SOCIOECONOMIC AND ECOLOGICAL OUTCOMES OF COMMUNITY CONSERVANCIES: A CASE STUDY OF NAIBUNGA COMMUNITY CONSERVANCY IN LAIKIPIA COUNTY, KENYA.

KEN OGAO OBURAH

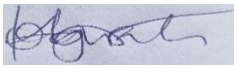
A Thesis Submitted to the Graduate School in Partial Fulfilment of the Requirement for the Master of Science Degree in Natural Resources Management of Egerton University

EGERTON UNIVERSITY
NOVEMBER 2022

DECLARATION AND RECOMMENDATION

Declaration

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

Signature:  Date: 02/11/2022

Ken Ogao Oburah

NM11/12122/17

Recommendation

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

Signature:  Date: 08 /11/2022

Wilfred O. Odadi, PhD

Department of Natural Resources,

Egerton University

Signature:  Date: 02/11/2022

Clement Lenachuru, PhD

Department of Natural Resources,

Egerton University

COPYRIGHT

DEDICATION

I dedicate this work to my mum Monica Akinyi Ndeda my siblings and all others who played a part in making this journey a success.

ACKNOWLEDGEMENTS

I am grateful to God for the gift of life and good health throughout my studies. Secondly, I would also like to thank the University for giving me a chance to further my studies. The supportive environment, kind staff, readily available learning facilities, and shrewd planning that enabled me to pursue my studies with minimal disruptions. I am forever grateful to my family. My Mum, Monica Akinyi Ndeda, has been with me through all hurdles. She gave me a reason to keep going on despite the overwhelming feeling of despair during this journey. I am truly indebted to my supervisors, who worked tirelessly and professionally to see me through this journey. Big thanks to Dr Wilfred Odadi for his invaluable contribution through his big ideas, reviews, comments, and edits. Dr Odadi's financial support through his **Future Leaders – Africa Independent Research (FLAIR) Fellowship Grant** was a game-changer for me. I cannot thank him enough. Dr Clement Lenachuru's wise counsel and time dedicated to my work cannot go unnoticed. Dr Bernard Kirui too. His first thought of me when an opportunity for financial support came through brought life to my academic journey. My fellow students have also been supportive. Through their company, advice and emotional support, I was kept going when things appeared to have hit a dead end. I am forever grateful to them. All those who played one part or the other in making my study a success, be assured that I will forever be grateful to you all.

ABSTRACT

The community conservancy model is regarded as an important approach for reducing land degradation, bolstering wildlife conservation, and enhancing pastoral livelihoods. However, this model necessitates some trade-offs such as alteration of traditional livestock grazing management practices and increased costs of wildlife conservation to local pastoralists. Therefore, there is need to understand the socioeconomic and ecological implications of community conservancies in communal rangelands, if we are to better enhance the sustainability of such rangelands. This study evaluated the socioeconomic and ecological outcomes of the community conservancy model in Naibunga Community Conservancy in northern Kenya. Specifically, the study assessed the level of pastoralists' involvement in conservancy conservation and management activities, their perceptions of conservancy-driven socio-economic impacts, and the conservancy's effects on vegetation, livestock and wild ungulate numbers. Regression analyses were performed on Normalized Difference Vegetation Index (NDVI) collected from Landsat 4, 5 and 7 for the periods before (1989-2003) and after (2006-2020) conservancy establishment. The analysis was also performed on wild ungulate and livestock population data obtained from the Directorate of Remote Sensing and Resource Survey (DRSRS) for the same period. Data collected from 19 experimental plots measuring 30 m x 30 m were also analysed for vegetation species diversity and composition. Descriptive statistics were used to summarise quantitative data and chi-square analyses used to test for association between categorical socioeconomic variables. Qualitative data were analysed thematically. Over 75% of respondents indicated that they were involved in conservancy management and conservation activities. Large proportions (65–90%) of respondents perceived conservancy-related improvements in their overall socioeconomic status. Involvement was positively associated with perceived socioeconomic improvements ($\chi^2 = 83.5$, $p < 0.01$). On the other hand, NDVI significantly declined before and assumed a significantly positive trend after conservancy establishment ($p<0.05$). Wild ungulates showed significant temporal trends before and not after ($p=0.033$) while livestock showed non-significant temporal trends before and after conservancy establishment ($p>0.076$). Based on these findings, the community conservancy model appears to have beneficial socioeconomic and ecological outcomes. These benefits can be enhanced by upscaling community-based conservancies across pastoral rangelands.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF ABBREVIATIONS AND ACRONYMS

ANN	Artificial Neutral Network
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVHRR	Advanced Very High-Resolution Radiometer
CBC	Community-Based Conservation
CBD	Convention on Biological Diversity
CITES	Convention on International Trade in Endangered Species
CORE	Conservation of Resources through Enterprise
DNDVI	Difference in Normalised Difference of Vegetation Index
DRSRS	Department of Remote Sensing and Resource Survey
ENVI	Environment for Visualizing Images
ETM+	Enhanced Thematic Mapper
FAO	Food and Agricultural Organization
GEE	Google Earth Engine
GPS	Global Positioning System
GoK	Government of Kenya
IUCN	International Union for Conservation of Nature
KWCA	Kenya Wildlife Conservancy Association
KWS	Kenya Wildlife Service
LED	Light Emitting Diode
LTM	Livestock To Market
MIKE	Monitoring Illegal Killing of Elephants
MNF	Minimum Noise Fraction
MODIS	Moderate Resolution Imaging Spectroradiometer
MSS	Multi-Spectral Scanner
NDVI	Normalised Difference of Vegetation Index
NIR	Near Infrared
NPS	National Police Service
NRT	Northern Rangeland Trust
OECD	Organisation for Economic Co-operation and Development
PAs	Protected Areas
SACCO	Savings and Credit Cooperatives
SDG	Sustainable Development Goals

SLC	Scan-Line Corrector
STM	State-and-Transition Model
SWIR	Short Wave Infrared
TLU	Total livestock Unit
TM	Thematic Mapper
UNCCD	United Nations Convention to Combat Desertification
UNEP	United Nations Environmental Programme
USAID	United States Agency for International Development

CHAPTER ONE

INTRODUCTION

1.1. Background Information

For a very long time, the establishment of protected areas (PAs) has been widely recognized as the most important approach to achieving conservation and sustainable development all over the world (Du *et al*., 2015). In Africa, PAs, most of which are state-owned, have served as the main conservation tool and remain the fundamental building blocks of biodiversity conservation (African Wildlife Foundation, 2016). They protect a diversity of ecosystems, provide key habitats for wildlife, and support vital ecosystem services upon which wildlife and people depend (Dudley, 2008). In 1992, the Convention on Biological Diversity (CBD) called on nations to establish protected areas in locations rich in biodiversity, particularly those requiring special conservation interventions (Jones, 2015; Kenya Wildlife Conservancy Association, 2016). As a result, the total protected-area coverage in Africa increased by nearly two-fold to encompass over 3.06 million square kilometres of terrestrial and marine habitats by the year 2016 (African Wildlife Foundation, 2016). These areas include national parks, national reserves, biosphere reserves, and national monuments.

Despite the increase in PAs, many of the world's wild plant and animal species still do not have viable resident populations in protected areas, and a substantial proportion remains domiciled outside protected areas (Dudley, 2008; Fynn & Bonyongo, 2011). This is partly attributed to the poor management of many PAs due to limited capacity (knowledge, space) and human and financial resources (Western *et al*., 2009). In addition, many PAs are too small and highly isolated to support viable populations of certain species, ecosystem dynamics, natural processes, biodiversity, genetic exchange, and wildlife movement (Krug, 2001; Fynn & Bonyongo, 2011). The small sizes of the PAs have also led to most wildlife populations being dispersed outside these PAs, which has led to a decline in their numbers (Krug, 2001). In East Africa, for example, an estimated 70% of wildlife populations are dispersed outside PAs, mostly on community and private lands (Mureithi *et al*., 2019; Western *et al*., 2009; Western & Gichohi, 1993). As such, there is overwhelming international and national support for the engagement of communities and landowners who live with wildlife or close to wildlife areas in efforts to sustainably conserve biodiversity and support community livelihoods (Carter *et al*., 2008; Jones, 2015). This has encompassed the involvement of local communities in conservation as an alternative conservation approach in

recognition of the costs the communities neighbouring state-owned PAs suffer (African Wildlife Foundation, 2016; Georgiadis, 2010).

The establishment of conservancies has been gaining prominence as a panacea for socio-economic and ecological problems facing many rangelands in Kenya and other parts of Africa (Carter *et al*., 2008; Gadd, 2005). Key to this effort has been the community conservancy approach, which has been regarded as an effective tool for conservation of wildlife outside protected areas and an effective way to engage private landowners and communities within the varied contexts (Brian, 2015; African Wildlife Foundation, 2016). In addition, the engagement over time has encompassed the involvement of local communities in conservation (community-based conservation) as an alternative approach to wildlife conservation in recognition of the costs the communities living with wildlife suffer (African Wildlife Foundation, 2016; Georgiadis, 2010). Consequently, many East African rangeland ecosystems are being transformed into community conservancies where pastoralism and biodiversity conservation are jointly pursued through collaborative, decentralised arrangements for managing communal lands and natural resources (Kimiti *et al*., 2017).

Community conservancies complement state-owned protected areas by providing additional wildlife habitat (Kenya Wildlife Conservancy Association, 2016). The conservancies are believed to act as a catalyst for wildlife conservation, environmental rehabilitation, resource conflict resolution and sustainable enterprise development for local communities (Mureithi *et al*., 2019; Suich, 2013). They also diversify land management, providing a range of habitat types to support a broader diversity of wildlife and ecosystems apart from providing platforms for direct community engagement and empowerment in taking part in and benefiting from conservation (Fynn & Bonyongo, 2011). In Kenya, for example, a community conservancy typically has a natural resource management plan that encompasses participatory land zoning designating zones for core conservation, livestock grazing and settlement (Mureithi *et al*., 2019). In addition, such conservancies typically implement sustainable land and grazing management practices such as community-based planned rotational grazing and rangeland restoration initiatives (Kimiti *et al*., 2017; Odadi *et al*., 2017). Many such conservancies have been established in many parts of Kenya. For example, in northern Kenya, many community conservancies have been established through the collaborative efforts between the Northern Rangelands Trust (NRT), an umbrella organization for community conservancies in the region, and communal group ranches (Northern Rangeland Trust, 2017).

Naibunga community conservancy is one good example of the community conservancies in northern Kenya. The conservancy, formed in 2003, comprises nine group ranches namely, Koija, Ilmotiok, Kijabe, Musul, Tiamamut, Munishoi, Ilpolei, Nkiroliti and Murupusi (Northern Rangeland Trust, 2017). Under the umbrella of the Northern rangeland trust, the conservancy implements a raft of ecological conservation and management activities geared towards enhancing the ecological integrity such as grazing management, waterpan establishment and management, invasive species control among others. In addition, the NRT assists the conservancy in enhancing community livelihoods through, for example, employing the local youths as rangers, introducing alternative livelihood sources such as beading for women, motorbike loans for youth groups apart from searching markets for community livestock (Kenya Wildlife Conservancy Association, 2016; Northern Rangeland Trust, 2017).

However, there has been concern that a number of the management practices carried out under the conservancy setting are generally in conflict with traditional pastoralism and associated resource use and governance practices (Lobo, 2016). Specifically, under the community conservancy management approach, pastoralists have to make trade-offs of their traditional practices to embrace land and grazing management practices that incorporate wildlife conservation and wildlife-based tourism (Bersaglio & Cleaver, 2020). For instance, livestock owners often complain of reduced grazing areas available to their livestock due to restricted access to certain areas (Bedelian & Ogutu, 2017). Additionally, pastoralists have had to contend with heightened human-wildlife conflicts in various forms, including increased livestock depredation by large carnivores and injuries to humans inflicted by wildlife, crop-raiding by wild herbivores, competition for pasture and water, and transmission of zoonotic diseases (Thirgood *et al*., 2005). In some instances, pastoralists are forced to enter into negotiated arrangements for access to grazing areas with private ranches at a fee (Mureithi *et al*., 2019). Despite these concerns, the impacts of community conservancies on the livelihoods of the local pastoral communities are not clearly understood. In addition, there is a paucity of scientific information on the impacts of land management practices of these conservancies on vegetation dynamics, wildlife and livestock populations. Such information is required for improved adaptive and sustainable management of communal pastoral rangelands.

1.2. Statement of the problem

Kenya's communal rangelands are vital for biodiversity conservation, livestock production, and pastoral communities' livelihoods. However, many of these rangelands continue to be under increasing threat from land degradation. Biodiversity diversity is on the decline, and livelihood sources of the local community impacted negatively. Whereas establishing community-based conservancies has been touted as a panacea for land degradation and associated ecological and socio-economic problems in these rangelands, the conservancies often introduce land management and conservation approaches that deviate from traditional governance structures and pastoral land and grazing management practices. Approaches such as land zoning, controlled stocking and introduced wildlife management and wildlife-based tourism in pastoral landscapes have led to reduced livestock mobility, heightened livestock-wildlife conflicts and reduced livestock stocking rate apart from pastoralists being forced to negotiate at a fee with private ranches for alternative grazing areas. This often raises concerns regarding the socio-ecological efficacy of the community conservancy approach in achieving its intended outcomes. As such, community conservancies potentially have significant ecological and socio-economic implications for local pastoralists. However, such implications have rarely been quantified scientifically. This study sought to address some of these concerns through scientific evaluation of the ecological and socio-economic impacts of the community conservancy model as implemented in communal pastoral rangelands in northern Kenya.

1.3. Objectives

1.3.1. Broad objective

To assess the socioeconomic and ecological impacts of the community conservancy model in communal rangelands of Kenya in order to contribute towards their sustainable management.

1.3.2. Specific objectives

i. To assess the level of community involvement in conservation and land management practices under the community conservancy setting.
ii. To evaluate the local community members' perception of socioeconomic outcomes of the community conservancy approach
iii. To assess the association between community members' involvement in conservancy management and their perception of socioeconomic outcomes of the conservancy.

iv. To assess the current vegetation species diversity and composition status of the community conservancy

v. To assess the effects of community conservancy on temporal trends of normalised difference vegetation index (NDVI; proxy for productivity).

vi. To assess the effects of the community conservancy approach on temporal trends in livestock and wild ungulate numbers.

1.4. Research questions

i. To what extent are local community members involved in conservancy management and conservation activities?

ii. What are the local community members' perceptions of conservancy-driven socioeconomic outcomes?

iii. How does community members' involvement in conservancy's conservation and management activities affect their perception of the socioeconomic outcomes of the conservancy?

iv. What is the current status of vegetation species diversity and composition?

v. How has the community conservancy approach influenced vegetation productivity as proxied by NDVI?

vi. How has the community conservancy approach affected livestock and wild ungulate numbers trends?

1.5. Justification

Kenya's development blueprints Vision 2030 and United Nations' sustainable development goals (SDG 15) aim to enhance the socio-economic well-being of Kenyans and reduce human impacts on the environment. Rangelands make up more than 80% of Kenya's landmass and support the livelihoods of millions of people through ranching, pastoralism, and wildlife-based ecotourism. Therefore, sustainable management of these rangelands is paramount if Kenya is to achieve her development aspirations. Community conservancies have been proposed as a tool for enhancing ecosystem services, bolstering wildlife conservation and increasing pastoral livelihoods in these rangelands. However, enhancing community conservancies' effectiveness and social acceptability requires scientific knowledge on their ecological and socio-economic impacts. By evaluating these impacts, this study will contribute towards improved management of community-based conservancies and sustainable management of Kenya's communal pastoral rangelands. Improved management of conservancies is vital for enhancing biodiversity conservation and pastoral livelihoods.

Specifically, this study's findings will be valuable to pastoral communities, county and national governments, conservationists, and other development agencies in formulating evidence-based strategies, policies, and programmes to enhance sustainable management of Kenya's communal pastoral rangelands. Specific recommendations will be put forth targeting conservation activities and strategies that should be adopted to enhance the effectiveness of the community conservancy model in achieving its intended outcomes.

1.6. Scope and limitation of the study

1.6.1. Scope

The study was temporally limited to 30 years, i.e., from 1989 to 2021. The study's spatial extent was limited to the area covered by the Naibunga Community Conservancy. Ecological assessments mainly captured current vegetation diversity and composition while socioeconomic assessments were limited to socioeconomic indicators derived from the World Bank Poverty Framework (World Bank, 2001). The main indicators used were the household income amounts, the security situation, accessibility to amenities such as schools, health facilities and water. Change in livestock numbers was also used as an additional indicator of socioeconomic change.

1.6.2. Limitation

During the study, several limitations were encountered. They included but not limited to uncooperative, dishonest and absent respondents. Poor quality, missing and irrelevant or inappropriate satellite images due to flight line issues and errors due to faulty Landsat 7 scanline corrector (SLC) were also encountered. Finding wild ungulate and livestock data was also difficult as data on specific wild ungulates such as elephants were missing for several survey periods. In addition, rough terrain and inaccessibility of some sites hindered ground-truthing activities. However, the study overcame most of these limitations and they did not have a significant effect on the study's results. For example, defective Landsat 7 imageries were gap-filled, cloud masked after a careful selection of high-quality imageries. In addition, it was expected that most of the respondent-related limitations would have minimal effects on the validity of the study findings as the sample size of respondents who participated in the study was large.

1.7. Assumptions

This study was conducted based on the following assumptions;

i) That the ecological impacts of the community conservancy are reflected by the changes observed on NDVI, wild ungulates and livestock trends overtime.

ii) That local community perception of the changes in the socioeconomic aspects assessed were a true reflection of the socioeconomic impacts of the conservancy described as either positive, negative or unchanged

iii) The perceived outcomes reported by the respondents satisfactorily represented and were as a result of the direct and indirect impacts of the community conservancy's conservation and management activities.

1.8. Definition of terms

Conservancy – Land set aside by individual landowner, body corporate, group of owners or a community for purposes of wildlife conservation and livestock rearing

Community/Communal conservancy – It is a community-based organisation created to support the management of community-owned land to improve biodiversity conservation, land management practices and community livelihoods**.**

Group ranch – A livestock production system where a group of people jointly hold title to land, maintain agreed herd sizes, and own livestock individually but herd them together.

Land use and land management practices – The different uses a piece of land is utilized for, and the Management practices applied during utilization.

Large wild herbivores – Includes ungulates such as elephants, giraffes, rhinos, zebras, antelopes, among others

Planned grazing – Is an organized kind of grazing where plants are provided enough time to recover after a grazing period while maintaining animal performance and moving toward desired long-term land productivity goals during the grazing season.

Ranch – Is an area of land, including various structures, set aside primarily for the practice of raising grazing livestock such as cattle and sheep.

Rangelands – Grasslands, shrub lands, and woodlands used as grazing land for both livestock and wildlife

Savanna – An open woody canopy with a continuous layer of herbaceous vegetation.

Socioeconomic aspects – Main aspects whose interaction has an effect on the general socioeconomic wellbeing of a community

Vegetation composition – Refers to all plant species found in a stand or landscape, including trees, shrubs, forbs, and grasses.

Vegetation dynamics – Spatial and temporal changes of vegetation cover and composition

Vegetation spatial changes – Refers to vegetation changes occurring in space, that it, changes exhibited by vegetation from one place to the other

Vegetation temporal changes – Refers to vegetation changes occurring over time

Vegetation structure – Refers to the physical arrangement of vegetation either vertically (crown heights) or horizontally (altitudinal arrangement) in a forest, woodland or savannah ecosystem.

CHAPTER TWO

LITERATURE REVIEW

2.1. Conceptualisation of conservancies as a conservation tool and a land-use system

According to International Union for the Conservation of Nature (IUCN), conservancies are protected areas with clearly defined geographical space recognized, dedicated and managed, through legal or other effective means to achieve the long-term conservation of nature with associated ecosystem services and cultural value (Kenya Wildlife Conservancy Association, 2016). Protected areas are the main tool of conservation in Africa and remain the fundamental building blocks of biodiversity conservation (African Wildlife Foundation, 2016). They protect a diversity of ecosystems, provide key habitats and safe havens for wildlife, and support vital ecosystem services upon which wildlife and people depend. The number of conservancies across the world is on the increase. In Namibia, for example, approximately 16 per cent of the country is in community conservancies (African Wildlife Foundation, 2016).

Kenya's Wildlife Conservation and Management Act 2013 defines a conservancy as land set aside by individual landowners, body corporate, groups of owners, or a community for purposes of wildlife conservation (GoK, 2013). The Act recognises community conservancies as basic units of conservation at a grass root level and legally defines conservancies as a form of land-use (King *et al*., 2015). According to KWS (2015), any person or community who owns the land on which wildlife inhabits may individually or collectively establish a wildlife conservancy. As such, many conservancies continue to be established in various parts of Kenya in recognition of the role of community and private protected areas in the conservation of wildlife and the natural environment (King *et al*., 2015). The conservancies also are increasingly being recognized as institutions, which are registered legal entities, for conservation, and Community land management (Kenya Wildlife Conservancy Association, 2016).

Community conservation began in the late 1970s as purely Park Outreach strategies that sought to enhance the biological integrity of national parks, reserves by working to educate and benefit local communities and enhance the role of protected areas in local plans (Barrow & Murphree, 2001). The strategy was first tried out in the wildlife dispersal areas of Amboseli National Park in 1974-1976, aimed at allowing the Maasai pastoralists who lived in the area to benefit from park fees from the newly commissioned park (Kantai, 2012).

Community conservation was entirely a state-led and administered prototype, with benefits-oriented more to the wider Kenyan economy than to the communities surrounding national parks (Kantai, 2012). The local community around the parks were only compensated for their land loss and provided with alternative sources of water for their livestock (Western, 1982)

In the early 1990s, the Kenya Wildlife Service introduced the Community Wildlife Service that aimed at minimizing human-wildlife conflict while enabling local people to benefit from adjacent protected areas (Barrow & Murphree, 2001). As a result, Kenya saw an increase in community conservation initiatives at a national level that saw a growth in the number of conservancies of various categorizations defined as private protected areas (Barrow & Murphree, 2001; Kantai, 2012). The private protected areas included group ranches, private ranches, and state-owned but community-managed land (Carter *et al*., 2008). Since then, Kenya continued to witness a new breed of conservation, firmly based on communal lands. The process of forming these community conservancies and their mode of operation evolved in the absence of a legal framework (Barrow & Murphree, 2001). Umbrella bodies encompassing several conservancies within one area spearheaded the formation process. For example, in the Northern part of Kenya, conservancies have been established under the leadership of regional conservation groups such as Northern Rangeland Trust (NRT) (Kantai, 2012). Il Ngwesi, Lekurukki, and Namunyak became the first such conservancies to be set in northern Kenya between 1996 and 1999 (Mureithi *et al*., 2019).

It was until early 2014, when Kenya's new Wildlife Act 2013 came into effect, that Community Conservancies were legally recognized as a form of land-use. Further regulations governing the conservation and management of conservancies and sanctuaries were developed in 2015 (King *et al*., 2015). These legislations have seen formalization of conservancies to the extent of conservancies increasingly being recognized as registered legal entities for conservation, land management and Community development, providing a foundation for economic growth in rural areas (King *et al*., 2015; KWCA, 2016). Today, conservancies continue to increase in Kenya. By 2018, 39 Community Conservancies covering 42,300 square kilometres of land had been established in the rangelands of Northern Kenya alone (Northern Rangeland Trust, 2019), which contain the world's vast grazing lands. As such, nomadic pastoral communities primarily utilize them for various traditional livestock production systems. In addition, the ecosystems support a significant portion of the continent's wildlife (Georgiadis *et al*., 2007; Sankaran *et al*., 2005).

2.2. Land management approaches in conservancies and Kenya's rangelands

Globally, conservancies have gained prominence as a sustainable approach in managing the vulnerable world's savanna rangeland ecosystems. In Africa, savanna rangeland ecosystems constitute 43% of the land area and support approximately 45% of its population. As such, the ecosystem is subjected to overutilization and, consequently, degradation (Gadd, 2005; Nyberg *et al*., 2015). Various land management and restoration programmes have been ongoing to address the degradation. Multiple management practices characterize rangeland savannas. The land management practices vary in intensity and extent and are implemented depending on the specific objectives of the landowner (Liniger & Studer, 2019). An ecosystem or landscape approach dominates most conservation strategies, aspiring to integrate the use and management of natural resources in sustainable ways across spatial scales that better match the historical extents of natural ecosystem processes (Pirot *et al*., 2000). In Laikipia, for example, there is the clearing of the undesirable species of *Acacia reficiens*. *A*fterwards, the cleared area is reseeded with *Cenchrus ciliaris*, a perennial bunched grass that has been successful in reseeding trials in other parts of Kenya (Kimiti *et al*., 2017; Nyberg *et al*., 2015). *C. ciliaris* has been used for reseeding on East African rangelands since the 1960s and is one of the three most common species for reseeding in Kenya alongside *Eragrostis superba* and *Enteropogon macrostachyus* (Liniger & Studer, 2019; Mganga *et al*., 2015; Mureithi *et al*., 2014).

In addition, there is also *Opuntia stricta* control being carried out through manual labour and time-intensive mechanical and chemical interventions. The chemical intervention involves the application of herbicides and manual uprooting as the mechanical intervention (Kinyua *et al*., 2010; Mganga *et al*., 2015). For example, attempt to control *Sanseviera intamida* mechanically from rehabilitated sites in Tiamamut Community Ranch by uprooting, heaping to dry or dumping in deep gullies have been going on with some success. *Acacia mellifera* and *A. reficiens* are controlled through de-branching and cutting branches to erect fences around enclosures (Mureithi *et al*., 2019). Both strategies have shown some initial promise (Kimiti *et al*., 2017). However, herbicides are expensive, and their effect on wildlife has not been clearly tested. Additionally, mechanical uprooting is labour and time-intensive and is not realistic for properties whose management cannot afford to purchase or hire the equipment required (Kimiti *et al*., 2017). A cochineal insect that acts as a predator to *O. stricta* in its native range, *Dactylopius opuntiae*, was also introduced to Laikipia (Kimiti *et al*., 2017).

There is also the use of mobile cattle enclosures, commonly referred to as 'bomas.' Bomas have demonstrated the ability to create vegetated patches in degraded areas (Veblen & Porensky, 2019). Bomas modify the soil surface texture and add nutrients into the soil, creating fertile patches that are frequently colonized by species of the Cynodon genus (Veblen & Porensky, 2019). Grazing system plans and drought preparedness have been critical for the effective management of mixed-use properties; this has been more important, especially for community conservancies that rely on both livestock production and wildlife management as a subsistence livelihood system (Kimiti *et al*., 2017; Kinnaird & O'Brien, 2012). For example, private landowners and community members sharing group ranch land manage livestock freely according to their own needs. Most ranch owners manage livestock with traditional herding methods (Kinnaird & O'brien, 2012) with varying stocking rates, while some landowners of private ranches are involved in implementing, maintaining, and monitoring their lands via specific rangeland management programmes. However, despite the need for grazing system plans, other ranches have expressed less interest in these formal programmes (Yurco, 2017). Studies show stocking levels on group ranches are high, typically >25 total livestock units (TLU) per $km^{2,}$ while that of conservancies, which are managed for livestock, wildlife, and tourism or research, stocking rate is moderate (10–20 TLU/km^2) (Kinnaird & O'brien, 2012).

