

**LAND USE CHANGE AND COMMUNITIES' KNOWLEDGE AND PERCEPTIONS
OF SITATUNGA ANTELOPE (*TRAGELAPHUS SPEKII*) IN SAIWA WETLAND,
TRANS-NZOIA COUNTY, KENYA**

MILLICENT ANYANGO OWITI

**A Thesis submitted to Graduate school in Partial Fulfilment of the Requirements for
the Master of Science Degree in Natural Resources Management of Egerton University.**

EGERTON UNIVERSITY

JUNE, 2024

DECLARATION AND RECOMMENDATION

Declaration

This thesis is my original work and has not been presented in any other University for the award of a degree.

Signature 


Date: 6/6/2024

Millicent Anyango Owiti

NM11/13008/21

Recommendation

This thesis has been submitted with our approval as University supervisors

Signature 

Date: 10/06/2024

Dr. Grace Kibue ,PhD

Department of Natural Resources,

Egerton University

Kenya

Signature 

Date: 10/06/2024

Dr. Maurice Ogoma, PhD

Department of Natural Resources,

Egerton University

Kenya

COPY RIGHT

©2024, **Millicent Anyango Owiti**

All Rights Reserved. No part of this thesis may be reproduced, transmitted or stored in any form or means such as electronic, mechanical or photocopying including recording or any information storage and retrieval system, or translated in any language, without prior written permission of the author or Egerton University on her behalf.

DEDICATION

This thesis is dedicated to my parents Geoffrey Owiti and Emma Otari, and to my dear brother Michael Owiti for always believing in me and being there when I needed them.

ACKNOWLEDGEMENT

First and foremost I give thanks to the Lord Almighty for the far he has brought me. I owe all the success of this research project to the input and tireless effort of different persons who made it possible. I would like to give my sincere gratitude to my supervisors, Dr. Grace Kibue and Dr. Maurice Ogoma for guiding me and providing positive feedbacks and comments that made this project worthwhile. I am indebted to Egerton University, Faculty of Environment and Resources Development, Department of Natural Resources for giving me a favourable environment which has enabled me to achieve this enormous cognizance. I would also like to acknowledge the TAGDev program, Egerton University, for their scholarship without which this study could not have been possible. Special thanks to all my lecturers and staff in the faculty level, I will always treasure the knowledge you bestowed in me and I am deeply inspired by your motivation. I'm grateful for Kenya wildlife service and Saiwa national park staff for making it possible for me to carry out my field work. My sincere gratitude also goes out to the local communities living around Saiwa National Park for participating as respondents and to my enumerators who aided in data collection in the study area. My acknowledgement and appreciation cannot be complete without paying special attention to my family and friends for their constant moral support throughout this educational journey. Thank you all.

ABSTRACT

Saiwa swamp is one of the critical wetlands in Kenya that is situated in the Saiwa watershed that is an important home to a wide range of wildlife and also a source of livelihoods to the local community. The swamp is facing threat to its existence due to human activities that have led to the swamp degradation with notable loss of native wildlife habitat, animal biodiversity and plant cover lost. The objectives of this study were to characterise different vegetation types in Saiwa swamp, to analyse Land Use Land Cover Change (LULC) and Sitatunga antelope population and to assess the local community knowledge and perception towards the conservation of Saiwa wetland. This study employed a mixed methods research design; household surveys, key informant interviews and Focus Group Discussions (FGDs). In addition, Landsat images were used to detect the land use land cover changes and to characterise vegetation type. Descriptive analysis and Chi-square were used to analyse household data while quantum geographic information system (QGIS) was used to establish the vegetation classes and the land cover changes. Key informant and FGDs were analysed using thematic areas. Analysis of Landsat imagery revealed notable changes in LULC patterns within Saiwa Wetland over the 30 years studied. The findings also reveal that the respondents are aware of the interrelatedness of their activities and the natural resources of the environment. They know that besides biodiversity conservation, the swamp plays an important role in providing the community with livelihoods, cultural and economic needs. The findings also established they are aware that their livelihood activities threaten the swamp. Therefore, protecting and managing the Saiwa swamp ecosystem is essential for the well-being of both present and future generations. For sustainability of both the swamp and community livelihoods, the County and National government should work together with all stakeholders to create and establish a culture of stewardship and collective responsibility among local communities. Most importantly, the community should be involved in designing conservation interventions as a key to ensuring adoption and implementation.

TABLE OF CONTENTS

DECLARATION AND RECOMMENDATION	ii
COPY RIGHT	iii
DEDICATION	iv
ACKNOWLEDGEMENT	v
ABSTRACT	vi
CHAPTER ONE	1
INTRODUCTION	1
1.1 Background information	1
1.2 Statement of the problem	3
1.3 Objectives of the study.....	3
1.3.1 Broad objective	3
1.3.2 Specific objectives.....	3
1.5 Justification	4
1.6 Scope/Limitations/Assumptions of the Study	4
1.6.1 Scope of the study.....	4
1.6.3 Assumptions.....	5
1.7 Definition of term.....	5
CHAPTER TWO	6
2.2 Human activities and Habitat change.....	8
2.2.1 Habitat loss.....	8
2.2.2 Habitat fragmentation	9
2.2.3 Habitat degradation.....	11
2.3 Land use land cover change	12
2.4 Impacts of human activities on Saiwa Swamp.....	14
2.5 Community awareness on biodiversity conservation.....	15
2.6 Research gaps.....	16
2.7 Theoretical framework	17
2.8 Conceptual framework	17
Figure 1: Conceptual framework.....	18
Source: Self (2023).....	18

CHAPTER THREE	19
3.1 Study area description	19
3.1.1 Climate	19
3.1.2 Soil	19
3.1.3 Economic activities	19
3.2 Research design.....	20
3.4 Sampling procedure and sample size	22
3.5 Data collection.....	23
3.5.2 Pretesting of the Questionnaire	24
3.5.3 Land use land cover change	24
3.5.4 Vegetation type characterization	24
3.5.5 Spatial data	24
3.5.6 Image/data processing	25
3.5.7 Land cover processing and classification.....	25
3.5.8 Change detection	28
3.5.9 Ground truthing	28
3.6 Data analysis	28
3.7 Ethical Consideration	28
3.8 Summary of data analysis	29
CHAPTER FOUR	30
RESULTS AND DISCUSSION	30
4.1 Introduction	30
4.2 Vegetation Characterization.....	30
4.3 Land cover trends and Sitatunga antelope population	32
4.3.1 Sitatunga antelope population	32
4.3.2 Land use land cover Image Classification	34
4.4 Community perception towards conservation of the Saiwa Wetland.....	37
4.4.6 Attitudes/perceptions towards management and conservation of the Swamp	46
CHAPTER FIVE	49
CONCLUSIONS AND RECOMMENDATIONS	49
5.1 Conclusion.....	49
5.3 Areas for further research.....	50
APPENDICES	69
Appendix 1: Questionnaire.....	69

Appendix 2: Key informants interview guide	75
Appendix 3: Focus group discussion guide.....	75
Appendix 4: Image of male and female Sitatunga	77
Appendix 5: Additional field photographs.....	77
Appendix 6: Ethical clearance.....	79
Appendix 7: Wildlife research permit.....	81
Appendix 8: NACOSTI permit	83
Appendix 9: Publication.....	84

LIST OF FIGURES

Figure 1: Conceptual framework	Error! Bookmark not defined.
Figure 2: Map of study site	Error! Bookmark not defined.
Figure 3: Saiwa wetland land cover classes	30
Figure 4: Trend analysis of Sitatunga antelope population.....	34
Figure 5: Saiwa wetland land cover classification for 1993, 2003, 2013 and 2023	34
Figure 6: Trend analysis of the land use land cover change	36
Figure 7: Changes in environmental parameters	39
Figure 8: Causes of the environmental changes	40
Figure 9: Respondents knowledge about Sitatunga	43
Figure 10: Actions taken to reduce human-wildlife conflicts at household level	44

LIST OF TABLES

Table 1: summary of research gaps	16
Table 2: population and household distribution.....	21
Table 3: Satellite images description (Source: USGS).....	26
Table 4: Land cover classification scheme used in the study	26
Table 5: Land cover types description.....	27
Table 6: summary of data analysis.....	29
Table 7: Vegetation type is saiwa swamp.....	31
Table 8: Land use land cover distribution	35
Table 9: Summary of demographic and socio-economic characteristics of respondents	37
Table 10: Anthropogenic factors influencing Sitatunga population	41
Table 11: Community awareness of various wildlife species.....	42
Table 12: Risks associated with changes in rainfall, temperature and vegetation.....	45
Table 13: Attitudes/perceptions towards management and conservation of the Swamp.....	47

LIST OF ABBREVIATIONS

IUCN	International union for conservation of nature
KWS	Kenya wildlife service
GIS	Geographic information system
LULC	Land use land cover
QGIS	Quantum geographic information system
SCP	Semi-automatic classification plug-in
USGS	united States geographical survey
NASA	National aeronautics and space administration
SPSS	Statistical package for social sciences

CHAPTER ONE

INTRODUCTION

1.1 Background information

Wetlands are places with a distinct ecosystem that are flooded with water either permanently or seasonally, and where oxygen-free processes prevail (Balwan & Kour 2021; Soni 2020; Mandishona & Knight 2022). Under the Ramsar international wetland conservation treaty (Ramsar, 2011), wetlands are defined as are areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres. Wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands.

Wetlands are among the most productive ecosystems in the biosphere for their ecological and economic value. They support, permanently or periodically, biologically diverse communities ranging from forests, mammals, fishes, birds (Arya & Syriac 2018; Smith *et al.*, 2019; Balwan & Kour 2021; Sharma *et al.*, 2021; Costanza 2021). Besides, wetlands mitigate floods, provide as nurseries for aquatic and terrestrial life, improve and preserve water quality, control shoreline erosion, recharge groundwater aquifers, produce food and energy for human use and opportunities for recreation and aesthetic appreciation and natural products (Arya & Syriac 2018; Balwan & Kour 2021; Nayak & Bhushan 2022; Spieles, 2022).

Kenya has a variety of wetlands stretching from the coastal and marine wetlands to the inland freshwater lakes, dams, rivers and swamps (Ramsar, 2006). Saiwa Swamp National Park was established to conserve the Sitatunga antelope species, (Owen 1970). The Park measuring 2.9 sq. km was gazetted in 1974 with the aim of protecting a small population of the rare antelope and acts as a breeding site for the crested crane. In the recent past, elephant grass has been colonizing this swamp thereby changing habitat suitability for Sitatunga. Other wildlife includes Bush bucks, Aardvarks, civets and Duiker. The park consists of an extensive swamp, a bushed-grassland and a gallery riverine forest as the major habitats. Saiwa swamp is mainly fed by the Kapenguria River that originates from the Cherengany hills in the North and Kipsaina River which originates from Mt. Elgon in the West. The two form river Saiwa which empties its waters in River Nzoia. In Kenya, intensification of agriculture and

especially flower farming has had a significant impact on the environment, altering habitats and posing a major threat to biodiversity. Of the 28,000 species assessed as being at risk of extinction on the IUCN Red List, agriculture is identified as a threat for 24,000 of them (IUCN, 2019).

The Sitatunga antelope, *Tragelaphus spekii* is a rare semi-aquatic antelope inhabiting wetlands (May & Lindholm, 2013). They live in dense wetland habitats and are under threat from human development (Ndawula *et al.*, 2013) even though they are listed as least concern by the international union for conservation of nature (IUCN). According to the IUCN red list, the total population size of sitatunga globally is around 170,000 individuals. The antelopes are found throughout Central Africa and East Africa. Confined in swampy and marshy habitats they can occur in tall and dense vegetation. These antelopes move along clearly marked tracks in their swampy habitat often leading to reed beds. The antelopes are herbivorous animals that feed mainly on new foliage, fresh aquatic grass, flowers, buds and seeds. According to the KWS census report 2021, the total population of the antelopes in Kenya is 473, in Saiwa they are only 60 in number. This is a huge decline since in 2018 they were reported to be 200 in the swamp.

Habitat loss resulting from land use changes affects ecological connectivity for different species (Clauzel & Foltete, 2016; Hartley *et al.*, 2013). For example, it may lead to an increase in the distance between suitable patches, subsequently resulting in a reduction in ecological connectivity for the concerned species (Edelsparre *et al.*, 2018). In the past two decades, landscape metrics have been used to analyse changes in landscape patterns to provide information on the potential impacts of biotic and abiotic functions. The extinction of much biodiversity in vast regions has been connected with habitat loss caused by land use land cover change (LULC) (Michelsen & Lindmer, 2015). Wetland habitats are vulnerable to degradation and decline due to human exploitation and modification (Marrison *et al.*, 2012). As human population increase, demand for resources such as land and water in riparian areas consequently increases. In Kenya, intensification of agriculture and especially flower farming has had a significant impact on the environment, altering habitats and posing a major threat to biodiversity.

The protection of natural lands is vital for conservation of biodiversity (Bignoli, 2016). However, protection of land alone is not always sufficient for maintaining historic species diversity. Policy and institutional mechanisms are lacking to encourage local participation in

design, implementation and local use of tourism resources (Ng'eno *et al.*, 2011). Identification of long term trends in habitat change may elucidate drivers of ecological processes, and therefore help understand mechanisms of landscape changes. This is important because while habitat succession and changes can affect landscape suitability either positively or negatively depending on target species. Landscape changes through fragmentation and direct loss of habitat significantly impairs species ability to carry out critical life activities such as foraging and breeding. Habitat loss can isolate critical habitats or entire populations (Sanders, 2018). An assessment and understanding of land cover land use changes, habitat change and current threats existing in the swamp will give information relevant to all land related action such as conservation planning.

1.2 Statement of the problem

Saiwa swamp one of the critical wetlands in Kenya is situated in the Saiwa watershed that is experiencing direct and indirect impacts of increased human population pressure, especially due to farming activities and human settlements (Miettinen *et al.*, 2011). These activities have jeopardised the ecosystem services such as water quality protection and flood prevention, led to habitat loss, water pollution and disrupted the migration patterns of the antelopes which in turn has threatened the existence and survival of Sitatunga antelope in a way that can bring the species to extinction. The number of the shy antelopes has dwindled over the years (Daily nation, 2020). Their population in Saiwa Park has dropped from 200 in the year 2018 to 60 in 2021 according to KWS census. Therefore, it is important to understand habitat management and the role communities surrounding such habitats have to play in its conservation

1.3 Objectives of the study

1.3.1 Broad objective

The study aimed to contribute to the conservation of the threatened Sitatunga antelope through habitat management.

1.3.2 Specific objectives

- i. To characterise the different vegetation types in Saiwa Swamp in relation to the Sitatunga habitat.
- ii. To analyse the land cover trends and Sitatunga population from 1993 to 2023.
- iii. To assess the Park-adjacent community's knowledge and perceptions towards Saiwa wetland.

1.4 Research questions

- i. What are the different types of vegetation in Saiwa Swamp National park?
- ii. What are the trends in land cover changes and Sitatunga population from 1993 to 2023?
- iii. What is the park adjacent community's knowledge and perception on the importance of Sitatunga and Saiwa wetland?

1.5 Justification

Intense human activities on natural ecosystems have led to ecosystem degradation with notable loss of native wildlife habitat, animal biodiversity and plant cover lost (Adla, *et al.*, 2022). The reduction in area of habitat has direct and indirect implications on its quality to support species and can lead to fragmented populations of species and isolation from each other (Hoban *et al.*, 2013). Saiwa swamp ecosystem being vital for both humankind and nature, its degradation will in turn jeopardise the ecosystem services such as water quality protection and flood prevention, also the economic aspect of tourism at large. The Sitatunga being the world's only aquatic antelope (Ndawula *et al.*, 2011) calls for the government and stakeholders to find complimentary ways of preserving the species and the wetland habitat. Therefore, this study sought to provide information on coexistence of wildlife and communities, how communities can adversely affect wildlife habitat and population through different practises and also inform other stakeholders such as the Kenya wildlife service, county governments and community based organisations on proper management and conservation of biodiversity. The study will also help achieve the sustainable development goal 15, life on land that seeks to protect, restore, and promote the sustainable use of terrestrial ecosystems. This includes sustainably managing forests, combating desertification, halting and reversing land degradation, and stopping biodiversity loss

1.6 Scope/Limitations/Assumptions of the Study

1.6.1 Scope of the study

The study was conducted in Saiwa Swamp National Park in Trans-Nzoia County, which cuts across two wards, Sitatunga and Sinyerere. This park is home for the Sitatunga antelopes that are threatened by anthropogenic activities. The study determined some of the land use land cover changes that have occurred in the study area and vegetation cover present. The research sought also to find out about the community perception and key informants involvement in the Sitatunga conservation.

1.6.2 Limitations of the study

Some of the sampled households' heads declined to participate in the questionnaire survey due to negative impact of human wildlife conflicts, the researcher however utilized the relation the community had with the honorary warden to win their confidence. There was limited data on Sitatunga antelope population over the 30 year period of study, however projections were done to ensure a comprehensive analysis. The sentinel 2 satellite was not able to determine the specific vegetation type but this was done by a ground truthing survey in the wetland.

1.6.3 Assumptions

This study assumed that respondents were factual, truthful and gave information that will be helpful in drawing conclusions and generalisations. It also assumed that the quality of the habitat decrease is proportional to an increase in human disturbances/Land use land cover change.

1.7 Definition of term

Biodiversity: Refers to the wide variety of ecosystems and living organisms

Geographical information system: A geographical Information system is a Computer system that analyses and displays geographically referenced information

Ground truthing: Information provided by direct observation opposed to information provided by inference

Habitat Fragmentation: Destruction of habitats leaving behind smaller unconnected areas

Habitat: A natural home or environment of an animal, plant or other organisms

Land cover: The physical material at the surface of the earth

Land use: The management and modification of natural environment into built environment

Landsat: A US scientific satellite that studies and photographs the earth's surface

Landscape: The visible features of an area of land

Park-adjacent community: People living around a park

Prior informed consent: Consent sought in advance of any activities being commenced

Ramsar convention: Inter-governmental treaty that provides the framework for conservation of wetlands.

Swamp: An area of land permanently saturated or filled with water with plants growing in it.

Wetlands: Area of land whose soil is saturated with water either permanently or seasonally

CHAPTER TWO

LITERATURE REVIEW

2.1. Importance of wetlands

Wetlands are found from the tundra to the tropics and on every continent except Antarctica. Wetlands vary widely because of regional and local differences in soils, topography, climate, hydrology, water chemistry, vegetation and other factors, including human disturbance. There are many kinds of wetlands and many ways to categorize them (Balwan & Kour 2021). Wetland classification is challenging due to vegetation cover dynamics with water fluctuation creating rapid and frequent changes in the type, distribution and density of plant coverage (Belluco *et al.*, 2006). The main wetland types are classified based on the dominant plants and the source of the water. For example, marshes are wetlands dominated by emergent vegetation such as reeds, cattails and sedges; swamps are ones dominated by woody vegetation such as trees and shrubs. Examples of wetlands classified by their sources of water include tidal wetlands (oceanic tides), estuaries (mixed tidal and river waters), floodplains (excess water from overflowed rivers or lakes), springs, seeps and fens (groundwater discharge out onto the surface), and bogs and vernal ponds (rainfall or melt water) (Keddy, 2013). There are four main types of wetlands namely swamp, marsh, bog, and fen based on the salinity of the water or the type of soil. Wetlands are also classified on the basis of wetland plants into four categories i.e. emergent, floaters, submerged and amphibious plants (Butt *et al.*, 2021; van der Valk 2020; Balwan & Kour 2021; Nayak & Bhushan 2022). The primary factor that distinguishes wetlands from terrestrial land forms or water bodies is the characteristic vegetation of aquatic plants, adapted to the unique anoxic hydric soils (Keddy, 2010).

