PREDICTING GRAZING CONFLICTS BASED ON LIMITED RESOURCES IN NORTHERN KENYA

DOMINIC MARINGA IKUATHU

A THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURE AD NATURAL RESOURCES IN PARTIAL FULFILLMENT FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURAL AND RURAL DEVELOPMENT OF THE KENYA METHODIST UNIVERSITY

SEPTEMBER 2018

DECLARATION

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

Dominic Maringa Ikuathu, BSc, MA.

Signed……………………………………Date……………………………

This thesis has been submitted with our approval as University Supervisors:

Dr. Mworia Mugambi, Ph.D.

Department of Agriculture and Natural Resources, Kenya Methodist University

Signed……………………………………Date…………………….………

Prof. Nathan Gichuki, Ph.D.

School of Biological Sciences, University of Nairobi

Signe……………………………………..Date: ……………………………

Prof. Ellis Njoka, Ph.D.

Department of Agriculture and Natural Resources, Kenya Methodist University

Signed…………………………………………Date…………………………

DEDICATION

I dedicate this work to my lovely Beatrice, Nelly, Judy, and Trevor.

ACKNOWLEDGEMENTS

It is my pleasure to thank the people who have helped me to make this thesis possible. First, I thank God who is my greatest teacher. I am indebted to my main supervisor, Dr. Mworia Mugambi (Ph.D.), for the guidance he has given me. His advice, insightful critique and encouragement have helped in shaping and writing this thesis. I am grateful to Prof. Nathan Gichuki (Ph.D.) and Prof. Ellis Njoka (Ph.D) whose advice, enthusiasm and insights have been of great input. I appreciate the support from Prof. Peter Kamau (Ph.D.), Dr Laititi Mutunga (Ph. D) and Dr. Peter Kihara (Ph.D) for their guidance and quality checking of this work. I acknowledge the support of Mpala Research Centre, Edward Ouko of RCMRD, and the management of Lewa, Ilngwesi, Ngarendare and Nasuulu conservancies for allowing me to carry out this research in their region. I also thank my friends and colleagues who always supported me throughout the research period. Finally, I thank my parents who, having no formal education themselves, saw the importance of putting me through it.

ABSTRACT

This study aimed at determining causes of grazing conflicts in Northern Kenya which were used to develop a conflicts predicting model. It specifically intended to evaluate seasonality of pasture resources, establishing how availability of grazing resources was related to grazing conflicts and predicting how communities were likely to cope with them. It was anchored on the theory that competition for limited forage triggers intra and inter-conservancy livestock movements, causing conflicts over grazing resources. The study used mixed methods of ecological, remote sensing and social survey designs. Purposive sampling was used to select four conservancies out of a population of fifteen, where three of them were community-managed while the fourth was privately owned which acted as a control. Two plots each measuring 50mx50m were set up in each of them using handheld Global Positioning System (GPS). Clip-dry-and-weigh method was used to assess grass biomass during dry and wet seasons. Five samples of clippings were obtained per plot using 0.5mx0.5m wire quadrant randomly in both seasons. Visual estimates were used to assess ground cover percentages, species variability and diversity along transects between the plots in both seasons and recorded in Range Condition Checklists and tables of quantities. A population of 106 respondents was picked through systematic random sampling from the lists of conservancy grazing committees and data collected using self-administered structured questionnaires, focused group discussions and content analysis of literature. The data was analyzed using Statistical Package for Social Sciences (SPSS) version 26. Frequency counts, means and percentages were computed for all quantitative data and results presented using frequency distribution tables and graphs. Qualitative data on status of the bio-physical, land-use and rainfall patterns were tracked using remote sensing techniques. Temporal and spatial variability of forage, land-use and land-cover changes were tracked using MODIS 250m resolution and Landsat-8 sensor, which were analysed using Quantum Geographical Information System (QGIS) to produce Normalized Difference Vegetation Indices (NDVI). The results established that forage and water availability and livestock numbers were responsible for the largest variability of grazing conflicts. It was found that seasonality of rainfall and the communities grazing regimes trigger livestock movements to unknown areas, sparking a trail of conflicts on their way. The research also found out that in the largest period of the year, community conservancies bore the greatest effects of environmental externalities due to lack of adherence to grazing plans leading to overgrazing and pasture degradation. It was further found that pastoral communities have different methods of copping with grazing conflicts in the study area. The study synthesized results on dependent and independent variables and came up with a new model for predicting grazing conflicts in Northern Kenya. The study recommended further investigations on the effects of other factors contributing to grazing conflicts that were not accounted for. It also recommended further research on methodology to establish the levels of competition for resources by different browsers. On practice, it recommended inclusion of structured dialogue in conflicts mitigation and diversification of social-economic activities by the pastoralists to cushion them from the effects of grazing conflicts. On policy, it recommended inclusion of local administration, national agencies and relevant stakeholders on conflicts mitigation processes to make them more authentic and resultant agreements enforceable.

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF ANNEXES

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS AND ACRONYMS

CDC-	Conservation Development Centre
DMO-	Disaster Monitoring Officer
GIS-	Geographical Information Systems
gm-	Gramm
Ha-	Hectares
KFS-	Kenya Forests Services
Kgha-^{1}-	Kilograms per Hectare
Kg-	Kilograms
km-	Kilometers
KWS-	Kenya Wildlife Conservancy
LWC-	Lewa Wildlife Conservancy
LULC-	Land Use and Land Cover Change
MODIS	Moderate Resolution Imaging Spectroradiometer
NACOSTI-	National Council of Science, Technology and Innovation
NDVI-	Normalized Difference Vegetation Index
NEMA-	National Environment Management Authority
NRT-	Northern Rangelands Trust
ODI-	Overseas Development Institute
OLF-	Oromo Liberation Front
QGIS	Quantum Geographical Information System
RCMRD-	Regional Centre for Mapping of Resources for Development
Shoats-	Sheep and Goats
USDA-	United States Department of Agriculture

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Pastoralism is a form of livelihood that involves keeping livestock mostly occupying the dry arid lands of the Horn of Africa. In recent years, this occupation has been challenged by a number of factors ranging from climate variability, development projects in the region, increasing poverty and population, conflicts and death of humans and livestock (Cornelia & Elisabeth, 2015).

As grazing resources become scarce over the recent years, owing to shrinking land sizes as a result of population growth, interstate conflicts are likely to occur in Eastern Africa, as pastoralists traverse the entire region in search of pasture and water. The state boundaries are free for all as they are unmarked and tracking of grazers movements is a challenge to governmental actors and other sector organisations in the region (Wafula, 2010).

In times of pasture scarcity especially during drought, Ethiopian grazers often cross the Kenyan border searching for water and pasture. This often leads to competition for the resources thus sparking a trail of violence and death. Banditry and cattle rustling is also associated with lack of pasture and trans-border clashes between communities of Northern Kenya and Southern Ethiopia (Thomson Reuters Foundation, 2006).

Northern Kenya, being mainly a dry region of scarce livestock resources, is currently undergoing tremendous transformation owing to changing geo-political situations as a result of emergence of new governance systems, shrinking resource base due to evererratic rainfall patterns, population increase as well as installations of new regional infrastructure (Kaye-Zwiebel & King, 2014). These changes coupled with negative climate trends have compounded challenges facing traditional pastoralism leading to weakened or skewed decision making on handling community grazing in the area. In recent past, conflicts over pasture and other grazing resources have arose as a result of wavering cultural, individual, organizational, governmental and environmental practices which influence resource use and management in the region (Kaye-Zwiebel & King, 2014).

Pastoralism is a critical form of livelihood in Kenya, accounting for over 80% economic livelihood of communities of Northern Kenya. Climatic variability in the region has over the years impacted negatively on the Northern rangelands bringing unpredictable changes in the pasture capacities of the grazing areas (Wafula, 2010).

