THE IMPACTS OF LAND-USE/COVER CHANGE ON PASTURE VIABILITY IN PASTORAL COMMUNITIES IN KILINDI DISTRICT, TANZANIA

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THE IMPACTS OF LAND-USE/COVER CHANGE ON PASTURE VIABILITY IN PASTORAL COMMUNITIES IN KILINDI DISTRICT, TANZANIA

By

Julius Daniel

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CERTIFICATION

The undersigned certifies that he has read and hereby recommends for acceptance by the University of Dar es Salaam a dissertation titled: ***The Impacts of Land Use/Cover Change on Pasture Viability in Pastoral Communities in Kilindi District***, ***Tanzania*** in Partial fulfilment of the requirements for the degree of Master of Science in Geographical Information Systems of the University of Dar es Salaam.

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Dr. Donald A. Mwiturubani

(Supervisor)

Date…………..

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I **Julius Daniel**, do hereby declare that this is my original dissertation and that this dissertation has not been shared with any other university or academic institution for any academic accreditation.

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DEDICATION

This dissertation is utterly dedicated to my treasured parents, my dad Daniel Paringo Ndiriamba, and Juliana Daniel for their untiring support throughout my entire academic career.

LIST OF ABBREVIATIONS

CA	Celluler Automata
DAS	District Administrative Secretary
DC	Digital Counts
DN	Digital Numbers
DED	District Executive Director
ETM+	Enhanced Thematic Mapper Plus
FAO	Food and Agriculture Organization of the United Nations
FGD	Focus Group Discussion
GIS	Geographical Information Sytems
GloVis	Global Visualization Viewer
GPS	Global Positioning System
GTZ	*Deutsche Gesellschaft fur Technische Zusammenarbeit* (German Agency for Technical Cooperation)
ha	Hectares
HIAP	Handeni Intergrated Agroforestry Project
IFAD	International Fund for Agricultural Development
KII	Key Informant Interview
LULC	Land Use and Land Cover
LULCC	Land Use and Land Cover Change
NBS	National Bureau of Statistics
NCMC	National Carbon Monitering Centre
OLI	Operational Land Viewer
RAS	Regional Administrative Secretary
RGB	Red, Green, Blue
TM	Thematic Mapper
UN	United Nations
UNEP	United Nations Environment Programme
USGS	United States Geological Survey
URT	United Republic of Tanzania
UTM	Universal Transverse Mercator

UVIC	University of Victoria

ABSTRACT

For the past 20 years, Kilindi district has seen increased land use and land cover change due to the influx of people and animals emigrating from various parts of the country, primarily Arusha, Kilimanjaro, and Manyara leading to high population growth and high pressure on land resources. This study was conducted in the wards of Kibirashi and Saunyi in the Kilindi district, with the primary objective of understanding the impacts of land use/cover change on pasture viability in pastoral communities during the period spanning from 2003 to 2023. This study's specific objectives aimed to examine spatial and temporal changes in land use and land cover, to assess the impacts of Land Use and Land Cover on pasture viability and to predict the future changes in land cover in Saunyi and Kibirashi wards for the next 20 years. This study used methods such as document review which included the collection of satellite imageries for 2003, 2014, and 2023 from USGS Earth Explorer and analyzed using IDRISI/TerrSet, ArcGIS, QGIS, and Microsoft Excel. Through observation, the study gathered ground truthing data using GPS and informative photos using cameras. The in-depth interviews were conducted to collect qualitative information whereby through purposive non-probability sampling a total of 44 people were interviewed in FGDs and 18 through key informant interviews. Qualitative data were analyzed thematically using Atlas.ti Furthermore, the study utilized the CA Markov model in IDRISI/TerrSet to make predictions regarding study area's future LULCC. The findings of this study revealed significant changes in land use and land cover within the study area. Notably, the cultivated land area expanded from 14,342 ha 10.8% of the total study area land cover in 2003 to 32,020 ha 24.19% of the total study area land cover in 2023. The total land cover for traditional pasture in the area such as woodland, grassland, and bushland decreased at an annual change of 18,060 ha from a total of 117,184 ha in 2003 to 99124 ha in 2023 which implies a 18.22 annual percentage change. These changes in land use and land cover had multifaceted impacts on pastures, including a reduction in pasture size, deterioration in pasture quality, and disruption of local pasture management practices. Predicted results suggest that by 2043, The total land use/cover for cultivation will occupy 29.24%, while woodland and bushland areas are expected to decrease to 18.46% and 29.35%, respectively. In light of these findings, this study recommends the implementation of effective and strategic land use and management plan initiatives to control agricultural and urban expansion and to mitigate the adverse effects of rapid land use and land cover changes on pastoral communities. Additionally, empowering pastoral communities in Kibirashi and Saunyi to engage in alternative income-generating activities is also advised to ensure the sustainability of their livelihoods.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER ONE
INTRODUCTION

1.1 General Introduction

The global land area, including inland waters and permanent snow and glaciers, amounts to 14.706 billion ha (FAO, 2022). Ever since the global land cover has significantly changed due to human activities and natural factors. Human influence on the global land cover can be traced as far back as the time when humans started to control fire and domesticated plants and animals where they cleared forests to wring higher value from the land (Lambin et al., 2003). About half of the ice-free land has been converted or substantially modified by human activities over the last 10,000 years, forests covered about 50% of the earth's land area 8,000 years ago as opposed to 30% in 2003, cropland increased from 300-400 million ha in 1700 to about 1599-1800 million hectares in the 1990s (Lambin et al., 2003), whereas significant decrease in traditional pastures for pastoralists such as steppes, savannas and grasslands (Yanda & Mung'ong'o, 2018) from 3200 million ha in 1700 to 1800-2700 ha is witnessed in the 1990s. Due to increased population and advancement in technology, there has been an alarming decrease in world forests (FAO, 2011).

1.2 Background of the Research Problem

Study shows that land use activities have been growing in varying degrees over time since the inception of the world and become more profound over the last 300 years, the start of the Industrial Revolution (Ramankutty et al., 2006). According to FAO, artificial surfaces notably urban and paved highways/airports doubled from 30 million ha in 2000 to almost 60 million ha in 2019, while tree-covered areas declined from 4.347 billion ha in 1992 to 4.270 in 2019 and areas under permanent crop increased from 1.877 billion ha in 1992 to 1.904 billion in 2019. Shrub land globally increased from 1,773 million ha in 1992 to 1,813 million ha in 2019 (FAO, 2022). The report also indicates decreases in shrubland from 1.615 billion ha in 1992 to 1.605 billion ha in 2019. Those changes in global land cover have significantly reduced pastures whereby areas used to graze animals such as grassland and shrub land reduced by 191 million ha between 2000-2019 from over 3.3 billion ha to 3.1 billion ha in 2019 with cropland expansion being the major driving force of the change. Changes in land cover also reduced the biophysical status of grassland where 34 per cent of grassland status was reduced due to overgrazing and inadequate livestock mobility causing soil compaction and erosion thus affecting soil function, plant growth and hydrological services (FAO, 2022). Sub-Saharan Africa is a region observed to be the home of pastoralists due to its potential in savanna, shrubs, steppes and woodland kinds of vegetables. Nevertheless, pastures in this region are under immersing pressure due to LULCC. Areas originally used as pastures are now being subdued by other land use activities most notably crop production and settlement activities (Hobbs N. Thompson and Reid, 2008).

In East Africa, big portions of former pastureland are now under crop cultivation and settlement activities with about 60-70 percent of forest taken for crop farming, and about 23% of former grassland is now under crop cultivation. Oxfam International also establishes that key pasture areas in East Africa such as dry season grazing lands are a target for agricultural use because of their productive potential (Kirkbride, 2008). For example, arable farming now takes place in about 56 percent of rangelands (33% of woodlands and 23% of grassland) (ibid). Tanzania in particular has witnessed significant changes in the land cover with a significant impact on pastures, for example, grassland decreased from 5.5 million ha in 1992 to 5.3 million ha in 2020, and shrub and tree-covered land decreased from 17.6 million ha in 1992 to 16.7 million in 2020 (FAO, 2023).

As observed by Blench, (2001), the growing population and improved transport mechanisms are pushing arable farming into more and more marginal areas. This expansion of crop farming activities into pastures in semi-arid Africa has made conflict between farmers and pastoralists an everyday occurrence (Blench, 2001). In the Kilindi district, population increases largely due to immigration have put pastureland in danger due to the expansion of crop farming, settlement, and overgrazing.

For many years the problem of pasture viability in terms of availability, quality and quantity, and accessibility has been aggravated by several factors such as climate change, expansion of cultivation, increase in protected forestry and game areas, and growth of human settlements (Mbwambo et al., 2016; Mwamfupe, 2015). In the west Asia countries and northern Africa countries, rangeland degradation has become a big problem. For instance, in countries such as Morocco and Tunisia, rangelands fell by 10% between the 1970s and 1990s, and in Algeria, rangelands fell by 14% in the same period (Mung'ong'o, 2022). In Tanzania for instance, a huge portion of pasture lands have been lost to conservation, and for private investments and cultivation (Mbwambo et al., 2016; Mwambene et al., 2014).

Despite these climatic hurdles the pastoral communities have for many years been able to resist the effects of climate change and seasonal variability of pastures due to their mobility nature (Jenet et al., 2016). For example, according to Kirkbride, (2008), mobility to many pastoralists is a key factor that has helped them to access pastures from distant areas and cope with the effects of climate change by moving their livestock according to pasture availability and seasonality. Because of the aridness and semi-aridness nature of the areas that are inhabited by many pastoral groups, particularly in Tanzania, many pastoralists have relied on a traditional seasonal utilization of pastures whereby they have plans for dry and wet seasons pastures (Kirkbride, 2008). To access some of those pastures' pastoralists relied on livestock mobility which enabled them to move to different areas seasonally to access pasture for their animals (Mwihomeke et al., 1998).

In recent years pasture viability has been immensely challenged by factors associated with population growth, conservation activities, economic requirements, and cultivation (Mwambene et al., 2014). These factors, for instance, conservation activities and cultivation are being empowered by favoring government policies (Muhammad et al., 2019). In many African countries and Tanzania in particular, pastures have been declining due to the appropriation of pasture land by the government and redirected to other activities due to negative government perception that pastoralism is an irrational, ecologically destructive, and economically inefficient production system (Hesse & MacGregor, 2006). Further, studies indicate that many pastures are now inaccessible by pastoralists due to the decline of livestock mobility as the result of conservation activities, and cultivation and settlement expansion (Jenet et al., 2016). All these factors have impacted pasture viability and in turn caused a lot of hardship to pastoral groups to sustain their livelihoods and at times found themselves in conflicts with other land users (Mwamfupe, 2015).

This study therefore, examined the change in land use and land cover activities from 2003 to 2023 to understand the type and magnitude of land use/cover changes and their associated impacts on pasture viability and the trajectory of future LULC activities in the pastoral communities of Kibirashi and Saunyi wards.

1.3 Statement of the Research Problem

For the past 20 years, Kilindi district has seen increased land use and land cover change due to the influx of people and animals emigrating from various parts of the country, primarily Arusha, Kilimanjaro, and Manyara. The immigrants came to the district for a variety of reasons, the most common of which were animal husbandry, crop cultivation, and settlement. The population increase in the district due to immigration is further adding pressure on the land, particularly on pasture viability. This study examined land-use/cover change issues over the last 20 years to understand the impacts of land-use/cover change activities on pasture viability in the two wards of Kibirashi and Saunyi.

1.4 Research Objective

This research's general and specific objectives are explained hereunder

1.3.1 General Objective

The general objective of this study was to understand the impacts of land use/cover changes on pasture viability in pastoral communities.

1.3.2 Specific Objectives

1. To examine spatial and temporal changes in land use and land cover in Kilindi district for the past 20 years.
2. To assess the impacts of Land Use and Land Cover on pasture viability in Kilindi district for the period of 2003 – 2023.
3. To predict the future changes in land cover in Kilindi district for the next 20 years until 2043.

1.3.3 Research Questions

1. How changes in land use and land cover (LULC) have occurred in Kilindi district from 2003 to 2023?
2. How did Land Use and Land Cover changes impact pasture viability in the Kilindi district?
3. What are the expected changes in land use and land cover in Kilindi district in twenty years?

1.5 Significance of the Study

Land use and land cover changes are a big problem facing the world today due to increased population and economic demands. In Tanzania and Kilindi district in particular LULCC is a big challenge to rural pastoral communities to implement their economic activities. Therefore, this study saw the need to assess the state of LULC, its impacts on pasture viability, and the future of LULC in the Kibirashi and Saunyi wards. The findings of this study will equip district government officials with vital information on the current and future state of LULC in pastoral areas as well its impacts on pasture viability which will help them to make informed decisions. In addition, this study's findings will help stakeholders of various professions including foresters, farmers, natural resource managers students, pastoralists, conservationists, and researchers in their activities in Kilindi. Lastly, this study being the first study conducted on LULCC on pasture viability, its findings will encourage the need for further research on LULCC about pastoralism and other community activities.

1.6 Scope of the Study

This study is limited to the Kilindi district in the two wards of Kibirashi and Saunyi on the issue of LULCC and pasture viability. The remote sensing data used in this study are from 2003, 2014, and 2023 which were used to assess the impacts of LULC changes in pastures in the study area for 20 years. This study used 62 in-depth interviews held among women, youth, herders, and traditional leaders and 6 villages out of 8 villages in the two wards of Kibirashi and Saunyi to draw conclusions and recommendations.

1.7 Organization of the Dissertation

This study is made up of five chapters and every chapter contains subsections. Chapter one provides the introduction of the study and its subtopics which includes a general introduction, background to the research problem, statement of the problem, objectives of the study and research questions, significance of the study, and the scope of the study. Chapter two is the literature review which includes a theoretical and conceptual literature review, a definition of key concepts, and research gaps. Chapter three describes the research methodology which is comprised of the research design, the study area, data collection methods, data processing and analysis, data validity and reliability, ethical considerations, and limitations of the study. Chapter four consists of the results and discussion and chapter five is comprised of the summary, conclusion, recommendations, and areas of further research.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter presents a review of various sources of information in the literature spectrum that informs the study's relevance. The chapter includes subtopics such as the definition of key terms and concepts, theoretical and empirical literature review, development of the conceptual framework and identifies the research gaps.

2.2 Definition of Key Terms and Concepts

This section defines the keywords used by the research to inform the purpose and intent of the study. It also includes definitions of the word that might not be easily understood by persons who are unfamiliar with this area of research. They include land use/cover, pastures, grassland, rangelands, and pastoralism.

2.2.1 Land Use and Land Cover (LULC)

According to Nedd et al., (2021), Land-use and land-cover can carry separate definitions, where land-use relates to what purpose the land is utilized, for example, agricultural or recreational use. In contrast, the land cover states specific landscape patterns and characteristics. Further, (Costa et al., 2018) defined land cover as the physical and biological cover of the earth's surface including artificial surfaces, agricultural areas, forests, semi-natural areas, wetlands, and water bodies.

2.2.2 Pastures

Pastures are the lands used for grazing and it is a most vital material and social resource in pastoralist communities (Catley et al., 2013). These are the lands with resources vital for livestock feeding such as grassland, shrub land and woodlands. Pastures in this study refer to the same meaning provided by Catley et al., (2013). Furthermore, the pastures discussed in this study included grasslands, woodlands, and bushlands as part of Kibirashi and Saunyi's traditional pastures.

2.2.3 Pastures Viability

As defined by Catley et al., (2013) Pastures are the lands used for grazing while the Merriam-Webster dictionary defines viability as the ability to function adequately (Merriam-Webster, 2024). Also, viability is defined in the context of supply chains by Ivanov, (2022) as the ability of a supply chain (SC) to maintain itself and survive in a changing environment, this study derived the meaning of pasture viability from these definitions and defined pasture viability as the ability of grazing lands to function adequately and survive the changing environment.

2.2.4 Grassland

Grassland is said to be a term that bridges pastureland and rangeland, it can be a natural or imposed ecosystem. In the context of natural vegetation, grassland includes grasses, legumes and other forbs and sometimes woody species may be present (Dixon et al., 2014). According to Prins & Kessler, (2014), grasslands can be divided into three types such as natural, herbaceous species (semi-natural) and herbage (domesticated forage). In the case of Kibirashi and Saunyi and in the context of this study grasslands means open areas characterized mostly by natural grasses.

2.2.5 Rangelands

Rangelands are defined as the Indigenous vegetation of grasses, forbs or shrubs and include native ecosystems (FAO, 2020). They sustain domestic animals and wildlife for grazing and browsing and host pastoralists, agro-pastoralists and ranchers as main populations (FAO, 2020). Rangeland is a broader term than grasslands, it includes regions where woody vegetation is dominant; moreover, it is common in texts describing land related to livestock production (Blench, 2001). This study uses that definition for rangelands in the study area.

2.2.6 Pastoralism

Pastoralism is defined by Dong, Kassam, Tourrand, et al., (2016), as a mobile form of livestock herding for either subsistence uses or commercial production. There are two major forms of pastoralism such as nomadic and transhumant with pastoral farming/enclosed ranching as the third form of pastoralism (Dong, Kassam, François, et al., 2016). The basic pastoralism features as described by (IFAD & FAO, 2016), are mobility, adaptation, flexibility, diversification, conservation, and mutual support. This study therefore adapts to this definition, by defining pastoralism as a mobile form of livestock keeping involving nomads, semi-nomads, transhumants, and agro-pastoralists.

2.3 Theoretical Literature Review

Various theories exist that describe the relationship that exists between land activities, and livelihood. These theories describe the interconnectedness that exists between activities such as pastoralism and the land cover. This study was guided by the System and participatory planning theories. While the system theory underscores the interrelationship existing between various elements and constituents of the society such as their livelihood activities, participatory theory insists on the importance of participatory decision-making in society to reach sustainable solutions considering the interconnection in the society as described by System Theory.

2.3.1 System Theory

As described by (Hester Patrick T.and Adams, 2017) systems theory is a broad term without a formally agreed-upon definition. The term has been used in different disciplines. The central notion of system theory is the concept that a 'system' is a coherent entity composed of interconnected and interdependent parts. The key founder of system theory is Ludwin Von Bertalanffy who founded general system theory in 1950. Since the 20th century, several systems theories emerged such as General System Theory, Living Systems Theory, Mathematical Systems Theory, and Social Systems Theory. When describing system theory ((Capra, 1996), emphasized that nature is seen as an interconnected web of relationships, in which the identification of specific patterns is dependent on the perspective of the human observer. While explaining the 'systems' approach Manning (1967), argued that an interrelationship exists between all elements and constituents of society. This implies that the essential factors related to public problems, issues, policies, and programs must always be considered and evaluated as interdependent components of a whole (Bertalanffy, 1968). In the field of land, land use/cover can be regarded as a system where each activity such as livestock keeping, crop cultivation, settlement, and infrastructure are interdependent and interrelated. Therefore, when taking a “systems approach, proper land use management will be achieved when all land users have sustainable and equitable access to land-based resources that support their communities. In the case of pastoralists, this means having access to and secure use of sustainable pastures to support their culture and economic uses.

2.3.2 Participatory Planning Theory

Participatory planning theory is a paradigm developed in the field of urban and town planning in the early 1960s in the United States. This paradigm is centred on the role of public involvement or participation in policy-making (Lagopoulos, 2018). Among the proponents and founders of this theory is Paul Davidoff, a US lawyer and planner who developed the theory of “Democratic Advocacy/Pluralism Planning”. According to Davidoff, (2015), values should be formulated not only by the planner, but clients should be involved including the people affected by the plan, with the awareness that there can be disagreements between users (Lagopoulos, 2018). Democracy Advocacy theory highlights the importance of incorporating the people, or communities which are directly linked to policy and decision making. System theory provides an approach to bringing users, people and communities into the planning process. Participatory planning theory calls for communities’ involvement in policy-making including plans for land use. As described in the system theory, the land is a system with its users, their respective activities and governing principles which form parts of the whole system in an interrelated and interdependent manner. From the perspective of system theory and participatory planning theory pastoralists are critical to be involved in land use planning to maintain their pastures, culture and economy.

2.4 Empirical Literature Review

Under this section of the empirical literature review, the literature is described as relevant to the study objectives, which include examining land-use/cover change over 20 years, the impacts of the change on pastures, pastoralists, and the prospects of future change in LULC.

2.4.1 Land Use and Land Cover Change

Land cover is dynamic and varies at different spatial and temporal scales (Cihlar, 2000), and its impacts are fundamental in the structures and functioning of the earth systems (Were et al., 2013). LULCC is driven by several factors such as climate change, population increase, and expansion of cultivation (Assede et al., 2023). Land cover and land use are closely interrelated which helps to improve the understanding of key local, regional, and planetary trends. According to FAO statistics from 2000 – 2020, these trends help to quantify human-driven land dynamics, such as the conversion of land to or from agriculture, deforestation, and land degradation (Potapov et al., 2022).

Land use and land cover change are far greater now than ever before (Ruddiman, 2003), driving unprecedented changes in ecosystems and environmental processes at local, regional, and global scales. Although LULCC is said to have started when humans started to control fire and domesticated plants and animals (Lambin et al., 2003), the rapid transformation of land cover with measurable impacts on today's landscape started about 300 years ago a period characterized by globalization and the dominance of capitalism (Ramankutty et al., 2006). About half of the ice-free land has been converted or substantially modified by human activities over the last 10,000 years and forests covered about 50% of the earth's land area 8000 years ago as opposed to 30% today (Lambin et al., 2003).

