ANALYSIS OF EFFECTS OF HUMAN ENCROACHMENT ON KIBORGOCH WETLAND AND ITS ECOSYSTEM SERVICES

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A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for the Degree of Master of Science in Environmental Science of Egerton University

EGERTON UNIVERSITY

OCTOBER, 2025

DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented for a degree in this or any other University.

Signature: .... Date 1st October 2025

Isiaho Glarion Khasandi

NM12/14549/18

Recommendation

This thesis has been submitted with our approval as university supervisors.

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DEDICATION

This work is dedicated to Yahweh, for He has brought me this far, as well as my child, Gabriella Mwende for her continuous motivation, inspiration and support in my life.

ACKNOWLEDGEMENTS

I appreciate God, Almighty for granting me the grace to be able to complete this journey. This research and thesis completion was made possible by support from particular individuals and institutions. I am so grateful for the support that I received from Egerton University, Faculty of Environment and Resources Development and the Research and Extension Section. I would also like to sincerely appreciate my supervisors, Prof. George M. Ogendi and Dr. Amon Karanja, who have given me invaluable insight, expertise, feedback and continuous encouragement. They literally held my hand through this journey and I am eternally grateful to them for this accomplishment in my academic segment. I also acknowledge Mr. Patrick Kurere, Mr. James Kimaru, and Mr. Chirchir Tuitoek from Kiborgoch Wildlife and Wetlands Conservancy for their immeasurable assistance during my fieldwork. Additionally, a special thanks go to the field assistants and local leaders of Kiborgoch Wildlife and Wetlands Conservancy for their contributions in the data collection process. Lastly, I appreciate my dear mother, Esther Aligulah for her unending encouragement, prayers and support which have actually been the foundation of my academic and personal growth.

ABSTRACT

Kiborgoch Wetland is an ecologically and socio-economically important ecosystem in Kenya, but faces increasing pressures from human-induced activities. Dominant macrophyte species include *Cyperus papyrus*, *Vachellia reficiens*, *Indigofera spinosa*, and *Cyperus alopecuroides*. In Marigat region, the most members of the local communities obtain their livelihoods from Kiborgoch Wetland resulting in overuse. The wetland degradation drivers such as uncontrolled grazing in dry and wet seasons, unclear land tenure, rapid population growth capitalizes by climate change and poor implementation of policies that protect wetlands have intensified unsustainable activities, including water abstraction, excessive harvesting of wetland vegetation, and agricultural expansion. The objective of this research study was to assessed the extent, drivers, and impacts of wetland encroachment from 1994 to 2024. The study utilized a mixed-methods research design combining macrophytes assessments, Geographic Information System analyses together with social surveys to evaluate spatial-temporal changes, ecological conditions, and socio-economic implicationsThe Southern section of the wetland showed the highest form of diversity for both Shannon Diversity Index and Simpson's Diversity Index, with an overall index of 0.81 for the entire wetland. This showed that the wetland is relatively diverse. Fabaceae and Cyperaceae were the most dominant macrophyte families in the wetland, with 36 plants species identified from 18 families. Drivers of degradation were also analyzed with overgrazing being the largest contributor together with encroachment as a result of agricultural expansion. Population growth, reduced river discharge and climate variability were also identified as drivers of Kiborgoch Wetland degradation. This work is important as it gives a spot light to conservation strategies that combine indigenous knowledge with scientific methods. It also emphasizes the need for sustainable land policies that would encourage the protection of ASAL wetland and enhancement of community involvement that would improve the resilience of Kiborgoch Wetland.

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LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
ASALs	Arid and Semi-Arid Lands
BCIDP	Baringo County Integrated Development Plan
CBD	Convention on Biological Diversity
DPSIR	Drivers, Pressure, State, Impact and Response
EMCA	Environmental Management and Coordination Act
ETM	Enhanced Thematic Mapper
FGD	Focus Group Discussion
GEF	Global Environment Facility
GIS	Geographic Information System
GPS	Global Positioning System
IPCC	Intergovernmental Panel on Climate Change
KNBS	Kenya National Bureau of Statistics
LANDSAT	Land Satellite
LULCC	Land Use and Land Cover Change
MDGs	Millennium Development Goals
MODIS	Moderate Resolution Imaging Spectroradiometer
NACOSTI	National Commission for Science, Technology and Innovation
NDVI	Normalized Difference Vegetation Index
RS	Remote Sensing
SDGs	Sustainable Development Goals
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER ONE
INTRODUCTION

1.1 Background of the study

Wetlands, such as bogs, marshes, and swamps, are vital habitats characterized by the presence of water either seasonally or permanently (Mitsch & Gosselink, 2015) and adequate to sustain unique vegetation adapted to thrive in waterlogged or saturated soil conditions (Wetlands, 2017). Although wetlands cover only a small portion of the Earth's surface, they deliver a wide range of vital ecosystem services (Chakraborty *et al*., 2023; Lahon *et al*., 2023). These critical ecosystems offer a wide range of ecological, hydrological, and socio-economic benefits, including water filtration, biodiversity support, carbon sequestration, and flood regulation (Altieri *et al.,* 2022; Imdad *et al*., 2023; Jisha & Puthur, 2021; Mitra *et al*., 2022; Nag *et al.,* 2023; Zekarias & Gelaw, 2025

Wetland's ability to perform important functions such as provision of ecosystem services that benefit humans and nature is threatened by human induced activities that include rapid and uncontrolled increase in population and dilapidated soil health conditions in arable land Gardner & Finlayson, 2018; Maitima *et al.,* 2009). The world has currently made management of wetlands a priority in a bid to conserve these important ecosystems (Sharma & Singh, 2021). The commendable efforts are unfortunately not yielding much fruits as anticipated as wetlands are still under threat from drainage, change in land use, expansion of agriculture, both livestock and crops, and negative impacts of invasive species and alteration of water patterns (Agostoni *et al.,* 2024; Brain & Prosser, 2022; Jamal *et al.,* 2025; Maru *et al.,* 2023; Pal *et al.,* 2024; Xu *et al.,* 2019).

The formation of wetlands largely depends on topography, geomorphology and geological structure that ultimately determine local microclimate and even drainage (Job & Sieben, 2022). From time in memorial, wetlands have been seen as important location for food production, which has led to them being drained and converted to agricultural fields (Mañego *et al*., 2024). This is because wetlands have very fertile soils and high moisture levels that is believed to lead to high yields (Ballut-Dajud *et al.,* 2022; Maithya *et al.,* 2022). In Africa, wetlands are regarded as important source of livelihood and sources of raw materials as well as herding grounds for livestock farmers as it rich in fodder and animal grasses (Marambanyika & Beckedahl, 2016; Marambanyika *et al.,* 2021). As a result of this, local neighboring communities over-depend on these ecosystems to meet their daily needs which continues to intensify pressure on them (Ofori *et al.,* 2021).

Wetlands are perceived to actively contribute to between 10% to 40% of annual food production in East African counties, especially in rural area (Schuyt, 2005). Notably, negative effects of climate change such as erratic rainfall patterns, prolonged drought and increased temperatures are placing further stress on the already delicate ecosystems (Desta *et al.,* 2012).

In Kenya, 3% to 4 % of the total land area is occupied by wetlands including lakes, swamps, mashes, blogs (Atlas, 2012; Macharia *et al.,* 2010). This total area may be regarded as a relatively small proportion but they are pivotal in sustaining both human lives and ecological well-being through sustaining biodiversity, regulate the cycle of water, and sustain the livelihood of riparian communities (Singha & Pal, 2023). Despite the impotence that is exhibited by and experienced from these ecosystems, they are continuously undergoing degradation that is mainly propelled by cultivation, overgrazing, unsustainable harvesting of wetland plants (Maua *et al.,* 2022; Oduor *et al*., 2015). This had resulted to reduced performance of ecological services (Alemayehu et al., 2023). It is further highlighted that wetland ecosystems are deteriorating more than any other ecosystems in the world as they are largely affected by expansion of infrastructure and land conversion (Ballut-Dajud *et al*., 2022).

Kiborgoch wetland, located in the Kiborgoch Community Wildlife and Wetland Conservancy is regarded as an important land map that supports local livelihood, and is of high importance in ecological and cultural landscape. Rising population pressure experienced due to movements from high potential areas to ASAL area has created unprecedented intensification of land use around the wetland. This has resulted to degradation that is not only linked to unsustainable cultivation, overgrazing, excessive harvesting of wetland vegetation for cottage industries but also contamination from municipal and industrial waste. This ahs in turn altered the natural dynamics of native plant cover and thus a poor ecological balance which eventually interferes with vital ecosystem services for nature and human alike.

1.1 Statement of the Problem

Kiborgoch wetland has over the years experienced degradation with poverty being at the center of it all. Poverty has brought about over-reliance and over-dependance of the wetland by members of the communities as a source of livelihood, for either farming, grazing on animals, harvesting of wetland plants for fuel, feeding and building. Additionally, poverty is also hindering investors from investing their resources to the conservation of this wetland because it is feared that over reliance on the wetland is more as opposed to the long-term benefit that could be derived from the ecosystem. In addition to the poverty problem, it is important to have a bigger picture of indirect and direct factors that contribute to the state of a degraded wetland as emphasized by Ondiek *et al.* (2020). This is because previous studies have mostly focused on issues of land degradation and socio-economic change, and overlooked issues that deal with understanding the condition of wetland vegetation, its ecological functioning, and the services they provide. Without such important information, it becomes extremely difficult to identify critical areas for intervention and therefore develop context-appropriate management strategies, or track the outcomes of restoration efforts (Adeel *et al*., 2007).

As a result, various human activities for example such as overgrazing, agricultural expansion, forest clearing, and settlement have disrupted key ecological processes. These disturbances have contributed to soil erosion, increased sediment and agrochemical loads in surface runoff, deforestation, land subdivision, and encroachment into fragile habitats. The combined influence of poverty-driven reliance on natural resources and escalating human pressure continues to undermine the ecological integrity and long-term sustainability of the Kiborgoch Wetland ecosystem.

1.2 Research Objective

1.2.1 Broad Objective

To contribute to the understanding of the degree of wetland encroachment and changes in wetland vegetation, and their impact on ecosystem services in Kiborgoch wetland.

1.2.2 Specific Objectives

i. To evaluate the spatial temporal vegetation changes in Kiborgoch wetland between 1994 to 2024.

ii. To analyse the drivers and extend of encroachment of Kiborgoch wetland between 1994 to 2024.

iii. To assess the effects of Kiborgoch wetland encroachment on ecosystem services.

1.3 Research Question

i. How have the vegetation changes evolved in Kiborgoch wetland from 1994 to 2004?

ii. What are the drivers and extend of encroachment in the Kiborgoch wetland from 1994 to

2024?

iii. How is the ecosystem services affected with the encroachment of Kiborgoch wetland?

1.4 Justification of the Study

The value of this study is to be able to positively contribute to the implementation of the Kunming-Montreal Global Biodiversity Framework (GBF) under the Convention on Biological Diversity. By generating site-specific information on wetland degradation, such as ASAL wetland like Kiborgoch wetland, its vegetation composition and condition, and human-induced drivers and pressures, this research provides critical baseline data to guide conservation planning, sustainable management, and restoration interventions. Both macrophytes and macrophytes provide home for migratory species, breeding and protection from predators (Crance, 1988). This study seeks to understanding their distribution, diversity, and response to anthropogenic pressures to supports the GBF's targets by informing strategies that reduce direct threats to biodiversity, promote ecosystem resilience, and foster sustainable utilization of wetland resources.

Up to date maps of LULCC Kiborgoch community wildlife and wetland conservancy was produced by this study. This will later be used to inform key decisions making agenda by stakeholders. It also sought to suggest sustainable approaches for restoring the wetland and its use by residents, fostering harmony between the wetland and the community. This effort directly supports Kenya's Vision 2030 aimed at transforming Kenya into a newly industrializing middle-income country providing a high quality of life to all its citizens by 2030 in a clean and secure environment.

To be able to support and implement the existing framework to support Baringo County Integrated Development Plan in achieving its objectives under the Environment, Protection, Water, and Natural Resources category, this study was essential. It contributed to giving direction to enhanced conservation efforts. This in turn aided in the safeguarding of priority area particularly through the restoration and rehabilitation of wetlands such as Kiborgoch.

Lastly, this analysis, aided in realizing the objective of Africa's 2063 Agenda, which aims for the equitable and sustainable utilization and management of water resources to foster socio-economic development, regional cooperation and environmental sustainability. By focusing on the conservation and management of wetland resource, the study contributes to ensuring long term viability of aquatic supplies.

1.5 Scope of the Study

To carry out this research, data collection was done in Kiborgoch Wetland between October and December 2024. The objective was to characterize wetland plant species, their composition, and their diversity, as well as to examine the drivers of wetland depletion and damage. These included the direct loss and degradation of plant cover due to wetland encroachment from 1994 to 2024, and the decline of ecosystem services resulting from human activities in and around the wetland.

1.6 Study Limitations

Potential biasness was anticipated to be one of the limitations when conduction social survey or key informants' interviews. To address this limitation, together with the research assistants, we combined social survey with ecological survey and did ground truthing to complement the information with RS data. Additionally, we assured respondents of anonymity and communicated the importance of providing honest information to support evidence-based conservation planning.

Secondly, the wetland area had physical inaccessibility due to dense vegetation, waterlogging, or restrictions related to private land boundaries. To deal with the problem, we utilized remote sensing technologies to capture data in hard-to-reach wetland sections. We also sought permission from actively involved local stakeholders to facilitate access and enhance community cooperation.

1.7 Definition of Terms

Anthropogenic interference - Refers to human induced activities that may lead to deterioration of a state any ecosystem.

Biodiversity - Variability among living organisms from all sources including ecosystems and the ecological complexes of which they are a part. It encompasses the ecosystem, species, and genetic diversity.

Climate change - Climate change refers to long-term alterations in the average weather patterns that characterize Earth's local, regional, and global climates.

Ecosystem services - These are the benefits that wildlife and ecosystems provide to humans. They encompass the diverse advantages derived from a healthy natural environment, including ecosystems such as agro-ecosystems, forests, grasslands, and aquatic systems.

Fragile ecosystems - This is an ecosystem that has been adversely affected by forces of nature resulting in the destabilization of the balance of the living and non-living organisms in it and making it vulnerable to destruction.

Hydrophyte - Vegetation adapted to grow in water or in soils that periodically experience low oxygen levels because of water saturation.

Land use change – This is alteration of the natural landscape by human activities, emphasizing its economic functions.

Sustainable use - means the present use of the environment or natural resources, which does not compromise the ability to use the same by future generations or degrade the carrying capacity of supporting ecosystems.

Wetland - This is a zone that collects and filters natural water. It is a zone through which the rainwater and snow seeps to eventually provide base flow to rivers, lakes and spring water and also provides for groundwater recharge.

Wetland functions – The physical, biological, chemical, and geological interactions among different components of the environment that occur within a wetland. There are many valuable functions that wetlands perform, but these can be grouped into three categories: functions that improve water quality, functions that change the water regime in a watershed such as flood storage, and functions that provide habitat for plants and animals.

Wetland restoration – This is re-establishment of a disturbed or altered wetland. This may include restoring original vegetation, hydrology, or other key parameters to recover wetland functions to their original or near-original state.

Wetland goods– This is wealth/physical items derived from natural products of wetlands, these includes fish and shellfish, blueberries, cranberries, timber and wild rice. Some medicines are derived from wetland soils and plants.

Wetland wise use - Wise use means maintenance of the ecological character of the wetland and allowance of sustainable use for the benefit of the people and the environment.

CHAPTER TWO

LITERATURE REVIEW

2.1 Functions and Dynamics of Wetland Vegetation

Vegetation forms the bedrock of ecological systems and serves as a focal point in numerous habitat dynamics models utilized for forecasting and management (Riddick *et al.,* 2017). For instance, Poyang Lake, considered a top biodiverse ecosystem globally, plays a critical role in East Asia's migratory bird habitats due to its wetland climate and abundant vegetation productivity (Yuan *et al.,* 2019). The plants that are found in a wetland area are important because they support biodiversity protection, regulate climate and store water (Bolpagni, 2020; Gallant, 2015; Faddema *et al.*, 2005).

Coastal wetland vegetation such as mangrove, act as a shield against the constant rising sea levels (Schuerch, 2018). These wetland plants trap soil particles and contribute to its formation through litter and its root systems. Wetlands can however adapt to rising waters by building up sediment vertically, effectively raising the land surface and reducing the risk of submergence (Bomer *et al.,* 2020). Wetland plant communities are not similar in all wetland bodies. Their makeup changes across different locations depending on factors such as climate (Liu *et al*., 2013), soil type (Liu *et al.,* 2022), and water cycle patterns (Toogood & Joyce, 2009). Wetland plants found in Kiborgoch wetland are not just essential in provision of ecosystem services such as food and water or maybe habitat but also plays impactful roles such as cleansing of water and controlling of soil erosion to name but a few (Deng *et al.,* 2014). The changes experienced in terms of shifts in wetland vegetation more often than not act as early indicators of changes in enough water for people and healthy nature (Tan *et al*., 2022). The structure and dynamics of these plant communities are largely driven by hydrological patterns, with vegetation responding adaptively to changes in water regimes (Yan *et al*., 2020; Yu *et al*., 2023).

In Africa, *Cyperus papyrus* is the most common species in permanent swamps (Beadle, 1981). In East African countries, seasonal wetlands are mostly inhabited by perennial grasses, while swampy areas give conducive environment for growth of tree species such as *Mitragyna stipulosa*, *Macaranga schweinfurthii*, *Phoenix reclinata*, and *Calamus deeratus* (Behn, 2022). Areas such as the shores of Lake Victoria, is dominated by wetland plants species such as *Cyperus papyrus* and/or *Miscanthidium violaceum*, species such as *Phragmites mauritius*, *Typha domingensis*, *Laudetia phragmitoides*, and *Vossia cuspidata* however are less dominant in Lake Victoria (Kansiime *et al*., 2007). Papyrus thrives in transitional zones between permanently wet and drier areas, which makes it a defining feature of the Lake Victoria Basin (Maithya *et al*., 2020). Wetlands in this region are highly productive and provide a wide range of vital environmental services (Osumba *et al.,* 2010).

It is also worth noting that wetland plants such as papyrus has currently become one of the most valuable resources in highly productive wetlands. In the past, it was harvested on a small scale for the purposes of crafting and construction (Onganya, 2023). It is now widely used commercially for a variety of purposes such as crafts, roofing, and fencing (Moindi, 2023). Other than these traditional uses, it also shows potential use for paper production (Mohamed, 2023), and as fodder for livestock (Abdelwahed, 2024), and even as a source of renewable energy (Jones, 2018).