Communities have their own systems of managing pasture in their regions which take them through wet and dry seasons and assist them to withstand droughts. Community conservancies and group ranches have been formed in a number of counties in the region, some of which have embraced different pasture management strategies. Grazing plans have been introduced in a number of them, whose results have been acclaimed to boost pasture capacities and environmental resilience. However, harsh climatic conditions have persisted, coupled with growing human population, shrinking resource base and pressure to conserve the environment. These have resulted to movements outside the conservancies in search of pasture, resulting to protracted conflicts within and outside the conservancies (Kaye & King, 2014).

Conflicts and other pressures arising over the diminishing resources have led communities in the region to adopt different pasture management systems that enable them to withstand pressure from diminishing resource base. Breakdown of traditional pastoral management systems due to increased population and frequent droughts is also aggravating conflicts between land owners and pastoralists (Selemani, 2014)

There has been protracted standoff often between grazers and land owners witnessed in the region especially during times of drought. This is not only affecting grazers and small scale farmers, but also wildlife conservationists and ranch owners. As livestock populations increase within a given community conservancy, the more and more grazing resources are required. This brings in intense competition for forage, water and other browsable resources, constraining the number of livestock that can inhabit a particular conservancy in a given time to match the level of resource supply as found out by Opiyo, Wasonga, Schilling & Mureithi, (2012).

In the majority of the community conservancies in the region, the most common annual and perenual grass types are the pin grass, *penisetum stramenium* and *P.mesianum*. These species are the commonly available browse for the most part of the year, although most of the above ground grass material especially the *P.messianum,* form hard tuffts with fibrous matter which is not palatable to livestock, meaning that only small percentage of browsable material is available on the top of the standing grass.

There are also a number of tree species which form part of the most important browse in the dry seasons (Rutagwenda &Wanyoike, 1994). These include Acacia *eafota*, *Comiphora spp*, *Euclea divinorum*, *Olea africana, Boscia angustifolia*, while most common shrubs are *Grewia similis* and *Camifora africana*. These species provide critical feed resources during droughts and therefore needs to be conserved (Maleko & Koipapi, 2015).

Ground cover observation in most of the conservancies exhibit widespread bareness comprising of large sections of sheet erosion and few anthills. Herbs include annual thorny ones like the devils thorn. Both herbs and shrubs are highly edged indicating they form the most precious browse in most part of the year (Vrachnakis, 2015). This study aimed at assessing how competition for limited grazing resources lead to inter-conservancy livestock migrations triggering conflicts over these resources in the Northern Kenya.

1.2 Statement of the Problem

In pastoral communities, critical grazing resources mainly pasture and water have been diminishing over the years and becoming a major cause of deadly conflicts. Traditional methods of grazing resources governance, planning and sharing, which have existed among the northern Kenya communities have presently faced immense challenges making the community conservancies fail to achieve peace and co-existence among their members and other neighbors. In recent times, intercommunity conflicts and invasion of private ranches and conservancies in search of pasture have been on the rise and have on many occasions led to loss of human lives and livestock in the region. The real or perceived drivers of grazing conflicts have not been well researched or their likely occurrences properly predicted using resources-based scientific or theoretical models. There was need for generating knowledge about how seasonality of grazing resources builds competition in the pastoral areas, eventually leading to grazing conflicts. This study sought to establish the relationship between available grazing resources and community grazing regimes and eventually came up with a model to predict inter and intra-conservancy grazing conflicts. It meant to bridge the gaps existing between the dynamics of resource availability and the current community grazing systems, and ultimately produce adoptable knowledge-based and sustainable mitigation strategies of grazing conflicts in parts of Northern Kenya.

1.3 Justification

Many studies on causes of grazing conflicts in Northern Kenya have been undertaken and lots of research done on ways of mitigating them (Abdile, 2017; Adan & Pkalya, 2006). However, conflicts on grazing resources continue undeterred, sometimes leading to fatalities (Houreld, 2017). Most institutions, organizations, and governments use lots of resources in conflict resolution, but without a system of early warning leading to timely actions, conflicts over grazing resources are bound to continue (Juma, 2015). This study engaged resource-based real-time social and ecological data of the area to gauge out real and perceived causes of grazing conflicts, and used these to develop a conflict predicting model. The model will assist pastoral communities, governments, researchers, investors and other stakeholders to use the new knowledge to predict occurrence of grazing conflicts in the region and put in place actions that lead to peaceful co-existence between different communities in Northern Kenya.

1.4 General Objective

The general objective of this study was to establish availability of grazing resources, prevailing grazing regimes and community coping mechanisms in order to apply them in predicting grazing conflicts in community conservancies of Northern Kenya and mitigating them.

1.5 Specific Objectives

i. To evaluate seasonality of pasture resources for livestock in Northern Kenya
ii. To determine the relationship between seasonal pasture resources and occurrence of grazing conflicts in Northern Kenya.

iii. To predict community coping methods under limiting grazing resources in Northern Kenya.

iv. To develop a predictive model for grazing resources versus grazing conflicts in Northern Kenya.

1.6 Research Questions

The study used research questions specifically for objectives (i) and (iii), which were:

i. What is the availability of grazing resources in different seasons of the year on the community conservancies of Northern Kenya?

ii. What coping methods are communities in Northern Kenya likely to engage in mitigating grazing conflicts in times of limited resource supply?

1.7 Research Hypothesis

The study used research hypothesis specifically for objective (ii) and (iv). The independent variables (Forage, competition for resources, water availability, stock numbers and rainfall) were taken as influencers of the dependent variable (Grazing conflicts) and therefore helped the study to test the following hypotheses:

$H_{1:}$ Forage availability has a significant influence on grazing conflicts in Northern Kenya

H_2: Competition for grazing resources has a significant influence on the grazing conflicts in Northern Kenya

H_3: Water availability and access has a significant influence on grazing conflicts in Northern Kenya

H_4: Livestock numbers have a significant influence on grazing conflicts in Northern Kenya

H_5: Annual precipitation has a significant influence on grazing conflicts in Northern Kenya

1.8 Outcomes

This study used the independent variables (forage biomass, distances to water, rainfall, and ground cover) to come up with a research-based conflict predicting model to enable Northern Kenya communities, whose main livelihood is grazing, to inform their decisions in managing community conservancies. The study came up with grazing resources threshold levels at which livestock numbers start increasing as a result of forage availability and which the numbers decline as a result of migrations to distant areas in search of forage and water. It analyzed the triggers of different grazing conflicts and how communities cope with them, and brought out the environmental externalities related to grazing conflicts in the study area. The study came up with findings to be used in policy decisions to assist the government in directing resources to support pastoral communities in Kenya. Assistance providers and stakeholders will use insights from this study to enable communities to better manage their rangelands, and eradicate inter and intra-conservancy conflicts and mitigate environmental externalities on group ranches and other community conservancies.

1.9 Significance of the Study

Grazing conflicts in Northern Kenya are very real threats to development of humanity both economically, socially and intellectually, making them a huge obstacle to the achievement of the Economic Pillar of Kenya Vision 2030 which sought to improve the prosperity of all regions of the country and all Kenyans by achieving a 10% Gross Domestic Product (GDP) growth rate by 2030 (GoK, 2008).

This study is significant to scholars of conflicts management in that it used real-time available grazing resources and linked them to related theoretical bases to build up a model for predicting grazing conflicts in Northern Kenya. It has therefore contributed new knowledge to the study of conflicts management. The study will also be useful to researchers and students of resource competition and conflicts in understanding how models can be useful in resource utilization and predicting grazing conflicts.