According to Lepers, cropland increased from 300-400 million ha in 1700 to about 1599-1800 million hectares in the 1990s. Also, there was a significant decrease in steppes, savannas, and grasslands from 3200 million ha in 1700 to 1800-2700 million ha in the 1990s (Lambin et al., 2003). FAO report 2022 indicates that artificial surfaces (urban and paved highways) doubled from 30 million ha in 1992 to 60 million ha in 2019, tree-covered area decreased from 4.3billion ha in 1992 to 4.2 billion ha in 2019 (FAO, 2022). A study by Suleiman H. M et al (2013) in El Gedaref state in South Sudan, shows the decrease of natural vegetation from 65.28% in 1979 to 9.69% in 2006 (Sulieman & Elagib, 2012). Changes in LULCC encompass the greatest environmental concerns of humanity today (Foley et al., 2005).

In the kilindi district, studies show that between 1980 and 1990 there was already high pressure on the land caused by the massive expansion of cultivation which already had effects on pastoralists (Mwihomeke et al., 1998). According to Mwihomeke et al., (1998), pastoralists were fairly evenly distributed in the area in the 1960s, while in the 1990s they started to concentrate on the dwindling amount of land still unused by agriculture. In the case of Kilindi and Kiteto districts climate change has contributed to the dwindling of pastures whereas, according to Mung'ong'o, (2022) in Kiteto district there was a decreasing trend of grazing lands for all livestock categories, whereby cattle pasture area decreased by -1018.7 hectares, and goat pastures decreased by -60.86 hectares. In Kilindi, cattle pasture decreased -333.89 hectares however goat's pastures for goats increased positively by 96.7 percent of the observed variance for the study period.

2.4.2 Impacts of Land Use and Land Cover Change on Pastures

Mohammed et al., (2017) carried out a study to analyze the LULC changes and the community perceptions of the impact and causes of land cover change in the lowlands of Bale rangelands, southeast Ethiopia. The results from the study show that cultivation land, bushland, and bare land expanded by 13.8%, 14.3%, 12.6%, and 22.3% respectively between 1986 and 2016, whereas woodland, grassland, and shrubby grassland declined by 33.82, 24.4 and 3.36% respectively.

Another study by Egeru et al., (2014), shows that the existence of pasture-like grasslands that once characterized the Karamoja plains is threatened by rapid encroachment of bushland and crop farming. The study indicates that the expansion of agricultural land and bare land occurred at the expense of grazing land over many areas (Sulieman & Elagib, 2012). One of the notable impacts of LULCC on pastoral communities is the loss of pasturelands resulting from the introduction or expansion of various activities such as crop farming, ranching, game parks, and urban expansion (Fratkin, 2001).

Another major aspect of pastures viability is their accessibility by pastoralists and their livestock as access to rangeland resources has become highly restricted thus putting the pastoral production system under increasing threat (Mekuyie et al., 2018).

According to Oxfam International, the key factor that enables many pastoralists to access the seasonal varying and distant pastures has been animal mobility (Kirkbride, 2008). The increase in population and expansion of other land use activities has affected animal mobility, making pastoralists vulnerable to droughts and other shocks (Jenet et al., 2016). Moreover, Changes in land use and land cover have contributed significantly to the disappearance of dry-season wells and associated grazing lands in southern Ethiopia (Catley et al., 2013). On the other hand, LULCC has led to environmental and local livelihood impacts such as rangeland degradation, bush encroachment, soil degradation, livestock loss, biodiversity loss, and poverty increase (Mussa et al., 2017). FAO also maintains that the adaptability and mobility of pastoralism have been undermined by climate change and pressure to increase agricultural production to feed a rapidly growing population (FAO, 2018). Back in the early 2000s in the Handeni district which included the nowadays Kilindi district pastures accessibility had started to face the constraints of a growing cultivation and farmers inversion of areas formally used by pastoralists the situation that led to increased farmer-herder conflicts. In response to this and other land-related conflicts, the village land use plan was proposed and implemented in some villages in Handeni district including the villages that are now in Kilindi district like Kibirashi village (Winnegge, 2005). The project named Handeni Integrated Agroforestry Project (HIAP), was conducted by the district government in collaboration with the GTZ.

Pastures have historically faced challenges related to climate such as scant rainfall and climatic hazards. Nonetheless, pastoralists in the eastern zone of Tanzania have traditionally supplemented pasture shortage during the dry season by supplying pods from trees such as Acacia Nilotica, Dichrostachys cinerea, and Acacia tortilis (Kavana et al., 2014). This study further established that overgrazing reduces the ability of pastures to produce and can lead to changes in botanical composition which in turn reduces the palatable and productive species and replaces them with unpalatable and less productive grass species.

Challenges to pasture viability are also explained as the result of the decrease in the quality of pastures. according to Kavana et al., (2014), the quality of forage at a particular period is assessed by the level of milk production and libido of the bulls. This is because when animals graze on good quality forage it increases milk production and libido of bulls. The quality of pastures is also indicated by the plant and grass species that constitute a certain pasture. In the eastern zone of Tanzania, the most valued grass species include Penicum species, Bothriochloa species, Brachiaria Deflexa, and Hyparrhenia species (Kavana et al., 2014).

2.4.3 The State of Future Land Use and Land Cover Changes

To sustainably and efficiently secure future biodiversity an understanding of the likely effects and factors that will cause that change is required. Titeux et al., (2016) suggest that effective management of biodiversity requires a forward-looking approach based on scenarios that explore biodiversity changes under future environmental conditions.

However, for a very long and despite being affected by multiple threats, most studies addressing the impacts of future environmental changes on biodiversity focus largely on a single threat: ‘climate change’ (Titeux et al., 2016). Nevertheless, direct destruction and degradation of habitats through land use and land cover changes are the most significant and immediate threats to biodiversity (Titeux et al., 2016).

By applying cellular automata (CA) and Markov modelling techniques, Moradi et al., (2020) projected that forestlands and grasslands will decrease by 3.79% and 7.31% in 2033 respectively in the Izeh-Pyon plain Khuzestan province, Iran. Detecting and predicting LULCC in natural resource management and environmental monitoring provides communities and decision-makers with useful information (Moradi et al., 2020).

2.5 Research Gap

The literature review revealed a bigger picture of land use and land cover change on pastoral lands and its subsequent impacts on the communities that depend on such activity for living. Studies such as (Assede et al., 2023; Hesse & MacGregor, 2006), indicated to be a significant expansion of cultivation at the expense of grazing lands and forestry. In Kilindi district for instance, in the late 1990s, (Mwihomeke et al., 1998) exposed that cultivation was already expanding into areas formally used as pastures therefore leading to conflicts between pastoralists and crop farmers. Mwihomeke's study discussed the Handeni Integrated Agroforestry Project (HIAP) conducted in the Handeni district which included the Kilindi district then between the 1990s and early 2000s aimed to reduce the degradation of natural resources and increase agricultural productivity in Handeni district (Klingebiel, 2000). That study foresaw the dire situation posed by competition over land resources which led to conflicts between farmers and pastoralists, and tensions with newcomers. The study also identified population growth driving force for resource competition (Klingebiel, 2000). In response to those challenges, HIAP adopted a project of land use planning where villagers drew maps demarcating different land uses in their villages in a participatory manner. Via this project, several villages including Kibirashi produced village land use plans that highlighted areas for cultivation, grazing, settlement, and forest reserves.

Based on the findings by (Klingebiel, 2000) and (Mwihomeke et al., 1998), HIAP did not perform land use/cover detection to assess the extent of cultivation into pasture lands nor did it try to conduct prediction for future land use and land cover in the Handeni district which then included Kilindi. Also, until now, there has been no study conducted in Kilindi district aimed at assessing the impacts of changes in LULC on pasture viability and pastoralism. This study therefore aimed to fill this gap to assess the land use and land cover change in the wards of Kibirashi and Saunyi by performing periodic land change detection and conclude on the impacts of those changes on pasture viability.

2.6 Conceptual Framework

The notion of a conceptual framework has been defined by different people offering different perspectives. The most recent definition of the concept is provided by Ravitch & Riggan, (2016), they define conceptual framework as an argument about why the topic one wishes to study matters, and why the means proposed to study it are appropriate and rigorous. Another relevant definition is offered by Miles, (2014), which states that a conceptual framework "explains either graphically or in narrative form, the main things to be studied, the key factors, concepts, or variables and the presumed relationships among them". These two definitions though may differ but they together provide a significant understanding of the concept. The conceptual framework is a worthwhile blueprint for the study to be undertaken. Just as Huberman's definition points out that conceptual framework can be presented in graphic or narrative form, this study will apply graphical representation following the Stufflebeam CIPP evaluation model (Stufflebeam, 2000). The System theory presented in the theoretical literature review section identifies the land as a system with many interrelated and interdependent components. This implies that public participation in the process of forming sustainable land policies, land use plans, and laws is critical for the sustainable utilization of land resources. Participation planning theory is also critical for the sustainable utilization of land resources and for sustainable land conflict management among competing groups including farmers and pastoralists.

The conceptual framework in Figure 2.1, presents the graphical analysis of the LULC change process and its impacts on pasture viability. The context is (1), is expressed in this study as drivers of LULCC. The empirical literature review in this study exposed some drivers of LULCC such as expansion of cultivation, climate change, population increase, and overgrazing.

The Input (2), is described by the Land governance which includes the country's land policies and laws, local and traditional practices that people use to govern the utilization of land resources particularly pastures, and land use and management plans. The literature provided information that substantiates some changes in land use and land cover are empowered by the country's laws and policies which to a certain degree are unfriendly to pastoralism's way of living.

The process (3), is described as the impacts of land use and land cover on the viability of pastures. The viability of pastures as discussed in the empirical literature review of this study includes the availability of enough pastures, accessibility and reachability of pastures ordinarily by livestock mobility and seasonal utilization of unevenly distributed pastures. another aspect of pasture viability is the quality of pastures which is described by the composition of pastures, milk production, value of livestock and the libido of bulls.

The output element (4), is described in this study as the viable pastures. This aspect is described as the end result when factors such as LULCC, and land governance are improved in a way favourable to pastures and pastoralism. Vible pastures are described as pastures that are available, accessible and of good quality.

This conceptual framework also details the interrelationship that exists between several factors in the circle of LULC change and its impacts on pasture viability as described in the System theory. The attainment of viable pastures, therefore, requires a participatory engagement and decision-making of different stakeholders and land users including pastoralists as indicated in the participatory planning theory.

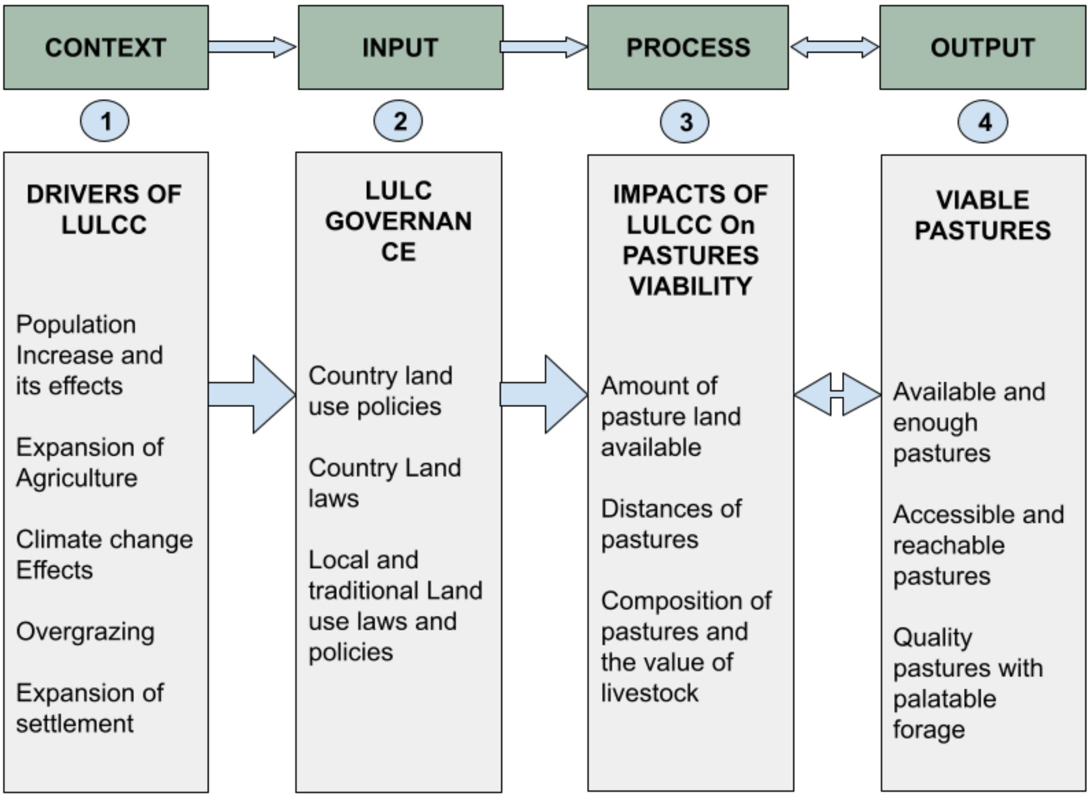

Figure 2.1: LULC Change Process and its Impacts on Pasture Viability
Source: Modified from Stufflebeam's Evaluation Model, (2000)

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This section includes a description of the study area, instruments used, data collection methods and tools, data analysis and presentation techniques. It emphasizes the techniques that were used to carry out the research study.

3.2 Research Design and Approach

This study used a case study design mixed method research design. According to Yin, (2009) the case study research design is more appropriate if the study requires an extensive and in-depth description of some social phenomena. The design is mostly guided by the 'how' or 'why' questions with the desire to understand complex social phenomena. This study questions sought answers on how the changes over LULC have occurred in 20 years period and how these changes impacted pasture viability in pastoral communities in Kilindi district. Further, the study used the mixed-method research approach. The mixed method approach dates back a long time but its popularity grew much in its recent past around the late 1980s and early 1990s based on work from individuals in diverse fields such as evaluation, education, management, sociology, and health sciences.

According to Creswell & Creswell, (2017), mixed methods research is an approach to inquiry involving collecting both quantitative and qualitative data, integrating those two forms of data, and using distinct designs that may involve assumptions and theoretical frameworks. This study had both quantitative and qualitative data. The study used quantitative data including remote sensing imageries that enabled this study to draw statistical conclusions on LULCC. Qualitative data included data collected from community groups such as women, youth, herders, and traditional leaders using in-depth interviews. The mixed research method was appropriate to this study due to the presence of both qualitative and quantitative data. Therefore, a method that would synergize the strength of the two data types was needed and mixed method design as (SAGE, 2006) calls it was meticulous in doing this. Mixed research design has been favoured by different researchers due to its ability to tap into the strength of the two approaches and address the challenges around them in a more effective way than using a single method (Creswell & Creswell , 2018).

3.3 Description of the Study Area

This section describes the study area which includes its geographical location, administrative units, Topography, soils, and climate/weather characteristics and presents the justification for its selection.

3.3.1 Geographical Location of the Study Area

This study was conducted in the Kilindi district, Tanzania, specifically in the wards of Kibirashi and Saunyi. The two wards have the majority of livestock and pastoralists in the district. Geographically, the study area is located in the northeastern part of Tanzania in the Tanga region. It lies between 5° 33′ 54.72″ S, and 37° 33′ 12.6″ E south of the equator. The two wards border the Kiteto district in the Manyara region in the west and Simanjiro district in Manyara as well in the north, and in the east, it borders the Kisangasa ward in the Kilindi district while in the south the study area shares borders with Mvungwe ward. The study area covers an area of 1,323.87 square kilometres. The area serves as home to the majority of pastoralists in Kilindi district.

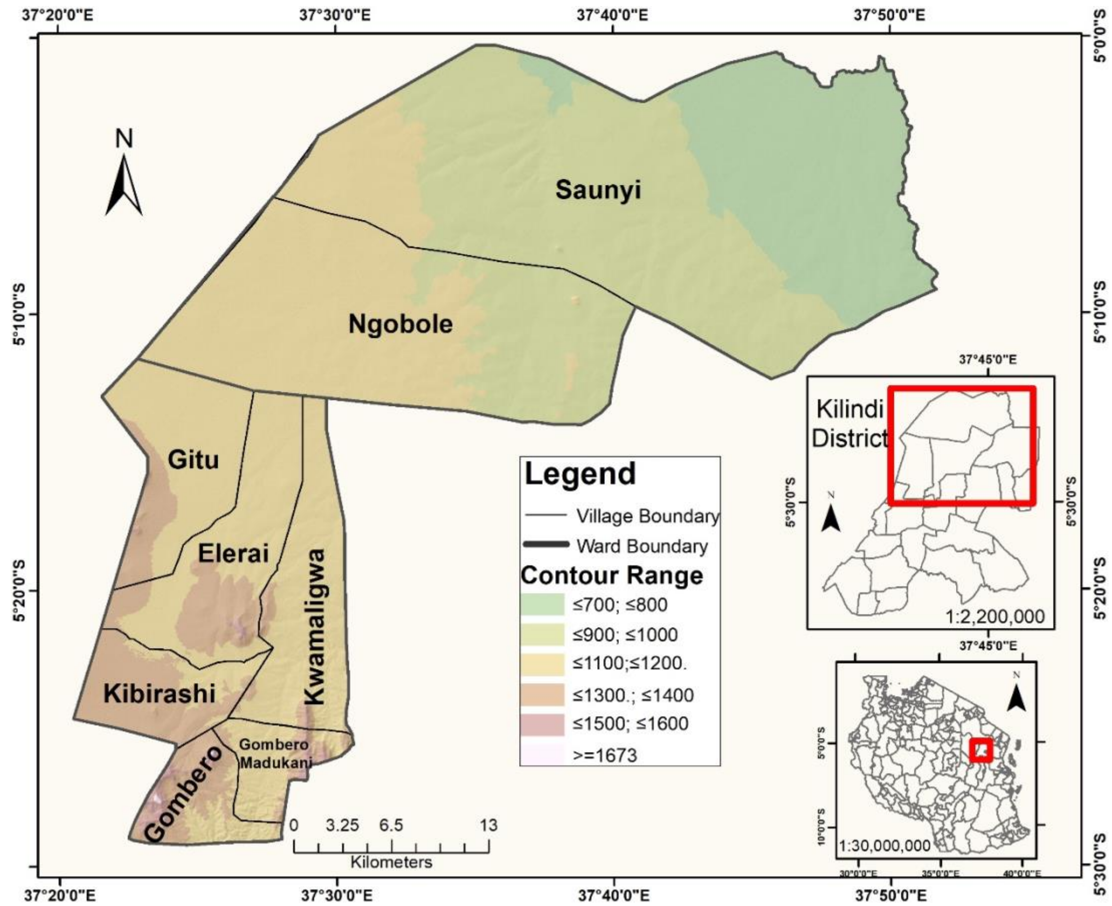

Figure 3.1: Study Area Map

Source: Modified from Tanzania Administrative Map, (2012)

3.3.2 Administrative Units

Kilindi district is made up of a total of 21 wards and 101 villages. The district's total population based on 2022 census is 398,391 (URT, 2022). Kibirashi and Saunyi wards in particular comprise a total of 8 villages with a total population of 38,796 (URT, 2022). Six villages; four from Kibirashi ward and two from Saunyi wards were selected to collect data that were used to make up the research findings, conclusions and recommendations. The six villages included Elerai, Kibirashi, Gitu, and Kwamaligwa from the Kibirashi ward, and Saunyi and Ngobole villages from Saunyi ward.

3.3.3 Topography, Climate/Weather, and Soil Characteristics

Kilindi district is located at an altitude ranging from 100m and 1600m above sea level. The highest altitude is characterized by the North Nguu mountains. While the lowest altitudes are characterized in the northeastern part of the districts, areas that are traditionally occupied by Maasai pastoralists (Mwihomeke et al., 1998). According to HIAP project information (2000), the study area's climate is defined by small to mid-range rains ranging from 600mm to 1000mm.

3.3.4 Economic Activities of the Study Area

The economic activities of the communities in the study area depend largely on the traditions of the various groups and on how and how far the land can be used (Mwihomeke et al., 1998). According to the Handeni Integrated Agroforestry Project (HIAP) which conducted an extensive project in the study area between the 1990s and 2000s, the major economic activities carried out by different groups in the Kilindi district are sedentary cultivation, pastoralism and small mining activities. As stated earlier, economic activities are majorly conducted on a traditional basis, whereas pastoral activities are majorly performed by the Maasai semi-nomads, and cultivation is conducted mostly by the Wanguu and Wazigua communities. In the Kibirashi ward majority of people from the Nguu tribe are mostly crop farmers with a small number of them engaging in agro-pastoral activities, while the minority Maasai groups are mostly semi-nomads and agro-pastoralists. In Saunyi the majority of people are pastoralists, however some people are engaging in cultivation for subsistence.

3.3.5 Justification for the Selection of the Study Area

The study area was specifically chosen for its relevance to the topic. The first reason is the density of pastoralism in the two wards. Kibirashi and Saunyi are the district's first and second most populous wards in terms of cattle, goats, and sheep, respectively. In addition, the two wards have seen massive immigration of other land users mostly crop farmers, which is putting additional pressure and changing the landscape as well as land conflicts that happened in early 2022 between pastoralists and crop farmers in Kibirashi and Elerai villages. Also, Kilindi district is a target of the ongoing process of moving pastoralists from Ngorongoro.

3.3.6 Targeted Population

According to Tuckman & Harper, (2012), target population (target group) is the group about which the researcher wants to gain information and draw conclusions. While the impacts of LULCC are relevant to all villages in the study area, this study focused on the pastoralists and agro-pastoralists of Kibirashi and Saunyi wards, as they are the groups directly connected to pastoral land use where the impacts of land use change are most felt.