2.3. Ecological and socio-economic impacts of communal conservancies and communal land management approaches

Savanna rangeland ecosystems are of global importance as they deliver multiple ecosystem goods and services (Sala & Maestre, 2014). Tropical savanna, in particular, is socio-economically important to humans (Sankaran *et al*., 2005). Ecologically, savanna ecosystems within communal conservancies provide dispersal areas for wildlife around National Parks and Reserves, increasing habitat available to wildlife; they keep critical wildlife corridors intact and provide space and protection for the recovery of critically endangered species (Mureithi *et al*., 2019). The ecosystems also host large wildlife and livestock populations, and thus, it supports the livelihoods of millions of people (Axelsson, 2018; Georgiadis *et al*., 2007; Sankaran *et al*., 2005). They also preserve a wide range of endemic species (Kanniah & Beringer, 2017), which are of great ecological importance. For example, the diverse endemic floras and faunas, including charismatic megafauna, are central to wildlife tourism and hunting, contributing hundreds of millions of dollars to African economies (Osborne *et al*., 2018).

However, unsustainable and competing land-use practices such as overstocking and therefore overgrazing, dryland agriculture, deforestation, and unmanaged sand and stone harvesting, charcoal production and unplanned human settlement have a negative impact on conservancies' savanna ecosystems (Mureithi *et al*., 2019). As such, there is consistent evidence of change in species composition along grazing gradients in these conservancies. This is despite the conservancies being established across the world's tropical rangelands to address the problem of habitat, biodiversity, and livelihoods loss in the livestock-wildlife interface environments (Williams *et al*., 2017). For example, the use of mobile cattle enclosures commonly referred to as 'bomas' have created patches of modified and distinct vegetation types. This is because of the continuous, long-term grazing that characterizes this approach.

According to Kinyua *et al.* (2010), overgrazing leads to land degradation through vegetation composition shifts, reduced primary productivity, which may be detrimental to palatable grass species recovery (Park *et al*., 2013). A reduction in tuft size often characterizes the changes, thus increasing bare ground cover and replacement of perennial grasses by annual grasses and other less palatable herbaceous vegetation (McGranahan *et al*., 2013). For example, there is a continuous increase of *Opuntia stricta* at the expense of native plants in Laikipia, Kenya (Tefera *et al*., 2007). Also, the most widespread invasive species in the conservancies such as *Acacia mellifera,* A. *reficiens, Opuntia spp. Datura sp., Propopsis juliflora, Sanseviera intamida* continue to undermine the quality and quantity of forage species (Moore *et al*., 2006). These invasive species suppress the growth of pasture grasses for livestock and wildlife. If ingested, *Datura sp.* and *Prosopis juliflora* have a poisoning effect on animals (Mureithi *et al*., 2019).

Socio-economically, savanna ecosystems within conservancies play a critical role in creating benefits to Communities and Landowners. The ecosystem provides a wide range of ecosystem goods and services ranging from fruits, meat and milk; wood, mainly timber and fuelwood, and recreational services (Sangha, 2006). Savanna ecosystem goods and services value exceeds $9 billion (Ryan *et al*., 2016). This is through commercial ranching, pastoral livestock keeping from which beef and milk are produced apart from being utilized for tourism purposes. These activities enable the local community to earn a living. Additionally, Conservancies create benefits to local communities and from wildlife, an important incentive that helps combat poaching. The conservancies also create local informer networks that are essential in the fight against other wildlife crimes (King *et al*., 2015). In particular,

conservancies have impacted lives through employment, peace, security, and tourism revenue. Critically, conservancies as a recognized land-use provide greater land-tenure security for private and community land (King *et al*., 2015). In addition, community and group conservancies promote social cohesion by creating a recognized and representative institution for stakeholders to make decisions about communal management of their land and resources (King *et al*., 2015).

2.4. Community involvement in land management practices

Community-based conservation is regarded as an institutional arrangement whose goals are to enhance human social well-being and sustain biodiversity (Galvin *et al*., 2018). It involves an arrangement encompassing governmental and non-governmental institutions, private individuals, and other local community participants (Galvin *et al*., 2018). In wildlife conservation, community involvement generally takes two forms; first, the people in and around wildlife protected areas participate in managing natural resources. Second, the management objectives are linked to local developmental needs (Jones, 2015). For example, in Kenya, community involvement has its origin from the United States Agency for International Development (USAID), funded Conservation of Resources through Enterprise (CORE) project in the early 1990s (Mureithi *et al*., 2019). Its goal was to improve benefits to communities and landowners in areas critical to parks and reserves and, in that way, achieve better conservation and management of natural resources (Mureithi *et al*., 2014, 2019).

According to the Constitution of Kenya 2010, local communities should access and derive benefits from natural resources through sustainable utilisation and equitable distribution of benefits (Odeck, 2011). As such, various laws have been enacted to actualize community participation in natural resource management; for example, the Wildlife Conservation and Management Act (2013). The Act recognises community conservancies as basic units of conservation at a grass root level (GoK, 2013). The Act further devolves wildlife management rights and tourism benefits to the rural communities that form a conservancy, empowering members to decide for themselves how to use the income they earn (Odeck, 2011). Other Acts that provide for community involvement in the daily management of the natural resources include the Land Act (2012), Forest Act (2005), National Forest policy of 2015, and Forests (Participation in Sustainable Forest Management) Rules (2009) (Kenya Forest Service, 2015)

2.5. Wildlife and Livestock Population Trends in Kenya's Rangeland

Wildlife and livestock population in the rangelands of Kenya have been extensively surveyed, analysed and determined since 1977. Analyses show livestock population has seen an increasing trend at the expense of the wildlife population, which has been on the decline (Ngene *et al*., 2017; Ogutu *et al*., 2016). Studies have associated the decline to human activities among other underlying causes. Data from the directorate of resource survey and remote sensing (DRSRS) on livestock and wildlife populations in the rangelands since 1977 revealed a decline in the wildlife population from the 1970s through to the 1990s (Ngene *et al*., 2017; Ottichilo *et al*., 2000). In the same period, the data show an increase in livestock populations. According to Ottichilo *et al.* (2000), the declining trend of wildlife population may be due to trade in wildlife trophies, weak land tenure policies and legislations. This necessitated the formation of wildlife conservation institutions such as KWS, the introduction of community-based wildlife programmes, and the formulation of national land-use policies as strategies to halt the declining wildlife populations in the Kenyan rangelands (Ottichilo *et al.*, 2000). Further, a monitoring programme was also established to gather ecological data.

In order to continue with the sustainable conservation of wildlife population, population monitoring as per the international standards and wildlife Act of 2013, Kenya has continuously been updating the status of its wildlife population through frequent surveys at least every five years (Litoroh *et al*, 2010). The survey in the Laikipia Samburu ecosystem, for example, shows a significant increase in the elephant population since 1992 (Litoroh *et al.,* 2010). A survey done in 2017 showed Laikipia Samburu ecosystem has an elephant population of approximately 7166, up from a population of 6365 in the year 2012 (Ngene *et al*., 2017). During the same period, the buffalo population were estimated to be at 4499, up from 4069 in 2012. Giraffes also increased to 4223, up from 2839 (Ngene *et al*., 2017).

On the other hand, livestock numbers have shown a varied trend. However, Ngene *et al.* (2017) reported that the Laikipia Samburu ecosystem had seen an increase in livestock since 2012. Ngene attributes this increase to a 2017 drought-driven influx of livestock into ranches. Further, Ngene notes that the livestock was widely distributed across the ecosystem as compared to their distribution in 2008. The 2017 survey by Ngene showed a clear separation of habitat use between wildlife and livestock in the entire surveyed Laikipia Samburu Meru Marsabit ecosystem, noting that wildlife, specifically; elephants, had been pushed out of the protected areas that surround Meru national parks. In general, the survey by Ngene found out that there were a total of 1,092,202 herds of livestock comprising of Cattle, shoats, donkeys,

and camels in the Laikipia-Samburu-Meru-Marsabit ecosystem. Of this population, 69% occurred in the Laikipia-Samburu ecosystem (Ngene *et al*., 2017).

2.6. Application of remote sensing in mapping vegetation temporal dynamics

Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times. It involves the application of multi-temporal datasets to analyse the temporal effects of a phenomenon quantitatively. Because of its nature of repetitive data acquisition, its synoptic view, and the digital format of its data suitable for computer processing, remotely sensed data has become the major data source for different change detection applications during the past decades (Lu *et al*., 2004). The basic premise in using remotely sensed data for change detection is that changes in the objects of interest will result in changes in reflectance values or local textures that are separable from changes caused by other factors such as differences in atmospheric conditions, illumination and viewing angles, and soil moistures (Deer, 1995). Change detection techniques are an active topic, and new techniques are constantly developed. The techniques include spectral mixture analysis, the Li–Strahler canopy model, Chi-square transformation, artificial neural networks (ANN), and multi-source data integration (Lu *et al.*, 2004).

Identifying a suitable change detection technique is of great significance in producing good quality change detection results. Before identifying and implementing certain techniques for cover change, certain aspects must be considered (Bhunia & Shit, 2013). For example, to successfully implement change detection analysis using remotely sensed data, careful considerations of the remote sensor system, environmental characteristics and image processing methods are required. The temporal, spatial, spectral and radiometric resolutions of remotely sensed data have a significant impact on the success of a remote sensing change detection project (Lu *et al.*, 2004). Also, multi-temporal image registration and radiometric and atmospheric corrections are important pre-processing requirements for cover change detection.

The image differencing of normalized difference vegetation index technique of classification (DNDVI) has widely been used with the many kinds of remote sensing data that are available for change detection applications. For example, Bhunia and Shit (2013) used the technique to explore the temporal changes in vegetation cover using the potential multi-temporal satellite data in Kangswati (Cossi) river and Dwarakeswar river interfluves area, West Bengal, with accuracies of 86.0%–92.0%. Historically, Landsat Multi-Spectral Scanner (MSS), TM, SPOT, AVHRR, radar and aerial photographs are the most common data sources, but new

sensors such as Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) are becoming important (Lu *et al*., 2004).

2.6.1. Supervised vs unsupervised image classification

Remote sensing image classification is a complex process involving many steps. They include the determination of a land cover classification system, collection of data sources, selection of a classification algorithm, extraction of thematic information, and accuracy assessment (Im & Jensen, 2008; Mallupattu *et al*., 2013). Supervised classification techniques require training a classification algorithm with reflectance data from known targets. The algorithm is then applied to the whole image to assign the pixels to classes. The classification accuracy has to be validated with samples independent of the training data, and it depends on the spectral separability of classes and the number of training samples (Bajwa & Kulkarni, 2011). Supervised classification methods can be useful and accurate, especially when certain, well-defined spectral classes have to be found from remotely sensed data. However, the availability of training and validation data is often a constraint.

On the other hand, unsupervised classification methods are an appealing alternative for image analysis, as they do not require previous knowledge of the image contents. Unsupervised classification methods are usually based on cluster analysis (Bajwa & Kulkarni, 2011). The analysis of the image to a cluster label level is referred to as object-based analysis. Object-based image analysis of high-resolution imagery has been successfully used for vegetation mapping, and such methods have obtained better classification results than with a traditional pixel-based classification for mapping invasive woody species (Hantson *et al*., 2012). Laliberte *et al*. (2004) used this method specifically for shrub encroachment mapping over time, while Smith *et al*. (2008) studied the process of juniper encroachment for 59 years.

2.7. Summary of knowledge gap

Few studies have examined the ecological implications of different forms of land use on ecological and socio-economic dynamics. There exist several reviews about various conservation approaches employed in the rangelands of northern Kenya. For example, Kinnaird and O'Brien (2012), investigated the effect of private land use on fauna species diversity. On the other hand, Mureithi *et al*. (2019) reviewed various literature on land use approaches in livestock wildlife interface within the northern Kenya. In addition, ecological

assessments at group ranch levels by Gregory-michelman (2017) and Mureithi *et al*. (2014) revealed varying results.

Whereas the studies appear to capture some aspects of conservancy model approach as one of the conservation strategies in this landscape, most of them rely on conventional evidences drawn from other landscapes across the world to highlight the importance of conservancy approach as a rangeland management tool. For example, Kinnaird and O'Brien (2012), solely focused on private land use approaches for management of rangelands and did not incorporate communal land management approaches under a conservancy setup. As such, the result of the study may necessarily not applicable in rangeland landscapes that utilizes communal conservancy approach. On the other hand, a review of the community-based approach and emerging land use by Mureithi *et al*. (2019) is entirely a review of existing literature as opposed to a scientific and experimental inquiry that incorporates both social and ecological survey processes. As such, evidence drawn thereof are hypothetical in nature that would require scientific validation process. For Gregory-michelman (2017) study using sub-metre-resolution satellite imagery to evaluate land-use change on four Kenyan group ranches with community-based conservation revealed significant changes in land use and settlement structure. However, the study mainly concentrated on the land cover changes due to settlement, an aspect of communal conservancy land management approach. As such, the study isolate a small component of a conservancy model producing such a biased result that cannot be referenced in a community conservancy model.

Another study by Mureithi *et al*. (2014) on the impacts of community-based conservation on the herbaceous layer and soil nutrients in Kenyan arid and semi-arid savanna found that the conservation approaches seemed to drive the semi-arid savannahs to exist in two steady states and transitions under the influence of grazing. However, the study's scope was group ranches as opposed to a conservancy set up. Since the governance structures, scope and the dynamics within a conservancy set up significantly differs from that of a group ranch level, the knowledge generated by this study does not adequately address conservation knowledge gaps posed by a community conservancy model. In addition, the studies did not assess the effects of such conservation practices on the socio-economic status of community members and on livestock numbers.

Under these circumstances, it is evident that there exists a significant knowledge gap, especially on the ecological and socio-economic implications of communal conservancy land use approach as a land management and conservation tool. This study, therefore, seeks to fill

this information gap by scientifically assessing both the ecological and socio-economic implications of the establishment of communal conservancies in the Laikipia-Samburu ecosystem using Naibunga conservancy as the representative study area. The information to be generated by the study will play an important role in helping establish frameworks for future assessments apart from contributing to the formulation of conservation policies that are in sync with the peculiar ecological and socioeconomic circumstances of rangeland landscapes in the northern part of Kenya and Africa.

Table 2.1. A summary of knowledge gaps

Authors	**Their findings**	**Knowledge gaps**
Kinnaird and O'Brien (2012)	Wild mammal species richness varied across the different types of private land use. Conservancies and sanctuaries had the highest species richness while fenced and group ranches had the lowest species richness	The study mainly focused on private land use mechanisms with special interest to wild mammals. There was therefore a need for an integrated study in a communal conservancy set up with a wider focus on wild ungulates, vegetation and socioeconomic aspects
Mureithi *et al*. (2019)	Significant increases in NDVI were reported by Oguge (2004), security improved due to NRT's integrated security networks among other observations	This is mainly a review of existing literature across various rangeland landscape across the world. Evidences derived lacks scientific validity and may be inapplicable or inappropriate to be applied in northern Kenya's peculiar rangeland landscape
Mureithi *et al*. (2014)	Conservation zones had significantly higher herbaceous diversity, species richness and relative abundance of both annual and perennial grasses, basal cover and herbage	This is an entirely ecological study at a group ranch level. There is a need for a study that incorporates both ecological and socioeconomic aspects at a conservancy level. In addition, evaluating local communities' perspective on impacts of the conservancy is important
Gregory-	There were significant	Uses satellite image to map land use change at

michelman (2017)	changes in structures and land modifications – non tourism and settlement structures increased significantly in all the studied ranches	a group ranch level as opposed to ecological changes. It specifically focused on settlement areas and therefore other ecological aspects within a conservancy set up is lacking. The study is based on a group ranch whose management approaches and operation significantly differs from that of a conservancy.

2.8. Theoretical framework

In applied rangeland science, the dominant question is how to manage grasslands for maximal long-term domestic livestock production without degrading the grassland to the extent that would make it unsuitable for further grazing. This requires a theoretical understanding of grasslands for an understanding of the reactions of grasslands to management. Westoby *et al*. (1989) explained that vegetation changes in the complex dynamics of arid and semi-arid ecosystems could be described in terms of discrete states and inter-state transitions in the State-and-Transition model (STM). STM is a theory explaining how ecosystems respond to disturbance. According to this model, for a determined system, there are different alternatives to vegetation states with different transitions between them. The transition into a different state is activated by a natural event such as abundant rain or extreme drought, by a disturbance and/or management action such as grazing, use of fire, or by the interaction of any of these factors (Heshmati & Mohebbi, 2013). The model is seen as a flexible way to organise information about ecosystem change and other concepts about ecosystem dynamics (Briske, 2017). The model links information about plant community composition with concepts of ecosystem dynamics to develop management plans aimed at long-term stewardship. For example, management practices such as altered herbivory intensity or even burning trigger changes in the range conditions via multiple pathways depending on the sequence of the driving factor that causes such changes. As such, the synthesis of the model can be used to develop predictions for how ecosystems respond to natural events and management actions (Bestelmeyer *et al*., 2017).

Further, STM promoted a broadened view of how vegetation can change (Westoby *et al*., 1989). This is to the extent that it is now widely acknowledged that vegetation change in response to grazing or weather variations may not occur along a single continuum but rather may produce multiple stable plant communities. It is also acknowledged that vegetation

change is not necessarily reversible and that the change can be discontinuous and sudden (Briske, 2017). As such, the model explains that there exist transient dynamics and state transitions. Transient dynamics are mainly driven by disturbance or weather events, producing significant but temporary changes in vegetation composition. On the other hand, state transitions are persistent changes of vegetation, which may be caused by internal ecosystem mechanisms, such as competitive dominance of invaders or plant-environment feedbacks that favour new species under the same soil and climate conditions (Bestelmeyer *et al*., 2017). In addition, larger perturbations such as drought and overgrazing may cause the system to cross an irreversible threshold where changes in soil conditions (related to reduced basal cover) and species composition may hinder the system from recovering (Wiegand *et al*., 2008). The model is conceptualised in figure 2.1.

In figure 2.1 below, multiple pathways, namely community pathways between plant community phases within states, reversible transitions, multiple thresholds, irreversible transitions, multiple pathways of change, and multiple steady states through which a plant community may undergo is clearly conceptualised

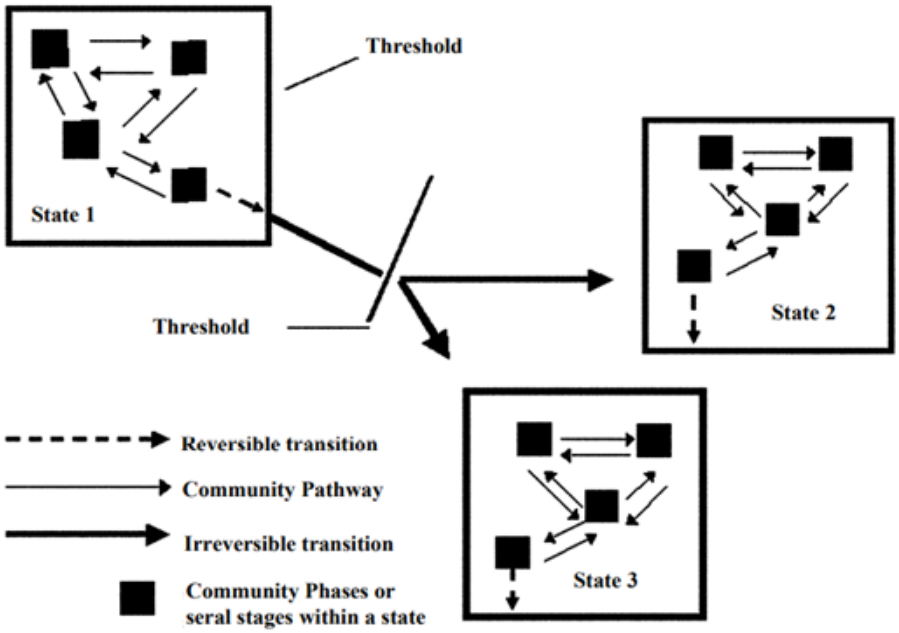


Figure 2.1: A conceptualised state-transition model Source: Stringham, et al. (2016)

On the other hand, the theory of island biogeography explains how the size of such habitat can be used to predict vegetation composition of a habitat. It was observed that the number of species tends to increase with an increase in area (Simberloff, 1974). It is thought that area/size acts primarily through habitats so much that as area increases, so does the number of

habitats, each with its complement of species (Simberloff, 1974). This study, therefore, relied on these models to try to explain any vegetation changes occasioned by different management approaches applied in Naibunga conservancy.

2.9. Conceptual framework

Vegetation diversity, structure, and composition is a measure of the overall performance of a complex system that is built up from the behaviour of its parts. The hierarchical, multiscalar paradigm proposes that a healthy ecosystem is one that maintains its complexity, structure, and resilience (Obati, 2007). However, with the human values attached to these ecosystems plus the environmental characteristics such as the edaphic factors, the general climatic condition of a region as captured in STM (Westoby *et al*., 1989), and habitat size (conservancy size) as explained by the theory of island biogeography (Simberloff, 1974), have far-reaching effects on the complexity, structure, and resilience of ecosystems. Furthermore, factors like disturbance and manipulations through restoration and land management practices driven by management objectives may alter transiently or permanently the species composition and structure. In view of the above, an ecosystem approach conceptualised in Figure 1 below was used as a guide when carrying out this assessment.

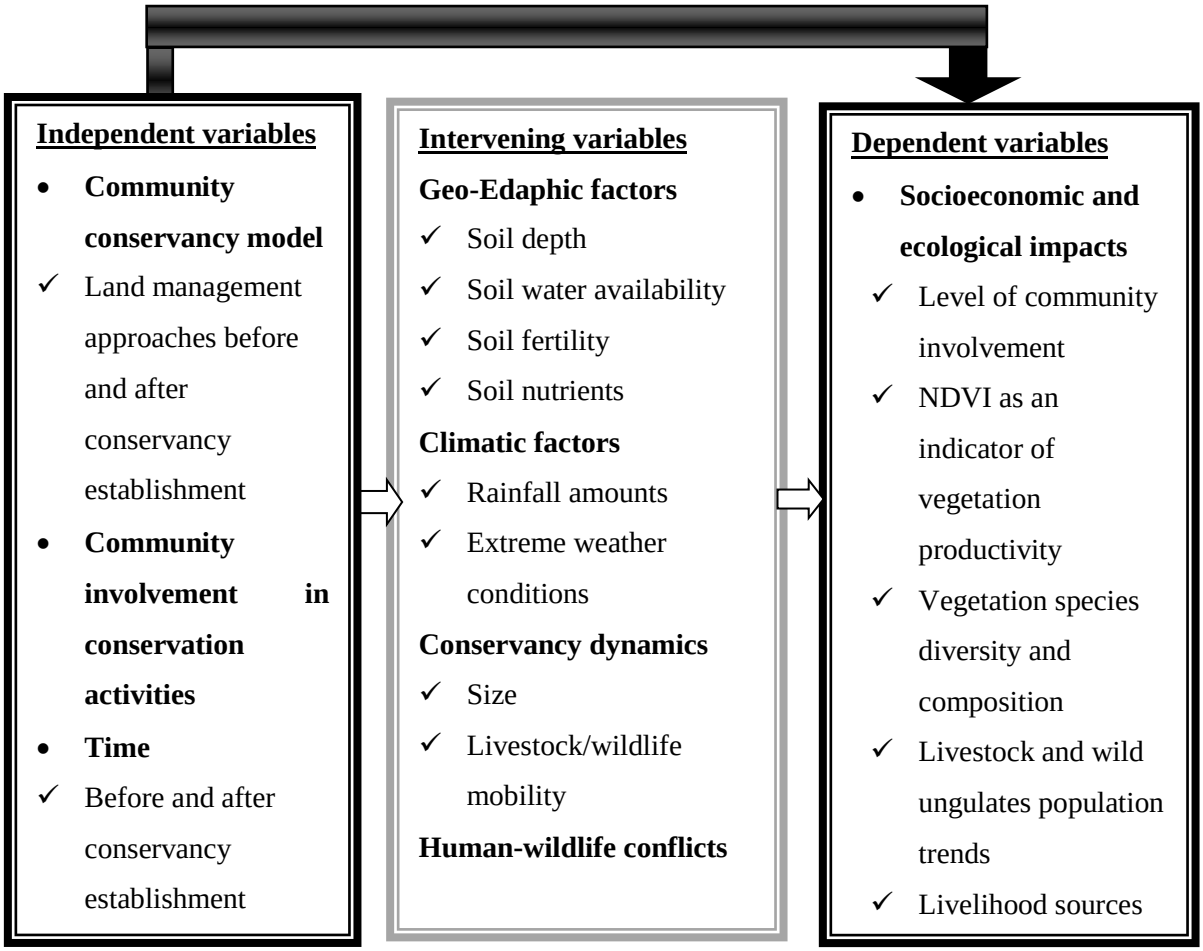


Figure 2.2: A conceptualisation of the interacting variables under study

CHAPTER THREE

MATERIALS AND METHODS

3.1. Study area

3.1.1. Location and size

The study was conducted at Naibunga Community Conservancy in Laikipia North Sub-County, Laikipia County, Kenya (Figure 3.1). The conservancy lies within longitude 36^0 5' - 37^0 15' and latitude 0^0 20' N – 0^0 35' N. Laikipia County is located in north-central Kenya and lies within longitude 36^o10' - 37^o3' E and latitude 0^o17' S - 0^o45' N. The conservancy is made up of nine communal group ranches; Koija, Kijabe, Tiamamut, Ilmotiok, Nkiloriti, Munishoi, Musul, Ilpolei, and Morupusi. It covers a total land area of 477 km^2.

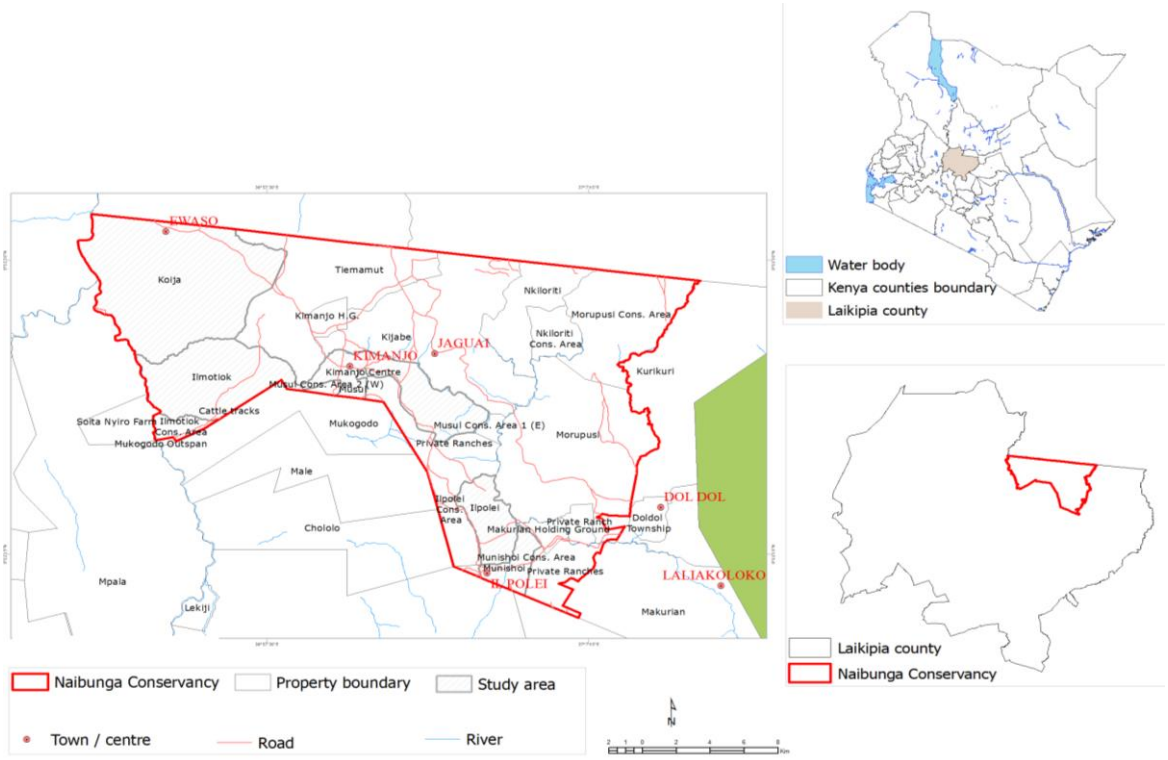


Figure 3.1: Map showing Naibunga Community Conservancy, Source: This study

3.1.2. Geology and soil types

The geologic formation of Laikipia County is underlain by metamorphic rocks of the Precambrian age exposed at the surface, mainly in the north-eastern part. Metamorphic rocks dominate the Mukogodo division, where Naibunga Community Conservancy is located. According to FAO classification 1987, most soils in the Laikipia plateau have developed from the tertiary metamorphic rocks leading to the formation of phaeozems, vertisols and

planosols types of soils (Ministry of Agriculture, 2007), which have largely been classified as loam, sand and clay. The plateaus areas are highly dominated by the black cotton loam-clay soils (County Government of Laikipia, 2018).