The study is significant to governments and policy makers who include National Government, County Governments, non-governmental organizations and other agencies engaged in resolution of grazing conflicts in Northern Kenya. This study shall be used as a tool in understanding and overturning the effects of grazing conflicts that hinder human development and environmental conservation in the region.

Community conservancies who act as moderators of resource-based conflicts are significant beneficiaries of this research in that they can use the knowledge generated to predict grazing conflicts to put in place applicable mitigation measures. It will also be useful to pastoralists in managing their resources to avert conflicts and their effects. They will be able to predict resource thresholds that trigger livestock movements and put in place friendly mitigation measures that fit their livelihoods.

1.10 Limitations of the Study

Northern Kenya is a vast region and is the biggest grazing zone in East Africa. There are many traditional group ranches, community conservancies and private ranches found in Laikipia and Isiolo where this study focused. Due to vastness and diversity of grazing sector in this region, the study limited itself to three community-owned and one private conservancy in study area. Therefore, the findings may not be representative of all grazing areas in Kenya.

There was also a limit in accessing respondents therefore organizing focused group discussions interviews and key informants took longer than anticipated. Due to security concerns in the region and the fact that this study took place during hardship seasons of the year when most pastoralists migrate to far regions, lots of movement was limited which required a lot of patience to obtain appointments and conduct a successful interview. The Majority of the respondents were illiterate thus limiting the speed with which to complete a questionnaire.

1.11 Delimitation of the Study

This study specifically focused on the community owned and privately-managed conservancies. It purposefully selected the conservancies having particular desired characteristics of boundaries, registration of members, existing committees and peace and accessibility. The choice to use social, ecological and remote sensing approaches was necessary to make the results stronger and relevant rather than a single method approach. The study only focused on the variables that were measurable and deemed as directly related to grazing resources, and did not intend to venture into unrelated issues like tribalism or regional politics. Where respondents were not able to read and answer the study instruments, research assistants took time and patience to read and interpret the questions for them to understand. It also limited itself to the existing theoretical models and related research on the topic.

1.12 Assumptions of the Study

This study assumed that all respondents who were contacted in the course of the research provided honest and reliable data. It also assumed that the ecological, social and secondary data sought and used in the cause of this study were as representative of the actual situation as possible.

1.13 Operational Definitions of Terms

Community

A group of people living in an area with common interest, language and lifestyle. They share a common sense of a place, geographical or environmental commonness, with similar interests or characteristics, for example a pastoralist community (Barzilai, 2003). In this study, they are the pastoralist communities living in regions of Northern Kenya particularly Isiolo and Laikipia counties.

Community Conservancy

These are resource areas formed and managed by the people who live or surround them and directly benefit from them. In this study, they are legally registered entities, created to organize and manage a common land and its resources using their available means (Northern Rangelands Trust, 2016).

Ecosystems

Are a dynamic complex of plant, animal and micro-organism communities and non-living environment interacting as a functional unit. They are energized by the sun and comprise the air, water, soil and living and non-living organisms all interacting and interdependent on each other. In this study, grazing ecosystems are the natural habitats occupied by humans, livestock, wild animals and varied types and amounts of vegetation particularly in Northern Kenya. They are dynamic and subject to periodic disturbance and are often in the process of recovering from past disturbances (Schindler, 1998).

Ecosystem Services

Ecosystem services are the benefits that society receives from nature, including regulation of climate, pollination of crops, provision of intellectual inspiration and recreational environment, as well as many essential goods such as food, fiber, and wood (Kristie & Lori, 2018). In rangeland ecosystems, services are often valued differently by different stakeholders interested in livestock production, water quality and quantity, biodiversity conservation, or carbon sequestration. Supply of ecosystem services depends on biophysical conditions and land-use history, and their availability is assessed using surveys of soils, plants and animals (Sala, Yahdijan, Havstard & Aguar, 2017).

Environmental Externalities

These are damages, interferences or losses of livelihoods arising as a result of people's interaction with their environment. They are the negative environmental effects felt by a party as a result of an action undertaken by another party, and not necessarily caused by themselves (Andrés & Diego, 2009). In this study Environmental externalities were the adverse effects of overgrazing and related conflicts felt by the wider community in Northern Kenya.

Drought

Is the significant reduction of forage and or/food production due to water deficiency in a rainy season. Metrological drought is the rainfall sum less than half of the long term arithmetic of monthly average. In this study it refers to a period of severe lack of rainfall characterized by high temperatures, poor land productivity culminating to overuse of resources due to limited availability and overpopulation of users (Natalie, 2018).

Group Ranch

Are ranches or grazing areas owned by communities and commonly found in Maasai Mara, Narok, Laikipia and Samburu counties of Kenya. They are categorized as large parcels of land occupied by a group of people living in a common area and carrying out an almost similar economic activity (Laws of Kenya, 2012).

Grazing Conflict

Are any forms of friction, disagreement, or discord arising within grazing groups when the beliefs or actions of one or more members of the group are either resisted by or unacceptable to one or more members of another group. They can occur among the members of similar or different ethnicity in the same country or cross border such as the Sudan grazing conflicts of 2012 (Michelle, 2014).

Growing Season

Defined as the period during which available water exceeds the amount needed by plants for survival (Jatzold, 1995). In this study the growing season is between April and June, and November-December.

Community Environmental Norms

Are indigenous beliefs and values which guide the way people organize different elements of environment in their region/estate. These are the pro-environmental behaviors by the people of Northern Kenya particularly in Isiolo and Lakipia counties, that determine and guide them to behave in a certain way towards environmental conservation and utilization of the natural resources (Mica, Wesley, Silva-Send & Boudrias, 2017).

Forage Resources

Are plant materials (mainly plant leaves and stems) eaten by grazers (Livestock and wildlife). It is an important factor to consider when determining stock rate per a certain area of grazing. In this study, it is a measurement of above ground forage by clipping and weighing the standing grass in a certain number of plots (Pratt & Rasmusen, 2001).

Indigenous Knowledge Systems

These are the intricate knowledge systems acquired over generations by communities as they interact with their environment, which comprises technologies, service, economic and philosophical learning. It comprises of traditional system of knowledge undiluted by the modern way of life, and passed down to generations by their elders. In this study, it is the knowledge of the traditions and culture of the people of Northern Kenya which anchors them to their traditional environment, the challenges they face and how they deal with them (Kgomotso, 2005).

Land-use and Cover

Land-use is the purpose of human activity on land space, while Land cover is the extent of that purpose, built land, farmlands, wetlands (Smith, Miles, Vissage & Pugh, 2004).

PGIS- Participatory Geographical Information Systems

Historical or lay knowledge on the environmental - community dynamics in a region acquired over time used to govern community's interaction with their natural resources. In this study, it has been used to refer to a system of historical approaches in managing and resolving conflicts in natural resource use, collaborative resource use planning and management and equity promotion among the locals (Rambaldi, 2010).

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews the works of other researchers and develops the conceptual framework of the new study. The main components of this chapter constitute related literature aimed at identifying gaps in relation to the field of study, exploring theories and empirical research on the topic in order to critique the conclusions made thereof on the subject under study, and relating the dependent variable with the independent variables to finally produce a summary of the chapter.

2.1 Theoretical Framework

A theoretical frame is a guide on which a research idea is systematically developed and anchored. It provides the philosophies on which the researcher will align the research based on the approaches and methods employed to arrive at the results and conclusions. It connects the social perspectives of natural resources and the conflicts arising due to the scramble for the resource availability. It identifies the concepts and defines their connection with the general thinking or accepted theory of the causes and consequences of natural resources conflicts. These concepts are developed into a general model which speculates on the connections between them and conflicts over natural resources (Brian, 2005).