3.4 Sampling Design

Sampling is defined as an act, process, or technique of selecting a suitable sample, or a representative population for the purpose of determining parameters or characteristics (Mugo Fridah, 2002). This section describes the sampling procedures, sample frame, and sampling techniques that were followed to effectively carry on the study. This section includes a description of the sample frame, sample size, and sampling techniques.

3.4.1Sample Frame

According to Shearer & Webster, (1985) and Mugo Fridah, (2002), a sample is a finite part of a statistical population whose properties are studied to gain information about the whole. Taherdoost, (2016), elaborated a sampling frame as a list of all cases from which the sample will be drawn. He further went on to say that the sampling frame must be representative of the population. As identified in the target population of the study area are the pastoralists and agropastoral groups in the study area with enough experience in land use/cover of the study area and a good understanding of pastures. The sample frame used in this study is elders who have lived in the area for over 20 years, youth, herders and traditional leaders. To better drive conclusions on the first objective from the community perspective, information from people who lived in the area for 20 years as also informed in the period of the selected satellite imageries between 2003 and 2023 was needed. Objective two required an assessment of the impacts of LULCC on pasture viability and therefore required diverse information from different groups of the community such as elders for experience, herders and youth for firsthand and contemporary information and traditional leaders were also required for issues regarding community governance and informed decisions regarding LULCC. This study also used satellite imageries from 2003, 2014, and 2023 taken between January and May, a wet season period for clear classification of the land use/cover of the study area. This is because being a semi-arid region, trees shade off their leaves and grass dries up during the dry season from July – November which makes it difficult to classify land use/cover as the whole land cover will have nearly similar characteristics. The satellite imageries were analyzed to conclude Objective Two and Objective Three.

3.4.2 Sample Size

This study gathered information from a sample population of 62 people for FGD and KIIs interviews. The sample population was selected from a purposive sampling of different groups from the community with a diverse understanding of pastures in the study area. For FGDs, the sample involved 16 youth, 16 elders, and 12 herders totaling 44 people. While the sample for Key Informant Interviews consisted of two elders (male and female), from each of the selected villages and 1 traditional leader from each of the selected 6 study villages totaling 18 individuals.

The two wards comprised 8 villages, but the study was conducted in 6 villages. The selected villages were Gitu, Kibirashi, Elerai, and Kwamaligwa in the Kibirashi ward and Ngobore and Saunyi villages in the Saunyi ward. Those villages were selected due to the number of pastoralists in the village. The selection of the villages was made in consultation with the ward government. According to the government of the respective wards in this study, the selected villages are home to the majority of pastoralists and livestock in their wards. For satellite images, the study used satellite imagery from 2003, 2014, and 2023. These images were chosen to measure change over 2 time periods not less than 5-year intervals. The selection of the satellite images used in this study was also enforced by the cloud cover, whereby a criterion of a maximum of 10% cloud cover was set to get a good and interpretable image.

3.4.3 Sampling Techniques

This study used non-probability purposive sampling techniques to obtain the sample population. According to Taherdoost, (2016), purposive non-probability sampling is mostly used when particular persons or events are selected deliberately to provide important information that cannot be obtained from other choices. Therefore, the sample population for this study was chosen based on a few pre-determined factors vital to the attainment of research objectives such as their experience and understanding of LULC of the study area for at least 10 years, and understanding of pastures and pastoralism in general which are vital information to assess the impact of LULCC on pastures viability.

This study, therefore, aimed at elders who have lived in the area for over 20 years with enough understanding of pastures to acquire data to examine the dynamics of LULCC and it impacts on pasture viability in their areas. The study also aimed at youth and herders to gather contemporary information. Further, the study also aimed at traditional leaders who have provided detailed local governance information regarding the utilization of pasture resources and impacts of LULCC from their perspective. The sample population was selected by consulting the elders in the respective villages who have helped to identify people with a deeper understanding of the state of pastures in their areas. Gender balance was considered in the selection of the samples whereby each group except the herders and traditional leader’s groups was comprised of men and women in equal representation. The sample from the group of traditional leaders was selected according to who was in the function at the time the study was conducted. For the case of the herder group, the sample group was comprised of young men between 15 – 25 years. It is the tradition of the majority of pastoral communities, that herders’ activities are mostly the men’s responsibility (Yanda & Mung’ong’o, 2018), so was the case in Kibirashi and Saunyi wards. The selection of the herders was done with the help of elders and village leaders.

3.5 Data Types and Sources

This study utilized data from both primary and secondary sources. Primary data was collected directly from the fieldwork through in-depth interviews and observation. Secondary data sources were also utilized to the greater benefit of the study. Secondary data was collected from existing documents in the literature such as the Kibirashi Village Land Use Plan and satellite images that were collected from online repositories provided by the USGS and GloVis.

3.6 Methods of Data Collection

According to Tuckman & Harper, (2012) data collection means a systematic process of gathering specific information with the goal of providing or refuting some facts. In that perspective, the nature of the data and the intended objectives determine the data collection methods. The following methods were applied to collect data for this study.

3.6.1 Documents Review

Document review is defined as the collection of data from documents, records, or other archival sources (Harrell & Bradley, 2009). The study perused documents and other archival data relevant to the study topic available at both online archives like the Handeni Integrated Agroforestry Project (HIAP) which conducted land use planning in some villages in the study area, and data in the Ministries of Land, and ministry of livestock and fisheries websites. Other data included Tanzania level three administrative maps 2012 collected from the National Bureau of Statistics (NBS) website. The information from these archives helped the study in making references and understanding the historical dynamics of LULCC in Kilindi and Tanzania as far as pasture viability is concerned.

3.6.2 In-Depth Interviews

This study employed two methods for data collection: in-depth interviews, including Key Informant Interviews, and Focus Group Discussions. These data were used to assess the impacts of land use/cover change on pasture viability in the Kibirashi and Saunyi wards. Data from key informants were collected from traditional leaders and elders, while data from focus group discussions were collected from various groups such as Elders, Herders, and Youth. Key informant interviews were collected from a total of 18 people described as two elders (male and female) and one traditional leader from each of the 6 selected villages. Focus Group Discussions were conducted on three groups such as elders, youth, and herders. The FGDs were conducted in six separate sessions due to the geographical distance between the wards. FGD data were collected from a total of 44 people. where the elders' group consisted of 16 people, 8 people per session, 16 participants from youth groups 8 per session, and 12 participants from herders' group 6 members per each FGD session.

The selection of participants for Key Informant Interviews (KIIs) and Focus Group Discussions (FGDs) was conducted using purposive sampling methods. Assistance from local community leaders and key informants was sought to identify individuals with deep knowledge of the subject matter within the community. Each participant was carefully chosen based on their expertise and understanding of the study topic. In collaboration with village leaders and elders, all interviewees for KIIs and FGDs were identified. The interviews and discussions were facilitated by the researcher, with the support of an assistant researcher who was responsible for taking detailed notes.

The insights gathered from the focus group discussions (FGDs) and key informant interviews (KIIs) provided valuable information based on experience and knowledge. The elders recalled historical land use practices and highlighted significant changes over the decades, attributing them to the expansion of settlements and agricultural activities. Furthermore, the youth demonstrated a blend of traditional knowledge and modern understanding of pasture issues, while the herders offered real-time observations on pasture conditions and reported challenges related to land use/cover change (LULCC) in relation to animal grazing.

3.6.3 Observation

Observation was another primary source of data for this study. Part of the observation included the identification of ground truthing points using the hand-held GPS at a 5m maximum precision. Those data were used as inferences during land classification on satellite imageries. These data were observed from different distinct land covers such as water, farms, settlements, bushland, forests, grassland, and woodland. Another observation method photography which included making photos of useful data like some plant species used by pastoralists as pastures that were described as in danger species due to LULCC.

3.6.4 Remote Sensing

Remote sensing was another secondary data source used in this study to collect the data crucial for assessing objectives 1 and 3. Spatial data included Landsat images, maps, and coordinates of the study area. Remote sensing data included satellite images such as Landsat images collected from USGs and GLOVIS online archives. The satellite images downloaded were from the years 2003, 2014, and 2023 with consideration of seasonal and phenological consideration (Kashaigili et al., 2006). The images downloaded had cloud cover of less than 10% taken between January and April each year. This is because, January to May months are the wet season months in the region which is a time when one can make proper and clear distinctions between different land covers, while the weather in the rest of the months is dry and trees shade off the leaves, and grass and crops dry up making the land cover almost similar and therefore pose challenges to identify different land use/covers over the land.

Table 3. 1: Characteristics of Collected Satellite Images

Satellite	Sensor	Path/Row	Acquisition Date	Season	Cloud cover
Landsat 7	ETM+	167/064	2003/02/06	Wet	7.0%
Landsat 8	OLI	167/064	2014/01/11	Wet	2.93%
Landsat 8/9	OLI/TIR	167/064	2023/02/05	Wet	3.93%

Source: USGS Earth Explorer, (2023)

3.7 Data Processing and Analysis

The data collected for this study were taken through a data analysis process which involved inspecting, cleaning, transforming, and modelling data to find useful information, draw conclusions, and support decision-making (Punch, 2016). The data in this study were analysed with tools such as QGIS, ArcGIS, IDRISI, and Atlas.ti. For spatial analysis, the first three were used, whereas for qualitative analysis, Atlas.ti was used. The data analysis was conducted regarding the data collected and objective requirements as further described in the following paragraphs.

3.7.1 Analysis and Processing of Land Use/Cover Change Data

To analyse spatial and temporal land use and land cover change in Kibirashi and Saunyi wards from 2003-2023 two analytical techniques were applied which were change detection and cross-tabulation which also included initial stages of pre-processing the data and collection of training samples.

3.7.1.1 Exploration of Satellite Images and Pre-processing

Upon downloading the images from the USGS and GLOVIS, they were subsequently imported into the IDRISI Selva software utilizing the import window, thereby facilitating their transformation into a format compatible with IDRISI/TerrSet. Subsequently, the window module in the IDRISI/TerrSet software was employed to clip the satellite images to align with the study area, streamlining the analysis process by eliminating extraneous image components. Furthermore, disparate data formats, such as study area shapefiles, underwent conversion into vector formats harmonious with IDRISI/TerrSet.

Initially, the digital counts of the mages were loaded into IDRISI/TerrSet. However, to improve image visibility and reflectance, they underwent atmospheric correction. This involved converting satellite-generated digital counts (DCs) to ground reflectance, specifically absolute surface reflectance (Chavez & others, 1996). The ATMOC module in IDRISI was used to conduct atmospheric corrections using Chavez's COST method, as outlined by Warner et al. (2021). Chavez's cost method requires the correction of each band individually using the data from the images and the image metadata. The identifier tool was used to identify areas of high haze values in a composite image for each band. Other data for atmospheric correction using Chavez's cost method were collected from the image metadata, including sun elevation, date and hours of acquisition in a specific year, Radiance Multiband Band to calculate the gains, and Radiance Add Band to calculate the Bias (Warner, Campagna, & Sangermano, 2020). The sun elevation angle during acquisition is used by the module to calculate the sun zenith angle (Chavez & others, 1996). Chavez's cost method uses a specific formula to convert digital counts into ground reflectance.

$$REF = \frac{(PI \, * (Lsat - Lhaze))}{(TAUv * (Eo * Cos\,(TZ) * TAUz + Edown))}$$

Where;

REF is Spectral reflectance of the surface, *Lhaze* is Upwelling atmospheric spectral radiance scattered in the direction of and at the sensor entrance pupil and within the sensor's field of view, *TAUv* is atmospheric transmittance along the path from the ground surface to the sensor *Eo* is Solar spectral irradiance on a surface perpendicular to the sun's rays outside the atmosphere. Eo contains the Earth-sun distance term (D*D) embedded and is in astronomical units (AUs are a function of time of year and range from about 0.983 to 1.017), *TZ* is the Angle of incidence of the direct solar flux onto the Earth's surface (solar zenith angle, Thetaz), *TAUz* Atmospheric transmittance along the path from the sun to the ground surface *Edown* Downwelling spectral irradiance at the surface due to scattered solar flux in the atmosphere

To enable easy identification and analysis of different land use/cover categories on Landsat images, layer stacking of different bands in RGB colour format was performed to create a false colour composite image. For example, a combination of bands (4, 3, 2) on Landsat 8 OLI and (3,2,1) on Landsat7 provided a natural colour expression of land use/cover of the area which was useful to identify cultivation and bare lands a lot easily. Other band combinations such as (5 6 4) on Landsat 8 OLI and (4 5 3) on Landsat 7 were used to express a false color for easier identification of water bodies from the land. The combination of bands (5 4 3) on Landsat 8 OLI and (4 3 2) on Landsat 7 were used to identify vegetation cover whereas areas with thick red color indicated the strong vegetation cover which were categorized as forest. Further, Linear contrast stretching of 1.0 per cent was applied from the lowest to the highest values to enhance image interpretation. All the satellite images and spatial data used in this study were registered under the Universal Transverse Mercator (UTM) coordinate system in zone 37 South, Datum Arc 1960.

3.7.1.2 Identification and Characterization of Training Samples

With the help of ground truthing points collected by the researcher from the field and the researcher's familiarity with study area training sites were collected by inspecting the satellite composite images and assigning each known land cover with an integer identifier. This was done by digitizing several polygons of each land cover with homogeneous pixel characteristics (Warner et al., 2021). Digitizing several helped in ensuring that each training site attained a number of pixels not less than the ten times total number of bands used. In this study, a total of 6 bands were used which set a demand for a number of pixels not less than 60 for each land cover for each signature (Warner et al., 2021). A high-resolution satellite images such as Google Earth were used to complement the identification of areas to collect training samples. The study identified training samples of 8 initial land covers such as water, woodland, bushland, bare land farms, settlement, planted farms, grassland, and forest.

3.7.1.3 Assessment of Signature Files

The training samples were used to create signature files for different land covers, including water, woodland, bushland, bare land farms, settlements, planted farms, grassland, and forest. The spectral characteristics of each signature file were analyzed using a histogram to identify similar land covers. It was found that settlements, bare land farms, and active farms had overlapping spectral characteristics. As a result, these land covers were combined into a single signature file, resulting in a final set of six land cover signature files: water, cultivation, forest, woodland, bushland, and grassland. These signature files were grouped into a collection of a signature group and used for maximum likelihood classification in the IDRISI/TerrSet MAXLIKE classifier.

3.7.1.4 Image Classification

Subsequent to the completion of the image pre-processing procedures, the images underwent a supervised classification process to delineate land use/cover classes. This classification was executed through a maximum likelihood classifier (MAXLIKE) under Tertset/IDRIS software image processing hard classifiers. The tool is regarded by Warner et al., (2021) as a powerful classification technique as it draws on differences between the class means, as well as differences between the covariance matrices. In short, according to Warner et al., (2021), the maximum likelihood classifier is based on Bayes' Theorem of conditional probability whereby the pixel of the image during classification is assigned to the class of highest probability. Using the signature group file developed in earlier stages, the MAXLIKE classifier under the IDRISI/TerrSet hard classifiers was run to produce the major six land use/cover classes such as Water, Cultivation, Forest, Woodland, Bushland, and Grassland. These classes also corroborate with FAO, (2002) and (NCMC, 2017), the classification of Tanzania's land cover. Table 2 shows the description of the six major land classes produced in the MAXLIKE classifier which represents the land cover of the study area for the years 2003, 2014, and 2023 as similar classification techniques and procedures were used to classify both satellite images of 2003, 2014, and 2023.

Table 3.2: Description of Final Land Use/Cover Classification

S/N	Land Use type	Description
1	Water	These are the areas covered with water which include natural ponds, artificial dams and streams
2	Cultivation	This type of land cover comprises all bare land such as land for village nucleated and local scattered settlements, farmland and sandy soils
3	Forest	Medium to high altitude trees. Therefore, it includes the montane and lowland forest
4	Woodland	This is the land covered mostly by trees. It includes closed to open woodland which is famously regarded as savanna woodland. This class is a merger of open woodland, bushed woodland, and Thickets.
5	Bushland	This is the land cover characterized by bushes. It includes open wood and grazing lands characterized by bushes.
6	Grassland	These are the areas dominated by natural herbaceous plants such as grasslands, prairies, steppes and savannahs.

Source: Author, 2024

3.7.1.5 Classification Accuracy Assessment

The final accuracy of image classification was evaluated using the ErrMat tool in IDRISI, which assesses the Kappa Agreement and Accuracy percentage. ErrMAT compares two images: the interpreted land cover map and an image containing the ground truthing result. It generates an error matrix showing the agreement between the land use image from classification and the ground-truthing image. In this study, a total of 300 random sample test points were created using the sample module in IDRISI/TerrSet. The ground truthing of these 300-point locations for each year was carried out by inspecting an enhanced image composite of the particular year.

In accordance with Warner et al. (2021), a minimum of 100 sample points is recommended for accuracy assessment, with a preference for a number closer to 300. The true land cover classes were documented in a text file by noting the digital value of each class in the IDRISI/TerrSet edit module. The point raster of the ground truthing for each year was subjected to ErrMAT analysis against the final land cover classification map. The ErrMAT accuracy assessment yielded the Kappa Index of Agreement (KIA) and the Overall Kappa, as well as column and row marginal totals, errors of omission and commission, an overall error measure, and confidence intervals. The overall Kappa seeks to adjust accuracy for the expected chance agreement. Accuracy can also be quantified by computing the percentage accuracy based on the number of points that matched their respective classes. The maps exhibited strong agreement with the real world, as indicated by the respective overall classification accuracies of 87.7%, 86.4%, and 87.6% for 2003, 2014, and 2023, along with their corresponding Kappa indexes of 0.82, 0.81, and 0.83. The detailed results of the ErrMat assessment are presented in Appendix 2.

3.7.1.6 Change Detection Analysis

Change analysis was conducted between the 2003 and 2023 satellite images using the land change modeller under the IDRISI software. This analysis assisted in assessing the changes in the land use/cover of Kibirashi and Sunyi areas by analyzing the gains and losses of each land cover over the course of 20 years, the net change and contribution to net change from each class and exchange among the land cover classes over time. This analysis was successfully conducted by analyzing graphs and change maps produced by the module.

3.7.1.7 Cross-Tabulation Analysis

Cross-tabulation analysis was conducted to compare land use/cover between different time periods (2003 - 2014, 2014 - 2023, and 2003 - 2023) using the CROSSTAB module in IDRISI software. This analysis involved comparing satellite images from distinct periods to identify differences. The module generated image and table outputs, which were then analyzed to determine differences between the two images. The pixel tabulation table results were used to calculate the changes in land classes between the 2003 and 2014 images in hectares.

Also in this study, cross-tabulation was performed to analyze land cover images from 2014 and 2023, as well as from 2003 and 2023. The computation of each land class in hectares involved the calculation of a single pixel's area, measuring 30m by 30m, which equals 900 square meters. This value was then multiplied by the total number of pixels in each land category and divided by 10,000 to quantify the area coverage of each land use/cover category in hectares, as well as the amount of land lost to other categories. The utilization of crosstabulation data facilitated the calculation of the annual rate of change for the land covers, providing a lucid interpretation of the change. The subsequent formulas were utilized to calculate the annual change (in hectares) and the annual rate change in percentage.

$$Annual\ Change = Later\ Image - Initial\ Image$$

$$Annual\ Change\ Rate = \left(\frac{Later\ Image - Initial\ Image}{Initial\ Image}\right) \times 100$$

3.7.2 Analysis of the Impacts of LULCC on Pasture Viability

In the assessment of the impacts of Land Use and Land Cover Change (LULCC) on pasture viability in the Kibirashi and Saunyi wards, qualitative information was collected from elders, youth, traditional leaders, and herders through in-depth interviews. The interviews were conducted in Swahili, a language widely understood in the study area, and the data was subsequently transcribed into English and uploaded into the Atlas.ti software.

Upon uploading the data into Atlas.ti, codes were generated to represent significant concepts, themes, or patterns that emerged from the qualitative information. The coding process facilitated the identification of similar characteristics and recurring patterns within the responses, and these coded quotes were then grouped accordingly. These groupings were instrumental in identifying overarching themes that explained the collective results regarding the impact of LULCC on pastures.

The themes formed the foundation for drawing meaningful conclusions and informing the broader study, ensuring a systematic examination of the impacts of LULCC on pastures and providing a robust framework for the study's conclusions and insights. This methodological approach not only ensured a systematic examination of the impacts of LULCC on pastures but also provided a robust framework for drawing meaningful conclusions and informing the broader study.

3.8 Predicting Future Land Use/Cover

Projection of land use/cover for the next 20 years was conducted using the CA_Markov tool. This was done by using the 2023 land classified image as the base map and the transition area files and suitability maps created by the Markov module. According to Takada et al., (2010), Markov is a statistical tool used to analyze a pair of land cover images and predict the situation of these land cover types in the future. In the process, Markov analysis produces a transition probability matrix, a transition areas matrix, and a set of conditional probability images (Takada et al., 2010). The conditional probability images depict the probability that each land cover type would be found at each pixel after a specified number of time units if the change rate remains constant. Transitional suitability images of road distance and settlements were grouped through Multi-criteria Evaluation (MCE). Markov technology uses the following formula

$$X_{t+C} = X_t A$$

Where, X_t is a 1-by-n row vector that gives the proportion of each category at the initial time t, where ‘n’ is the number of categories in the land use classification. C, is the number of years between the initial year t and the subsequent year of observation and A is an n-by-n matrix in which each element dij is the conditional probability that a pixel transition to category j by time $t + C$ given that it is category i at time t

3.9 Data Presentation

For better presentation of the findings, this study applied different techniques such as maps, graphs, and tables. Maps, graphs, and tables are mainly used to present the findings of quantitative data mostly ascribed to objective one and objective three. The findings for objective two were done in narrative way presented in themes as the data relied mostly on qualitative information gathered from FGDS and KIIs.