In general, wetland plant communities are organized according to water permanence, depth and degree of soil saturation from deep-water wetlands to seasonally flooded basins and potholes. Many studies have been conducted to discern wetland vegetation communities using remote sensing imagery. Multispectral remote sensing data, for example, Landsat imagery and hyper spectral remote sensing imagery, have been used to map wetland vegetation types (Adam *et al.*, 2010; Pengra *et al.*, 2007). Remotely sensed data provide an efficient method for mapping and monitoring biodiversity and habitat change across broad spatial extents and with fine resolution (Guo *et al.*, 2017; Navarro *et al.*, 2017; Pettorelli *et al.*, 2016).

Natural wetlands are intrinsically heterogeneous and are typically composed of a mosaic of ecosystem patches with different plant types and hydrological conditions. Wetland plants are adapted to grow in water or on soil that at least periodically is deficient in oxygen due to excessive water content. They have morphological, physiological and reproductive adaptations that allow them to thrive in inundated or saturated soils where non-hydrophytes (upland plants) cannot. Plant communities dominated by hydrophytes are referred to as hydrophytic plant communities (Eggers *et al.*, 2015). The adaptation of these plant communities to a water-dominated environment is the basis for their use in improving the water quality in constructed wetlands (Guntenspergen *et al.*, 2020).

Wetlands play a crucial role in the environment due to their diverse habitats and ecosystem services. They are essential for mitigating the impacts of climate change, providing habitat for various species, and improving water quality by filtering pollutants (Dean *et al.*, 2013; Zedler, 2003; Messer *et al.*, 2019). Despite covering only a small percentage of the Earth's surface, wetlands contribute significantly to renewable ecosystem services, such as flood mitigation, climate regulation, and biodiversity maintenance (Messer *et al.*, 2019; Li *et al.*, 2014). These ecosystems are vital for human well-being, as they offer services like water purification, carbon sequestration, and habitat provision (Zhang *et al.*, 2013; Bhatta *et al.*, 2016; Watts & Everard, 2016). The economic value of wetlands is substantial, with estimates suggesting that wetland ecosystem services globally account for a significant portion of the total ecosystem services value (Dung & Le, 2022). Studies have shown that wetlands provide valuable goods and services, with the total value of wetland ecosystem services in specific regions reaching billions of dollars annually. Furthermore, wetlands are crucial for supporting livelihoods, especially in rural communities dependent on services like fishing, tourism, and fuel wood. Global efforts to safeguard wetlands have been escalating, with initiatives such as wetland restoration, creation, and wildlife habitat management contributing to the expansion of wetland acreage and ecosystem services (Chen *et al.*, 2015).

Despite their ecological and economic importance, wetlands are under serious threat due to anthropogenic factors, such as intensified agriculture, rapid urbanization and the construction of transport networks (Sharma *et al.*, 2020; Gardner *et al.*, 2015; Davidson 2014; Mitsch *et al.*, 2015). This is further confounded by climate change as it has been shown to have severe

influence on weather patterns, food production, ecosystem health, species distributions and phenology, and human health (IPCC, 2022; Maja & Ayano, 2021; Ogidi & Akpan, 2022).

2.2 Human activities and Habitat change

Increase in human population and its consequent substantial pressure on natural resources leading to severe degradation of terrestrial and aquatic resources and their associated biodiversity (Maja & Ayano, 2021; Ogidi & Akpan, 2022; X. Wang, 2022). This has further led to modifications in the local environmental conditions in which certain organisms live. Changes in habitat will cause changes in food availability, changes in migration patterns and stress on wildlife populations. Habitat change can be divided into three components: habitat loss, habitat fragmentation, and habitat degradation (Mitchell, 2016). These are critical issues affecting biodiversity and ecosystems globally. Habitat destruction, degradation, and fragmentation are the main threats to wildlife survival, leading to the loss of natural habitats essential for various species to thrive (Klappenbauch, 2021). These processes not only threaten wildlife but also have significant implications for human populations, as healthy ecosystems provide essential services like clean air, water, and food.

2.2.1 Habitat loss

Habitat loss is defined as the loss of suitable habitat for a particular species, so that the species no longer occurs in the area (Lindenmeier & Fischer, 2013). Human activities over the past century, especially since 1950, coinciding with unprecedented rates of population growth, have exposed ecosystems to significant changes and stresses (Crutzen, 2002). Critical habitats are being lost and degraded, ecosystems are being destabilized by pollution, climate change and direct human impact, and populations of many species are declining to critical levels (Baillie *et al.*, 2004; IUCN, 2011). Anthropogenic factors can have significant effects on ecosystem functioning and stability, often reflected in changes in biodiversity (Mengesha *et al.*, 2014). Loss of biodiversity has negative impacts on human well-being because it supports the functioning of the ecosystems on which we depend. Biodiversity describes the genetic pool, distribution and variety of species and ecosystems (Secretariat of the Convention on Biological Diversity, 2010). Habitat loss leads to a reduction in the variety of species that can survive in an area, impacting the overall biodiversity of ecosystems

Agricultural land use is a common cause of global habitat loss and is likely to increase significantly (Tilman *et al.*, 2001). Agricultural pesticides have been linked to wildlife mortality and species extinction in agricultural landscapes (Gibbs *et al.*, 2009; Ortego *et al.*, 2007; Benton *et al.*, 2002). As habitats are destroyed or fragmented, species may struggle to find suitable areas to live and reproduce, increasing the risk of extinction for many plants and animals (Murtoff *et al.*, 2023). Habitat loss disrupts the balance within ecosystems, affecting species interactions, food chains, and ecosystem services like pollination and nutrient cycling. It also makes it difficult for migratory species to find suitable resting and feeding areas along their migration routes, impacting their survival.

Changing agricultural practices, such as reducing pesticide loads, maintaining habitat heterogeneity near agricultural areas, and limiting monocultures, can provide significant ecological benefits. These include increasing populations of native species that can persist even in relatively intensively managed agricultural landscapes and increasing agricultural productivity by maintaining or enhancing ecosystem services such as pollination and pest control (Collard *et al.*, 2009; Malézieux *et al.*, 2009; Ortego *et al.*, 2007). Climate change will also exacerbate the effects of habitat loss. Biological effects of climate change have been observed in the form of changes in the geographic range of species (Jarema *et al.*, 2009; Franco *et al.*, 2006). These effects represent systematic trends with considerable long-term ramifications. Evidence increasingly suggests that climate change could prove catastrophic for biodiversity conservation in many areas, possibly exceeding even the massive negative effects of habitat loss (Sekercioglu *et al.*, 2008; Jetz *et al.*, 2007).These factors collectively contribute to the reduction or elimination of habitats where organisms live and reproduce, posing a significant threat to biodiversity and species survival globally.

2.2.2 Habitat fragmentation

Habitat fragmentation is the process by which large and contiguous habitats are divided into smaller, isolated patches (Ap *et al.*, 2019). Human activities have been observed to cause fragmentation such as land conversion, altering the environment quickly and leading to species extinction. Human development can also lead to habitat fragmentation, as natural areas are carved up and split into smaller portions. Natural causes such as geological processes can slowly alter the layout of the physical environment, contributing to speciation. Fragmentation reduces

animal ranges and restricts their movement, thus placing them at a higher risk of extinction. Breaking up habitat can also separate animal populations reducing genetic diversity (Rehnus *et al.*, 2018). If the loss of natural habitat around the world does not slow, more extinction will follow (Gérard *et al.*, 2017). Multiple interrelated phenomena contribute to how species are affected by anthropogenic habitat fragmentation, but typically loss of species diversity occur (Krauss *et al.*, 2010). Fragmentation can result in smaller population sizes, increased risk of local extinction, inbreeding, and reduced ability for species to adapt to changing environments (Martin, 2018) Although some habitats are naturally patchy in terms of abiotic and biotic conditions, human action have profoundly fragmented landscapes across the world (Haddat *et al.*, 2015), altering the quality and connectivity of habitats.

Fragmentation increases the relative amount of habitat edge in each patch, influencing a greater proportion of the habitat area. Edge effects can include changes in light penetration, wind speeds, chemical drift from adjacent areas, and the spread of unsuitable species, affecting the survival of different species differently (Clober *et al.*, 2015).Satellite data sets reveal at high resolution how human activities are transforming global ecosystems. Foremost among these observations are those of forest cover because of the high contrast between forest and anthropogenic land cover types. Deforestation, which was already widespread in temperate regions in the mid-18th to 20th centuries and increased in the tropics over the past half century, has resulted in the loss of more than a third of all forest cover worldwide (Hansen *et al.*, 2013). Most forests are well within the range where human activities, altered microclimate, and non-forest species may influence and degrade them (Broadbent *et al.*, 2008).

2.2.3 Habitat degradation

Habitat degradation describes the process by which the quality of habitats deteriorates. Habitat degradation can occur as a result of natural processes such as drought, extreme heat and cold or human activities such as forestry, agriculture and urbanization (IPBES, 2019). Habitat degradation is another consequence of human development. Humans indirectly contribute to habitat degradation through pollution, climate change and the introduction of invasive species, which reduce environmental quality and make it difficult for native flora and fauna to thrive. As the population increases, people use more and more land for agriculture and urban development, and the scope is getting wider. Degraded soil is often lost through erosion, decomposition and nutrient depletion (Klappenbauch, 2021).

Habitat degradation is currently the most important human-caused cause of species extinction. The main cause of habitat degradation worldwide is agriculture, followed by urban sprawl, logging, mining and certain fishing activities. Habitat degradation significantly impacts wildlife populations by reducing the quality of the environment, making it challenging for native plants and animals to thrive (Hanski, 2011). Furthermore, habitat degradation can disrupt the balance of species in the food chain. It can reduce the number of organisms due to toxicity caused by contaminants, leading to changes in community structure where tolerant or resistant organisms may benefit compared to others. This shift in community composition can have cascading effects on the entire food chain, altering predator-prey relationships and overall ecosystem dynamics. Degradation of a species habitat can change the adaptive landscape to such an extent that the species can no longer survive and become extinct. This can occur through direct effects, such as making the environment toxic, or indirectly by limiting the ability of a species to compete effectively for reduced resources or with new competing species (Wikipedia, 2017). Habitat degradation significantly impacts the behaviour of wildlife by forcing animals to adjust their physiological and behavioural responses to cope with the changes in their environment (Rahman & Candolin, 2022). This disruption can lead to changes in animal behaviour, such as altered movement patterns, shifts in foraging strategies, and modifications in reproductive activities, as they strive to adapt to the degraded habitat (Clare & Emily, 2021).

Estimates suggest that 3.4 million km² (21%) of the world's inland wetlands have been lost since 1700, with the majority of losses occurring for conversion to croplands. Wetland loss has been

concentrated in Europe, the United States, and China, and rapidly expanded during the mid-20th century (Jackson & MacIntyre, 2023). Additionally, habitat degradation can increase competition among species for limited resources, trigger changes in predator-prey dynamics, and influence the overall ecosystem functioning, ultimately shaping the behaviour of wildlife in response to the altered conditions (Hanski, 2011). Habitat degradation can also take the form of physical destruction of niche habitats. The widespread destruction of tropical rainforests and open grasslands is widely cited as an example (Wilson, 2002). The loss of dense forests eliminates the infrastructure that many species need to survive.

2.3 Land use land cover change

Land use land cover (LULC) has two separate terminologies often used interchangeably (Rawat & Kumar, 2015). Land cover, which refers to the biophysical characteristics of earth's surface including distribution of vegetation, water, soil and other physical features of the land. Land use refers to the way in which land has been used by humans and their habitat, usually with emphasis on functional role of land for economic activities (McConnel, 2015; Arsanjani, 2011).

Land-use and land-cover (LULC) changes have been identified as a major driver of global and regional environmental change and are now increasingly recognized in anthropogenic environmental impact assessments worldwide (Verburg *et al.*, 2015; Brovkin *et al.*, 2013; Foley *et al.*, 2005). Although natural forces have dominated the appearance of the earth's surface for billions of years, humans are now recognized as the primary driver shaping the modern global environment (Ellis, 2011). Agricultural activities, forest management and energy demand are increasingly influencing the functioning of the soil system. Anthropogenic changes in land use and land cover are estimated to contribute to anthropogenic carbon dioxide (Le Quere *et al.*, 2015; Houghton *et al.*, 2012) and non-carbon dioxide (GHG) greenhouse gas emissions (Smith *et al.*; Tubiello *et al.*, 2015). However, greenhouse gas emissions associated with land use and land-use change are the largest source of uncertainty in global carbon budgets (Ballantyne *et al.*, 2015). In addition to biogeochemical effects on carbon and nitrogen cycles, LULC changes and land management have been found to alter biophysical properties of the Earth's surface (e.g., albedo, soil moisture, and surface roughness), particularly in the past when LULC has changed dramatically region by region (Pitman *et al.*, 2015). This in turn has a feedback on the climate system. Roughly 38% of the earth's terrestrial surface are used for either growing crops or

livestock grazing, which is expected to rise to 60% in the next century if the trend is unabated (Wade *et al.*, 2008).

Land is a finite natural resource that sustains diverse ecosystems in Sub Saharan Africa. To date, there have been significant land use and cover changes throughout this region. Land use and land cover changes are key indicators of anthropogenic changes to the environment and are a critical contributor to loss of biodiversity and land degradation (Lambin, Geist & Lepers, 2003). During a period of 25 years (1975-2000) about five million hectares of both forest and natural non-forest vegetation is being lost annually to the development of new agricultural lands in sub-Sahara Africa (Brink & Eva, 2009).

In Kenya, the recent increase in intensive commercial horticulture has affected land use and land use change in central agricultural production areas (Francis, 2014; Becht *et al.*, 2005). Uneven clustering of large farms, pumping of surface water for irrigation, clearing of marginal land and continuous tillage to increase the yield of fresh produce throughout the year are some of the activities that affect the consumption and management of environmental resources (Owiti & Oswe, 2007; Aeschbacher *et al.*, 2005). The horticulture industry is labour intensive and attracts people to the sub-basin, leading to high population density and unplanned settlement growth (Muriuki *et al.*, 2011). Uncontrolled growth in sub-basins puts pressure on environmental resources and exacerbates degradation and competition between and within species (Barrow, 2006), which can increase watershed vulnerability to climate change.

The main driving forces of LULC change can be traced to the consumption demands of the increasing population that is a major issue of concern in relation to change in the natural environment (Molla, 2014). Land use change can trigger soil degradation and soil erosion, which changes watershed properties that may cause flooding in nearby areas (Gashaw *et al.*, 2018). Desertification, loss of biodiversity, habitat destruction, soil degradation, and a reduced ability of the watershed to sustain natural resources and ecosystem services are the consequences of land use land cover change (Woldeyohannes, 2018).

Ineffective land use could deteriorate environmental quality and loss of prime agricultural lands and this in turn causes loss of wildlife habitat (Mangesha, 2014). Land use changes also contribute to habitat loss for diverse species such as small mammals, birds, and plants. Many wild plant species that act as habitats for birds and bees (important pollinators) are at risk of

extinction in the near future (Perrings & Halkos, 2015). Deforestation is a global environmental hazard leading to land use and land cover changes. The main drivers of deforestation have been agriculture, logging, grazing, urbanisation, road construction and mining (Ozor & Odo, 2008). Deforestation has many negative effects on the environment the most dramatic impact being loss of habitat for millions of species with serious implications for eco-tourism. It also drives climate change (Nat-geographic, 2015). Deforestation, in particular, impacts climate change by modifying the latent heat flux, or earth's energy budget based on evaporation into and/or condensation within the atmosphere (Myhre *et al.*, 2013). Climate change has already had observable impacts on biodiversity, ecosystems, and the benefits they provide to society. These impacts include the migration of native species to new areas and the spread of invasive species (Ritchen & Houghton, 2011). The consequences of land use change challenge conservation, management, and rehabilitation activities (Ayele *et al.*, 2014).

2.4 Impacts of human activities on Saiwa Swamp

Human population increase has negative implications on the sustainability of the wetland through activities such as deforestation, soil erosion and loss of the more adaptable indigenous vegetation (Kithiia, 2006). People have settled in or near wetlands, and cultivate areas close to the riverbanks. Wetland encroachment has resulted in riverbank erosion of the Sinyerere and Kipsaina Rivers. Besides, surface run-off and river discharge increase when natural vegetation is cleared or degraded, triggering extreme flooding events and soil erosion. According to Kenya Wildlife Service (KWS) most of the wetlands are facing threats of extinction. The threats are fuelled largely by increasing demand for land as the human and wildlife populations continue growing, extreme pollution from agricultural practices, urbanization, industrialization, illegal abstraction from Feeder Rivers and springs, deforestation, and unplanned grazing patterns (KWS 2022, Mohamed 2024). Saiwa swamp is exposed to threats of extinction because of both direct and indirect impacts from a growing human population, particularly due to farming and urbanization (Mohamed, 2024). Intensification of agriculture and especially flower farming has had a significant impact on the environment, altering habitats and posing a major threat to biodiversity. Intensive agricultural activities are a major threat to the Saiwa wetlands and their biodiversity. Most farmers in the area, in order to increase their yields, use agro-chemicals, which then are carried by runoff to the wetlands, thus changing the water chemistry, and triggering vegetation succession (elephant grass has displaced the native *Typha* vegetation), and

other ecological changes (Mohamed, 2024). This situation further endangers the Sitatunga antelope (*Tragelaphus spekei*), which is endemic to the swamp. Sitatunga is semi aquatic and so specialised that it occurs only in swamps or permanent marshes, partial to papyrus and phragmites. Sitatunga graze on young papyrus and reed shoots for the bulk of their diets as they spend majority of their time in water.

2.5 Community awareness on biodiversity conservation

Biodiversity mediates ecosystem functions and influences human well-being through its services. Biodiversity conservation awareness is defined as how people know the impact of human behaviour on biodiversity (Cosquer *et al.*, 2012; Bosone *et al.*, 2022).

Communities depend on biodiversity for a living and this means greater demand for natural resources. The major direct drivers of human induced biodiversity loss are habitat loss and fragmentation (Reidsma *et al.*, Brink & Hugh, 2009), pollution, overexploitation, climate change and alien invasive species (Powell *et al.*, 2011). Environmental awareness is directly linked to environmental knowledge, attitudes and actions. It is now widely recognised that disseminating information to and enhancing knowledge of rural communities is essential for biodiversity conservation (Van der Ploeg *et al.*, 2011; Buxton *et al.*, 2021). A number of state agencies and non-governmental organisations have launched awareness campaigns to help communities understand the economic, social and biological importance of biodiversity conservation in their respective areas. However, there is little documented information on the effectiveness of these campaigns in cultivating a positive attitude, behaviour and actions among communities. If people become more knowledgeable of the environment and its issues they will in turn become more aware of the environment and its challenges thus will be motivated to act in a responsible way (Fahlquist, 2008). Low level of environmental awareness can be associated with negative attitudes towards biodiversity conservation (Macura *et al.*, 2011; Børresen *et al.*, 2023). If biodiversity plays its essential role of supplying humans' well-being and people still have a low awareness level of biodiversity conservation, the earth will continue facing rapid extinction level (Manda *et al.*, 2011, Oguh *et al.*, 2021). Ultimately humans will be seriously impacted by biodiversity loss.

2.6 Research gaps

Table 1: summary of research gaps

Author/authors	Themes	Key findings	Gap identified
Ruto <i>et al.</i> (2018)	Land use land cover changes in Saiwa swamp watershed, western Kenya	The study elucidated changes in the main land cover types within Saiwa swamp national park occasioned by human activities.	The study did not investigate how these land cover type changes affect the Sitatunga antelope population in the park.
Ng'eno <i>et al.</i> (2011)	Residents decision making in tourism at Sitatunga's swampy habitat	The study focused on residents in decision making and their support towards conservation	This study however did not quantify the multiplication effect of tourism benefits to local people
Ndawula <i>et al.</i> (2011)	Understanding Sitatunga habitats through diet analysis in Rushebaya wetland	The study mentioned that Sitatunga fed mostly on the edge of the wetland	It did not identify the capacity the wetland can support in terms of Sitatunga food and habitat requirement.