3.1.3. Drainage

Laikipia County's main drainage is the Ewaso Nyiro North basin, whose tributaries emanates from the Abadares and Mt. Kenya. The tributaries include Ewaso Narok, Pesi, Ewaso Ngiro, Ngobit, Engare, Segera and Naromoru Rivers (County Government of Laikipia, 2018). The rivers generally follow the undulating plateau terrain of Laikipia that inclines towards the North. In Laikipia north, the landscape is largely characterized by multiple tributaries and temporary rivers that always contain water during the wet season that eventually flow into the Ewaso Ngiro drainage basin. The basin, which is one the largest basin in Kenya, in turn, empties into the Lorian Swamp in eastern Kenya (County Government of Laikipia, 2018).

3.1.4. Vegetation

Naibunga Community Conservancy is largely characterized by savanna vegetation of varying densities of woody vegetation, including *Acacia* woodlands, "open" savanna grassland and bushlands. The woodlands are dominated by whistling-thorn acacia *(Acacia drepanalobium)* while savanna and bushlands are dominated by either continuous or discontinuous layer of perennial grasses such as *Eragrostis tenifolia, Cenchrus ciliaris, Aristida cogesta* with widely spaced trees and shrubs dominated by wait-a-bit thorn *(Acacia mellifera*), mgunga (*Acacia etbaica*), prickly thorn (*Acacia brevispica*), and white cross berry (*Grewia tenae*) (Kinnaird & O' Brien, 2012). The savanna and bushlands form very important grazing areas for livestock. Some areas have also been encroached by unpalatable weeds, such as *Sanseviera intamida, Opuntia spp., Ipomea spp,* which have significantly reduced important grazing areas (Kinyua *et al*., 2010).

3.1.5. Fauna

The conservancy is home to a variety of wild animals. It is also an important home and a migratory corridor for elephants. In addition, the conservancy is home to populations of zebras (both plains and Grevy's zebras), gazelle, gerenuk, eland, greater and lesser kudu, baboons, spotted and striped hyenas, leopard, lions, wild dogs, cheetah, ostrich, hippopotamus and crocodile are found in the Ewaso Nyiro River. Other small animals include rabbits and tortoises among other wildlife species (Mureithi *et al*., 2019; Naibunga Community Conservancy, 2017).

3.1.6. Climate

Naibunga experiences relief rainfall due to its altitude and location. On average, the conservancy receives slightly over 400mm annually, with an increasing gradient of up to 700mm towards Mukogodo Forest. Rainfall typically falls in two seasons; the long rains between April and June and the short rains between October and December. The annual mean temperature of the county ranges between 16^{o}C and 26^{o}C (Ministry of Environment and Forestry, 2018).

3.1.7. Land use and socio-economic activities

The area is dominated by communal group ranches (Letai, 2011). The main socioeconomic activities in the area include pastoralism-based livestock rearing, wildlife conservation, and wildlife-based tourism. Other socioeconomic activities include small-scale farming, small businesses such as motorbike transport ("bodaboda"), charcoal burning, beekeeping and subsistence hunting (Graham, 2012). A number of the locals are also employed in the conservancies as rangers, scouts and managers (Northern Rangeland Trust, 2017).

3.2. Study design

The study used a case study research design, an in-depth, multifaceted research design aimed at analysing specific issues within the boundaries of a specific environment. Since this study sought to establish the implications of a community conservancy model as a land management practice, widely used in most rangeland savannas, a case study research design was the ideal research design for the study. This study used Naibunga Community Conservancy as a case within which the community conservancy model is implemented as a land management and conservation practice to elucidate its socioeconomic and ecological outcomes. The study involved both socioeconomic and ecological assessments.

3.2.1. Assessment of conservancy's socioeconomic impacts

Social assessments were conducted to collect data on conservancy demographics, conservancy conservation and management practices, the level of community involvement in these practices, and community perceptions of the socioeconomic outcomes of the conservancy. Both quantitative household surveys and qualitative surveys (key informant interviews) were conducted to perform these assessments.

- **Target population**

The target population for household surveys comprised of all inhabitants of the Naibunga Community Conservancy. Households were used as the basic sampling units in these household surveys. By the time of the surveys, the conservancy had a total of 5806 households distributed across five administrative locations, namely, Mumonyot, Il Digiri, Oloibosoit, Il Polei and Il Motiok) (Kenya National Bureau of Statistics, 2019).

- **Sample size and sampling procedure**

The study used a sample of size of 368 (358 household heads and 10 key informants) distributed approximately equally among the five selected group ranches was used (Table 3.1). A minimum of 360 respondents were deemed enough based on Cochran's (1963) sample size formula for categorical data (Bartlett II *et al*., 2001) as shown below:

$$n = \frac{n_0}{1+\frac{(n_0-1)}{N}}$$

Where:

n_0 = the Cochran's recommended sample size calculated as:

$$n_0 = \frac{Z^2 Pq}{e^2}$$

n = sample size,

p = the sample proportion (q = 1- p),

Z= the standard variant at a given significance level (α = 0.05) and

e = acceptable error (precision).

N = the total population

In calculating the sample size, "p" was taken to be equal to 0.5, whereas "N" was 2913 (i.e, the total number of households in Naibunga Community Conservancy).

$n_0 = \frac{1.96^2 x 0.5 x 0.5}{0.05^2} = 385$

Z=1.96,

p=0.5 and an acceptable error of 5 % (e).

q= the weighting variable and computed as 1-P (0.5)

The sample size was be determined as:

$n = \frac{385}{1+\frac{(385-1)}{5806}} \approx 360$

A multi-stage random sampling procedure was used to select the households included in the study. First, five group ranches, namely, Koija, Ilmotiok, Musul, Munishoi, and Murupusi were randomly selected from a total of nine group ranches that constituted the Naibunga Community Conservancy. Secondly, within each selected group ranch, households that were included in the survey were randomly selected from every settlement (locally known as "manyattas") encountered.

Table 3.1. Household distribution in the selected Group ranches

No.	Location	Sub-location	Group ranch	No. of selected households
1.	Ildigiri	Kimanjo	Musul	72
2.	Ilmotiok	Ilmotiok	Ilmotiok	70
3.	Oloiborsoit	Ewaso	Koija	72
4.	Ilpolei	Ilpolei	Ilpolei and Munishoi	35 (pretesting) 72
5.	Mumonyot	Mumonyot	Murupusi	72
	TOTAL			**358 + 10 Key informants**

- **Data collection methods**

The quantitative household survey was conducted using structured questionnaires. The questionnaires were administered face-to-face to the heads of selected households or their suitable representatives. The data collected included household demographics, the extent of involvement in conservancy management and conservation activities (measured as the number of hours per week), sources of livelihood and perceptions on the socioeconomic impacts of the conservancy. For socioeconomic impact assessment, the study used the socioeconomic indicators derived from the World Bank Poverty Framework (World Bank, 2001). The framework views socioeconomic status as a complex product of the opportunities available to a household, the security under which such opportunities are exploited, and the empowerment level a household or community possess (World Bank, 2001). The indicators used were average household income, accessibility to amenities such as schools, health facilities and water, and security. Change in livestock numbers was also used as an additional indicator of socioeconomic change.

In addition to the household survey, the study employed key informant interviews. The key informants were the chairpersons of the five selected group ranches (1 chairperson per group

ranch) and four conservancy and youth leaders of various conservancy management committees. The key informants were interviewed on socioeconomic activities initiated by the conservancy, perceived conservancy-related impacts on average household incomes, access to water, health facilities and schools, and the security situation within the conservancy.

- **Questionnaire validity and reliability tests**

For validity tests, the study's semi-structured questionnaire was subjected to expert opinions. According to Tsang *et al*. (2017), expert content judgement of items included in the questionnaire is important as it provides a chance to assess whether the items adequately captures the constructs intended to be assessed. For this study, expert opinions on questions in the questionnaire were analysed and discussed in depth by several experts in the field of wildlife conservation. The analysis led to the removal of some questions that did not add value to the study in achieving its objectives and additions of other questions apart from translating the questions from English to Swahili to enhance question precision and to make the questions as simple as possible.

For reliability test, a respondent-driven pilot study was conducted prior to the execution of actual social surveys. According to Perneger *et al*. (2015), a default sample size of 30 participants is recommended for questionnaire pretesting. This is because samples below 30 may not be adequate to expose problems a questionnaire may exhibit. Therefore, a subsample of 36 participants were randomly selected from Il Polei Group Ranch, which did not form part of the actual study. Data collected from the pilot study were analysed for reliability tests. Cronbach's alpha was used to test whether the questionnaire was reliable and able to produce consistent results over time as per the rule of George and Mallery (2003) and Djamba and Neuman (2002) and that the result produced was accurate and adequately represented the total population under study (Radhakrishna, 2007).

The reliability test result showed Cronbach's alpha coefficient of 0.7 (Table 3.2), a coefficient strong enough to suggest that the items in the questionnaire had relatively high internal consistency (Taherdoost, 2018). For the validity test, the survey tools were subjected to expert judgement in order to determine whether the content of the questionnaires and key informant guide was adequate.

Table 3.2. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.695	.642	31

3.2.2. Assessment of conservancy's ecological impacts

- **Vegetation assessments: field and satellite data collection**

To assess the current vegetation status, 19 (30m x 30m) plots were established in the conservation areas across the five selected group ranches. A randomly selected path (small road) in the conservation area measuring 400 metres long was used as a transect line. Two plots 200 metres apart were established on both sides of the transect line. The plots were also established 100 metres away from the path to reduce the edge effect. In total, four survey plots were established in each of the selected group ranches except for Ilpolei, where three plots were established due to security threats (presence of elephants). Field data on three vegetation classes, namely, herb-layer vegetation (forbs and grasses), shrubs and trees were collected in each plot. Vegetation attributes of interest were plant form, tree and shrub height, and species composition for each vegetation class. Two diagonal transects were established for vegetation sampling in each plot, with trees and shrubs sampled along separate transects. Six sampling points approximately 5 m apart were established along each transect. All trees and shrubs encountered within a 2m radius of each sampling point along each tree/shrub sampling transect were identified, counted, and their heights measured. Tree and shrub height was measured using a poll metre. For forbs and grasses, a 0.5m by 0.5m quadrat was placed at each sampling of the six sampling points along the respective transect, and all plants within the quadrat were identified, counted and recorded by species. A handheld Germini GPS gadget was used to record the geolocation of the plot centroids.

Plot data collection by use of quatrat

Tree height measurement by use of poll metre

A randomly laid 0.5m by 0.5m quadrat

Possing for a photo with one of local field assistant

Plate 3.1. Data collection using quadrat (herb layer) and poll metre (tree/shrub) height

To assess the effect of the conservancy on NDVI temporal dynamics, multi-temporal medium-scale Landsat satellite imageries were downloaded and processed in google earth engine (GEE) code editor. Satellite imageries, which come already atmospheric, radiometric and geometric correction pre-processed, were further pre-processed mainly to fill gaps in Landsat 7 images for the year between 2003 and 2007 occasioned by faulty Landsat 7 scanline corrector (SLC) in Google Earth Engine (GEE). Normalized difference vegetation index analysis was then performed using Google earth engine code editor. The NDVI was calculated for both the dry season (January - March) and wet season (April – June) for each of the 19 field plots established in the five group ranches for 30 years (1989 – 2020) sub-divided into the periods before (1989 – 2003) and after (2006 – 2020) conservancy

establishment. Normalized difference vegetation index was calculated as the normalized difference between the red and near-infrared bands from an image:

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)}$$

Where NIR is the near-infrared band value for a cell and RED is the red band value for the cell.

- **Wild ungulates and livestock data collection**

Data on wildlife and livestock numbers were obtained from the Directorate of Resource Survey and Remote Sensing (DRSRS). The DRSRS employs an aerial sample count survey every three to five years. For the present study, data used were for the periods 1989 - 2003 (pre-conservancy establishment) and 2005 - 2020 (post-conservancy establishment). The animal counts data used in this study emanated from DRSRS surveys that were conducted using a low flying aircraft at the height of approximately 120m (400ft) above the ground (Georgiadis *et al*., 2011). During these surveys, topographic sheets of scale 1:250,000 were used in pre-flight planning to define the survey area boundary and the location of parallel transects, oriented north–south, each separated by a fixed distance (5 km for a low-resolution survey or 2.5 km for a high-resolution survey) (Georgiadis *et al*., 2011; Ngene *et al*., 2017). Flying at about 190 km/h and at a height above the ground of 122 m (using a radar altimeter), the pilot navigated transects oriented north-south using GPS. Observers counted animals that fell within narrow strips of known width (150 m) on either side of the aircraft, defined by rods attached to the wing struts (Georgiadis *et al*., 2011; Kinnaird *et al*., 2015; Ngene *et al*., 2017). The method surveyed a subset of the study area, and the results were extrapolated to the total study area. The study area was divided into several blocks ranging from 200 – 600km^2, and sampling was conducted along a strip of 0.282km width (Georgiadis *et al*., 2011; Ngene *et al*., 2017). Animals sampled were grouped into fifteen wildlife and four livestock species (cattle, sheep and goats, donkeys and camels). Animals aerial counts in Kenya has been carried out since the 1960s, with the department of resource surveys and remote sensing tasked to carry out the surveys (Ngene *et al*., 2017). The census is guided by international standards recommended for Monitoring Illegal Killing of Elephants (MIKE) as formulated under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Ngene *et al*., 2017). Of particular interest was the animal counts data collected during 1989-2020.

3.3. Data analysis

3.3.1. Analysis of data on socioeconomic aspects

Data on socioeconomic aspects were cleaned, organized and responses appropriately coded. Quantitative data were analysed using Statistical Package for Social Sciences (SPSS) statistical software version 26 (IBM Corporation, 2019). Descriptive statistics (percentages and counts) were used to summarize these data. The Chi-square test was used to test for association between various categorical variables. Specifically, the association between local perceptions of conservancy-related socioeconomic outcomes and involvement in conservancy management and conservation activities were tested. In addition, the association between gender and education, the association between each of selected demographic attributes (gender, education, household size, livestock ownership, and herd size and respondents': 1) perception of conservancy-related socioeconomic outcomes; and 2) involvement in conservancy management and conservation activities were tested. For multi-level factors, levels were combined for better interpretation, or when doing so was necessary to satisfy the Chi-square test of association's assumption of at least 80% of cells having expected count values not lower than 5 (Mchugh, 2013). The levels of each factor used in these Chi-square tests are specified in Table 3.3. Statistical significance was accepted at $p < 0.05$.

Table 3.3. Various variables and their levels as used in original (household survey) assessments and Chi-square tests of association.

Variable	Original Level assessed	Levels used for Chi-square tests
Socioeconomic indicators	Increased/Improved, No change, Decreased/Deteriorated	Increased/Improved, No change/decreased or deteriorated
Involvement	Involved, Not involved	Involved, Not involved
Involvement levels (hours per week)	0, 1-10, 11-20, >20	Not used in chi square tests
Gender	Male, Female	Male, Female
Education level	None, Primary, Secondary, Tertiary	None, Primary, Secondary, Tertiary (for association test with gender)
	None, Primary, Secondary,	No formal education, Formal

	Tertiary	education (for association test with variables other than gender)
Household size	<2, 3-5, 6-8, >9	1-5, >6
Occupation	Farmer, Civil servant, Business person, Others	Not used in chi square tests
Main source of livelihood	Pastoralism, Formal employment, Bee keeping, Other	Not used in chi square tests
Livestock type	Cattle, Sheep & Goats, Camels, Donkeys	Not used in chi square tests
Cattle ownership	Yes, No	Yes, No
Sheep and goat ownership	Yes, No	Yes, No
Camel ownership	Yes, No	Yes, No
Donkey ownership	Yes, No	Yes, No
Cattle herd size	0, 1-50, 51 - 100, >100	1-50, >50
Sheep and goat herd size	0, 1-50, 51 - 100, >100	1-50, >50
Camel herd size	0, 1-50, 51 - 100, >100	Not used in chi square tests

Qualitative data from key informant interviews were analysed using thematic analysis. Specifically, the data were grouped and summarized under three main themes: 1) the conservancy's strategies to enhance socioeconomic wellbeing of local community members; 2) the conservancy's strategies and initiatives for local community participation in conservancy management and conservation activities; and 3) the socioeconomic outcomes of the conservancy's socioeconomic development and conservation strategies, initiatives and programmes.

3.3.2. Analysis of vegetation, wild ungulate and livestock data

Vegetation data, namely, tree/shrub heights and vegetation species diversity and composition, were cleaned and entered into an excel sheet. The data were then fed into R statistical software package and Minitab version 20. Minitab was used to summarize the data into families and genus in tabular form. In addition, tree and shrub mean heights were evaluated and summarized. Simpson's vegetation index (D) was used to describe plant species diversity. Vegan package in R software was used to calculate Simpson diversity indices for vegetation. Simpson's diversity index accounts for the number of species (species diversity) and their abundance. The diversity indices were calculated for each site sampled: Ilmotiok, Ilpolei, Koija, Musul and Munishoi as:

$$D = \frac{1-\Sigma n(n-1)}{N(N-1)}$$

Where:

n is the number of individuals of individuals of one species

N = the total number of all individuals

Trend-plot analysis was performed to describe changes in NDVI across time. The analysis was performed for 30 years (1989 – 2020), before (1989 – 2003) and after (2006 – 2020) conservancy establishment, with a two-year transition period (2004 and 2005) in between the periods. Since the data did not observe the normality and equal variance assumptions, a non-parametric Mann-Witney test was used to compare the NDVI median values prior to and after conservancy establishment. To test the effects of conservancy establishment on vegetation and livestock and wild ungulate numbers over time, simple linear regression analyses were performed on NDVI, livestock numbers, and wild ungulate numbers against time. Specific species numbers of livestock and wild ungulate were also regressed against time separately for both periods. In addition, two-sample t-tests were performed to establish whether there were any significant differences in livestock and wild ungulate numbers prior to and after conservancy establishment. Livestock species included cattle, sheep and goats, donkeys and camels, while wild ungulates included elephants, Burchell's and Gravy's zebras and antelopes. Antelopes comprised of Grant gazelles, Thomson gazelles, gerenuk, impala and oryx.

Table 3.4. A summary of data analysis techniques for each objective

Objectives	**Variables**		**Data analysis technique**	**Data analysis tools**
	Independent variable	Dependent variable		
1) To assess the level of community involvement in conservation and land management practices under the community conservancy setting.	- Gender - Age of household heads - Community conservancy model - Land management activities in the conservancy	- Hours of involvement	- Descriptive statistics - Thematic analysis - Distribution tables - Chi-square analysis	- Minitab version 20
2) To evaluate the local community members' perceptions of socioeconomic outcomes of the community conservancy 3) To determine the extent community members' perceptions shape community involvement in conservancy management and conservation activities.	- Household - Gender - Education level - Level of involvement in land management practices - Socio-economic activities under the community conservancy model	- Socio economic status	- Descriptive statistic - Chi-square analysis - Thematic analysis	- IBM SPSS Statistics 26

4) To assess the current vegetation diversity and composition status 5) To determine the effects of community conservancy on normalised difference vegetation index (NDVI; proxy for productivity).	-	Community Conservancy model (management practices) - Time	-	NDVI	-	Linear mixed models	-	Minitab version 20
6) To assess the effects of the community conservancy approach on temporal trends in livestock and wild ungulate populations.	-	Community conservancy model (management practices) - Time	-	Ungulate population - Temporal population trends	-	Normal linear regression	-	Minitab version 20

CHAPTER FOUR

RESULTS

4.1. Demographics

4.1.1. Gender

A majority (199) of the household sampled, representing 61.4% of the total households, were headed by males. The remaining 125 households representing 38.6% of the household sampled were headed either by the female or the male household head (male) was away during the time of visit, probably tending to livestock as they are pastoralists in nature (Table 4.1).

Table 4.1. Respondents' proportion by their gender

Gender	Freq.	Percent	Valid Percent	Cumulative Percent
Male	199	61.4	61.4	61.4
Female	125	38.6	38.6	100.0
Total	324	100.0	100.0	

4.1.2. Education level

A majority (53.7 %) of the household heads did not have basic education, while 40.4% of the respondent had the least primary education. Only 5.9% had tertiary level education (table 4.2)

Table 4.2. Respondents' proportions based on their levels of education

		Freq.	Percent	Valid Percent	Cumulative Percent
Valid	None	174	53.7	53.7	53.7
	Primary	93	28.7	28.7	82.4
	Secondary	38	11.7	11.7	94.1
	Tertiary	19	5.9	5.9	100.0
	Total	324	100.0	100.0	

4.1.3. Occupation

The majority of the household heads (87.7%) were occupationally farmers. The rest of the households were either businesspersons (9.3%) or working as civil servants (3.1%). Most (88.3%) households depended on pastoralism as the main source of livelihood. The rest

depended on either small businesses (6.5%), beekeeping (3.4%), or formal employment (1.9%) as the main source of livelihood (table 4.3).

Households that depended on pastoralism as the main source of livelihood made the majority (82.4%) of those household heads that indicated farming as their main occupation (Table 4.3). This underscores that pastoralism is the main livelihood source for the local community in the study area.

Table 4.3. Respondents' occupation clustered by their main source of livelihoods

			Occupation			
			Farmer	**Civil Servant**	**Business person**	**Row totals**
Main source of livelihood	Pastoralism	Count	267	5	14	286
		%	**82.4**	1.5	4.3	88.3
	Formal Employment	Count	2	4	0	6
		%	0.6	1.2	0.0	1.9
	Bee Keeping	Count	7	1	3	11
		%	2.2	0.3	0.9	3.4
	Business	Count	8	0	13	21
		%	2.5	0.0	4.0	6.5
Total		**Count**	**284**	**10**	**30**	**324**
		% of Total	**87.7**	**3.1**	**9.3**	**100.0**

4.1.4. Main source of household livelihood

A majority (88.6%) of the respondents depended on pastoralism as their main source of livelihood. The rest highlighted either business (6.3%), Bee keeping (3.1%) or formal employment (2.0%) as their main source of livelihoods (Table 4.4).

Table 4.4. Respondents' proportion based on their main source of livelihoods

	Frequency	Percent	Valid Percent	Cumulative Percent
Pastoralism	312	88.6	88.6	88.6
Formal Employment	7	2.0	2.0	90.6
Bee Keeping	11	3.1	3.1	93.8
Business	22	6.3	6.3	100.0
Total	352	100.0	100.0	

- **Livestock ownership**

Most (76.4%) of the respondents who said they were pastoralists owned less than 50 head of cattle, 48% and 44.7% of them owned 1-50 and 50-100 small stock (sheep and goats), respectively (Table 2). However, donkeys and camels were uncommon, as more than 72% of the sampled households owned neither of these livestock types (Table 4.5). Therefore, this makes cattle and shoat the main livestock reared by the local pastoralist community in the study area.

Table 4.5. Ownership of various types of livestock by respondents

	Herd size categories			
Herd type	**0**	**1 - 50**	**51 - 100**	**Over 100**
Cattle	57	272	25	2
	16.0%	76.4%	7.0%	0.6%
Sheep and Goats	12	171	159	14
	3.4%	48.0%	44.7%	3.9%
Donkeys	289	65	1	1
	81.2%	18.3%	0.3%	0.3%
Camels	259	60	33	4
	72.8%	16.9%	9.3%	1.1%

4.2. Community involvement in conservancy management and conservation activities

4.2.1. Level of community involvement

More than 75% of the respondents reported that they were involved in conservancy management and conservation activities. A majority (82.5%) of the respondent involved in conservancy management and land management activities reported an involvement level of

between 1 - 10 hours per week, whereas 10.8% and 6.7% reported involvement levels of 11-20 hours and over 20 hrs, respectively (Figure 4.1).

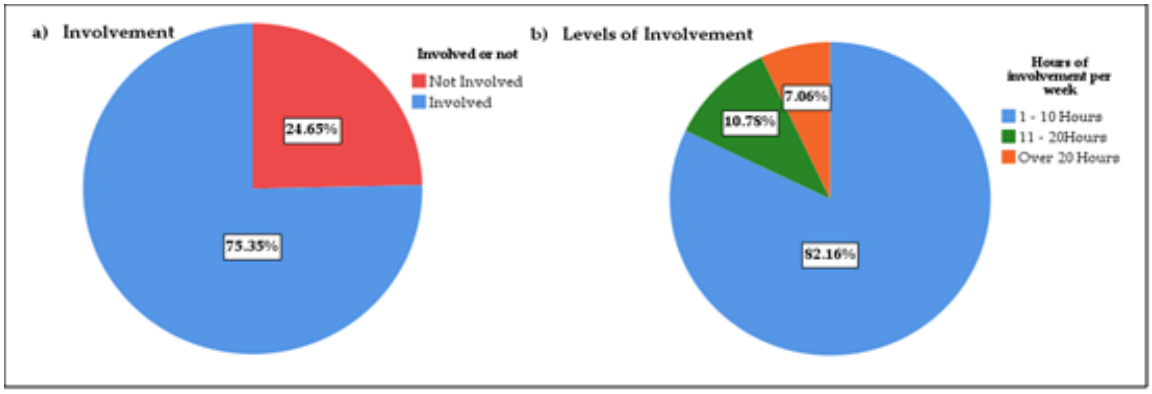


Figure 4.1: Proportions of the level of community involvement in hours per week

In addition, the majority (95.9%) of the involved respondents expressed their satisfaction with the level of involvement. For example, most (95.1%) of those involved for between 1-10 hrs per week felt they were adequately involved. On the other hand, all the respondents who indicated that they were involved for 11-20 hrs per week and over 20 hrs per felt that the conservancy had adequately involved them in the management and land management activities (Table 4.7).

Table 4.6. Adequacy of specific levels of involvement

			Are you adequately involved		Total
			Yes	No	
Hours of involvement per week	1 - 10 Hours	Count	194	10	204
		% within Hours of involvement per week	95.1	4.9	100.0
	11 – 20 Hours	Count	25	0	25
		% within Hours of involvement per week	100.0	0.0	100.0
	Over 20 Hours	Count	17	0	17
		% within Hours of involvement per week	100.0	0.0	100.0
Total		Count	236	10	246
		% within Hours of involvement per week	95.9	4.1	100.0

4.2.2. Ways of community involvement

Key informants listed various rangeland management programmes that community members were involved in: holistic management (community-based planned rotational grazing), rehabilitation of water points, soil erosion control, grass reseeding, and control of invasive species such as *Opuntia* and *Sansevieria spp*., and participatory land zoning programmes. The key informants further indicated that most of these activities are carried out in collaboration with NRT and other organizations in the region. For instance, through a partnership with NRT, the community conservancy established various green houses across communal group ranches from which a Cochineal fungus used as a biological control of the invasive plant *Opuntia spp*. is cultured.