2.2 Wetland's Ecosystem Services

Wetlands are very important natural ecosystems that have many benefits for people and nature alike (Tooth *et al.,* 2015). They help with the regulation of flow of water while also reducing flooding, recharge groundwater sources, helps in cycle nutrients, retention of sediments, and store carbon (Mitsch *et al*., 2013; Mitsch & Gosselink, 2015). The structure and function wetlands are shaped by water patterns conditions, though local variations actually occur depending on the landform and continuous catchment processes (Grenfell *et al.,* 2019). Additionally, coastal wetlands are valuable in protecting ecosystems from rising sea levels and extreme weather events (Zheng *et al.,* 2023). They also play a pivotal role in the control of floods, which is a problem experienced with the change in climatic conditions, preventing erosion, stabilizing shorelines, and filtering water to reduce pollutants (Jisha & Puthur, 2021). Some wetlands remain connected to underlying aquifers (Chen, 2023) therefore acting like natural sponges therby storing water during dry periods and helping manage floods when rainfall is heavy (Cong *et al.,* 2023).

Wetlands are able to preserve their water capacity and storage depending on their hydrological cycle together with rainfall season changes (Maltby & Acreman, 2011). When they are full to their maximum capacity, they are not in a position to hold much more water (Acreman *et al.*, 2007). Organisms of all sizes depend on wetlands as their habitat, therefore making the ecosystems being considered as remarkably biodiverse (Hammer & Bastian, 2020). Almost all known waterbirds species, in one way or another heavily rely on wetlands as crucial feeding and breeding habitats (Rajpar & Zakaria, 2013). Several factors however influence bird presence, including wetland size, water depth, vegetation cover, topography, and connectivity with other wetlands (Giosa *et al.,* 2018). Wetlands which are smaller in size support a considerable smaller diversity as opposed to bigger wetlands that supports wider range of species therefore offering more diversity, breeding opportunities as well as foraging (Giosa *et al.*, 2018). Water depth, in particular, affects habitat accessibility. Shallow wetlands tend to attract more species, as they can accommodate non-diving birds that cannot forage in deeper waters (Guadagnin & Maltchik, 2007; Sebastian-Gonzales & Green, 2014).

Deterioration of the conditions of wetland affect migratory bird which rely on the ecosystem during their long journey (He *et al.,* 2023). It is therefore of utmost importance to protect these ecosystems for this reason. Swamps, mangroves, peatlands, and marshes play a pivotal role in global carbon cycle (Bautista *et al.,* 2023). Their sediments act as long-term carbon stores, while the ecosystems themselves contribute roughly 40% of global methane emissions. With some of the highest carbon densities among terrestrial ecosystems, wetlands also have a remarkable capacity to sequester additional carbon dioxide (Skeie *et al.,* 2023). The low-oxygen soils common in these habitats' slow decomposition, allowing organic matter to accumulate over time and making wetlands significant sinks for atmospheric carbon. In some cases, they can hold more than 40% of soil carbon (Moritz *et al.,* 2023). Wetlands that support the growth of paddy rise also supports farmers in such a way that they reduce dependency on agrochemicals and limit pollution discharge to water sources (Ravikumar *et al.,* 2022). Moreover, wetlands support diverse biota that help sustain rice productivity through nutrient cycling and natural regulation of pests and diseases (Xing *et al.,* 2023).

2.3 Change in Land Cover as a Result of Anthropogenic Pressure

Human induced pressure on the environments in mainly caused by LULLC (Roy *et al.,* 2022). This include practices such as agro-pastoral activities that is mainly driving an increase land degradation because large tracks of land are converted to accommodate forage planting as well as livestock rearing (Abdirahman, 2021). These changes are further worsened by continuous land fragmentation and intensified by expanding human settlements and the transformation of previously undisturbed ecosystems (Roy *et al.*, 2022). This challenging scenario is further compounded by shifts land use patterns, such as the conversion of grasslands to paddies, woodlands to croplands, and barren areas to built-up environments, which accelerate surface water pollution and disrupt hydrological connectivity, leading to increased sediment delivery in river systems

(Mondal *et al.,* 2024).

East Africa is experiencing notable LULLC (Berihun *et al.,* 2019), which is mainly caused by human activities subsequently affecting both nature and community's source of livelihood (Marchant, 2021). Due to land fragmentation that is done for reasons of purchase, inheritance and lease, the sizes of land parcels continue to get smaller and smaller in the region. This has led to growing demand for land resource and therefore interference with ecosystems such as natural forest (Brandt, 2020). This is evident by the recent statistics that show impacts of the continuous growth in human population with an average of 2% per annum, which is directly proportional to decrease in the forest cover in East Africa by 1% annually, between 1990 and 2015 (Berihun *et al*., 2019).

2.4 Impacts of Anthropogenic Activities on Wetland

Anthropogenic activities such as draining of wetlands, have negative impacts on the very ecosystems including disruption of soil structure, degradation of vegetation, and reduction in the ecosystem's ability to store Carbon (Ekka *et al.*, 2023; Lenart, 2009; Mou *et al*., 2018). Anzali Wetland is a casualty of brutal human induced activities that has altered the hydrological partners of the wetland, and in turn increased sedimentation level in the (JICA & Moja, 2004). In addition, increase in human population and the resulting expansion of impervious surfaces in surrounding catchments have further modified the timing and distribution of water entering these wetlands.

ASAL wetlands are important in that region as it provides essential resources that are otherwise limited such as water (Awandu, 2023). Unfortunately, ASAL wetlands are always under threat due to climate change, anthropogenic activities and poor implementation of legal systems that protect and conserve wetlands (Barbier *et al.,* 2011). Rapid urbanization as well as expansion of agricultural activities, including livestock and crop farming, are causing havoc in coastal wetland (Kirwan & Megonigal, 2013). Additionally, human activities have led to decline in species that depend on coastal ecosystem, threatening their habitat (Perennou *et al.,* 2018). Last but not lease, expanded agriculture into riparian area causes eutrophication of water bodies due to run off of nitrogen found in fertilizer, thereby putting aquatic life at risk (Pérez-Ruzafa *et al.,* 2019; Sadutto et al., 2021). Such intensive human activities alter, interfere and eventually degrade the delicate balance of these ecosystems, reducing their ability to support biodiversity and provide ecosystem services such as biogeochemical and physical processes, further threatening the health and sustainability of estuarine and coastal ecosystems (Tian *et al.,* 2016). These pressures are intensified by climate change, which alters rainfall availability and flow patterns for agriculture and urban use, resulting in greater habitat disruption and pollutant buildup (Mekonnen & Hoekstra, 2016). Invasive alien species add another layer of stress by displacing native species and interfering with key ecological functions (Taylor *et al.*, 2021).

2.5 Summary of Knowledge Gaps

Drivers and pressure affecting wetlands are well documented in the existing literature. However, how different human activities are interfering with the wellbeing of wetlands, especially in regards to spatial-temporal aspect is still understudies. Systematically and quantitatively estimating the impacts of human disturbances on wetlands has long been a challenge, with few methods available to link wetland degradation, ecosystem services, and anthropogenic pressures. In Kenya, numerous wetland areas are being converted into agricultural fields, industrial sites, and residential developments, yet detailed information on the extent of this encroachment or utilization is scarce.

The essence of this research was to actually focused on analyzing the magnitude of human disturbances in Kiborgoch wetland over a span of thirty years, using a combination of field surveys, remote sensing data which was reliably obtained from MODIS NDVI 1992 to MODIS NDVI 2022 and participatory social survey data. Assessing the ecosystem services provided by wetlands is a critical step toward their protection, but research on wetland utilization and its effects on these services remains limited (Maithya *et al.,* 2022).

Wang *et al*. (2022), on his research regarding wetland conservation, pointed out the fact that there is need for a comprehensive analysis to be done moving forward in regards to factors influencing wetland distribution, particularly biodiversity and water level dynamics, which in most cases are often neglected in existing models. This was similarly echoed by Dube *et al.* (2023) who vehemently advocated for a transdisciplinary approach to monitor wetlands especially in the semi-arid regions of sub-Saharan Africa to curb ongoing degradation (Ondiek *et al*., 2020). There is need to investigate deeper both direct and indirect causes of wetland loss (Ibid.,). Furthermore, adaptive management such involving the community in restoration acuities to make them feel part and parcel of restoration as well as stakeholder participation, is crucial for any restoration project/activity to work effectively and purposefully (Namaalwa *et al*., 2013). Ondere (2016) showed a critical knowledge gap in linking land cover changes with socio-ecological dynamics. This is essential for achieving sustainable wetland management in areas such as Yala Swamp, Kenya (Njagi and Mwangi, 2023).

2.6 Theoretical Framework

The theoretical framework that guided this research thesis was DPSIR framework by Peter Kristensen, (2004) which gives the linkages of drivers, pressure, state, impact, and response.

2.6.1 Drivers

Drivers of wetlands degradation can either be direct drivers or indirect drivers. Direct drivers refer to factors which physically altering the wetland's landscape such as land use changes, pollution, and habitat modification. Indirect drivers on the other hand refer to societal and economic processes that affects wetland.

2.6.2 Pressure

Some pressures can completely destroy wetlands. While others simply alter how they function and the life they support, the changes may affect biodiversity and reduce the ecological value of wetland area. Direct pressures involve poor water quality from pollution or sediment buildup. They can as well include clearing vegetation, disturbing animal habitats, or altering natural water flows through draining, filling, or channeling activities.

2.6.3 State

Anthropogenic activities such as expanded agriculture into wetlands, over-harvesting of wetland plants and change in draining of wetland contribute to the degradation and reduction of wetlands by changing water quality and flow patterns, increasing the input of pollutants, and disturbing native species through habitat disruption and the introduction of non-native organisms. Wetland loss and degradation reflect affect wetland negatively, shifting wetland conditions, often as a result of direct or indirect human actions that cause long-term declines such as biological productivity, ecological function, or the benefits wetlands provide to people (Craig *et al.,* 1979).

2.6.4 Impact

The impacts of wetland destruction and its function have negative consequences that may not only affect the current generation but future generations as well. Some of the negative impacts include increased flooding, loss of species, and declining water quality, reduction of habitat diversity and alteration of existing landscape.

2.6.5 Response

Responses involve restoration activities that maintain the ecological balance of a wetland. These include actively participating in programs that aim to protect and restore wetlands. It entails reaching out to local communities as well as local and state organizations, environmental conservation organizations, and other interested non-governmental organizations. Additionally, it is important to call out illegal activities including unauthorized dumping into wetlands to authorities' necessary authorities like National Environmental Management Authority and to prioritize the use of native species when undertaking planting activities.

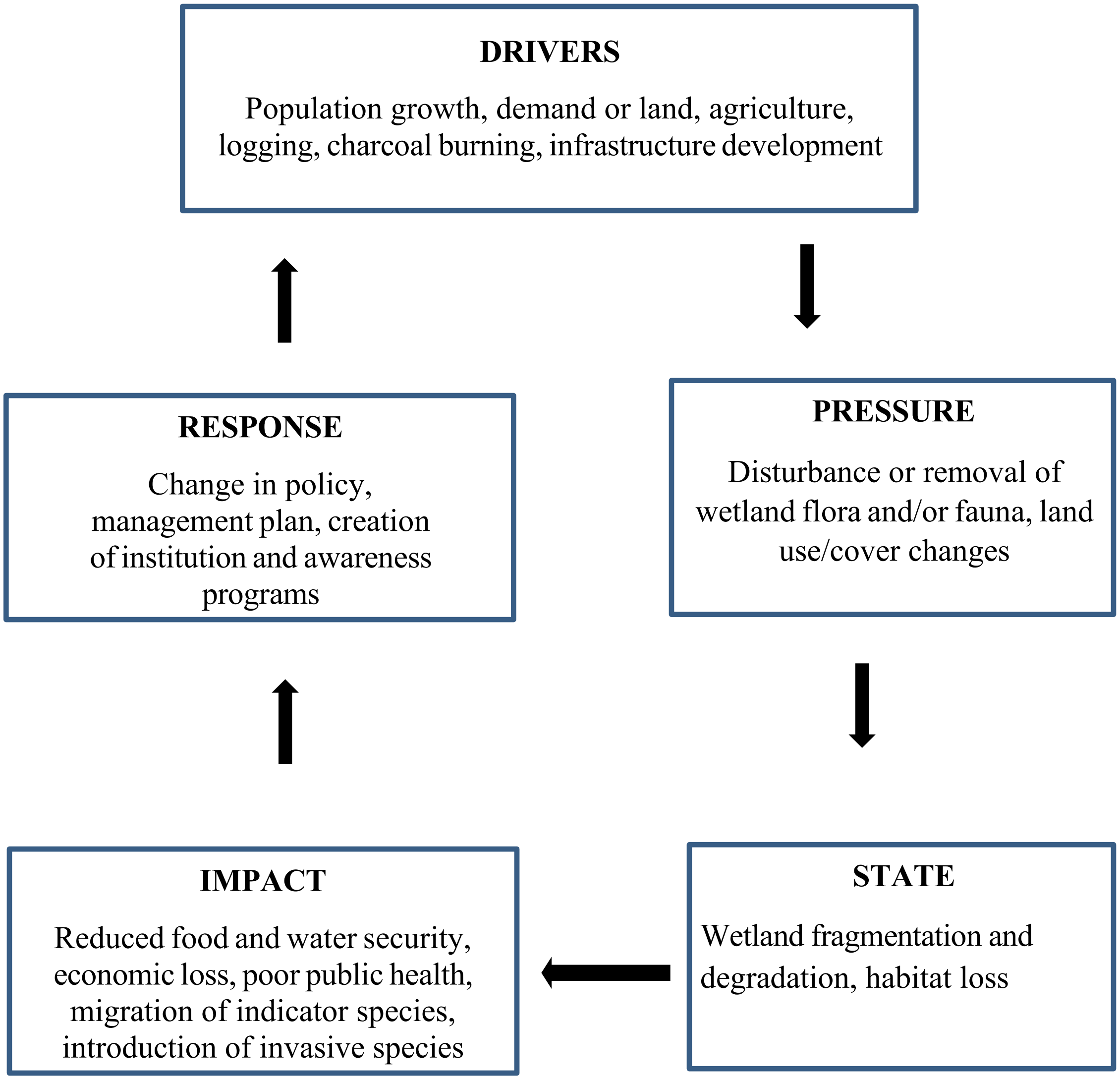

Figure 2.1: Theoretical Framework on Linkages Between Drivers, Pressure, State, Impact, and Response (DPSIR Framework; Peter Kristensen, 2004)

2.7 Conceptual Framework

In the present day, what stands to be the greatest problems as far as wetlands sustainability is concerned is uncontrolled and rapid population growth and expansion of urban settings such as city and town. Impacts of wetland interference which may result to degradation results in habitat loss and significant alterations to water patterns. As depicted in Figure 2.2 the diagram shows the conceptual framework that guided the entire study to accomplish its set objectives. It illustrates the relationship that is brought about when independent variables such as wetland plant cover encroachment and land cover changes interact with intervening variables including and legal frameworks and climate change causes dependent variables such as like direct habitat loss, hydrological alterations, and degraded water quality, ultimately leading to potential wetland loss. The essence of this research was to addresses the research gap by quantifying the extent of encroachment that compromises wetland sustainability.

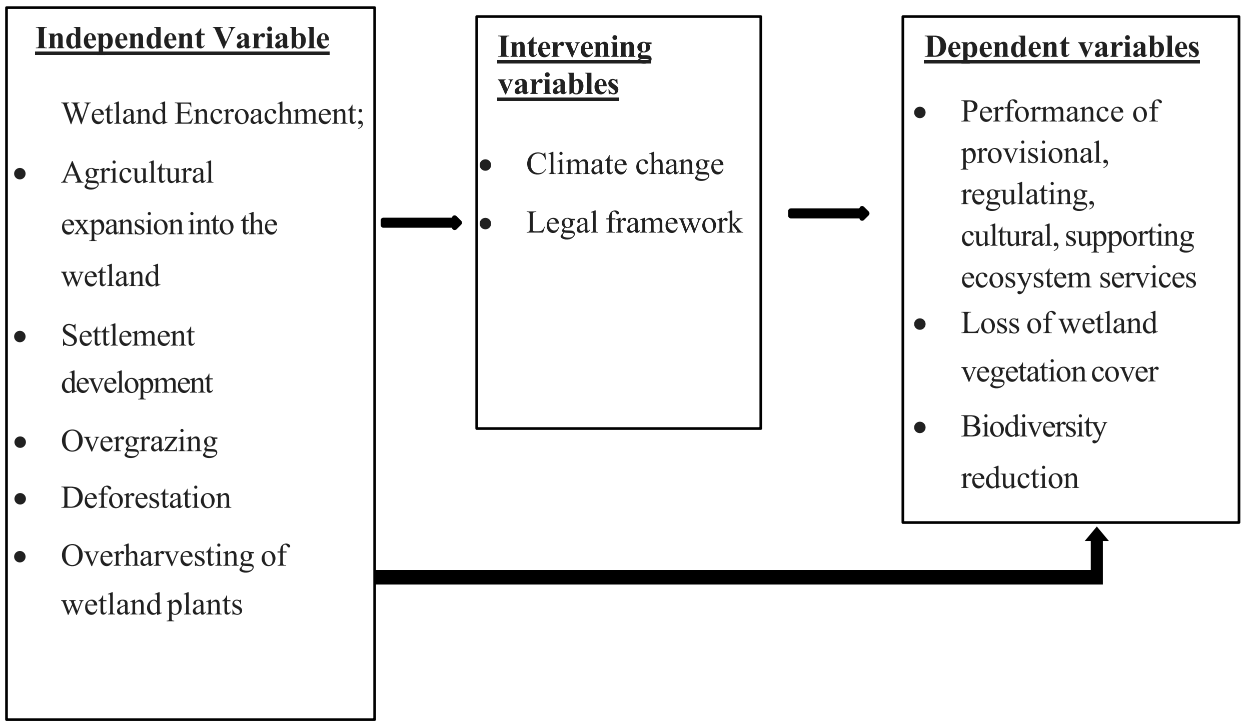

Figure 2.2: Conceptual Framework

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of the Study Area

The Kiborgoch Community Wildlife and Wetland Conservancy, located within Marigat Sub-County, encompasses the Loboi Plain and includes the regions of Loboi, Sandai, and Kapkuikui, which are further subdivided into villages such as Chepkekeren, Chelaba, Chepkoimet, Kabasis, Kapkinoi, Kerio, Koibakirwok, Loboi, Lokuru, Mokokwo, Ngarie, Poi, Sandai, Sesia, Sukutek, Tambarweche, Tingtingion, Tuiyono, Tuitik, Tirion, Twetie, and Sokotoiwo.