2.7 Theoretical framework

The study was based on the island biogeography theory. The theory of island biogeography (MacArthur & Wilson, 1967) offers a good explanation for why habitat loss drives species extinction. In this theory, an island is described as more than just a piece of land surrounded by water. It includes mountain peaks, a lake surrounded by a desert, a patch of woodland or even a national park (Biology dictionary, 2017). The theory uses oceanic islands as a model system to explain the richness and uniqueness of species both plants and animals found in an isolated area. It predicts that large islands have more species than small ones because they can accommodate more individuals, which cause those species to be better buffered against extinctions. The two events that determine the number of species found in an isolated ecosystem are immigration and extinction. Research shows that how big the island is and how far it is from the mainland has great influence on the richness of species found there (Biology dictionary, 2017).

Island biogeography best fits this study as it influences the size of national parks to improve biodiversity and mitigate the effects of immigration and extinction, affect where wildlife corridors are placed, where and how big or small they are and can help researchers pinpoint areas where plants and animals might be in danger of extinction.

2.8 Conceptual framework

Habitats are affected by various biophysical and societal factors operating on several spatial and temporal levels. This framework highlights the complex interactions between human activities and natural systems, and the need for conservation to address the underlying drivers of habitat change and threats facing Sitatunga antelope. The independent variables in this study were habitat change, land use change, habitat fragmentation, habitat degradation, invasive species, human population growth and community knowledge, while the dependent variable being Sitatunga antelope population. These two variables are affected by various interventions such as community participation, policy and governance and invasive species.

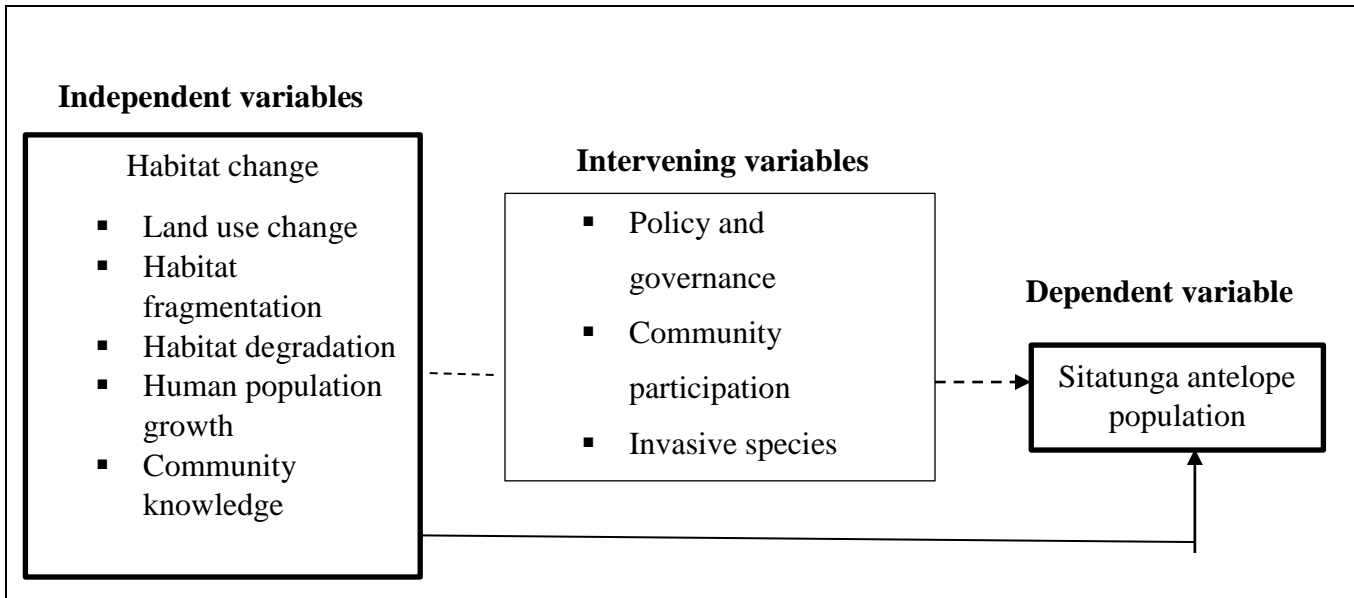


Figure 1: Conceptual framework

Source: Self (2023)

CHAPTER THREE

METHODOLOGY

3.1 Study area description

This study was conducted in Saiwa swamp national park that forms part of the Saiwa wetland in the Western part of Kenya. It is the smallest park in Kenya only 3km² and was gazetted in 1974 as a national park with the aim of protecting the sitatunga antelope. It is located near Kitale, Trans-Nzoia county in rift valley province Kenya, positioned 1°6'N 35°7'E (KWS, 2021)

3.1.1 Climate

Saiwa has 188 rainy days annually; the annual rainfall varies from approximately 2,200mm to 1,700mm per annum. The main rainy season is from April to August and dry season from December to February (KFS, 2015). The temperature ranges from mean annual minimum of 10°C to mean maximum of 37°C with an altitude of 1,860-1,880m above sea level (KWS, 2022).

3.1.2 Soil

The soils are moderately deep and of good structure and high organic matter content and viable acidity. The northern parts have deep to shallow soils which are liable to sheet erosion (KFS, 2015). Saiwa swamp is under laid by acid to intermediate rocks of the Precambrian basement system covered by a layer of tertiary sediments resulting from volcanic activity on Mt. Elgon (Kavishe, 2001). Sediments and sand resulting from eruption of the Cherengany ranges led to the creation of hard crust. As a result, the crust forms a high water table at 2.7m below surface (Akwee, 2010)

3.1.3 Economic activities

Agriculture is the predominant economic activity in the county and is the leading sub-sector in terms of employment, food security, income earning and overall contribution to the socio-economic wellbeing of the people, large maize and wheat farming characterise the major use of land in the county. Main food crops grown in the county are maize, wheat, tea, coffee, beans and potatoes (Mbuni *et al*, 2020; Rotich, 2019). Other economic activities are tourism, horticulture, commercial business, livestock keeping and fishing.

Map of the study areas

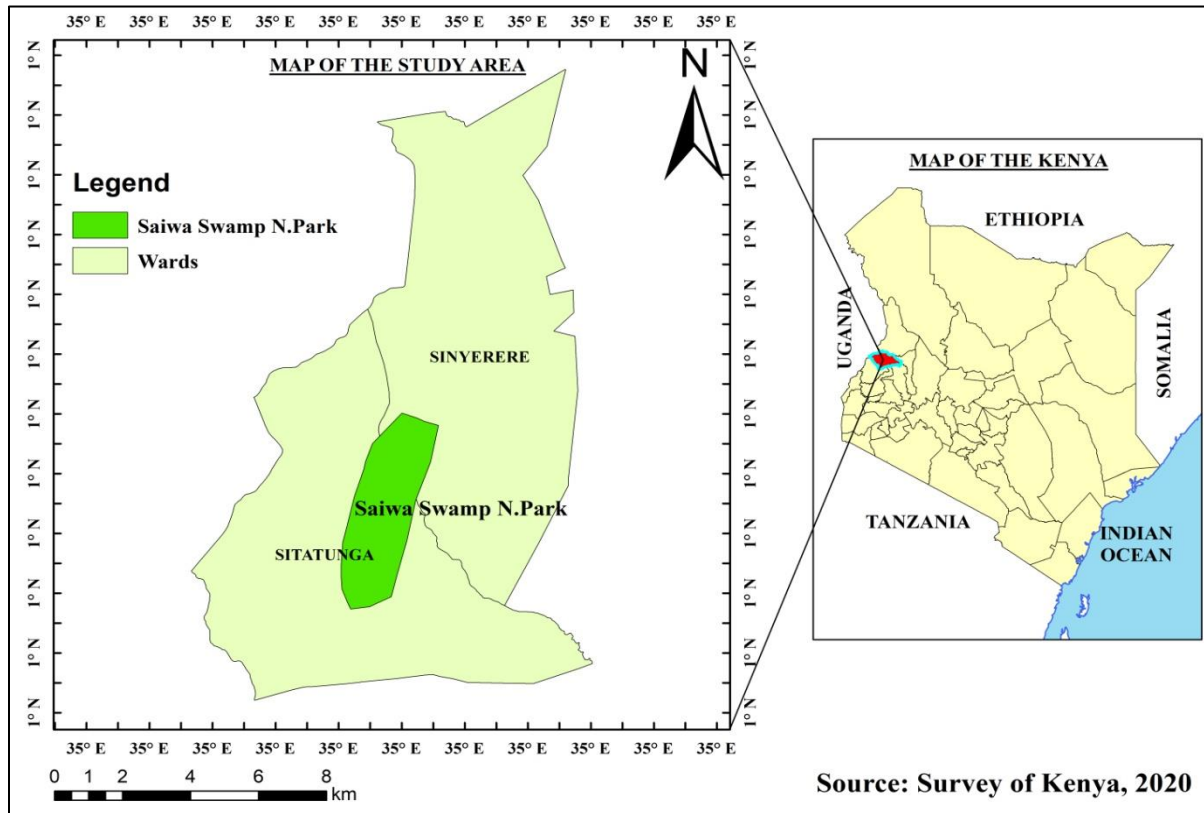


Figure 1: map of study site

3.2 Research design

This study adopted a mixed methods research design to provide a better understanding of the research problem and multiple viewpoints (Klassen *et al.*, 2012). Triangulation of data sources, types and methods were used to strengthen and improve reliability of data by cross-checking information received from the respondents (Anney, 2014; Bush, 2012).

3.3 Target Population

The target population was households, Kenya wildlife service warden, chiefs, ward administrators and village elders within Sinyerere and Sitatunga electoral wards of Cherengany sub-County, Trans-nzoia County. There were 10,561 households in Sinyerere and Sitatunga electoral wards. The unit of analysis for the quantitative household survey was the household. The qualitative approach had a number of actors involved in the various activities and

responsibilities (Patton & Patton, 2002). Sinyerere and Sitatunga are electoral wards within Cherengany sub-County. The total population of the two wards is 46,242 persons (KNBS census, 2019) broken down as follows:

Table 2: population and household distribution

Ward	Sub-location	Approx. population	Approx. households
Sitatunga	Sitatunga	31,725	7,232
Sinyerere	Sinyerere	6,765	1,556
	Kipsaina	7,752	1,773
	Sub-total	46,242	10,561

The independent variables were habitat change, land use change, habitat fragmentation, habitat degradation, human population growth, community knowledge while the dependent variable was Sitatunga antelope population. The intervening variables included community participation, policy and governance, and invasive species.

The use of Landsat images, GIS (Geographic information systems) and remote sensing tools in data collection was important in understanding LULC changes and vegetation type in a given area as different aggregates of spatial data can be compared at a single point and time is possible hence determining the cause-effect relationship.

Use of both GIS systems and remote sensing tools together with other biophysical tools for data collection is important in creating an enhanced understanding of dynamics of LULC within a given area. Furthermore, the local community perspectives provided a crosschecking base for the different dynamics that were observed through remote sensing (Nzunda *et al*, 2013).

For qualitative data, the study entailed the use of semi-structured questionnaires to collect data from the sample population from the local community in assessing their perception towards conservation of the Sitatunga antelope in Saiwa swamp.

3.4 Sampling procedure and sample size

Most social researchers commonly use a coefficient of variation of 60% according to Nassiuma (2000). This study used the same coefficient of 60% to obtain the sample size. The Nassiuma formula is given below

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

Where N= the population size

n= expected sample size

C= the coefficient of variation (0.6)

e= the margin error (0.05)

$$\text{Sample size } n = \frac{46242 \times (0.6)^2}{0.6^2 + (46242-1)0.05^2}$$

$$= \frac{16647.12}{115.9625}$$

$$= 143.556 = 144$$

For Sitatunga sub-location;

$$\text{If } 46242 = 144$$

$$31,725 = ? \quad (31725 \times 144 / 46242)$$

$$= 99$$

For Sinyerere sub-location;

$$\text{If } 46242 = 144$$

$$6765 = ? \quad (6765 \times 144 / 46242)$$

$$= 21$$

For Kipsaina sub-location;

$$\text{If } 46342 = 144$$

$$7752=? (7752 \times 144 / 46242)$$

$$=24$$

In addition to quantitative surveys, qualitative surveys were conducted through key informant interviews (KII) and focus group discussions (FGDs). A total of four key informants were selected for KII. These were the KWS County Warden, chiefs/sub-chiefs, village elders, Ward administrators). The key informants were selected basis on their knowledge and experience of various aspects of sitatunga antelope and their habitats. A total of two FGDs consisting of six to eight discussants were conducted.

3.5 Data collection

3.5.1. Interviews

Quantitative primary social data was obtained through use of semi-structured questionnaires that were administered. Face-to-face interviewing was chosen because it yields highest response rates in survey research and it gives room for the researcher to clarify ambiguous responses (Bernard, 2013). In addition, focused group discussions and key informant interviews were conducted to give more insight to issues that were not well captured in the questionnaires and guide and highlight the differences between participants (Van Eeuwijk & Angehrn, 2017). A checklist was used to moderate the discussions (Lloyd-Evans, 2006). Questions on awareness, attitude and practices/actions taken to promote conservation of Sitatunga and the swamp were presented as a statement and put on a five-point Likert scale (Kibue, Pan, Zheng, Zhengdong, & Mao, 2015; Marshall, Park, Howden, Dowd, & Jakku, 2013) and other questions were closed- and open-ended. The questionnaires were administered to a sample size of 144 from the 10,561 households that were randomly sampled (Noor, Tajik, & Golzar, 2022). Before the commencement of interviews, respondents were briefed about the purpose of the study and asked if they were willing to participate. After giving consent, all interviews and discussions were recorded. Secondary data was collected throughout the research period from government sources, annual reports, journals, books and any other relevant literature.

3.5.2 Pretesting of the Questionnaire

Prior to the actual field data collection, the questionnaire was pretested to allow for restructuring of questions and solving all questionnaire-related problems before the actual data collection (Simon, 2006). A pilot study took place in Barut Ward, Nakuru County. It involved 30 randomly selected respondents representing 10 percent of the total sample size, which is sufficient to test the reliability of the questionnaire (Babey, 2019; Sorzano et al., 2018). The Cronbach Alpha Scale was employed to measure the questionnaire's reliability. A reliability criterion of 0.70 or higher was required for the instrument to be considered suitable for the study (Ustun et al., 2022). Pilot study generated a reliability coefficient of 0.713, surpassing the threshold, thus validating the instrument's reliability as satisfactory.

3.5.3 Land use land cover change

Satellite imagery of the LULC changes within the swamp was acquired dating back from the year 1993. It comprised of a 30- year multi- temporal satellite images at an interval of 10 years that is, Landsat 7 and 8 imageries of 1993-2023, downloaded from USGS Earth Explorer website (<https://earthexplorer.usgs.gov/>). Image quality assessment was carried out before downloading the best quality images for the study area. The images from the websites are relatively cheap, easily accessible and have appropriate spectral and spatial resolutions (Wekesa *et al.*, 2020; Xian & Homer, 2010).

3.5.4 Vegetation type characterization

Sentinel-2 image was used in the study. The high spectral resolution of sentinel -2 imagery enabled the extraction of different features (Kaplan, 2021). Ground truthing survey was also done as the images captured were not clear enough to determine specific vegetation type. Belt transects were placed and sampling done in 1m x 1m quadrants placed at intervals of 10 meters and all species within the quadrant were identified and recorded.

3.5.5 Spatial data

Data Preparation/Pre-processing, Data Processing, Change Detection and Ground truthing was conducted as follows.

3.5.6 Image/data processing

Satellite image processing involved three main processes, that is, image enhancement, Geo-referencing and geo-coding. Image Enhancement is the process of making a raw image better interpretable for a particular application. Geo-referencing is the process of establishing the relationship between row and column numbers, and real-world coordinates of an image while geo-coding is the process where a new image is produced with arranged pixels in the geometry of the map or master image (Kirui, 2008). Image processing included Preprocessing, transformation, correction, and classification. Pre-processing techniques for satellite images for example involve; false color compositing of multispectral bands were used to discern the unique features to carry out classification using Idrisi remote sensing software. Concatenation was done to delimit the area of interest from the satellite images. Image color stretching and enhancement was also done to improve the contrast and color sharpness in the images.

The Satellite employed in this study i.e. Landsat 6, 7 and 8 have an Enhanced Thematic Mapper Plus (ETM+) that continues to provide earth observations on an 8-day interval. The sensor design is improvised such that it has a higher signal-to-noise ratio (SNR), narrow near-infrared waveband and a greater radiometric sensitivity highlight. This has improved the need for investigating the land surface observation properties hence improving its consistency in relation to the data from other satellite sensors and its predecessors (Ke *et al.*, 2015).

3.5.7 Land cover processing and classification

For the determination of spatio-temporal land use and land cover changes in the Saiwa wetland, geographic information system (GIS) and remote sensing techniques were used to carry out processing and analysis of the obtained remotely sensed data to meet the study objectives. The study utilized remote-sensing data (medium resolution satellite images) for the 1993, 2003, 2013, and 2023 periods. A field survey was conducted to facilitate ground truthing, analysis, and accuracy assessment processes. Saiwa swamp boundary was used as the study area. The study area polygon was used to select cloud free images and appropriate off-nadir angle of inclination and date of acquisition from the United States Geological Surveys (USGS) glovis website (<https://glovis.usgs.gov/>). The LANDSAT imagery used covered a period of 10 year intervals starting in 1993 and ending in 2023 for the wet seasons. The satellite images described in Table 3 were utilized in the study. They included Landsat Thematic Mapper (TM) at 30 meter resolution,

Landsat Enhanced Thematic Mapper (ETM+) at 30 meter plus and the 15 meter panchromatic band, Operation Land Imager (OLI) at 15 meter resolution and, lastly, the Sentinel images at 10 meter resolution.

Table 3: Satellite images description (Source: USGS)

Satellite Sensor	Acquisition Dates	Resolution (meters)	Website search ID
TM	Jun 1993	30m	LT05_L1TP_170059_19940922_20200912_
ETM+	Feb 2003	30m	LE07_L1TP_170059_20030518_20200916
OLI	Jan 2013	15m	LC08_L1TP_170059_20130724_20200912
Sentinel	Mar 2023	10m	T36NYG_20230903T074619






TM = Thematic Mapper sensor; ETM+ = Enhanced Thematic Mapper plus sensor, OLI= Operation Land Imager and Sentinel.

Table 4: Land cover classification scheme used in the study

Cover class	Description
Forests Area(FA)	The continuous stand of trees, many of which may attain a height of 50 m including natural forest, mangrove and plantation forest.
Grass/Shrub (G/S)	Areas of land covered with scattered grasses, shrubs
Grass/Bare (G/B)	Areas with exposed soil and rock outcrops with pits of scattered grass.
Reeds/Papyrus(R/P)	Areas covered by reeds and papyrus vegetation
Water areas (WA)	Areas naturally or artificially covered by water shallow deep.

There were 5 LULC classes targeted for mapping including 3 vegetation classes. The vegetation classes were adopted from Mutangas (1994) vegetation map as shown in table 5 below.