According to key informant interviews, community members also participate in conservancy management and conservation programmes in various other ways, including active participation in management decision-making through various committees such as business committee, grazing committee, water committee, and through annual conservancy meetings. Key informants also indicated that local participation in these committees is important in ensuring that conservancy members influence management decisions. In addition, they revealed that under the community conservancy setting, community members are regularly trained to strengthen their capacity to participate more effectively in conservancy management and conservation activities.

4.3. Local community's perceptions of socio-economic impacts of the conservancy

A majority (90.1%) of the respondents perceived that the conservancy had changed their overall socio-economic status. Of these, 99.0% indicated that their status had generally improved (Table 4.7).

Table 4.7. General change in socioeconomic status

		Has the socioeconomic status changed in general			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	292	90.1	90.1	**90.1**
	No	32	9.9	9.9	100.0
	Total	324	100.0	100.0	

			How has the socioeconomic status changed generally			Total
			Improved	worsened/ Deteriorated	Not changed	
Has the socioeconomic status changed in general	Yes	Freq.	289	3	0	292
		Percent	**99.0**	1.0	0.0	100.0
	No	Freq.	2	2	28	32
		Percent	6.3	6.3	87.5	100.0
Total		Freq.	291	5	28	324
		Percent	89.8	1.5	8.6	100.0

Analysis of other socioeconomic attributes revealed that the security situation, accessibility to grazing resources, household income and accessibility to schools improved the most, with more than 72% of the respondents perceiving improvements in these attributes. The second tier constituted the improvements in accessibility to health facilities and livestock numbers, with 66.1% and 65.3% of the respondents perceiving improvements in these attributes, respectively (Table 1). Moderate proportions (52.9% and 53.5%) of respondents perceived improvements in the status of roads and accessibility to water, whereas only slightly more than 25% of the respondents perceived improved accessibility to electricity (Table 4.9). Based on livestock type, high proportions (67-70%) of respondents perceived increases in the number of cattle and sheep and goats. In contrast, only 22.1% and 8.1% of respondents perceived increases in camel and donkey numbers, respectively (Table 4.9).

Table 4.8. Respondents' perceptions of conservancy-related changes in various socioeconomic indicators.

	Increased or Improved		No change		Decreased or Deteriorated	
Variables	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
How socioeconomic status changed generally	293	89.6	28	8.6	6	1.8
How livestock numbers changed	233	65.3	93	26.1	31	8.7
How cattle numbers changed	250	70.0	75	21.0	32	9.0
How goat/sheep numbers changed	240	67.2	62	17.4	55	15.4
How camel numbers changed	79	22.1	261	73.1	17	4.8
How donkey numbers changed	29	8.1	292	81.8	36	10.1
How the average household income changed	269	75.4	35	9.8	53	14.8
How accessibility to water changed	189	52.9	101	28.3	67	18.8
How accessibility to health facilities changed	236	66.1	106	29.7	15	4.2
How accessibility to schools changed	258	72.3	92	25.8	7	2.0
How status of roads changed	191	53.5	103	28.9	63	17.6
How accessibility to grazing resources changed	275	77.0	29	8.1	53	14.8
How accessibility to electricity changed	92	25.8	252	70.6	13	3.6
How security status changed	293	82.1	13	3.6	51	14.3

Key informant interviews revealed increased employment opportunities for local community members under the community conservancy setting. For example, through collaboration between the community conservancy and the Northern Rangelands Trust (NRT), an umbrella membership organization for community conservancies in the region, local community members get employed as conservancy managers, community scouts (rangers), and grazing coordinators. Key informants also indicated that through partnerships with NRT and other stakeholders, members of the conservancy benefit from improved access to livestock markets through initiatives such as "Livestock to Market" (LTM) and "livestockWORKS" (Northern Rangelands Trust, 2020) (Northern Rangeland Trust, 2019). They further noted that these initiatives have helped minimize reliance on exploitative intermediaries, enabling local pastoralists to maximize profits from livestock sales.

In addition, the key informants revealed that through partnerships with various stakeholders, the conservancy has improved market access for local women's handicraft products. The key informants further revealed that various youth groups are usually trained on financial management before accessing credit facilities such as savings and credit co-operatives

(SACCO) loans for entrepreneurship under the conservancy. Further, the key informants indicated that local conservancy members are benefiting from increased livestock productivity due to conservancy-related improvements in ecological conditions coupled with increased access to grazing resources.

Regarding security, the key informants revealed that through partnerships with NRT, the conservancy had employed community scouts who conduct community patrols to help maintain security. In addition, the key informants indicated that the conservancy has a functional conflict resolution committee, which "has immensely contributed to timely response in case of attacks by cattle rustlers, and mediation of any misunderstanding". Explaining the impact of insecurity, one key informant said, "Insecurity has been costing us our livestock and grazing resources. We have frequently suffered incursions from Isiolo and Samburu. When they attack one area of the conservancy, there is always a shift in (grazing) pressure from the insecure areas to secure areas. For example, the current insecurity situation in Tiamamut has shifted (grazing) pressure into Musul, Koija and Il Motiok leading to scarce grazing resources in those areas".

However, the key informants indicated that the security situation has generally improved across the conservancy due to conservancy-led security enhancement efforts. The key informant further observed, "However, the situation is not as bad as it were before, we now have improved security and with improved security, we at least have had enough grazing resources for ourselves as our community patrol teams in many occasions have foiled such attacks before they happen. In addition, National Police Reservists have helped a lot as they collaborate with Administration Police to respond timely to any insecurity situation".

Concerning accessibility to water, the key informants indicated that although the conservancy has helped increase the number of water pans across the landscape, accessibility to water remains a challenge because such water pans dry up almost immediately when dry season sets in. They also noted that water scarcity is one of the biggest problems facing local community members, who are often forced to walk for long distances in search of water. One of the key informants opined, "Water is not enough as we share the same with our livestock, wildlife particularly elephants". However, the key informants indicated that the conservancy currently has a water committee charged with managing and rehabilitating existing water points.

The key informants indicated that one way through which the conservancy enhances accessibility to schools is by providing bursaries to needy students. Furthermore, regarding access to health facilities, the key informants revealed that conservancy helps offset hospital bills for needy community members from time to time.

4.4. Effects of community involvement in conservation activities on their perception of socioeconomic impacts of the conservancy

Chi-square test between the level of pastoralists' involvement and the perceived socioeconomic improvements revealed positive and significant associations. Respondents' perception of conservancy-driven change in their overall socioeconomic status was significantly associated with their involvement in conservancy management and conservation activities ($\chi^2 = 83.5$, $p < 0.001$; Table 4.9). Specifically, a higher than expected proportion of respondents who perceived improvement in their overall socioeconomic status were involved in these activities (Table 4.9). Conversely, lower than expected proportions of respondents who perceived either no change or a decrease in their overall socioeconomic status were involved in these activities (Table 4.9). These patterns were similar for nearly all other socioeconomic indicators (all $\chi^2 > 6.1$, $p< 0.048$; Table 4.10). The only exception was that respondents' perception of conservancy-related change in donkey numbers was not significantly associated with their involvement in conservancy management and conservation activities ($\chi^2 = 2.9$, $p = 0.232$; Table 4.9).

Table 4.9. Chi-square tests for association between respondents' perceptions of conservancy-related socioeconomic outcomes and their involvement in conservancy management and conservation activities. Values in parentheses are expected counts.

		Involvement					
		Involved		Not involved			
		Freq.	%	Freq.	%	χ2	*p*-Value
How socioeconomic status changed generally	Increased/Improved	243 (221.3)	82.9	50 (71.7)	17.1		
	No change	4 (21.1)	14.3	24 (6.9)	85.7		
	Decreased/Deteriorated	0 (4.5)	0.0	6 (6.0)	100.0	84.1	< 0.001
How livestock numbers changed	Increased/Improved	204 (179.5)	87.6	29 (53.5)	12.4		
	No change	53 (71.6)	57.0	40 (21.4)	43.0		
	Decreased/Deteriorated	18 (23.9)	58.1	13 (7.1)	41.9	41.0	<0 .001
How cattle numbers changed	Increased/Improved	218 (192.6)	87.2	32 (57.4)	12.8		
	No change	37 (57.8)	49.3	38 (17.2)	50.7		
	Decreased/Deteriorated	20 (24.6)	62.5	12 (7.40	37.5	51.0	<0 .001
How goat/sheep numbers changed	Increased/Improved	203 (184.9)	84.6	37 (55.1)	15.4		
	No change	32 (47.8)	51.6	30 (14.2)	48.4		
	Decreased/Deteriorated	40 (42.4)	72.7	15 (12.6)	27.3	31.0	<0 .001
How camel numbers changed	Increased/Improved	78 (60.9)	98.7	1 (18.1)	1.3		
	No change	187 (201.1)	71.6	74 (59.9)	28.4		
	Decreased/Deteriorated	10 (13.1)	58.8	7 (3.9)	41.2	28.5	<0 .001
How donkey numbers changed	Increased/Improved	26 (22.3)	89.7	3 (6.7)	10.3		
	No change	221 (224.9)	75.7	71 (67.1)	24.3		
	Decreased/Deteriorated	28 (27.7)	77.8	8 (8.3)	22.2	2.9	0.232
How the average household income changed	Increased/Improved	236 (207.2)	87.7	33 (61.8)	12.3		
	No change	21 (27.0)	60.0	14 (8.0)	40.0		
	Decreased/Deteriorated	18 (40.8)	34.0	35 (12.2)	66.0	78.7	<0 .001
How accessibility to water changed	Increased/Improved	155 (145.6)	82.0	34 (43.4)	18.0		
	No change	74 (77.8)	73.3	27 (23.2)	26.7		
	Decreased/Deteriorated	46 (51.6)	68.7	21 (15.4)	31.3	6.1	0.047
How accessibility to health facility changed	Increased/Improved	198 (181.8)	83.9	38 (54.2)	16.1		
	No change	63 (81.7)	59.4	43 (24.3)	40.6		
	Decreased/Deteriorated	14 (11.6)	93.3	1 (3.4)	6.7	27.1	<0 .001
How accessibility	Increased/Improved	220 (198.7)	85.3	38 (59.3)	14.7		

to schools changed	No change	49 (70.9)	53.3	43 (21.1)	46.7	
	Decreased/Deteriorated	6 (5.4)	85.7	1 (1.6)	14.3	39.6 <0 .001
How status of roads	Increased/Improved	175 (147.1)	91.6	16 (43.9)	8.4	
changed	No change	62 (79.3)	60.2	41 (23.7)	39.8	
	Decreased/Deteriorated	38 (48.5)	60.3	25 (14.5)	39.7	49.4 <0 .001
How accessibility	Increased/Improved	226 (211.8)	82.2	49 (63.2)	17.8	
to grazing resources	No change	22 (22.3)	75.9	7 (6.7)	24.1	
changed	Decreased/Deteriorated	27 (40.8)	50.9	26 (12.2)	49.1	24.5 <0 .001
How accessibility	Increased/Improved	87 (70.9)	94.6	5 (21.1)	5.4	
to electricity	No change	175 (194.1)	69.4	77 (57.9)	30.6	
changed	Decreased/Deteriorated	13 (10.0)	100.0	0 (3.0)	0.0	28.1 <0 .001
How security status	Increased/Improved	244 (225.7)	83.3	49 (67.3)	16.7	
changed	No change	10 (10.0)	76.9	3 (3.0)	23.1	
	Decreased/Deteriorated	21 (39.3)	41.2	30 (11.7)	58.8	43.5 <0 .001

Perception of conservancy-related change in socioeconomic status was also associated with various demographic factors, namely, household size, cattle ownership, camel ownership, and sheep and goat herd size (all $\chi^2 > 9.5$, $p < 0.016$; Table 4.10). Specifically, a higher than expected proportion of respondents from households with fewer (1-5) members perceived that their socioeconomic status had improved since the conservancy establishment and vice versa (Table 4.10). Similarly, higher than expected proportions of cattle, camel, and owners of no more than 50 sheep and goats reported conservancy-related socioeconomic status improvement and vice versa. However, perception of overall socioeconomic status change was not associated with both gender and formal education ($\chi^2 < 0.3$, $p > 0.178$; Table 4.10).

Table 4.10. Chi-square tests of association between respondents' perceptions of conservancy-related socioeconomic outcomes and various demographic factors. Values in parentheses are expected counts.

		Changes in overall socioeconomic status					
		Improved		**Not Improved**			
		Freq.	**%**	**Freq.**	**%**	**χ2**	***p*-Value**
Gender	Male	178 (179.2)	89.0	22 (20.8)	11.0		
	Female	115 (113.8)	90.6	12 (13.2)	9.4	0.2	0.654
Education level	No formal education	154 (157.7)	87.5	22 (18.3)	12.5		
	Formal education	139 (135.3)	92.1	12 (15.7)	7.9	1.8	0.179
Household size	1 - 5	192 (184.4)	93.2	14 (21.6)	6.8		
	6 and above	98 (105.6)	83.1	20 (12.4)	16.9	8.2	0.004
Own cattle?	Yes	258 (245.4)	94.2	16 (28.6)	5.8		
	No	34 (46.6)	65.4	18 (5.4)	34.6	38.7	<0.001
Owns sheep & goats?	Yes	286 (283.0)	90.5	30 (33.0)	9.5		
	No	6 (9.0)	60.0	4 (1.0)	40.0	9.7	0.002
Own donkeys?	Yes	55 (55.5)	88.7	7 (6.5)	11.3		
	No	237 (236.5)	89.8	27(27.5)	10.2	0.1	0.805
Own camels?	Yes	91 (81.5)	100.0	0 (9.5)	0.0		
	No	201 (210.5)	85.5	34 (24.5)	14.5	14.7	<0.001
Number of cattle	1 - 50	236 (236.3)	94.0	15(14.7)	6.0		
	51 and Above	22 (21.7)	95.7	1(1.3)	4.3	0.1	0.750
Number of sheep & goats	1 - 50	142 (139.4)	92.2	12(14.6)	7.8		
	51 and Above	144 (146.6)	88.9	18(15.4)	11.1	1.0	0.314

Analyses of association between specific socioeconomic indicators and demographic factors revealed mixed results. Of note, there was an association between gender and perception of change in accessibility to grazing resources; a higher than expected proportion of female respondents perceived improved accessibility to these resources, whereas the reverse was the case for male respondents ($\chi^2 = 15.7$, $p < 0.001$; Table 4.11).

Table 4.11. Chi-square tests of association between respondents' gender and their perceptions of conservancy-related changes in various socioeconomic indicators. Values in parentheses are expected counts.

		Gender					
		Male		Female			
		Freq.	%	Freq.	%	χ^2	*p*-Value
How livestock numbers changed	Increased/Improved	147(142.9)	67.1	86 (90.1)	62.3		
	No change	58 (57.1)	26.5	35 (35.9)	25.4		
	Decreased/Deteriorated	14 (19.0)	6.4	17 (12.0)	12.3	3.76	0.152
How the average household income changed	Increased/Improved	168 (165.0)	76.7	101(104.0)	73.2		
	No change	25 (21.5)	11.4	10 (13.5)	7.2		
	Decreased/Deteriorated	26 (32.5)	11.9	27 (20.5)	19.6	5.015	0.081
How accessibility to water changed	Increased/Improved	118 (115.9)	53.9	71 (73.1)	51.4		
	No change	66 (62.0)	30.1	35 (39.0)	25.4		
	Decreased/Deteriorated	35 (41.1)	16.0	32 (25.9)	23.2	3.12	0.210
How accessibility to health facility changed	Increased/Improved	152 (144.8)	69.4	84 (91.2)	60.9		
	No change	60 (65.0)	27.4	46(41.0)	33.3		
	Decreased/Deteriorated	7 (9.2)	3.2	8 (5.8)	5.8	3.30	0.192
How accessibility to schools changed	Increased/Improved	157 (158.3)	71.7	101 (99.7)	73.2		
	No change	59 (56.4)	26.9	33 (35.6)	23.9		
	Decreased/Deteriorated	3 (4.3)	1.4	4 (2.7)	2.9	1.34	0.513
How status of roads changed	Increased/Improved	122 (117.2)	55.7	69 (73.80	50.0		
	No change	56 (63.2)	25.6	47 (39.8)	34.1		
	Decreased/Deteriorated	41 (38.6)	18.7	22 (24.4)	15.9	3.00	0.223
How accessibility to grazing resources changed	Increased/Improved	160 (168.7)	73.1	115(106.3)	83.3		
	No change	14 (17.8)	6.4	15 (11.2)	10.9		
	Decreased/Deteriorated	45 (32.5)	20.5	8 (20.5)	5.8	15.66	<0.001
How accessibility to electricity changed	Increased/Improved	53 (56.4)	24.2	39 (35.6)	28.3		
	No change	162 (154.6)	74.0	90 (97.4)	65.2		
	Decreased/Deteriorated	4 (8.0)	1.8	9 (5.0)	6.5	6.59	0.037
How security status changed	Increased/Improved	182 (179.7)	83.1	111(113.3)	80.4		
	No change	8 (8.0)	3.7	5 (5.0)	3.6		
	Decreased/Deteriorated	29 (31.3)	13.2	22 (19.7)	15.9	0.506	0.777

Also notably, cattle ownership and camel ownership positively associated with perceptions of improvements in security status, livestock numbers, household income, and accessibility to

health facilities (all $\chi^2 > 7.0$, $p < 0.03$; Tables 4.12 & 4.14). We noted similar association patterns for ownership of sheep and goats, but these results did not meet one of the requisite assumptions of the Chi-square test (Table 4.13). Camel ownership was also associated positively with the perception of improved access to forage resources ($\chi^2 = 6.7$, $p = 0.035$; Table 4.14). Conversely, cattle ownership is associated negatively with perceived improvements in accessibility to water and status of roads ($\chi^2 = 6.5$, $p = 0.038$; Table 4.12). However, cattle herd size was not significantly associated with any of the socioeconomic indicators (all $\chi^2 < 3.2$, $p > 0.192$; Table 4.15).

Table 4.12. Chi-square tests of association between cattle ownership and respondents' perceptions of conservancy-related changes in various socioeconomic indicators. Values in parentheses are expected counts.

		Own Cattle					
		Yes		**No**			
		Freq.	**%**	**Freq.**	**%**	χ^2	***p*-Value**
How livestock numbers changed	Increased/Improved	216(195.7)	72.2	17 (37.3)	29.8		
	No change	64 (77.3)	21.4	28 (14.7)	49.1		
	Decreased/Deteriorated	19 (26.0)	6.4	12 (5.0)	21.1	39.27	<0.001
How the average household income changed	Increased/Improved	243(225.9)	81.3	26 (43.1)	45.6		
	No change	26 (29.4)	8.7	9 (5.6)	15.8		
	Decreased/Deteriorated	30 (43.7)	10.0	22 (8.3)	38.6	37.25	<0.001
How accessibility to water changed	Increased/Improved	150(158.7)	50.2	39 (30.3)	68.4		
	No change	90 (84.0)	30.1	10 (16.0)	17.5		
	Decreased/Deteriorated	59 (53.6)	19.7	8 (10.7)	14.0	6.52	0.038
How accessibility to health facility changed	Increased/Improved	206(197.4)	68.9	29 (37.6)	50.9		
	No change	82 (89.0)	27.4	24 (17.0)	42.1		
	Decreased/Deteriorated	11 (12.6)	3.7	4 (2.4)	7.0	7.09	0.029
How accessibility to schools changed	Increased/Improved	228(215.9)	76.3	29 (41.1)	50.9		
	No change	64 (77.3)	21.4	28 (14.7)	49.1		
	Decreased/Deteriorated	7 (5.9)	2.3	0 (1.1)	0.0	19.84	<0.001
How status of roads changed	Increased/Improved	162(160.4)	54.2	29 (30.6)	50.9		
	No change	79 (86.5)	26.4	24 (16.5)	42.1		
	Decreased/Deteriorated	58(52.1)	19.4	4 (9.9)	7.0	8.38	0.015
How accessibility to grazing resources changed	Increased/Improved	228(231.0)	76.3	47 (44.0)	82.5		
	No change	25 (24.4)	8.4	4 (4.6)	7.0		
	Decreased/Deteriorated	46 (43.7)	15.4	6 (8.3)	10.5	1.118	0.572

How accessibility to electricity changed	Increased/Improved	74 (77.3)	24.7	18 (14.7)	31.6		
	No change	214(211.7)	71.6	38 (40.3)	66.7		
	Decreased/Deteriorated	11 (10.1)	3.7	1 (1.9)	1.8	1.553	0.460
How security status changed	Increased/Improved	258(245.2)	86.3	34 (46.8)	59.6		
	No change	10 (10.9)	3.3	3 (2.1)	5.3		
	Decreased/Deteriorated	31 (42.8)	10.4	20 (8.2)	35.1	25.05	<0.001

Table 4.13. Chi-square tests of association between sheep and goat ownership and respondents' perceptions of conservancy-related changes in various socioeconomic indicators. Values in parentheses are expected counts.

		Own Sheep and Goats					
		Yes		**No**			
		Freq.	**%**	**Freq.**	**%**	χ^2	***p*-Value**
How livestock numbers changed	Increased/Improved	233(225.1)	67.7	0 (7.9)	0.0		
	No change	81 (88.9)	23.5	11 (3.1)	91.7		
	Decreased/Deteriorated	30 (30.0)	8.7	1 (1.0)	8.3	28.95	<0.001
How the average household income changed	Increased/Improved	265(259.9)	77.0	4 (9.1)	33.3		
	No change	28 (33.8)	8.1	7 (1.2)	58.3		
	Decreased/Deteriorated	51 (50.1	14.8	1 (1.8)	8.3	32.98	<0.001
How accessibility to water changed	Increased/Improved	184(182.6)	53.5	5 (6.4)	41.7		
	No change	93 (96.6)	27.0	7 (3.4)	58.3		
	Decreased/Deteriorated	67 (64.7)	19.5	0 (2.3)	0.0	6.686	0.035
How accessibility to health facility changed	Increased/Improved	230(227.1)	66.9	5 (7.9)	41.7		
	No change	99 (102.4)	28.8	7 (3.6)	58.3		
	Decreased/Deteriorated	15 (14.5)	4.4	0 (0.5)	0.0	5.040	0.080
How accessibility to schools changed	Increased/Improved	252(248.3)	73.3	5 (8.7)	41.7		
	No change	85 (88.9)	24.7	7 (3.1)	58.3		
	Decreased/Deteriorated	7 (6.8)	2.0	0 (0.2)	0.0	6.920	0.031
How status of roads changed	Increased/Improved	183(184.6)	53.2	8 (6.4)	66.7		
	No change	99 (99.5)	28.8	4 (3.5)	33.3		
	Decreased/Deteriorated	62 (59.9)	18.0	0 (2.1)	0.0	2.638	0.267
How accessibility to grazing resources changed	Increased/Improved	268(265.7)	77.9	7 (9.3)	58.3		
	No change	25 (28.0)	7.3	4 (1.0)	33.3		
	Decreased/Deteriorated	51 (50.2)	14.8	1 (1.8)	8.3	10.581	0.005
How accessibility to electricity changed	Increased/Improved	90 (88.9)	26.2	2 (3.1)	16.7		
	No change	242(243.5)	70.3	10 (8.5)	83.3		

How security status changed	Decreased/Deteriorated	12 (11.6)	3.5	0 (0.4)	0.0	1.100	0.577
	Increased/Improved	283(282.2)	82.3	9 (9.8)	75.0		
	No change	11 (12.6)	3.2	2 (0.4)	16.7		
	Decreased/Deteriorated	50 (49.3)	14.5	1 (1.7)	8.3	6.147	0.046

Table 4.14. Chi-square tests of association between camel ownership and respondents' perception of conservancy-related changes in various socioeconomic indicators. Values in parentheses are expected counts.

		Own Camels					
		Yes		**No**			
		Freq.	**%**	**Freq.**	**%**	χ^2	***p*-Value**
How livestock numbers changed	Increased/Improved	80 (63.5)	82.5	153 (169.5)	59.1		
	No change	12 (25.1)	12.4	80 (66.9)	30.9		
	Decreased/Deteriorated	5 (8.4)	5.2	26 (22.6)	10.0	17.20	<0.001
How the average household income changed	Increased/Improved	82 (73.3)	84.5	187 (195.7)	72.2		
	No change	11 (9.5)	11.3	24 (25.5)	9.3		
	Decreased/Deteriorated	4 (14.2)	4.1	48 (37.8)	18.5	11.76	0.003
How accessibility to water changed	Increased/Improved	52 (52.5)	53.6	137 (137.5)	52.9		
	No change	32 (27.2)	33.0	68 (72.8)	26.3		
	Decreased/Deteriorated	13 (18.3)	13.4	54 (48.7)	20.8	3.226	0.199
How accessibility to health facility changed	Increased/Improved	86 (64.0)	88.7	149 (171.0)	57.5		
	No change	9 (28.9)	9.3	97 (77.1)	37.5		
	Decreased/Deteriorated	2 (4.1)	2.1	13 (10.9)	5.0	30.638	<0.001
How accessibility to schools changed	Increased/Improved	85 (70.0)	87.6	172 (187.0)	66.4		
	No change	9 (225.1)	9.3	83 (66.9)	32.0		
	Decreased/Deteriorated	3 (1.9)	3.1	4 (5.1)	1.5	19.42	<0.001
How status of roads changed	Increased/Improved	58 (52.0)	59.8	133 (139.0)	51.4		
	No change	21 (28.1)	21.6	82 (74.9)	31.7		
	Decreased/Deteriorated	18 (16.9)	18.6	44 (45.1)	17.0	3.482	0.175
How accessibility to grazing resources changed	Increased/Improved	77 (74.9)	79.4	198 (200.1)	76.4		
	No change	12 (7.9)	12.4	17 (21.1)	6.6		
	Decreased/Deteriorated	8 (14.2)	8.2	44 (37.8)	17.0	6.692	0.035
How accessibility to electricity changed	Increased/Improved	6 (25.1)	6.2	86 (66.9)	33.2		
	No change	88 (68.7)	90.7	164 (183.3)	63.3		
	Decreased/Deteriorated	3 (3.3)	3.1	9 (8.7)	3.5	27.45	<0.001
How security status	Increased/Improved	90 (79.6)	92.8	202 (212.4)	78.0		

changed	No change	6 (3.5)	6.2	7 (9.5)	2.7		
	Decreased/Deteriorated	1 (13.9)	1.0	50 (37.1)	19.3	20.68	<0.001

Table 4.15. Chi-square tests of association between respondents' cattle herd size and their perceptions of conservancy-related changes in various socioeconomic indicators. Values in parentheses are expected counts.