2.1.1 Mauthasian Theory of Demand and Supply of resources

Classical theories have argued that due to limited supply of resources, the demand will exceed supply leading to conflicts. They have also argued that conflicts arising as a result of natural resources due to over population and diminishing resources are traditional checks which come in to return to equilibrium the status of demand and supply of resources (Price, 1998). They argue that deminished supply of natural resources such as water, food and space will eventually exceed the needs of human consumption leading to negative social outcomes such as war, diseases, calamities and human migration, the inevitable results being poverty and disaster (Brian, 2005).

2.1.2 Theory of the Society and Natural Resource Conflicts

Economic theories have supported creation of market systems in order to balance demand and supply of resources. A system that is more fairly distributive in nature is rare in the natural resources scenario, but fair accessibility for all can be more helpful to bring about well-balanced and dynamic societies (Clark, 1973). It postulates that the more scarce the resource becomes, the more it dictates a change of consumption patterns among its dependants, thus deterring overconsumption and wastage, and forces them to explore alternatives and substitutions for their survival. Critics of classical theorists, in this context, have argued that the more scarce the resource gets, the more the impetus the population gets to continue exploiting it, in order to take advantage of higher prices and make profits, thus the resource eventually becomes extinct, disappears or is devastated (Clark, 1973).

Scarcity or extinction of resource in demand therefore leads to myriads of conflicts over natural resources. This is well illustrated by poaching of endangered wildlife to obtain trophies for sale, leading to an almost extinction of certain species like the rhinoceros, elephants, or the Columbus monkeys (Davidson, 1999). The economic theory, sometimes referred to as the Marxist theory, has been attributed to political conflicts where societies of the ‘haves’ rise up due to their vast accumulation of wealth, to dominate and control politics of the ‘have-nots’ (Trainer, 1998).

2.1.3 Environmental externalities and international security theory

There has been an upsurge of theories on the relationship between environmental degradation and international conflicts in the last few decades, leading to emergence of a field of environmental security to study effects of land degradation and scarcity on an international outlook (Dabelko, 1996). It was originally understood as the effects of environmental depletion and degradation due to violent conflicts. However, environmental security, according to Graegar (1996), now commonly refers to the relationship between the state of the physical environment and the general state of social, ecological, and political well-being in societies. The Homer-Dixon (1991) theory for instance, pointed out to natural resource scarcity as the potential drivers of international conflicts and cross border insecurity.

2.1.4 Society copping methods to conflicts theory

The Homer-Dixon theory of natural resource (1994) conflicts tends to assert that negative consequences of natural resource scarcity may include human migration and expulsion, receptivity to insurgency, decreased economic productivity, and a weakened state. The theory attempts to show connectivity between livestock migrations with grazing conflicts, often witnessed when pastoral communities in East Africa move with their livestock during times of forage scarcity.

According to Schnaiberg & Gould (2000),"The wide variation between the levels and types of ecological damage inflicted by the nations of the world guarantees that nations will come into conflict with one another over solutions to global environmental problems. Similarly, the wide variation among nations in terms of the distribution of benefits received from ecosystem withdrawals and additions will also necessitate conflict in the international arena". The nexus of this theory with the present study, is manifested when communities or their subsets practice cattle rustling as a way of wealth accumulation, replace their stock after deaths, or cultural practices dictates invasions of other communities to acquire stock or manifest power over them.

2.1.5 Theory of competition and species survival in grazing scenario

Competition in grazing scenario applies where different species of animals are competing for a common shared resource (Murray and Brown, 1993). Each browser takes in as much as possible to satisfy its dietary requirements, as the resource in question diminishes with time. Increase in population of certain browser species means technical displacement of the other as far as available forage is concerned, thus leading to declining population of the less powerful species (Begon, Townsed & Harper JL, 2006). In such a scenario, pastoralists start noticing declining health of their livestock, thereby prepare for movements to other areas in search of pasture and water, leaving the weaker stock behind. In grazing communities, intraspecific competition leads to dominance by the most adaptable species, a common phenomenon seen where sheep, more specialised in hard and enduring parts of the forage, take over large fields after outcompeting cattle (Murray & Brown, 1993).

The causes of competition are in general very simple; organisms are forced to share limited resources like food, water, space and sexual partners. Competition can be much more indirect, not involving physical contact, when individuals make the life of their competitors more difficult by reducing the availability of resources, i.e. by consuming these resources (Begon et al., 2006). Ecologists have developed mathematical models to better explain species competition for limited resources (Volterra, 1926). The classic model was developed to show how interference between species competing for a resource leads to species removal or extinction, and eventually displacement (MoyaLarano, El-Sayyid & Fox, 2007).

Tilman, (1982; 1990), tried to explain how consumer-resource theory applies in a species competition scenario, which can still be applied in the field of ecological competition for grazing resources (Sterner & Elser, 2002). It argues that declining resources leads to declining population, and those species that have better mechanistic survival ability, like those which can store their forage for dietary requirements in future, have better dominance over those that cannot (Aksnes & Egge, 1991). This can be used to predict the outcome of a competition in a field where forage is fluctuating with time (Ducobu, Huisman, Jonker & Mur, 1998).

Limited resources in a grazing area leads to various forms of competition between the species, livestock and communities dependent on them. There are theoretical and mathematical models that are developed and used to predict outcomes of competition of species for a resource, based on the knowledge of the resource in question, their behavior, numbers and growth characteristics (Tilman, 1982).

In Northern Kenya for instance, competition for forage and water occurs between animal species that is livestock, wildlife and human populations. This has been variously linked to increase in livestock and human population, over grazing, limited resources migrations and often grazing conflicts. Plant species also compete for limited water and nutrient base, often leading to the scenario of fluctuating forage availability, lack of water and emergence of and spreading of the invasive or alien species not native to those areas (Davis, Grime & Thomson, 2000).

This model has relevance to the present study, where competition for grazing resources often leads to some individuals or communities attempting to outcompete others with similar resource requirements through aggressive resource use and overstocking. The model denotes that when there is competition for a single resource, the quantity of the resource can be used to predict the outcome of competition, in this case grazing conflicts, with a high degree of accuracy.

2.1.6 Grazing resources contest competition model

Species competition for grazing resources can take a form of contest, where the winner takes it all. In Northern Kenya, this is well exhibited where some species of wildlife like buffalos displace livestock due to their aggressiveness, body size and large groupings (Chirichella, Apollonio, & Rory, 2014). On the other hand, sheep compete with cattle, where cattle take up the upper and softer part of the browse, leaving sheep to gnaw on the lower parts of the grass (Heying, 2004). This can also take a form of dominance where communities want to defend their grazing fields for grass and ward off invasions by other pastoralists, or some wildlife are defending their territories like lions and rhinos for hierarchy and reproduction (Den Berg, Rossing & Grasman, 2006).

2.1.7 Resource-based scramble competition model

This is well exhibited where the grazing resource is open and accessible to all the species, and communities in the region. The resource is usually utilized until it is completely depleted, therefore domestic and wild species are left to migrate long distances to look for more and better resources. This is the most common scenario in Northern Kenya, where lack of grazing plans in most of the conservancies exists. It is actually seen as one of the contributors of grazing conflicts as the resource is perceived to belong to all (Den Berg et al, 2006).

In such a situation, the available resource is not able to sustain all the needs of both livestock and wildlife species competing for the same shared resource. Therefore, there is general deterioration in health, value and population decline occurs either due to death or migration (Berryman, 1997; Branstrom & Sumpter, 2005).

Distances to water and other resources increase as a result of diminishing grazing resources and over population, making people and livestock to spend more time seeking for them. This reduces the energy and time for doing other activities in the communities, and therefore poverty and environmental externalities are widespread among the Northern Kenya pastoralists (Heying, 2004).