Table 5: Land cover types description

Land cover type	Cover descriptive features
	<p>Open grassland - Includes areas covered mainly by herbaceous cover (grass), with widely dispersed (less than 2%) clusters of scrub cover. (Mutangah, 1994)</p>
	<p>Mixed forest - Areas covered by <i>Olea Africana</i>, <i>Acacia gerrardii</i>, and interspersed with <i>Acacia xanthophloea</i>, <i>Tarchonanthus camphoratum</i>, <i>Euphorbia candelabrum</i></p>
	<p>Shoreline marsh - Regularly flooded/swampy areas covered with aquatic plants-marshes, straw and reeds. Also referred to as alkaline marsh.</p>
	<p>Water body - All areas covered by water either naturally such as the lake or constructed artefacts such as reservoirs, ponds, sewer treatment plants, and farm dams</p>
	<p>Bare soil - Includes degraded patches, continuous rock surface, hard pans, excavated/exposed soil, earth roads or areas with less than 4% vegetative cover</p>

3.5.8 Change detection

This was achieved through post classification. Post classification refinement was done to improve the accuracy of the classification. This employed a multi-date post-classification comparison change detection algorithm (Liu & Zhou 2004; Morgan & Hodgson 2021). The map derived in 1993 was compared with the maps of subsequent years all through to 2023 using QGIS (Cheruto *et al.*, 2016).

3.5.9 Ground truthing

This is the process of determining the accuracy of data collected in the field to remotely sensed data. It is essential to identify features of interest in Remote Sensing before image processing. This was possible through a field survey (ground truthing) (Kiplangat, 2015). This process allows the researcher to relate the remotely sensed information to the actual information on the ground (Weiss *et al.*, 2020; Van der Meer 2012). Ground verification was done by performing surface and GPS observations to confirm the precision of the classified map of the LULC derived (Cheruto *et al.*, 2016). This was done after post analysis aiming to validate the findings of the image data.

3.6 Data analysis

For LULC, post classification refinement was done to improve the accuracy of the classification. This employed a multi date post-classification comparison change detection algorithm. The maps obtained for the different years were compared and analysed using quantum geographic information system (QGIS). A trend analysis was used to determine the extent of land use land cover change that has occurred within the years. Vegetation characterization was analysed using classification algorithm where supervised classification was done to improve performance. Descriptive analysis was used to summarise the data collected. Analysis of quantitative data was descriptive in form of graphs and tables. Numerical findings that take the form of tabulations, percentages, and means, data were analysed using statistical package for social sciences (SPSS).

3.7 Ethical Consideration

Before the study was conducted, ethical clearance was sought from Egerton University's graduate school. A permit from NACOSTI was also obtained to enable ease of access to

information from the respondents in the areas of study. Confidentiality was assured to them and a prior informed consent (PIC) was sought regarding the information inquired from them.

3.8 Summary of data analysis

Table 6: summary of data analysis

Research question	Objective	Independent variable	Dependent variable	Data analysis
Q1	To characterize different vegetation type in Saiwa swamp in relation to Sitatunga habitat	Vegetation type	Sitatunga habitat	Classification algorithm (Descriptive analysis)
Q2	To analyze the land cover trends and Sitatunga population	Land cover	Sitatunga antelope population	Change detection algorithm (Descriptive analysis)
Q3	To assess park adjacent community's knowledge and perception towards Saiwa wetland	Local community	Saiwa wetland	Ordinal regression Chi-square test (using measures of central tendency)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the analysis and discussion of the findings of the study. These include; the insights and perceptions of the community regarding the Sitatunga antelope, land use land cover changes, and vegetation cover within the park.

4.2 Vegetation Characterization

The satellite images downloaded showed a set of 3 classes of vegetation type in the park which are forests, papyrus reeds, grass/shrubs and Grass. The specific type of vegetation in each category was confirmed on ground by means of survey as the satellite resolution could not clearly capture the exact vegetation type.

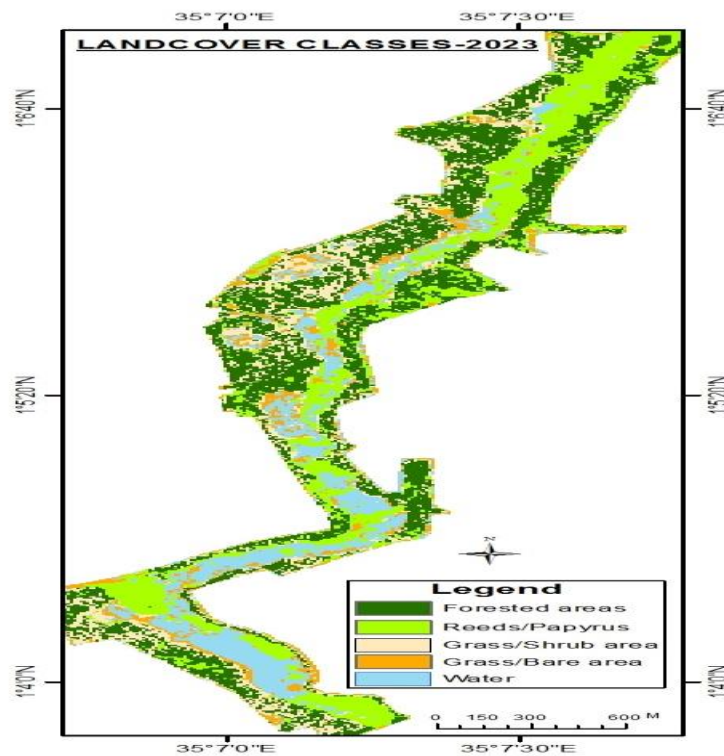


Figure 2: Saiwa wetland land cover classes

The grass/shrub vegetation in Saiwa Swamp National Park is characterized by a diverse range of plant species, including *Africana prunus*, *Maesa lanceolate*, *Acacia hockii*, and others as shown in Table 7 below. This diversity suggests a healthy and varied habitat that can support different

wildlife species. The presence of *Melinus minutiflora* and *Setaria fasilata* indicates the existence of grasses that may contribute to the park's overall ecosystem. Shrubs play an important role in the ecosystem of Saiwa Swamp National Park by providing food and habitat for various species (Palapala *et al.*, 2020) These shrubs likely provide food and shelter for smaller animals like insects, birds, and small mammals and also contribute to the overall biodiversity and structure of the park's vegetation, creating a diverse habitat for a wide range of species. Their presence helps maintain the ecological balance and resilience of the Saiwa Swamp ecosystem (Wang *et al.*, 2019).

The forested areas are dominated by various tree species, including Fig trees, exotic banana trees, Acacia trees, *Afzelia Africana*, and *Syzygium* trees. This suggests a mix of indigenous and exotic tree species, contributing to the overall canopy cover in specific regions of the park. The forested areas provide habitat and resources for other wildlife, such as the rare and endangered sitatunga antelope, as well as primates like the white and black colobus monkeys and the rare De Brazza's monkey (KWS, 2021)The reeds in Saiwa National Park include papyrus reeds, *Scirpoides holoschoenus*, *Typha latifolia*, *Typha domingensis*, and *Echinocloa pyramidalis*. Reeds are crucial components of wetland ecosystems, playing a role in water purification, sediment stabilization, and providing habitat for aquatic organisms.

Table 7: Vegetation type is saiwa swamp

Grass/Shrub vegetation	Forested area	Reeds
<i>Africana Prunus</i>	<i>Ficus sycomorus L</i>	<i>Papyrus Reeds</i>
<i>Maesa Lanceolate</i>	<i>Ficus Cyathistipula</i>	<i>Scirpoides Holoschoenus</i>
<i>Acacia Hockii</i>	<i>Cavendish banana</i>	<i>Typha Latifolia</i>
<i>Maytenus Heterophylla</i>	<i>Musa sikkimensis</i>	<i>Typha Domingensis</i>
<i>Periploca Liuearfolia</i>	<i>Afzelia Africana</i>	<i>Echinocloa Pyramidalis</i>
	<i>Syzygium Trees</i>	

4.3 Land cover trends and Sitatunga antelope population

4.3.1 Sitatunga antelope population

This study aimed to assess the land use and land cover changes with the population dynamics of the Sitatunga antelope over a thirty-year period. However, due to insufficient historical population records, extrapolation was done to estimate or predict the Sitatunga antelope's population for a period of 30 years as shown in figure 4 below. It involves extending a trend or pattern observed in a dataset beyond the range of the available data points to make forecasts or draw conclusions about future events or conditions. Advanced statistical techniques, such as generalized linear models, can be employed to analyse time series data of wildlife populations. These models help identify trends over time by fitting a regression line to abundance data collected from various locations (Barnes *et al.*, 2016)

The first national Sitatunga census in Kenya was undertaken in 2021, resulting in limited available data. Population records for the Sitatunga antelope in Saiwa National Park are only available for three recent years. In 2018, the population was recorded at 200 individuals. This number dramatically decreased to 26 in 2019, before slightly recovering to 60 by 2021.

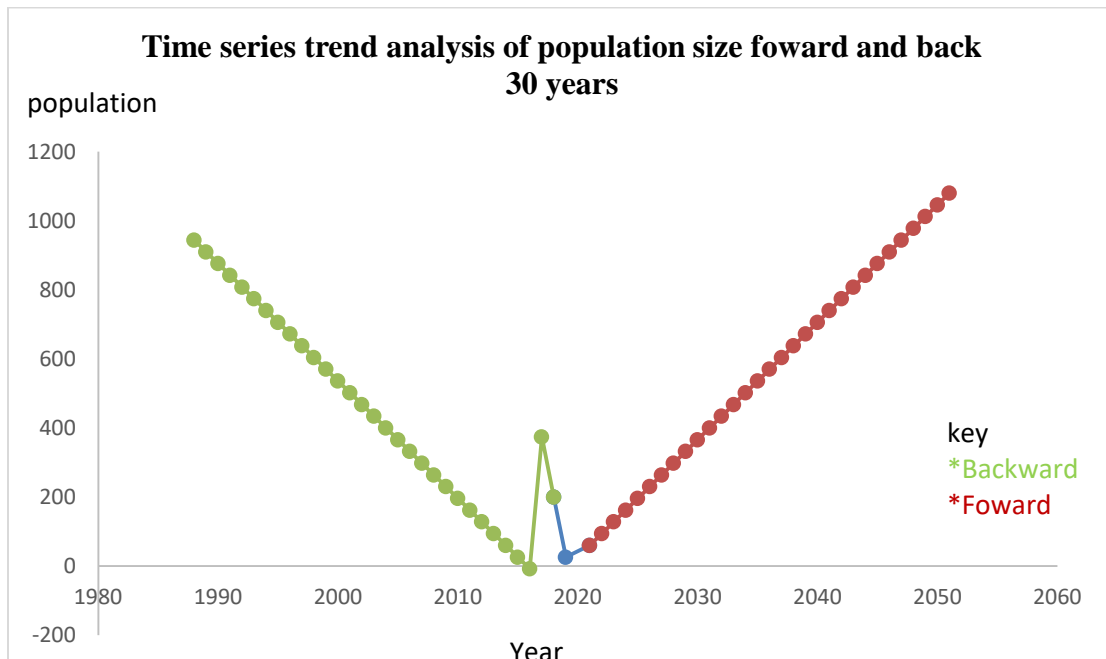


Figure 3: Trend analysis of Sitatunga antelope population

The population from the trend analysis for the past 30 years shows a decrease in the numbers, from 774 in 1993 to 128 in 2023. This decline is primarily attributed to habitat loss driven by land use changes, which critically impact the ecological connectivity necessary for these species. Approximately 85% of the Sitatunga population in certain wetlands has been lost, largely due to poaching and the degradation of papyrus habitats (Ogoma *et al.*, 2023). As the human population in the region increases, the demand for land and water resources in riparian zones also rises, leading to extensive anthropogenic pressures such as logging, sand mining, and agricultural encroachment. These activities significantly affect the Sitatunga's living conditions (Ogutu *et al.*, 2017; Newmark, 2008). Moreover, the conversion of forestland into cropland and human settlements has disrupted the natural migration patterns of the Sitatunga antelope, further fragmenting their habitat in the wetland areas (Foley *et al.*, 2005).

Climate change poses additional threats by altering the wetland ecosystem, thus impacting the availability of food and shelter for the Sitatunga (Thirgood *et al.*, 2004). Challenges in implementing conservation measures exacerbate these issues in the region. These challenges include the presence of invasive species, socio-political factors, resource constraints, population pressure, and conflicts between local communities and conservation efforts, often stemming from a perceived lack of direct benefits from conservation initiatives (Western *et al.*, 2009).

The trend line into the future however shows a steady increase from 128 in 2023 to 1046 in the year 2050. This can be realized by synthesizing ecological research and implementing effective habitat management practices, stakeholders can work towards stabilizing and potentially increasing Sitatunga populations in their natural habitats. Integrating wildlife population extrapolation with land use and land cover change analysis is essential for effective conservation planning. This holistic approach enables more informed decision-making regarding habitat protection and restoration efforts.

4.3.2 Land use land cover Image Classification

GIS maps were produced to show the change in land cover area for the period from 1993 to 2023 as shown in figure 5 below.

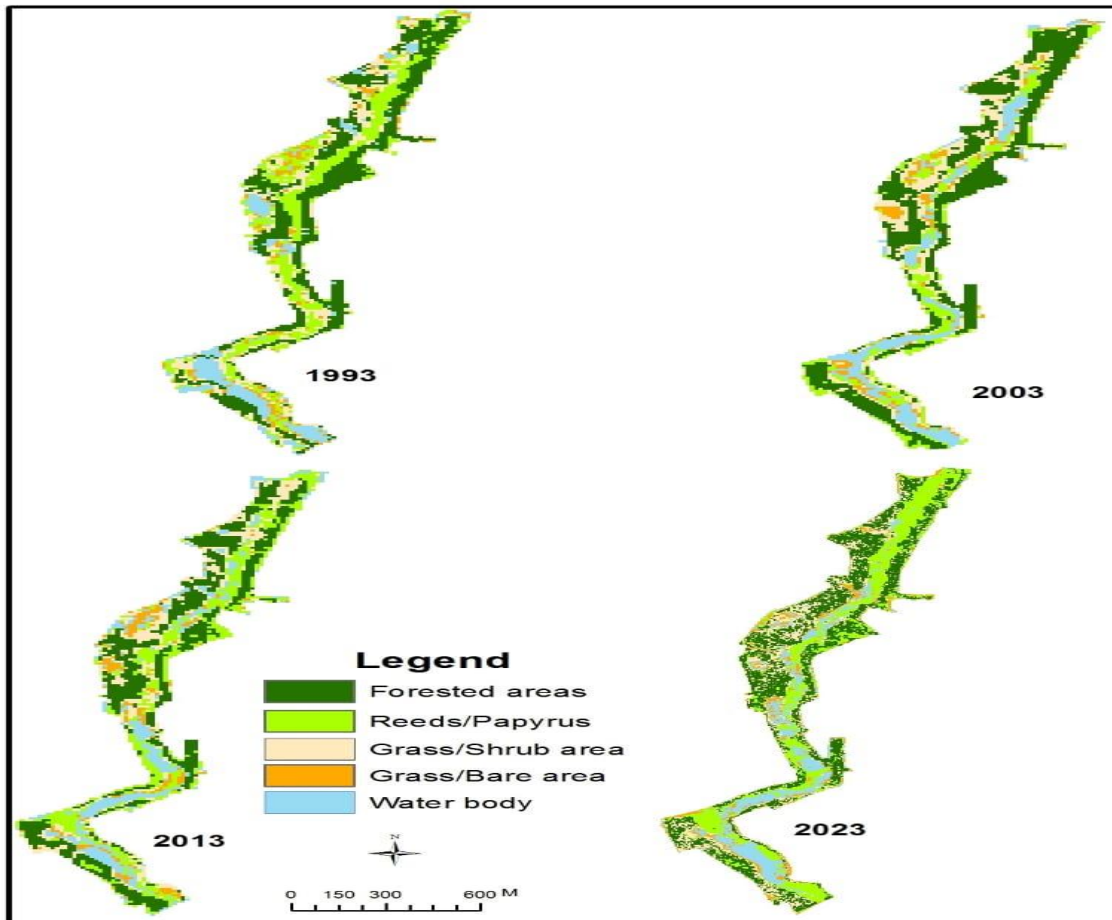


Figure 5: Saiwa wetland land cover classification for 1993, 2003, 2013 and 2023

The analysis of land cover types between 1993 and 2023 reveals notable changes, particularly in forested areas and grass/shrub areas (Table 8). The forested area decreased from 37% in 1993 to 34% in 2023. This decline can be attributed to human activities such as logging, mining, and agricultural encroachment, as well as climatic conditions (CIFOR, 2018). These activities significantly contribute to deforestation and forest degradation, which in turn impacts the Sitatunga antelope by reducing their habitat and shelter, essential for their survival and reproduction.

The conversion of forestland to cropland and settlements, driven by increasing population pressures, further exacerbates habitat loss for the Sitatunga. The decrease in shrub land, from 19% in 2003 to 16% in 2023, also reduces the availability of food and cover for the antelope, thereby impacting their foraging behavior and increasing vulnerability to predators (Foley *et al.*, 2005).

Interestingly, the area covered by papyrus reeds has slightly increased from 24% in 1993 to 26% in 2023. This increase can be attributed to the deposition of agricultural chemicals, which promote the growth of papyrus reeds by supplying essential nutrients in diluted forms (Johnson, 2022). While this might provide additional cover for the Sitatunga, it could also indicate changes in water quality and wetland dynamics that might not be favorable in the long term.

The bare areas in the wetland have increased slightly from 6% in 1993 to 8% in 2023, despite a slight drop in 2013. This increase in bare areas is likely due to land cover changes and anthropogenic activities that degrade the wetland ecosystem (Chen *et al.*, 2019). Such degradation disrupts the delicate balance of the ecosystem, reducing the availability of suitable habitats for the Sitatunga.

Water areas have also seen an increase from 13% in 1993 to 16% in 2023. This rise can be attributed to factors such as poor drainage, increased water supply, and slow water flow (Smith, 2021). While an increase in water areas might seem beneficial, it could also signify alterations in the hydrology of the swamps, potentially impacting the habitat structure and availability for the Sitatunga (Zhao *et al.*, 2018).

Table 8: Land use land cover distribution

Class Type	1993(Area Ha)	% cover	2003(Area Ha)	% cover	2013(Area Ha)	% cover	2023(Area Ha)	% cover
Forested Areas	107	37	110	38	104	36	100	34
Reeds/Papyrus	70	24	57	20	69	24	75	26

s

Grass/Shrub Areas	56	19	58	20	53	18	47	16
Grass/Bare Areas	18	6	21	7	20	7	23	8
Water Areas	39	13	44	15	45	16	45	16
TOTAL	290	100	290	100	290	100	290	100

The trends observed in land use and land cover changes are further illustrated in Figure 6, which provides a visual representation of these shifts over the years. These trends reflect the impact of various anthropogenic activities and natural processes on the land cover, which consequently affect the habitat and population dynamics of the Sitatunga antelope in the Saiwa wetland. The reduction in forested and shrub areas directly affects their habitat availability, increasing the likelihood of population decline due to insufficient shelter and food resources. Conversely, increases in papyrus reeds and water areas, while potentially beneficial in the short term, may indicate broader ecological changes that could destabilize the wetland's ecosystem and negatively impact the Sitatunga in the long run.