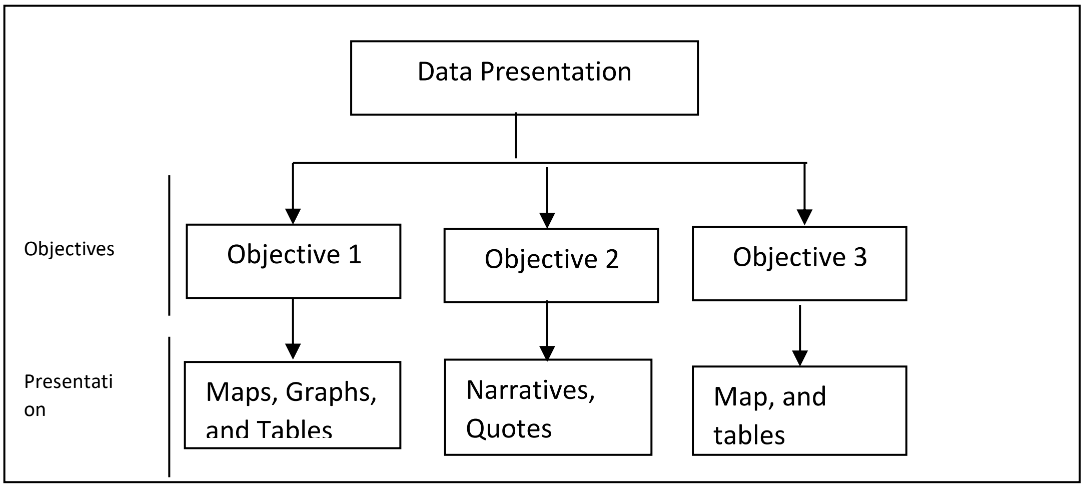

Figure 3.2: Data Presentation Methods

Source: Author, 2024

3.10 Ethical Consideration

Ethical consideration in research is a critical aspect of research as studies sometimes infringe on the rights of individuals with some degree of risk. The risks may range from minor discomfort or embarrassment to much more severe effects on participants' physical and emotional wellbeing (Marczyk et al., 2010). To make sure that this study is conducted openly and formally a researcher sought a data collection permit from the university governance and later followed the procedures to collect permits in the offices of RAS, and DAS and carried introductory letters to ward and village offices. Participants of FGDs and KIIs were identified in codes and positions respectively, Appendices 3-5. The researcher also observed a high degree of respect for people's way of life and adhered to their traditions to make the data collection process a smooth and successful undertaking.

3.11 Validity and Reliability

The tools used to gather information were all tested to ensure their efficiency before being applied directly in the field. Also, the assistant researcher was trained on the tools and research ethics to make sure that there is accuracy and validity of the data collected. For quantitative data such as image classification and land change detection classification accuracy assessments were conducted and its accuracy and kappa index were produced and examined to measure the levels of accuracy and agreement of the data respectively.

Table 3. 3: Research Methodology Summary

S/N	Specific Objective	Data Collected	Data Sources	Analysis Tool	Analysis Conducted
1	To examine spatial and temporal changes in land use and land cover in Saunyi and Kibirashi wards for the past 20 years	-Landsat images for 2003, 2014, and 2023 Google Earth high-resolution images Ground truthing points	-USGS earth explorer -GLOVIS -Google Earth -Hand held GPS -Digital Camera	ArcGIS to create maps land use/cover maps IDRISI/TerrSet for image classification and change detection QGIS for creation of study area map	-LULCC classification -Change Detection Classification accuracy Assessment
2	To assess the impacts of Land Use and Land Cover on pasture viability in Saunyi and Kibirashi wards for the period of 2003 – 2023	-Qualitative data through In-depth Interviews Observation of the situation of pastures	Key informant interviews on Traditional leaders and Elders FGDs on Youth, Elders and Herders	Atlas.ti Microsoft Excel	-Thematic Analysis
3	To predict the future changes in land cover in Saunyi and Kibirashi wards for the next 20 years until 2043.	A classified 2023 image map Transition probability maps Suitability Maps	2023 image classification Markov module outputs	IDRISI/TerrSet	Prediction of future land use/cover of Kibirashi and Saunyi wards in 20 years

Source: Author, (2024)

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

In this pivotal section, the study embarks on an exploration of the culmination of the extensive study. The Results and Findings chapter stands as a testament to the diligence and dedication invested in the study endeavours. Here, the study presents the empirical outcomes, analyses, and interpretations that shed light on the research questions and objectives.

4.2 Spatial and Temporal Changes in LULC in the Study Area

Changes in the land cover happen at a certain place and time. This study assessed the spatial and temporal change in the Kibirashi and Saunyi ward's land use/cover by classifying satellite images taken in three distinct periods: 2003, 2014, and 2023. To put the changes in quantitative perspective the study employed cross-tabulation and change detection of those images.

4.2.1 Land Use/Cover Assessment

The land use/cover in the wards of Kibirashi and Saunyi demonstrated significant change over time. The changes were assessed by classifying the land use/covers of Landsat images from 2003, 2014, and 2023. The maps of the classified images as indicated in Figures 4.1 – 4.3 shows qualitative changing aspects of the land use and land cover in the study area. Further, table 4.1 quantified the size of each land use/cover in hectares and percentage at each given year. The study also examined the spatial trend of change in the land use/cover classes and emphatically on land covered by pastures. The direction of change in each land use/cover in the study area was examined using the graphical and tabular presentation of the land use/cover of the study area. Figure 4.4 shows the direction of change in each land category between 2003 and 2023, while Table 4.5 the direction of change in percentage. Whereas, Land categories in the later year that have increased percentage from the earlier year indicated a positive direction, while those that indicated a decrease from the earlier year have indicated a negative direction

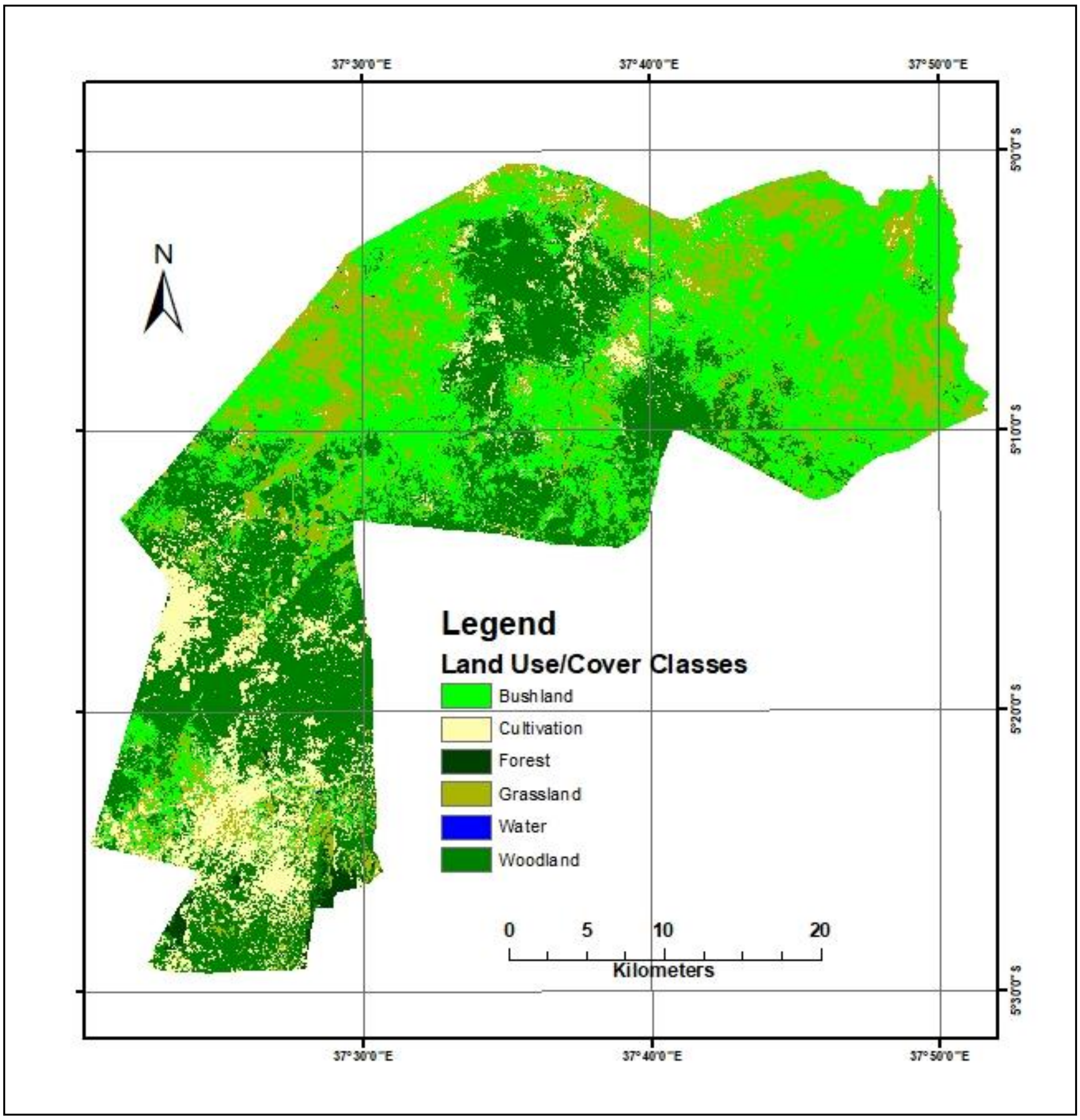

Figure 4.1: Classified Land Use and Land Cover of 2003

Source: Author from Classification of 2003 Landsat Image, 2024

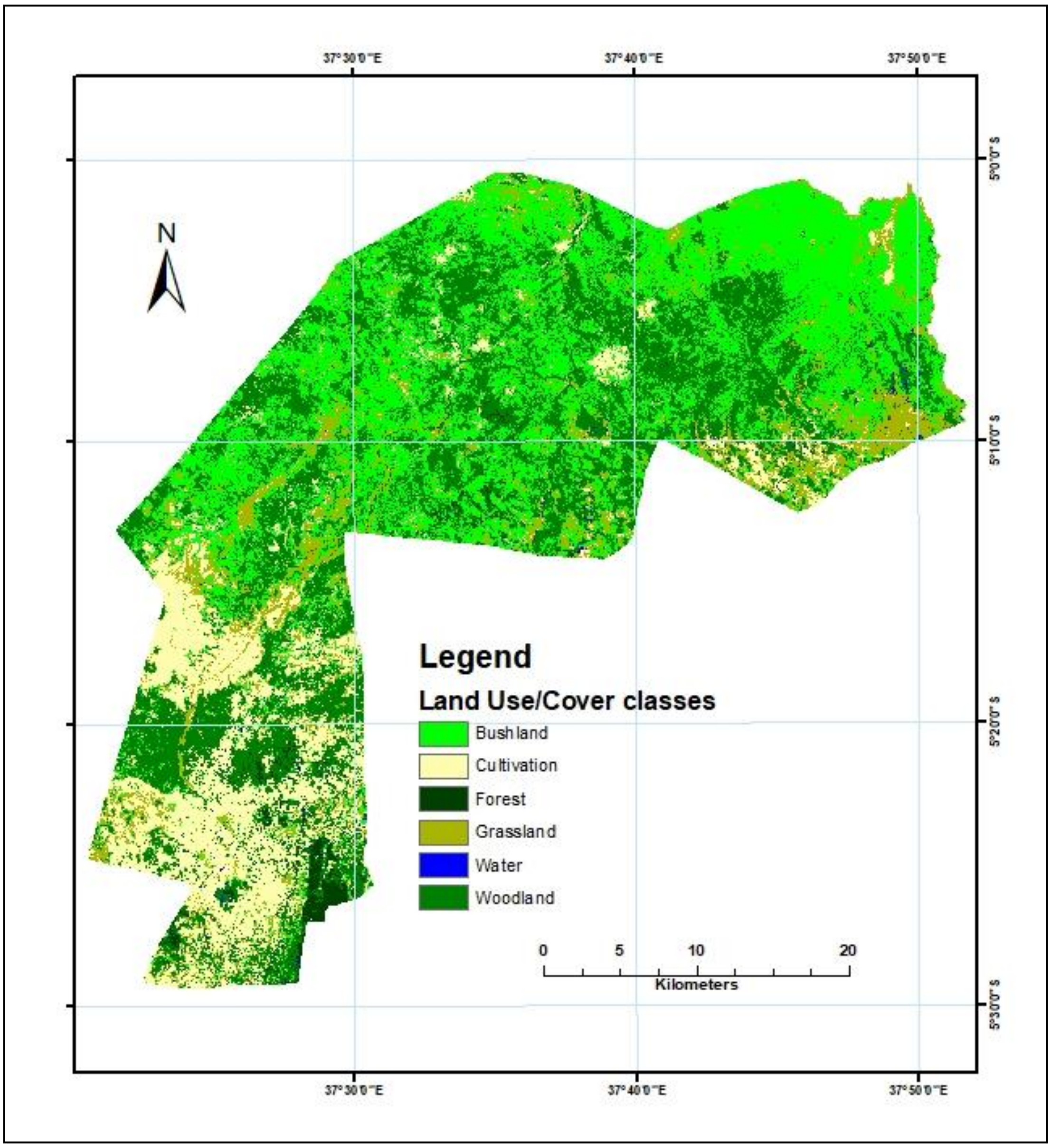

Figure 4. 2: Classified Land Use and Land Cover of 2014

Source: Author from Classification of 2014 Landsat Image, 2024

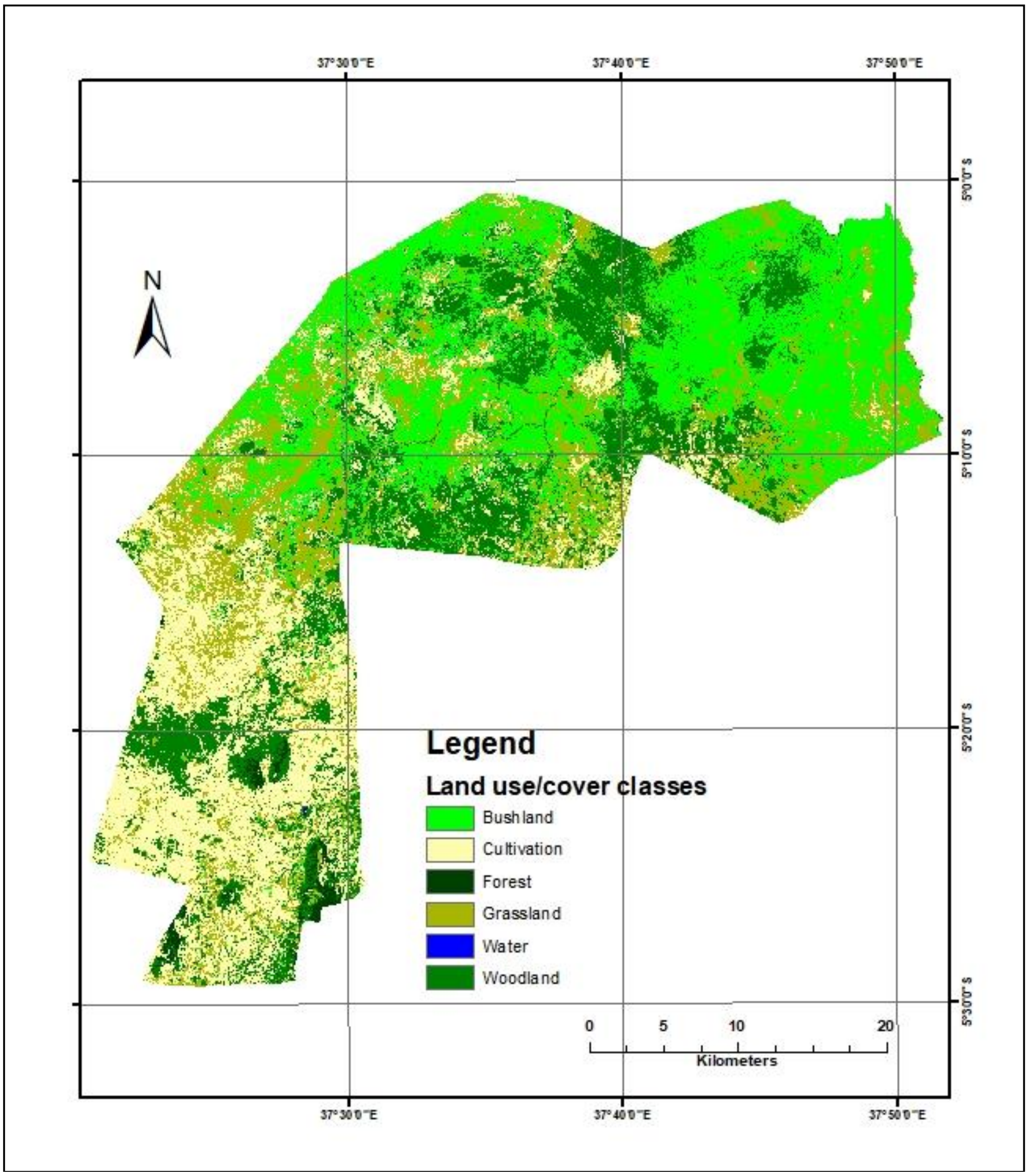

Figure 4. 3: Classified Land Use and Land Cover of 2023
Source: Author from the Classification of 2023 Landsat Image, 2024

A visual analysis of the study area maps of the classified satellite images, shows that bushland cover is the biggest land cover in the study area followed by woodland and cultivation. Bushland characterized largely the northern parts of the study area, while woodland and cultivation have occupied largely the southern and middle parts of the study area. The classified land use and land cover maps of 2003, 2014, and 2023, the study area have demonstrated a lot of changes in different parts of the map. Cultivation land cover indicated a steady increase extending largely into woodland areas. The 2014 land cover showed an increase of woodland in the middle area and northern parts of the study area mainly in Saunyi wards. Looking at the grassland cover, it shows a significant increase in 2023 where grassland emerged in the central part of the study area north of Kibirashi ward along cultivation area.

Quantitative change of the land cover portrays information that complements the qualitative interpretation of the maps. The data shows that bushland continued to be the dominant land cover in the study area where it covered 48,113 ha in 2003, 48,583 ha in 2014 and 41,798 ha in 2023 which is a 36.34%, 36.7%, and 31.37% of land covered by bushland in 2003, 2014, and 2023 respectively. The land covered by woodland was the second largest land cover in the study area in 2003 and 2014 covering 44,328 ha and 46,046 ha respectively, however, it dropped to the third largest land cover in 2023 where it covered only 29,400 ha equals 22.21% of total study area land. Grassland covered 24,743 ha (18.69%) in 2003 but decreased in 2014 to 13,846 ha (10.46%), however, it increased in 2023 to 27,926ha which is 21.09% of land covered by grassland in 2023. Table 4.1 shows the area size of each land class in hectares (ha) and percentage (%) in 2003, 2014, and 2023.

Table 4.1: The Distribution of LULC in 2003, 2014, and 2023 in Hectares and Percentage

Year	2003		2014		2023	
Category	Ha	(%)	Ha	(%)	Ha	(%)
Water	20	0.02	343	0.26	11	0.01
Cultivation	14,342	10.8	21,594	16.31	32,020	24.19
Forest	842	0.64	1,976	1.49	1,233	0.93
Woodland	44,328	33.48	46,046	34.78	29,400	22.21
Bushland	48,113	36.34	48,583	36.7	41,798	31.37
Grassland	24,743	18.69	13,846	10.46	27,926	21.09

Source: Author’s Tabulation from Classified Maps, 2024

4.2.2 Change Detection of LULC in the Study Area

The statistical representation of the changes in land use/cover in the study area is indicated in tables 4.2-4.4. the tables indicate the rate of change in each land use/cover category in hectares and percentages. The rate of change is significant to understanding the magnitude that each land use/cover has changed and facilitated the identification of land covers that are in danger of decline over the years.

Table 4. 2: LULC Annual Change and Annual Rate of Change 2003-2014

	2003 area (ha)	2014 size (ha)	Annual Change (ha)	Annual Change Rate (%)
Water	20	343	323	1,615
Cultivation	14,342	21,594	7,252	50.56
Forest	842	1,976	1,134	134.69
Woodland	44,328	46,046	1,718	3.87
Bushland	48,113	48,583	470	0.98
Grassland	24,743	13,846	-10,897	-44.04

Source: Author's Tabulation from Classified Maps, 2024

Table 4. 3: LULC Annual Change and Annual Rate of Change 2014-2023

	2014 area (ha)	2023 size (ha)	Annual Change (ha)	Annual Change Rate (%)
Water	343	11	-332	-96.79
Cultivation	21,594	32,020	10,426	48.28
Forest	1,976	1,233	-743	-37.6
Woodland	46,046	29,400	-16,646	-36.15
Bushland	48,583	41,798	-6,785	-13.97
Grassland	13,846	27,926	14,080	101.69

Source: Author's Tabulation from Classified Maps, 2024

Table 4. 4: LULC Annual Change and Annual Rate of Change 2003-2023

	2003 area (ha)	2023 area (ha)	Annual Change (ha)	Annual Change Rate (%)
WA	20	11	-9	-0.01
CU	14,342	32,020	17,678	123.26
FO	842	1,233	391	46.44
WO	44,328	29,400	-14,928	-33.68
BU	48,113	41,798	-6,315	-13.13
GR	24,743	27,926	3,183	12.86

Source: Author's Tabulation from Classified Maps, 2024

The result indicates that the area under cultivation increased at a percentage change of 50.46 between 2003 and 2014 Table 4.2. This is indicated by the increase of cultivation by an annual change of 7,252 ha from 14,342 ha of the total study area land in 2003 to 21,594 ha in 2014 Table 4.2. The percentage rate of change in cultivation as indicated in Table 4.3, further increased between 2014 and 2023 at an annual change rate of 48.28% from 21,594 ha (16.31% of the total study area) in 2014 to 32,020 ha (21.18% of the total study area) in 2023.