Scrambling for a shared resource is more balanced where the competitors are of same species but in grazing in community owned group ranches, the common scenario is mixed species of browsers and grazers, competing with wildlife and other ungulates (Sharrov, 1997). As espoused by Evegeni, Michael, MacDonald, Van Dyken, Katya, and Michael, (2015), crowding or scrambling for certain resources among species, leads to unstable relationships including conflicts (Pratt & Gwinne, 1977). Table 2.1 presents a summary of the basic theories and key concepts introduced in the above discussion of social scientific theories on the interaction of society and natural resources:

Table 2.1:

Basic Theories on Natural Resource Conflict

Approach	Basic Theory	Important concept
Malthusian Theory	Due to population growth, human consumption will eventually exceed the availability of natural resources, causing negative social outcomes like war, disease, and famine	Population Growth, Natural Resource Scarcity, Social Breakdown
Classical Economic Theory	A system based on supply and demand will bring about social system capable of addressing scarcity. Scarcity deters over consumption, thus minimizing the need for disputes over resources	Economic Development, Trade, innovation
Marxist Theory	Free markets create disparities in wealth, thus generating conflicts of interest between the "haves" and the "have-nots.	Social Inequality Conflict
Schnaiberg and Gould Theory	Economic development causes inequality and natural resource degradation and depletion which will contribute to conflicts	Economic Development Natural Resource Scarcity Conflict
Tilman's competition Theory	Declining resources leads to declining population. Storage of resources for the future consumption leads to better species dominance	Dominance of species over others
Classical Sociological Theory	Macro-structural changes in social organization affects social adaptability. Population growth and competition for resources result in an increasingly complex division of labour, which increases social adaptability and decreases conflict.	Social Adaptability and conflict. Population Growth and overstocking leads to competition for resources aggravating grazing conflicts
Homer-Dixon Theory	Natural resource scarcity can cause conflict indirectly by causing social breakdown. Negative consequences of scarcity include human migration and expulsion, receptivity to insurgency, decreased economic productivity, and a weakened state.	Natural Resource Scarcity Social Breakdown Conflict for resources

Source: Adopted from Brian, (2005)

The theories speculate, in different ways, on the relationship between the decreasing availability and quality of natural resources and the level of social conflict, which may result from it (Brian, 2005).

2.2 Evaluating Available Grazing Resources in Northern Kenya

Rangelands vary in their forage availability, distribution and biomass palatability. These factors contribute to the grazing potential of the particular rangelands (Clarke, 1986). There are various ways of range potential assessment, however, the rangelands monitoring requires an understanding of other concepts that are of relevance to successful evaluation of the grazing resources available in a grazing landscape (Kimiti, 2016; USDA, 1996; FAO, 1990).

2.2.1 Assessment of stocking rates

Most rangelands in Kenya have differing pasture potential mostly being as a result of varying soil and rainfall characteristics (Onyango, 2011). Determining their accurate stocking rates has sometimes been challenging. According to the USDA (1997), when a certain number of a particular animal species graze on a unit of land for a period of time, this is referred to as stocking rate (Frost, 2019). Stocking rates in Kenyan rangelands have been difficult to estimate owing to stock population and movements in the regions in recent years. However, this is normally estimated as number of animal units per unit area, where animal unit is considered to be one mature head of cattle of approximately 453kg with a calf of up to 6 months of age (Onyango, 2011) if it is a cow.

2.2.2 Carrying capacity

Grazing in Kenyan rangelands involves extensive movements of livestock between seasons of pasture availability in the communal pastoral livelihoods of Northern

Kenya. Group ranching in Kenya faces innumerable challenges owing to maximum numbers of animal units that can be sustained in a unit area (McConnell & Daniel, 2002; Veit, 2011). The problems range from curtailed stock mobility due to fencing of land, competition from tourism establishments and sparsely distributed water resources as well as overgrazing (Ng'ethe, 1993). In Northern Kenya scenario, carrying capacity is a highly variable factor, depending on seasonality of rainfall and forage, numbers of livestock and their movements and frequent droughts experienced in the area sometimes leading to deadly conflicts (Breman, 2016). It is imperative to estimate carrying capacity of communal rangelands in Northern Kenya, though many times it faces a challenge of lack of proper data of livestock numbers, past history of the grazing fields, forage estimates and past stocking rates (Frost, 2009; Craig, 2017).

2.2.3 Forage resources and biomass production in the study area

Forage and water are the most critical resources in the grazing regimes of Northern Kenya. Scattered bush lands, grass and shrubs consisting of short, hedged and highly browsed species are most common (Ericksen, Said, Leeuw, Silvestri, Zaibet, Kifugo, Sijmons, Kinoti, Ng'ang'a, Landsberg & Stickler, 2011). Forage and water availability are highly affected by seasonal rainfall, biophysical environment and are highly variable in geographical distribution. Laikipia and Isiolo rangelands occur on varying altitudes with similarly variable rainfall patterns, different soils and vegetation types and characteristics (Herlocker, Dirschil, & Frame, 1993). These rangelands are also used by different livestock species having distinctly different forage and water requirements as well as different capacities to harvest feed from natural pastures (Herlocker et al, 1993).

Some of the communal rangelands in the landscape have relatively sustainable forage productivity and water resources, especially those that are on the higher altitudes and therefore have a higher potential for productivity and livestock development. In the lower topographies of the more arid North, grazing resources are more constrained, leading to frequent migrations often associated with various conflicts. Rainfall fluctuations leads to poor forage production which affects livestock markets leading to poor economic base of the population (Jatzold, 1995).

2.2.4 Clip-and-weigh method

For communities to establish the potential of their grazing fields, it is important to estimate its carrying capacity. This can be carried out in various ways and one most common method is clip-and-weigh (Lovel, 2012). This involves randomly distributing the 0.5mx0.5m grid and clipping all the standing forage therein. This is then dried and weighed once. The resultant weights are then averaged and interpreted to arrive at the actual stocking rate of a particular field (*NDMC*, accessed 12-08-2018; Thurrow & Herlocker, 1993).

This method requires clipping as many samples as possible (at least 15), depending on the uniformity of the grazing field and ensuring that they are representative of the entire field, then the samples are dried, weighed, averaged and divided by the number of samples. This is then multiplied by ten to make it kg/ha. If the range condition is increasingly variable, one will require more samples (Pratt & Rasmusen, 2001).

For example in a rangeland producing 2000kg/ha, available forage would be: 2000x0.25=500kg/ha. This is then based on air dried weight and calculated into forage consumed by a certain animal per month. To get the stocking rate, the available forage is divided by the animal weight, say a native head of cattle of 350kg, then the stocking rate will be 1.4 animal unit months per hectare (USDA, 1997). In research, electronic ovens are easier to use since they can be set to desired temperature levels, and therefore are more preferred to oven-dry the samples to achieve 100% dry matter content, rather than air-dried forage which normally achieves about 80% dry matter (Herlocker, 1999).