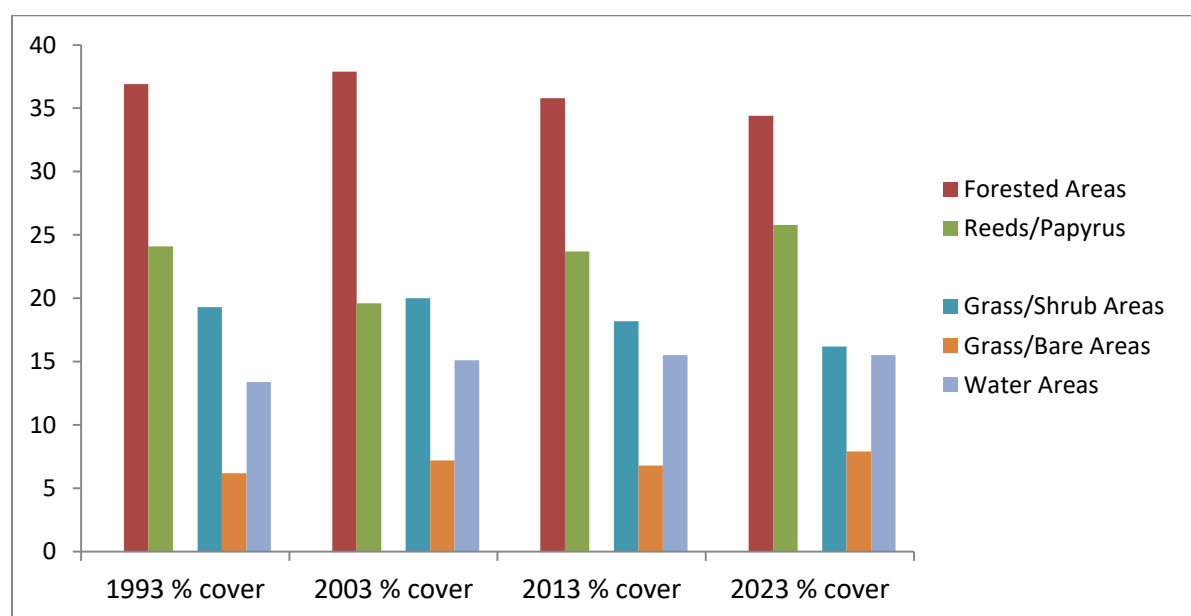


Figure 6: Trend analysis of the land use land cover change

4.4 Park adjacent community perception towards conservation of the Saiwa Wetland

Community perception towards environment and natural resources is an important aspect that determines the success of any effort aimed at environmental conservation and protection. To understand the perception of adjacent community towards conservation of Sitatunga (*Tragelaphus spekei*). A total of 144 questionnaires were administered as per the sampling technique used in the study. The respondents filled out 141 questionnaires while 3 others declined, yielding a 98% return rate, which the study found to be adequate to achieve its objectives. According to Mugenda & Mugenda (2003), a return rate of at least 70% is considered acceptable for data analysis. In the current study, nearly 100 % response rate was achieved. This level of success can be attributed to the community's interest in the conservation of the Sitatunga antelopes and the restoration of their habitat. The successful return of all questionnaires could also be attributed to effective communication, administration, and coordination of the questionnaires in the data collection process.

4.4.1 Demographic and socio-economic characteristics of respondents

The respondents were nearly balanced by gender (Female 49% and Male, 51%). The demographic and socioeconomic parameters are shown in Table 9. In regard to education, majority of the respondents (43%) have attained secondary education, 36 % primary, 13% university while 8% have not attained any formal education. Majority of the respondents (48%) were self-employed and particularly engaged themselves in farming activities. 40% were unemployed although they could engage themselves in casual works from time to time while 12 % had formal employment. Majority (50%) had lived in the study area for more than 20 years.

Table 9: Summary of demographic and socio-economic characteristics of respondents

Variable	Category	Frequency (%)
Gender	Male	51
	Female	49
Age (Years)	<30	32

	31 – 40	27
	41-50	19
	>50	22
Education level	No School attended	9
	Primary	36
	Secondary	43
	University	13
Employment status	Employed	12
	Farmers	48
	Unemployed	40
Land size (Acres)	Up to 1	57
	1.1-2.0	21
	2.1-3.0	11
	3.1-4.0	6
	4.1-5.0	4
	Above 5.1	2
Time of residency(Years)	Up to 5	3
	6-10	9
	11-15	21
	16-20	17
	Above 20	50

Socio-demographic factors have been found to play a role in shaping public perceptions of wildlife conservation and management strategies (Miao *et al.*, 2021; Jew & Bonnington, 2011). Moreover, research indicates that respondents' characteristics, perceived benefits, and interest in wildlife can influence their support for funding options for conservation efforts Beardmore *et al.*, (2021). Cross tabulation analysis of the level of education of the respondent and knowledge of the environment showed a significant association; X^2 (DF=3, n=141) =16.046, p=0.014). This finding is similar to a study by (Gandiwa *et al.*, 2013) that education and environmental awareness among local communities have been associated with reduced incidences of human-wildlife conflicts, as educated individuals are more equipped to minimize risks and damages caused by wild animals

Cross tabulation between the time lived and knowledge about environmental changes showed that respondents who had lived longer in the study area were more knowledgeable about the environmental changes; X^2 (df=12, n=141) =56.143, p<0.05). This observation is similar to (Migueis *et al.*, 2019) that the longer an individual lived in a community that interacts with wildlife, the more knowledge they tend to acquire about local wildlife.

4.4.2 Community Awareness of environmental changes in the study area.

The respondents are aware of the changes that have occurred in the study area. They mainly referred to rainfall, temperature and vegetation cover. They made the following observations; decrease in rainfall (51%), increase in temperature (37%) and decline in vegetation cover (74%).

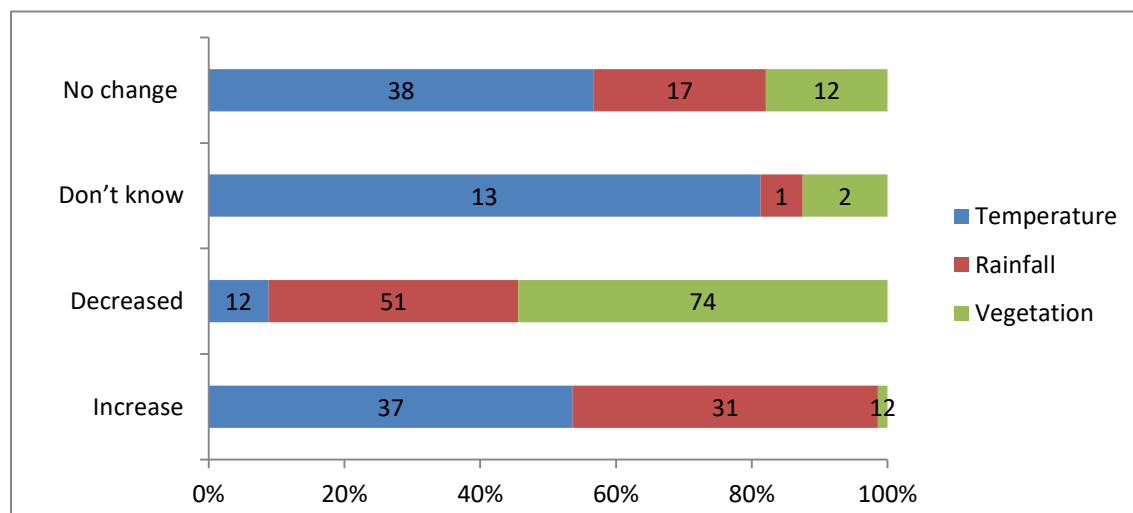


Figure 7: Changes in environmental parameters

Cross tabulation analysis between the changes in Sitatunga population showed that rainfall and vegetation cover played a key role in the observed changes in the Sitatunga population. The chi-square value for rainfall X^2 (df=3, n=141) =7.857, p=0.049) and vegetation X^2 (df=3, n=141) =15.811, p=0.001).Changes in rainfall and vegetation cover can significantly impact the Sitatunga antelope, affecting both their habitat and food sources (Murwany, 2023).

Focus group discussions attributed the changes to human population increase. According to the discussants the population has been growing rapidly from the time when the government declared it a settlement scheme in 1969. Consequently, environmental resources have been overexploited to meet the needs of the growing population.

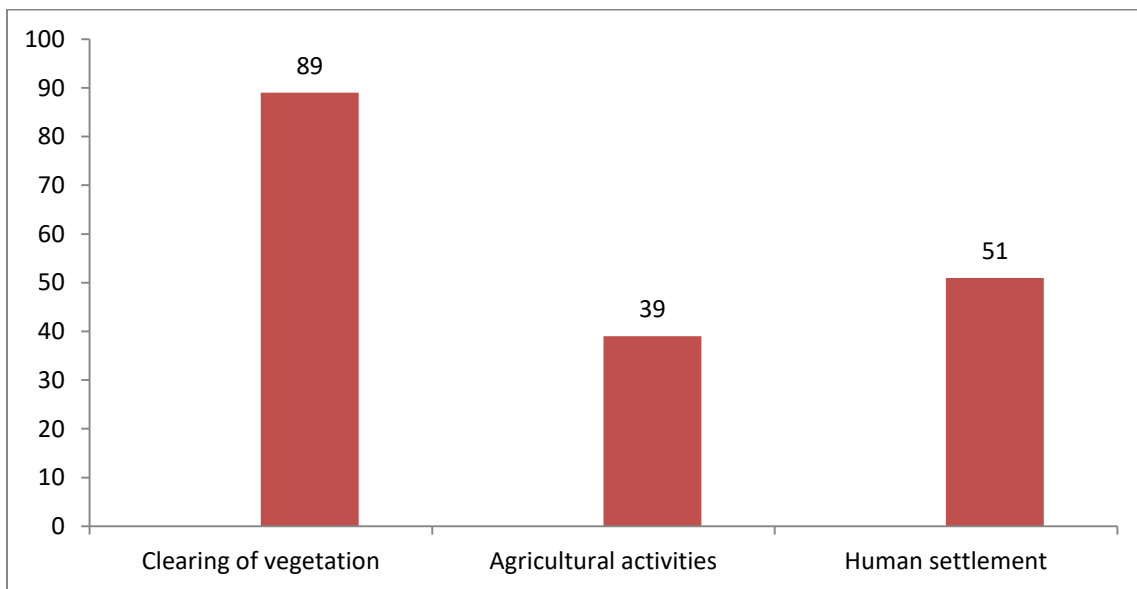


Figure 8: Causes of the environmental changes

When asked to identify the causes of the environmental changes, majority of the respondents cited deforestation (89%), human settlement (51%) and agricultural activities (39%). Cross tabulation analysis between the changes in Sitatunga population and the human activities showed that clearing of vegetation and agricultural activities were significantly associated with changes in Sitatunga population. The chi square test in both cases were significant at $\alpha=0.05$. X^2 (df=1, n=141) =8.347, p=0.004) and X^2 (df=1, n=141) =6.338, p=0.012), respectively. It has been

established that agricultural encroachment can lead to habitat degradation for sitatungas by replacing wetland plants with crops and altering wetland drainage, affecting water levels and vegetation structure (Brownlee *et al.*, 2022).

Table 10: Anthropogenic factors influencing Sitatunga population

Anthropogenic activities	<i>Response</i>		X ²	df	P value
	Yes (%)	No (%)			
Vegetation clearing	89	11	08.347	1	0.004*
Agricultural activities	39	61	6.338	1	0.012*
Human settlement	51	49	1.161	1	0.287

***Significant at $\alpha=0.05$**

These findings are similar to other studies that relate increase in human population to rapid urbanization and intensified agriculture, placing substantial pressure on natural capital leading to severe degradation of terrestrial and aquatic resources and their associated biodiversity (Maja & Ayano, 2021; Ogidi & Akpan, 2022; X. Wang, 2022). Moreover, clearing vegetation to pave way for human activities also interferes with ecological functions and ecosystem health (Runyan *et al.*, 2012).

Eighty five percent (85 %) of the respondents felt concerned about the changes in environmental parameters and the consequences they are likely to have especially on Sitatunga population during the focus group discussion and key informant interview with the KWS officers, it was evident that the number of Sitatunga has been steadily declining to human activities, the KWS officers said that the swamp has been invaded by the elephant grass which is fast replacing the native vegetation and consequently threatening the swamp fauna and flora. A study by (Chen *et al.*, 2016) has established that community concerns about the environment can be influenced by various environmental threats such as flooding, droughts, and habitat degradation and have been shown to play a significant role in environmental issues. Gray & O'Connor, (1990).

4.4.3 Knowledge of the Swamp resources and importance of the Swamp

Agriculture is the mainstay of economy of the study area and has resulted in substantial pressure on natural resources and particularly the Saiwa Swamp. Therefore, community awareness of the interrelatedness of their activities and the environment is crucial for effective conservation efforts. Research has demonstrated that engaging local communities and raising awareness about the impacts of human activities on wildlife can lead to more positive attitudes towards conservation (Bitanyi *et al.*, 2012; Govind & Jayson, 2021). The study revealed that all the respondents were aware of the various wildlife species in the area but the commonly cited are shown in (Table 11). There was a significant relationship between age and knowledge; X^2 (df=12, n=141)=71.73, $p<0.05$). The age-related differences in community attitudes towards wildlife management exist, reflecting changing social values over time (Carter *et al.*, 2020).

Table 11: Community awareness of various wildlife species

	Awareness	
	Frequency	Percentage
Sitatunga	141	100%
Cranes	175	53%
Monkeys	138	98%
Snakes	136	97%

Research has demonstrated that engaging local communities and raising awareness about the impacts of human activities on wildlife can lead to more positive attitudes towards conservation (Bitanyi *et al.*, 2012; Govind & Jayson, 2021). Eighty six percent of the respondents denied hunting wildlife for food or any other product while 14 % admitted hunting for food happens. This could be attributed to fear that if they admission of such activities would land them in trouble with the KWS.

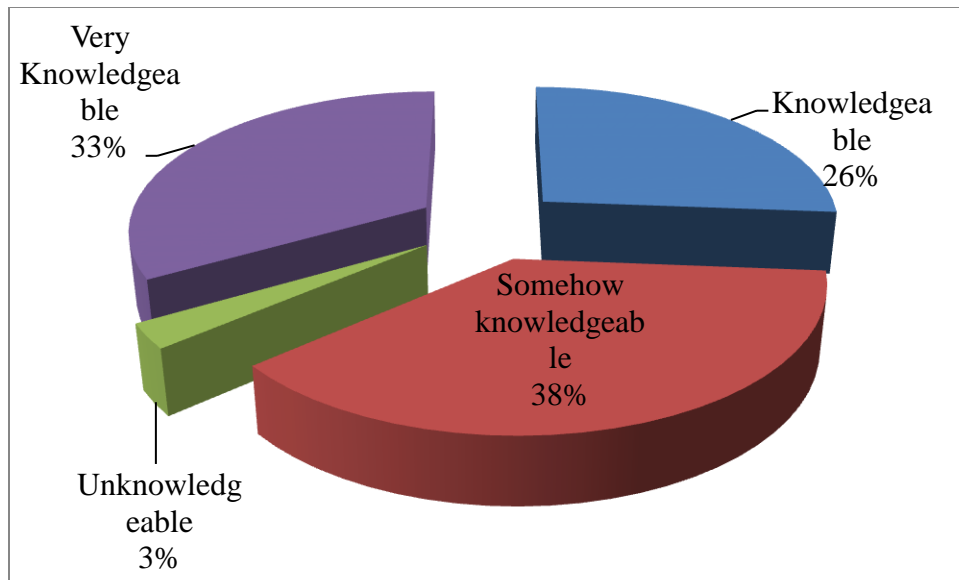


Figure 9: Respondents knowledge about Sitatunga

When asked to rate their knowledge about Sitatunga antelope, 33% of respondents indicated they were very knowledgeable, 38% were somehow knowledgeable, 26% were knowledgeable while 3% had no knowledge at all (Fig 9).

All discussants affirmed that the swamp is important to their livelihoods because they obtain food, water, firewood, earns them business and employment through tourism, offers educational and research opportunities and acts as cultural and spiritual connections to the land. They also stated that the swamp has gone through serious transformation in terms of its size, vegetation and wildlife because of encroachment and agricultural activities. They said that there are efforts by the community based organizations, government and other stakeholders to restore the wetland.

4.4.4 Human-wildlife Conflicts and reduction measures

Whenever wildlife and humans inhabit a shared ecosystem, conflicts are bound to occur lead to negative results, such as loss of property, livelihoods, and even life (Sulistiyono, 2023) and hence the need to have interventions in place to ensure harmonious co-existence between the wildlife and humans (Schakner *et al.*, 2016). In this study, the results showed that majority of the respondents (98 %) have encountered conflict situation with wildlife. The main type of conflicts in the study area reported is crop raiding. Group discussions revealed that attacks on humans and livestock rarely occur.



Figure 10: Actions taken to reduce human-wildlife conflicts at household level

Survey data showed that the respondents have taken actions to deter the wildlife from raiding their crops. Nearly all, 91% have used live fences, 28% raised dogs to chase the wildlife away and others called KWS officers (Figure 10). Fencing has been shown to play a crucial role in mitigating human-wildlife conflicts by reducing encounters and conflicts between humans and wildlife (Durant *et al.*, 2015; Kassily *et al.*, 2008).

When asked what they think could be done by the Kenya wildlife authorities, all the respondents indicated that the authority should fence the entire park using electricity while 18% felt that provision of wildlife corridors will be a better way of deterring the animals. Studies have shown that wildlife corridors play a crucial role in reducing human-wildlife conflicts by providing safe passages for animals to move between fragmented habitats. These corridors help in maintaining genetic diversity, facilitating animal dispersal, restoring ecological processes, and ultimately decreasing conflicts between humans and wildlife (Rathore *et al.*, 2012).

The study findings were corroborated during the group discussions. The discussants noted that these methods were not effective enough and the KWS officers were rarely available when needed. The KWS officials also indicated they could not effectively carry out their operations due to shortage of human and material resources. The discussants revealed that out of frustration, they attack and sometimes kill the animals, though they fully understand that it is illegal to kill wild animals. Studies (Redford *et al.*, 2015; Hermoso *et al.*, 2016) have shown that conservation

efforts, such as creating wildlife corridors and protecting critical habitats, are crucial in mitigating the impacts of habitat loss, fragmentation, and degradation on biodiversity and ecosystem health.

The presumed young generation viewed wildlife in terms of how much money they could make from their presence citing benefits from tourism and employment while the more mature viewed them in terms of cultural heritage and value for future generations. Efforts to conserve and manage wetlands are essential to ensure their continued provision of ecosystem services. It has been established that, as society becomes increasingly aware of the importance of wetlands, there is a growing acknowledgment of the necessity to protect and conserve these vital ecosystems (Lu *et al.*, 2021).

This observation is similar to (Kibue *et al.*, 2011; Manfredo *et al.*, 2020) who established that that people’s attitude varied depending on individual values, situations and the community value of wildlife. Discussions revealed that women more than men disliked wildlife. This negative attitude could be partly attributed to the women’s inability to defend themselves and their vulnerability to consequences of crop raids by the wildlife. Moreover, the local leaders noted that since 57 per cent of the respondents own a maximum of 1 ha of land (Table 9), on which a single raid can cause substantial damage.

4.4.5 Risks/Threats associated with changes in environmental parameters

Perception of risks associated with human activities varies widely based on their impacts on livelihood and other factors. According to this study, most respondents agreed with all the statements about risks associated with human activities on the environments. Majority of the respondents strongly agreed or agreed that the environmental changes will cause: Adverse effects on agriculture (82%), Land degradation (79%), severe droughts and floods (90 %), Decrease in water quantity and quality (91 %), Change in vegetation composition (88 %), and Conflicts between human and wildlife (75 %).