		Number of Cattle					
		1–50		**51 and Above**			
		Count	**%**	**Count**	**%**	χ^2	***p*-Value**
How livestock numbers changed	Increased/Improved	196 (196.5)	72.1	20 (19.5)	74.1		
	No change	61 (58.2)	22.4	3 (5.8)	11.1		
	Decreased/Deteriorated	15 (17.31)	5.5	4 (1.7)	14.8	4.826	0.90
How the average household income changed	Increased/Improved	219 (221.1)	80.5	24 (21.9)	88.9		
	No change	24 (23.7)	8.8	2 (2.3)	7.4		
	Decreased/Deteriorated	29 (27.3)	10.7	1 (2.7)	3.7	1.454	0.483
How accessibility to water changed	Increased/Improved	138 (136.5)	50.7	12 (13.5)	44.4		
	No change	81 (81.9)	29.8	9 (8.1)	33.3		
	Decreased/Deteriorated	53 (53.7)	19.5	6 (5.3)	22.2	0.390	0.823
How accessibility to health facility changed	Increased/Improved	185 (187.4)	68.0	21 (18.6)	77.8		
	No change	76 (74.6)	27.9	6 (7.4)	22.2		
	Decreased/Deteriorated	11 (10)	4.0	0 (1.0)	0.0	1.725	0.422
How accessibility to schools changed	Increased/Improved	205 (207.4)	75.4	23 (20.6)	85.2		
	No change	60 (58.2)	22.1	4 (5.8)	14.8		
	Decreased/Deteriorated	7 (6.4)	2.6	0 (0.6)	0.0	1.607	0.448
How status of roads changed	Increased/Improved	148 (147.4)	54.4	14 (14.6)	51.9		
	No change	70 (71.9)	25.7	9 (7.1)	33.3		
	Decreased/Deteriorated	54 (52.8)	19.9	4 (5.2)	14.8	0.888	0.642
How accessibility to grazing resources changed	Increased/Improved	204 (207.4)	75.0	24 (20.6)	88.9		
	No change	23 (22.7)	8.5	2 (2.3)	7.4		
	Decreased/Deteriorated	45 (41.8)	16.5	1 (4.2)	3.7	3.286	0.193
How accessibility to electricity changed	Increased/Improved	70 (67.3)	25.7	4 (6.7)	14.8		
	No change	193 (194.7)	71.0	21 (19.3)	77.8		
	Decreased/Deteriorated	9 (10.0)	3.3	2 (1.0)	7.4	2.465	0.292
How security status changed	Increased/Improved	235 (234.7)	86.4	23 (23.3)	85.2		
	No change	8 (9.1)	2.9	2 (0.9)	7.4		
	Decreased/Deteriorated	29 (28.2)	10.7	2 (2.8)	7.4	1.720	0.423

Local involvement in conservancy management and conservation activities was associated with several demographic factors (all $\chi^2 > 4.5$, $p < 0.034$; Table 4.16). Specifically, higher than expected proportions of female respondents, respondents with formal education, and those from households with fewer (1-5) individuals reported being involved in these activities (Table 4.16). Conversely, lower than expected proportions of male respondents, respondents with no formal education, and respondents from larger households were involved in these activities (Table 4.16). In addition, higher than expected proportions of respondents who owned cattle, those who owned camels, and those with no more than 50 sheep and goats indicated that they were involved in conservancy management and conservation activities (Table 4.16). In contrast, lower than expected proportions of cattle owners, camel owners, and owners of more than 50 sheep and goats were involved in these activities (Table 4.16).

Table 4.16. Chi-square tests of association between respondents' involvement in conservancy management and conservation programmes, and various demographic factors. Values in parentheses are expected counts.

		Involvement					
		Involved		**Not involved**			
		Freq.	**%**	**Freq.**	**%**	**χ2**	***p*-value**
Gender	Male	160 (168.7)	73.1	59 (50.3)	26.9		
	Female	115 (106.3)	83.3	23 (31.7)	16.7	5.1	0.025
Education level	No formal education	141 (149.4)	72.7	53 (44.6)	27.3		
	Formal education	134 (125.6)	82.2	29 (37.4)	17.8	4.6	0.033
Household size	1 - 5	191 (175.7)	84.1	36 (51.3)	15.9		
	6 and above	83 (98.3)	65.4	44 (28.7)	34.6	16.4	< 0.001
Own cattle?	Yes	239 (230.1)	79.9	60 (68.9)	20.1		
	No	35 (43.9)	61.4	22 (13.1)	38.6	9.3	0.002
Own sheep &	Yes	263 (264.8)	76.5	81 (79.2)	23.5		
goats?	No	11 (9.2)	91.7	1 (2.8)	8.3	1.5	0.219
Own donkeys	Yes	46 (51.6)	68.7	21 (15.4)	31.3		
	No	228 (222.4)	78.9	61 (66.6)	21.1	3.2	0.073
Own camels?	Yes	88 (74.7)	90.7	9 (22.3)	9.3		
	No	186 (199.3)	71.8	73 (59.7)	28.2	14.2	< 0.001
Number of cattle	1 - 50	215 (217.4)	79.0	57 (54.6)	21.0		
	51 and Above	24 (21.6)	88.9	3 (5.4)	11.1	1.5	0.224
Number of sheep &	1 - 50	140 (130.7)	81.9	31 (40.3)	18.1		
goats	51 and Above	123 (132.3)	71.1	50 (40.7)	28.9	5.5	0.019

Key informant interviews revealed that conservancy-driven socio-economic improvements were partly linked to frameworks initiated by the conservancy through which various entities such as Northern Rangeland Trust (NRT) and other governmental and non-governmental organisations that provide economic assistance to the local community. For example, through the assistance of NRT, Naibunga Conservancy established various greenhouses across communal group ranches from which a *Cochineal* fungus was used as a biological control of the invasive plant *Opuntia* spp. is cultured. The conservancy also sought markets for livestock and women's beadwork products. This enabled the local community to maximize profits as middlemen were eliminated. Land management activities such as soil erosion control and grass reseeding were reported to have led to improved ecological conditions and increased access to grazing resources, consequently improving pastoralism, which is the main livelihood source for the local. In addition, key informants indicated that local community training programmes in various management and conservation practices enhanced both local community participation and capacity to carry out conservation and management practices.

4.5. Current vegetation species diversity and composition

4.5.1. Vegetation species composition

A total of 55 plant species belonging to 46 genus and 23 plant families were recorded. *Acacia etbaica* and *Acacia mellifera* were the most common woody species, with 20 and 32 individuals, respectively, sampled across the study area (Table 4.17). *Acacia brevispica* was only sampled in Koija group ranch, while *Acacia xanthoplea* was encountered only once throughout the survey. Other woody species frequently encountered included the *Euphorbiaceae* family, mainly *Croton dichogamus* and *Euphorbia spp* (Plate 2a). The Herb layer made the majority of plant species (45 species) across the conservancy (Table 4.17).

a. Euphorbia spp

b. Sansevieria spp

c. Spiny barleria spp

d. Opuntia spp

Plate 4:1. Some of the most common species in the study region

Table 4.17. Summarised vegetation species of Naibunga Community Conservancy

Plant form	**Family**	**Genus**	**Plant species**	**No. of encounters**
Herb	Acanthaceae	Barleria	*Spiny Barleria spp*	19
		Blepharis	*Blepharis edulis*	7
		Dyschoriste	*Dyschoriste radicans*	2
		Justicia	*Justicia white spp*	19
		Monechma	*Monechma ciliatum*	10
	Amaranthaceae	Achyrathes	*Achyrathes aspera*	1
		Alternanthera	*Alternanthera pungens*	5
		Chenopodium	*Chenopodium carinatum*	2
		Cyathula	*Cyathula cylindrica*	6
	Asparagaceae	Lily	*Lily spp*	1

		Sansevieria	*Sansevieria cylindrica*	25
	Asteraceae	Aspilia	*Aspilia africana*	14
		Gutenbergia	*Gutenbergia purpurea*	1
		Guternbergia	*Guternbergia luteoalbum*	1
		Helichrysum	*Helichrysum luteoalbum*	1
	Cactaceae	Opuntia	*Opuntia spp*	12
	Commelinaceae	Commelina	*Commelina benghalensis*	6
	Convolvulaceae	Ipomea	*Ipomea spp*	13
	Cyperaceae	Cyperus	*Cyperus rotundus*	15
		Kyllinga	*Kyllinga nervosa*	1
	Fabaceae/Leguminosae	Indigofera	*Indigofera schimperi*	19
	Geraniaceae	Monsonia	*Monsonia angustifolia*	1
	Lamiaceae	Plectranthus	*Plectranthus tomentosa*	3
	Malvaceae	Hibiscus	*Hibiscus calyphyllus*	16
	Nyctaginaceae	Commicarpus	*Commicarpus spp*	1
	Phyllanthaceae	Phyllanthus	*Phyllanthus rotundifolius*	2
	Poaceae	Aristida	*Aristida congesta*	14
			Aristida keniensis	3
		Bracheria	*Bracheria eruciformis*	1
		Cenchrus	*Cenchrus ciliaris*	33
		Cynodon	*Cynodon dactylon*	7
			Cynodon plactitatius	2
		Digitaria	*Digitaria macroblephara*	3
		Enteropogon	*Enteropogon macrostachyus*	1
		Eragrostis	*Eragrostis tenuifolia*	55
		Harpachne	*Harpachne schimperi*	2

		Lintonia	*Lintonia nutans*	1
		Pennisetum	*Pennisetum mezianum*	6
			Pennisetum stramineum	12
		Sporobolus	*Sporobolus festivus*	1
		Tragas	*Tragas betronium*	2
	Polygonaceae	Oxygonum	*Oxygonum sinuatum*	2
	Portulacaceae	Portulaca	*Portulaca oleracea*	3
	Solanaceae	Solanum	*Solanum incanum*	27
	Vitaceae	Cissus	*Cissus populnea*	1
Herb Total				**379**
Tree/Shrub	Euphorbiaceae	Croton	*Croton dichogamus*	8
		Euphorbia	*Euphorbia spp*	6
	Fabaceae	Acacia	*Acacia brevispica*	4
			Acacia etbaica	20
			Acacia mellifera	32
			Acacia nilotica	4
			Acacia tortilis	16
			Acacia xanthofloea	1
	Tiliaceae	Grewia	*Grewia tenax*	4
	Zygophyllaceae	Balanites	*Balanites aegyptiaca*	4
Tree/Shrub Total				99
Grand Total				478

4.5.2. Vegetation structural composition

Structurally, vegetation was divided into three storeys. Tall trees of *Acacia* and *Balanite* species of heights > 3metres formed the upper storey while tree and shrub species of *Grewia tenax* and *Croton dichogamus* of height < 3metres formed the middle storey. Large-leaved herbaceous plants and grasses constituted the understorey. Acacia species with rare occurrences of *Balanites aegyptiaca* constituted the upper canopy. Tree/shrubs heights

ranged between 0.150 metres and 5.78 metres. Overall, the tree/shrub mean height of 1.73 metres (Table 4.18).

Table 4.18. Tree/shrub species mean height distribution for the selected group ranches across Naibunga Community Conservancy

Block	Plant species	Total count	Per cent	Mean height	SE Mean	St-Dev	Min height	Max height
Ilmotiok	*Acacia etbaica*	9	45	2.706	0.462	1.387	0.490	4.610
	Acacia mellifera	9	45	1.880	0.460	1.380	0.320	3.460
	Balanites aegyptiaca	2	10	0.570	0.110	0.156	0.460	0.680
Ilpolei	*Acacia etbaica*	4	25.00	1.403	0.463	0.925	0.200	2.350
	Acacia mellifera	6	37.50	2.862	0.171	0.419	2.320	3.370
	Acacia nilotica	1	6.25	1.4800	*	*	1.4800	1.4800
	Acacia tortilis	4	25.00	1.555	0.719	1.439	0.150	3.270
	Grewia tenax	1	6.25	0.2200	*	*	0.22000	0.22000
Koija	*Acacia brevispica*	4	15.3846	1.045	0.273	0.545	0.510	1.790
	Acacia etbaica	2	7.6923	4.01	1.77	2.50	2.24	5.78
	Acacia mellifera	4	15.3846	2.72	1.04	2.09	0.25	5.24
	Acacia tortilis	2	7.6923	2.650	0.420	0.594	2.230	3.070
	Croton dichogamus	8	30.7692	1.857	0.266	0.752	0.940	3.340
	Euphorbia spp	6	23.0769	1.482	0.199	0.487	0.730	2.230
Munishoi	*Acacia etbaica*	5	21.7391	2.236	0.733	1.639	0.450	4.400
	Acacia mellifera	13	56.5217	1.415	0.333	1.201	0.160	3.500
	Acacia tortilis	1	4.3478	0.4400	*	*	0.44000	0.44000
	Balanites aegyptiaca	2	8.6957	1.210	0.370	0.523	0.840	1.580
	Grewia tenax	2	8.6957	0.355	0.155	0.219	0.200	0.510
Musul	*Acacia nilotica*	3	20.0000	1.513	0.407	0.706	0.790	2.200
	Acacia tortilis	9	60.0000	1.006	0.285	0.855	0.170	2.980
	Acacia xanthofloea	1	6.6667	2.7900	*	*	2.7900	2.7900
	Grewia tenax	1	6.6667	0.2900	*	*	0.29000	0.29000
Overall	*Acacia brevispica*	4	4	1.045	0.273	0.545	0.510	1.790
	Acacia etbaica	20	20	2.458	0.344	1.540	0.200	5.780
	Acacia mellifera	32	32	1.980	0.241	1.363	0.160	5.240

Acacia nilotica	4	4	1.505	0.288	0.576	0.790	2.200
Acacia tortilis	16	16	1.313	0.273	1.090	0.150	3.270
Acacia xanthofloea	1	1	2.7900	*	*	2.7900	2.7900
Balanites aegyptiaca	4	4	0.890	0.243	0.486	0.460	1.580
Croton dichogamus	8	8	1.857	0.266	0.752	0.940	3.340
Euphorbia spp	6	6	1.482	0.199	0.487	0.730	2.230
Grewia tenax	4	4	0.3050	0.0710	0.142	0.2000	0.5100

4.5.3. Vegetation species diversity

Simpson's species diversity index ranged between 0.8794 and 0.9524 across all sampled sites (Table 4.19). Koija Group Ranch had the highest plant species diversity, followed by Ilmotiok. Ilpolei had the lowest plant species diversity (Table 4.19).

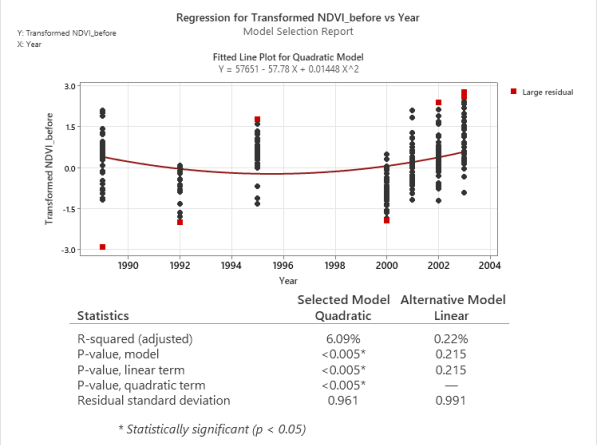
Table 4.19. Simpson's diversity indices for selected group ranches

No.	Site Name (Sampling block)	Simpson index of diversity
1.	Ilmotiok	1 - 0.9312
2.	Ilpolei	1 - 0.8971
3.	Koija	1 - 0.9524
4.	Munishoi	1 - 0.9260
5.	Musul	1 - 0.8794

4.5.4. Effects of community conservancy model on Normalized Difference Vegetation Index (NDVI)

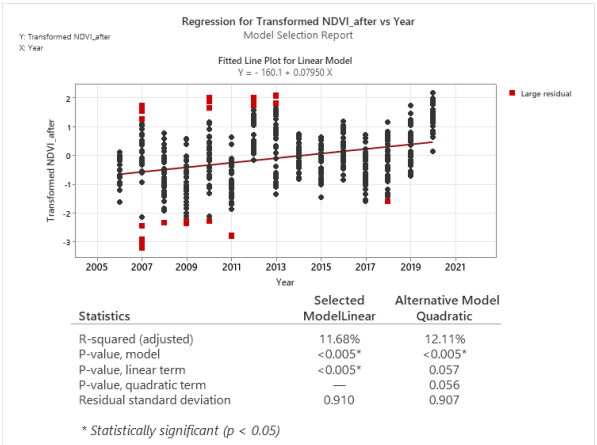
- **Regression plot analysis results**

Year and Period were significant predictors of NDVI ($F_{1, 794} > 52.80$, $p < 0.01$). The NDVI temporal trend for the period prior to conservancy establishment (1989 – 2003) showed a decreasing trend in mean NDVI before assuming an increasing trend (Figure 4.2). On the other hand, the NDVI for post-conservancy establishment (2006 – 2020) showed increasing temporal trend throughout the period (Figure 4.2). The decline in NDVI in the better part of the first 14 years before the conservancy was established and the increasing trend after the conservancy establishment were statistically significant ($p < 0.05$, Figure 4.3). In addition, NDVI showed significant temporal trends for dry and wet seasons in both periods ($p<0.05$, Figure 4.3).



Statistics	Selected Model Quadratic	Alternative Model Linear
R-squared (adjusted)	6.09%	0.22%
P-value, model	<0.005*	0.215
P-value, linear term	<0.005*	0.215
P-value, quadratic term	<0.005*	—
Residual standard deviation	0.961	0.991

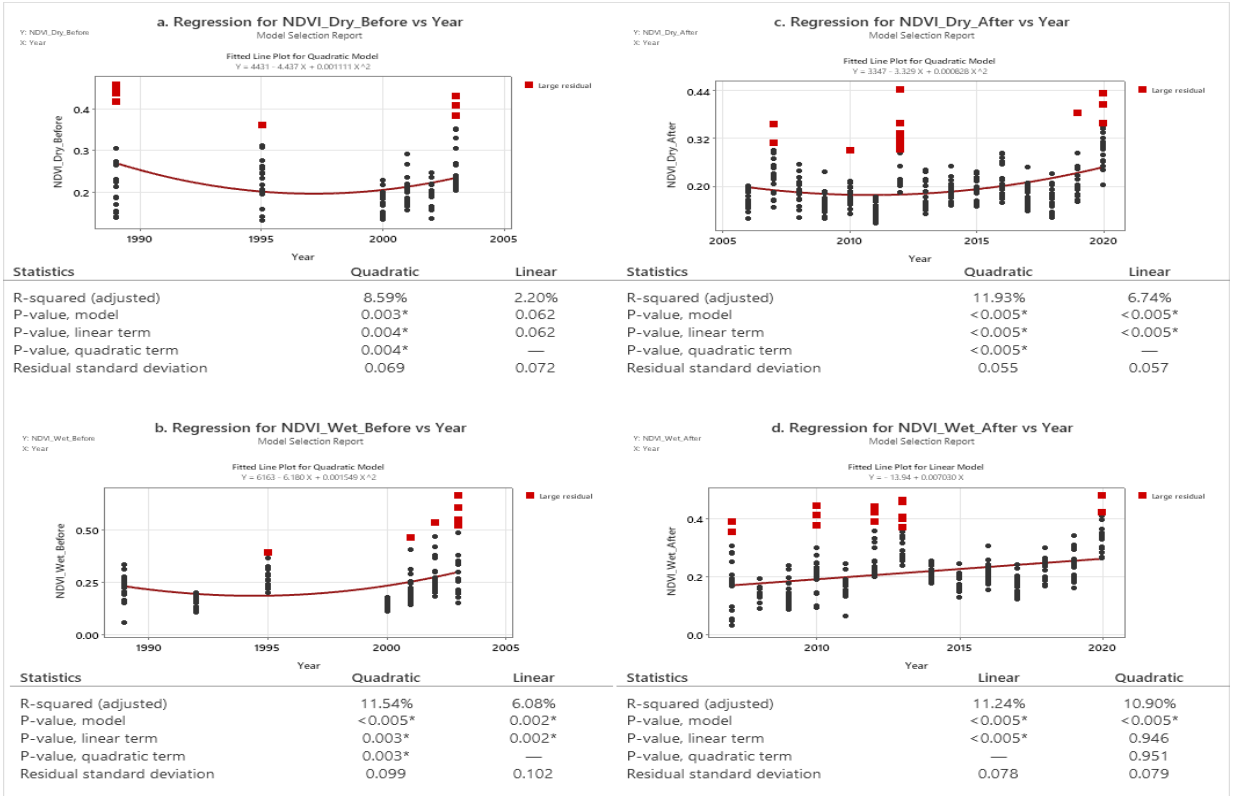
** Statistically significant (p < 0.05)*



Statistics	Selected ModelLinear	Alternative Model Quadratic
R-squared (adjusted)	11.68%	12.11%
P-value, model	<0.005*	<0.005*
P-value, linear term	<0.005*	0.057
P-value, quadratic term	—	0.056
Residual standard deviation	0.910	0.907

** Statistically significant (p < 0.05)*

Figure 4.2. Regression Analysis plot of NDVI before and after the establishment of Naibunga Community Conservancy



Statistics	Quadratic	Linear
R-squared (adjusted)	8.59%	2.20%
P-value, model	0.003*	0.062
P-value, linear term	0.004*	0.062
P-value, quadratic term	0.004*	—
Residual standard deviation	0.069	0.072

Statistics	Quadratic	Linear
R-squared (adjusted)	11.93%	6.74%
P-value, model	<0.005*	<0.005*
P-value, linear term	<0.005*	<0.005*
P-value, quadratic term	<0.005*	—
Residual standard deviation	0.055	0.057

Statistics	Quadratic	Linear
R-squared (adjusted)	11.54%	6.08%
P-value, model	<0.005*	0.002*
P-value, linear term	0.003*	0.002*
P-value, quadratic term	0.003*	—
Residual standard deviation	0.099	0.102

Statistics	Linear	Quadratic
R-squared (adjusted)	11.24%	10.90%
P-value, model	<0.005*	<0.005*
P-value, linear term	<0.005*	0.946
P-value, quadratic term	—	0.951
Residual standard deviation	0.078	0.079

Figure 4.3. Regression analysis of NDVI for the dry and wet season before and after conservancy establishment

- **Mann-Whitney test results**

The NDVI median value for the period before (0.2100) and after (0.1922) conservancy establishment were significantly different (p<0.01, table 4.20).

Table 4.20. Mann-Whitney test results

Null hypothesis: H_0: $\eta_1 - \eta_2 = 0$ Alternative hypothesis: H_1: $\eta_1 - \eta_2 \neq 0$		
Method	**W-Value**	**P-Value**
Not adjusted for ties	109287.00	0.000
Adjusted for ties	109287.00	0.000

4.6. Effects of the conservancy on the trends of livestock and wild ungulate numbers

Livestock formed the majority of herbivores in the Naibunga conservancy ecosystem (Table 4.21). Wild Ungulate population ranged between 40 and 1500 throughout the 1990 - 2016 survey periods for each survey. Wild ungulates recorded during the survey included elephants, Burchell's and Grevy's zebras, Grant's gazelles, Thomson's gazelles, gerenuk, impala and oryx (Table 4.21).

Table 4.21. Livestock and wild Ungulate data for Naibunga conservancy between 1990 and 2016

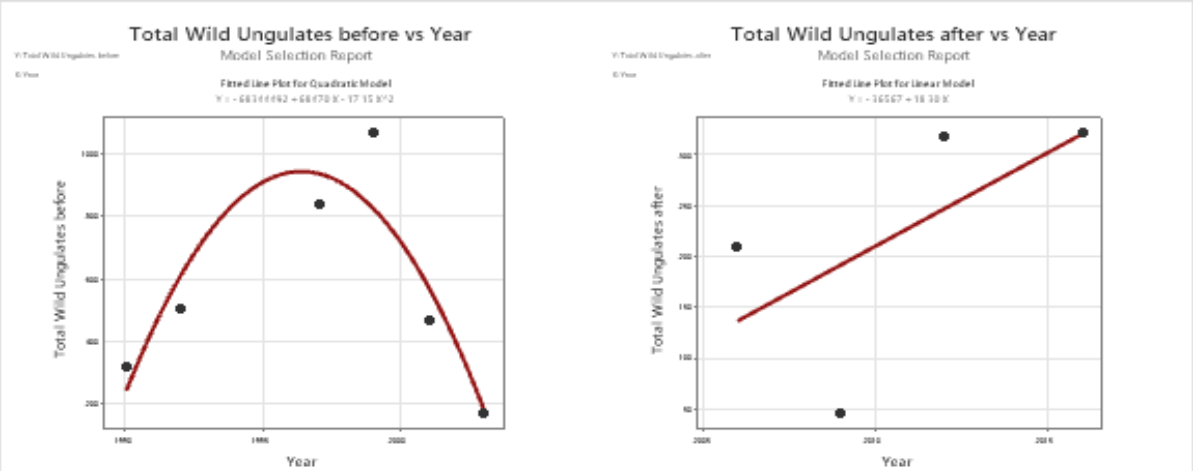
Year	Cattle	Sheep and Goats	Camels	Donkeys	Elephants	Zebras	Antelopes
1990	15059	28163	-	2338	-	-	321
1992	1974	8733	712	-	40	61	406
1997	3560	15949	438	242	121	167	548
1999	6479	17652	532	332	-	598	465
2001	3687	17210	503	483	-	154	317
2003	9869	28505	218	268	-	108	67
2005	8763	15353	140	281	90	70	50
2009	3176	32406	164	202	28	-	19
2012	4829	31600	375	144	0	241	76
2016	4953	36829	74	222	0	120	101

Source: Directorate of Resource Survey and Remote sensing, Kenya (2021)

4.6.1. Regression analysis result of livestock and wild ungulate numbers against time

The wild ungulate numbers increased in the first half before conservancy establishment and declined in the last half of the same period. Regression analyses results show that the temporal trends in the numbers of wild ungulate were statistically significant before and statistically insignificant after conservancy establishment (p =0.033 and p= 0.392,

respectively, Figure 4.3). Antelopes (but not elephants and zebras) showed significant negative temporal trends before conservancy establishment (p=0.002, Figure 4.4a). Antelope numbers significantly declined during this period to the extent that the total number of antelopes were significantly different between the two periods (t = -3.42, p=0.009). Elephants (but not antelopes and zebras) showed a significant declining trend after conservancy establishment (p = 0.045, Figure 4.4d)



Statistics	Selected Model Quadratic	Alternative Model Linear
R-squared (adjusted)	70.88%	0.00%
P-value, model	0.073	0.950
P-value, linear term	0.033*	0.950
P-value, quadratic term	0.033*	—
Residual standard deviation	178.199	368.998

Statistics	Selected Model Linear	Alternative Model Quadratic
R-squared (adjusted)	5.45%	0.00%
P-value, model	0.392	0.747
P-value, linear term	0.392	0.781
P-value, quadratic term	—	0.780
Residual standard deviation	125.008	166.369

Figure 4.4. Regression analyses for wild ungulate before and after conservancy establishment

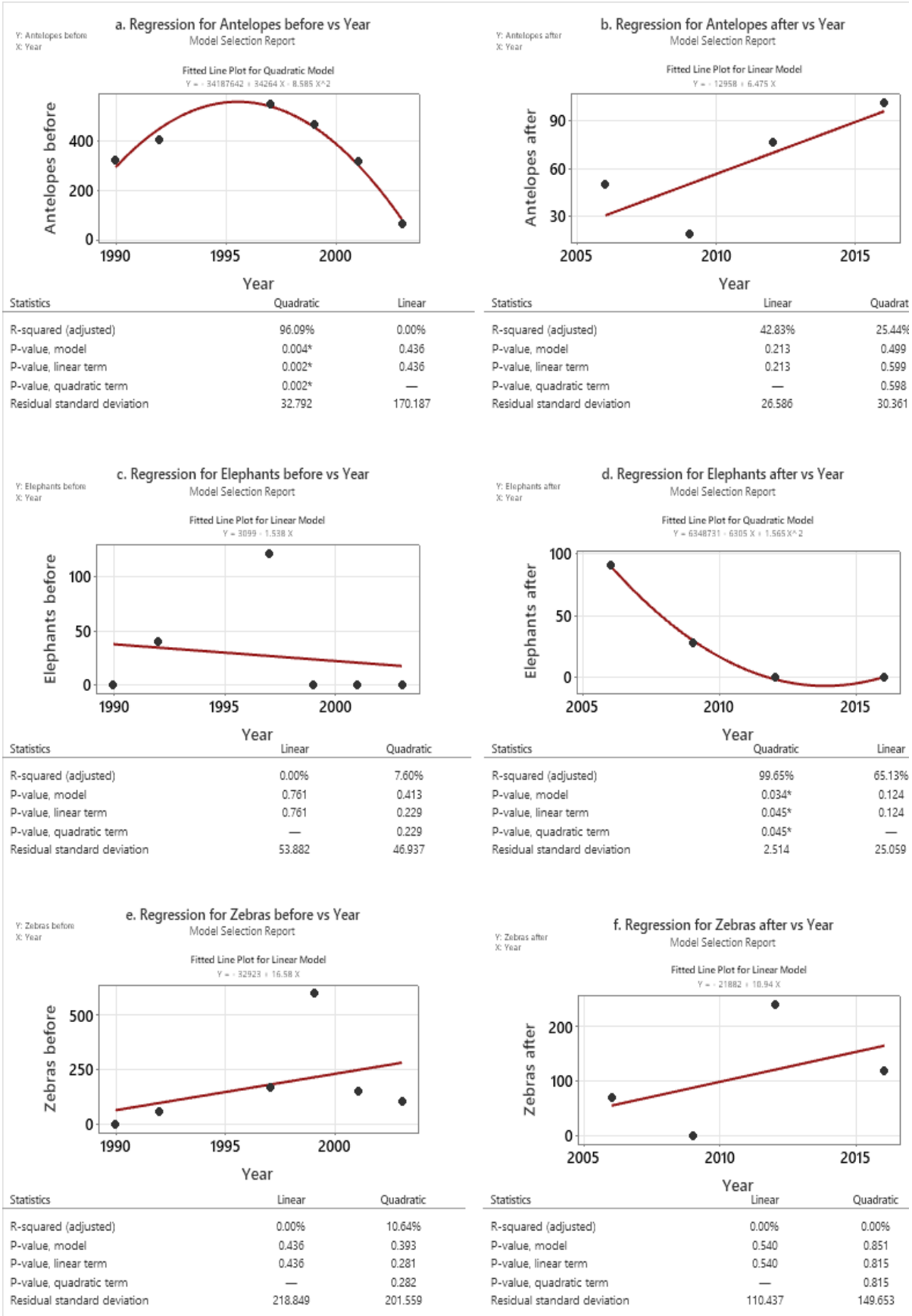


Figure 4.5. Regression analyses for various species of wild ungulates before and after conservancy establishment

Livestock numbers remained unchanged prior to conservancy establishment and increased after conservancy establishment. However, the trends were statistically not significant (p > 0.076, Figure 4.6 b). In addition, the specific livestock species exhibited non-significant varying temporal trends in their numbers before and after conservancy establishment. For example, cattle numbers showed a declining trend in the two periods (Figure 4.6 c and 4.6 d), while sheep and goats showed varying rates of increase in their numbers before and after conservancy establishment (Figure 4.6 e and 4.6 f).