In community grazing areas of Northern Kenya, it is difficult to determine the stocking rates due to erratic terrain conditions and unpredictable movement of livestock in search of pasture. This is usually done based on ground observations of growth trends, grass abundance, ground bareness and the estimated livestock numbers (Hernderson, 2012; Onyango 2011). The results are adjusted using trial and error methods to yield trends depending on the ground conditions of the range (Herlocker, 1999). Table 2.2 shows the procedure to follow in estimating animal intake by species:

Table 2.2:
Animal intake by species (converted to SI units)

Species	Intake (% of body weight per day)	Intake Kg per day
Mature Cattle	2 to 3	9 to 14
Sheep	2.5 to 3.5	2.25 to 4.5
Goats	4 to 5	1.35 to 2.25

(Source: National Range and Pasture Handbook, 1997)

2.2.5 GIS techniques for evaluating forage and pasture availability

Remote sensing techniques have been used in various fields to assess habitat changes. One of these techniques is the Normalized Difference Vegetation Index (NDVI) (Gandhi, Pathiban, Thumalu, Christy, 2015). Holme, Burnside & Mitchel (1987) acknowledged and described it " NDVI is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum, and is adopted to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation or not"

NDVI is widely used in agriculture to predict drought, estimate crop yields, and help to make farming decisions (GisGeography, accessed July 2018). It is applied by ecologists to estimate healthy vegetation on rangelands and to assess dwindling grazing landscapes. In forestry, it has been used to estimate forest resources, forest cover and yield using leave area index. In grazing, NDVI is helpful to predict grazing resources in order to mitigate related conflicts by evaluating biomass indices availability, ground cover, percent bareness, and general forage availability (Gandhi, et al, 2015).

Healthy vegetation strongly absorbs almost all the visible light while reflecting larger portions of the near infrared light falling on them. On the contrary, poor or unhealthy vegetation reflects large portions of visible light while absorbing the near infrared light falling on them (GisGeography, accessed July 2018). Degraded and bare soils are portrayed as moderate reflectors and absorbers of both lights in an electromagnetic scale (Holme et, al 1987; Gandhi, et al, 2015). Near-infra-red (NIR) and red lights are the most useful electromagnetic spectrum ranges to assess the status of vegetation in an area, and the bigger the difference between them, the more the available forage in the rangelands. To assess healthy vegetation, one can calculate the Normalised Difference Vegetation Index manually by using the formula:

NDVI = (NIR-RED) ÷ (NIR+RED)

Where:

NDVI-Vegetation health or greenness

NIR-Near Infra-red light strongly reflected by healthy vegetation

RED-Red light strongly absorbed by healthy vegetation (GisGeography, accessed July 2018).

It is normally useful where one wants to clearly separate identical areas of vegetation like those under cloudy conditions and those under bright sunshine to avoid giving them a similar value (Holme, et al., 1987; Gandhi, et al, 2015). It is necessary to allocate acceptable absolute differences between the colour bands, therefore, the total of the reflectances are divided (Holme, et al., 1987). The NDVI maps can be easily created using the image analysis tool bar in ArcGis 10 that requires imagery with NIR and RED colour bands. The value of the ratios range between -1 to 1 (GisGeography, accessed July 2018, Holme, et al., 1987). Those which fall under extreme negative represent water while those near zero depict barren, degraded or severely eroded soils, and those above 0.6 represent healthy or live vegetation (Holme, et al., 1987).

2.2.6 Relationship between Grazing Resources and Grazing Conflicts

Lack of accessibility to or unavailable grazing and other livelihood resources in Northern Kenya has for decades led to disputes and conflicts. Political manipulation or conflicts of interests between state actors, industries like tourism, agriculture and forestry found in the area have always led to disputed claims over the allocation of or access to natural resources. These conflicts of interest can arise within and between the actors in the area and the resource in dispute (Houreld, 2017).

The state of the resource in the Northern rangelands has deteriorated over time, as a result of variable climatic changes, infrastructural and other developments in the area, thus shrinking the traditional grazing fields which later leads to migration and conflicts between pastoralists and private ranchers and other communities (Ogutu, Piepho, Said, Ojwang, Njino, Kifugo, 2016). The resource base has declined overtime which has exacerbated pressure on communities, ranchers and private investors, often leading to conflicts, with all players spending substantial amounts of time and energy in resolving them (Chandraskhan, 1997).

2.2.7 Grazing conflicts among pastoral communities in Northern Kenya

Pastoralism is an economic activity that occupies the largest of Kenya's landmass and is the livelihood and cultural activity practiced by the majority of the population of northern Kenya

(Okumu, 2014). It is practiced on the cast areas on northern Kenya on both sides of the border between Kenya and Somalia, Ethiopia, Sudan, and spreads to Uganda and takes the large swathes of rangelands between Kenya and Tanzania.. The last population census reported that pastoralists numbered nearly six million or about one seventh of the total national population which was estimated at around 40 million (KNBS, 2009). According to the Kenya Economic and Household Survey of 2009, Pastoralism is practiced by different ethnic and linguistic groups in Kenya, ranging from the most prominent ones like the Maasai, Samburu, Somalis, Borana and the Pokots, as well as smaller groups who include the Ogieks, Taita and the Redile (KNBS, 2009).

Trust lands and group ranches are the common land ownership systems in northern Kenya, and their management has largely been informal, characterized by vague leadership and lacking in structural governance. This ambiguity and lack of modern tenure systems has often resulted to segregation into clanisms with larger ones groups claiming large areas, and often invading their weaker neighbours for grazing resources in times of droughts. The porous border between Kenya and Somalia and the secessionist war in the northeaster neighbor in the 1990s led to influx of Somali refugees into Kenya, led smuggling, poaching and other crimes, and had the overall effects of making the region appear unattractive to other Kenyan communities leading to its state of exclusion and under development for many decades. (Veit, 2011; Okumu, 2014).

Isiolo borders the agricultural and populous Meru and Laikipia counties on one side and the dry Wajir, Garissa and Marsabit counties on the other. During the colonial period, the Boran were protected in their exclusively designated grazing lands East of the Gotu falls, which grazing area was designated exclusive Boran tribal grazing land. The exclusive designation lapsed, and in independent Kenya, the protection is no more. As Okumu (2014) reports, traditional grazing communities in the area are losing grazing lands as seen in the case of Borans versus Somalis in Ewaso Ngiro basin. Somali population in Isiolo County has expanded from 10 to 35 percent between 1960 and 1990, while the population of Meru agriculturists flowing into the wetter areas of Isiolo town has also grown dramatically (Ericksen, Said, Leeuw, Silvestri, Zaibet, Kifugo, Sijmons, Kinoti, Ng'ang'a, Landsberg, Stickler, 2011). The resistance to such take over by local Somali, Boran and Samburu has led to a deadly struggle for grazing land with the incoming peoples. As a result of multiple ethnicity and diversity, security in this region is a complex issue requiring joint interventions by multiple players, bearing in mind that in recent times, it has clearly shown that the contest is largely due to competition for resources (Okumu, 2014).

2.2.8 Conflict over water and pasture in Northern Kenya

In the past few years, Northern Kenya has undergone severe drought, forcing many of the resident pastoralists to move with their livestock as far away as neighboring countries of Ethiopia and Tanzania in search of pasture and water (Odongo, 2016). This has worsened the already volatile conditions existing in the region, as movement of livestock has led to competition for the scarce resource, often leading to deadly conflicts among communities (Noor, 2017). As IRIN, (2009) reported, Over the years especially during droughts times, herders cannot manage their grazing resources and therefore result to migrations in large numbers sometimes going across borders into Ethiopia, and Tanzania. These movements of large stock often leave a trail of conflicts and destruction, sometimes resulting to deaths, invasion of private property and arrests and prosecutions of herders

(IRIN, 2009). In March 2017, Reuters reported that "a gun battle between two pastoralist communities competing for grazing killed at least 10 people in Northern Kenya on Sunday morning, police said, and raising questions about the government's ability to maintain peace before August elections". "Armed cattle herders from Isiolo and Samburu counties fought over grazing access along the two county borders," said Isiolo County police commander Charles Ontita (Noor, 2017; Pkalya, Adan, & Masinde, 2003).