Table 12: Risks associated with changes in rainfall, temperature and vegetation

Risk/threats	SD	D	NS	A	SA
Adverse effects on agriculture	0	5	0	82	13
Land degradation	0	14	3	79	4

Land cover change	0	26	18	56	0
Land fragmentation	0	33	20	46	1
Decreased sitatunga population	0	19	19	57	5
Change in water quality & quantity	0	5	3	91	1
Severe drought & floods	1	6	2	90	1
Change in vegetation cover	1	6	4	88	1
Human wildlife conflict	2	21	0	75	2

SD= Strongly Disagree D=Disagree NS= Not Sure A= Agree SA= strongly Agree

These findings can be explained by the fact that the respondents largely depend on agriculture for livelihood and there is proven interrelationship between agriculture and environmental resources. Moreover, both droughts and floods have negative impacts on agriculture and by extension food security. Other studies, (Cervantes-Escobar *et al.*, 2023; Abdulmalik *et al.*, 2022) on threats facing wetlands due to disturbance, have shown that perceptions vary depending on factors such as cultural background, personal experiences, education, and media influence. Some activities may be perceived as highly risky by some individuals or groups or regions depending on their while others may view them as relatively safe.

4.4.6 Attitudes/perceptions towards management and conservation of the Swamp

Management and conservation of natural resources has certainly become a big challenge in the face of fast growing populations and associated pressure on environmental resources. In the face of massive land fragmentation, habitat destruction, biodiversity loss and climate change, positive attitudes towards conservation is crucial. According to this study, most respondents agreed with all the statements about conservation of the swamp and its environment. Majority of the respondents strongly agreed or agreed that; Planting trees can restore the wetland environment (93%); Traditional farming practices restore the wetland environment (40 %); I have a duty to sensitize community about importance of the wetland (93%); I am prepared to follow laws to minimize human impacts on the swamp (100%); It is the Government duty to reduce human-wildlife conflicts (99%); Government policies can adequately address wildlife conflicts (28%);

Involving community in formulation of policies can reduce human-wildlife conflicts (89%) (Table 13). There was a significant relationship between education and Involving community in formulation of policies can reduce human-wildlife conflicts; X^2 (df=3, n=141)= 10.33, p=0.016); age and the following statements: traditional farming practices can restore the wetland; X^2 (df=9, n=141)= 17.48, p=0.042; planting trees can restore the wetland X^2 (df=6, n=141)= 15.34, p=0.018 and I have a duty to sensitize the community about importance of the swamp; X^2 (df=6, n=141)= 12.82, p=0.016);.

Table 13: Attitudes/perceptions towards management and conservation of the Swamp

Statement	Level of agreement				
	SD	D	N	A	SA
Afforestation	0	4%	3%	86%	7%
Traditional agricultural practices	1%	55%	4%	39%	1%
Sensitization of community	0	16%	1%	78%	5%
Obeying the laws	0	0	0	99%	1%
Government duty to reduce human-wildlife conflict	0	1%	0	88%	11%
Government policies	0	71%	1%	24%	4%
Community involvement in policy formulation	0	11%	0	85%	4%

SD = Strongly Agree D= Disagree N= Neutral A= Agree SA= Strongly Agree

In agreement with our study, other studies (Ochieng *et al.*, 2021; Shibia, 2010; Jew & Bonnington, 2011; Biru *et al.*, 2017) have established that various factors such as age, gender, level of education, household size, occupation, and proximity to protected areas influence local people's attitudes towards wildlife conservation. Factors like wealth, ethnicity, religion, and length of residence in an area, as well as exposure to human-wildlife conflicts, knowledge of

wildlife, and agreement with wildlife management decisions, also impact attitudes towards wildlife and protected areas (Merz *et al.*, 2021; Alexander *et al.*, 2022). Understanding these factors is essential for designing effective conservation strategies that resonate with local communities and promote sustainable coexistence between humans and wildlife.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusion

Saiwa wetland consists of three distinct areas wetland with reeds, bulrushes, and tall swamp grasses, wooded grassland, and a tropical forest area with wild fig trees and swamp palms. The study findings indicate a diverse range of plant species that suggests a healthy and varied habitat that can support different wildlife species.

The land use land cover in the study over the 30 years found notable changes, largely in the forested area. Decline in forested area around the wetland can be attributed to the anthropogenic activities and change in climatic conditions. Human activities like logging, sand mining and agricultural encroachment in the area play significant role in deforestation and degradation of Saiwa wetland. In relation to the limited sitatunga antelope population data obtained these changes have had a direct and indirect impact on the decline of the antelopes in the swamp.

The park adjacent community views regarding the wetland conservation confirmed that there has been a decline in Sitatunga sightings over the years and the need to conserve its habitat for restoration.

This study underscores the importance of understanding habitat change dynamics and community perspectives in effective Sitatunga antelope and its habitat conservation. Understanding these influences is vital for designing effective conservation policies and management approaches that resonate with diverse stakeholder groups and promote sustainable coexistence between humans and wildlife. By understanding the value of wetlands and the services they provide, communities can make informed decisions to protect and sustainably manage these critical ecosystems.

5.2 Recommendations

This study makes the following recommendations:

- i. Long term monitoring of Sitatunga antelope population.
- ii. The youth should be involved in the habitat restoration initiatives and policy making processes.
- iii. Enhancing community involvement in conservation efforts in Saiwa wetland.

5.3 Areas for further research

- i. Assessment of habitat connectivity in wetland areas.
- ii. An evaluation of effectiveness of conservation policies and governance mechanisms
- iii. A Study of the impact of human-wildlife conflicts on wildlife populations (case study of Sitatunga antelope)

REFERENCES

- Abdoulaye, D., Anthelme, G., Célestin, K. Y., Bandama, B. E., Yves, K. A., Declémence, N. B. P., & Inza, K. (2019). Seasonal distribution of duikers in the different vegetation types of Taï National Park (Côte d'Ivoire). *International Journal of Biosciences*, *14*, 386-397.
- Adam, E., Mutanga, O., & Rugege, D. (2010). Multispectral and hyper spectral remote sensing for identification and mapping of wetland vegetation: a review. *Wetlands ecology and management*, *18*, 281-296.
- Adla, K., Dejan, K., Neira, D., & Dragana, Š. (2022). Degradation of ecosystems and loss of ecosystem services. In *One health* (pp. 281-327). Academic Press.
- Alexander R, Braczkowski, Christopher J, O Bryan, Christian Lessman, Carlo Rondinini, Anna P. Crysrl, Sophie Gilbert, Martin Stringer, Luke Gibson & Duan Biggs (2023). The unequal burden of human wildlife conflict. *6*(128).
- Allen, M. J. (2017). The southern English chalklands: molluscan evidence for the nature of post-glacial woodland cover. *Molluscs in archaeology; methods, approaches and applications*, 144-164.
- Ap, J., Riggio, J., Tait, A., & Baillie, J. (2019). Global areas of low human impact ('low impact areas') and fragmentation of the natural world. *Scientific Reports*, *9*(1).
<https://doi.org/10.1038/s41598-019-50558-6>
- Arias Pedro, Dancers Cora, Liu Pascal, Pilkauskas Paul (2003). The world banana economy 1985-2002. Rome: food and agriculture organisation of United Nations. ISUN 92-5-105057-0. ISSN 1810-0783.
- Armaw, A., & Molla, M. B. (2022). Assessing the trend and magnitude of land cover dynamics and its major driving forces in Omo National Park, Southern Ethiopia. *Cogent Social Sciences*, *8*(1), 2042055.
- Arora, N. K., & Mishra, I. (2019). United Nations Sustainable Development Goals 2030 and environmental sustainability: race against time. *Environmental Sustainability*, *2*(4), 339-342.

- Attwood, S. J., Park, S. E., Maron, M., Collard, S. J., Robinson, D., Reardon-Smith, K. M., & Cockfield, G. (2009). Declining birds in Australian agricultural landscapes may benefit from aspects of the European agri-environment model. *Biological Conservation*, *142*(10), 1981-1991.
- Balodi, K. N. and Anwar, M. (2018). Community attitude and religious bonding in human-wildlife conflict mitigation: a study of kilpura-khatima-surai corridor, terai arc landscape, india. *Asian Journal of Environment & Ecology*, *7*(1), 1-13.
- Barnes, M., Craigie, I., Harrison, L. *et al.* Wildlife population trends in protected areas predicted by national socio-economic metrics and body size. *Nat Commun* *7*, 12747 (2016).
<https://doi.org/10.1038/ncomms12747>
- Beardmore, B., Holsman, R. H., & Collins, A. R. (2021). Determinants of support for funding options for fish and wildlife conservation in wisconsin. *Wildlife Society Bulletin*, *45*(3),
- Beckerman, A., Benton, T. G., Ranta, E., Kaitala, V., & Lundberg, P. (2002). Population dynamic consequences of delayed life-history effects. *Trends in Ecology & Evolution*, *17*(6), 263-269.
- Belluco, E., Camuffo, M., Ferrari, S., Modenese, L., Silvestri, S., Marani, A., & Marani, M. (2006). Mapping salt-marsh vegetation by multispectral and hyperspectral remote sensing. *Remote sensing of environment*, *105*(1), 54-67.
- Benjamin Luke Payne & Jacob Bro-Jorgensen (2016).disproportionate climate induced range loss forecast for the most threatened African antelopes. *Current biology*, Doi 10.1016/j.cub.2016.02.067
- Bhatta, L. D., Chaudhary, S., Pandit, A., Baral, H., Das, P. J., & Stork, N. E. (2016). Ecosystem service changes and livelihood impacts in the maguri-motapung wetlands of assam, india. *Land*, *5*(2), 15.
- Bingham Mike (2014). *Ficus Cyathistipula warb.sub species Cyathistipula flora of Zambia*. Zambiaflora.com

- Biru, Y., Tessema, Z. K., & Urge, M. (2017). Perception and attitude of pastoralists on livestock-wildlife interactions around awash national park, Ethiopia: implication for biodiversity conservation. *Ecological Processes*, 6(1).
- Børresen, S. T., Ulimboka, R., Nyahongo, J., Ranke, P. S., Skjaervø, G. R., & Røskaft, E. (2023). The role of education in biodiversity conservation: Can knowledge and understanding alter locals' views and attitudes towards ecosystem services?. *Environmental Education Research*, 29(1), 148-163.
- Bosone, L., Chaurand, N., & Chevrier, M. (2022). To change or not to change? Perceived psychological barriers to individuals' behavioural changes in favour of biodiversity conservation. *Ecosystems and People*, 18(1), 315-328.
- Breuer T, Amin R, Walher Franken O, Ndoassi C, Ngo Bata M. (2008) intransitive variation in ability to detect tropical forest mammals, *African journal of ecology* 50, 335-342
- Brink, A. B., & Eva, H. D. (2009). Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach. *Applied geography*, 29(4), 501-512.
- Brooks, T. M., Akçakaya, H. R., Burgess, N. D., Butchart, S. H., Hilton-Taylor, C., Hoffmann, M., ... & Young, B. E. (2016). Analysing biodiversity and conservation knowledge products to support regional environmental assessments. *Scientific data*, 3(1), 1-14.
- Brownlee, M. B., Warbington, C. H., & Boyce, M. S. (2022). Monitoring sitatunga (*tragelaphus spekii*) populations using camera traps. *African Journal of Ecology*, 60(3), 377-385. <https://doi.org/10.1111/aje.12972>
- Burke, S. (2020). Environmental impacts on mental health. *Handbook of Rural, Remote, and Very Remote Mental Health*, 1-18.
- Burrows J.E, Lottery S.M, Schmidt E, (2018). Trees and shrubs Mozambique publishing print matters cape town. Page 189.
- Butchart, S. H. M., Stattersfield, A. J., Bennun, L. A., Shutes, S. M., Akçakaya, H. R., Baillie, J. E. M., ... & Mace, G. M. (2004). Measuring global trends in the status of biodiversity: Red List Indices for birds. *PLoS biology*, 2(12), e383.

- Buxton, R. T., Bennett, J. R., Reid, A. J., Shulman, C., Cooke, S. J., Francis, C. M., ... & Smith, P. A. (2021). Key information needs to move from knowledge to action for biodiversity conservation in Canada. *Biological Conservation*, 256, 108983.
- Camille H. Warbington & Mark S. Boyce (2020). Population density of *Sitatunga* in riverine wetland habitats. Vol 24
- Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological annihilation via the on-going sixth mass extinction signalled by vertebrate population losses and declines. *Proceedings of the national academy of sciences*, 114(30), E6089-E6096.
- Cervantes-Escobar, A., Ruiz-Luna, A., & Berlanga-Robles, C. A. (2023). Social perceptions of ecosystem services delivered by coastal wetlands: their value and the threats they face in northwestern Mexico. *Ethnobiology and Conservation*, 12.
- Chen, H., Wang, G., Lü, X., Jiang, M., & Mendelsohn, I. A. (2015). Balancing the needs of China's wetland conservation and rice production. *Environmental Science & Technology*, 49(11), 6385-6393.
- Chira, R. M. (2003). Changes in wildlife habitat and numbers in Embu and Mbeere districts, Eastern Province, Kenya. *LUCID Working Paper*.
- Ciria M.P, Salano M.L & Soriano p (2015). Role of macrophyte *Typha latifolia* in a constructed wetland for waste water treatment and assessment of its potential as biomass fuel, vol 92 issue 24 pages 535-544
- Contreras Hermosilla A (2000). Forest management. Center for international forestry research (CIFOR).
- Convention of wetlands of international importance. Ramsar (1971). United Nations treaty series no.14583.
- Cosquer, A., Raymond, R., & Prevot-Julliard, A. C. (2012). Observations of everyday biodiversity: a new perspective for conservation?. *Ecology and Society*, 17(4).
- Crutzen, P. J. (2016). Geology of mankind. *Paul J. Crutzen: A pioneer on atmospheric chemistry and climate change in the Anthropocene*, 211-215.

- Dandan Zhao, Hong S.He, Wen J.Wang, Jiping Liu,Haibo Du, Miaomiao Wu & Xinyuan Tan (2018). Distribution and driving factors of forest swamp conversions in a cold temperate region.int j environ res public health 15(10)2103
- Dean, A. P., Lynch, S. F. L., Rowland, P. R., Toft, B. D., Pittman, J. K., & White, K. (2013). Natural wetlands are efficient at providing long-term metal remediation of freshwater systems polluted by acid mine drainage. *Environmental Science & Technology*, 47(21)
- Denis Saunders A, Lencie Fahrig, Victor Arroyo Rodrigues, Joseph Bennet R, Veronique Boucher, Eliana Cazetta, David Currie, Felix Eigenbrod, Susan Harrison P, Jochen Jaehner, Nichola Koper, Amanda Martin, Mark Vellend. (2019) is habitat degradation bad for biodiversity? *Biological conservation* 230,179-186,
- Diane McLeish. (2017) *sanctuary for the sitatunga*. <https://conservationmag.org>
- Diop F.N, Lansdown D.R (2020). *Echinocloa Pyramidalis*. IUCN redlist of threatened species. E.t164478A140431796.
- Dung, N. M. and Le, N. P. (2022). Economic valuation of regulating ecosystem services of thuy wetland in the red river delta of vietnam. *Review of Applied Socio-Economic Research*, 23(1), 97-108.
- Durant, S. M., Becker, M. S., Creel, S., Bashir, S., Dickman, A., Beudels-Jamar, R., ... & Pettorelli, N. (2015). Developing fencing policies for dryland ecosystems. *Journal of Applied Ecology*, 52(3), 544-551.
- Eben Broodbent, Gregory Asher, Michael Keller, David Knapp, Paulo Oliveria, Jose Silva. (2008) forest fragmentation and edge effects from deforestation and selective logging in the Brazilian amazon
- Edelsparre, A. H., Shahid, A., & Fitzpatrick, M. J. (2018). Habitat connectivity is determined by the scale of habitat loss and dispersal strategy. *Ecology and Evolution*, 8(11), 5508-5514.
- Etienne Fluet Chouinard, Benjamin D. Stocker, Zhen Zhang, Avni Malhotra, Joe R. Meltan, Benjamin Palter, Jed O. Kaplan, Robert B Jackson & Peter B McIntyre (2023). Extensive global wetland loss over the past three centuries.

- Farmer, M., Cooper, T., Swales, V., & Silcock, P. (2008). Funding for farmland biodiversity in the EU: Gaining evidence for the EU budget review. *Institute for European Environmental Policy*.
- Formanski, F. J., Pein, M. M., Loschelder, D. D., Engler, J., Husen, O., & Majer, J. M. (2022). Tipping points ahead? how laypeople respond to linear versus nonlinear climate change predictions. *Climatic Change*, 175(1-2).
- Frank Adriansen, Chardon J.P, Geert De Blust, Else Swinnen, Villaba S, Hubert Gulinck, Erik Mattysen. (2003) Landscape and urban planning
- G da Silva (2011). *Maytenus heterophylla* & *maytenus senegalensis*, two traditional herbal medicines.
- Gachimbi, L. N. (2002). Technical report on soil survey and sampling: Loitokitok division, Kajiado District, Kenya. *LUCID Working Paper*.
- Gandiwa, E., Heitkönig, I. M. A., Lokhorst, A. M., Prins, H. H. T., & Leeuwis, C. (2013). Campfire and human-wildlife conflicts in local communities bordering northern gonarezhou national park, Zimbabwe. *Ecology and Society*, 18(4).
<https://doi.org/10.5751/es-05817-180407>
- Gashaw, T., Tulu, T., Argaw, M., & Worqlul, A. W. (2018). Modeling the hydrological impacts of land use/land cover changes in the Andassa watershed, Blue Nile Basin, Ethiopia. *Science of the Total Environment*, 619, 1394-1408.
- Goyder, D.J, Gilbert, M.G & Venter, H.J.T (2020). Apocynaceae (part 2) flora Zambia 7(2) pages 4-5
- Green facts (2022): *habitat change*, <https://www.greenfacts.org>
- Guntenspergen, G. R., Stearns, F., & Kadlec, J. A. (2020). Wetland vegetation. In *Constructed wetlands for wastewater treatment* (pp. 73-88). CRC Press.
- Haddad, N. M., Brudvig, L. A., Damschen, E. I., Evans, D. M., Johnson, B. L., Levey, D. J., & Weldon, A. J. (2014). Potential negative ecological effects of corridors. *Conservation Biology*, 28(5), 1178-1187.