3.1.1 Location of the Study Area

This work was conducted in Kiborgoch Wildlife and Wetland Conservancy and its environs. It is located at (0°22'N/36°03'E) North of Lake Bogoria. The wetland is located in the Rift Valley region of Kenya, characterized by its elevation of 1411 meters above sea level. It is fed from warm springs with a temperature of 35^{0} C and pH of 6.4-6.9 emanating from the grid fault of the Rift floor.

3.1.2 Climate and Soil Characteristics

The overall climate of the Eastern Rift Valley is semi-arid with most wetlands particularly the lakes being alkaline or saline. The climatic condition around Kiborgoch wetland is semi-arid with a precipitation of 700 mm per year and evapotranspiration rate of 2500 mm per year. The study area receives an average annual rainfall of 700–800 mm, with mean temperatures around 30°C. Potential evaporation in the region exceeds 2,500 mm per year.

The soils are characteristic of the deep faulted floor of the Rift Valley, formed on tertiary basic igneous rocks. They are generally well-drained, moderately deep, and range in color from dark reddish-brown to reddish-brown.

3.1.3 Population and Economic Activities

Marigat, which is the Sub-County where Kiborgoch Wildlife and Wetland Conservancy is located is predominantly occupied by Kalenjin from Tugen sub-tribe. In the yester years, the community was known to have informal land inheritance system or land ownership. Grazing of their livestock was managed by clan or sub-tribe members, while only male children in the community customarily inherited their father's livestock (Vedeld, 1990). Today, the advancement of land reform has changed the traditional inheritance system to a more robust and formal inheritance rights for both livestock and land (Kandagor, 1993), which has actually led to individualization and commercialization of land.

According KNBS (2019), Marigat Sub-County had a population of 90,955 people from Loboi, Sandai, and Kapkuikui locations.

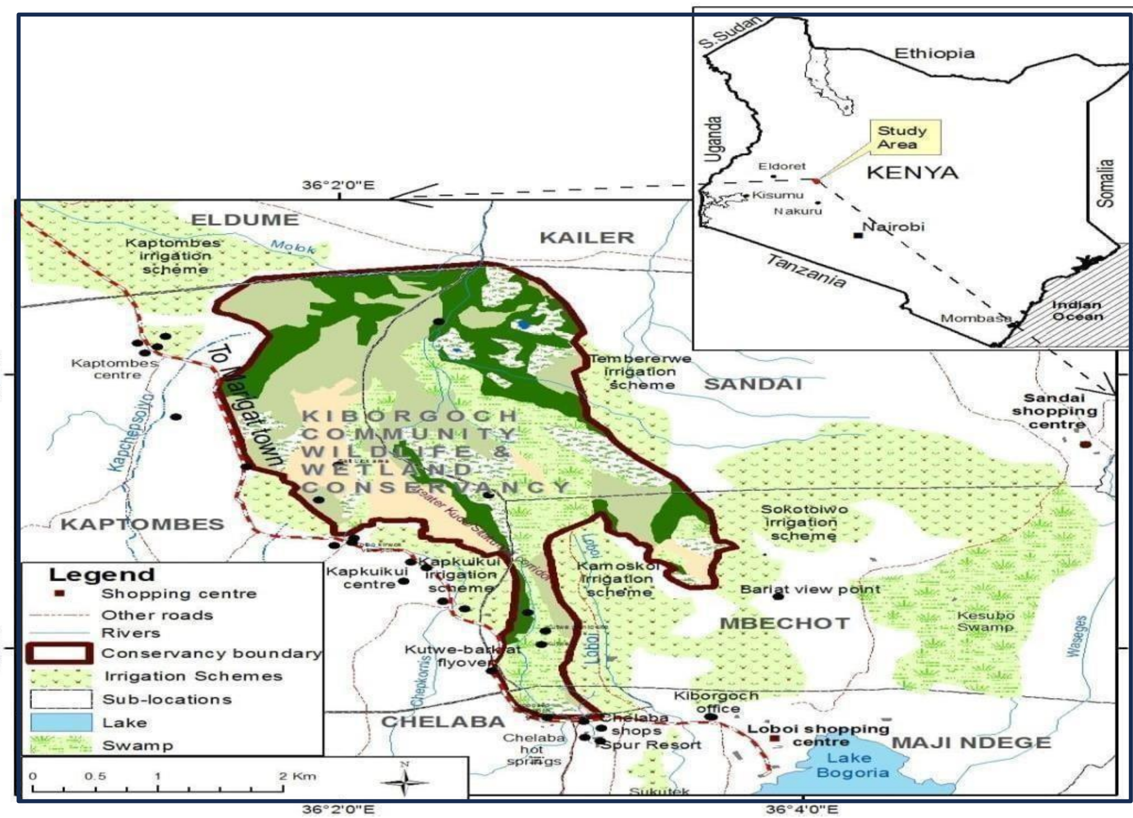

Figure 3.1: The Area of Study from Topographical Maps (Kenya)

3.2 Research Design

The research design that was used in this work was mixed-methods research design, which integrated quantitative and qualitative approaches. Data that was used for quantitative segment was obtained via wetland vegetation assessment, LULC analysis using GIS and remote sensing, and household surveys. To augment and confirm the quantitative data, qualitative data were obtained through FGDs and interviews with the wetland's key informants.

3.3 Target Population and Sampling

3.3.1 Target Population

Marigat Sub-County with 849 households (KNBS, 2019) was used to calculate the sample frame that guided the social survey to select the responded of the questionnaire.

3.3.2 Sampling Procedure and Sample Size

Yamane (1967), sample size calculation formulae was used as shown, $n= N/ \{1+N(e)^2\}$ Where; n= Sample size, N=Population size, e= Desired fixed margin of error (8%)

$n=849/ \{1+849(0.08)^2\}$

n=131.92 and therefore

n=132 households

132 households were sampled to be used in the survey of social questionnaires across Marigat Sub-County (Table 3.1).

Table 3.1: Proportionate distribution of households sampled per sub-location in Marigat Sub-County

Location	Sub-location	Land area (km^2)	Population-2019	Number of households	Sample size
Loboi	Maji/Ndege	14.6	989	161	25
	Chelaba	17.1	679	110	17
Sandai	Sandai	5.9	1,217	204	32
	Mbechut	12.4	1,048	170	26
Kapkuikui	Kapkuikui	40.7	739	119	19
	Kaptombes	5.5	495	85	13
Total		—	**5,167**	**849**	**132**

Note: Sample size refers to the number of households selected proportionately per sub-location

3.4 Data Collection Method

3.4.1 Vegetation and Land Use Assessment (GIS and Remote Sensing)

Images obtained from LANDSAT and MODIS were used to examine vegetation and land use changes over the stipulated study period of 30 years. The spatial resolution of MODIS was perfect in the use of this research since it ranges from 250 meters to 1 kilometer in spatial resolution and provides daily observation. It is flawed by courser resolution limit level that may overlook capturing detailed surface features which is actually complemented by LANDSAT images that provide medium spatial resolution of 30m. It also provides better images that give surface details but unfortunately takes 16 days revisit to monitor daily changes. To be able to address the shortcomings of both images, data fusion technique was applied which combined observations from multiples sensors.

To fulfil the objective of assessing vegetation changes from 1994 to 2024, MODIS NDVI 16-day composite data obtained from the USGS Earth database. Baseline imagery was set to be from the year 1994 with additional data collected for 2004, 2014, and 2024. NDVI was used to assess the growth status of flora using spectral data. The analysis mostly relied on the ratio between near-infrared (841–876 nm) and red (620–670 nm) bands, which are essential for mapping vegetation and assessing its health. Due to the ability of NDVI to detect seasonal and interannual vegetation changes, it was widely used to gather vegetation data in this research. Healthy plants strongly reflect near-infrared light while absorbing red light, so high NDVI values generally indicate dense, vigorous vegetation, whereas low values point to stressed or sparse vegetation, or non-vegetated areas, due to its strong correlation with vegetation productivity (Fensholt & Proud, 2012). NDVI values range from -1 to 1 and are closely linked to chlorophyll activity, increasing with greater vegetation density or coverage.

Secondary data from Landsat imagery: Landsat 5 (1994) and Landsat 7 (2004) were employed, with the SLC-off issue on Landsat 7 after 2003 managed using gap-filling techniques with ETM+ and TM sensors. Landsat 8 imagery (2014 and 2024) provided high-quality data through OLI and TM sensors, allowing for consistent monitoring of vegetation over the required 30-year period. Four satellite images, captured at ten-year intervals (1994, 2004, 2014, and 2024), Landsat TM/OLI: 30m spatial resolution, 16-day revisit cycle (1994, 2004, 2014, 2024) and MODIS NDVI (16-day composite): 250m spatial resolution, available from 1999 onward (2004, 2014, 2024). Timing was of essence to be able to have images that had minimal cloud interferences. Images from December 31st was used for all respective years since the region experiences only one dry period that starts in September and ends in May.

3.4.2 Data Acquisition and Change Detection Techniques

LANDSAT and MODIS data were downloaded from USGS Earth Explorer platform, which is a reliable source of high-quality LANDSAT imagery. Landsat imagery, and were selected for minimal cloud cover and peak vegetation greenness. LULCC images were then analyzed for year 1994, 2004, 2014 and 2024. For capture effective change detection, it is crucial to use relatively cloud-free images for each selected date, (December 31st), which is more achievable during the dry season (Kiage & Liu, 2009). Selecting imagery from the same calendar dates helped to minimize reflectance differences caused by seasonal variations in plant cover and changes in solar inclination. Ensuring that data used for spatiotemporal analysis are seasonally aligned further improves the accuracy of detecting vegetation and land cover changes (Oehmcke *et al*., 2020).

3.4.2.1 Image Classification

Image classification that was used in this research thesis involved converting multi-band raster images into a single-band raster that categorized different land cover types (Nagi, 2011; Richards, 2022). Both supervised and unsupervised classifications were applied. Supervised classification refers to an analyst selecting training samples to define spectral signatures while unsupervised classification is where the software automatically identifies spectral patterns (Lillesand & Kiefer, 1994). Unsupervised classification was first applied to group the imagery into preliminary LULC categories which was then followed by supervised classification in ArcGIS, where multiple training samples were created for each identified class. Similar classes were then merged using the merger function, and a minimum distance-to-means classifier was applied to define the final four LULC categories which are grassland vegetation, seasonal wetland vegetation, permanent wetland vegetation and bareland vegetation.

3.4.2.2 Reference Data

Reference data is important in interpreting, analyzing, and validating remotely sensed imagery (Lillesand *et al.*, 2004). Reference data was widely used in processing data even when many types are not collected directly at the site level and may only approximate actual conditions. To ensure the accuracy of the identified LULC classifications in this study, high-resolution Google Earth imagery was first used to identify land cover types, which were then verified through field visits. During these visits, pictures were taken and GPS coordinates were recorded to support the assessment of satellite imagery. One last step was to ensure that 1:50,000 UTM topographic maps were consulted to identify key study features, including wetlands and other land uses. This verification process was conducted throughout the study as it is a requirement.

3.4.2.3 Field Vegetation Assessment

Data collection for ecological macrophytes was done between the months of October and December 2024. It utilized stratified random sampling design to collect vegetation. Kiborgoch Wetland was divided into 3 sections because it is approximately 1.5 km². The sections were Northern section, Middle section, and Southern section which was about 0.5 km² each. Depending on the distribution of vegetations in the wetlands section, sampling points were selected randoml for each section. Nine plots were established in each section, with three plots allocated to trees, shrubs, and herbs, following the methodology of Khan *et al.* (2019). Plot sizes were species-specific: 1 m² for herbs, 5 m² for shrubs, and 30 m² for trees, allowing for detailed assessment of species abundance.

Within each plot, the density, frequency, and cover of all recorded plant species were measured, and then the average values were calculated. These relative values were then used to compute the Shannon–Wiener Diversity Index (H') and Simpson's Diversity Index (D).

3.4.3 Social Survey

3.4.3.1 Questionnaire

Appendix A shows the semi structured questionnaire that was used in this research to get information on insights, opinion, and thoughts that regarded Kiborgoch wetland and the changes it had experienced over time from the local communities. Semi-structured questionnaire also focused on participants' recollections of observed wetland changes over the stipulated time and collect information on livelihood activities, hydrological patterns, and biodiversity, including both flora and fauna. The questions also evaluate land use practices around the wetland, the impacts of changes in plant cover, and potential management strategies. To analyze the responses gotten form the survey, stratified random sampling approach was used.

3.4.3.2 Focus Group Discussion (FGDs)

FGD were basically used to complement the information that household survey captured. This is because, FGD questions were open ended and therefore allowed responded to express their thoughts, concerns, and opinions in an open manner. This work culminated respondents from 3 FGDs, each with 10–18 participants. The mode of choosing participants ensured that representation across gender, age groups, and livelihood activities was equal and provided a range of perspectives on wetland use and conservation as follows:

i. FDGs participants had to have lived in the vicinity more than 10 years.
ii. Responded directly depended on the wetland, example: smallholder farmers, pastoralists, water users, basket weavers and fishermen.
iii. Key wetland representatives including the area elders, women's group members, and youth, were there to capture traditional knowledge, generational perspectives, and varied conservation roles.

The three FGDS, were attended as follows; FGD A, had female participant, FGD B has youth participants and lastly FGD C had mix of elders and active resource users. Each session lasted about 2.5 hours with participants age ranging from as low as 18 years old to as old as 76 years old.

Participants also reflected on the vulnerable groups most affected by wetland degradation, the socio-economic and cultural opportunities associated with wetland resources, and proposed community-based recommendations for sustainable management. Data from the FGDs were captured in both audio and visual formats, transcribed, and later thematically coded for analysis (Appendix D: Participant Registration Form).

3.4.3.3 Validity and Reliability

This is a survey, usually conducted on a small scale, carried out prior to the main survey, primarily to gather information to improve the efficiency of the main survey. It was used to test the questionnaire to determine the time taken by the field procedure. Prior to data collection, a pilot survey was conducted in October 2024 in Kesubo Swamp and its environs. The instruments for data collection were validated by conducting 15 semi-structured questionnaires in the core research area of Kesubo Swamp, as well as in the peripheral research area surrounding the wetland.

3.5 Data Analysis

3.5.1 Evaluation of the Spatial-Temporal Vegetation Changes in Kiborgoch Wetland (1994-2024)

Vegetation dynamics were assessed using Landsat imagery. The analysis included descriptive statistics such as mean comparisons and correlation analysis to identify trends and relationships. The Shannon Diversity Index (H') and Simpson's Diversity Index (D) were used to quantify diversity. Landsat and MODIS imagery were used to assess vegetation and land use changes over a 30-year period from 1994 to 2024. MODIS and LANDAST images were both used as they complement one another, and to overcome the shortcomings of both data sets data fusion techniques was applied. This is because MODIS has the ability differentiation between vegetated and non-vegetated areas whereas LANDSAT cannot differentiate vegetative and non-vegetative areas. Additionally, MODIS gives daily global observations, with spatial resolutions ranging from 250 meters to 1 kilometer whereas MODIS has lower spatial resolution, its high revisit frequency makes it useful for monitoring temporal changes even when the surface details are not well captured. LANDSAT imagery offers medium spatial resolution (30 meters), which is more effective.

3.5.2 Analysis of the Drivers and Extent of Encroachment on Kiborgoch Wetland (1994–2024)

Encroachment was evaluated using a mixed-methods approach, combining household surveys, FGD and RS analysis. Questionnaire responses were analyzed using descriptive statistics to find out drivers of encroachment, effects on ecosystem services. It basically included means, correlations, frequency distributions, and cross-tabulations. This was used to characterize household socio-economic conditions, land tenure, drivers of wetland encroachment, and their effects on ecosystem services.

Images from LANDSAT was used to complement data by providing spatial trends in encroachment over time. Animal grazing in both dry and wet seasons, population growth, and agricultural expansion were frequently mentioned as major drivers of encroachment. Verbatim quotes, presented in later sections, provide a bigger picture and deeper context and help enrich the quantitative findings.

3.5.3 Assessment of the Effects of Wetland Encroachment on Ecosystem Services

To compare the significance of observed differences, ANOVA was used to compare difference in diversity in the wetland section where as Chi-square tests were conducted to test the importance of ecosystem services to the population from Kiborgoch wetland. Mean comparison and correlation analysis was used to check on the effects on ecosystem services to examine descriptive statistics. To determine the, supported by frequency counts and cross-tabulations.

Quantitative data from the questionnaires were carefully edited, coded, and analyzed in SPSS, observing a 95% confidence interval (CI) applied to the results. This data included methods of land ownership, means of livelihood just to name but a few. Descriptive measures, including percentages, means, and charts, were used to summarize and present the findings. In addition, audio recordings from the focus group discussions (FGDs) were transcribed into English for qualitative analysis.

3.6 Ethical Consideration

All necessary approvals from relevant authorities together with informed consent from participants were obtained including, participants' registration form and NACOSTI permit, Ref No:

430886.

All participants in the social surveys and the FGDs were informed about the study objectives, and participation was voluntary. Subsequently, their responses were kept confidential, and efforts were made to respect the Tugen cultural norms, avoid harm, and maintain transparency throughout the research process.

Field activities were conducted in a manner that protected the integrity of the Kiborgoch wetland ecosystem. Furthermore, the study adhered to the Environmental Management and Coordination Act (EMCA, 1999), ensuring that data collection and spatial analyses did not negatively affect the natural environment.

CHAPTER FOUR

RESULTS

4.1 Land Use/Cover Change Analysis Using Remote Sensing and GIS

This section seeks to get answer to the following research questions; *How has vegetation in the Kiborgoch Wetland changed between 1994 and 2024?* and *What are the drivers and extent of wetland encroachment during this period?* Addressing these questions will be able provide a deeper understanding of the dominant land uses in that surround Kiborgoch wetland with the conservancy as the boundary and their implications on socio-economic activities and therefore the wetland conservation. Land use transformations were observed across varying spatial-temporal scales. This is a reflection of the complicated relationship between human and environmental Watson *et al.,* 2014).