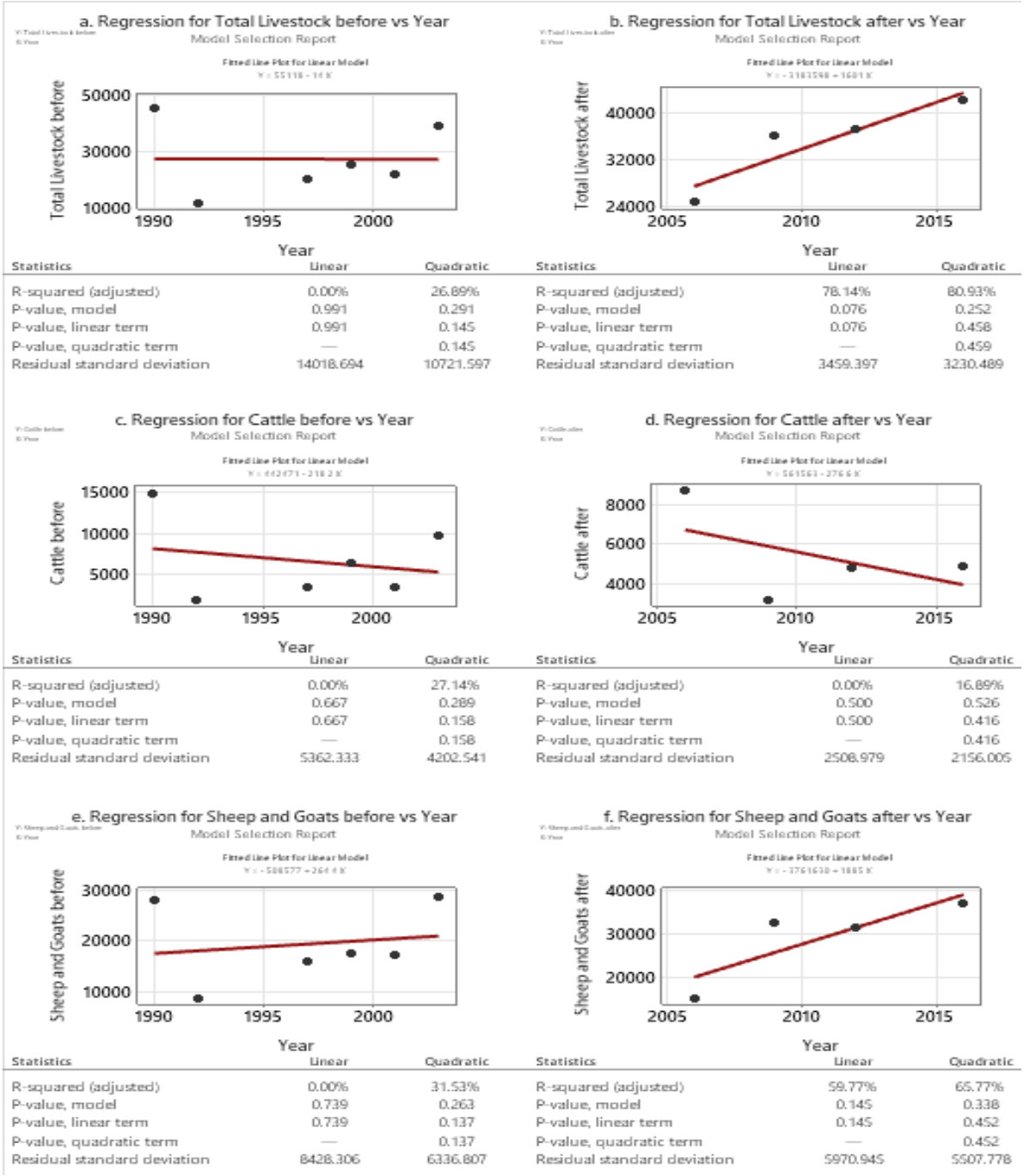


Figure 4.6. Regression analyses of total livestock numbers before and after conservancy establishment

CHAPTER FIVE

DISCUSSION

5.1. Conservancy-related socioeconomic impacts

Socioeconomic outcomes are important in determining the success or failure and consequently, the general impacts of community-based conservation initiatives. This is because local community members will likely support initiatives that improve their socioeconomic well-being and shun those that they deem non-beneficial to them (Goodwin & Santilli, 2009; Oduor, 2020; Riehl *et al*., 2015; Syallow, 2013). This study shows that a vast majority (~ 90%) of local community members perceived improvement in their socioeconomic status following conservancy establishment. Also, large proportions (> 65%) of community members perceived conservancy-related improvements in several other socioeconomic indicators, namely, security situation, access to grazing resources, household income, access to educational and health facilities, and livestock numbers. These findings generally suggest that the community conservancy model, as applied in this study region, can improve the socio-economic wellbeing of local pastoralists.

A high proportion of respondents reported perceived improvement in the security situation. This is consistent with a recent report from northern Kenya indicating that nearly eight-tenths of conservancy members felt safer due to security enhancement and peace-building efforts undertaken by conservancies (Northern Rangelands Trust, 2020). In the region within which Naibunga is found and similar pastoralist settings across sub-Saharan Africa, local communities commonly suffer from various forms of insecurity. They include livestock theft (e.g., cattle raiding), wildlife poaching, banditry, invasions and illegal grazing, and conflict over natural resources (Kantai, 2012; KWCA, 2016; Liniger & Studer, 2019). Such persistent insecurity threatens pastoralists' socioeconomic well-being by impairing their ability to participate more effectively in income-generating activities (Mbugua, 2016; Nyariki & Amwata, 2019). This study attributes improved security to better coordination and enhanced peacebuilding and conflict resolution efforts under the community conservancy framework. Community conservancies within the area where this study was conducted often invest in community policing to complement efforts by local and national government agencies and non-governmental organizations (KWCA, 2016; Northern Rangeland Trust, 2019; Northern Rangelands Trust, 2020). Specifically, the conservancies work closely with the Northern Rangelands Trust (NRT), Kenya's National Police Service (NPS), Kenya Wildlife Service

(KWS) and county governments to provide a community-driven approach to tackling security and reducing conflict. Key informant interviewed in this study revealed that similar security enhancement efforts are implemented in Naibunga Conservancy.

This study also found that local perception of improved security was positively associated with cattle ownership and camel ownership, suggesting that enhancing security is particularly important for livestock owners. A similar association was noted between security perception and ownership of sheep and goats; however, this particular finding should be interpreted with caution because it was not statistically valid (i.e., less than 80% of cells had expected frequency values equal to or greater than 5). Livestock (especially cattle, sheep, goats and camels) are highly valued and are a major source of livelihoods for pastoral communities in Kenya's arid and semiarid regions (Keane *et al*., 2016; Nyariki & Amwata, 2019). Therefore, pastoralists may be particularly concerned about the security of their livestock.

This study's result also observed perceived improvements in livestock numbers and accessibility to grazing resources. At face value, the perceived improvement may appear somewhat surprising. Under the community conservancy framework within the region where this study was conducted, local pastoralists typically make trade-offs by setting aside portions of their communal land for wildlife conservation (Kimiti *et al*., 2017; Krug, 2001; Mureithi *et al*., 2019). As such, it was expected that this would reduce the area available for grazing their livestock. However, local community members are usually allowed to graze their livestock in these areas during the dry season (Glew *et al*., 2010), thereby partly mitigating the impact of this trade-off. The fact that large proportions of respondents perceived these improvements suggests that it is possible to achieve a win-win outcome for both biodiversity conservation and livestock production under the community conservancy framework.

This study partly attributes improvements in accessibility to grazing resources and livestock numbers to the various conservancy-driven land and grazing management initiatives revealed by the key informants. As attested by the key informants, grazing management initiatives may have improved rangeland condition and forage availability for both livestock and wildlife, consistent with previous findings in the study region (Hauck & Rubenstein, 2017; Lalampaa *et al*., 2016; Odadi *et al*., 2017). Further, this study relates these improvements to improved security under a community conservancy setting. Specifically, the study posits that improved security reduces livestock losses to theft, thereby contributing to overall increases in livestock numbers across the landscape. In addition, improved security minimizes

incursion grazing and conflicts over resources, thereby increasing forage availability for local community members' livestock. These arguments are supported by the views of key informants, who pointed out the negative impacts of insecurity on livestock and grazing resources. As the key informants observed, insecurity reduces accessibility to grazing resources because pastoralists tend to avoid herding their livestock in areas they consider insecure. Consequently, their high concentrations in areas considered safer lead to overgrazing and subsequent degradation of forage resources in these areas. As such, in addition to allowing pastoralists' livestock access to conservation periodically, community conservancies can enhance socioeconomic and conservation outcomes by increasing efforts towards implementing community-based sustainable land and grazing management practices and enhancing security for local pastoralists and their livestock.

Other perceived conservancy-driven improvements included the average household income, increased accessibility to health facilities, and increased accessibility to schools. Improvements in average household income were positively associated with livestock ownership (especially cattle and camels). This suggests that livestock keeping is a major driver of household income improvement since an overwhelming majority of community members in this study region are pastoralists. Under the community conservancy framework, local pastoralists can derive enhanced benefits from livestock through multiple pathways. One such pathway is improved profitability of livestock sales through the various conservancy-driven market access enhancement initiatives for livestock that the key informants identified. As pointed out by the key informants, such initiatives enable local pastoralists to maximize profits by selling their livestock at more competitive prices. Consistent with these findings, it was recently reported that cattle sales by pastoralists from community conservancies in northern Kenya improved by nearly 50% over one year due to such livestock market enhancement initiatives (Northern Rangelands Trust, 2020). As such, the findings of this study underscore the important role such conservancy-driven market access initiatives for livestock play in improving local livelihoods.

In addition to improved livestock markets, increased pastoralists' household income could also be related to increased livestock productivity triggered by conservancy-driven improved availability of forage resources (Lalampaa *et al*., 2016; Odadi *et al*., 2017). Furthermore, this study posits that an improved security situation creates an enabling environment for better livestock rearing and productivity, thereby leading to improved household income for local

pastoralists. Improvement in local household income can additionally be related to employment and business opportunities created by the conservancy based on the information obtained from key informant interviews. The creation of such opportunities appears to be vital in helping local community members diversify their income streams, leading to increased local household incomes.

The study's findings on perceived changes in accessibility to schools and health facilities resonate with information obtained from key informants and the conservancy's current strategic plan (Northern Rangeland Trust, 2017). Specifically, the conservancy strives to improve accessibility to schools in various ways, including expanding education facilities to include adult education and boarding schools, lobbying community members to increase school enrolment and awarding bursaries to needy students. In terms of health, the conservancy prioritises the construction of health facilities to cover as many settlements as possible, enhancing mobile clinic and ambulance services and training community health workers. The observed perceived improvements in accessibility to schools and health facilities generally suggests that the conservancy is making some progress on these fronts. However, based on this study's findings, the majority of local community members had no formal education, and that just one out of ten members had post-primary education. Therefore, more efforts need to be directed towards enhancing accessibility to educational facilities. Notably, the observed positive association between formal education and involvement in conservancy activities suggests that expanding educational opportunities for local community members will be beneficial to local community members while also contributing towards desirable outcomes for conservancy management and conservation programmes.

In addition, the positive association between local perception of improvement in access to both schools and health facilities and livestock ownership suggests that livestock owners may be having better access to these facilities, likely because of higher household income. This argument is consistent with the positive association between the perception of improved household income and livestock ownership that was observed in this study. In addition, there is evidence that pastoralists in this region sell their livestock to pay school fees for their children (Mwangi *et al*., 2020), further underscoring the role of livestock in enhancing accessibility to schools. Therefore, community conservancies should redouble their efforts to create a favourable environment for livestock rearing as a strategy to enhance local household

incomes and accessibility to these facilities. In addition, based on the observed gender disparity in formal education (females were less educated than males), community conservancies should further direct their efforts towards enhancing girl-child education to address this disparity.

The conservancy also focuses on improving the road network and improving access to water by renovating water points and constructing water pans (Northern Rangeland Trust, 2017). However, the fact that only moderate proportions (~53%) of respondents perceived improvements in these facilities indicates that more needs to be done on these fronts. The findings of this study on local perception of change in water accessibility are consistent with information from the study's key informants. Whereas the key informants indicated that the conservancy had attempted to increase accessibility to water, they also indicated that water scarcity remains a big challenge for local community members. As opined by key informants, water scarcity heightens conflicts among people as well as between people and wildlife. The observed negative association between the perception of improved accessibility to water and cattle ownership suggests that available water sources are insufficient not only for people but also for livestock and wildlife. Therefore, to better enhance conservation and socioeconomic outcomes, community conservancies should focus on developing more effective strategies to improve water availability for pastoralists, their livestock and wildlife.

The fact that an overwhelming majority (more than seven-tenths) of respondents did not perceive improvement in accessibility to electricity may be due to difficulties in distributing mains electricity in such vast and sparsely populated landscapes. This could be one of the reasons why improving accessibility to electricity has not been prioritised, based on the conservancy's current strategic plan (Northern Rangeland Trust, 2017). This study proposes that community conservancies in such pastoral landscapes should direct more efforts towards improving local accessibility to alternative energy sources, especially solar power, if they are to better enhance the socioeconomic well-being of local pastoralists. Such an intervention could importantly bolster the local economy by enhancing domestic lighting, accessibility to water through solar-powered water pumps, and the use of mobile phones, which is fast expanding in these pastoral regions (Butt, 2015). In addition, improving local accessibility to solar power could better mitigate human-wildlife conflicts through the use of solar-powered light-emitting diode (LED) flashlights to reduce livestock depredation by lions (Lesilau *et al*., 2018).

5.2. Local community involvement in Conservancy Management and Conservation Activities and its effect on community perception of conservancy's socioeconomic impacts

Local participation has been identified as a key determinant of socioeconomic and conservation outcomes of community-based conservation projects (Brooks, *et al*., 2013; Goodwin & Santilli, 2009; Lichtenfeldet., 2019; Liniger & Studer, 2019). In this study, an overwhelming majority of participants reported that they are involved in the various conservancy's management and conservation activities. Key informants revealed that the local communities are mainly involved in rangeland rehabilitation and restoration, community-based grazing management, participation in management committees, and capacity building. An overwhelming majority (nearly eight-tenths) of respondents reporting involvement in these activities demonstrated a considerably high level of support for the conservancy and its programmes among local community members. Generally, the level of involvement of 1 – 10 hrs per weeks was reported by the majority of the respondents. The observed overwhelming majority of respondents reporting to be involved for not more than 10 hours per week suggests that this is the participation level that best balances engagement in individual activities with engagement in conservancy activities.

The study showed a significant association between local community involvement in the conservancy's management and conservation activities and their perception of the socioeconomic impacts of the conservancy. Specifically, a positive association was observed between local community members' involvement in these activities and their perceptions of conservancy-related socioeconomic improvements. These findings resonate with other studies showing that local perceptions of socioeconomic benefits of community-based conservation initiatives play a pivotal role in increasing local participation in such initiatives (Ward *et al*., 2018; Wyman & Stein, 2010). In addition, the study shows that community involvement was positively associated with formal education, livestock ownership and gender. Respondents with some level of formal education reported involvement in conservancy management activities underscoring the importance of education in enhancing local participation in these activities. Education has been identified as a key factor in improving local participation in conservation (Kaeser, 2016). Specifically, formal education importantly prepares people to participate in activities that require the application of skills and knowledge and improves their self-confidence (OECD, 2013).

The study also noted a higher than expected proportion of females reporting involvement in conservancy management and conservation activities, suggesting that females can play a pivotal role in community-based initiatives, as has also been reported elsewhere (Keane *et al*., 2016; Ray *et al*., 2017). It is noteworthy that this gender disparity in local participation in conservancy activities was observed despite females being generally less educated than males, yet education positively influenced local participation. While what drove gender disparity in local participation is unclear, this study posits that the observed gender disparity in perception of conservancy-related improvement in accessibility to grazing resources could be responsible. In addition, men in this study region largely take care of cattle, which usually require more forage and water, and are normally herded in far-flung areas away from homesteads (Mwangi *et al*., 2020). Therefore, males engaged in cattle herding may have little time to participate in conservancy management and conservation activities.

The observed positive association between livestock ownership and local community members' participation in conservancy activities can be attributed to the fact that livestock ownership was also positively associated with the perception of conservancy-related socioeconomic improvements, a major determinant of local participation. Livestock owners appear to be more motivated to participate in these activities as a way of ensuring better livestock productivity and profitability. However, this study attributed an exceptional negative relationship between sheep and goat herd size and involvement in conservancy activities to the possibility that households with larger herd sizes have less time available to participate in conservancy activities as they have more animals to look after.

5.3. Vegetation attributes

The Naibunga Community Conservancy has a generally low plant species diversity based on the relatively low values of Simpson's diversity (0.8794 and 0.9524) observed in this study. This shows that the probability of sampling two individuals belonging to two different species is very low across all the sampled blocks. According to Hooper *et al*. (2005), higher species diversity is required for a stable supply of ecosystem goods and services. In addition, higher species richness reduces the susceptibility of an ecosystem to invasive and exotic species (Hooper *et al*., 2005).

The study noted that the study area is dominated by large-leaved herbaceous species ranging from *Solanum* spp, *Justicia* spp, *Commelina* spp., *Ipomea*, *Barleria*, among others. The emergence and domination of large-leaved herbaceous species imply the vegetation of the

study region may be undergoing some transition. According to the State and Transition Model (STM), vegetation transitions may be activated by natural events such as abundant rain or extreme drought, by artificial events such as disturbance and/or management action such as grazing, use of fire, or by the interaction of any of these factors (Heshmati & Mohebbi, 2013). This observation collaborates the fact that establishment of Naibunga conservancy and the subsequent introduced management and conservation activities may be having ecological impacts. As conceptualised by this study, management practices such as altered herbivory intensity, grass reseeding, mechanical management of invasives species, among others trigger changes in the range conditions via multiple pathways depending on the sequence of the driving factor that causes such changes (Briske, 2017; Heshmati & Mohebbi, 2013). This leads to shifts in vegetation composition along multiple continuums producing multiple stable plant communities due to internal ecosystem mechanisms, such as competitive dominance of invaders like *Opuntia* spp and *Sansevieria* spp or plant-environment feedbacks that favour new species under the same soil and climate conditions (Bestelmeyer *et al*., 2017). The continuous domination of invasive plant species such as *Opuntia* spp and *Sansevieria* spp at the expense of the native plants poses a great threat to the availability of grazing resources as they undermine the quality and quantity of forage species for livestock and wildlife (Moore *et al*., 2006). This will further have unfavourable implications on the livelihood of the local pastoral community, who entirely depend on pastoralism as the main source of livelihood.

However, despite the existing risk of reduced forage due to the replacement of perennial grasses, this study revealed a concerted effort to curb the spread of invasive species and increase forage species. For example, the key informant interviews revealed that the conservancy had initiated communal planned rotational grazing, biological and mechanical control of invasive species and reseeding programmes. Some success have been reported in reseeding trials in various parts of Kenya (Kimiti *et al*., 2017; Nyberg *et al*., 2015). In addition, this study revealed a significantly increasing trend in NDVI after conservancy establishment as opposed to a declining NDVI trend that had been observed before conservancy establishment. Similar results were reported in studies carried out within the conservancy by Mureithi *et al*. (2019) and Oguge (2005). It is, however, important to note that despite the stable NDVI trends, NDVI values remained low after the conservancy was established. This implied a slow ecosystem recovery process mediated by unfavourable environmental and climatic factors experienced in the area. In addition, ground-truthing data

show that vegetation is hugely composed of large-leaved annual herbs, coupled with invasive species such as *Opuntia* spp and *Sansevieria* spp that are unpalatable to livestock (Geng *et al*., 2019; Odadi *et al*., 2017). Large-leaved vegetation may render this ecosystem unproductive and unable to provide foraging resources to livestock and wild herbivores. In addition, large-leaved vegetation may be highly unstable under fluctuating climatic conditions and disturbance (Geng *et al*., 2019). As such, land management practices and continuous conservation efforts geared towards enhancing the takeover of species of importance needs to be intensified to ensure that the use of such ecosystems does not compromise its ecological integrity.

5.4. Livestock and wild ungulate numbers dynamics

Wild ungulates were generally less abundant compared to livestock. While livestock numbers ranged in tens of thousands, while that of wild ungulates ranged below one thousand in all the surveys carried between 1990 and 2016. The population of sheep and goats, which make the majority of livestock, continued to show an increasing trend. At the same time, wild ungulate species such as zebras and antelopes exhibited a declining temporal trend in their numbers. These findings are in agreement with previous studies generally indicating increasing livestock numbers at the expense of wildlife numbers (Ogutu *et al*., 2016, 2017; Ottichilo *et al*., 2000). For instance, it had been previously estimated that some species had declined by up to 68% between 1977 and 2016 (Ogutu *et al*., 2016). Declines in wildlife numbers in the study region have been associated with increased human settlement, land tenure regimes that fragmented rangeland ecosystems into small private ranches, consequently, giving a competitive advantage to livestock for forage, arable agricultural expansion that has alienated wildlife and frequent occurrence of drought due to climate change (Ogutu *et al*., 2016, 2017; Ottichilo *et al*., 2000)

The conservancy significantly affected specific populations of livestock and wild ungulate. Sheep and goats' population significantly increased after conservancy establishment while the antelope population significantly declined. The sheep and goats' population appear to be doing better than other livestock and wild ungulate species. This may be attributed to several reasons. First, their small body size and low metabolic requirements that enable them to minimize their requirements in areas or seasons where food sources are limited in quality and quantity (Daramola & Adeloye, 2008; Rook *et al*., 2004). However, wild ungulates of similar body size, specifically antelopes, appear not to perform as well as sheep and goats. The study shows that the antelope numbers significantly reduced before the conservancy establishment

and did not show any significant positive trend after the conservancy establishment. The possible explanation for this would be the human factors involved. For example, Dettenmaier *et al*. (2017) noted that the role of human dimensions in grazing indirectly contributes to ecological outcomes of grazing systems. As such, this study posits that the observed higher sheep and goats' number compared to wild ungulate of similar body size could be due to the role of humans in facilitating sheep and goat grazing at the expense of wild ungulate.

Second, studies on the livestock and wildlife co-existence in the rangelands argue that livestock grazing systems constitute a complex combination of factors (Augustine *et al*., 2011; Dettenmaier *et al*., 2017; Krausman *et al*., 2009; Niamir-Fuller *et al*., 2012; Veblen *et al*., 2015; Veblen & Young, 2010). The factors include animal type, stocking rate, animal distribution, timing, duration, frequency, among other factors. The interaction of these factors may have invariably good or bad effects on wildlife. For example, cattle corrals or bomas have been shown to leave behind patches of areas characterized by highly nutritious forage. Proximity and exclusive access of sheep and goats compared to wild ungulates to these areas may be working more to the advantage of sheep and goats as opposed to wild ungulates (Augustine *et al*., 2011; Muchiru *et al*., 2009; Treydte *et al*., 2006). In addition, livestock grazing management systems have been shown to affect rangeland ecosystem structure, in turn influencing the flow of other ecosystem goods and services and ultimately affecting wildlife numbers (Kimuyu *et al*., 2017; Veblen & Porensky, 2019).

Lastly, poor soil nutrients and widely varied geological attributes of most tropical rangelands could hugely affect wild ungulate numbers than livestock (Augustine *et al*., 2011). This is because livestock may easily overcome these barriers through adaptive advantage presented to them through human-mediated grazing approaches. For example, Niamir-Fuller *et al*. (2012) observed that pastoralists and their livestock harass and exclude other grazers and herbivores species from areas around water points apart from transforming the formerly open landscape with soft boundary like fences. In addition, the highly occupied areas with human settlement could also be affecting wildlife herbivore populations, as wild animals tend to avoid areas heavily occupied by humans (Niamir-Fuller *et al*., 2012). Therefore, important livestock population regulatory mechanisms need to be prioritized to balance livestock and wild ungulate numbers. For example, ecological models capturing the relationships between livestock and wild ungulate numbers need to be developed and implemented.