- Hagos, F., Yemane, T., Ibrahim, K. M., Mangiacotti, M., & Sacchi, R. (2023). Combined Effects of Climate, Vegetation, Human-Related Land Use and Livestock on the Distribution of the Three Indigenous Species of Gazelle in Eritrea. *Animals*, 13(9), 1490.
- Hermoso, V., Abell, R., Linke, S., & Boon, P. J. (2016). The role of protected areas for freshwater biodiversity conservation: challenges and opportunities in a rapidly changing world. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 26(S1), 3-11.
- Hoban, S. M., Mezzavilla, M., Gaggiotti, O. E., Benazzo, A., Van Oosterhout, C., & Bertorelle, G. (2013). High variance in reproductive success generates a false signature of a genetic bottleneck in populations of constant size: a simulation study. *BMC bioinformatics*, 14, 1-10.
- Holmes, C. D., Prather, M. J., Søvde, O. A., & Myhre, G. (2013). Future methane, hydroxyl, and their uncertainties: key climate and emission parameters for future predictions. *Atmospheric Chemistry and Physics*, 13(1), 285-302.
- Hossein Madadi, Hossein Moradi, Alizera Soffianin, Dolrassoul A, Josef Senn, Davide Geneletti.D (2017) degradation of natural habitats by roads: environmental impact assessment review 65,147-155
- Hu, H., Liu, W., & Cao, M. (2008). Impact of land use and land cover changes on ecosystem services in Menglun, Xishuangbanna, and Southwest China. *Environmental monitoring and assessment*, 146, 147-156.
- Huang, J., Cao, W., Wang, H., & Wang, Z. (2020). Affect path to flood protective coping behaviors using sem based on a survey in shenzhen, china. *International Journal of Environmental Research and Public Health*, 17(3), 940.
- Hurlbert, A. H., & Jetz, W. (2007). Species richness, hotspots, and the scale dependence of range maps in ecology and conservation. *Proceedings of the National Academy of Sciences*, 104(33), 13384-13389.
- Hyde M.A, Wursten B.T, Ballings P & Coates Palgrave M (2024). Flora of Malawi google maps:periplocalinearfolia.http://www.malawiflora.com . Species id=220060

- Infrastructure and ecology network Europe IENE (2022).7 solutions to reduce transport infrastructure impacts on wildlife
- IUCN(2019).SSC global tree specialist group."Ficus sycomorus" Red List of Threatened Species doi:10.2305/IUCN.UK.20192.RLTS.T146188430A146199148.en
- Jacob Bro-Jorgensen (2020).Conserving African ungulates under climate change:do communal and private conservancies fill gaps in the protected area network effectively?
- Jalin, N, J, and Mabsharif, Z. (2018). Factors affecting the awareness of biodiversity conservation among students in Malaysia private university. *International journal of engineering and technology* 7(4135), 791-795.
- Janse, J. H., Van Dam, A. A., Hes, E. M., de Klein, J. J., Finlayson, C. M., Janssen, A. B., ... & Verhoeven, J. T. (2019). Towards a global model for wetlands ecosystem services. *Current Opinion in Environmental Sustainability*, 36, 11-19.
- Januchowski-Hartley, S. R., McIntyre, P. B., Diebel, M., Doran, P. J., Infante, D. M., Joseph, C., & Allan, J. D. (2013). Restoring aquatic ecosystem connectivity requires expanding inventories of both dams and road crossings. *Frontiers in Ecology and the Environment*, 11(4), 211-217.
- Jew, E. and Bonnington, C. (2011). Socio-demographic factors influence the attitudes of local residents towards trophy hunting activities in the Kilombero valley, Tanzania. *African Journal of Ecology*, 49(3), 277-285.
- Jew, E. and Bonnington, C. (2011). Socio-demographic factors influence the attitudes of local residents towards trophy hunting activities in the Kilombero valley, Tanzania. *African Journal of Ecology*, 49(3), 277-285.
- John Dorney and Paul Adamus. (2018) history of wetlands and stream RAMS1, 1-6
- Jomal Jokar Arsanjani. (2011) dynamic land use land cover change modelling: geo-simulation and multi-agent modelling

- Joseph Ndawula, Mnason Tweheyo, David Tumusiime M, Gerarld Eilu. (2011) Understanding sitatunga (*tragelaphus spekii*) habitats through diet analysis in Rushebeya Kanyabaha wetland, Uganda
- Julius Kipkemboi & Anne A. Van Dam (2016). Papyrus wetlands. *The wetland book* pp 1-15
- Kang, H. M., Zaitlen, N. A., Wade, C. M., Kirby, A., Heckerman, D., Daly, M. J., & Eskin, E. (2008). Efficient control of population structure in model organism association mapping. *Genetics*, 178(3), 1709-1723.
- Kaplan, G. (2021). Broad leaved and coniferous forests classification on google earth engine using sentinel imagery. *Environmental science*. 3(64)
- Karaya, R. N., Onyango, C. A., & Ogendi, G. M. (2021). A community-GIS supported dryland use and cover change assessment: The case of the Njemps flats in Kenya. *Cogent Food & Agriculture*, 7(1), 1872852.
- Karp Miles (2019). The banana is one step closer to disappearing. National geographic. The original.
- Katherine Gibbs, Robin Mackey, David Currie. (2009) human land use, agriculture, pesticide and losses of imperilled species
- Keddy P.A, (2015) wetland ecology principles and plant communities of Minnesota and Wisconsin
- Kenya wildlife service, (2007), saiwa swamp national park.
- Kibue, G. W., Karachi, M. K., Maara, N. T., & Cheboi, E. K. (2011). Perpetuated human-wildlife wars: A case study of the marauding elephants in Mbuvari Small Scale Farms, Embu, Kenya. *Eastern Africa Social Science Research Review*, 27(1), 33-48.
- Kinuthia, S. (2018). Major Ethnic Groups in Egypt. *Last modified July, 20*.
- Kirui, W. K. (2008). Analysis of catchment hydrologic response under changing land use the case of upper Molo river catchment, Kenya (*Doctoral dissertation, Egerton University*).

- Klassen, A. C., Creswell, J., Plano Clark, V. L., Smith, K. C., & Meissner, H. I. (2012). Best practices in mixed methods for quality of life research. *Quality of life Research*, 21, 377-380.
- Krauss, J., Bommarco, R., Guardiola, M., Heikkinen, R. K., Helm, A., Kuussaari, M., & Steffan-Dewenter, I. (2010). Habitat fragmentation causes immediate and time-delayed biodiversity loss at different trophic levels. *Ecology letters*, 13(5), 597-605.
- Laari Prosper Basommi, Qing-feng Guan, Dan-dan Cheng, Sudhir Kumar Singh. (2016) dynamics of land use change in mining area: a case study of Nadowi District, Ghana 13,633-642
- Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual review of environment and resources*, 28(1), 205-241.
- Laura Klappenbach (2021) habitat loss, fragmentation and destruction
- Lee, T. M., Markowitz, E. M., Howe, P. D., Ko, C., & Leiserowitz, A. (2015). Predictors of public climate change awareness and risk perception around the world. *Nature Climate Change*, 5(11), 1014-1020.
- Lindenmayer, D. B., & Fischer, J. (2013). *Habitat fragmentation and landscape change: an ecological and conservation synthesis*. Island Press.
- Liu, H., & Zhou, Q. (2004). Accuracy analysis of remote sensing change detection by rule-based rationality evaluation with post-classification comparison. *International Journal of Remote Sensing*, 25(5), 1037-1050.
- Lü, L., Xiong, H., Wang, Y., Lan, G., Liu, W., & Li, N. (2021). Quantify wetland bird habitat selection in urban environment.. <https://doi.org/10.21203/rs.3.rs-162634/v1>
- Makate, C., Makate, M., & Mango, N. (2017). Smallholder farmers' perceptions on climate change and the use of sustainable agricultural practices in the chinyanja triangle, southern Africa. *Social Sciences*, 6(1), 30.

- Malézieux, E., Crozat, Y., Dupraz, C., Laurans, M., Makowski, D., Ozier-Lafontaine, H., & Valantin-Morison, M. (2009). Mixing plant species in cropping systems: concepts, tools and models: a review. *Sustainable agriculture*, 329-353.
- Mandal, F.B., Chatarjee, C., and Ghosh, A. (2011). Ecosystems and human well-being. *Journal of environment and socio-biology*, 8(1), 25-42.
- Mander, Ü., Tournebize, J., Tonderski, K., Verhoeven, J. T., & Mitsch, W. J. (2017). Planning and establishment principles for constructed wetlands and riparian buffer zones in agricultural catchments. *Ecological Engineering*, 103, 296-300.
- Maria Carolina Olivia Basil, Raul De Magalhaes Filho, Mario Marcos Do Santo, Marcos Esdras Leite, Maria Das Dores & Luiz Alberto Falcao (2018). Land cover changes and drivers of palm swamp degradation in south-eastern Brazil from 1984-2018.
- Marie E. Hardouin & Anna L. Hargreaves (2023). mapping nationally and globally at risk species to identify hotspots for (and gaps in) conservation.
- May, J., & Lindholm, R. (2013). *Tragelaphus spekii* Sitatunga. *Mammals of Africa*, 6, 172-178.
- Meena, D. C., Dubey, R., Pal, R., Dubey, S. K., & Bishnoi, R. (2022). Assessment of farmer's attitude and social vulnerability to climate change in the semi-arid region. *Indian Journal of Extension Education*, 58(3), 46-50.
- Meena, D. C., Dubey, R., Pal, R., Dubey, S. K., & Bishnoi, R. (2022). Assessment of farmer's attitude and social vulnerability to climate change in the semi-arid region. *Indian Journal of Extension Education*, 58(3), 46-50.
- Mengesha, G., Bekele, A., Fraser, G., & Mamo, Y. (2014). Land use, land cover and climate change impacts on the bird community in and around Lake Zeway, Ethiopia. *International Journal of Biodiversity and Conservation*, 6(3), 256-270.
- Merz, L., Pienaar, E. F., T, F., & Muyengwa, S. (2021). Tolerance of wildlife in protected area borderlands.. <https://doi.org/10.1101/2021.03.27.436188>

- Messer, T. L., Douglas-Mankin, K. R., Nelson, N., & Etheridge, J. R. (2019). Wetland ecosystem resilience: protecting and restoring valuable ecosystems. *Transactions of the ASABE*, 62(6)
- Miao, Z., Wang, Q., Lu, X., Chen, D., Zhang, W., Zhou, X., ... & MacMillan, D. C. (2021). Compassionate conservation and the challenge of sustainable wildlife management: a survey of the urban public of china. *Animals*, 11(9), 2521.
- Miettinen, J., Shi, C., & Liew, S. C. (2011). Deforestation rates in insular southeast asia between 2000 and 2010. *Global Change Biology*, 17(7), 2261-2270.
<https://doi.org/10.1111/j.1365-2486.2011.02398.x>
- Mimet, A., Clauzel, C., & Foltête, J. C. (2016). Locating wildlife crossings for multispecies connectivity across linear infrastructures. *Landscape Ecology*, 31(9), 1955-1973.
- Ministry of natural resources Malaysia, (2016). National policy on biological diversity, *ministry of natural resources and environment, 2016-2025*
- Mitchell Irwin, (2016) habitat change, loss, fragmentation and degradation. An introduction to primate conservation, 111-127
- Morgan, G. R., & Hodgson, M. E. (2021). A Post-Classification Change Detection Model with Confidences in High Resolution Multi-Date sUAS Imagery in Coastal South Carolina. *International Journal of Remote Sensing*, 42(11), 4309-4336.
- Morrison, E. H. J., Upton, C., Odhiambo-K'Oyooh, K., & Harper, D. M. (2012). Managing the natural capital of papyrus within riparian zones of Lake Victoria, Kenya. *Hydrobiologia*, 692, 5-17.
- Morrison, M. L., & Mathewson, H. A. (Eds.). (2015). *Wildlife habitat conservation: concepts, challenges, and solutions*. JHU Press.
- Muiruri, E. J., Nyangweso, P. M., Langat, B. K., & Kipsat, M. J. (2011). Farmer's inaccessibility to agricultural credit in Nyandarua District, Kenya. *Asian Journal of Agriculture and Rural Development*, 1(2), 64-68.

- Murwany, P. H., Kityo, R., Ssekuubwa, E., & Tweheyo, M. (2023). Sitatunga (*tragelaphus spekii*) food sources and habitat use in marsh–savannah-cultivation mosaics. *African Journal of Ecology*, 62(1).
- N Paiecznik (2013) invasive species, CABI compendium.2265
- National geographic (2015) environment.nationalgeographic.com/environment/global-warming/deforestation-overview/
- Ochieng, C. N., Thenya, T., Shah, P., & Odwe, G. (2021). Awareness of traditional knowledge and attitudes towards wildlife conservation among Maasai communities: the case of enkusero sampu conservancy, Kajiado County in Kenya. *African Journal of Ecology*, 59(3), 712-723.
- Ogoma, M., Akwany, L., & Adhiambo, R. (2023). Application of community climate change adaptation assessment tools for climate adaptation planning in yala wetlands complex, lake victoria basin, kenya. *Open Journal of Ecology*, 13(05), 271-290.
<https://doi.org/10.4236/oje.2023.135018>
- Oguh, C. E., Obiwulu, E. N. O., Umezina, O. J., Ameh, S. E., Ugwu, C. V., & Sheshi, I. M. (2021). Ecosystem and ecological services; need for biodiversity conservation-a critical review. *Asian Journal of Biology*, 11(4), 1-14.
- Ortego, J., Aparicio, J. M., Muñoz, A., & Bonal, R. (2007). Malathion applied at standard rates reduces fledgling condition and adult male survival in a wild lesser kestrel population. *Animal Conservation*, 10(3), 312-319.
- Ottar Michelsen and Jan Paul Lindner, (2015) why include impacts of biodiversity from land use in LCIA and how to select useful indicators. *Sustainability*: 6278-6302
- Ozor, N., & Odo, P. (2008). Community Strategies for the Conservation and Preservation of Forest Resources in Nsukka Agricultural Zone of Nigeria. *Agro-Science*, 7(1), 27-32.
- Pajewski, T., Gołębiewska, B., & Sobolewska, A. (2019). The area of farms and their influence on generating negative externalities. *European Research Studies Journal*, XXII(Issue 4), 3-14.

- Patricia Kefilwe Mogomosti, Lesego S Stone, Geomoene E.J Mogomosti & Nqobizitha Dube (2020). factors influencing community participation in wildlife conservation. Pages 372-386
- Pengra, B. W., Johnston, C. A., & Loveland, T. R. (2007). Mapping an invasive plant, *Phragmites australis*, in coastal wetlands using the EO-1 Hyperion hyperspectral sensor. *Remote Sensing of Environment*, 108(1), 74-81.
- Perrings, C., & Halkos, G. (2015). Agriculture and the threat to biodiversity in sub-Saharan Africa. *Environmental Research Letters*, 10(9), 095015.
- Pettorelli, N., Wegmann, M., Skidmore, A., Múcher, S., Dawson, T. P., Fernandez, M., & Geller, G. N. (2016). Framing the concept of satellite remote sensing essential biodiversity variables: challenges and future directions. *Remote sensing in ecology and conservation*, 2(3), 122-131.
- Pornwiwan Pothasin, Stephen G. Compton & Parsit Wangpakapattanawong (2019) Riparian ficus tree communities: the distribution and abundance of riparian fig trees in northern Thailand
- Rathore, C. S., Dubey, Y., Shrivastava, A., Pathak, P., & Patil, V. K. (2012). Opportunities of habitat connectivity for tiger (*panthera tigris*) between kanha and pench national parks in madhya pradesh, india. *PLoS ONE*, 7(7)
- Rehnus, M., Bollmann, K., Schmatz, D. R., Hackländer, K., & Braunisch, V. (2018). Alpine glacial relict species losing out to climate change: The case of the fragmented mountain hare population (*Lepus timidus*) in the Alps. *Global change biology*, 24(7), 3236-3253.
- Richard A. Giliba & Genesis Tambang Yengoh (2020). Predicting suitable habitats of the African cherry (*prunus Africana*) under climate change in Tanzania
- Runyan, C. W., D'Odorico, P., & Lawrence, D. (2012). Physical and biological feedbacks of deforestation. *Reviews of Geophysics*, 50(4).
- Ruto, W. S., Kanya, J. I., Muchugu, E., Ngetich, N. K., & Kinyamario, J. I. Land Use-Land-Cover Changes in Saiwa Swamp Watershed, Western Kenya.

- Sanjay Kumar, Gaurav Joshi, Nitesh Takarker, Rawat J, Savita Palni, Arvind Pandey (2015) application of GIS science in land use land cover dynamics over 28 years, A case study of Haldwani town, India
- Sefi Makonen (2020). Coexistence between humans and wildlife: the nature, causes and mitigation of human wildlife conflict around Bale mountains national park, South East Ethiopia.51
- Sefi Mekonen (2020).coexistence between human and wildlife: the nature, causes and mitigations of human wildlife conflict around Bale mountains national park, southeast Ethiopia.BMC Ecology article: 51
- Shanon Wolfe (2014). Carnivorous figs: the relationship between wasps and figs, university of Carlifonia
- Shibia, M. (2010). Determinants of attitudes and perceptions on resource use and management of marsabit national reserve, kenya. *Journal of Human Ecology*, 30(1), 55-62.
- Souza-Filho, P. W. M., de Souza, E. B., Júnior, R. O. S., Nascimento Jr, W. R., de Mendonça, B. R. V., Guimarães, J. T. F., ... & Siqueira, J. O. (2016). Four decades of land-cover, land-use and hydroclimatology changes in the Itacaiúnas River watershed, south-eastern Amazon. *Journal of environmental management*, 167, 175-184.
- Sulistiyono, N., Marsudi, S., Ahda, M., Asmanijar, W., Tobing, G. L., & Zahirah, A. (2023). The economic value of forest environmental services for mitigating human-wildlife conflict in the village around management section of national park (mns) vi besitang, gunung leuser national park. *IOP Conference Series: Earth and Environmental Science*, 1188(1), 012010. <https://doi.org/10.1088/1755-1315/1188/1/012010>
- Sun, Y. and Han, Z. (2018). Climate change risk perception in taiwan: correlation with individual and societal factors. *International Journal of Environmental Research and Public Health*, 15(1), 91.
- Susoy Vladislavi, Herman Mathew's, Kanzaki Natsumi, Kruger Meike, Nguyen Chau, Rödelperger Christian, Roseler Waltraud, Weiler Christian, Giblin Davis, Robin

- Rogsdale, Erik J. Somer(2016).large scale diversification without genetic isolation in nematode symbionts of fiof. *science awareness* 2(1):e1501031
- Tait, L., Bind, J., Charan-Dixon, H., Hawes, I., Pirker, J., & Schiel, D. (2019). Unmanned aerial vehicles (UAVs) for monitoring macroalgal biodiversity: Comparison of RGB and multispectral imaging sensors for biodiversity assessments. *Remote Sensing*, *11*(19), 2332.
- Tilman, D., Fargione, J., Wolff, B., D'antonio, C., Dobson, A., Howarth, R., & Swackhamer, D. (2001). Forecasting agriculturally driven global environmental change. *science*, *292*(5515), 281-284.
- Timberlake J.R, Baylis J, Dowell Lemaire, Congdom F, Branch B, Collins, Fishpool L, Fransisco L, (2012). Mt. Mabu Mozambique: biodiversity and conservation report produced under Darwin initiative award 15/036. Royal botanic Gardens page 74.
- Tyukavina, A., Hansen, M. C., Potapov, P. V., Stehman, S. V., Smith-Rodriguez, K., Okpa, C., & Aguilar, R. (2017). Types and rates of forest disturbance in Brazilian Legal Amazon, 2000–2013. *Science advances*, *3*(4), e1601047.
- United states environmental protection agency (EPA). (2021) climate impacts on agriculture and food supply
- USDA, NRCS (2015).Typha latifolia. The plants database (plants.usda.gov)
- Vačkář, D., ten Brink, B., Loh, J., Baillie, J. E., & Reyers, B. (2012). Review of multispecies indices for monitoring human impacts on biodiversity. *Ecological Indicators*, *17*, 58-67.
- Van der Meer, F. (2012). Remote-sensing image analysis and geostatistics. *International Journal of Remote Sensing*, *33*(18), 5644-5676.
- Van der Ploeg, J., Caullan, C and Groot, W.T. (2011). Assessing the effectiveness of environmental education: mobilizing public support for Philippine crocodile conservation. *Conservation lett.* *4*:313-323.
- Van Horne, B., & Wiens, J. A. (2015). Managing habitats in a changing world. *Wildlife habitat conservation: concepts, challenges, and solutions. USA, Johns Hopkins University Press & The Wildlife Society*, 34-43.