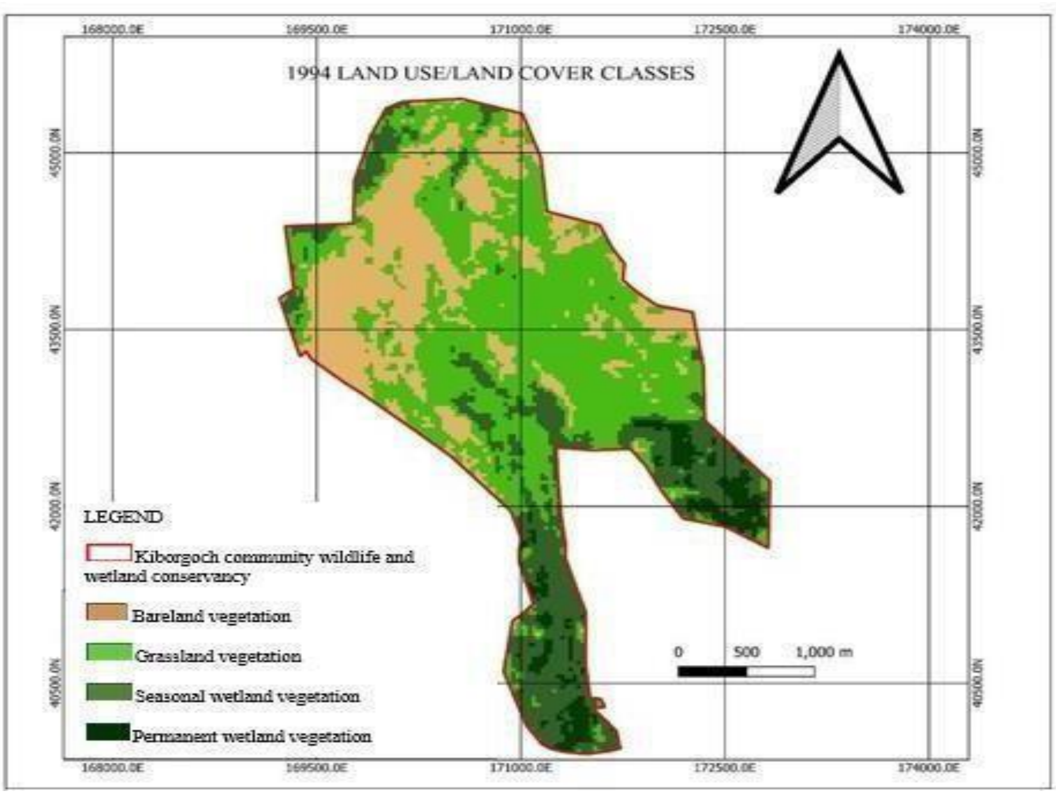

Figure 4.1: Land use/Land Cover Classes Identified and Mapped in 1994

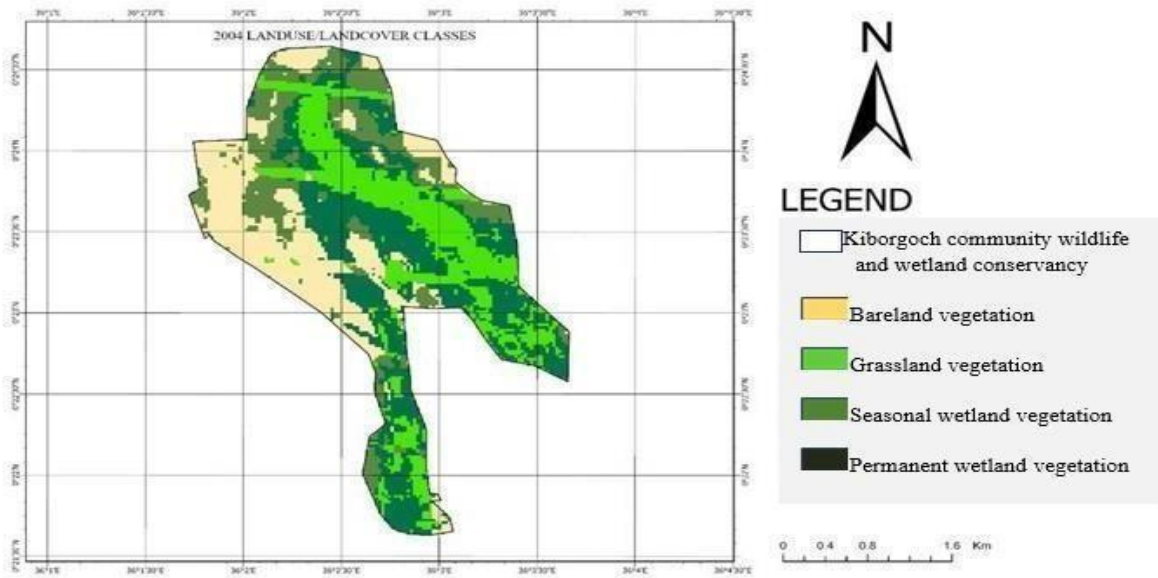

Figure 4.2: Land use/Land Cover Classes Identified and Mapped in 2004

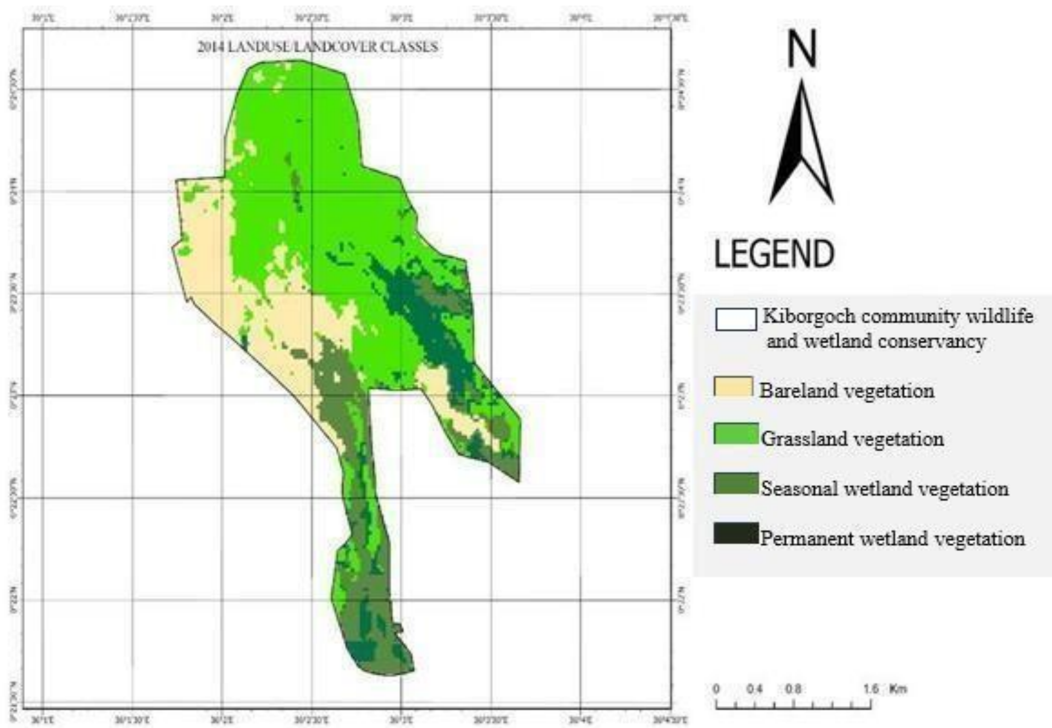

Figure 4.3: Land use/Land Cover Classes Identified and Mapped in 2014

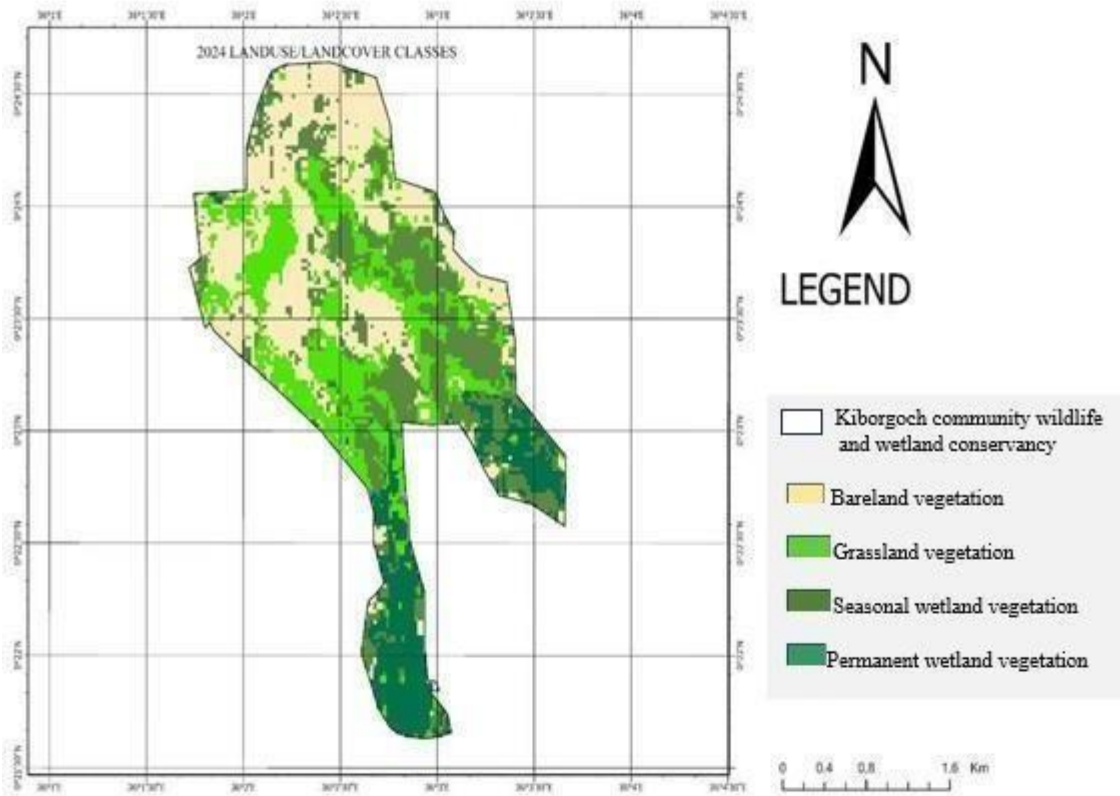

Figure 4.4: Land use/Land Cover Classes Identified and Mapped in 2024

Figure 4.5 illustrates the changes in land cover in Kiborgoch Community Wildlife and Wetland Conservancy between 1994 and 2024. Bareland increase from base year of 1994 to 2024 from 131.84 ha to 199.16 ha, and this can be attributed to factors such as settlement expansion from migration from high potential areas to the ASAL region as earlier depicted in the statement of the problem. Due to other human induced factors such as draining of wetland bodies, abstraction of flow of water from river Loboi into Kiborgoch wetland and climate related pressure such a s erratic rainfall, and prolonged dry periods, seasonal wetland vegetation experienced frequent fluctuations, initially rising from 138.36 ha in 1994 to 396.11 ha by 2014, before declining to 179.13 ha in 2024. In contrast, permanent wetland vegetation on the other hand showed consistent growth over the study period, increasing from 99.18 ha to 150.36 ha, attributed to stable ecological conditions in these areas. Impacts of grazing, land conversion, and other ecosystem disturbances had a negative toll on the grassland cover. It showed a declined sharply from 445.31 ha in 1994 to 165.90 ha in 2014, before partially recovering to 286.03 ha by 2024.

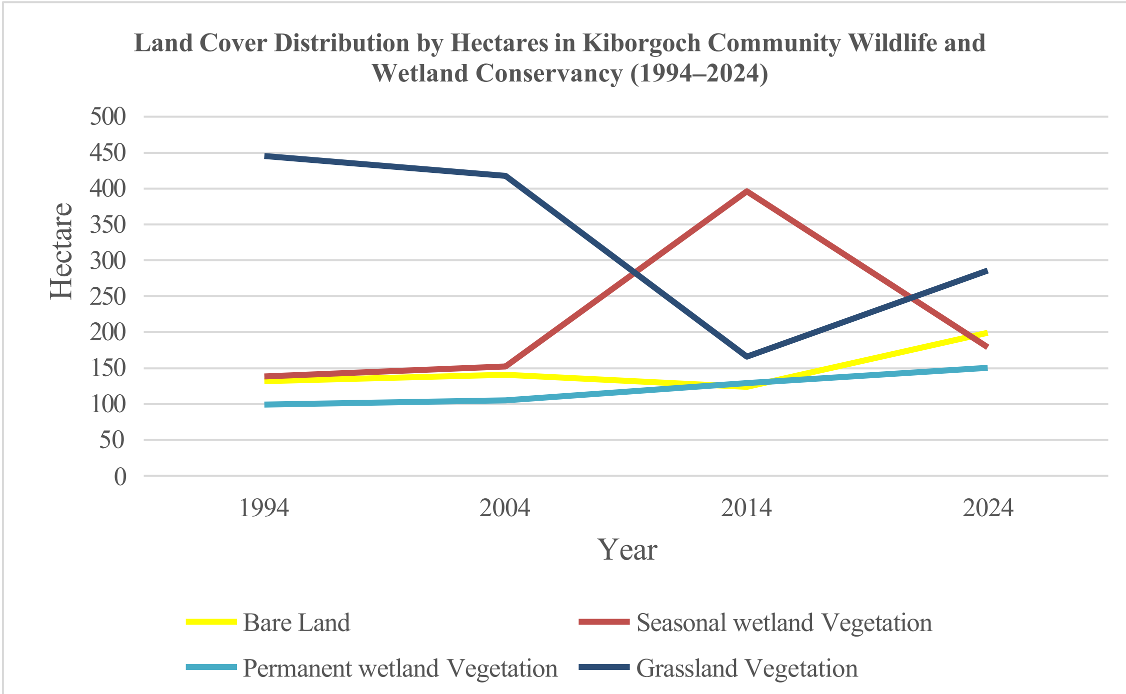

Figure 4.5: Land Use/Land Cover Changes Between 1994 and 2024

4.2 Wetland Vegetation Assessment

Macrophytes sampling including trees, shrubs, herbs were carried out in the three sections of the wetland between the months of November and December 2024. Within each section, nine transects were established, three per section, following the methodology described by Khan *et al.* (2019). Sampling locations were selected to capture diversity and distributions of macrophytes across the wetland,

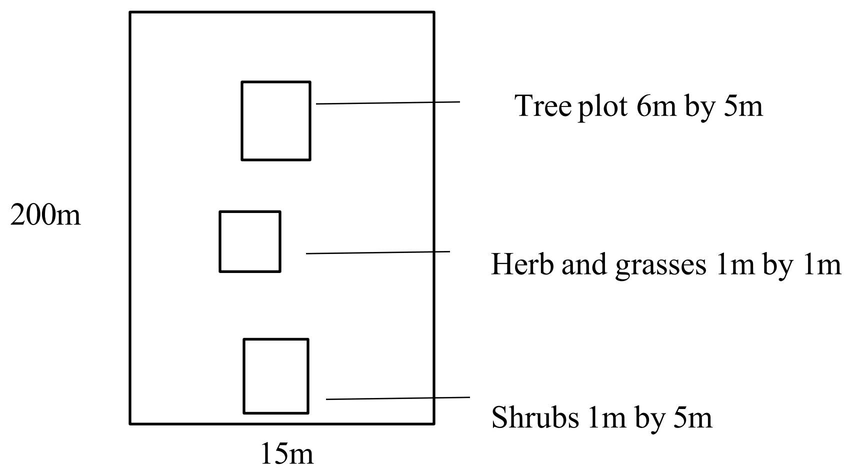

Figure 4.6: Layout of the Transect and Dimensions of Different Plot Sizes
Source: Author's Field data (2024)

To sample different macrophytes in the wetland, random sampling methods was used (Boyd & Svejcar, 2004; Clary, 1995) but considered plants abundance using a transect -plot method (Buckland & Turnock, 1992). Plot sizes varied depending on the size of plants, that is 1 m² for herbs and grasses, 5 m² for shrubs, and 30 m² for trees (Figure 4.6)

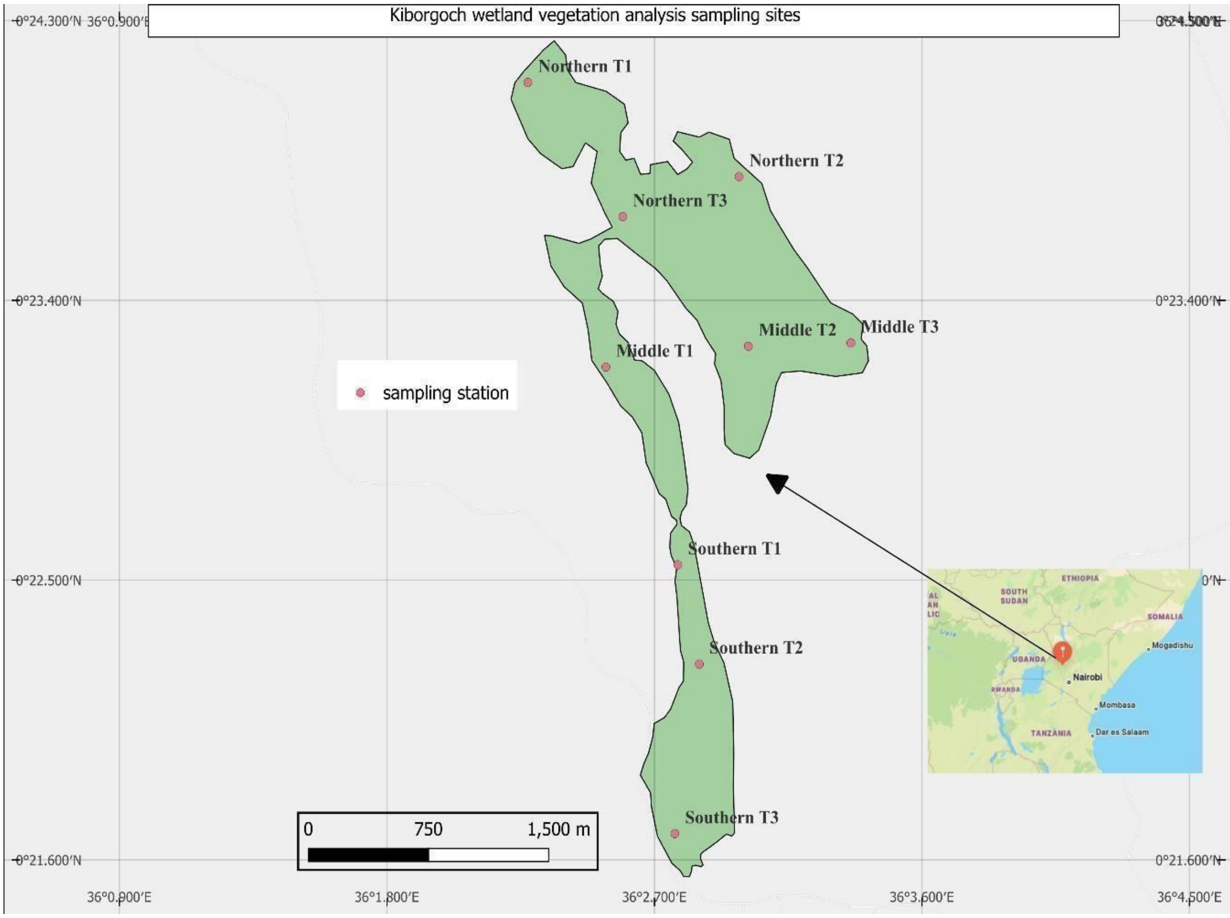

Figure 4.7: Sampling Location Across the Wetland Section

Source: Modified from GOK (2018)

