above named who is a bonafide student of Maasai Mara University in the School of Tourism and Natural Resources Management, undertaking Masters in Environmental Studies on topic entitled **"An assessment of Socio-Economic Impacts of Land Use and Land Cover Changes in Narok North Sub-County, Kenya".** This is a 2 year programme that entails 1 year course work and 1 year research work.

In this regard, Ms Anne shall be collecting data from the Narok North Sub-County region, and it is therefore to kindly request you to allow her conduct her research on the same.

Any assistance accorded to her shall be highly appreciated.

20 MAY 2016

(Supervisor)
Dr. Mabwoga

APPENDIX IV: RESEARCH AUHORISATION FROM NACOSTI

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

Telephone: +254-20-2213471,
2241349,3310571,2219420
Fax: +254-20-318245,318249
Email:dg@nacosti.go.ke
Website: www.nacosti.go.ke
when replying please quote

9th Floor, Utalii House
Uhuru Highway
P.O. Box 30623-00100
NAIROBI-KENYA

Ref: No **NACOSTI/P/17/50174/16675** Date: **4th May, 2017**

Anne Nairuko Mootian
Maasai Mara University
P.O Box 861-20500
NAROK.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on **"An Assessment of Socio-Economic Impact of Land Use and Land Cover Changes in Narok North Sub - County, Kenya."** I am please to inform you that you have been authorized to undertake research in Narok County for the period ending 4th May, 2018.

You are advised to report to the **County Commissioner and the County Director of Education, Narok County** before embarking on the research project.

On completion of the research, you are expected to submit **two hard copies and one soft copy in pdf** of the research report/thesis to our offices

GODFREY P. KALERWA MSc., MBA, MKIM
FOR: DIRECTOR-GENERAL/CEO

Copy to:

The County Commissioner
Kajiado County.

The County Director of Education
Kajiado County.

The County Commissioner
Narok County.

APPENDIX V: LETTER FROM OFFICE OF COUNTY COMMISSIONER

OFFICE OF THE PRESIDENT

MINISTRY OF INTERIOR
AND
COORDINATION OF NATIONAL GOVERNMENT

Telegram: "COUNTY", Narok County
Telephone: Narok [050] 22305/22435
Email. Countycommissioner86@yahoo.com
If calling or telephoning ask for the undersigned
When replying please quote:

County Commissioner's Office
Narok County,
P.O. Box 4 – 20500
NAROK

OUR REF: CC/NRK/15/6/VOL.1./43 **7th November, 2018**

Deputy County Commissioners
Narok county

RE: RESEARCH AUTHORIZATION, ANNE NAIRUKO MOOTIAN
The bearer of this letter is a student of maasai mara university

She has been authororized to carry out Research on " **An Assessment of Socio-Economic Impacts of Land Use and Land Cover Changes in Narok North Sub-county, Kenya."**

The purpose of this letter is to request you to accord her the necessary assistance

PATRICK OMBOGO
FOR: COUNTY COMMISSIONER
NAROK COUNTY

CC Anne Nairuko Mootian

APPENDIX VI: AUTHORISATION FROM MINISTRY OF EDUCATION

REPUBLIC OF KENYA

MINISTRY OF EDUCATION

State Department of Early Learning and Basic Education

FAX NO. 050-22391
When replying please quote;

Ref. CDE/NRK/RES/VOL1/158

COUNTY DIRECTOR OF EDUCATION
NAROK COUNTY
P.O BOX 18
NAROK

DATE: 30th October, 2018

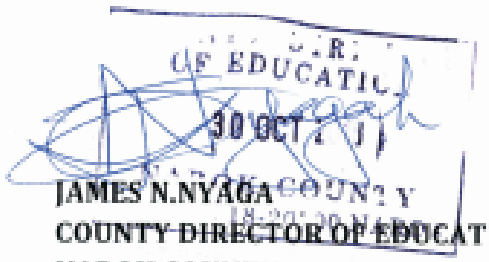
TO WHOM IT MAY CO CONCERN

RE: RESEARCH AUTHORIZATION - ANNE NAIRUKO MOOTIAN.

The above mentioned is astudent of Maasai Mara University,

She has been authororized to carry out Research on " **An Assessment of Socio-Economic Impacts of Land Use and Land Cover Changes in Narok North Sub-County, Kenya.**"

Please accord her the necessary assistance



JAMES N.NYAGA
COUNTY DIRECTOR OF EDUCATION
NAROK COUNTY

C.C

- The County Commissioner – **Narok**
- Anne Nairuko Mootian