- Van Noort S, Gardliner A.J, Tolley K.A, (2007).New records of ficus (moraciae) species emphasise the significance of iselbergs in Mozambique. *South African journal of botany* 73(4):642-649.
- Van Wyk B & Can Wyk p (2013). *Field guide to trees of southern Africa*. (Second edition) struck, South Africa pages 166-167.
- Vishnevetsky Jane, White Thomas, Palmater Aaron, Flaushman Moshe, Cohen Yuval,Elad Yigal, Velcheva Margarita, Hananoa Uri, Sahar Nachman, Parl Avihai (2011).Improved tolerance towards fungal diseases in transgenic cavendish banana. *Transgenic research* 20(1)61-72
- Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2012). The risk perception paradox—implications for governance and communication of natural hazards. *Risk Analysis*, 33(6), 1049-1065.
- Watts, B. and Everard, M. (2016). Economic incentives for the nonregulatory conservation and management of wetlands. *The Wetland Book*, 1-9.
- Wayub Xu, Linxia Xu, Yuqi Cao, Tiagang Zheng, Yaling Wang, Kun Cheng Lee, Huxuan Dani, Cheng Zeng (2024). community perspectives of flagships species: can conservation motivators mitigate human wildlife conflicts?
- Webb, C.J,Simpson, M.J.A, (2011) seeds of New Zealand gymnosperm and dicotyledond.christchurch, manuka press
- Webetu Yihunie Belay et al (2018).antimalarial activity of stem bark of periploca linearifolia during early and established plasmodium infection in mice. *Evid based complement alternat med*.
- Weiss, M., Jacob, F., & Duveiller, G. (2020). Remote sensing for agricultural applications: A meta-review. *Remote sensing of environment*, 236, 111402.
- Wekesa, C., Kirui, B. K., Maranga, E. K., & Muturi, G. M. (2020). The fate of Taita Hills forest fragments: Evaluation of forest cover change between 1973 and 2016 using Landsat imagery.

- Widanagama D, Shane Freeland, Joanne R, Shaffer Aaron (2021). “*typha latifolia* “ IUCN redlist of threatened species
- Wilson Kipkore, Bernard WAnjohi & Gabriel Kigen (2014). A study of the medicinal plants used by the marakwet community in Kenya. *Journal of ethnobiology and ethnomedicine* 10(24).
- Wilson, E. O. (2002). What is nature worth? *The Wilson Quarterly* (1976-), 26(1), 20-39.
- WoldeYohannes, A., Cotter, M., Kelboro, G., & Dessalegn, W. (2018). Land use and land cover changes and their effects on the landscape of Abaya-Chamo Basin, Southern Ethiopia. *Land*, 7(1), 2.
- Xu, X., Liu, H., Zhen-shan, L., Jiao, F., & Gong, H. (2019). Relationship of abrupt vegetation change to climate change and ecological engineering with multi-timescale analysis in the karst region, southwest china. *Remote Sensing*, 11(13)
- Zedler, J. B. (2003). Wetlands at your service: reducing impacts of agriculture at the watershed scale. *Frontiers in Ecology and the Environment*, 1(2), 65-72.
- Zhang, Y., Zhou, D., Niu, Z., & Fengjiao, X. (2013). Valuation of lake and marsh wetlands ecosystem services in china. *Chinese Geographical Science*, 24(3), 269-278.

APPENDICES

Appendix 1: Questionnaire

**A QUESTIONNAIRE ON COMMUNITY KNOWLEDGE AND PERCEPTION
TOWARDS SAIWA WETLAND CONSERVATION.**

My name is Millicent Anyango Owiti. I am a MSc. student in the Department of Natural Resources, Egerton University. I am working on a research assessing habitat change and current threats to Sitatunga antelope population. To enable me acquire this information, I will be interviewing members of the communities within Sinyerere and Sitatunga Wards to know their level of awareness about the Sitatunga antelope. As one of the selected people in the area for the interview, I kindly request you to participate in this study. I assure you that the information you will provide for this study will be treated with utmost confidentiality and will only be used for research purposes only. For any enquiries, kindly contact me on the contact details below.

CONTACT: Millicent Anyango Owiti, Phone No: 0711432884 E-mail: millienyango@gmail.com

Interview date.....

SURVEY QUESTIONNAIRE

Section 1. Household information

Name of the interviewee:	Gender of interviewee Male <input type="checkbox"/> female <input type="checkbox"/>	Age
Highest level of education attained Primary/ <input type="checkbox"/> Secondary/ <input type="checkbox"/> University? <input type="checkbox"/>	Household head? 0= no, 1= yes	Sub-location Sitatunga <input type="checkbox"/> Sinyerere <input type="checkbox"/> Kipsaina <input type="checkbox"/>
Ward Sinyerere <input type="checkbox"/> Sitatunga <input type="checkbox"/>	Employment status Employed <input type="checkbox"/> self-employed <input type="checkbox"/>	Farm size

	unemployed <input type="checkbox"/>	
--	-------------------------------------	--

Section 2: Knowledge on Sitatunga and Vegetation Change

1) How long have you lived in the area? 5 Years 10 Years 15 Years 20 Years
>20 Years

2) Are you aware of any wildlife species in this area? Yes No

3) If yes, please list them.

Sitatunga monkeys cranes Snakes

4) Are there animals that are hunted for food or any traditional activity? Yes No

5) If yes, please list them

Sitatunga antelopes Monkeys cranes snakes,

6) Are there cases of conflicts between human and wildlife? Yes No

7) If yes list them.

Crop raiding attacks on humans Attacks on Livestock

8) In your opinion what can be done to reduce the human/wildlife conflicts?

Barriers corridors mapping hotspots collaring

9) Have you seen/heard about sitatunga antelopes before this interview? Yes No

10) When did you start seeing the antelopes? 5 Years 10 Years 15 Years
20 Years >20 Years

11) How knowledgeable about sitatunga antelopes are you?

Very knowledgeable Knowledgeable Somehow knowledgeable
 Unknowledgeable

12) In the table below, indicate by ticking (√) on the appropriate box changes observed on the following areas

Parameter	Changes observed			
	Increase	Decrease	No change	Don't know
Rainfall				
Temperature				
Vegetation				

13) Have you observed any changes in sitatunga population/numbers as a result of changes in the parameters above? Yes No

14) In your opinion, what are the causes of the changes in question 13 above?

Climate change habitat degradation human wildlife conflict industrialization

15) Indicate by assigning a tick (√) the option that shows your opinion about the following threats/risks associated to the changes in the parameters in question 12 above. **1 = strongly disagree, 2= disagree, 3= not sure, 4= agree and 5= 'strongly agree'**

Threat	1	2	3	4	5
Adverse effects on agriculture					
Land degradation					

Land cover change					
Land fragmentation					
Decrease in the number of sitatunga					
Change in water quality and quantity					
Severe droughts and floods					
Change in vegetation composition					
Conflicts between human and wildlife					

16) According to you, what are the main causes of the changes in number 12 above?

- a. There are no changes
- b. Clearing vegetation
- c. Agriculture activities
- d. Industrial activities
- e. Human settlement

Section 3: Attitudes on sitatunga and vegetation conservation

17) Are you concerned/ worried about the changes in the parameters in number 12 and the consequences on sitatunga? Yes No

18) If yes, how concerned are you? a) Very concerned b) Somehow concerned c) Least bothered

19) What is your opinion on the following statements (tick appropriately)

Statement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Afforestation can help restoration of sitatunga habitat					
Traditional agricultural practices can improve natural habitats for sitatunga					
I have a duty to sensitize community about sitatunga conservation					
I am prepared to follow laws that promote wildlife conservation					
It is the Government duty to reduce wildlife-human conflicts					
Government policies can adequately address human-wildlife conflicts					
Involving community in formulation of policies can promote harmonious human-wildlife co-existence					

20) Have you ever taken any action(s) to reduce human-wildlife conflicts? Yes No

21) If YES in 15, please list the actions which you took

Safe disposal of leftovers use of Guard dogs erecting of barriers

22) If NO in 21, what stops you?

- f. I don't care
- g. Lack of information
- h. It is not a community concern
- i. I am not aware of actions to take
- j. It is the government's responsibility

Section 4. Practices towards wildlife and vegetation conservation

23) Have you taken any action(s) to ensure wildlife and vegetation conservation Yes [] No []

24) If yes, list the actions have you taken

Safe disposal of waste [] donating to wildlife foundations [] Forest rehabilitation

25) If no, what has prevented you?

- k. I don't care
- l. Lack of information
- m. It is not a community concern
- n. It is the government responsibility

26) In your opinion, what should be done by the government to strengthen the practices mentioned above (in 25?)

Enact laws on protected areas [] allocating funds towards conservation [] Community engagement []

Appendix 2: Key informants interview guide

1. What is your role in general?
2. What is the role of community in park management and conservation?
3. How does the community benefit through conservation of the national park?
4. Are you aware of the presence of Sitatunga antelopes in this area? 5. What is their approximate population?
6. How has the population changed from 30 years back to now? (Rate or % of positive or negative change)
7. In your opinion, do you think the Sitatunga plays an important role in this ecosystem? If yes, mention them
8. Are there any threats facing their population and existence? If yes, please mention them
9. What conservation and protection strategies are employed by the local people and how they relate to the wildlife act?
10. Are there efforts to mainstream human/wildlife issues into county government policies, strategies and plans?
11. Give an estimate of annual budgetary allocation to the climate change unit/effort
12. Are there initiatives to raise awareness among the county residents (in schools, public events etc.) on human/wildlife conflicts effects? If so, list some of the activities undertaken in the last 10 years
13. Are there collaborative efforts with communities, institutions and other actors on climate change awareness raising?
14. What is the role of education, gender and economic status as factors enabling the participation of communities in conservation?
15. What are some of the challenges faced in implementation of certain policies?

16. Are there conflicts between humans and Sitatunga antelope in the area?
17. If yes how do you respond to these conflicts?
18. What would you suggest as the best way to address the challenges in wildlife conservation?
19. Are there any organizations, institutions, or individuals working towards addressing the challenges? If yes, mention them
20. What efforts are in place to promote human/wildlife coexistence?

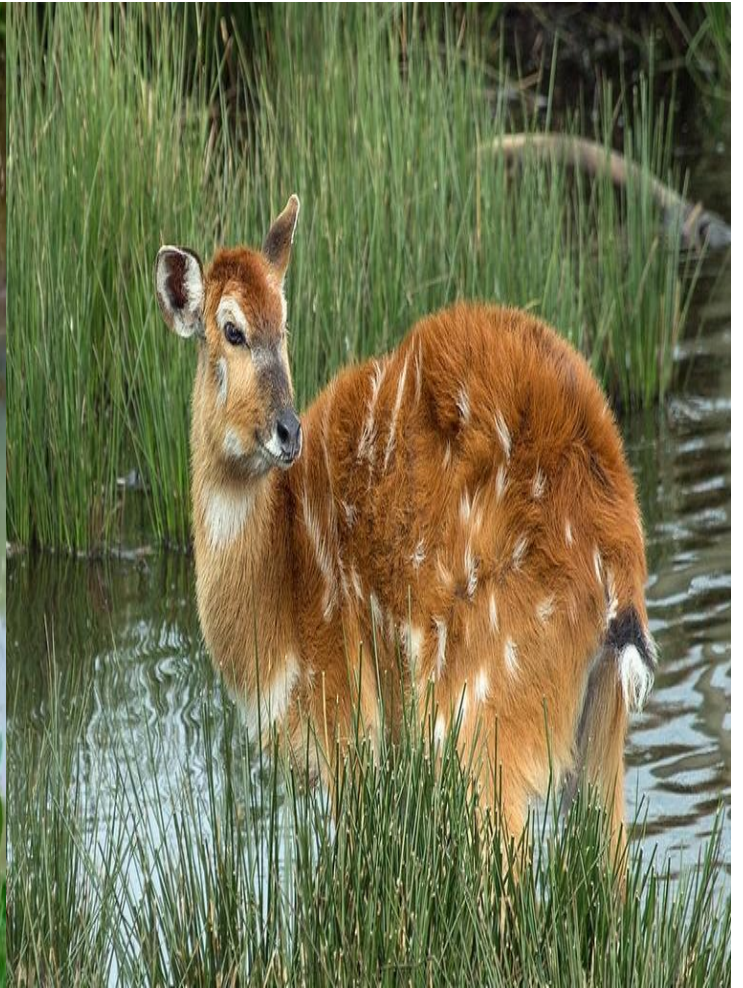
Appendix 3: Focus group discussion guide

1. What is the serious wildlife conservation problem in the area?
2. What are the possible challenges of having wildlife in this area?
3. Do you know of the current Sitatunga antelope population?
4. What is the importance of the Sitatunga antelope in the environment?
5. Which activities promote the Sitatunga antelope conservation?
6. Which activities threaten the Sitatunga antelope?
7. What are the major land use land cover changes observed in the area overtime?
8. What is your view of the future of wildlife outside protected areas?

Appendix 4: Image of male and female Sitatunga



Male Sitatunga antelope

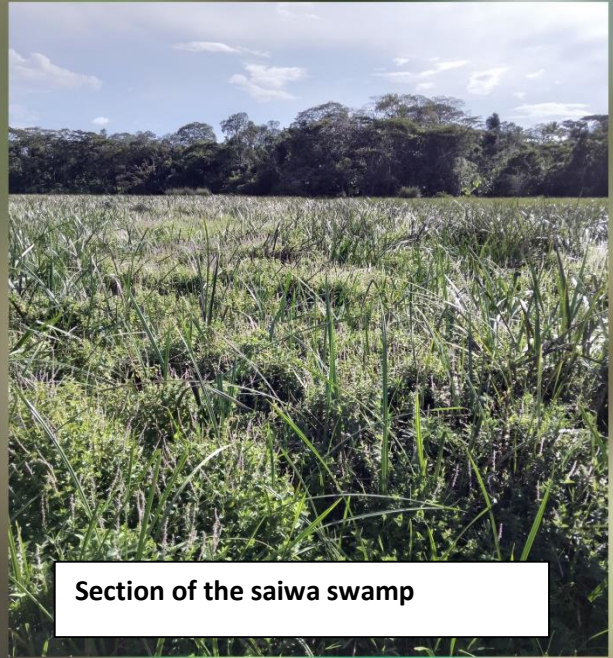


Female Sitatunga antelope

Appendix 5: additional field photographs



Researcher interviewing a community member



Section of the saiwa swamp



Grassland surrounded by forested area



A female Sitatunga antelope grazing

Appendix 6: Ethical clearance

EGERTON

IVERSITY

TEL: (051) 2217808

P. O. BOX



536 FAX: 051-2217942 EGERTON

EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS REVIEW COMMITTEE

EU/RE/DIR/009

Approval No. EUISERC/APP/286/2023

25th October 2023

Millicent Anyango Owiti

P.O. Box 536-20115

Egerton

Telephone: +254711432884

E-mail: millienyango@gmail.com

Dear Millicent,

RE: ETHICAL APPROVAL: AN ASSESSMENT OF HABITAT CHANGE EFFECT ON THE SITATUNGA ANTELOPE (*TRAGELAPHUS SPEKII*) POPULATION IN SAIWA WETLAND, TRANS-NZIOIA COUNTY, KENYA

This is to inform you that the ***Egerton University Institutional Scientific and Ethics Review Committee*** has reviewed and approved your above research proposal. Your application approval number is ***EUISERC/APP/286/2023***. The approval period is ***25th October, 2023 –26th October, 2024***

This approval is subject to compliance with the following requirements;

- i. Only approved documents including (informed consents, study instruments, MTA) will be used.
- ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***Egerton University Institutional Scientific and Ethics Review Committee***.
- iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours of notification
- iv. Any changes, anticipated or otherwise that may increase the risks or affect safety or welfare of study participants and others or affect the integrity of the research must be reported to ***Egerton University Institutional Scientific and Ethics Review Committee*** within 72 hours.

- v. Clearance for Material Transfer of biological specimens must be obtained from relevant institutions.
- vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

“Transforming Lives through Quality Education”

- vii. Submission of an executive summary report within 90 days upon completion of the study to **Egerton University Institutional Scientific and Ethics Review Committee.**

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) <https://oris.nacosti.go.ke> and also obtain other clearances needed.

Yours sincerely,



Prof. Raphael M. Ngure

**CHAIRMAN, EGERTON UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICS
REVIEW CTTEE**

RMN/BK/



“Transforming Lives through Quality Education”

Appendix 7: Wildlife research permit



Ref: WRT1/Conf. 713.1

26th September 2023

Millicent Anyango Owiti,

Egerton University-
Njoro, P.O. Box 536-
20115, Egerton-Njoro

Email: millienyango@gmail.com

Dear Millicent,

Research Permit No. WRT1-0336-07-23

We acknowledge your application for a permit to conduct your M.Sc. research approved at the Egerton University Njoro in Kenya titled An Assessment of Habitat Change Effect on the Sitatunga Antelope (*Tragelaphus Spekii*) Population in Saiwa Wetland, Trans-Nzoia County, Kenya. You are granted a permit to conduct the research in Saiwa Wetland, Trans-Nzoia County from September 2023 to August 2024 upon payment of the WRTI permit fee of Kshs 6,000.

You shall prepare and submit executed Prior Informed consent (PIC) and Mutually Agreed Terms (MAT) within 3 months from the date of issue of this permit. You shall comply with the Kenya Wildlife Service (KWS) guidelines on research within and outside protected areas. Before commencing your fieldwork, you obtain NACOSTI license and discuss your research workplan

with KWS Senior Assistant Directors for the Western Conservation Area (WCA) in your study areas and the WRTI Principal Scientist, Inland waters and wetlands ecosystems.

You will submit a copy of the final report of your research findings to the undersigned.

Yours Sincere/y,



DR. PATRICK OMONDI, OGW
DIRECTOR/CEO

Copy to: KWS Director, *Wildlife and Community Service
 KWS Senior Assistant Director WCA
 WRTI Principal Scientist, Inland waters and Wetlands Ecosystem.

Appendix 8: NACOSTI permit

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 775085	Date of Issue: 24/January/2024
RESEARCH LICENSE	
	
This is to Certify that Miss. Millicent Anyango Owiti of Egerton University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Transzoia on the topic: An assessment of habitat change effect on the Sitatunga antelope (tragelaphus spekii) in Saiwa wetland, Trans-Nzoia county, Kenya for the period ending : 24/January/2025.	
License No: NACOSTLP/24/32480	
775085 Applicant Identification Number	 Director General NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
	Verification QR Code 
NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.	
See overleaf for conditions	

Appendix 9: publication

(RESEARCH ARTICLE)



Land use land cover change and its potential implications on conservation of Sitatunga antelope in Saiwa wetland, western Kenya

Millicent Anyango Owiti *, Maurice Ongong'a Ogoma and Grace Wanjiru Kibue

Department of Natural Resources, Egerton University, P.O. Box 536-20115, Egerton, Kenya.

Open Access Research Journal of Science and Technology, 2024, 11(02), 001-012

Publication history: Received on 21 May 2024; revised on 30 June 2024; accepted on 03 July 2024

Article DOI: <https://doi.org/10.53022/oarjst.2024.11.2.0084>

Abstract

Land use and land cover (LULC) changes are significant drivers of global environmental change, impacting ecosystem processes, biological cycles, and biodiversity. This study aimed to describe the LULC changes in Saiwa Wetland from 1993 to 2023 and discuss their potential impacts on the rare Sitatunga antelope. We utilized remote sensing and GIS technologies, downloading cloud-free Landsat images from the USGS website, including Landsat TM, ETM+, OLI, and Sentinel images. These images underwent supervised and unsupervised classification to identify spectral signatures of various LULC classes. Post-classification refinement and a multi-date post-classification comparison algorithm using QGIS were employed for change detection. The analysis identified five LULC classes: forested areas, reeds/papyrus, grass/shrub areas, bare areas, and water areas. Results indicated a decrease in forested areas from 37% in 1993 to 34% in 2023 and a reduction in grass/shrub areas from 19% to 16%. Conversely, reeds/papyrus increased from 24% to 26%, and bare areas increased from 6% to 8%. Water areas also saw an increase from 13% to 16%. These changes are attributed to human activities such as logging, mining, and agricultural encroachment, along with climatic changes. We envisage that the LULC changes could have effects on the habitats of Sitatunga antelope whose population has declined dramatically from 200 individuals in 2018 to 60 in 2021 in the Saiwa wetland ecosystem. Immediate conservation and restoration measures are essential to preserve the integrity of the Saiwa wetland ecosystem and its associated biodiversity.

Keywords: Land use land cover; Geographic information system; Remote sensing; Saiwa wetland; Sitatunga antelope