Sampling sites across the wetland divide into sections; Northern, Middle and Southern are depicted in Figure 4.7

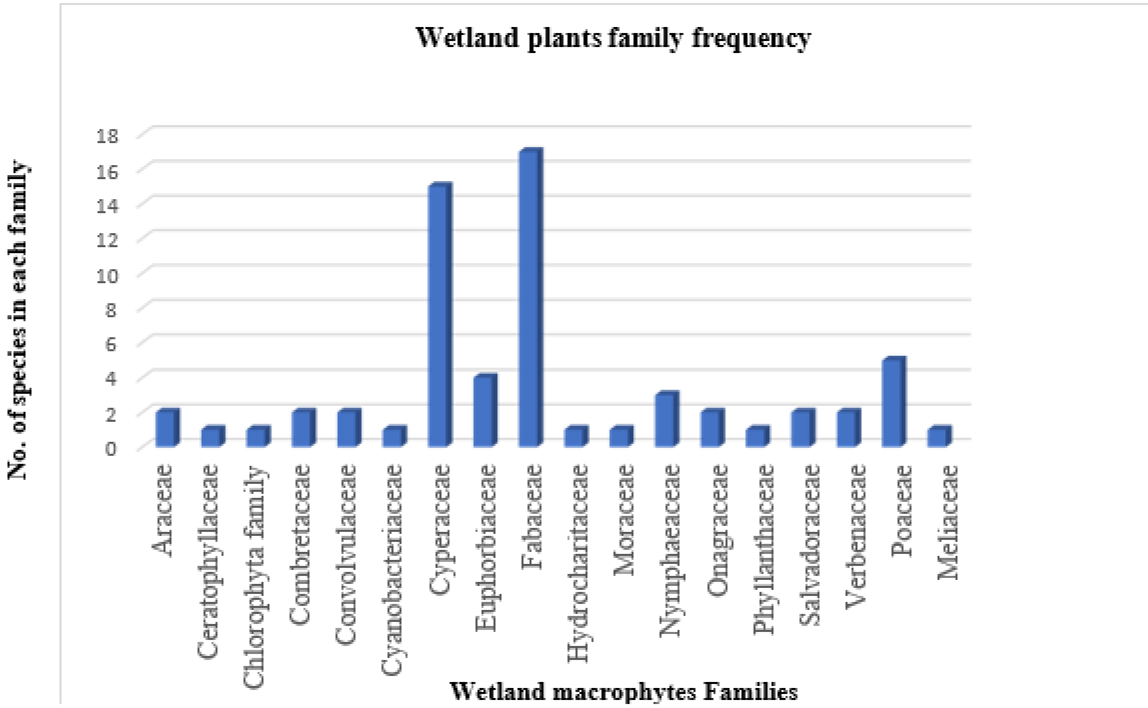

Figure 4.8: Family Dominance Frequency

4.2.1 Wetland Plant Analysis

In the Northern section, the Fabaceae and Cyperaceae families were the most frequent, comprising 36.4% and 26.3%, respectively. The Cyperaceae family dominated the middle section with 57.1%. In the Southern section, the Fabaceae and Cyperaceae families had the highest frequencies, at 30% and 20%, respectively. The general dominant family in the wetland are Fabaceae and Cyperaceae families as illustrated in Figure 4.8. The plant species were identified with the help of literature.

The wetland is characterized by varying water depths, with the Southern end being the deepest at approximately 2 meters deep, gradually shallowing as it extends Northward, away from the spring sources. Grasses primarily dominate the Northern part, while shrubs and sedges dominate the Southern end. The middle section of the wetland has the fewest identified macrophytes species, with no trees present. The total number of wetland vegetation species, families, their local names, and the average number of individual plants per unit transect are summarized in Appendix D Table 1, 2, 3, and 4 for the respective sections of the wetland.

4.2.2 Wetland Plants Distribution

The total number of plots in total (three each for trees, shrubs and herbs per transect) were as outlined by Khan *et al.* (2019). Plot sizes varied: 1 m² for herbs, 5 m² for shrubs, and 30 m² for trees, to assess the density of individual plant species.

Table 4.1: Average abundance of trees, shrubs/sedges, and herbs/grasses across Northern, middle, and Southern transects in Kiborgoch wetland (2024)

Life Form	Sample Area	Northern Transect	Middle Transect	Southern Transect
Plot 1				
1.Trees	30 m²	6	–	5
2. Shrubs and sedge	5 m²	59	52	66
3. Herbs and grasses	1 m²	64	75	73
Plot 2				
1.Trees	30 m²	3	–	7
2. Shrubs and sedge	5 m²	56	14	66
3. Herbs and grasses	1 m²	57	41	32
Plot 3				
1.Trees	30 m²	2	–	6
2. Shrubs and sedge	5 m²	28	74	16
3. Herbs and grasses	1 m²	63	57	45

Note: (–): absence of the life form in that plot.

4.2.3 Shannon Diversity Index (H') and Simpson's Diversity Index (D)

The Shannon Diversity Index (H') values for the Kiborgoch wetland sections ranged from low to medium diversity. The northern section exhibited moderate diversity, the middle section showed low diversity, while the southern section recorded high diversity. According to Albueajee *et al.* (2020), Baliton *et al*. (2020), and Fajardo *et al*. (2022), the Shannon Diversity Index ranges from 0 to 5, with values interpreted as follows: 1.99 or below indicates very low diversity; 2.00–2.49 represents low diversity; 2.50–2.99 indicates moderate diversity; 3.00–3.49 reflects high diversity;

and 3.50 and above denote very high diversity, as shown in Table 4.2.

The Simpson Diversity Index provides a score ranging from 0 (no diversity) to 1 (complete diversity). Scores between 0.01 and 0.4 indicate a low level of diversity, 0.41 to 0.6 represent a moderate level, 0.61 to 0.8 suggest a moderately high level, and scores from 0.81 to 0.99 reflect a high level of diversity (Guajardo, 2015). The Kiborgoch wetland is generally regarded as having a high level of diversity, as all sections have a Simpson value greater than 0.81.

Table 4.2: Shannon and Simpson diversity indices for the Northern, middle, and Southern sections of Kiborgoch Wetland (2024)

Wetland Section	Shannon Diversity Index	Simpson's Diversity Index
Northern	2.82	0.94
middle	2.00	0.87
Southern	3.23	0.96

Note: Shannon Diversity Index (H') = $-\Sigma(Pi) * \ln(Pi)$;
Simpson's Diversity Index $D = 1 - (\Sigma\, n(n-1)) / (N(N-1))$

4.2.4 ANOVA Analysis of Plant Diversity Across Different Sections of Kiborgoch Wetland

ANOVA was chosen to assess plant diversity across the three wetland sections; North, Middle, and South because it is specifically designed to test for statistically significant differences among three or more groups (Table 4.3). The dependent variable, plant diversity, is continuous, and the factor of interest is the wetland section, making ANOVA more appropriate and powerful than performing multiple t-tests, which could inflate the risk of Type I error.

The results indicate a significant variation in plant diversity among the wetland sections ($F = 13.6$, $p < 0.01$), confirming that at least one section differs significantly from the others. The Southern section, middle and Northern sections had mean diversity 11.38, 4 and 8.5 respectively (Table 4.3). This indicates that regardless of the fact that the sections are located in the same wetland, they have different diversity and therefore conservation approach should be targeted and tailored for each wetland's section. The middle section needs targeted restoration and stricter protection strategies since it is the most affected part of the wetland.

Table 4.3: One-way ANOVA results for variation in plants diversity across wetland section

Sources of variation	SS	df	MS	F	P-Value	F-Critical
Between group	3.5883×10^2	2	1.7941×10^2	1.3527×10^1	1.33×10^{-5}	3.1453
Within group	8.2231×10^2	62	1.3263×10^1	–	–	–
Total	1.1811×10^3	64	–	–	–	–

Note: SS: Sum of Squares; **df:** Degrees of freedom; **MS:** Mean Square = SS / df; **F-critical:** Value from F-distribution table at $\alpha = 0.05$

4.3 Social Survey Results

Social survey included use of semi-structured questionnaires and 3 FGDs. It was used to investigate the human aspect that leads to change in land use, livelihood, perception, historical aspects that affected the wetland directly and indirectly.

4.3.1 Historical Management and Land Tenure Changes in Kiborgoch Wetland

Juma, Sawe and Korongoi age-set are Kalenjin age-set that led to the establishment of Kiborgoch Community Wildlife and Wetland Conservancy. They were in charge of protecting the wetland by facilitating controlled grazing on riparian wetland zone, watering points and wetland's plant harvesting. They were responsible for rotational grazing on the wetland, where animals were only allowed to graze in the wetland during the dry season, and animals were kept way from the wetland during wet periods.

Agricultural activities in 1970's, including crop production, forage production and irrigation establishment were done manually without intervention of agricultural mechanization we utilize in the present day. Counsel of elders together with the age sets enforced regulations that governed the protection of the wetland. Such regulations included prohibiting destructive practices like charcoal burning and land clearing with fire. They also guided the community on sustainable wetland use and pasture management.

Mechanization of agriculture started taking root in the conservancy between 1985 to 1990, where tractor-based farming and efficient irrigation systems were introduced leading to establishment of intensive agriculture. This led to migration of a greater population into the region as the land was known to be fertile and produced high yield especially horticultural crops such as melons, pawpaw, and mangoes. During this period, the region experienced a great rise in land buying from people from other regions in the country. Between 1997 and 2000, the government at the time led by the late president Moi introduced *Prosopis juliflora* as a strategy of reforestation in the ASAL region. It unfortunately became an invasive species that spread uncontrollably in the region causing changes in the course Loboi River and subsequently disrupted local livelihoods.

Table 4.4 shows that 78% of land in the region was inherited, whereas 18.9 % was acquired through purchase. Verbatim responses

- *"In the past, we grazed here in turns. Elders made rules. Now, anyone can enter any time."*
- *"Land buying started when irrigation farming became profitable. People came from other places."*

Table 4.4: Methods of land acquisition data

Methods of land acquisition	**Frequency**	**Percentage (%)**	**Cumulative percentage (%)**
Purchase	25	18.9	18.9
Inherit	103	78	98
Gift	3	2.3	100
Lease	1	0.8	
Total	**132**	**100**	

Note: Percentages and cumulative percentages were calculated from a total sample size of 132 respondents.

4.3.2 Socio-Economic Activities and Livelihoods

The Tugen community, from the Kalenjin tribe, predominantly occupy this region with their main source of livelihood as livestock rearing and crop cultivation using irrigation method of production. As illustrated in Figure 4.9, 83% of livelihoods in the region is based on mixed production combining livestock farming and crop faming. Subsistence crop cultivation including maize and bean, cash crop cultivation including horticultural crops, and livestock keeping had 6%, 5% and 4 % respectively.

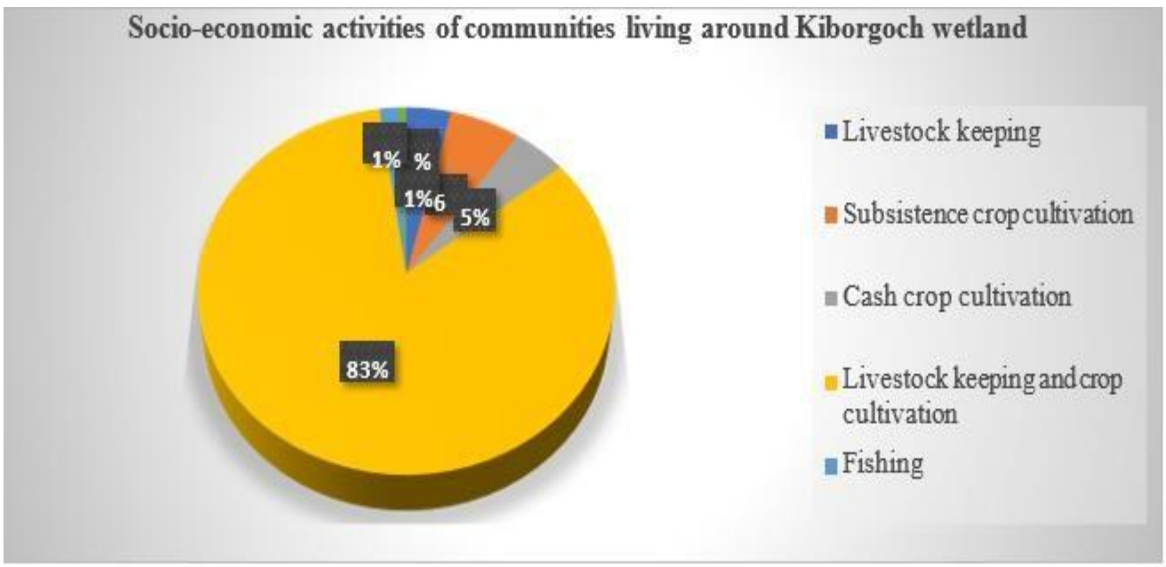

Figure 4.9: Socio-Economic Analysis of Kiborgoch Wildlife and Wetland Conservancy

Economic activities such as livestock production, crop production and fishing in Kiborgoch directly depend on Kiborgoch Wetland. This is because the wetland has fertile support to support farming, fodder to support livestock farming, and water to support all activities including both farming and livestock production. It also supports cottage and building industry by providing papyrus, and building pole. It is important to extensively look at the socio-economic activities so that insights will be given to how vital the wetland is in sustaining livelihood.

4.3.3 Drivers of Kiborgoch Wetland Encroachment

Understanding drivers of wetland degradation is essential in delivering the key objective of this research, which is to examine divers and their corresponding extend of encroachment from 1994 to 2024. This is illustrated by Figure 4.10 which depicts overgrazing as the leading contributor with 23.1%. Other drivers include expanding crop production, climate variability, and population growth. Similarly, reduced river flow shows equally the same effects. Overharvesting of wetlands plants including papyrus, herbs, fodder, building pole and timber stands at 6.5%. Thia may be considered a considerably lower impact level but nonetheless their impact is pronounced as far as loss of breeding ground and habitat for wild and migratory bird is concerned

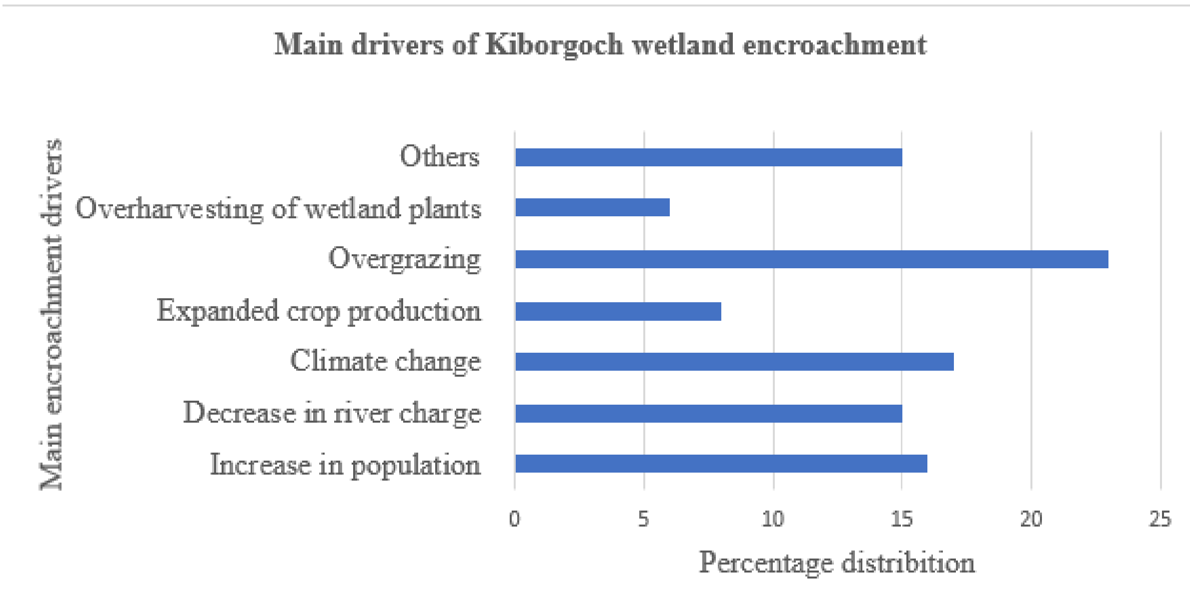

Figure 4.10: Analysis of Main Drivers of Kiborgoch Wetland Encroachment

4.3.4 Provision Ecosystem Services

Provisional ecosystem services are the benefits that are derived from a wetland ecosystem and includes food production and provision on clean water. Kiborgoch wetland is particularly important as it is situated in an ASAL region and sustains economic activities that are heavily relying on water. This includes crop production, livestock farming and cottage industry, fishing, production of water for household use, wild vegetables and herbs use and other cultural benefits (Figure 4.11).