2.2.9 The concepts of grazing conflicts and their resolution

Conflict arises when interests of two or more parties coincide and at least one of the parties seeks to assert its interests at the expense of the other party's interests. Conflict has also been described as `a social phenomenon that can result from instantaneous or gradual changes that create diverging interests and needs'. Conflicts can involve two parties (by-partisan) or several parties (`multiparty conflicts') and can arise in numerous contexts, on numerous levels and over numerous issues (Chandraskhan, 1997).

Conflicts are multidimensional and frequently involve complex interactions between many parties involved. However, for analytical purposes, it is useful to identify the following four dimensions of a conflict: the actors; the resource in dispute; the stake that each actor has in the resource; and the stage that the conflict has reached (i.e. the time dimension). The environmental dimension will be added to each of these. According to Chandraskhan (2007), the actors are generally the disputants (e.g. government departments, private companies and local communities) but may also include other parties, such as governments, who may have an interest in peaceful resolution of social conflicts. The interaction between the actors is frequently crucial in determining the terms on which the conflict will be resolved, if it is resolved. The resource at stake can be characterized as synergistic, complementary, competitive or antagonistic actions of parties involved. Of these, the competitive and antagonistic interactions are likely to give rise to conflict (physical, biological, social or economic) (Chandraskhan, 1997).

2.3 Community Coping Methods on Kenyan Pastoral Landscape

Kenyan pastoral communities in Northern Kenya have developed a number of approaches that range from traditional methods to electronic approaches in pasture management, (Okinda, 2018). Group ranches have played a major role in providing a basis for collective grazing management by grazing communities in Northern Kenya. Conservancies have been created to strengthen the already weakening group ranching, and Community Land Bill which seeks to entrench the community conservancies is undergoing scrutiny in Kenyan parliament (Njagi, 2016; Okinda, 2018). The governance in these community conservancies entail grazing committees whose part of their role is to mitigate grazing conflicts, survey conservancies for availability of pasture, agree on grazing units and schedules within the conservancies while implementing a monitoring procedure (Montana S.U, 1993). The community conservancies have enabled pastoralists to initiate grass management approaches which include holistic management, overcoming the severe effects of drought as well as enabling the government and other assistance providers to intervene in times of conflicts or hardships (Voice of America, 2017).

2.3.1 Traditional grazing regimes among Kenyan pastoralists

Pastoralists in Northern Kenya and those organized in group ranches setup have indigenous ways of allocating seasonal grazing areas, depending on availability of pasture and water (Berger, 1993). Grazing conflicts arise mostly where there is scramble for forage on blocks that are claimed by certain group versus the incoming new groups, or where traditional livestock migratory routes have been curtailed by another group (Ayana & Adugna., 2006). Land ownership traditionally being under group ranches has faced severe challenges in recent years, with some pastoral groups like the Maasai, whose movements take them across the border to Tanzania, having experienced barriers as a result of emerging land ownership systems on the rangelands (Campbell, Gichohi, Mwangi & Chege, 2000).

Inevitably, as observed by IRIN, (2011), these curtailments of traditional movement routes, have resulted in pastoralists coming directly into conflict with the law, security systems or breaking through private wildlife conservancies, or coming into conflict with wildlife when using the traditional wildlife dispersion corridors (Western and Wright, 1994). Graham, (1989) noted that pastoralism in Kenya, especially for the Maasai, converted from communal lands to group ranching in the 1960s. Since the colonial times, communal land was managed by community members who grazed their livestock while taking care of the boundaries, grazing resources and degradation (Veit, 2011).

However, the creation of group ranches in the 1960s curtailed livestock movements, effectively confining the Maasai into group ownership. Group ranching has of late faced immense pressure from members who want to own individual parcels, while the grazing resource is immensely constrained as a result of extensive and continuous grazing by the members and the migrating stock (Burnsilver & Mwangi, 2007).

This pressure on savanna rangelands, where most of the group ranches occur, has over the years led to deterioration of the grazing resource-base, due to degradation occasioned by intensive grazing (Skarpe, 1992). This is linked to the theory that the traditional Maasai grazing system were organized in community grazing plans that rotated throughout the rangelands in different seasons of the year, thus effectively alleviating degradation and related environmental deterioration (Burnsilver & Mwangi, 2007).

2.3.2 Community competition for grazing in Northern Kenya

Grazing in Northern Kenya has been associated with land degradation and other environmental externalities. Continuous removal of browsable parts of plants has caused poor growth on vegetation, resulting to short and stunted shrubs and hardy herbs (Briske & Richards, 1995). This defoliation of grass and other vegetation affects plant production and the overall forage availability on the conservancies, leading to regular movements of livestock often associated with grazing conflicts between individuals, or among the neighboring pastoral communities of Northern and Northwestern Kenya (Francis, Wasonga, Schilling, Mureithi, 2012).

There is widespread reduction of vegetation vigour as a result, and this coupled with effects of adverse climate changes of recent years in the region, leads to emergence or existence of widely spaced stunted trees, small groups of hard stock grass species and emergence of unpalatable invasive species (Briske & Richards, 1995). These have small photosynthetic surface area, thus impacting the entire plant surface area, height, diameter and root mass. Root formation and functionality are undermined due to reduced growth capacity as a result of chronic and intensive grazing thus affecting the plant's water and nutrient uptake (Hodgkinson & Becking 1977, Francis et al, 2012).

Communities that have well established grazing plans, undertake proactive holistic grazing arrangement like is seen on private conservancies (Savory, 2015), or are able to practice season based grazing giving the rangelands enough time to rest, have experienced better grazing times with reliable forage and stable soils (Holechek, Pieper,& Herbel, 2001). Holistic approaches to grazing are reviving hopes of rebuilding lost forage potential of the Northern Kenya conservancies and therefore are seen as of great importance to the grazing planners in the region (Lalampaa, Wasonga., Njoka, Rubenstein, 2016).

2.3.3 Community grazing resources conservation

Rangeland ecosystems are capturing greater public attention with growing recognition of the variety of products and services they provide. These ecosystems are increasingly recognized as sources of water, biodiversity, recreation, aesthetics, wildlife habitat, carbon sequestration, and residential sites in addition to livestock products (Havstad, Debra, Brown & Skaggs, 2007).

Conservation goals often emerge at large scale, and even though the flexibility associated with rotational grazing systems can provide managers with opportunities to manipulate grazing bird nesting success, periodic plant establishment or reproduction, fuel accumulation or suppression. There has not yet been a comprehensive accounting of the conservation effects associated with the large-scale adoption of grazing systems. While there has been a need to link grazing experiments and actual environmental responses to grazing, the majority of researchers have not yet collected and analysed appropriate variables to yield decisions for real-time environmental conservation (Hickman, Hartnett, Cochran &Owensby, 2004).

The response of soil hydrological characteristics represents an important exception to this generalization based on a substantial number of experimental investigations conducted in the 1970s and 1980s. The response of soil hydrological characteristics to grazing largely parallels those of other ecological variables in that stocking rate is the most important driver, irrespective of grazing system (Thurow, 1991).

Continuous removal of large amounts of plant cover and biomass by intensive grazing reduces the potential to dissipate the energy of raindrop impact and overland flow. The erosive energy of water and the long term reduction of organic matter additions to the soil detrimentally affect numerous soil properties including bulk density, disruption of biotic crusts, reduced aggregate stability and organic matter content. This reduces infiltration rate and increase sediment yield and runoff. Animal trampling is another source of mechanical energy that breaks soil aggregates and is, therefore, negatively correlated with maintenance of soil structure necessary for high infiltration rates (Warren, Thurrow, Blackburn, & Grza, 1986; Holechek et al, 2000).