The area under woodland cover increased a little bit in 2014 at an annual change of 1,718 ha, (3.85% annual rate change) from 44,328 ha in 2003 to 46,046 ha in 2014. however, the woodland cover decreased at an annual change rate of -36.15% between 2014 and 2023 from 46,046 ha in 2014 to 29,400 ha in 2023 which is an expression of -16,646 annual change. In the span of 20 years (2003-2023), woodland and bushlands decreased at an annual change rate of -33.68% and -13.13% respectively as shown in Table 4.4. Between 2003 and 2023 cultivation land cover increased significantly from 14,342 ha (10.8% of total area size) to 32,020 ha (24.19% of total area size) respectively Table 4.4 which marks a 123.06% percentage of change.

The total area covered by forest increased from 842 ha (0.64%) in 2003 to 1,976 ha (1.49%) in 2014 which marks 132.84 annual percentage of change in Table 4.2, however, it shrunk at an annual percentage of -37.6% between 2014 and 2023 whereby the area under forest occupied 1,233 ha (0.93%) in 2023 Table 4.3. This however still higher compared to the total area covered by forest in 2003 at an annual change of 391 between 2003 and 2023 Table 4.4.

The areas under bushland cover had a slight increase at an annual rate change of 0.98 % between 2003 and 2014 from 48,113 ha (36.34% of total the study area) to 48,583 ha (36.70% of the total study area) respectively which is an annual change of 470 ha table 4.2. Between 2014 and 2023 bushland land cover declined to 41,798 ha (31.57% of total land cover) in 2023 a -13.98% percentage decrease table 4.4. Areas under grassland indicated a significant decrease between 2003 and 2014 from 24,743 ha (18.68%) to 13,846 (10.46%) ha respectively table 4.2, however, it later increased Between 2014 and 2023, where the area under grassland cover increased to 27,926 ha table 4.4 to occupying 21.09% of the total study area in 2023.

4.2.3 The Dynamics of Pasture Lands Against Cultivation Land Use/Cover

The areas that are regarded as traditional grazing land such as woodland, bushland and grassland (Yanda & Mung'ong'o, 2018), demonstrated significant dynamic change over the time of 20 years from 2003 to 2023. The changes have been assessed through annual change and annual rate of change in Table 4.2 – 4.4 as well by assessing the loss and gains, net change, and contribution of each of these pasture land classes to cultivation which is the leading land class to net change.

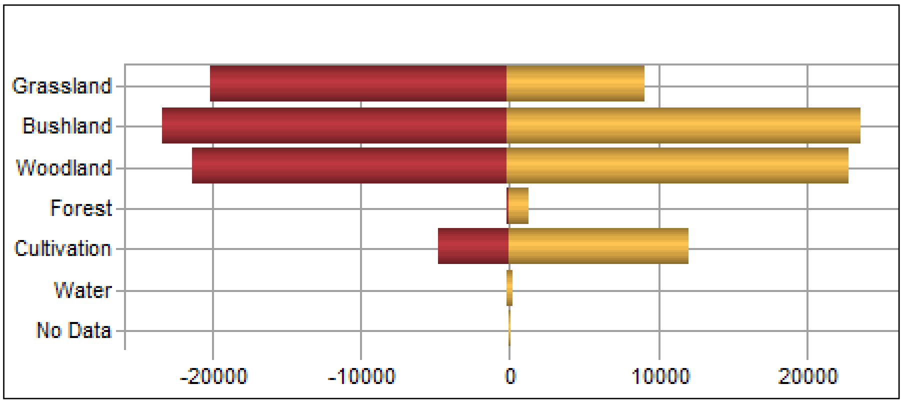

Figure 4. 4: LULC Gains and Losses 2003 - 2014

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

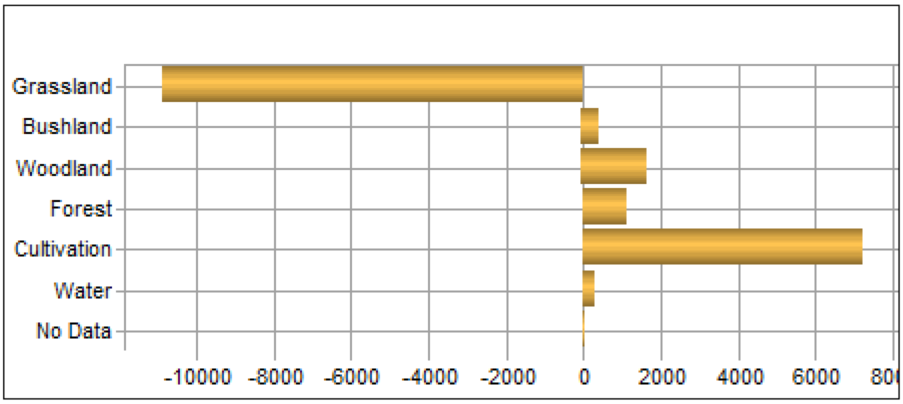

Figure 4.5: LULC Net Change 2003 – 2014

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

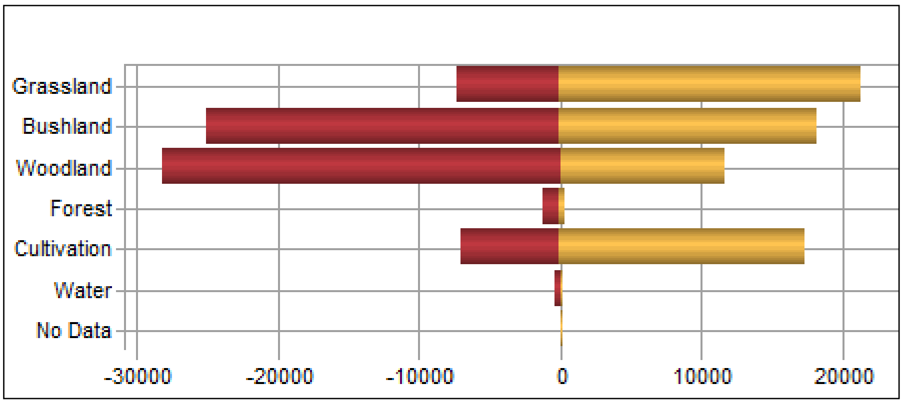

Figure 4.6: LULC Gains and Losses 2014 - 2023

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

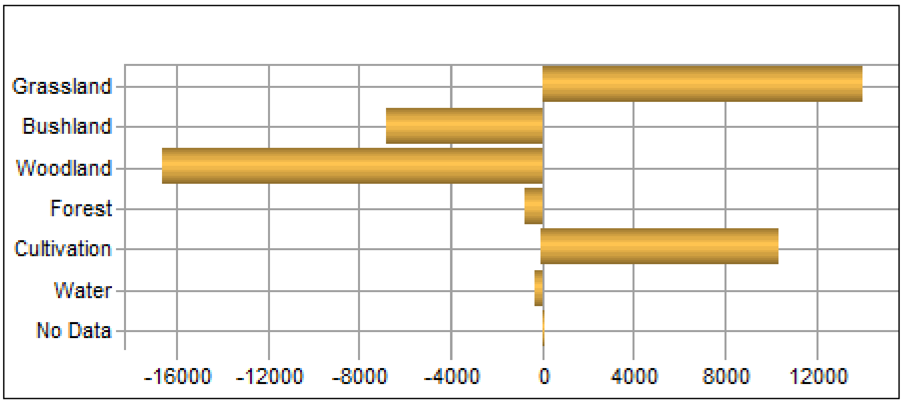

Figure 4.7: LULC Net Change 2014 – 2023

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

The traditional pasture lands decreased from a total of 117,184 hectares, covering 88.52% of the total land area in 2003, to a total of 108,475 hectares in 2014, which accounted for 81.93% of the total study area in 2014. However, the net change in Land Use and Land Cover (LULC) in 2014 indicates a slight positive change in woodland and bushland pastures, as shown in Figure 4.8. In 2014, only grassland in the traditional pastures land use/cover class decreased as can be seen in the gains and losses graph in Figure 4.6. In 2023 traditional pasture lands further decreased to 74.87% of the total area. Big changes occurred in woodland and bushland as indicated in the gains and losses and their respective net change values in Figures 4.8 – 4.9.

In the span of 20 years from 2003 to 2023, the area under cultivation has over doubled from 14,342 ha (10.84% of the total area size) in 2003 to 32,020 ha (24.18% of the total area size) in 2023 which was marked by the annual percentage change of 123.26% Table 4.4. The increase in cultivation has occurred at the expense of traditional pasture lands. For example, in 2023 cultivation land has the highest net change value in the positive direction as indicated in Figure 4.10 and the biggest contributors to that change are the pasture lands such as woodland, bushland, and grassland which contributed 13,547 ha, 5,106 ha, and 4,074 ha each respectively. The graph in Figure 4.10 illustrates the contribution of pasture lands to cultivation in 2023. A huge shift in pasture lands to cultivation occurred in Kibirashi ward Figure 4.11, where big portions of woodland, bushland, and grassland transitioned to cultivation in 2003 - 2023.

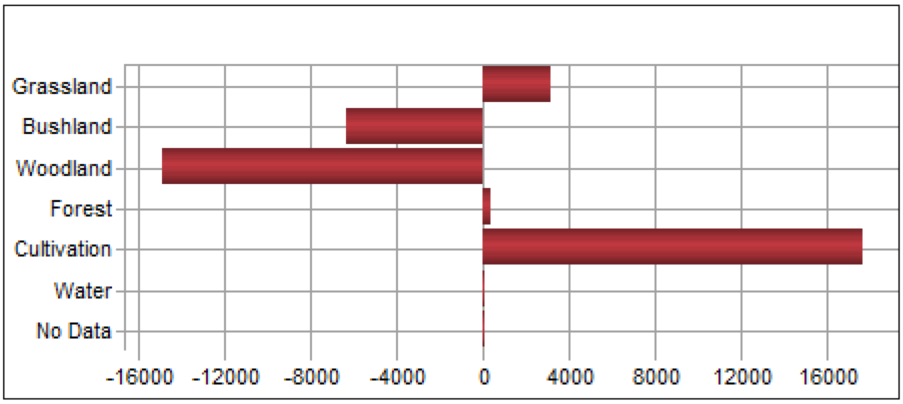

Figure 4. 8:LULC Net Change 2003 – 2024

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

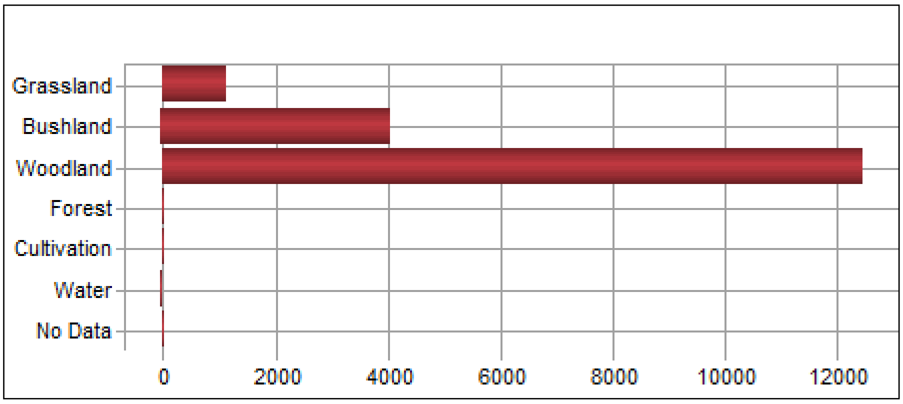

Figure 4. 9: Contribution to Net Change in Cultivation 2023 in Hectares

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

Despite a decrease in the total pasture land use/cover in 2023, the changes were not universal across all pasture land covers because grassland increased at an annual rate change of 12.86% in 2023 from 24,743ha in 2003 to 27,926ha in 2023. The increase however occurred in former woodland areas also turned into cultivation. While grassland has increased between 2003 and 2023, its accessibility by pastoralists has become restricted to a minimum due to the increase in private plots, such as unprepared farms, to which pastoralists have no access. The distant areas in the north of the map formally covered by grassland are overtaken by bushland and woodland making them attractive to farmers. Figure 4.13, shows the exchange between bushland and grassland in the years 2003 and 2023. As shown in Figure 4.13, the bushland has been converted into grassland in the lower sections of the map, which are surrounded by farms. Figure 4.10 is a graphical presentation of a percentage change in pasture lands against cultivation.

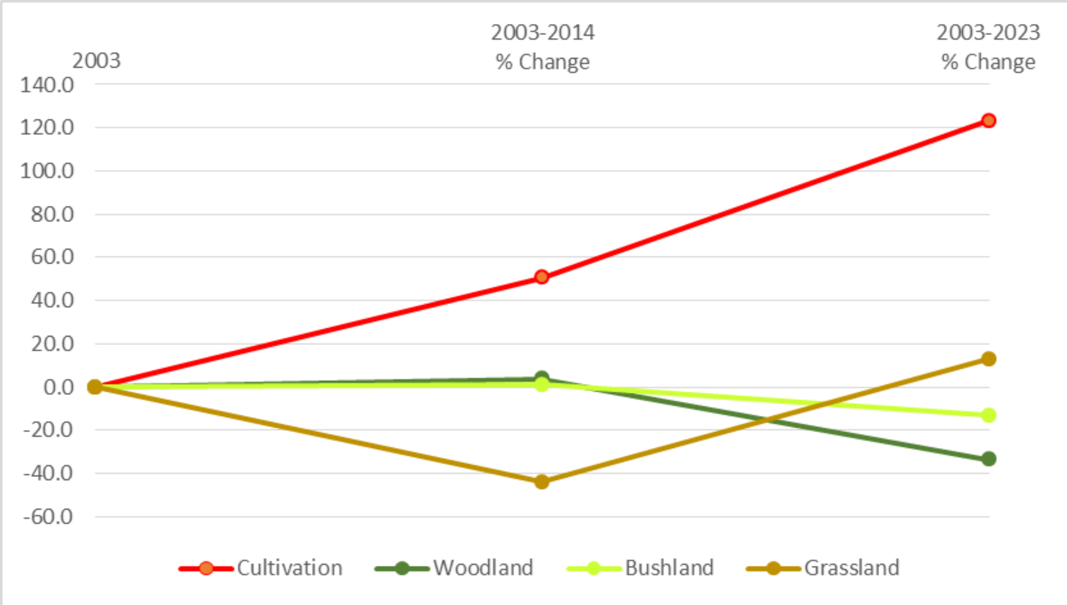

Figure 4.10: A Percentage Change of Pasture Lands Against Cultivation in 2003, 2014, and 2023

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

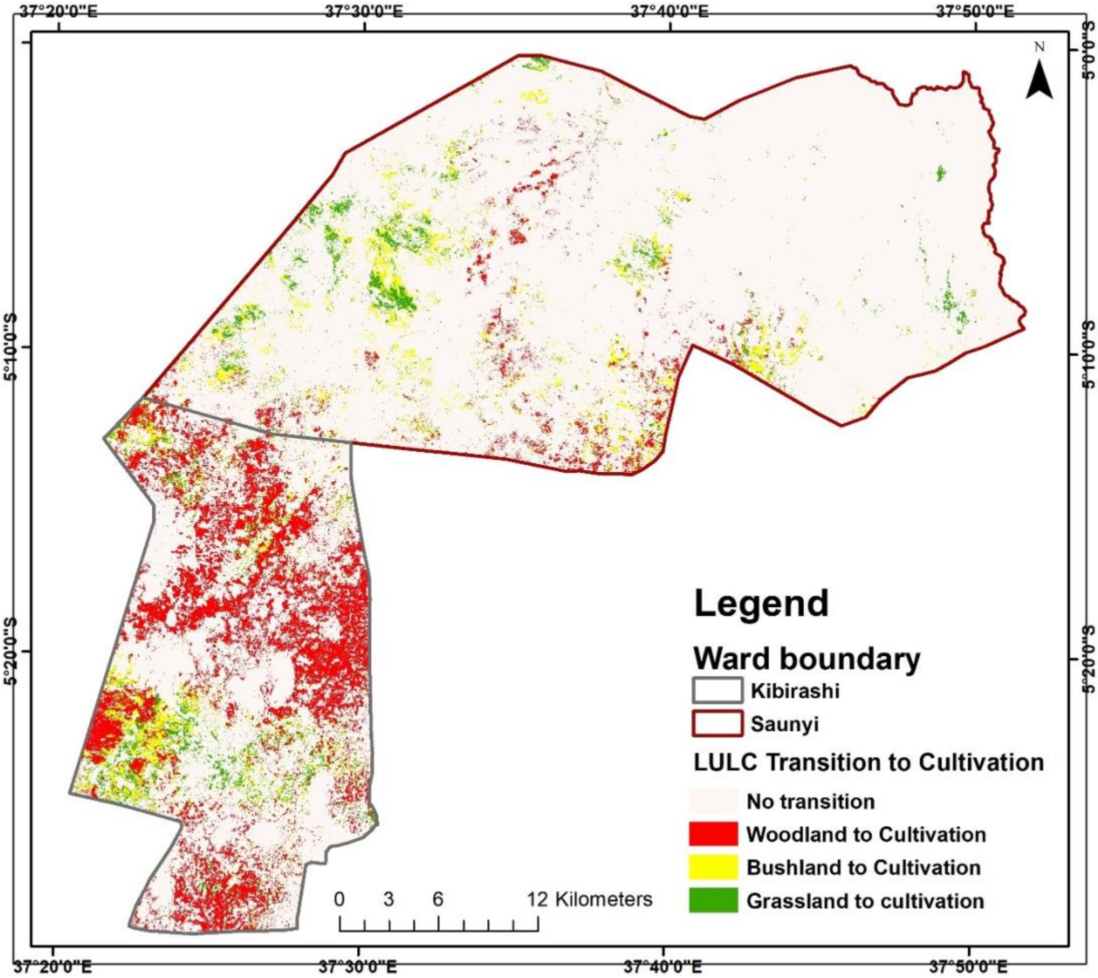

Figure 4.11: Pasturelands Transition to Cultivation, 2003 – 2023

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

4.2.4 The Spatial Trend and Distribution of Changes in LULC

The LULC change in Kibirashi and Saunyi wards occurred across the landscape. Some areas experienced more significant changes than others and some changes have occurred in some areas more or less than the other. Figure 4.11 shows the LULC gains and losses between 2003 - 2023. The trend and intensity of LULC change are indicated in the transition and cubic trend maps in Figures 4.11 and 4.14 respectively. Traditional pastures such as woodland, Bushland, and Grassland have indicated significant spatial trends and directions of change in both directions between 2003, 2014, and 2023, however, the overall difference between 2003 and 2023 indicates that woodland and bushland decreased while grassland indicated slight increase. On the contrary, the area under cultivation increased successively between 2003 and 2023

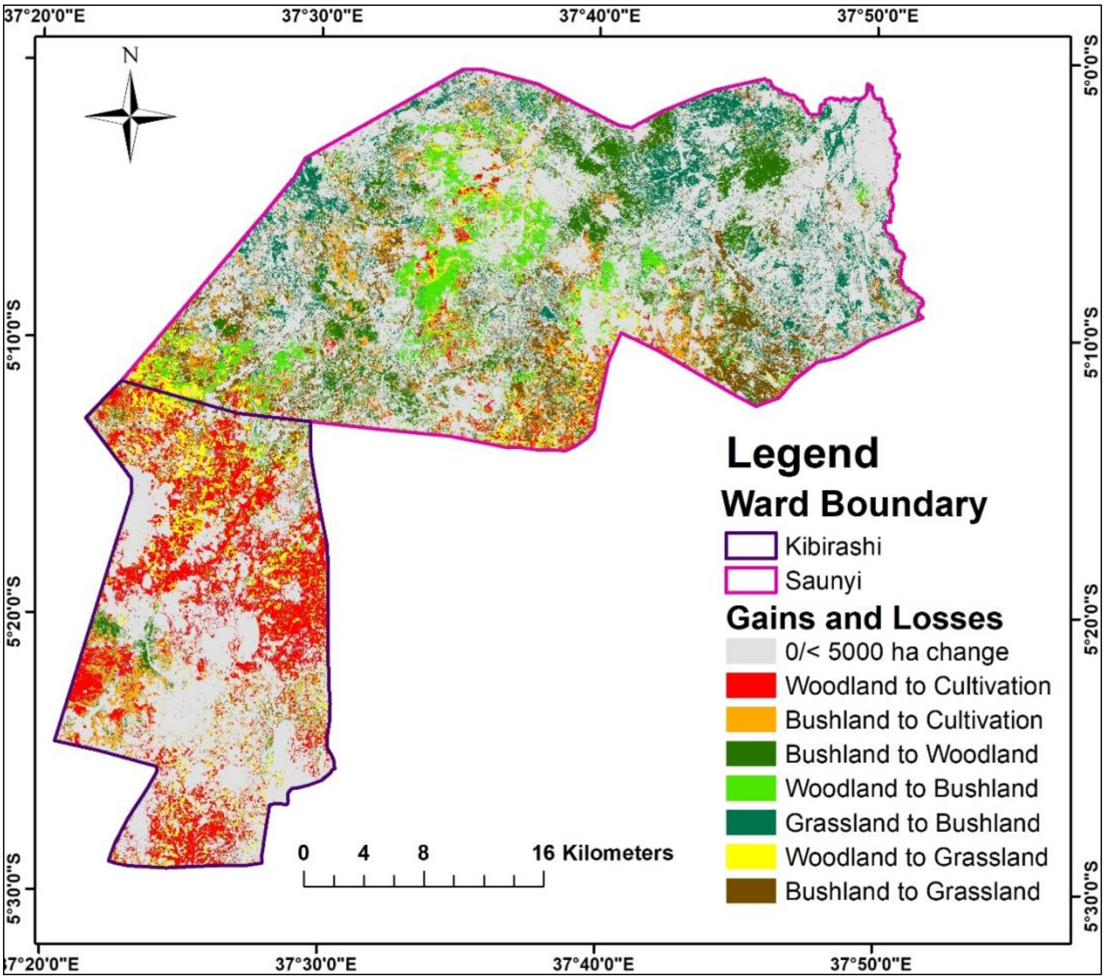

Figure 4. 12: LULC Gains and Losses 2003-2023

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

The changes in the Kibirashi and Saunyi wards land use/cover for a period of 20 years (2003-2023), happened in different directions each land cover gaining and losing from and to other land categories. The results, as illustrated in Figure 4.11, indicate that between 2003 and 2023, a significant amount of woodland in Kibirashi has been lost to cultivation, while both bushland and woodland in the Saunyi ward have been affected. Additionally, grassland has experienced a substantial loss to bushland in the Saunyi ward, as shown in Figures 4.12 and 4.13. The gains and losses in LULC between 2003 - 2014, 2014 – 2023, and 2003 – 2023 are further presented in Tables 4.5 – 4.7. The net change information indicates that cultivation is the greatest driver of net change in the study area.