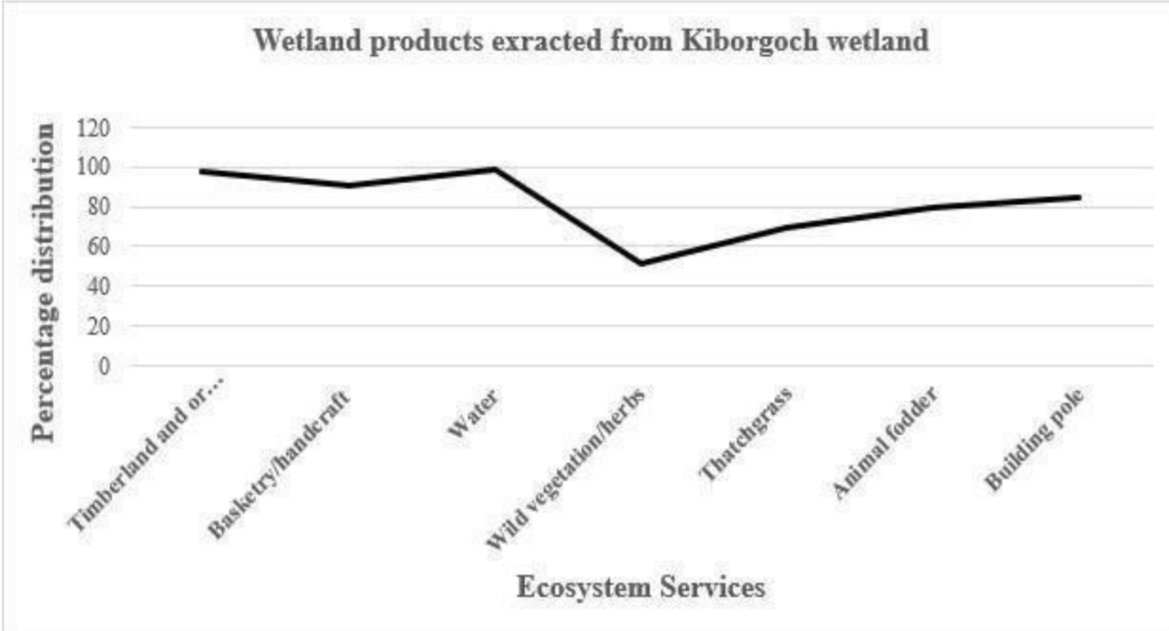

Figure 4.11: Percentage Distribution of Products that are Extracted from the Wetland

Chi-square goodness-of-fit test (Table 4.5) was performed to determine the preference of different wetland's ecosystem service. It was based on null hypothesis that all services are utilized equally by the respondents. The expected frequency for each service was then calculated as the total number of responses divided by the number of services, giving:

E = Total count/Number of services = 509/6 = 84.83

Table 4.5: Chi-Square test for the importance of wetland ecosystem services

Ecosystem Service	O	E	O−E	(O−E) ²	(O−E) ² / E
Crop cultivation	84	84.83	-0.83	0.69	0.008
Grazing	115	84.83	30.17	910.2	10.73
Source of water	82	84.83	-2.83	8.01	0.094
Socio-cultural	71	84.83	-13.83	191.3	2.26
Cottage industry	93	84.83	8.17	66.7	0.79
Herbs, fruits, vegetables	64	84.83	-20.83	434	5.12

Note: O = observed frequency; E = expected frequency; values were used to compute the Chi-square statistic to test the association between ecosystem services and wetland use categories.

$\chi^2 = \sum (O_i - E_i)^2/E_i,$

$=18.99$

With five degrees of freedom (df = 5) and a critical value of 11.07 at $\alpha = 0.05$, the calculated χ^2 value of 18.99 exceeds the threshold, leading to rejection of the null hypothesis. This result indicates that the community does not rely equally on all wetland ecosystem services; usage varies according to the type of service.

Livestock production relies heavily on the wetland as 115 respondents stated that they graze their animals in the wetland in dry and wet periods of the year. 93 respondents on the other hand get raw materials for small scale cottage from the wetland. This includes papyrus for basketry and weaving. While 84 people responded to using the wetland for crop production, farming for subsistence and cash crop farming, 64 people harvest wild vegetables, herbs and fruits for their consumption.

This clearly show that Kiborgoch wetland support a wide variety of ecosystem services that benefit s people in different ways. Uneven reliance of ecosystem services derived from the wetland shows priority area for targeted management and conservation. Effective conservation planning should therefore balance short-term community needs with the long-term sustainability of the wetland ecosystem.

4.3.4.1 Cottage Industry

Cottage industry in this region involves a part of socio-economic activities that includes using papyrus reeds from the wetland for crafting, weaving, basketry as well as harvesting building materials such as thatch grass for roofing, poles and timber. Table 4.6 clearly illustrates that 47.7% regard the wetland as very important source of raw materials while 39.4% regard it as important.

Table 4.6: Perceived importance of ecosystem services: sources of raw materials for building and cottage industry

Importance	Frequency	Valid percent	Cumulative percentage
Very important	52	39.4	39.4
Important	63	47.7	87.1
Less important	17	12.9	100
Total	132	100	-

Note: Percent and valid percent values are based on the total number of respondents (N = 132). Cumulative percent represents the running total across importance categories.

4.3.4.2 Crop Cultivation

63.6% of the community depend on the wetland and R. Loboi for farming activities either by drawing water for irrigation of crops, or planting crops on riparian areas of the wetland. This is because the wetland has fertile soils and high moisture content that supports agriculture that is very vital in thesis ASAL region.

Table 4.7: frequency of respondents' participation: use of the Kiborgoch wetland or River Loboi for irrigation farming

Response	Frequency (n)	Percentage (%)
Yes	84	63.6
No	14	10.6
Not applicable	34	25.8
Total	132	100

Note: Percentages are based on the total number of respondents (**N = 132**).

4.3.4.3 Grazing

Fodder, grass and water are essential in rearing livestock and the wetland provides all this in both dry and wet seasons of the year (Figure 4.12). Over-grazing however, causes stress and loss of wetland's vegetation, increases soil compaction and reduces water retention, contributing to the ongoing degradation (Mihailou & Massaro, 2021; Skovlin, 2021).

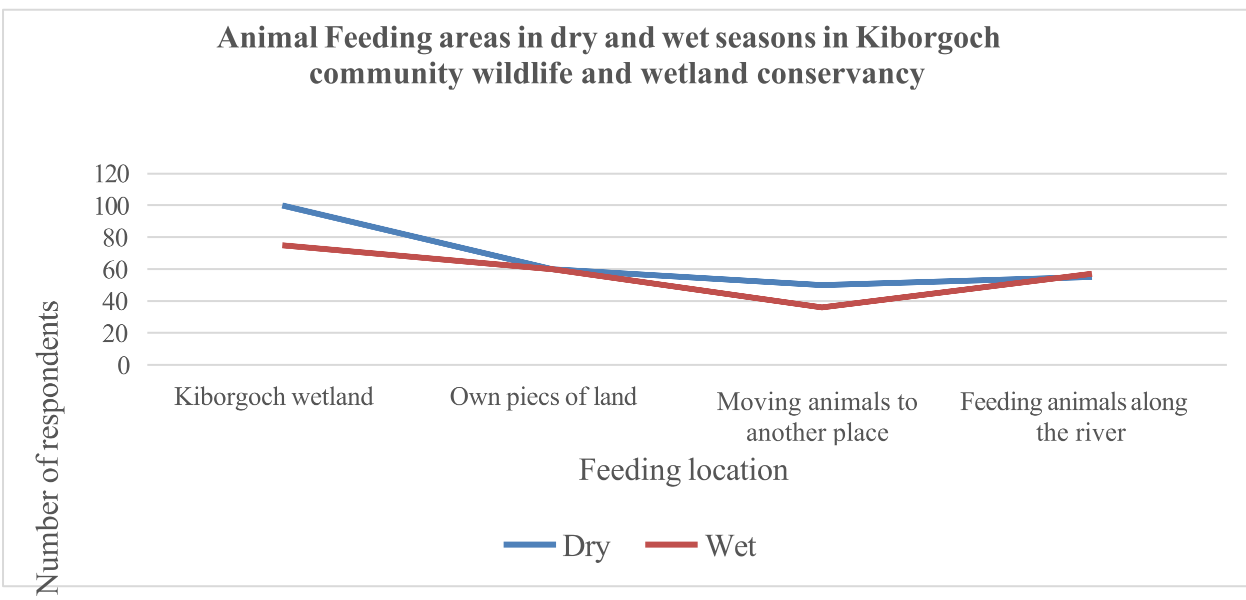

Figure 4.12: Wetland Used to Feed Livestock During Dry and Wet Seasons

4.3.4.4 Source of Wild Vegetation/Fruit and Herbs

48% of the local community gather edible plants consisting of wild vegetable, herbs and fruits (Figure 4.13). This wetland product provides the community with nutrition, health and livelihood.

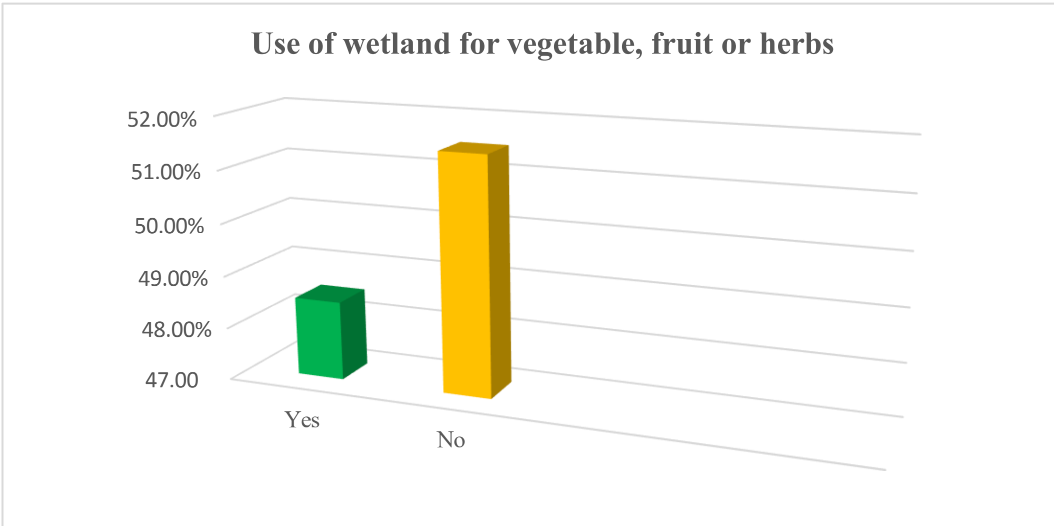

Figure 4.13: Consumers of Fruits, Vegetable or Herbs

4.3.5. Effects of Encroachment on Ecosystem and Community

It is of essence to acknowledge the fact that encroachment has detrimental effects on nature and people depending on an ecosystem. Some of the negative effects include loss of species, a decline in ecosystem services, and increased social vulnerabilities.

4.3.5.1 Impact on Wildlife

Figure 4.14 illustrate that 56.8% of respondents indicate that habitat loss, overgrazing and interference with the wetland has led to decline in animals and birds' populations. 32.6% on the other hand claim that habitat changes have forced species to migrate or adapt to new conditions, while 10.6% noted that wetland degradation has led to complete loss of certain indigenous species. Negative impacts on wildlife and migratory birds not only threaten the ecological balance of the wetland but also disrupt food webs and undermine the wetland's ability to support livelihoods linked to wildlife, including tourism and cultural practices.

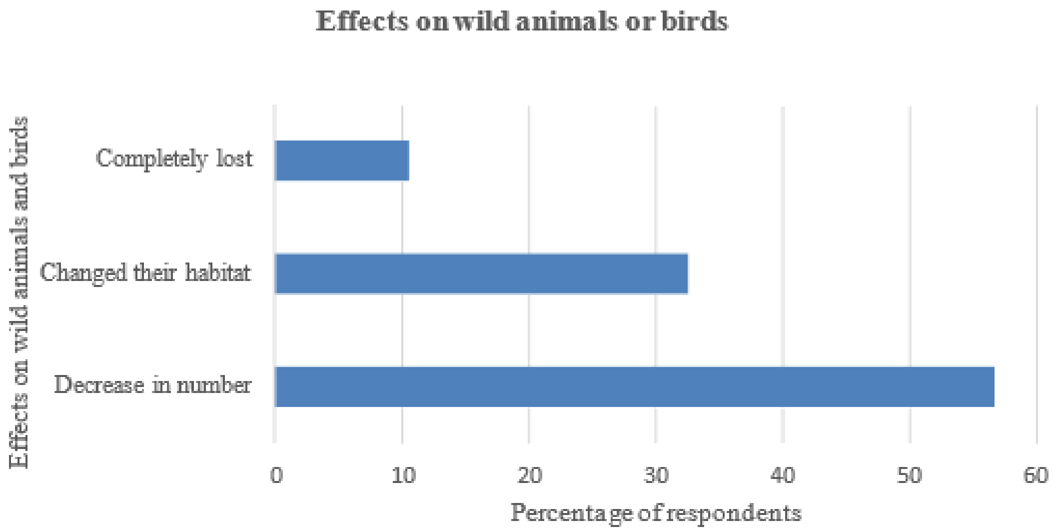

Figure 4.14: Effects of Kiborgoch Encroachment on Birds and animals

4.3.5.2 Community Vulnerabilities

Vulnerable groups consisting of women, children and elderly are most affected with negative impacts of wetland degradation. Reduced water availability cause women to trek for long distances to fetch water for their households. This was revealed in a FGD session for women where one woman lamented on the plights of water availability in the area saying "*During dry periods of the year, the wetland water reduces across the wetland and even R. Loboi. This makes us to sometimes walk for many kilometers to obtain water for our animals and households*,". Another woman seconded this by saying, "*Irrigation becomes difficult when the river dries up, this affects our crops especially vegetables and fruits.*"

Pastoralists face great challenge during dry seasons of the year in this region. This includes loss of pasture and insufficient water levels for their animals. Urbanization and expansion of agricultural land area make it even more difficult for pastoralists and their livelihoods as they have reduced rangeland areas. This causes them to rotate animals more often or overgraze the remaining pasture as indicated by one of them in one of the FGD sessions. He categorically said that, "*Grazing land is becoming smaller and smaller each season because farmers are expanding their lands as well as settlement, which has made us together with our animals vulnerable. We have to therefore adapt by rotating our animals more frequently compared to yester years*,". Another pastoralist also said, "*During the dry season, we have less grass for our goats and cows, so some animals get weak or die.*"

Encroachment has not only affected people and their domestic animals; wildlife has also been affected brutally as well. There is rapid increase in human-wildlife conflict causing crop damage, livestock loss through wildlife predation and even people being attached by wild animals such as pythons.

Table 4.8: Vulnerable groups, their types of vulnerability, and causes in Kiborgoch Wetland

Group affected	Vulnerability type	Cause
Women and children	Water access, safety	Wetland degradation, wildlife threat
Elderly livestock farmers	Loss of pasture	Invasive species, water shortage
Wildlife	Habitat loss, food scarcity	Human encroachment, human-wildlife competition

Note: Vulnerability types and causes were identified through focus group discussions and field observations in Kiborgoch Wetland.

4.3.5.3 Socio-Economic Opportunities Amidst Encroachment

Figure 4.15 illustrated how the wetland continues to be a source of livelihood amidst severe encroachment in the recent years. It supports tourism, basketry, bee keeping, education, research such as this and cultural practices including male circumcision.

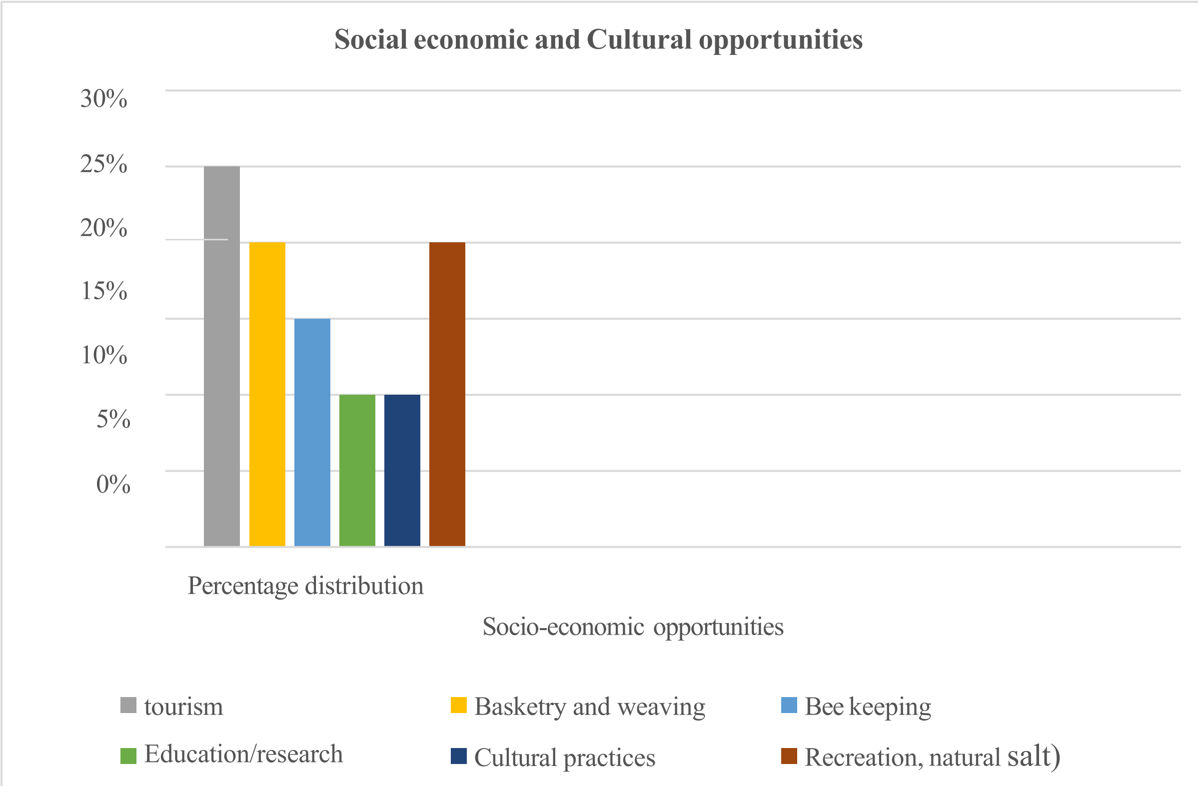

Figure 4.15: Social-Economic and Cultural Opportunities of Kiborgoch Wetland

4.3.5.4 Community-led Mitigation Strategies

Table 4.9 shows how communities around Kiborgoch Wetland have developed strategies to adapt to impacts of degradation of the wetland to ensure livelihood and the ecosystem's health is intact. Some of the strategies include water harvesting practices such as collection of water via water pans that comes in hand in watering livestock. This was revealed during a FDG session where a member stated that, "We *dig small water pans to store rainwater; this helps us water our crops and animals when the wetland dries*."

Other adaptive strategies also include transition from inorganic farming to organic farming. It involves the use of compost, manure, and mulching, to enhance soil fertility and crop yields. Its advantages include; it reduces dependence on wetland water and promotes sustainable agriculture. This was evident in this verbatim response, "*We started using compost and manure to improve soil instead of depending too much on river water."*

Last but not least, *Prosopis juliflora,* an invasive species that has become difficult to control in the region, is currently managed by members actively remove or control the invasive plants to restore native vegetation, improve grazing areas, and maintain ecological balance. "*We cut down Prosopis trees that block our grazing land and plant native grasses in their place.*" a local farmer reported.