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

In the current the current period where climate change is increasingly impacting livelihoods and functional abilities of numerous ecosystems in providing valuable goods and services, community conservancies have been touted as a panacea to land degradation and enhancing livelihoods in rangeland ecosystems. It appears the community conservancy model is making strides in achieving these objectives if the result of this study is anything to go by. A summary of the findings of this study shows:

i. A large proportion (nearly eight-tenths) of community members were involved in conservancy management and conservation activities suggesting that the community conservancies is a good approach that can be harnessed to enhance participatory conservation approach of communal rangelands.

ii. The study showed that local participation in these activities positively influenced local community members' perceptions of conservancy-related socioeconomic outcomes and therefore, the general community conservancy impacts. However, other aspects such as livestock ownership, and possession of formal education played a role in influencing community members' perceptions of community conservancy's impacts. In addition, the study observed gender disparity in local participation in conservancy activities, with a higher proportion of females reporting participation compared to males.

a. A vast majority (nine-tenths) of local community members perceived that their overall socioeconomic status had improved since the establishment of the conservancy. In addition, large proportions of local community members perceived conservancy-related improvements in various other socioeconomic attributes, including security situation, household income, livestock numbers, and accessibility to grazing resources, schools, and health facilities. These improvements were attributed to various initiatives implemented by the conservancy, including peace and security enhancement, community-based rangeland restoration and grazing management, enhancement of access to livestock markets, employment, and small business opportunities, and provision of educational bursaries.

b. Low to moderate proportions of community members perceived improvements in the status of roads, and accessibility to water and electricity, suggesting slower progress in addressing the challenges associated with these socioeconomic attributes.

iii. Plant species diversity was generally low across the conservancy, which is worrying given that higher plant species are important for ecosystem integrity and in the provision of ecosystem services for wildlife, livestock and people.

iv. The study also showed a declining NDVI trend prior to but not after the conservancy establishment, indicating that the establishment of the conservancy contributed towards minimizing rangeland degradation.

v. The livestock numbers were significantly higher than that of wild ungulates. Specifically, sheep and goats significantly pushed up livestock populations. The high livestock population was attributed to factors such as sheep and goats having the ability to utilize the lower quality and quantity grazing resources due to their small body. In addition, the overly occupied Naibunga conservancy with human settlement discouraged wild ungulate populations.

Taken together, these findings suggest that the community conservancy model as applied in the study region can improve the socioeconomic well-being of local pastoralists and consequently contribute towards tackling the global challenge of balancing socioeconomic development interests with wildlife conservation interests.

6.2. Recommendations

6.2.1. Management implication

i. For sustainable socioeconomic and environmental impacts, community conservancies should prioritise multi-pronged strategies that maximize socioeconomic benefits for local community members. In particular, because the vast majority of members of such conservancies are pastoralists, who primarily rely on livestock for survival, strategies that enhance the security of pastoralists and their livestock, rangeland and livestock productivity, and accessibility to water should be given utmost priority.

ii. This study suggests that community conservancies should focus on addressing individual-level differences in involvement in conservancy management and conservation activities if they are to better achieve broad-based, equitable and sustainable participation in these activities by local community members. This is because of the observed negative association between community involvement in

conservancy's management and conservation activities and ownership of sheep and goats.

iii. The conservancies should prioritise identifying and addressing the disparities in local participation related to educational status, gender, and livestock ownership and herd size differences among local community members.

iv. In addition, such community conservancies should focus on increasing accessibility to educational facilities to address low literacy levels among local community members, especially girls, to address gender-based inequity in education. Further, the conservancies should focus on improving infrastructure and explore ways of enhancing local accessibility to alternative energy sources, especially solar power, to spur further socioeconomic development in such remote landscapes.

v. To enhance their socioeconomic and conservation outcomes further, community conservancies should devise and implement strategies to enhance and entrench local community participation in conservancy programmes. In particular, the conservancies should pay greater attention to identifying and addressing the major barriers to behaviour change and equitable local participation in conservancy activities, including barriers to education and gender equity.

vi. Rehabilitation and conservation efforts should be designed to considerably suppress invasive, non-forage and unpalatable species such as *Opuntia* and *Sansevieria.* At the same time, effort should be directed to enhance forage species through enhanced grass reseeding, halting degradation drivers such as overgrazing through intensification of planned grazing. This will help realize meaningful and beneficial vegetation composition to pastoral communities inhabiting this and other similar ecosystems around the world.

6.2.2. Areas for future research

i. The study observed that education positively correlated with participation in conservancy management and conservation activity. Yet, a higher proportion of women than males reported participation despite females being generally less educated than males. While what drove gender disparity in local participation is unclear, this study posits that the fact that male take part in herding their cattle, they may not be having enough time to participate in conservation related management activities. However, more research is needed to establish the reasons behind the observed disparity.

ii. Due to difficulties in understanding the driving factors behind the inverse relationship between livestock, particularly sheep and goats and wild ungulate population, this study suggests future research to investigate the effects of livestock grazing on wildlife numbers to account for the complex grazing dynamics that may be working to the disadvantage of wild ungulate numbers.

iii. Whereas several studies have given possible reasons for the observed inverse relationship in temporal trends in the total number of livestock and wild ungulate, there has been no attempt to address the problem. This study recommends that future studies should focus on documenting the livestock type, timing and frequency of grazing, duration, and stocking rate and their interaction with wild ungulate type present and the effect of the interaction on the population trends. In addition, this study suggests the development of ecological models that explain relationships between livestock and wild ungulate numbers, which will be helpful in the development and implementation of strategies to address this problem in this and similar rangeland set up across the world.

REFERENCES

African Wildlife Foundation. (2016). *African Conservancies Volume: Towards Best Practices* (Vol. 1). African Wildlife Foundation.

Augustine, D. J., Veblen, K. E., Goheen, J. R., Riginos, C., & Young, T. P. (2011). Pathways for Positive Cattle–Wildlife Interactions in Semiarid Rangelands. *Smithsonian Contributions to Zoology*, *632*, 55–71. https://doi.org/10.5479/si.00810282.632.55

Bajwa, S., & Kulkarni, S. (2011). Hyperspectral Data Mining. In *Hyperspectral Remote Sensing of Vegetation* (pp. 93–120). CRC Press. https://doi.org/10.1201/b11222-8

Barrow, E., & Murphree, M. (2001). Community conservation from concept to practice: a practical framework. *African Wildlife and Livelihoods: The Promise AndPerformance of Community Conservation*, *8*, 24–37.

Bartlett II, J. E., Kotrlik, J. W., & Higgins, C. C. (2001). Determing appropriate sample size in survey research. *Information Technology, Learning, and Performance Journal*, *19*(1), 43–50.

Bedelian, C., & Ogutu, J. O. (2017). Trade-offs for climate-resilient pastoral livelihoods in wildlife conservancies in the Mara ecosystem, Kenya. *Pastoralism*, *7*(1), 1–22. https://doi.org/10.1186/s13570-017-0085-1

Bersaglio, B., & Cleaver, F. (2020). The Institutional Workings of Community Conservancies in Kenya. *Conservation and Society*, *16*(4), 467–480. https://doi.org/10.4103/cs.cs

Bestelmeyer, B. T. B. B. T., Ash, A., … J. B.-R., 2017, U., Brown, J. R., Densambuu, B., Fernández-Giménez, M., Johanson, J., Levi, M., Lopez, D., Peinetti, R., Rumpff, L., & Shaver, P. (2017). State and Transition Models: Theory, Applications, and Challenges. In *library.oapen.org*. https://library.oapen.org/bitstream/handle/20.500.12657/27988/1002009.pdf?sequence=1#page=313

Bhunia, S., & Shit, P. K. (2013). Identifiction of temporal dynamics of vegetation coverage using remote sensing and GIS: A case study of western part of West Bengal, India. *International Journal of Current Research*, *May 2014*. https://www.researchgate.net/publication/236667208

Briske, D. D. (Ed.). (2017). *Rangeland systems, processes, managment and challenges*.

https://doi.org/10.1007/978-3-319-46709-2_2

Brooks, J., Waylen, K. A., & Mulder, M. B. (2013). Assessing community-based conservation projects: A systematic review and multilevel analysis of attitudinal, behavioral, ecological, and economic outcomes. *Environmental Evidence*, *2*(1), 1–34. https://doi.org/10.1186/2047-2382-2-2

Butt, B. (2015). Herding by mobile phone: Technology, social networks and the "transformation" of pastoral herding in East Africa. *Human Ecology*, *43*(1), 1–14. https://doi.org/10.1007/s10745-014-9710-4

Carter, E., Adams, W. M., & Hutton, J. (2008). Private protected areas: Management regimes, tenure arrangements and protected area categorization in East Africa. *Oryx*, *42*(2), 177–186. https://doi.org/10.1017/S0030605308007655

County Government of Laikipia. (2018). *County Integrated Development Plan 2018 - 2022* (Issue June).

Daramola, J. O., & Adeloye, A. A. (2008). *Physiological adaptation to the humid tropics with special reference to the West African Dwarf (WAD) goat*. https://doi.org/10.1007/s11250-008-9267-6

Deer, P. (1995). *Digital change detection techniques in remote sensing* (p. 53). https://apps.dtic.mil/sti/citations/ADA300761

Dettenmaier, S. J., Messmer, T. A., Hovick, T. J., Dahlgren, D. K., & Seth Dettenmaier, C. J. (2017). Effects of livestock grazing on rangeland biodiversity: A meta-analysis of grouse populations. *7620 | Ecology and Evolution*, *7*, 7620–7627. https://doi.org/10.1002/ece3.3287

Djamba, Y. K., & Neuman, W. L. (2002). Social Research Methods: Qualitative and Quantitative Approaches. In *Teaching Sociology* (Vol. 30, Issue 3). https://doi.org/10.2307/3211488

Du, W., Penabaz-Wiley, S. M., Njeru, A. M., & Kinoshita, I. (2015). Models and approaches for integrating protected areas with their surroundings: A review of the literature. *Sustainability (Switzerland)*, *7*(7), 8151–8177. https://doi.org/10.3390/su7078151

Dudley, N. (2008). Guidelines for Applying Protected Area Management Categories. In N. Dudley (Ed.), *Physical Review B* (Vol. 38). IUCN. https://doi.org/10.1103/PhysRevB.38.10724

Fynn, R. W. S., & Bonyongo, M. C. (2011). Functional conservation areas and the future of Africa's wildlife. *African Journal of Ecology*, *49*(2), 175–188. https://doi.org/10.1111/j.1365-2028.2010.01245.x

Gadd, M. E. (2005). Conservation outside of parks: Attitudes of local people in Laikipia, Kenya. *Environmental Conservation*, *32*(1), 50–63. https://doi.org/10.1017/S0376892905001918

Galvin, K. A., Beeton, T. A., & Luizza, M. W. (2018). African community-based conservation: A systematic review of social and ecological outcomes. *Ecology and Society*, *23*(3). https://doi.org/10.5751/ES-10217-230339

Geng, S., Shi, P., Song, M., Zong, N., Zu, J., & Zhu, W. (2019). Diversity of vegetation composition enhances ecosystem stability along elevational gradients in the Taihang Mountains, China. *Ecological Indicators*, *104*, 594–603. https://doi.org/10.1016/J.ECOLIND.2019.05.038

Georgiadis, N. J. (2011). Introduction: Conserving Wildlife in Kenya's Ewaso Landscape. *Smithsonian Contributions to Zoology*, *632*, 1–10. https://doi.org/10.5479/si.00810282.632.1

Georgiadis, N. J., Ihwagi, F., Olwero, J. G. N., & Romañach, S. S. (2007). Savanna herbivore dynamics in a livestock-dominated landscape. II: Ecological, conservation, and management implications of predator restoration. *Biological Conservation*, *137*(3), 473–483. https://doi.org/10.1016/j.biocon.2007.03.006

Georgiadis, N. J., Ojwang', G., Olwero, N., & Aike, G. (2011). Reassessing Aerial Sample Surveys for Wildlife Monitoring, Conservation, and Management. *Smithsonian Contributions to Zoology*, *632*, 31–42. https://doi.org/10.5479/si.00810282.632.31

Glew, L., Hudson, M. D., & Osborne, P. E. (2010). *Evaluating the effectiveness of community-based conservation in northern Kenya: A report to The Nature Conservancy.* (Issue August). University of Southampton School of civil Engineering and the Environment. https://www.nature.org/media/asia-pacific/mongolia-gobi-project-assessment.pdf

GoK. (2013). *The Wildlife Conservation and Management Act, 2013*. *18*.

Goodwin, H., & Santilli, R. (2009). Community-Based Tourism: a success? *Tourism Management*, *11*, 1–37. http://www.andamandiscoveries.com/press/press-harold-

goodwin.pdf

Graham, M. (2012). *Laikipia Wildlife Forum. A wildlife Conservation Strategy for Laikipia County (2013-2030)*. Laikipia Wildlife Forum. https://laikipia.org/wp-content/uploads/2020/03/strat_lwf2012final3small.pdf

Hantson, W., Kooistra, L., & Slim, P. A. (2012). Mapping invasive woody species in coastal dunes in the Netherlands: a remote sensing approach using LIDAR and high-resolution aerial photographs. *Applied Vegetation Science*, *15*(4), 536–547. https://doi.org/10.1111/j.1654-109X.2012.01194.x

Hauck, S., & Rubenstein, D. I. (2017). Pastoralist societies in flux: A conceptual framework analysis of herding and land use among the Mukugodo Maasai of Kenya. *Pastoralism*, *7*(1). https://doi.org/10.1186/s13570-017-0090-4

Heshmati, G. A., & Mohebbi, Z. (2013). *Development of State-and-Transition Models (STM): Integrating Ecosystem Function, Structure and Energy to STM Gholam*. *2*(4), 687–696. https://doi.org/10.1038/nature12340

Hooper, D. U., Chapin, F. S., Ewel, J. J., Hector, A., Inchausti, P., Lavorel, S., Lawton, J. H., Lodge, D. M., Loreau, M., Naeem, S., Schmid, B., Setälä, H., Symstad, A. J., Vandermeer, J., & Wardle, D. A. (2005). Effects of biodiversity on ecosystem functioning: A consensus of current knowledge. *Ecological Monographs*, *75*(1), 3–35. https://doi.org/10.1890/04-0922

IBM Corperation. (2019). *IBM SPSS Statistics for Windows* (Patent No. Version 26.0). Armonk. https://www.google.com/search?q=IBM+Corp.+Released+2019.+IBM+SPSS+Statistics+for+Windows%2C+Version+26.0.+Armonk%2C+NY%3A+IBM+Corp&sxsrf=ALeKk00u6UETqouRh6XoS9-93cdurlf0_w%3A1622911785817&source=hp&ei=Kau7YNTgL4uWlwTmwJWQDw&iflsig=AINFCbYAAAAAYLu5OUljspdb

Im, J., & Jensen, J. R. (2008). Hyperspectral Remote Sensing of Vegetation. *Geography Compass*, *2*(6), 1943–1961. https://doi.org/10.1111/j.1749-8198.2008.00182.x

Jones, B. T. B. (2015). *Community Conservation in Africa. Successes and Failures – Lessons for the Current Poaching Crisis*. Centre D'Estudis Africans i Interculturals (CEA). https://centredestudisafricans.org/wp-content/uploads/2015/11/Barcelona-paper-BJ-

final.pdf

Kaeser, A. S. (2016). Attitudes and Barriers to Women' s Participation in a Proposed Community-Based Conservation Program in Western Belize. In *Ph.D Dissertation, The University of Tennessee, Knoxville, Tennessee*. https://trace.tennessee.edu/utk_graddiss/3932

Kanniah, K. D., & Beringer, J. (2017). Tropical Savanna Ecosystems. *International Encyclopedia of Geography: People, the Earth, Environment and Technology*, 1–10. https://doi.org/10.1002/9781118786352.wbieg0802

Kantai, R. (2012). Tracing Community conservation evolution, power relations and sustainability in Northern Kenya. In *Masters Thesis, University of Oxford, United Kingdom* (Issue September).

Keane, A., Gurd, H., Kaelo, D., Said, M. Y., Leeuw, J. De, Rowcliffe, J. M., & Homewood, K. (2016). Gender differentiated preferences for a Community-based conservation initiative. *PLoS ONE*, *11*(3), 1–15. https://doi.org/10.1371/journal.pone.0152432

Kenya National Bureau of Statistics. (2019). *2019 Kenya Population and Housing Census: Volume II i: Vol. II*. https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-i-population-by-county-and-sub-county

Kenya Wildlife Conservancy Association. (2016). *State of Wildlife Conservancies in Kenya Report*. 84. https://kwcakenya.com/wp-content/uploads/2018/01/SoC-Report.pdf

Kimiti, D. W., Jeffrey, A. C. H., Adam, E. H., & Abbott, L. E. (2017). Rehabilitation of community-owned , mixed-use rangelands : lessons from the Ewaso ecosystem in Kenya. *Plant Ecology*, *218*(1), 23–37. https://doi.org/10.1007/s11258-016-0691-9

Kimuyu, D. M., Veblen, K. E., Riginos, C., Chira, R. M., Githaiga, J. M., & Young, T. P. (2017). Influence of cattle on browsing and grazing wildlife varies with rainfall and presence of megaherbivores. *Ecological Applications*, *27*(3), 786–798. https://doi.org/10.1002/eap.1482

King, J., Kaelo, D., Buzzard, B., & Warigia, G. (2015). *Establishing a Wildlife Conservancy in Kenya: A guide for Private land-Owners and Cmmunities*. https://www.undp.org/sites/g/files/zskgke326/files/migration/ke/1010601c55739cc80b47788d4116745131792d320ba5bcc457fc14c309f5d0cd.pdf

King, J., Lalampaa, T., Craig, I., & Harrison, M. (2015). *A guide to establishing community*

conservancies – the NRT model (Issue Version 1, p. 40). https://www.academia.edu/17039125/A_guide_to_establishing_community_conservancies_the_NRT_model?auto=download

Kinnaird, M. F., Brien, T. G. O., Society, W. C., Strindberg, S., & Society, W. C. (2015). *Assessment of Aerial Sample Count Surveys as a Monitoring Method to Track Changes in Livestock and Wildlife Across Laikipia County*. *August*. https://doi.org/10.13140/RG.2.1.2498.2246

Kinnaird, M. F., & O'brien, T. G. (2012). Effects of Private-Land Use, Livestock Management, and Human Tolerance on Diversity, Distribution, and Abundance of Large African Mammals. *Conservation Biology*, *26*(6), 1026–1039. https://doi.org/10.1111/j.1523-1739.2012.01942.x

Kinyua, D., McGeoch, L. E., Georgiadis, N., & Young, T. P. (2010). Short-Term and Long-Term Effects of Soil Ripping, Seeding, and Fertilization on the Restoration of a Tropical Rangeland. *Restoration Ecology*, *18*(SUPPL. 1), 226–233. https://doi.org/10.1111/j.1526-100X.2009.00594.x

Krausman, P. R., Naugle, D. E., Frisina, M. R., Northrup, R., Bleich, V. C., Block, W. M., Wallace, M. C., Wright, J. D., & Krausman, B. P. R. (2009). Society for Range Management Habitat , and Rangeland Values. *Society for Range Management*, *31*(5), 15–19.

Krug, W. (2001). Private supply of protected land in southern Africa: a review of markets, approaches, barriers and issues. *World Bank / OECD International Workshop on Market Creation for Biodiversity Products and Services*, 1–42. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.625.6330&rep=rep1&type=pdf

KWCA. (2016). *State of Wildlife Conservations in Kenya Report 2016* (pp. 1–84). Kenya Wildlife Conservancies Association. https://collaborativeconservation.org/media/sites/142/2018/01/State-of-Wildlife-Conservancies-in-Kenya-Report-_KWCA.pdf

KWS. (2015). *Wildlife Conservation and Management (Conservancy and Sanctuary) Regulations*. *151*(47), 10–17. https://doi.org/10.1145/3132847.3132886

Lalampaa, P. K., Wasonga, O. V., Rubenstein, D. I., & Njoka, J. T. (2016). Effects of holistic

grazing management on milk production, weight gain, and visitation to grazing areas by livestock and wildlife in Laikipia County, Kenya. *Ecological Processes*, *5*(1). https://doi.org/10.1186/s13717-016-0061-5

Laliberte, A. S., Rango, A., Havstad, K. M., Paris, J. F., Beck, R. F., McNeely, R., & Gonzalez, A. L. (2004). Object-oriented image analysis for mapping shrub encroachment from 1937 to 2003 in southern New Mexico. *Remote Sensing of Environment*, *93*(1–2), 198–210. https://doi.org/10.1016/J.RSE.2004.07.011

Lesilau, F., Fonck, M., Gatta, M., Musyoki, C., Zelfde, M. van t., Persoon, G. A., Musters, K. C. J. M., De Snoo, G. R., & De Iongh, H. H. (2018). Effectiveness of a LED flashlight technique in reducing livestock depredation by lions (Panthera leo) around Nairobi National Park, Kenya. *PLoS ONE*, *13*(1), 1–18. https://doi.org/10.1371/journal.pone.0190898

Letai, J. (2011). Land Deals in Kenya : The Genesis of Land Deals in Kenya and its Implication on Pastoral Livelihoods – A Case Study of Laikipia District , 2011. *International Conference of Global Land Grabbing*, 1–11. http://landportal.info/sites/default/files/land_deals_in_kenya-initial_report_for_laikipia_district2.pdf

Lichtenfeld, L. L., Naro, E. M., & Snowden, E. (2019). *Community, Conservation, and Collaboration: A Framework for Success*. National Geographic Society, Washington D.C, and African People & Wildlife, Arusha, Tanzania. https://media.nationalgeographic.org/assets/file/APW_Community_Engagement_Framework_Final_10.23.19.pdf

Liniger, H., & Studer, R. M. (2019). *Sustainable rangeland management in Sub-Saharan Africa - Guideline to good practice*. University of Bern. https://cgspace.cgiar.org/bitstream/handle/10568/102164/rangeland_low_full_version.pdf?sequence=2

Litoroh, M., Ihwangi, F. W., Mayienda, R., Bernard, J., & Douglas-Hamilton, I. (2010). Total Aerial Count of Elephants in Laikipia-Samburu Ecosystem in November 2008. *Kenya Wildlife Service, Nairobi, Kenya*, *November 2008*. https://www.academia.edu/download/9703140/2010 litoroh *et al* total aerial count of elephants in laikipia-samburu ecosystem.pdf

Lobo, P. G. & A. (2016). On the relationship between land tenure and land degradation: A

case study in the Otjozondjupa Region (Namibia) based on satellite data. *Global Governance/Politics, Climate Justice & Agrarian/Social Justice: Linkages and Challenges, February*. https://www.iss.nl/sites/corporate/files/43-ICAS_CP_Gilolm_and_Lobo.pdf

Lu, D., Mausel, P., Brondízio, E., & Moran, E. (2004). Change detection techniques. *International Journal of Remote Sensing*, *25*(12), 2365–2407. https://doi.org/10.1080/0143116031000139863

Mallupattu, P. K., Sreenivasula, R., & Jayarama, R. (2013). Analysis of land use/land cover changes using remote sensing data and GIS at an Urban Area, Tirupati, India. *The Scientific World Journal*, *2013*(Figure 1), 1–7. https://doi.org/10.1155/2013/268623

Mbugua, N. R. (2016). The Causes and Impact of Insecurity on Pastoralists Economies: The Case of West Pokot County, Kenya (1990-2015). In *Masters Thesis, University of Nairobi, Nairobi, Kenya*. http://erepository.uonbi.ac.ke/bitstream/handle/11295/97661/Mbugua-The Causes And Impact Of Insecurity On Pastoralists Economies The Case Of West Pokot County%2C Kenya %281990-2015%29..pdf?sequence=1

McGranahan, D. A., Engle, D. M., Fuhlendorf, S. D., Miller, J. R., & Debinski, D. M. (2013). Multivariate analysis of rangeland vegetation and soil organic carbon describes degradation, informs restoration and conservation. *Land*, *2*(3), 328–350. https://doi.org/10.3390/land2030328

Mchugh, M. L. (2013). The Chi-square test of independence Lessons in biostatistics. *Biochemia Medica*, *23*(2), 143–149. http://dx.doi.org/10.11613/BM.2013.018

Mganga, K. Z., Musimba, N. K. R., Nyariki, D. M., Nyangito, M. M., & Mwang'ombe, A. W. (2015). The choice of grass species to combat desertification in semi-arid Kenyan rangelands is greatly influenced by their forage value for livestock. *Grass and Forage Science*, *70*(1), 161–167. https://doi.org/10.1111/gfs.12089

Ministry of Agriculture. (2007). Arid And Semi-Arid Lands Branch, Laikipia District : A Pre-Investment Study Of Human And Natural Resources. In *Range Management Division, Nairobi* (Vol. 3, pp. 63–76). https://edepot.wur.nl/486351

Ministry of Environment and Forestry. (2018). *A report on Forest Resources Management and Logging activities in Kenya*. *April*. http://www.environment.go.ke/wp-

content/uploads/2018/08/Forest-Report.pdf

Moore, M. M., Casey, C. A., Bakker, J. D., Springer, J. D., Fulé, P. Z., Covington, W. W., & Laughlin, D. C. (2006). Herbaceous Vegetation Responses (1992–2004) to Restoration Treatments in a Ponderosa Pine Forest. *Rangeland Ecology & Management*, *59*(2), 135–144. https://doi.org/10.2111/05-051R2.1

Muchiru, A. N., Western, D., & Reid, R. S. (2009). The impact of abandoned pastoral settlements on plant and nutrient succession in an African savanna ecosystem. *Journal of Arid Environments*, *73*(3), 322–331. https://doi.org/10.1016/J.JARIDENV.2008.09.018

Mureithi, S. M., Verdoodt, A., Njoka, J. T., Gachene, C. K. K., Warinwa, F., & Van Ranst, E. (2016). Impact of Community Conservation Management on Herbaceous Layer and Soil Nutrients in a Kenyan Semi-Arid Savannah. *Land Degradation and Development*, *27*(8), 1820–1830. https://doi.org/10.1002/ldr.2315

Mureithi, S. M., Verdoodt, A., Njoka, J. T., Olesarioyo, J. S., & Van Ranst, E. (2019). Community-Based Conservation: An Emerging Land Use at the Livestock-Wildlife Interface in Northern Kenya. In J. Kideghesho (Ed.), *Wildlife Management - Failures, Successes and Prospects* (pp. 61–79). IntechOpen. https://doi.org/10.5772/intechopen.73854

Mwangi, V., Owuor, S., Kiteme, B., & Giger, M. (2020). Beef production in the rangelands: A comparative assessment between pastoralism and large-scale ranching in Laikipia county, Kenya. *Agriculture (Switzerland)*, *10*(9), 1–15. https://doi.org/10.3390/agriculture10090399

Ngene, S. M., Mukeka, J., & Kiambi, S. (2017). *Aerial total count of elephants, buffalo, giraffe and Grevy's zebra in Laikipia-Samburu-Marsabit ecosystem* (Issue February). Kenya Wildlife Service (KWS). https://www.researchgate.net/publication/325145734

Niamir-Fuller, M., Kerven, C., Reid, R., & Milner-Gulland, E. (2012). Co-existence of wildlife and pastoralism on extensive rangelands: competition or compatibility? *Pastoralism*, *2*(1), 1–14. https://doi.org/10.1186/2041-7136-2-8/METRICS

Northern Rangeland Trust. (2017). *Naibunga Community Conservancy: Conservancy Management and Community Development Plan (2017-2021)*. Nothern Rangeland Trust.

https://static1.squarespace.com/static/5af1629f12b13f5ce97ca0b5/t/5b63dd9a352f5311a5194e22/1533271462023/CMP_NAIBUNGA_LowRes_SinglePages.pdf

Northern Rangeland Trust. (2019). *State of Conservancies Report 2018*. Nothern Rangeland Trust. https://static1.squarespace.com/static/5af1629f12b13f5ce97ca0b5/t/5d80b9cacfc39b45b4c49db7/1568717288456/SOCR2018_FINAL_LR_web.pdf

Northern Rangelands Trust. (2020). *State of Conservancies Report 2019*. 1–41. https://static1.squarespace.com/static/5af1629f12b13f5ce97ca0b5/t/5e398ee62156d43c562498bf/1580830499016/LOWRES.FINAL_State+of+Conservancies+Report+2019.pdf