The spatial trend of change between 2003 and 2023 as shown in Figure 4.14 indicates that a major transition to cultivation land occurred in the middle toward the bottom of the map which are areas formerly covered by woodlands. Figure 4.14 shows the trend of change from all land categories to cultivation in 2003 - 2023 which further highlights that a huge transition to agriculture occurred mostly in the southern part of the study area mostly in Kibirashi ward, an area earlier covered mostly by woodland. Another problem with pasture land is the transition of grassland to bushland which is an important pasture land for cattle. These changes can be seen in Figure 4.13 which shows an exchange between grassland and bushland in 2003 – 2023.

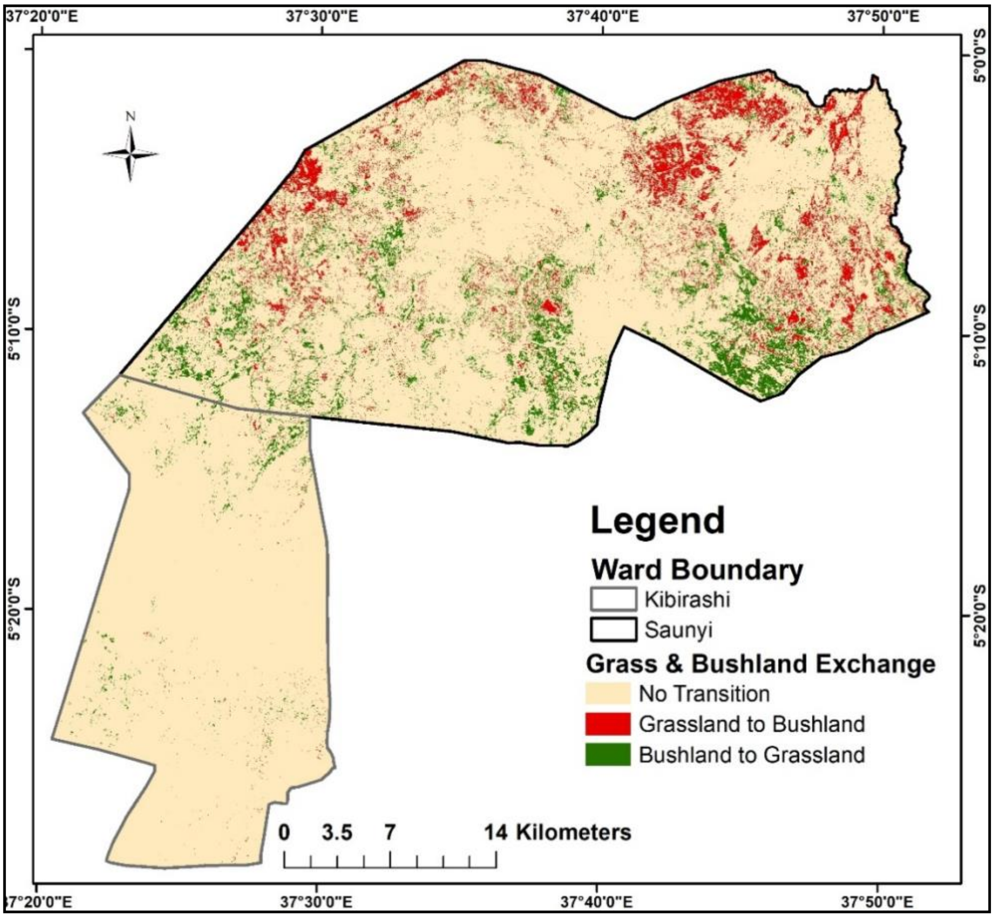

Figure 4. 13: Exchange Between Grassland and Bushland, 2003-2023

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

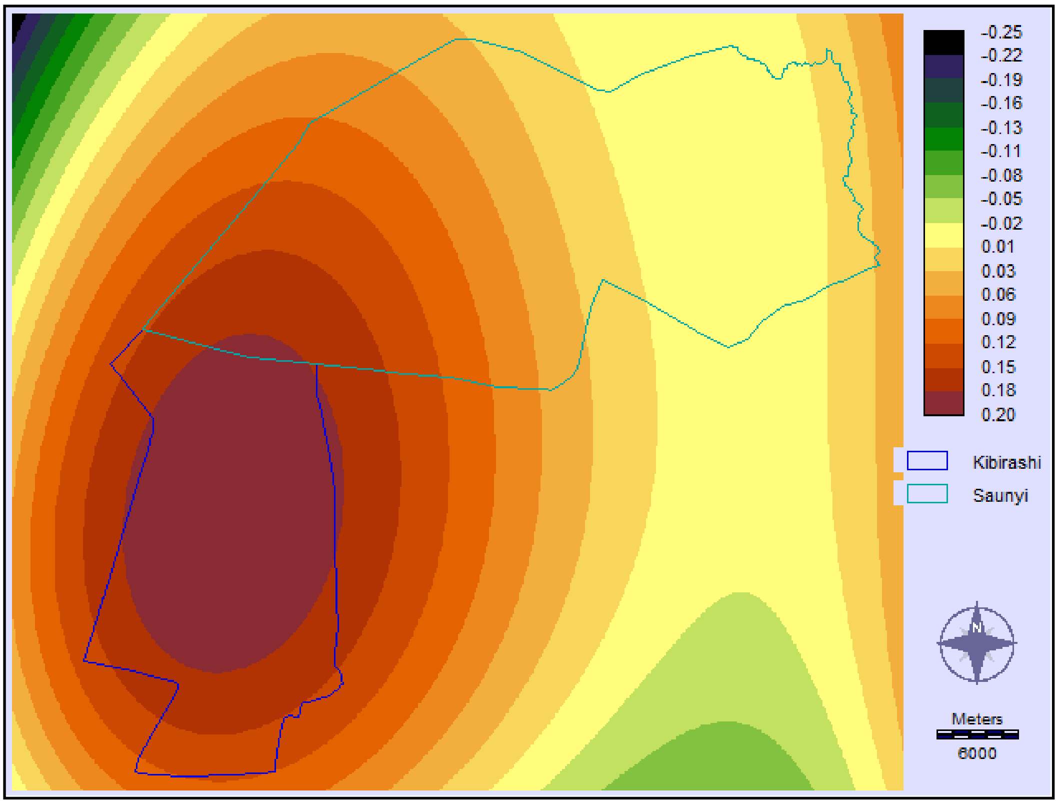

Figure 4.14: Transition of all LULC to Cultivation, 2003 - 2023

Source: Author Based on Land Change Modeler 2003-2023 Results, 2024

4.2.5 Cross-Tabulation

As stated by Momeni Amirand Pincus, (2018), cross-tabulation is a powerful statistical technique that can help conclude the distribution of data, association of events with each other or their correlation with each other. This study used cross-tabulation to tabulate the amount of change between periodic satellite images such as 2003-2014, 2014-2023, and 2003 – 2023. Tables 4.5 – 4.7 are the results of the cross-tabulation of these images. The data in the tables highlights the changes in each land use/cover in hectares and the amount that each land category maintained between two distinct periods.

In the sub-headers rows in Tables 4.5 - 4.7, WA stands for Water, CU for cultivation, FO for forest, WO for woodland, BU for bushland and GR for grassland and the values in bracket represent the amount of hectares of LULC in a particular category that remained unchanged in a particular time frame.

Table 4. 5: Cross-Tabulation Between 2003 and 2014 (Areas in Hectares)

Year		**2003**						
	LULC class	WA	CU	FO	WO	BU	GR	Total
2014	Water	**(0)**	38	4	123	79	99	343
	Cultivation	5	**(9,567)**	6	6,394	2,734	2,888	21,594
	Forest	0	77	**(659)**	1,078	39	123	1,976
	Woodland	7	1,403	167	**(23,076)**	15,647	5,746	46,046
	Bushland	6	1,836	3	10,772	**(24,731)**	11,235	48,583
	Grassland	2	1,421	3	2,885	4,883	**(4,652)**	13,846
	Total	20	14,342	842	44,328	48,113	24,743	132,398

Source: Author's Tabulation of Satellite Images, 2023

Table 4. 6: Cross-Tabulation Between 2014 and 2023 (Areas in Hectares)

Year		2014						
	Land class	WA	CU	FO	WO	BU	GR	**Total**
2023	Water	**(0)**	6	0	3	1	1	11
	Cultivation	100	**(14,552)**	206	7,641	6,133	3,388	32,020
	Forest	6	17	**(765)**	420	13	12	1,233
	Woodland	73	1,066	899	**(17,801)**	8,682	879	29,400
	Bushland	40	855	23	14,258	**(23,495)**	3,127	41,798
	Grassland	124	5,098	83	5,923	10,258	**(6,440)**	27,926
	Total	343	21,594	1,976	46,046	48,582	13,847	132,398

Source: Author's Tabulation of Satellite Images, 2023

Table 4. 7: Cross-Tabulation Between 2003 and 2023 (Areas in Hectares)

Year		2003						
	Land classes	WA	CU	FO	WO	BU	GR	Total
2023	Water	**(7)**	1	0	0	0	2	11
	Cultivation	4	**(9236)**	54	13,547	5,106	4,074	32,020
	Forest	0	86	**(605)**	453	4	86	1,233
	Woodland	0	1,061	157	**(16823)**	8,239	3,120	29,400
	Bushland	6	1,009	1	6,216	**(25161)**	9,405	41,798
	Grassland	3	2,950	25	7,290	9,604	**(8056)**	27,926
	Total	20	14,342	842	44,328	48,113	24,743	132,398

Source: Author's Tabulation of Satellite Images, 2023

The cross-tabulation data presented in Tables 4.5 – 4.7 were also used in the earlier sections of this chapter to show the changes and magnitude of change for one land class to another and to itself in different periods and to complement the results of the change detection on the study area. Nonetheless, these tables further presented important information regarding the dynamics of each land use/cover in particular the role of pasture land use/cover categories such as grassland, woodland, and bushland (Yanda & Mung'ong'o, 2016) to the expansion of cultivation. For instance, the data expressed a huge transition of traditional pasture land into cultivation, between 2003 and 2014, traditional pasture land use/cover contributed a total of 12,016 ha to cultivation. In the 2014 – 2023 period, pasture lands contributed a total of 17,162ha to cultivation.

4.3 Impacts of LULCC on Pasture Viability

The impacts of Land Use and Land Cover Change (LULCC) on the viability of pastures in Kibirashi and Saunyi wards were examined by collecting qualitative information from focus groups and key informants. The collected data was then analyzed thematically using ATLAS.ti software, revealing three major themes: Pasture Availability, Pasture Accessibility, and Pasture Quality.

4.3.1 Pasture Availability

The data indicated that LULCC has led to a shortage of pastures for pastoralists animals resulting from expansion of agriculture, population increase, increased numbers of livestock and lack of rains. The discussion with the group of elders emphasized that cultivation is a major factor leading to the decrease in pastures in Kibirashi and Saunyi. They stated that cultivation has encroached upon traditional pasturelands, resulting in the loss of significant pasture lands. The youth and herder groups also identified agriculture as a key factor contributing to the shortage of pastures for pastoralists in the two wards. One young man from Elerai village said:

> *"As far as I can see, the farms have overtaken the pastoral land. And people cutting forests leads to lack of grazing areas for livestock and there is also an increase in settlement"*

These findings concur with the findings by Catley et al., (2013) which indicated that the expansion of cultivation impacted pastoralists' mobility to access pastures.
The data also indicated that another activity impacting the availability of pastures is the expansion of settlements. The study found that the growth of human settlements and urbanization encroached into traditional grazing areas. One elder Kibirashi village noted that,

> *"Currently, there is an increase in population and buildings compared to the past twenty years, something that is shrinking the availability of pastures."*

As land is converted for residential, and commercial purposes, livestock lose their traditional pasture lands. This factor was also found to be impacting the availability of pasture in the Gode district, in Ethiopia in research done by Worku et al., (2018) which asserted that the decline of pastureland is the result of human pressure on the land for settlement and cultivation.

Third, an increase in livestock numbers. However, many of the interviewed individuals and groups signified crop cultivation as a major reason for reduced pastures in Kibirashi and Saunyi, but the findings also indicated that the rise in livestock populations exacerbated the pressure on available grazing lands. A youth from Ngobore village ascertained that;

> *"The increase in livestock has also affected the grazing areas, because now the livestock are using the same area frequently to get pasture and thus affecting the ability of grasses to grow to maturity".*

An argument complemented by the finding of Gebeyehu et al., (2023), which identified the increase of livestock as a reason for overgrazing hence the demise of pastures. The elderly group further stressed that, with more livestock to feed, the demand for pastures intensifies, leading to overgrazing and degradation of the existing grazing areas. The findings further align with a report on rangelands by Oxfam International (Kirkbride, 2008), which showed that the expansion of farms into rangelands has significantly contributed to the decline of pastures. The data also revealed that the shortage of rains has impacted the growth process of grasses hence reducing the satiety of livestock. While responding to a question regarding the impacts of the changes in climate and weather patterns associated with LULCC, an elder from Gitu village stated:

> *"The change in land use/cover have led to increased dry seasons and thus leads to the death of many cows for hunger, due to insufficient grass a situation that made many people to experience stress and sometimes commit suicide when they see many cows die"*

The data results also indicated that charcoal burning, timbering, and sand extraction activities are also contributing to the shortage of pastures in Kibirashi and Saunyi wards. Moreover, the elders emphasized that due to insufficient traditional pastures, they have started purchasing farm residuals as supplementary food to sustain their livestock, especially during dry seasons.

4.3.2 Quality of Pastures

Another theme that emerged from the data findings is the impact of LULCC on the quality of pastures. The elders believe that high-quality pastures provide palatable, nutritious feed that enhances milk production, livestock health, and market value. The elders believed that palatable feed is the one with proper botanical composition. This description of the quality of pastures is also seen in the findings of Kavana et al., (2014) who in addition described the libido of bulls as another aspect that can be used to determine the quality of pastures. The findings indicated that there has been a decline in the quality of pastures. For example, an elder argued that:

> "*The quality of the grass has deteriorated. To a large extent, the grass now and in the past is different. Currently, in many areas where there was grass, small plants are growing that are not productive fodder for our livestock and some are inedible to livestock at all"*.

The elders' account aligns with Kavana et al.'s (2014) findings, which showed that confining pastoralists to small areas has led to overgrazing. This has caused a shift from productive to unproductive feed. The research also identified factors linked to Land Use and Land Cover Change (LULCC) affecting pasture quality. These include the disappearance of controlled grass burning, tree and grass species, and an increase in insects, pests, and associated diseases. Several studies, such as those by Angassa & Oba (2008) and McCarthy et al. (2001), discuss the decline in pasture quality due to the disappearance of controlled burning and the replacement of grasslands with woody vegetation.

The loss of vegetation diversity due to land use/cover change, particularly the conversion of natural pasturelands for agriculture or settlement purposes, resulted in the loss of diverse plant species. Discussions with elders indicated that some grasses and vegetation species, like the acacia tortilis, and acacia nilotica trees shown in Figure 4.15, play a crucial role in providing nutritious fodder for livestock, especially during dry seasons when other sources of forage are scarce. Kavana et al., (2014) defines these trees as multipurpose trees due to their demand for pastoralists for pasture and demand for other groups for charcoal activities. are disappearing due to agriculture expansion, charcoal burning, and bloc burning activities.

The data also identified other palatable species that provide productive feed for livestock, especially during the dry season. These species include wandering jaw (scientifically known as Tradescantia fluminensis) and salt marsh grass. The data indicated that these species are disappearing in many areas in Kibirashi and Saunyi wards. According to the elders, these species store a good amount of water and have high nutrients that help to strengthen the livestock's health during dry and hot seasons. The elders argued that the disappearance of palatable feed has reduced the quality of pastures in their lands, making the livestock incapable of sustaining increasingly prolonged droughts.

Figure 4.15: The Acacia Tortilis Tree, a Dry Season Source of Pastures
Source: Author from Field Observation, (2023)

Moreover, the findings revealed that climate change had had adverse effects on pasture quality. The information gathered from key informants and focus groups indicated that the decrease in rainfall which is associated to deforestation for cultivation has led to the deterioration of grasslands. Many elders stressed that in many areas grass has been overtaken by some alien plant species that are inedible to the livestock or have small nutrients, therefore affecting the health and productivity of the animals. This argument is also backed by the findings by Mbwambo et al., (2016) in who indicated that climate change and expansion of crop cultivation have aggravated the problem of pasture and feed resources in terms of quantity and quality.

The third factor that led to the decline in pasture quality is the overuse and degradation of pastures. Overusing existing pastures is a critical factor linked to land use and land cover change (LULCC), which contributes to the decline in pasture quality. Information from the FGD and KII respondents shows that LULCC has reduced pastoral lands, causing large animal herds to concentrate in small areas. This overgrazing leads to pastures not having enough time to recover and regenerate, as they lack adequate rest periods. An elder from Kwamaligwa village mentioned,

> *"The health of the grass and other pastures has decreased significantly due to frequent trampling by livestock."*

According to them, overgrazing leads to the degradation of pastures, causing a decrease in their nutritional content and overall quality. These findings are in line with the findings by (Kavana et al., 2014). The elders stressed categorically that the overutilization of pastures is the result of land use/cover change where many pasturelands have been overtaken by other activities particularly crop cultivation and settlements leaving the small patches where all animals flock into daily without resting time.

The fourth factor is the absence of controlled burning. Controlled burning is a traditional practice used by pastoralists to manage grasslands and stimulate new growth. The elders explained that in the past 20 years, there was an abundance of pasture lands, allowing for surplus grasses to be strategically burned to ensure the regeneration of new and quality grass. However, changes in land use have reduced many pasturelands, while those that remain are overutilized and face prolonged droughts, limiting the surplus grasses available for burning and affecting grass quality management. The findings show that controlled burning helped the community eradicate the growth of invasive plant species and promote the growth of nutritious grasses. Conversely, grasses are being replaced by alien species, including bushes and inedible new species. These findings are supported by research at Nyangatom agropastoral in southwest Ethiopia (Gebeyehu et al., 2023). The discussion further indicated that the deterioration in the quality of grass and other pastures is also weakening the health of the animals.

The fifth factor identified is an increase in insect populations and livestock diseases. The discussions revealed that the changes in land use/cover exacerbated the increase of insect populations in the grass therefore leading to deadly diseases. The elders were concerned that, the loss of controlled burning, vegetation diversity, and the increasing degradation of pastures create an environment conducive to an increase in insect populations like ticks and tsetse fly. It's worth noting that the observation of the increase in insects and diseases is not just limited to the knowledge of the elderly, but was also noticed by the younger generation, as one of them mentioned:

> "*When we were growing up there were not many diseases, but now diseases have increased due to the increase of insects in the grass. Probably because they are not burned these days as there is no grass left".*

The interviewed groups believed that burning the grass was helping pastoralists to remove infectious insects such as ticks and tsetse flies from the land and grasses hence reducing livestock diseases. The data indicated that insects such as Tsetse fly spread diseases such as trypanosomiasis, which, according to the elders, kills many of their animals and weakens many more. The role that insects such as tsetse flies play as vectors for various livestock diseases is also discussed by Bett et al., (2017), however in terms of climate change. Thus, a decrease in pasture quality weakens the immune systems of animals, putting them at risk for disease.