Finally, overgrazing is the driver of degradation in the region. Controlled or rotational grazing systems have been implemented to prevent overgrazing and soil degradation. One pastoralist observed, "*We graze our cattle in shifts and leave some areas to recover, as elders taught us.*"

Table 4.9: Community-led conservation strategies and expected outcomes

Strategy	Expected Output
Water harvesting (rooftop, pans)	Drought resilience
Organic farming	Reduced chemical pollution
Invasive species management	Restoration of native vegetation
On-farm pasture development	Reduced pressure on wetland

4.4 Spatial–Temporal Vegetation Changes and Macrophyte Diversity in Kiborgoch Wetland (1994–2024)

18 plant families were identified in the wetland culminating to 36 species. This shows a broad array of vegetation structure in the wetland. Cyperaceae family which accounted for 30% showed the most dominance, not only in the entire wetland but in the zones as well. This was equally reposted in Loboi swamp (Muasya *et al.,* 2004), reflecting taxa is consistent with findings from other ASAL wetlands. Similar environmental pressure such as overgrazing, deforestation, vegetation harvesting, and upstream water diversion are also affecting other ASAL wetland (Ballut-Dajud *et al.,* 2022; Kereri, 2018; Soboka & Gemechu, 2021).

Grassland includes herbaceous plants species such as *Pennisetum clandestinum* and *Cenchrus ciliaris. They are* increasingly fragmented, affecting both livestock forage availability and wildlife habitat (Waheed *et al.,* 2022; Riesch *et al.,* 2019). Grassland vegetation experienced a decline in area translating to −35.77%. This emanates from land use conversions over the years. It reduced from 445.31 ha in 1994 to 286.03 ha by 2024. This can be attributed to grazing pressure, cultivation, and upstream sediment deposition.

Bare land which refers to areas with exposed soil and minimal vegetation, increased from 131.84 ha in 1994 to 199.16 ha in 2024, a 51.06% rise. This increase is attributed to ongoing land degradation caused by overgrazing, deforestation, and unregulated cultivation (Kereri, 2018; Soboka & Gemechu, 2021). Species such as *Cyperus esculentus* are ordinarily dormant in bare land areas. They are known to heavily contribute to soil erosion and sedimentation of wetland channels (Eskandari *et al.*, 2022).

Seasonal wetland vegetation on the other hand was 138.36 ha in 1994 and declining to 179.13 ha by 2024. Hydrological variability, which increase during seasons of high rainfall and reduces during dry periods, causes water abstraction and siltation upstream of rivers such as R. Loboi (Ballut-Dajud *et al.*, 2022; Liu *et al.,* 2023). Macrophytes, including *Typha domingensis*, *Cyperus papyrus*, and *Echinochloa stagnina*, dominate the seasonal wetland areas. They provide temporary habitats and forage for wildlife and migratory birds. Instability experienced by seasonal wetland vegetation indicates that the area is vulnerable to climatic stresses human induced activities, which actually threatens their ability to provide ecosystem services in the long-term basis (Agidie *et al.,* 2024; Kola *et al.,* 2025).

Permanent wetland vegetation, which refers to wetland that is permanently occupied by water all though the year, increase in area from 99.18 ha in 1994 to 150.36 ha in 2024, which translates to 51.60%. Cyperaceae family maintain to be the dominant family in this land use class and is known to be rich in species as well. This however causes constant interference resulting from ongoing grazing, harvesting, and hydrological modifications (Muasya *et al.,* 2004; Kundu *et al*., 2024). This vegetation class is important because it provide key ecosystem services including water filtration, habitat provision, and carbon sequestration. Unfortunatley, dominance resilient species are slowly interfering with the system's ability diversity (Isaac *et al*., 2025).

Land cover change and macrophytes diversity data from this research indicate that Kiborgoch Wetland is transforming from wetland dominated by grass to wetland that is dominated by swamps and bare land.

4.5 Drivers and Extend of encroachment of Kiborgoch wetland between 1994 to 2024

Overdependence on Kiborgoch Wetland have greatly impacted the wetland's health and its ability to effectively perform ecosystem services for example hydrological functions such as provision of clean water has been affected. This has been brought about by large extraction of water at Maji Moto and Kamoskoi area for the purposes of irrigation of large tracks of land upstream. This has lowered surface and ground water notably during dry periods (Davidson *et al.,* 2019; Ramsar Convention, 2019). Reduced water availability in the wetland has brough about inadequate flood control, maintenance of water base flow as well as slow recharge groundwater. This results to diminishing water security for both people and wildlife (Osland *et al.,* 2022).

Overharvesting and overgrazing of macrophytes and negatively impacted the vegetation's health in totality. Some of indigenous macrophyte species have declined or become extinct (Chakraborty *et al.,* 2023; Lake Bogoria National Reserve Management Plan, 2019). Wetland's plant cover trap sediment and nutrients using its roots, they also strengthen soil stability and increases carbon sequestration level, without which all the benefits are not achieved. Overgrazing on the other hand depleting biomass, compacting soils, and promoting the spread of less palatable or invasive species (Skovlin, 2021; Mihailou & Massaro, 2021). Wetland's vegetation loss and soil compaction cause surface runoff by increasing the rate of soil erosion reducing the wetland's resilience to climatic variability (Rebelo *et al*., 2018).

Decline in vegetation impacts habitat for wetland-dependent wildlife reducing biodiversity (Mitsch & Gosselink, 2015). The quality of habitats and biodiversity has been compromised with as a result of vegetation loss. As the integrity of vegetation continues to be corrupted plant species continue to disappear. Habitats for wetland-dependent wildlife not only deteriorate but also impacts biodiversity. Once the wetlands vegetation becomes inadequate for wildlife, they tend to enter into human settlement territories leading to (UNEP, 2020).

Other economic activities such as pastoralism, farming, small scale industries in cottage are equally affected (Kiprop *et al.,* 2023). Traditional wetland management practices such as rotational grazing and demarcation of animal watering points have put pressures on the wetland making a platform for unsustainable use of wetland resources with no accountability (Assessment, 2005).

4.6 Effects of Kiborgoch Wetland Encroachment on Ecosystem Services

Encroachment into the Kiborgoch Wetland consequently led to reduction of its ability to deliver important ecosystem services. Excessive water withdrawal at Maji Moto and Kamoskoi has lowered water availability flowing though the Wetland to Lake Baringo, which in turn disrupts hydrological processes that sustain wetland ecosystems (Ramsar Convention, 2018). The purpose of water abstraction is for irrigation, domestic use, and livestock use which cause decline in surface water and groundwater levels. These hydrological changes negatively affect wetland-dependent plant species, resulting to the replacement of sensitive species with species more tolerant of disturbance (Osland *et al.,* 2022).

Overharvesting of wetland plants for the purposes of roofing, food, building, weaving and basketry causes loss of indigenous species which is important for fodder and medicinal resources production as well as materials for construction and local industries. This has led to the species being extensively removed (Lake Bogoria National Reserve Management Plan, 2019). This loss has led to reduces plant cover, simplifies habitat structure, and disrupts ecological processes such as nutrient cycling and carbon storage (Sharma & Naik, 2024). Provisioning and regulating services are as a result compromised which directly affects pastoralists, farmers, and small-scale entrepreneurs who depend on wetland resources.

Overgrazing, amongst other negative impacts, has led to accelerating desiccation and lowering resilience to climate variability of wetlands (Skovlin, 2021). This is because during dry periods animals tend to shift to palatable and invasive species. This in turn has caused decreased biodiversity thus undermining its role as a productive forage zone (Mihailou & Massaro, 2021). Vegetation transformation in turn affects how wetland perform secondary ecosystem services, including wildlife habitat, forcing animals into farmlands and increasing human–wildlife conflicts (UNEP, 2020).

The relationship between reduced ecosystem service production and over-reliance on the wetland is evident in this research. Ecosystem services such as water regulation, vegetation cover, have in totality reduced. Habitats for wetland-dependent species such as wild animals and migratory bird species have reduced, threatening biodiversity (Mitsch & Gosselink, 2015; Rebelo *et al.,* 2018). The potential of wetland to sequester Carbon is reduced because biomass from the plants' communities including macrophytes is lost. Degradation has direct impact on socio-economic aspects of the community which increases vulnerability for communities who rely on the wetland for products such as forage, water, and raw materials (Angima, 2021).

This work was not without challenges and limitations, one of which was language barrier. Kiborgoch wetland loculation is in deep rural areas of Baringo County which is dominated by

Tugen people who speak Tugen language. During FGDs meetings and questionnaire surveys information given was translated to English from Tugen language. This however led to subtle cultural nuances. Dependance of qualitative data may not give a full picture of the wetland's information required for this work. To mitigate this field surveys and RS was used to ensure reliability and credibility of data provided.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

5.1.1 Spatial-Temporal Vegetation Changes (1994-2024)

LULC analysis of The Kiborgoch community wildlife and wetland conservancy from 1994 to 2024, show that grassland vegetation, temporary wetland vegetation and permanent wetland vegetations has reduced notably from 2014 to 2014 as a result of extensive anthropogenic activities. Bareland on the other land expanded as a result of agricultural encroachment, overgrazing, and settlement development at the expense of natural vegetation.

Reduced species richness is evidence of ecological stress and reduced wetland functionality. This is shown by recission of indigenous plants species in the wetland such as *Cyperus papyrus* and *Typha domingensis.* To complement RS data, field assessments and macrophyte surveys were done and this data collaborated that Kiborgoch wetland is degraded and require immediate intervention to salvage the situation.

5.1.1 Drivers and Extent of Encroachment (1994–2024)

Kiborgoch Wetland's intensified degradation is as a result of socio-economic pressure, population growth as well as governance challenges. This has resulted to a rapid demand of land and natural resources bringing about intensified livestock and crop production within the wetland area. Crop production farmers continue to convert deep riparian lands into farm lands due to their fertile soil and high moisture content resulting to high yields of crops such as maize, beans, and horticultural produce. Pastoralists on the other hand have intensified livestock production, increasing the number of livestock such as cattle, goat, sheep, donkey and camel. Overstocking and overgrazing of these livestock has brought about vegetation loss, soil compaction, and reduced regenerative capacity of the wetland which is more severe during the months of December to May, which is the dry periods of this region.

Unclear land tenure and poor governance have deeply caused competition of the wetland resource as they have encouraged open access to the wetland. This has resulted to it being viewed as a communal land igniting unruly behaviors amongst the local community members such as unregulated grazing, fuelwood collection, as well as settlement expansion. These interferences have accelerated Kiborgoch wetland degradation, leading to habitat fragmentation, biodiversity loss, and diminished ecosystem resilience.

5.1.2 Effects of Encroachment on Ecosystem Services

With the present deteriorated condition of the Kiborgoch Wetland, essential ecological services that are to be performed by this wetland has been negatively affected. Reduction of wetland plant vegetation cover has interfered with the wetland's capacity to control floods, retain water and filter sediments and nutrients that finds its way into other water sources affecting the water quality. Further, the loss of macrophytes has also affected the ability of the wetland to supply resources that local communities depend on, for example shortage of livestock's forage, building materials, herbs and fish. This has impacted the livelihood of the community negatively.

Due to habitat loss and fragmentation, breeding and feeding grounds for wild animals and water birds that depend on Kiborgoch wetland has greatly reduced. This has subsequently led to loss of biodiversity and has increased human-wildlife conflict due to scrambling of the resources from the wetland. This is therefore evidence of the connection between wetland's vegetation health and key ecosystem services provided by the wetland.

5.2 Recommendations

Continuous and close monitoring of Kiborgoch wetland specifically looking at the plant cover and species composition should be carried out using GIS, RS and complemented by regular field visit. This is to ensure that up do date maps are produced regular to monitor the progress of plants in the different sections of the wetland. This will help to improve the condition of plants in the wetland and halt its salvage. Restoration efforts should include transplanting of native wetland plants into the wetland section that is deprived. It is worth also to actively involve the local community so that they feel part of the team and embrace restoration activities.

To curb the negative effects of encroachments drivers such as unsustainable grazing, agricultural expansion into wetlands, there should strong conservation institutions and policies that will curb, halt and punish conservation offenders. Additionally, there should be clear demarcation of wetland boundaries and establishment of buffer zones that can put a limit to human interference and guide sustainable land use. Community involvement and public education should be vast to make people understand the importance of wetland conservation and eliminate the negative ideas that people have about wetland being a pathetic landmass. The use of traditional governance like the use of elders to govern grazing and watering points in the wetland like in the early 90s, would be grate to exercise control and order. Lastly, having alternative means of livelihood such as been keeping, agroforestry and eco-tourism reduce the pressure that Kiborgoch as been experiencing presently.

Reviving the wetland to be in a position where it can effectively perform it ecosystem services is of utmost importance. This can be achieved by rehabilitation of natural water channels such as River. Loboi that passes through the wetland supplying constant water. Additionally, sustainable grazing and agricultural farming practices, including controlled grazing, organic farming, and reduced usage of agrochemical, should be encouraged to restore soil fertility and vegetation cover around the wetland. Wildlife habitat protection conservation programs targeting wildlife habitat restoration and ecological connectivity will support biodiversity and enhance ecosystem service provision. Integrating ecosystem service valuation into development planning can help balance conservation with community livelihoods.

Future research should focus on the socio-economic aspects of wetland degradation. It should comprehensively investigate how community livelihoods and land-use decisions influence conservation outcomes. Also, detailed hydrological and water quality studies are needed to assess nutrient loading, sedimentation, and pollution levels. Exploring nature-based solutions, such as constructed wetlands, payment for ecosystem services, and ecological restoration models, will provide practical strategies for improving the resilience and sustainability of Kiborgoch Wetland.

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APPENDICES

Appendix A: Survey Questionnaire for Kiborgoch Wetland Study

This academic research is being conducted by Glarion, a student from the Environmental Science Department at Egerton University. Its goal is to better understand anthropogenic practices and their direct and indirect impacts on Kiborgoch wetland. The study aims to analyze plant composition in the wetland as well as drivers and extend of encroachment and subsequent effects on ecosystem services provided by the wetland. The information you provide will be kept confidential and used solely for the purposes of this study. Your responses will help document the impacts of human activities on wetland resources and ecosystem services, contributing to the conservation of wetlands in Kenya.

Instructions for the Enumerators

1. Introduce yourself and tell the respondents the purpose of the study before the interview
2. Tick the box on the closed questions as indicated
3. Write interviewees responses clearly (For the respondents that may be unable to read and write)
4. Please indicate the responses in the English language only (Translate where possible)

Name of the enumerator……………………………………………………….………

Name of respondent (Optional) ………………………….…………………………

Name of the village………………………………………………….…………….

Date……………………………………………………

HISTORICAL BACKGROUND OF KIBORGOCH WETLAND

1.0 Were you born in this area?

Yes ☐ No ☐

1.1 If yes, which of the following most effectively describes how your piece of land looked like at the time you settled here?

☐ Thickly forested ☐ moderately forested ☐ slightly forested ☐ Others (specify)

……………………………………………………………………………………………….

1.2 What methods or processes did you use to acquire your piece of land

☐ Purchase ☐ inheritance ☐ gift ☐ lease ☐ or other means?

……………………………………………………………………………………………….

1.3 What socio-economic activities did you participate in the earlier years?

……………………………………………………………………………………………….

SOCIO-ECONOMIC PRACTICES AROUND KIBORGOCH WETLAND

1.1.1 What types of farming activities are you involved in?

☐ Commercial/Subsistence Farmer ☐ Agro-pastoralists ☐ Fisher man/woman

☐ Logger ☐ Craftsman/artisan

Others (please specify)

………………………………………………………………………………….

1.1.2 What agricultural activities do you engage in?

☐ Livestock keeping ☐ Subsistence crop-cultivation ☐ cash crop-cultivation

☐ Livestock keeping and crop cultivation ☐ Others (specify) -------------------------

1.1.3 What other materials or products do you collect from the wetland?

a. Nearby river
b. Kiborgoch wetland
c. Ponds
d. Piped water supply
e. Boreholes
f. Springs /streams
g. Others(specify)---

1.1.4 If your answer to 1.1.3 above is nearby river or stream, and/or the wetland, is the water used for irrigation farming?

☐ Yes ☐ No

1.1.5 If your answer to 1.1.3 above is nearby river or stream, and or the wetland, is the water used for livestock production or in fishing pond?

☐ Yes ☐ No

1.1.6 What are the other products that you extract from the wetland?

ENVIRONMENTAL PRODUCT	YES	NO
Timber and/or Firewood		
Raw materials for basketry/handcrafts /Cottage.		
Water		
Vegetables		
Thatch grass		
Animal fodder		
Building poles		

Others(specify)		

1.1.7 How would you rank the different uses of the wetland in terms of importance, from least important to most important?

USES OF WETLAND	**VERY IMPORTANT**	**IMPORTANT**	**LESS IMPORTANT**
Crop cultivation			
Grazing			
Source of water			
Socio-cultural activities			
Raw material for building/cottage industry			
Others(specify)			

1.1.8 Are you involved in livestock keeping?

☐ Yes ☐ No

If applicable, indicate which types of livestock you keep and whether their numbers have risen in recent years.

1.1.9 In the dry season, where do you normally provide feed for your livestock?

(a) Nearest the wetland (i) Yes (ii) No

(b) Along river valleys (i) Yes (ii) No

(c) Are your animals relocated to other areas? (i) Yes (ii) No

(d) Is any land under your ownership? (i) Yes (ii) No

(e) Other (if any, please specify)

1.1.10 During the wet season, where do you usually graze or feed your animals?

(a) Wetland (i) Yes (ii) No

(b) Do you graze your animals along river valleys? (i) Yes (ii) No

(c) Do you hold any land? (i) Yes (ii) No

(d) Other (describe)

IMPACTS OF WETLAND INTERFERENCE ON PLANT COVER CHANGES AND WATER RESOURCES

1.3.1 ow has the size of the wetland changed over the last 10 years, according to your observations?

(a) Has the wetland decreased in size? (i) Yes (ii) No

(b) No change in wetland size? (i) Yes (ii) No

(c) Has there been a growth in the wetland's size? (i) Yes (ii) No

(d) Do none of the above options describe the wetland? (i) Yes (ii) No

1.3.2 If there has been a decline in the wetland, what do you consider the contributing factors?

(a) Has population growth impacted the wetland? (i) Yes (ii) No

(b) Reduction in river flow as a contributing factor? (i) Yes (ii) No

(c) Is climate change a contributing factor? (i) Yes (ii) No

(d) Has the expansion of agricultural land affected the wetland? (i) Yes (ii) No

(e) Has excessive grazing affected the wetland? (i) Yes (ii) No

(f) Are none of the listed factors responsible? (i) Yes (ii) No

1.3.3 What are some of the services that have been affected with the change that has occurred in the wetland over the years?