Nyariki, D. M., & Amwata, D. A. (2019). The value of pastoralism in Kenya: Application of total economic value approach. *Pastoralism*, *9*(1). https://doi.org/10.1186/s13570-019-0144-x

Nyberg, G., Knutsson, P., Ostwald, M., Öborn, I., Wredle, E., Otieno, D. J., Mureithi, S., Mwangi, P., Said, M. Y., Jirström, M., Grönvall, A., Wernersson, J., Svanlund, S., Saxer, L., Geutjes, L., Karmebäck, V., Wairore, J. N., Wambui, R., De Leeuw, J., & Malmer, A. (2015). Enclosures in West Pokot, Kenya: Transforming land, livestock and livelihoods in drylands. *Pastoralism*, *5*(1). https://doi.org/10.1186/s13570-015-0044-7

Obati, O. G. (2007). An Investigation of Forest Ecosystem Health in Relation to Anthropogenic Disturbance in the Southwestern Mau Forest Reserve , Kenya. In *Exchange Organizational Behavior Teaching Journal*. https://d-nb.info/985919086/34

Odadi, W. O., Fargione, J., & Rubenstein, D. I. (2017). Vegetation, Wildlife, and Livestock Responses to Planned Grazing Management in an African Pastoral Landscape. *Land Degradation and Development*, *28*(7), 2030–2038. https://doi.org/10.1002/ldr.2725

Odeck, D. I. (2011). *Assessing the Role of Oloisukut Community Conservancy in the Management of Wildlife Resources in Narok County, Kenya*. http://erepository.uonbi.ac.ke/bitstream/handle/11295/99233/Odeck_Assessing The Role Of Oloisukut Community Conservancy In The Management Of Wildlife Resources In Narok County, Kenya.pdf?sequence=1&isAllowed=y

Oduor, A. M. O. O. (2020). Benefits and Challenges of community-based wildlife conservancies in Kenya's Maasai Mara ecosystem. *Journal of Environmental Management*, *260*(November), 110133. https://doi.org/10.13140/RG.2.2.12719.15523

OECD. (2013). What are the social benefits of education? In *Choice Reviews Online* (Vol. 35, Issue 10, pp. 1–4). OECD. https://doi.org/https://doi.org/10.1787/5k4ddxnl39vk-en

Oguge, N. O. (2005). Monitoring and Evaluation of Community based Natural Resource Manage-ment Programmes: Biological Databases and Range Conditions in Koija, Tiamamut and Kijabe group ranches of Laikipia District. In *African Wildlife Foundation report* (p. 55). https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=oguge+et+al+guge+NO.+Monitoring+and+Evaluation+of+Community+based+Natural+Resource+Manage%02ment+Programmes%3A+Biological+Databases+and+Range+Conditions+in+Koija%2C+Tiamamut+and++Kijabe+group+ranches

Ogutu, J. O., Kuloba, B., Piepho, H. P., & Kanga, E. (2017). Wildlife population dynamics in human-dominated landscapes under community-based conservation: The example of Nakuru Wildlife Conservancy, Kenya. *PLoS ONE*, *12*(1). https://doi.org/10.1371/JOURNAL.PONE.0169730

Ogutu, J. O., Piepho, H. P., Said, M. Y., Ojwang, G. O., Njino, L. W., Kifugo, S. C., & Wargute, P. W. (2016). Extreme wildlife declines and concurrent increase in livestock numbers in Kenya: What are the causes? *PLoS ONE*, *11*(9). https://doi.org/10.1371/JOURNAL.PONE.0163249

Osborne, C. P., Charles-Dominique, T., Stevens, N., Bond, W. J., Midgley, G., & Lehmann, C. E. R. (2018). Human impacts in African savannas are mediated by plant functional traits. *New Phytologist*, *220*(1), 10–24. https://doi.org/10.1111/nph.15236

Ottichilo, W. K., Grunblatt, J., Said, M. Y., & Wargute, P. W. (2000). Wildlife and Livestock Population Trends in the Kenya Rangeland. *Wildlife Conservation by Sustainable Use*, 203–218. https://doi.org/10.1007/978-94-011-4012-6_10

Park, K. H., Qu, Z. Q., Wan, Q. Q., Ding, G. D., & Wu, B. (2013). Effects of enclosures on vegetation recovery and succession in Hulunbeier steppe, China. *Forest Science and Technology*, *9*(1), 25–32. https://doi.org/10.1080/21580103.2013.774124

Perneger, T. V., Courvoisier, D. S., Hudelson, P. M., & Gayet-Ageron, A. (2015). Sample size for pre-tests of questionnaires. *Quality of Life Research : An International Journal of Quality of Life Aspects of Treatment, Care and Rehabilitation*, *24*(1), 147–151. https://doi.org/10.1007/S11136-014-0752-2

Radhakrishna, R. B. (2007). Tips for Developing and Testing Questionnaires/Instruments. *Journal of Extention*. https://www.joe.org/joe/2007february/tt2.php

Ray, B., Mukherjee, P., Bhattacharya, R. N., Ray, B., Mukherjee, P., & Bhattacharya, R. N. (2017). Attitudes and cooperation: does gender matter in community-based forest management? *Environment and Development Economics*, *22*(5), 594–623. https://econpapers.repec.org/RePEc:cup:endeec:v:22:y:2017:i:05:p:594-623_00

Riehl, B., Zerriffi, H., & Naidoo, R. (2015). Effects of community-based natural resource management on household welfare in Namibia. *PLoS ONE*, *10*(5). https://doi.org/10.1371/journal.pone.0125531

Rook, A. J., Dumont, B., Isselstein, J., Osoro, K., WallisDeVries, M. F., Parente, G., & Mills, J. (2004). Matching type of livestock to desired biodiversity outcomes in pastures – a review. *Biological Conservation*, *119*(2), 137–150. https://doi.org/10.1016/J.BIOCON.2003.11.010

Ryan, C. M., Pritchard, R., McNicol, I., Owen, M., Fisher, J. A., & Lehmann, C. (2016). Ecosystem services from southern African woodlands and their future under global change. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *371*(1703). https://doi.org/10.1098/rstb.2015.0312

Sangha, K. K. (2006). The role of ecosystem services from tropical savannas in well-being of Aboriginal people : A scoping study. In *Tropical Savannas Cooperative Research Centre*. https://www.researchgate.net/profile/Kamaljit-Sangha-2/publication/260752923_The_role_of_ecosystem_services_from_tropical_savannas_in_well-being_of_Aboriginal_people_A_scoping_study_A_report_for_the_Tropical_Savannas_Cooperative_Research_Centre/links/00b4

Sankaran, M., Hanan, N. P., Scholes, R. J., Ratnam, J., Augustine, D. J., Cade, B. S., Gignoux, J., Higgins, S. I., Le Roux, X., Ludwig, F., Ardo, J., Banyikwa, F., Bronn, A., Bucini, G., Caylor, K. K., Coughenour, M. B., Diouf, A., Ekaya, W., Feral, C. J., … Zambatis, N. (2005). Determinants of woody cover in African savannas. *Nature*, *438*(7069), 846–849. https://doi.org/10.1038/nature04070

Simberloff, D. S. (1974). Equilibrium Theory of Island Biogeography and Ecology. *Annual Review of Ecology and Systematics*, *5*(1), 161–182. https://doi.org/10.1146/annurev.es.05.110174.001113

Smith, A. M. S., Strand, E. K., Steele, C. M., Hann, D. B., Garrity, S. R., Falkowski, M. J., & Evans, J. S. (2008). Production of vegetation spatial-structure maps by per-object analysis of juniper encroachment in multitemporal aerial photographs. *Canadian Journal of Remote Sensing*, *34*, S268–S285. https://doi.org/10.5589/m08-048

Stringham, T., Krueger, W., & Shaver, P. (2016). State and transition modeling: An ecological process approach. *Journal of Range Management*, *56*(2), 106–113. https://doi.org/10.2458/azu_jrm_v56i2_stringham

Suich, H. (2013). Evaluating the household level outcomes of community based natural resource management: The Tchuma Tchato Project and Kwandu Conservancy. *Ecology and Society*, *18*(4). https://doi.org/10.5751/ES-05875-180425

Syallow, D. M. (2013). *The Role of Community Conservancies in Wildlife Conservation and Livelihoods Systems of The Maasai: A Case Study of Enoonkishu Conservancy, Narok County, Kenya*. http://erepository.uonbi.ac.ke/handle/11295/60385

Taherdoost, H. (2018). Validity and Reliability of the Research Instrument; How to Test the Validation of a Questionnaire/Survey in a Research. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3205040

Tefera, S., Snyman, H. A., & Smit, G. N. (2007). Rangeland dynamics of southern Ethiopia: (2). Assessment of woody vegetation structure in relation to land use and distance from water in semi-arid Borana rangelands. *Journal of Environmental Management*, *85*(2), 443–452. https://doi.org/10.1016/j.jenvman.2006.10.008

Thirgood, S., Woodroffe, R., & Rabinowitz, A. (2005). The impact of human–wildlife conflict on human lives and livelihoods. In R. Woodroffe, S. Thirgood, & A. Rabinowitz (Eds.), *People and Wildlife, Conflict or Co-existence?* (pp. 13–26). Cambridge University Press. https://doi.org/10.1017/CBO9780511614774.003

Treydte, A. C., Bernasconi, S. M., Kreuzer, M., & Edwards, P. J. (2006). Diet of the Common Warthog (Phacochoerus africanus) on Former Cattle Grounds in a Tanzanian Savanna. *Journal of Mammalogy*, *87*(5), 889–898. https://doi.org/10.1644/05-MAMM-A-336R2.1

Tsang, S., Royse, C. F., & Terkawi, A. S. (2017). Guidelines for developing, translating, and validating a questionnaire in perioperative and pain medicine. In *Saudi Journal of Anaesthesia* (Vol. 11, Issue 5, pp. S80–S89). Wolters Kluwer -- Medknow Publications.

https://doi.org/10.4103/sja.SJA_203_17

Veblen, K. E., Nehring, K. C., McGlone, C. M., & Ritchie, M. E. (2015). Contrasting effects of different mammalian herbivores on sagebrush plant communities. *PLoS ONE*, *10*(2). https://doi.org/10.1371/JOURNAL.PONE.0118016

Veblen, K. E., & Porensky, L. M. (2019). Thresholds are in the eye of the beholder: plants and wildlife respond differently to short-term cattle corrals. *Ecological Applications*, *29*(8), 1–15. https://doi.org/10.1002/eap.1982

Veblen, K. E., & Young, T. P. (2010). Contrasting effects of cattle and wildlife on the vegetation development of a savanna landscape mosaic. *Journal of Ecology*, *98*(5), 993–1001. https://doi.org/10.1111/J.1365-2745.2010.01705.X

Ward, C., Holmes, G., & Stringer, L. (2018). Perceived barriers to and drivers of community participation in protected-area governance. *Conservation Biology*, *32*(2), 437–446. https://doi.org/10.1111/cobi.13000

Western, D., & Gichohi, H. (1993). Segregation effects and the impoverishment of savanna parks: the case for ecosystem viability analysis. *African Journal of Ecology*, *31*(4), 269–281. https://doi.org/10.1111/j.1365-2028.1993.tb00541.x

Western, D., Russell, S., & Cuthil, I. (2009). The status of wildlife in protected areas compared to non-protected areas of Kenya. *PLoS ONE*, *4*(7). https://doi.org/10.1371/journal.pone.0006140

Westoby, M., Walker, B., & Noy-Meir, I. (1989). Opportunistic management for rangelands not at equilibrium. *Journal of Range Management*, *42*(4), 266–274. https://doi.org/10.2307/3899492

Wiegand, T., Wiegand, K., & Pütz, S. (2008). Grassland Models. In *Encyclopedia of Ecology, Five-Volume Set* (pp. 1754–1765). https://doi.org/10.1016/B978-008045405-4.00185-3

Williams, D., Thorne, J. H., Sumba, D., Muruthi, P., & Gregory-Michelman, N. (2017). Evaluating outcomes of community-based conservation on Kenyan group ranches with remote sensing. *Environmental Conservation*, *45*(2), 173–182. https://doi.org/10.1017/S0376892917000418

World Bank. (2001). World Development Report 2000/2001: Attacking Poverty. In *Oxford University Press*. Oxford University Press.

http://documents.worldbank.org/curated/en/230351468332946759/pdf/226840WDR00PUB0ng0poverty0200002001.pdf%0Ahttp://openknowledge.worldbank.org/handle

Wyman, M., & Stein, T. (2010). Examining the linkages between community benefits, place-based meanings, and conservation program involvement: A study within the community baboon sanctuary, Belize. *Society and Natural Resources*, *23*(6), 542–556. https://doi.org/10.1080/08941920902878267

Yurco, K. (2017). *Herders and herdsmen : The remaking of pastoral livelihoods in Laikipia , Kenya*. https://doi.org/10.1186/s13570-017-0086-0

APPENDICES

Appendix A: Household questionnaire

Serial number…… Interview date_____

1. **Ranch: (**Tick appropriately)
    a. **Munishoi ( )**
    b. **Koija ( )**
    c. **Morupusi ( )**
    d. **Ilmotiok ( )**
    e. **Mosul ( )**

PART A: PERSONAL INFORMATION

2. Gender		Male		Female			
3. Education level	**Tick (x)**	**4. Occupation**	**Tick (x)**	**5. Marital status**	**Tick (x)**	**6. Household size (no. individuals)**	**(x)**
Tertiary		Farmer		Single		< 2	
Secondary		Civil servant		Married		3 - 5	
Primary		Businessperson		Widowed or divorced		6 - 8	
None		Other (specify)				> 9	

PART B: LEVEL OF COMMUNITY PARTICIPATION

7. Are you or any member of your household involved in implementing management practices in the conservancy? (Je, wewe au kaya yako mnahusika katika kutekeleza mpangilio na usimamizi katika uhifadhi?)

Yes ( ) No ( )

8. How many hours per week are you or a member of your household involved in the management of the conservancy? (Je, ni kwa masaa mangapi kwa wiki wewe au mwanakaya wako unahusika katika usimamizi wa uhifadhi)

0hrs ( ) 1 - 5 hrs ( ) 6 - 10 hrs ( ) 11 - 15 hrs ( ) 16 - 20 hrs ( ) Over 20 hrs ( )

9. How has the involvement changed since the establishment of the conservancy? (lako ni ndio, je! kuhusishwa kwako imebadilika vipi tangu uhifadhi huu ulipoanzishwa?)

Increased ( ) Decreased ( ) Not changed ( )

(Imeongezeka) (Imepungua) (Haijabadilika)

10. List ways in which you or a member of your household is involved in these land management practices of the conservancy. (Orodhesha njia ambazo wewe au mwanakaya wako unashiriki katika mipangilio ya usimamizi wa uhifandhi)

i. …….

ii. …….

iii. …….

11. In your view, are you adequately involved in the management practices of the conservancy? (Kwa maoni yako, je! Unahusika vya kutosha katika mipangilio ya usimamizi wa wa uhifadhi?)

Yes ( ) No ( )

PART C: CHANGES IN SOCIO-ECONOMIC STATUS

12. Which one of the following forms your main livelihood source? Please choose one and tick appropriately (Je! Ni ipi kati ya aina zifuatazo inaunda chanzo chako kuu cha mapato?) tafadhali chagua moja na weka alama ipasvyo.

Pastoralism (ufugaji) ( )

Formal employment (Ajira rasmi) ( )

Bee keeping (Ukulima wa nyuki) ( )

Business (Biashara) ( )

Other (Please specify) ((Nyinginezo (Tafadhali taja)) ( )

……..

13. How has your income amount from the above chosen livelihood source changed since Naibunga Conservancy was established? (Je! Ni vipi chanzo chako cha mapato uliochagua hapo juu imebadilika tangu Uhifadhi wa Naibunga ulipoanzishwa?)

Pastoralism Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
(ufuguji) (imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

Formal employment Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
(Ajira rasmi) (imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

Bee keeping Increased ☐ Decreased ☐ No change ☐Not Applicable ☐
(ukulima wa nyuki) (imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

Business Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
(Biashara) (imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

Other as specified above Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
(Nyinginezo ulivyovitaja)(imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

14. What are the current livestock numbers under your household (cattle, camels, goats/sheep, and donkeys)? Tick appropriately ((Idadi ya mifugo chini ya kaya yako ni ngapi kwa sasa? (ng'ombe, ngamia, mbuzi / kondoo, na punda). Tiki ipasavyo))

Livestock (mifugo) Total number (Idadi)	Cattle (Ng'ombe)	Goats/sheep (Kondoo/Mbuzi)	Donkeys (Punda)	Camels (Ngamia)
0				
1 - 10				
11 - 30				
31 - 50				
51 - 100				
> 100				

15. Has your livestock numbers changed since Naibunga Conservancy was established? (Je! Idadi ya mifugo yako imebadilika tangu Uhifadhi wa Naibunga ulipoanzishwa?)

Yes ( ) No ( )

16. How has your livestock number changed? (Je! Idadi yako ya mifugo imebadilikaje?)

Cattle: Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
Ng'ombe:(imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

Goats/sheep: Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
Kondoo/Mbuzi: (imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

Camels: Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
Ngamia: (imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

Donkeys: Increased ☐ Decreased ☐ No change ☐ Not Applicable ☐
Punda: (imeongezeka) (imepungua) (haijabadilika) (Haitumiki)

17. How have the following socio-economic aspects changed after the establishment of Naibunga conservancy? (Je! Mambo haya yafuatayo yamebadilikaje baada ya kuanzishwa kwa hifadhi?) Tick (√) appropriately

No.	**Socio-economic aspect**	**Increased/improved (Imeimarika)**	**Decreased/worsened (Imedorora)**	**No change (Haijabadilika)**
1.	Perceived poverty			

	levels (Viwango vya umasikini inavyoonekana)			
2.	Average household income per annum (Wastani wa mapato ya kaya kwa mwaka)			
3.	Access to water (Upatikanaji wa maji)			
4.	Access to health facility (Upatikanaji wa kituo cha afya)			
5.	Access to schools (Upatikanaji wa shule)			
6.	State of roads (Barabara)			
7.	Access to grazing resource (Ufikiaji wa rasilimali ya malisho)			
8.	Access to electricity Upatikanaji wa umeme			
9.	Security (usalama)			
10.	Others (specify)			

18. In general, has your socio-economic status changed after the establishment of Naibunga conservancy? (Je! Kwa ujumla, Uhifadhi umebadilisha hali yako ya kijamii na kiuchumi?)

Yes ( ) No ( )

19. If yes, how has your socio-economic status changed? (Iwapo Jibu lako ni ndio,Je hali yako ya kiuchumi imebadilika aje?

Generally improved ( ) Generally worsened/deteriorated ( ) Not applicable ( )
(Imeimarika kiujumla) (imedorora kiujumla) (Haitumiki)

PART D: CHANGES IN WILDLIFE NUMBERS

20. In your opinion, have the wild herbivores increased or decreased since the establishment of the conservancy? (Je! Kwa mafikirio yako, wanyama pori wanaokula mimea wameongezeka au wamepungua tangu kuanzishwa kwa uhifadhi?)

Increased ( ) Decreased ( ) Not Applicable ( )
(imeongezeka) (imepungua) (Haitumiki)

21. In your opinion, has the number of large carnivores increased or decreased since the establishment of the conservancy? (Je! Kwa mafikirio yako, wanyama pori wanaokula wanyama wengine wameongezeka au wamepungua tangu kuanzishwa kwa uhifadhi?)

Increased ( ) Decreased ( ) Not Applicable ( )
(imeongezeka) (imepungua) (Haitumiki)

Appendix B: Key Informant Interview guide

1. What is the size of the ranch you are managing?
2. What are the land management practices being implemented by the ranch and /or the conservancy? Is this done all across the constituent ranches?
3. Are the local community involved in the implementation of land management practices? How are they involved?
4. To what level are the local community members involved in land management practices? (in hours per week)
5. Has the management practices changed since/after the establishment of the conservancy? How has the management practices changed?
6. Has the management practices had any impacts on the general well-being of the ranch and the conservancy at large?
7. For example, how do you compare the current stocking rate and the stocking rate before the establishment of the conservancy?
8. How has vegetation, and wild herbivore population been affected?
9. How has the conservancy's management approaches affected the livelihoods and livelihood sources of the ranch members? Please elaborate.
10. Have the impacts had any socioeconomic consequences on ranch members

Appendix C: Vegetation composition data tally sheets

Plot Number	Location	Date

S/N	Species	Geo Coordinates:	F/S/T	E/N	DBH cm	Height m
1.						
2.						
3.						
4.						
5.						
6.						
7.						
8.						
9.						
10.						

E = Exotic N = Native F = Forb S = Shrub T = Tree

Appendix D: Research permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **896546**

Date of Issue: **25/January/2021**

RESEARCH LICENSE

This is to Certify that Mr.. Ken Ogao Oburah of Egerton University, has been licensed to conduct research in Laikipia on the topic: ASSESSMENT OF ECOLOGICAL AND SOCIO-ECONOMIC EFFECTS OF COMMUNITY CONSERVANCY MODEL IN NAIBUNGA, LAIKIPIA COUNTY, KENYA for the period ending : 25/January/2022.

License No: **NACOSTI/P/21/8617**

896546

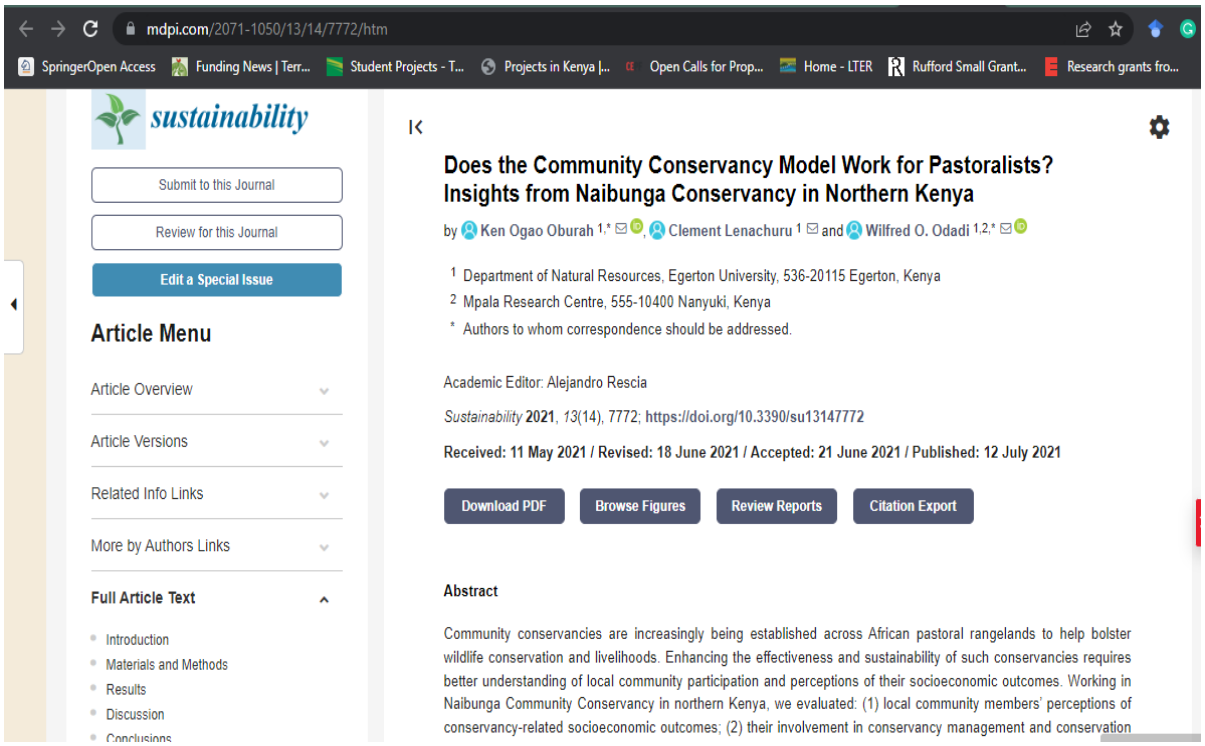
Applicant Identification Number

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.

Appendix E: Snapshot of abstract of publications



mdpi.com/2071-1050/13/14/7772/htm

SpringerOpen Access | Funding News | Terr... | Student Projects - T... | Projects in Kenya |... | Open Calls for Prop... | Home - LTER | Rufford Small Grant... | Research grants fro...

sustainability

Submit to this Journal

Review for this Journal

Edit a Special Issue

Article Menu

Article Overview

Article Versions

Related Info Links

More by Authors Links

Full Article Text

- Introduction
- Materials and Methods
- Results
- Discussion
- Conclusions

Does the Community Conservancy Model Work for Pastoralists? Insights from Naibunga Conservancy in Northern Kenya

by Ken Ogao Oburah [1,*], Clement Lenachuru [1] and Wilfred O. Odadi [1,2,*]

[1] Department of Natural Resources, Egerton University, 536-20115 Egerton, Kenya
[2] Mpala Research Centre, 555-10400 Nanyuki, Kenya
* Authors to whom correspondence should be addressed.

Academic Editor: Alejandro Rescia

Sustainability **2021**, *13*(14), 7772; https://doi.org/10.3390/su13147772

Received: 11 May 2021 / Revised: 18 June 2021 / Accepted: 21 June 2021 / Published: 12 July 2021

Download PDF | Browse Figures | Review Reports | Citation Export

Abstract

Community conservancies are increasingly being established across African pastoral rangelands to help bolster wildlife conservation and livelihoods. Enhancing the effectiveness and sustainability of such conservancies requires better understanding of local community participation and perceptions of their socioeconomic outcomes. Working in Naibunga Community Conservancy in northern Kenya, we evaluated: (1) local community members' perceptions of conservancy-related socioeconomic outcomes; (2) their involvement in conservancy management and conservation activities; and (3) association between these factors (perceptions and involvement) and various demographic factors. We conducted surveys in 358 households, selected using multi-stage sampling, and additionally interviewed key informants. Large proportions (65–90%) respondents perceived conservancy-related improvements in their overall socioeconomic status, security, household income, livestock numbers, and accessibility to grazing resources, schools, and health facilities. Over 75% of respondents indicated that they were involved in conservancy management and conservation activities. Involvement in these activities was positively associated with perception of socioeconomic improvements. In addition, various demographic factors shaped both perceptions of socioeconomic changes and involvement in conservancy activities. Our findings suggest that community conservancies can improve local pastoralists' socioeconomic wellbeing. Such conservancies can achieve far greater outcomes with greater focus on maximizing socioeconomic benefits for local pastoralists and enhancing their participation in conservancy activities.

Keywords: **African savanna rangelands; biodiversity conservation; community-based conservation; community conservancy; land degradation; pastoralists' livelihoods; pastoralism; sustainable land management practices**

- Results
- Discussion
- Conclusions
- Author Contributions
- Funding
- Institutional Review Board Statement
- Informed Consent Statement
- Data Availability Statement
- Acknowledgments
- Conflicts of Interest
- Appendix A
- References

1. Introduction

Despite a twofold global increase in government-protected conservation areas over the past five decades, such protected areas are considered too small and highly isolated to support viable populations of wildlife [1,2]. Consequently, large proportions of the world's wildlife are found outside government-protected areas [2,3]. In East Africa, for example, it is estimated that 70% of wildlife populations are dispersed outside government-protected areas, mostly on community and private lands [4,5,6]. However, wildlife populations have been rapidly dwindling in these areas [1], partly due to increased land degradation, habitat loss, and increased human–wildlife conflicts.

The continued decline in wildlife populations has made it necessary for national and international support towards engaging communities and private landowners who live with wildlife in efforts to sustainably conserv