In discussions about pasture quality, people raised concerns about livestock productivity. Women noted that the livestock were not producing as much milk as they did 20 years ago, attributing this decline to the lower quality of grass. This is supported by the findings of Kavana et al., (2014), who emphasized that the level of milk production and libido of bulls can be used to assess the quality of forage. Additionally, elderly men highlighted the decrease in livestock market value as another indicator of declining pasture quality. They linked the loss of weight in livestock to insufficient and poor-quality pastures. The findings indicated that factors such as reduced rainfall, limited access to traditional grazing lands, and the decline of pasture quality due to the disappearance of certain grass and plant species have contributed to the decline in animal productivity. One elder from Saunyi village noted that:

> *"Changes in land use have affected pastures in many ways such as water depletion, livestock thinning, lack of milk, decline in livestock prices, traveling long distances to find pastures and interaction with*

> *agriculture leading to many court cases and conflicts between herdsmen and farmers".*

The traditional leaders noted that the decline in animal productivity has driven many families to poverty. A contention that is backed up by the FAO's work on rangelands and pastoralism in its twenty-seven session, 28th September – 2nd October, (2020), which explained that prolonged and recurring droughts cause animal prices fall due to body weight loss, while staple food prices increase, resulting in chronic poverty and hunger.

4.3.3 Pasture Accessibility

The data results also indicated that changes in land use/cover have disrupted pastures accessibility. The findings indicated several factors related to pasture accessibility that are impacted by LULCC including the disruption of traditional pasture utilization mechanisms, and limited animal mobility.

4.3.3.1 Disruption of Traditional Plans of Pasture Use

Wet and dry season pastures: like many traditional Pastoral communities living in savanna and semi-arid climates (Russell et al., 2018), the pastoralists in Kibirashi and Saunyi, used to rely on seasonal livestock movement to access wet and dry season pastures. The findings revealed that during the wet season when there is abundant rainy water in the natural ponds, animals are moved to distant pastures and in the dry season, livestock are brought back to settled areas and rely on water dug from underground sources. The pastoralists' seasonal utilization of pastures is of pastures has a matter of discussion for many scholars such as (Kirkbride, 2008; Muhammad et al., 2019). One member in a herders group discussion said;

> *"We separate our pastures according to the periods of the year such as the rainy season and the dry season, so we have pastures for the summer season and pastures for the rainy season"*

The research findings also revealed that the expansion of agriculture and settlements into pasturelands has disrupted traditional methods of using some pastures. These areas have been converted to crop farming or turned into private property, making them inaccessible to pastoralists. The study shows that wet season pastures are at greater risk of becoming inaccessible due to invasion by crop farmers and other pastoralists from distant places when livestock are moved back home during the dry season for easier access to water from permanent sources such as underground wells and artificial dams. A herder from Saunyi ward said:

> *"Once we move our animals from their distant pastures to home during dry season, the farmers invade the places and open new farms and when the rains start our livestock lack good areas to migrate to get enough pastures"*

In regard to settlement expansion, traditional leaders explained that human settlements also encroached into traditional dry season pastures, making them inaccessible and domicile. Those findings corroborated with findings by Lambin et al., (2003), which indicated that the expansion of settlements has reduced the accessibility of pastures by the pastoralists. The traditional leaders also explained that the accessibility of some pastures is restricted by the rapidly growing population which also led to divisions of the lands into private plots.

> *"Also, people are starting to divide the remaining areas and take possession of the slew, which is increasingly reducing the free areas available for feeding the livestock"*

That argument from traditional leaders is supported by research by Morara et al., (2014) in Kajiado Kenya, which showed that the selling of land to private owners flocking from urban sites led to LULCC and pasture decline in the area.

4.3.3.2 Livestock Mobility

The discussions with the elders and youth groups indicated that the expansions of agriculture and permanent settlements, have overtaken these lands and blocked the trails that are used by pastoralists to access these pastures according to seasons of the year. The situation is believed to be restricting livestock mobility to access some of the pastures. One youth from Elerai village noted that:

> *"At the moment, agriculture is blocking the paths used by livestock to go to the pastures and water, something that is leading quarrels with farm owners"*

These findings are in consistent with the findings by Kimiti et al., (2018) in Amboseli Kenya which indicated that the expansion of settlements, agriculture and population increase is restricting livestock mobility which is a key strategy used by pastoralists to exploit resources in environments that are highly variable in space and time. The significance of livestock mobility in pastoralism is also highlighted by Oxfam International, in its 116 Oxfam briefing paper which stressed that pastoralists rely on freedom of movement to be able to manage the rangelands effectively, whereby inability to move affects the pastoralists' sustainable production of their livestock (Kirkbride, 2008) and (Mwambene et al., 2014).

The overall consequence of the inability of pastoralists to access some pastures as explained by elders, youth, and herders are frequent conflicts with crop farmers, lack of freedom among animal herders while on duty and pastoralist's difficulties in maintaining their health and productivity of their livestock, leading to potential economic and social hardships and overgrazing over the remained pastures. An argument consistent to Tessema et al., (2014) findings that if mobility is constrained it may lead to overgrazing and thus to a lack of pasture sustainability.

> *"Currently there is a big problem on the trails used to go to the water due to the increase of farm fields along those animal trails, a situation that leads to the lack of freedom of the herders and frequent conflicts with farmers"*.

Generally, the study found out that the impacts of LULCC on pastures viability is also exacerbated by the lack of effective land use and management policies viable to pastoralists. To mitigate the risks of pasture insufficiency, unavailability, and accessibility of traditional pastures, pastoralists have adopted some mechanisms to sustain their livestock. From the discussions with the elders, and key informants in Kibirashi and Saunyi, they explained that in these days, pastoralists are relying on farm residuals and maize bran as alternative pastures for their livestock during dry season.

The elders also indicated that some pastoralists started to reduce the size of their herds to small manageable numbers.

4.4 Prediction of Future LULCC in the Study Area

Prediction of the future land use and land cover of the study area indicated a foreseeable situation of further decline in pasture lands. Figures 4.16 and 4.17, are the projected map of land use/cover in Kibirashi and Saunyi wards in 20 years and conditional probability maps. The map in Figure 4.16, provides a qualitative expression of the spatial changes of the land use/cover in 20 years. The conditional probability maps in Figure 4.17, explain the probability that each pixel will belong to a particular class in 2043 should the rate of change remain constant. Table 4.8, shows the size of each projected land category in hectares.

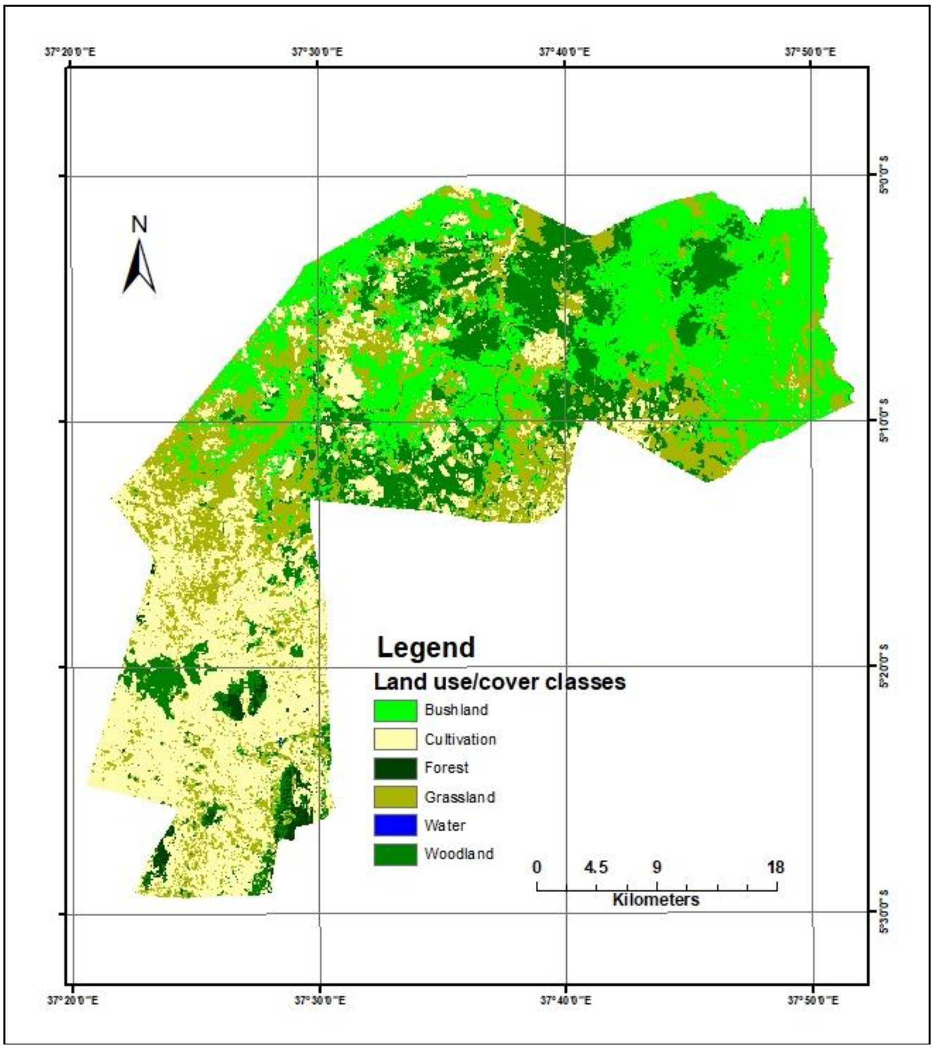

Figure 4.16: The Predicted LULC Map of Kibirashi and Saunyi in 2043

Source: Author, From Satellite Image Analyis, 2024

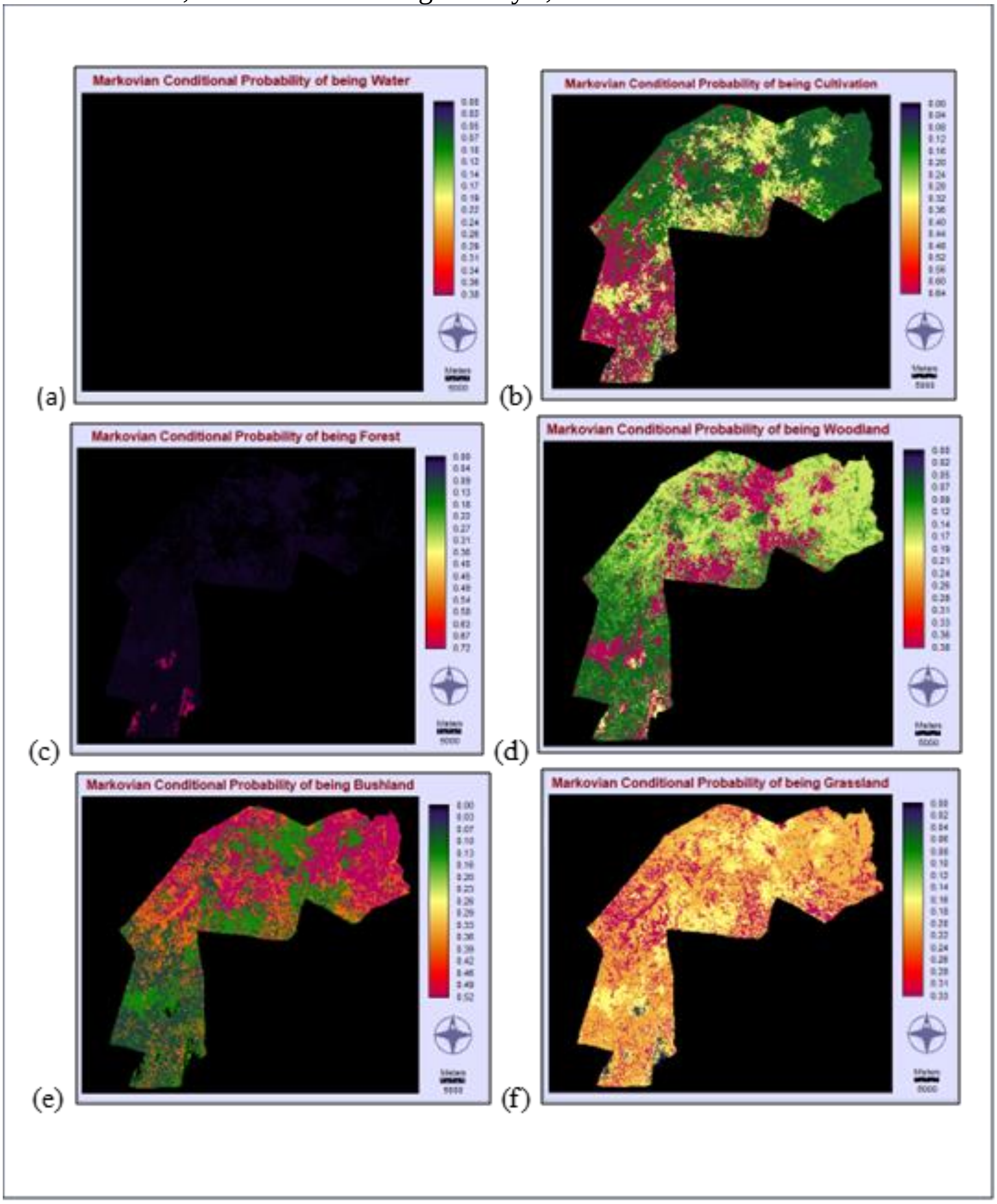

Figure 4.17: Markovian Conditional Probability Maps
Source: Author, From Satellite Image Analysis, 2024

Figure 4.17, shows a Conditional probability of being water (A)**,** Conditional probability of being cultivation (b)**,** Conditional probability of becoming forest (c), Conditional probability map of becoming woodland (d)**,** Conditional probability of becoming bushland € and Conditional probability of becoming grassland (f). The maps were used for prediction of LULCC in the study area for future 20 years.

Table 4.8, demonstrates the projected of land use/cover of Kibirashi and saunyi wards by year 2043 if the rate of change remains the same as it happened in the past 20 years. The results in the table indicate that the area will be dominated by bushland by 38,852 ha which is 29.35% of the total area, followed by cultivation which occupies 38,718 ha which is 29.24% of the total area. Woodland is expected to demonstrate significant decrease to 24,437 ha, which is 18.46% of the total land use/cover. Grassland is expected also to increase and occupy 28,953 ha, 21.87% of the total area.

Table 4.8: Projection of LULC of Kibirashi and Saunyi in 2043

Land Category	Area coverage (ha) in 2043	Area coverage (%) in 2043
Water	7	0.005
Cultivation	38,718	29.24
Forest	1,423	1.07
Woodland	24,437	18.46
Bushland	38,854	29.35
Grassland	28,953	21.87

Source: Author's Tabulation of Satellite Images, 2023

As shown in the projected map (*Figure 4.16)*, grassland is likely to occupy the middle parts of the area along with cultivation. This indicates that the accessibility of the grasses by pastoralists will be limited.

Generally, the predicted results indicate that the total traditional pasture lands in Kibirashi and Saunyi such as Woodland, Grassland, and Bushland will further decrease at a total percentage decrease of -6.94%, from 99,124 ha (74.87%) in 2023 to 92244 ha (69.68%) in 2043. However, the area could be further diminished as the grass that grows beside the farm fields will be inaccessible to local pastoralists. Moreover, the areas under woodland cover are likely to be dominated by established farms especially in the down part of the map which is Kibirashi ward.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This section of the study presents the summary, conclusion, and recommendations of the study

5.2 Summary

This study was conducted in two wards in Kilindi district namely Kibirashi, and Saunyi known to be the most populous wards as far as pastoralism is concerned. The study was conducted with the overall objective to understand the impacts of land use/cover change on pastures viability in pastoral communities.

This study has approached the overall goal by the use of the three specific objectives. First, to assess the spatial and temporal land use/cover change in the study area. Secondly, to assess the impacts of land use/cover change on pasture viability, and. Thirdly the study aimed to predict the state of land use/cover in the study area for 20 years later.

The design of the study was a mixed method design whereby the study relied on quantitative and qualitative information. Quantitative information was collected from open-source archives such as Landsat images from USGS and GLOVIS online depositories and analysed through GIS software such as IDRIS, ArcMap, and Quantum GIS. Qualitative data were collected from elders, youth, traditional leaders, and herders from the two wards, then analysed thematically using an online software namely Atlas.ti. The data results of the qualitative data analysis were presented in quotes, themes, maps, graphs and tables.

The study has indicated that significant changes in land use/cover in Kibirashi and Saunyi wards have occurred with significant impacts to pastures viability. The study revealed that the areas regarded as traditional pasture lands such as woodland, grassland, and bushland has reduced significantly from a total of 117,184 ha in 2003 to 99,124 ha in 2023 a 15.4% decrease. The prediction analysis for the next 20 years indicated that the area under traditional pastures will continue to decrease from 99,124 ha (74.87%) of the total study area land in 2023 to 92,244 ha (69.68%) in 2043. In contrast, the area under cultivation that increased from 14,342 ha in 2003 to 32,020 ha in 2023 a 123.2% increase is projected to a further 20.91% increase between 2023 and 2043 from 32,020 ha to 38,718 ha.

The results also indicate that the changes in land use/cover impacted the pasture's viability in several ways such decrease in pastureland area size, reduced quality of pastures, and inaccessibility and poor management of pastures. The study further revealed factors leading to rapid decrease of pastures associated to changes in land use/cover as well as consequences to pastoralists which include expansion of cultivation and settlements, charcoal and bloc burning, climate change, and timbering activities. The study concludes by offering recommendations to assist in rescuing pastures from further deterioration.

5.3 Conclusion

The study concludes that the land use/cover in the Kibirashi and Saunyi wards changed significantly between 2003 and 2023. The study also concludes that changes in land use/cover have significantly altered the quality and size of pastures in the study area. Among the impacts, the study revealed that there has been a deterioration of pasture qualities and the disappearance of some grass and tree species that are critical for pastoralism and the well-being of livestock. In this perspective, the study found that the deterioration of pasture qualities, the decrease in the size of pastures, as well as the disruption of local pasture management mechanisms, have led to significant negative impacts on pastoral communities which include communities, sliding into poverty, frequent clashes with crop farmers, and the increase in pests and diseases.

5.4 Recommendations

Following the findings of the study, several actions and factors are recommended to mitigate the impacts of land use/cover change and serve pastures and pastoral communities from the brink of total collapse.

1. The government of Kilindi district should initiate and implement effective land use plans and management policies that will lower the rate of LULC changes.
2. The study also recommends that the district government as well as ward and village government to formulate and implement policies that aim to mitigate the impacts of LULCC by stopping deforestation of any nature to save their areas from desertification and other chronic climate hazards, that are impactful to pasture viability.
3. The study also recommends to the national government to put measures in place that strategically aim to manage future LULCC.
4. The study also recommends that the government to adopt land policies that will secure and defend pastures and give pastoralism a formal recognition so that the communities that rely on it for survival can prosper and meet the basic needs of their families going into the future.

5.5 Areas of Further Study

As the study uncovered a serious impacts of land use/cover on pastures viability, the study suggests for further studies to focus on the economic and cultural challenges facing the pastoral communities as the result of land use/cover change. The study also suggests further studies to assess the laws and policies in the livestock sector if they are friendly to pastoralism and pastoral communities.

REFERENCES

Assede, E. S. P., Orou, H., Biaou, S. S. H., Geldenhuys, C. J., Ahononga, F. C., & Chirwa, P. W. (2023). Understanding Drivers of Land Use and Land Cover Change in Africa: A Review. *Current Landscape Ecology Reports*, *8*(2), 62–72. https://doi.org/10.1007/s40823-023-00087-w

Bertalanffy, L. von. (1968). *General system theory: Foundations, development, applications*. G. Braziller.

Bett, B., Kiunga, P., Gachohi, J., Sindato, C., Mbotha, D., Robinson, T., Lindahl, J., & Grace, D. (2017). Effects of climate change on the occurrence and distribution of livestock diseases. *Preventive Veterinary Medicine*, *137*, 119–129.

Blench, R. (2001). *"You Can't Go Home Again": Pastoralism in the New Millennium: 9p.103). London: Overseas Development Institute.* Citeseer.

Capra, F. (1996). *The web of life: A new synthesis of mind and matter* (Vol. 132). HarperCollins London.

Catley, A., Lind, J., & Scoones, I. (2013). *Pastoralism and development in Africa: Dynamic change at the margins*. Taylor & Francis.

Chavez, P. S., & others. (1996). Image-based atmospheric corrections-revisited and improved. *Photogrammetric Engineering and Remote Sensing*, *62*(9), 1025–1035.

Cihlar, J. (2000). Land cover mapping of large areas from satellites: status and research priorities. *International Journal of Remote Sensing*, *21*(6–7), 1093–1114.

Costa, H., Almeida, D., Vala, F., Marcelino, F., & Caetano, M. (2018). Land cover mapping from remotely sensed and auxiliary data for harmonized official statistics. *ISPRS International Journal of Geo-Information*, *7*(4), 157.

Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage publications.

Davidoff, P. (2015). Advocacy and pluralism in planning. In *The city reader* (pp. 525–535). Routledge.

Dixon, A. P., Faber-Langendoen, D., Josse, C., Morrison, J., & Loucks, C. J. (2014). Distribution mapping of world grassland types. *Journal of Biogeography*, *41*(11), 2003–2019.

Dong, S., Kassam, K.-A. S., François, J., & Boone Editors, R. B. (2016). *Building Resilience of Human-Natural Systems of Pastoralism in the Developing World*.

Dong, S., Kassam, K.-A. S., Tourrand, J. F., & Boone, R. B. (2016). Building resilience of human-natural systems of pastoralism in the developing world. *Edited by Shikui Dong, Karim-Aly S. Kassam, Jean François Tourrand and Randall B. Boone. Switzerland: Springer*. https://doi.org/https://doi.org/10.1007/978-3-319-30732-9_2

Egeru, A., Wasonga, O., Kyagulanyi, J., Majaliwa, G. J. M., MacOpiyo, L., & Mburu, J. (2014). Spatio-temporal dynamics of forage and land cover changes in Karamoja sub-region, Uganda. *Pastoralism*, *4*, 1–21.