1.3.4 What are the ecological impacts of encroachment on biodiversity within Kiborgoch wetland?

1.3.5 Have you noticed loss or disappearance or particular wetland plants species in the wetland or the area over the past years? If yes, please state the names of the species

1.3.6 What animals/bird have been affected due to the wetland degradation and how?

1.3.7 What impact have natural disasters (e.g., floods, droughts) had on wetland encroachment?

1.3.8 How has the loss of wetland area affected ecosystem services provided by Kiborgoch wetland?

SUGGESTIONS ON MANAGEMENT OF WETLANDS

1.3.9 Should measures be taken to protect this wetland? (i) Yes (ii) No

If you answered yes, what reasons support protecting this wetland

(a) Does wildlife and tourism justify protecting the wetland? (i) Yes (ii) No

(b) Is water supply a reason for protection? (i) Yes (ii) No

(c) Protection due to socio-cultural activities? (i) Yes (ii) No

(d) Does the wetland provide food and other natural resources? (i) Yes (ii) No

(e) Not applicable from the above

1.3.10 If you answered no, what are your reasons for not supporting its protection?

(a) Acts against insects and tsetse flies that infect humans and animals? (i) Yes (ii) No

(b) Does it support animals that negatively impact crops, e.g., baboons? (i) Yes (ii) No

(c) Uses land that would otherwise be for grazing? (i) Yes (ii) No

(d) Do none of the above apply?

1.3.11 In your opinion what can be done to improve the state of Kiborgoch wetland

1.3.12 How have changes in climate (e.g., rainfall patterns, temperature changes) affected the extent of Kiborgoch wetland?

Thank you for your responses.

Appendix B: Key Informants Interview

A key informant interview guide (Appendix B) was used to gather information on the key themes mentioned above by asking the following questions:

1. What in your view are the main drivers of encroachment?
2. What are some of the negative effects that are associated with Kiborgoch wetland encroachment?
3. What kinds of vulnerabilities exist among wetland communities and the environment?
4. Who is affected by the wetland interference or the effect on ecosystems services and by what?
5. What socio economic/cultural opportunities exist in wetland areas?
6. What specific benefits do people derive from the wetlands?
7. How are people adapting against floods or drought so as to exploit opportunities in the wetland?

History of land use and tenure

1. Could you provide a brief overview of how the land tenure system in this area has changed over time?
2. How do community members currently gain access to pasture or grazing land?
3. What is the current nature of land tenure for the following land use types:
   a. Grazing areas
   b. Dryland farming or crop cultivation areas
4. What has historically been the main economic activity of people in this area?
5. What are the key challenges facing land users today that may affect or interfere with the Kiborgoch wetland?
6. How has land tenure evolved over the last thirty years?
   i. Are land sales and subdivisions increasing, decreasing, or remaining the same compared to the past?
   ii. Are outsiders attempting to purchase land here, and if so, what do you think attracts them?

Water

Please provide your comments and recommendations regarding:

1. Factors contributing to limited water availability for irrigation, which may affect nearby wetlands.
2. Drying of watering points, streams, or other water sources.
3. Conflict over water use between herders and farmers.

Communal Resources

1. How can someone acquire a piece of land within the wetlands today?
2. Besides grazing and crop cultivation, are there other benefits people derive from these wetlands?
3. Do you think land users have reasons or incentives to protect the wetlands?

Thank you for your responses.

Appendix C: Plant Species Recorded in Kiborgoch Wetland's Section

Table 1: Plant Species Recorded in the Northern Section of Kiborgoch Wetland

Botanical name	Common	Family name	Local name	Category
Vachellia reficiens	False umbrella tress	Fabaceae	Barsule	Tree
Acacia senegal	Gum acacia	Fabaceae	Chemange	Tree
Acacia mellifera	Black thorn	Fabaceae	Ngorore	Tree
Acacia tortilis	Umbrella thorn	Fabaceae	Sesia	Tree
Acacia Seyal	Shittah tree	Fabaceae	Chepkuto	Tree
Acacia nilotica	Gum Arabic tree	Fabaceae	Chepkuto	Tree
Acalypha indica	Indian acalypha	Euphorbiaceae		Herb
Salvadora persica	Toothbrush tree	Salvadoraceae	Seketet	Tree
Prosopis juliflora	Mathenge	Fabaceae	Bestus	Tree
Acalypha fruticosa	Birch leaved acalypha	Euphorbiaceae	Lokumu	Herb
Lantana camara	Common lantana	Verbenaceae	Cheramba	Shrub
Ludwigia ssp	Primrose-willow	Onagraceae	Chepchomunio	Herb
Indigofera spinosa	True indigo	Fabaceae	Ariapngwany	Shrub
Ipomoea aquaticaForssk.	Water spinach	Convolvulaceae	Singintwo	Herb
Carex spicata	Spiked sedge	Cyperaceae	Chepngatip	Sedge
Cyperus alopecuroides	Foxtail flatsedge	Cyperaceae	Chepkenge	Sedge
Cyperus papyrus	Papyrus	Cyperaceae	Kutwe	Sedge
Cyperus laevigatus	Cyperus reed	Cyperaceae	lavaiwe	Sedge
Nymphaeaceae	Water lilies	Nymphaeaceae	Teldet	Herb

Cyperus alternifolius	Umbrella sedge	Cyperaceae	Maitutie	Sedge
Leersia hexandra	Swamp rice grass.	Poaceae	-	Grass
Typha domingensis	Southern cattail	Typhaceae	-	Grass
Paspalidium geminatum	Alligator Grass	Poaceae	-	Grass

Table 2: Plant Species Recorded in the Middle Section of Kiborgoch Wetland

Botanical name	**Common**	**Family name**	**Local name**	**Category**
Cyperus papyrus	Papyrus	Cyperaceae	Kutwe	Sedge
Cyperus laevigatus	Cyperus reed	Cyperaceae	lavaiwe	Sedge
Nymphaeaceae	Water lilies	Nymphaeaceae	Teldet	Herb
Cyperus alternifolius	Umbrella sedge	Cyperaceae	Maitutie	Sedge
Carex spicata	Spiked sedge	Cyperaceae	Chepngatip	Sedge
Ceratophyllum demersum,	Hornwort	Ceratophyllaceae	-	Herb
Typha domingensis	Southern cattail	Typhaceae	-	Grass
Paspalidium geminatum	Alligator Grass	Poaceae	-	Grass

Table 3: Plant Species Recorded in the Southern Section of Kiborgoch Wetland

Botanical name	Common	Family name	Local name	Category
Acacia senegal	Gum acacia	Fabaceae	Chemange	Tree
Azadirachta indica (L.) Juss.	Neem tree	Meliaceae	Mwarobor	Tree
Vachellia reficiens	False umbrella tress	Fabaceae	Barsule	Tree
Aeschynomene pfundii	-	Fabaceae	-	Tree
Acacia tortilis	Umbrella thorn	Fabaceae	Sesia	Tree
Acacia mellifera	Black thorn	Fabaceae	Ngorore	Tree
Ficus sycomorus	Sycamore Fig	Moraceae	Lokoine	Tree
Combretum molle	Velvet bushwillow	Combretaceae	Chepkony	Shrub
Terminalia brownii	Red pod terminalia	Combretaceae	Kofutine	Tree
Tarchonanthus comploratus	Camphor bush	Asteraceae/ Tarchonanthus	Chepkwekwot	Shrub
Acacia brevispica	Wait-a-bit thorn	Fabaceae	Kornista	Tree
Salvadora persica	Toothbrush tree	Salvadoraceae	Sokotoiwo	Tree
Tamarindus indica	Tamarind	Fabaceae	Orwo/leku	Tree
Prosopis juliflora	Mathenge	Fabaceae	Bestus	Tree

Acalypha indica	Indian copperleaf	Euphorbiaceae	Walboyon	Herb
Cyperus papyrus	Papyrus	Cyperaceae	Kutwe	Sedge
Cyperus laevigatus	Cyperus reed	Cyperaceae	lavaiwe	Sedge
Cyperus difformis	Rice sedge	Cyperaceae	Chepkiret	Sedge
Cyperus alternifolius	Umbrella sedge/	Cyperaceae	Maitutie	Sedge
Cyperus alopecuroides	Foxtail flatsedge	Cyperaceae	Lamara	Sedge
Aeschynomene indica	Budda pea	Fabaceae	Chepkeit	Herb
Nymphaeaceae	Water lilies	Nymphaeaceae	Teldet	Herb
Pistia stratiotes	Water cabbage	Araceae	Teldet	Herb
Najas minor	brittle waternymph	Hydrocharitaceae	Argutye	Herb
Ceratophyllum demersum	rigid hornwort	Ceratophyllaceae	Lengnee	Herb
Carex spicata	Spiked sedge	Cyperaceae	Chepngatip	Sedge
Acalypha fruticosa	Birch leaved acalypha	Euphorbiaceae	Lokune	Shrub
Lantana camara	Common lantana	Verbenaceae	Cheramba	Shrub
Ludwigia ssp	Perennial water		pri	

rose	Onagraceae	Chepchomuni o	Herb

Ipomoea ssp	Pink morning glory	Convolvulaceae	Singinto	Herb
Indigofera spinosa	True indigo	Fabaceae	Arupngwany	Shrub
Phyllantus sepialis	Phyllanthus specialis	Phyllanthaceae	Arap lakwa	Shrub
Typha domingensis	Southern cattail	Poaceae	-	Grass
Paspalidium geminatum	Alligator Grass	Poaceae	-	Grass

Appendix D: Focus Group Participants Registration Form

Name	ID no	Contact	Group representative
Tuitoek Chirchir	31411273	0728852390	Youth
Fancy Kiprotich	23257454	0711414558	Community liason officer
Symon Kiprop	20097223	0729509833	Pastureland/livestock production
Elizabeth Chepkochei	5307973	0722475607	Women representative (Sotiche women group)
Roggers Motoloi	27730369	0702317196	Friends of nature Bogoria
Agnetta Kibet	39116559	0724602660	Honey farmers
Ivy Kibon	27561796	0715690362	Crop production farmers
Dennis Rotich	25855164	0724614016	Area chief
Harriet Cheptoo	42587261	0707727288	Lake Baringo Water association
James Kimaru	20214082	0722446262	Lake Baringo national reserve
Maurine Barmasat	23791137	0727796674	Lake Baringo secondary school
Kipsoi Bartuin	32322679	0722993110	Fishermen representative
Evans Kemboi	20517293	0721441579	Sandai dairy farmers
Tricy Kimereng	36754473	0714520831	Veterinary service officer
Rodgers Molongoi	-	-	Program coordinator indigenous women groups
Ivy Kubul	-	-	Lake Bogoria Spa
Simon Kiprop	-	-	Village elder Chlelaba sub location
Patrick Kureres		0720385096	Translator

Appendix E: Land Use/Land Cover Acreage

Land Cover Changes and Transformations in Kiborgoch Wildlife and Wetland Conservancy (1994–2024)

Land Cover Type	1994 (Hectare)	2004 (Hectare)	2014 (Hectare)	2024 (Hectare)	Change (1994–2004)	Change (2004–2014)	Change (2014–2024)	Total Change (1994–2024)	% Change (1994–2024)
Bare Land	131.84	140.25	123.87	199.16	8.41 (↑)	-16.38 (↓)	75.29 (↑)	67.32 (↑)	51.06%
Seasonal wetland Vegetation	138.36	152.22	396.11	179.13	13.86 (↑)	243.89 (↑)	-216.98 (↓)	40.77 (↑)	29.47%
Permanent wetland Vegetation	99.18	104.67	128.82	150.36	5.49 (↑)	24.15 (↑)	21.54 (↑)	51.18 (↑)	51.60%
Grassland Vegetation	445.31	417.55	165.9	286.03	-27.76 (↓)	-251.65 (↓)	120.13 (↑)	-159.28 (↓)	−35.77%
Total Area	814.69	814.69	814.69	814.69	-	-	-	-	-

Appendix F: Abstracts of Publications

East African Journal of Environment and Natural Resources
eajenr.eanso.org
Volume 8, Issue 2, 2025
Print ISSN: 2707-4234 | Online ISSN: 2707-4242
Title DOI: https://doi.org/10.37284/2707-4242

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Assessing Land Use and Vegetation Change in Kiborgoch Wetland Conservancy, Kenya: Evidence from 30 Years of Remote Sensing (1994–2024)

Glarion Isiaho[1], Prof. George Morara Ogendi, PhD[1] & Dr. Amon Mwangi Karanja, PhD[2]*

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[2] Masinde Muliro University of Science and Technology, P. O. Box 190-50100, Kakamega, Kenya.
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Article DOI: https://doi.org/10.37284/eajenr.8.2.3336

Date Published:

17 July 2025

Keywords:

Kiborgoch Conservancy, Land Use Change, Wetland Vegetation, Grassland Degradation, Swamp Expansion, Remote Sensing, Conservation Planning.

ABSTRACT

Wetlands are critical socio-ecological systems that support biodiversity, regulate hydrological cycles, and sustain livelihoods across East Africa. Despite their importance, these ecosystems are increasingly threatened by anthropogenic pressures and climate variability. This study assessed land use and vegetation changes in the Kiborgoch Wildlife and Wetland Conservancy, located in Kenya's Rift Valley, over 30 years (1994–2024). Using Landsat satellite imagery, Normalized Difference Vegetation Index (NDVI) time series, and GIS analysis, land cover was classified into four primary categories: bareland, wetland vegetation, swamp vegetation, and grassland vegetation. The results revealed substantial landscape transformations, including a 51% increase in bareland, a 52% increase in swamp vegetation, and a 36% decline in grassland vegetation. Wetland vegetation exhibited non-linear trends, peaking in 2014 before declining by 2024. NDVI analysis indicated spatially variable trends in vegetation health, with pronounced degradation near settlements and agricultural zones. These changes were largely driven by land encroachment, upstream water abstraction, and the harvesting of vegetation. The findings highlight the urgent need for targeted conservation strategies, enhanced spatial monitoring, and strengthened community-based management to safeguard the ecological integrity of conservancy-managed wetlands in Kenya.

APA CITATION

Isiaho, G., Ogendi, G. M. & Karanja, A. M. (2025). Assessing Land Use and Vegetation Change in Kiborgoch Wetland Conservancy, Kenya: Evidence from 30 Years of Remote Sensing (1994–2024). *East African Journal of Environment and*

East African Journal of Environment and Natural Resources

eajenr.eanso.org

Volume 8, Issue 2, 2025

Print ISSN: 2707-4234 | Online ISSN: 2707-4242

Title DOI: https://doi.org/10.37284/2707-4242

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Thirty Years of Wetland Transformation: Socio-Ecological Drivers of Degradation in Kiborgoch, Kenya

Glarion Isiaho[1], Prof. George Ogendi, PhD[1] & Dr. Amon Karanja, PhD[2]*

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Article DOI: https://doi.org/10.37284/eajenr.8.2.3279

Date Published: *07 July 2025*

Keywords:

Wetland Degradation, Community Perceptions, Ecosystem Services, Land Tenure, Conservation Strategies.

ABSTRACT

Wetlands in arid and semi-arid regions are increasingly threatened by human activities, leading to the disruption of their ecological functions. This study investigates the socio-ecological dynamics of Kiborgoch Wetland, Kenya, over a 30-year period (1994–2024), focusing on institutional factors, land tenure, livelihood practices, and community perceptions of degradation. A mixed-methods approach was employed, combining structured household surveys (n=132) with qualitative data from focus group discussions and key informant interviews. The findings reveal that overgrazing (17.9%) is the most significant driver of degradation, alongside agricultural expansion, water overextraction, population growth, and overharvesting of wetland vegetation. While Prosopis juliflora, an invasive species, was noted as a concern by community members, it was a relatively less emphasised factor compared to direct land use pressures. Inheritance-based tenure dominates land access in the region, shaping how resources are used and managed. The wetland historically provided vital ecosystem services, including water, pasture, materials for basketry, and cultural space, but has suffered biodiversity loss, water scarcity, and soil degradation. Community narratives indicate a decline in traditional governance and ecological knowledge-sharing, weakening local conservation capacity. The study recommends integrated, community-led management strategies that merge traditional ecological knowledge with scientific practices to ensure the wetland's long-term sustainability and the protection of dependent livelihoods.

APA CITATION

Isiaho, G., Ogendi, G. & Karanja, A. (2025). Thirty Years of Wetland Transformation: Socio-Ecological Drivers of Degradation in Kiborgoch, Kenya. *East African Journal of Environment and Natural Resources, 8*(2), 209-227.

Appendix G: NACOSTI Clearance Certificate

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RefNo: 430886

Date ofIssue: 08/November/2024

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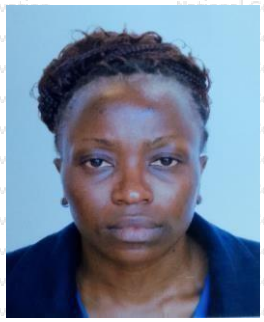

This is to Certify that Ms.. Glarion Isiaho of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Baringo on the topic: ASSESSMENT OF KIBORGOCH WETLAND ENCROACHMENT AND ITS EFFECTS ON ECOSYSTEM SERVICES IN BARINGO COUNTY for the period ending: 08/November/2025.

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Appendix H: Egerton University Ethics Clearance Certificate

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www.egerton.ac.ke

OFFICE OF THE DIRECTOR GRADUATE SCHOOL

Ref: NM12/14549/18

Date: 24th October, 2024

The Director General
National Commission for Science Technology and Innovation,
P. O. Box 30623-00100
NAIROBI.

Dear Sir,

RE: REQUEST FOR RESEARCH PERMIT– MS. GLARION KHASANDI ISIAHO REG. NO. NM12/14549/18

This is to introduce and confirm to you that the above named student is in the Department of Environmental Science, Faculty of Environment & Resource Development, Egerton University.

She is a bona-fide registered Msc student in this University. Her research topic is **"Assessment of Kiborgoch Wetland Encroachment and Its Effects on Ecosystem Services in Baringo County."**

She is at the stage of collecting field data. Please issue her with a research permit to enable her undertake the studies.

Your kind assistance to her will be highly appreciated.

Yours faithfully,

DIRECTOR, BOARD OF POST GRADUATE STUDIES
25 OCT 2024

Prof. George Ogendi PhD
DIRECTOR, DIRECTORATE OF POSTGRADUATE STUDIES

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