FAO. (2002). *Forestry - Workshop on Tropical Secondary Forest Management in Africa: Reality and Perspectives*.

FAO. (2011). State of the world's forests. *State of the World's Forests (FAO)*.

FAO. (2018). *Pastoralism in Africa's drylands Reducing risks, addressing vulnerability and enhancing resilience*.

FAO. (2020). *E COMMITTEE ON AGRICULTURE Twenty-seventh Session FAO's work on Rangelands and Pastoralism, and proposal for an International Year of Rangelands and Pastoralists*. http://www.fao.org/3/j8919e/j8919e.pdf

FAO. (2022). The State of the World's Forests 2022. In *The State of the World's Forests 2022*. FAO. https://doi.org/10.4060/cb9360en

FAO. (2023). *Food and Agriculture Organization of the United Nations*. https://www.fao.org/faostat/en/#data/LC

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., Chapin, F. S., Coe, M. T., Daily, G. C., Gibbs, H. K., & others. (2005). Global consequences of land use. *Science*, *309*(5734), 570–574.

Fratkin, E. (2001). East African Pastoralism in Transition: Maasai, Boran, and Rendille Cases and African Pastoralist Systems: An Integrated Approach, coedited with Kath. In *Studies Review* (Vol. 44, Issue 3).

Gebeyehu, A. K., Snelder, D., & Sonneveld, B. (2023). Land use-land cover dynamics, and local perceptions of change drivers among Nyangatom agro-pastoralists, Southwest Ethiopia. *Land Use Policy*, *131*, 106745.

Harrell, M. C., & Bradley, M. (2009). *Data collection methods: Semi-structured interviews and focus groups*. 146.

Hesse, C., & MacGregor, J. (2006). *Pastoralism: Drylands' Invisible Asset?: Developing a Framework for Assessing the Value of Pastoralism in East Africa* (Vol. 142). Iied.

Hester Patrick T. and Adams, K. MacG. (2017). Systems Theory. In *Systemic Decision Making: Fundamentals for Addressing Problems and Messes* (pp. 55–99). Springer International Publishing. https://doi.org/10.1007/978-3-319-54672-8_4

Hobbs N. Thompson and Reid, R. S. and G. K. A. and E. J. E. (2008). Fragmentation of Arid and Semi-Arid Ecosystems: Implications for People and Animals. In R. S. and J. R. H. B. and H. N. T. Galvin Kathleen A. and Reid (Ed.), *Fragmentation in Semi-Arid and Arid Landscapes: Consequences for Human and Natural Systems* (pp. 25–44). Springer Netherlands. https://doi.org/10.1007/978-1-4020-4906-4_2

IFAD, & FAO. (2016). *FAO's and IFAD's Engagement in Pastoral Development Joint Evaluation Synthesis*. https://www.fao.org/3/bd503e/BD503E.pdf

Ivanov, D. (2022). Viable supply chain model: integrating agility, resilience and sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic. *Annals of Operations Research*, *319*(1), 1411–1431.

Jenet, A., Buono, N., Di Lello, S., Gomarasca, M., Heine, C., Mason, S., Nori, M., Saavedra, R., & Van Troos, K. (2016). *The path to greener pastures: pastoralism, the backbone of the world's drylands*. 27–32. https://doi.org/10.13140/RG.2.2.11042.22725

Kashaigili, J. J., Mbilinyi, B. P., Mccartney, M., & Mwanuzi, F. L. (2006). Dynamics of Usangu plains wetlands: Use of remote sensing and GIS as management decision tools. *Physics and Chemistry of the Earth, Parts a/B/C, 31*(15–16), 967–975.

Kavana, P. Y., Kakengi, V. A. M., & others. (2014). Availability of pasture for domestic and wild herbivores in grazing land of Mpanda Tanzania. *Livestock Research for Rural Development*, *26*(2).

Kimiti, K. S., Western, D., Mbau, J. S., & Wasonga, O. V. (2018). Impacts of long-term land-use changes on herd size and mobility among pastoral households in Amboseli ecosystem, Kenya. *Ecological Processes*, *7*, 1–9.

Kirkbride, M. (2008). *Survival of the fittest: Pastoralism and climate change in East Africa* (Vol. 116). Oxfam.

Klingebiel, S. (2000). *Socio-political impact of development cooperation measures in Tanzania: analysing impacts on local tensions and conflicts*. German Development Inst.

Lagopoulos, A. P. (2018). Land-use planning methodology and middle-ground planning theories. *Urban Science*, *2*(3), 93.

Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources*, *28*(1), 205–241.

Marczyk, G. R., DeMatteo, D., & Festinger, D. (2010). *Essentials of research design and methodology*. John Wiley & Sons.

Mbwambo, N., Nandonde, S., Ndomba, C., & Desta, S. (2016). Assessment of animal feed resources in Tanzania. *Tanzania Livestock Master Plan Background Paper*, 7.

Mekuyie, M., Jordaan, A., & Melka, Y. (2018). Land-use and land-cover changes and their drivers in rangeland-dependent pastoral communities in the southern Afar Region of Ethiopia. *African Journal of Range & Forage Science*, *35*(1), 33–43.

Merriam-Webster. (2024). *Viability Definition & Meaning - Merriam-Webster*. https://www.merriam-webster.com/dictionary/viability

Miles, M. B. (2014). *Qualitative data analysis: a methods sourcebook* (edition 3). SAGE Publications Ltd.

Mohammed, M., Habtamu, T., & Yared, M. (2017). Land use/cover change analysis and local community perception towards land cover change in the lowland of Bale rangelands, Southeast Ethiopia. *International Journal of*

Biodiversity and Conservation, *9*(12), 363–372. https://doi.org/10.5897/ijbc2017.1131

Momeni Amir and Pincus, M. and L. J. (2018). Cross Tabulation and Categorical Data Analysis. In *Introduction to Statistical Methods in Pathology* (pp. 93–120). Springer International Publishing. https://doi.org/10.1007/978-3-319-60543-2_5

Moradi, F., Kaboli, H. S., & Lashkarara, B. (2020). Projection of future land use/cover change in the Izeh-Pyon Plain of Iran using CA-Markov model. *Arabian Journal of Geosciences*, *13*(19), 998.

Morara, M. K., MacOpiyo, L., & Kogi-Makau, W. (2014). *Land use, land cover change in urban pastoral interface. A case of Kajiado County, Kenya*.

Mugo Fridah, W. (2002). Sampling in research. *Retrieved July*, *30*, 2019.

Muhammad, K., Mohammad, N., Abdullah, K., Mehmet, S., Ashfaq, A. K., & Wajid, R. (2019). Socio-political and ecological stresses on traditional pastoral systems: A review. *Journal of Geographical Sciences*, *29*, 1758–1770.

Mung'ong'o, H. G. (2022). Agro-pastoralist Resilience: Emerging Challenges towards Innovated Pathways of Climate Change Effects in Semi-arid areas of Kiteto and Kilindi Districts, Tanzania. *African Journal of Accounting and Social Science Studies*, *4*(1), 19–45. https://doi.org/10.4314/ajasss.v4i1.2

Mussa, M., Teka, H., & Mesfin, Y. (2017). Land use/cover change analysis and local community perception towards land cover change in the lowland of Bale rangelands, Southeast Ethiopia. *International Journal of Biodiversity and Conservation*, *9*(12), 363–372.

Mwambene, P. L., Mbwile, R. P., Höggel, F. U., Kimbi, E. C., Materu, J., Mwaiganju, A., & Madoffe, S. (2014). Assessing dynamics of forced livestock movements, livelihoods and future development options for pastoralists/agro-pastoralists in Ruvuma and Lindi Regions, in the Southern Tanzania. *Livestock Research for Rural Development*, *26*(1).

Mwamfupe, D. (2015). Persistence of farmer-herder conflicts in Tanzania. *International Journal of Scientific and Research Publications*, *5*(2), 1–8.

Mwihomeke, S. T., Msangi, T. H., Mabula, C. K., Ylhäisi, J., & Mndeme, K. C. H. (1998). Traditionally protected forests and nature conservation in the North

Pare Mountains and Handeni District, Tanzania. *Journal of East African Natural History*, *87*(1), 279–290.

NCMC. (2017). *THE UNITED REPUBLIC OF TANZANIA TANZANIA'S FOREST REFERENCE EMISSION LEVEL SUBMISSION TO THE UNFCCC*. https://www.ncmc.sua.ac.tz/wp-content/uploads//2018/files/FREL/Tanzanias-forest-reference-FINAL.pdf

Nedd, R., Light, K., Owens, M., James, N., Johnson, E., & Anandhi, A. (2021). A synthesis of land use/land cover studies: Definitions, classification systems, meta-studies, challenges and knowledge gaps on a global landscape. *Land*, *10*(9), 994.

Potapov, P., Hansen, M. C., Pickens, A., Hernandez-Serna, A., Tyukavina, A., Turubanova, S., Zalles, V., Li, X., Khan, A., Stolle, F., Harris, N., Song, X. P., Baggett, A., Kommareddy, I., & Kommareddy, A. (2022). The Global 2000-2020 Land Cover and Land Use Change Dataset Derived From the Landsat Archive: First Results. *Frontiers in Remote Sensing*, *3*. https://doi.org/10.3389/frsen.2022.856903

Prins, W. H., & Kessler, W. (2014). The European Grassland Federation at 50: past, present and future. *Grassland Science in Europe, Vol. 19*, 60.

Punch, K. F. (2016). *Developing effective research proposals*. SAGE Publications Ltd.

Ramankutty, N., Graumlich, L., Achard, F., Alves, D., Chhabra, A., DeFries, R. S., Foley, J. A., Geist, H., Houghton, R. A., Goldewijk, K. K., & others. (2006). Global land-cover change: Recent progress, remaining challenges. *Land-Use and Land-Cover Change: Local Processes and Global Impacts*, 9–39.

Ravitch, S. M., & Riggan, M. (2016). *Reason & rigor: How conceptual frameworks guide research*. Sage Publications.

Ruddiman, W. F. (2003). The anthropogenic greenhouse era began thousands of years ago. *Climatic Change*, *61*(3), 261–293.

Russell, S., Tyrrell, P., & Western, D. (2018). Seasonal interactions of pastoralists and wildlife in relation to pasture in an African savanna ecosystem. *Journal of Arid Environments*, *154*, 70–81.

SAGE. (2006). *The Sage Dictionary of Social Research Methods*.

Shearer, C. A., & Webster, J. (1985). Aquatic hyphomycete communities in the River Teign. III. Comparison of sampling techniques. *Transactions of the British Mycological Society*, *84*(3), 509–518.

Stufflebeam, D. L. (2000). The CIPP model for evaluation. In *Evaluation models: Viewpoints on educational and human services evaluation* (pp. 279–317). Springer.

Sulieman, H. M., & Elagib, N. A. (2012). Implications of climate, land-use and land-cover changes for pastoralism in eastern Sudan. *Journal of Arid Environments*, *85*, 132–141. https://doi.org/10.1016/j.jaridenv.2012.05.001

Taherdoost, H. (2016). Sampling Methods in Research Methodology; How to Choose a Sampling Technique for Research. In *International Journal of Academic Research in Management (IJARM)* (Vol. 5, Issue 2). https://ssrn.com/abstract=3205035

Takada, T., Miyamoto, A., & Hasegawa, S. F. (2010). Derivation of a yearly transition probability matrix for land-use dynamics and its applications. *Landscape Ecology*, *25*, 561–572.

Tessema, W. K., Ingenbleek, P. T. M., & Van Trijp, H. C. M. (2014). Pastoralism, sustainability, and marketing. A review. In *Agronomy for Sustainable Development* (Vol. 34, Issue 1, pp. 75–92). EDP Sciences. https://doi.org/10.1007/s13593-013-0167-4

Titeux, N., Henle, K., Mihoub, J.-B., Regos, A., Geijzendorffer, I. R., Cramer, W., Verburg, P. H., & Brotons, L. (2016). Biodiversity scenarios neglect future land-use changes. *Global Change Biology*, *22*(7), 2505–2515.

Tuckman, B. W., & Harper, B. E. (2012). *Conducting educational research* (six edition). Rowman & Littlefi eld Publishers, Inc.

URT. (2022). *The United Republic of Tanzania Administrative Units Population Distribution Report*.

Warner, T. A., Campagna, D. J., & Sangermano, F. (2021). *S I ® A Beginner's Guide*.

Were, K. O., Dick, Ø. B., & Singh, B. R. (2013). Remotely sensing the spatial and temporal land cover changes in Eastern Mau forest reserve and Lake Nakuru drainage basin, Kenya. *Applied Geography*, *41*, 75–86.

Winnegge, R. (2005). Participatory approach in integrated watershed management. *Proceedings of Topics of Integrated Watershed Management*, *3*, 187–202.

Worku, A., Garedew, E., & Yimer, F. (2018). Assessment of Land use Land cover change and its Implication on Agro-pastoral area of Gode District, Somali Regional State Ethiopia. *Journal of Environment and Earth Science*, *18*(1).

Yanda, P. Z., & Mung'ong'o, C. G. (2018). *Pastoralism and climate change in East Africa*. Mkuki na Nyota Publishers.

Yin, R. K. (2009). *Case study research: Design and methods* (Vol. 5). sage.

APPENDICES

Appendix 1: Research questions

The following were the guiding questions for key informants and the FGDs

TOPIC ONE: GENERAL CHANGES

1. Can you describe any noticeable changes in the land use and land cover in this area over the past 20 years? (For youth as far as they remember)?
2. What specific activities or developments have contributed to changes in the landscape?

TOPIC TWO: IMPACTS OF LAND USE/COVER ON PASTURE VIABILITY

Pasture Quality

3. Have you observed changes in the quality of the pastures where you graze your animals due to LULCC?
4. How do these changes impact the nutritional value of the available forage?

Availability of Pasture

5. Have there been alterations in the availability of pastureland for your animals due to LULCC?
6. How have these changes affected the size and accessibility of grazing areas?

Climate and Weather Patterns

7. Have you noticed any shifts in climate or weather patterns that have affected the pastures as a result of LULCC?
8. How have these changes influenced the growth and regrowth of vegetation in the pastures?

Biodiversity and Ecosystem Health

9. In your experience, how has the biodiversity of the pasture ecosystem changed over time as a result of LULCC?
10. What are the implications of these changes for the overall health of the pasture ecosystem?

Impacts on Livestock Health

11. Have you observed any effects on the health of your livestock due to changes in pasture conditions as a result of LULCC?
12. How have you adapted your animal husbandry practices to address these health concerns?

TOPIC THREE: ADAPTATION STRATEGIES

13. What strategies have you employed to cope with the changing land usd/cover and pasture conditions?
14. Are there traditional or innovative methods that have proven effective in mitigating the impacts of LULCC?

TOPIC FOUR: LONG-TERM CONCERNS

15. Looking ahead, what are your long-term concerns regarding the sustainability of pasture resources in relation to LULCC?

16. What measures do you think could help in sustaining viable pastures for future generations?

Appendix 2: Classification Accuracies (%)

	YEAR	**2003**		**2014**		**2023**	
LAND USE/COVER	Accuracy	UA	PA	UA	PA	UA	PA
	Water	0	0	100	100	0.0	0
	Cultivation	71.46	58.18	95.87	95.87	86.78	77.78
	Forest	100	79.72	100	100	66.21	100
	Woodland	91.40	86.43	92.30	86.95	89.09	84.48
	Bushland	76.12	92.28	0.840	85.39	88.78	84.06
	Grassland	79.23	76.35	85.4	93.60	70.23	92.18
Overall Accuracy		**87.7**		**87.5**		**87.6**	
O. Kappa Index		**0.82**		**0.899**		**0.84**	

UA = User's Accuracy, **PA** = Producer's Accuracy

Appendix 3: University reference letter to Tanga Regional Administrative Secretary

UNITED REPUBLIC OF TANZANIA

MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGY

UNIVERSITY OF DAR ES SALAAM

OFFICE OF THE VICE CHANCELLOR

Ref. No: AB3/12(B) Date: 23 April, 2023

Regional Administrative Secretary
Tanga Region

RE: REQUEST FOR RESEARCH CLEARANCE

1. The purpose of this letter is to introduce to you **Julius Daniel** who is a bonafide student of the University of Dar es Salaam (UDSM) and who is at the moment required to conduct research. Our students undertake research activities as part of their study programmes.

2. In accordance with government circular letter Ref. No. MPEC/R/10/1 dated 4th July 1980, the Vice-Chancellor of the University of Dar es Salaam is empowered to issue research clearances to staff members and students of the University of Dar es Salaam on behalf of the government and the Tanzania Commission for Science and Technology (COSTECH). I am pleased to inform you that I have granted a research clearance to **Julius Daniel**.

3. I therefore, kindly request you to grant any help that may enable the student(s) achieve the research objectives. Specifically we request your permission for the researcher to meet and talk to the leaders and other relevant stakeholders in your administrative area in connection with this research.

4. The title of the research is **"The Impacts of Land-use/cover Change on Pastures in Pastoral Communities in Kilindi District, Tanzania"**.

5. The period of the research is from **10 April, 2023 to 31 December, 2023** and the research will cover **Tanga region**.

6. Should there be any restriction, you are kindly requested to advise us accordingly. In case you may require further information, please do not hesitate to contact us through the Directorate of Research and Publication, Tel. +255 22 2410500-8 Ext. 2084 or +255 22 2410727 and E-mail: research@udsm.ac.tz

Yours sincerely,

William A.L Anangisye

VICE CHANCELLOR

Cranford Pratt Building, University of Dar es Salaam, P.O. Box 35091, Dar es Salaam.
Phone: +255 22 2410500-8 Ext. 2084, Direct: +255 22 2410700, Email: vc@admin.udsm.ac.tz, Website: www.udsm.ac.tz

Appendix 4: Regional clearance letter

THE UNITED REPUBLIC OF TANZANIA
PRESIDENT'S OFFICE

REGIONAL ADDMINISTARTIVE AND LOCAL GOVERNMENT

Phone: 027 2642421
Fax: 027 2647752
E-mail: ras.tanga@tamisemi.go.tz

Regional Commissioner's Office
P.O.BOX 5095
TANGA

22th may, 2023

Ref. No.DA.228/258/07/52

Director,
Kilindi District Council,
P.O.Box 18
Songe
KILINDI

RE: REQUEST FOR RESEARCH CLEARANCE

Reference is made to the heading above

2. Iam pleased to introduce *Mr Julius Daniel* who is a bonafide student of the University of Dar es Salaam (UDSM) with ***Registration number 2021 – 06 – 01953*** and who is at the moment required to conduct research. The title of the research is ***'The impacts of Land – use / cover Change on Pastures in Pastoral Communities in Kilindi District Tanzania'.***

3. In accordance with the Government Circular Letter with Ref. No. MPEC/R/10/01 dated 4th July, 1980 the Vice Chancellor of the University on behalf of the Government and the Tanzania Commission for Science and Technology (COSTECH). Iam pleased to inform you that I have granted and research clearance to ***Mr. Julius Daniel***.

1

4. Kindly, be informed that the permission to collect data for academic research project has been granted from 10th April, 2023 to 31st December, 2023. Pleased accord them for any needed assistance so that this research study is success.

5. Thanking you for continued cooperation.

Athanas S. Michael
For: REGIONAL ADMINISTRATIVE SECRETARY,
TANGA

Copy: District Administrative Secretary,
KILINDI

Mr. Julius Daniel
P.O.Box 35091
DAR ES SALAAM

Appendix 5: District Clearance Letter

JAMHURI YA MUUNGANO WA TANZANIA

OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA

HALMASHAURI YA WILAYA YA KILINDI

Unapojibu tafadhali taja:

Kumb. Na. KDC/C.50/50/233 26/05/2023

Watendaji Kata za
Kibirashi na Saunyi,
KILINDI.

YAH: KIBALI CHA KUFANYA UTAFITI KUHUSU THE IMPACTS OF LAND-USE/COVER CHANGE ON PASTURES IN PASTORAL COMMUNITIES IN KILINDI DISTRICT TANZANIA.

Tafadhali husika na mada hapo juu.

2. Ofisi ya Mkurugenzi Mtendaji Wilaya imepokea barua kutoka Ofisi ya Mkuu wa Mkoa yenye Kumb. Na. DA.228/258/07/52 ya tarehe 22/05/2023 inayo hitaji kibali kwa ajili ya utafiti kuhusu" **(THE IMPACTS OF LAND- USE/COVER CHANGE ON PASTURES IN PASTORAL COMMUNITIES IN KILINDI DISTRICT TANZANIA)**

3. Utafiti huu utafanyika kati ya April 10, 2023 hadi mwezi Desemba 31, 2023. Hivyo mnaelekezwa kutoa ushirikiano utakao hitajika ili kukamilisha utafiti huu kama ilivyokusudiwa. Aidha Takwimu zitakazo kusanywa kutokana na utafiti huu ni kwaajili ya matumizi ya ndani tu.

4. Kwa barua hii idhini imetolewa kwa **Bw, Julius Daniel** mwanafunzi kutoka Chuo Kikuu cha Dar es Salaam kwa ajili ya kufanya utafiti katika Halmashauri.

5. Nawatakia utekelezaji mwema.

Kulwa S.Ngurai
Kny.MKURUGENZI MTENDAJI (W)
KILINDI.

Kny: MKURUGENZI MTENDAJI
HALMASHAURI YA WILAYA
KILINDI

Nakala: Mkurugenzi Mtendaji (W) – Aione kwenye jalada
KILINDI

2 barabara ya kasumo, S.L.P 18 Songe-Kilindi, postikode: 21982, Simu:+255 27 2977306, nukushi: +255 27 2977307,barua pepe: ded@kilindidc.go.tz tovuti:-www.kilindidc.go