2.3.4 Community, environment and vegetation responses to conflicts

Conflict over natural resources is usually accompanied by loss of the true value the resource offers to the environment and communities (Chandraskhan, 1997). In most cases, these environmental values are not taken into account when it comes to competition for the resources. This is because they are not the direct values communities reap from environment like forage crops (Mulinge, Gicheru, Murithi, Maingi, Evelyne, Kirui and Mirzabaev 2015). The loss of the hidden environmental benefits such as biodiversity, wet lands, soil nutrients, ground water, clean air, and climate regulation are not accounted for and the cost of damaging them or losing them not clearly foreseen or borne by the communities (Mulinge et. al, 2015). The cost of dealing with such damages is sometimes ignored until consequences such as degradation, invasive species, unpredictable climate patterns, droughts and loss of fertile soils take over the daily lives of the community (Chebet, 2013). Uncontrolled grazing in the forests for instance, leads to loss of top soils through resultant flooding, diminishing water sources in the ecosystem, decreased canopy cover, loss of economic livelihoods and acute poverty (Otieno, 2013).

Vegetation on rangelands responds in different ways depending on the nature of grazing taking place (Manley, Hart., Samuel., Smith, Waggoner Jr., & Manley, 1997). Intensive and continuous grazing not only hurts the soil due to intensive trampling thus causing different forms of soil erosion, but affects plant growth and diversity (Mould, 2014). Extended grazing targeting certain palatable grass species leads to disappearance of such species from an area, and sometimes has been associated with modifying species composition and emergence of alien or invasive species in an area (Peter & Mark, 2002). In some conservancies of Northern Kenya, holistic range management combining principles of ecological balancing with seasonal rotation of stock and forage availability has helped to improve the primary productivity of the range. Forage quality is always a result of uncontrolled grazing as grazers go for the soft, palatable parts of the grass leaving hard tufts of unbrowsable parts (Manley, et al,1997).

2.3.5 Overgrazing and ecosystem externalities

Overgrazing results when standing grass and other forage materials are subjected to lengthy periods of grazing without undisturbed rotation periods to regenerate and utilize nutrients. It occurs when a particular number of browsers, including livestock and wildlife spend more time in a grazing area than the space, time and resource can allow (Galt, Molinar, Navarro, Joseph, & Holecheck, 2000). In order to come up with a sustainable grazing system, grazing managers have to consider time of forage recovery in a particular grazing area. This avoids continuous and selective browsing of the palatable parts and gives rangelands time for recovery (Tong, Richard & Seong, 2016).

Grazing systems which put in place proper grazing plans, based on the production capacity of the areas in consideration have enough time for grass recovery, often factoring in a clear rotation system to harmonize grass growth and consumption by livestock or wildlife (Bransby & Tainton, 1977; Galt et al, 2000). Kenyan rangelands support different categories of browsable grass forage (Trollope, 1990). Both increaser and decreaser categories are found abundantly dominating the Kenyan rangelands, (Mganga, Muzito, Nyariki, Nyariki, Wangombe, 2013). Trollope (1990), noted thus: 'decreaser species dominate ranges in good condition and decrease with over or undergrazing. Increaser I species dominate in undergrazed or selectively utilized rangelands, and Increaser II species dominate in rangelands that are overgrazed' (Trollope, 1990).

In Kenyan rangelands, increaser II species are good indicators of overgrazing which are tough, fibrous and unpalatable (Botha, 1999). Grass tufts distances can be used as good indicators of signs of degradation. Observation of inter tuft distances, (Trollope & Trollope, 1999), measurement of grass heights and observation of leave and stem composition help to indicate vulnerability of the field to erosion and other externalities as well as palatability of the forage. As the range bareness increases, the lesser the productivity of the rangeland (Oudtshoorn, 1992). Productivity declines with time leading to lesser biomass cover, exposing the soil to other factors of degradation all leading to poor rangelands (Morgan, 1995).

2.3.6 Community-prescribed grazing on communal rangelands in Kenya

The USDA defines prescribed grazing as "the controlled harvest of vegetation with grazing or browsing animals, managed with the intent to achieve a specified objective" (USDA, 1997). As way of controlling the negative environmental effects of overgrazing, such as degradation and invasion by intrusive and unpalatable species, prescribed grazing considers compatibility with the local range situation for maximum economic and ecological outputs (U.S Fish &Wildlife Service, 2009). This practice assumes a form of holistic approach to grazing management with an aim of improving forage performance, excluding invasive or alien species while improving the quality and quantity of the forage support base that is water and soil (USDA, 1997).

In Kenyan pastoral conditions, development of workable grazing systems with acceptable grazing plans and holding a sustainable number of livestock per given period of time has been a challenge to the community conservancies and group ranches. Due to highly variable conditions of rainfall and vegetation, the communities grazing systems end up accelerating the poor conditions in the group ranches (Ng'ethe, 1993) and prescribed grazing. Incorporation of appropriate approaches like prescribed grazing through developing and upholding viable management plans and use of new technologies like electronic applications will save the Kenyan pastoralist from relying on traditional scouting methods for pasture and water availability (Okinda, 2018).

2.3.7 Analyzing resource conflicts through contest-success function

The Contest Success Function (CSF) was applied by Butler and Gates (2012) in studying climate, conflict and property rights as key issues in African range wars. The CSF model puts into perspective the allocation or misallocation of resources in the absence of a property rights regime in a weak or fragile state characterized by endemic ethnic violence as exemplified by pastoralist groups in the Karamoja cluster and, more specifically, in North-western Kenya among the Turkana, the Pokot and the Samburu. The CSF model assumes that the level of inter-ethnic violence between two herding groups in a pastoral rangeland is highly dependent upon the "levels of property rights protection (PRP) and the government bias on property rights enforcement (Bias)" (Butler & Gates, 2012). As Butler and Gates (2012) explain: "Our CSF model incorporates the notion that, increasing Property Rights Protection (PRP) reduces the effectiveness of fighting, which implies increasing the equilibrium allocation of productive effort. Our model also accounts for the potential bias towards one interpretation of property rights over another".

Property rights bias can occur between pastoralist groups when territory is divided between groups granting exclusive rights to one particular group and excluding others from grazing rights. Bias and property rights protection interact to produce a non-monotonic result affecting the level of conflict in a society. More particularly, if a society has a moderate level of PRP, but some degree of bias away from equity, an increase in PRP can result in either a decrease or an increase in the amount of fighting between the two groups. Thus, simply increasing PRP without addressing equity and bias issues can actually increase the risk of armed conflict between pastoralists (Butler & Gates, 2012).

Armed conflicts has become a common occurrence in the region due to influx of illegal firearms, which has caused challenges to the government security and other humanitarian agencies operating in the regions. Armed violence has not only resulted due to lack of resources, but sometimes perpetrated by local politics, cultural practices and competition for resources through clannism and tribalism (IRIN, 2009).

Seasonality of rainfall has widely been associated with escalation of grazing conflicts in northern Kenya. Many of the residents end up losing their livestock through deaths, or it becomes severely weakened due to poor health as result of prolonged droughts. The onset of rains is seen as an opportunity to restock, thus motivating morans to look for easier ways of acquiring stock, most often by invading their neighboring communities. Occurrence of rains also coincides with cultural activities like boys transition to moranism through circumcision, after which culture dictates them to acquire property of their own. This has also been associated with frequent cattle rustling in Laikipia, Samburu and Isiolo, and road banditry along Isiolo-Marsabit highway targeting traders from Nairobi to the north or vise versa.

(IRIN, 2009).

2.3.8 Other triggers of resource conflicts in Northern Kenya

Population increase in the Northern Kenya and the surrounding areas has seen most of the rangelands transisting from communal grazing lands to small scale farming, a very common scenario on the traditional grazing lands between Meru North and Isiolo South sub-counties (Selemani, 2014). This has fueled grazing conflicts between the peasant farmers and the traditional grazers, as well as exacerbated degradation and loss of land in the area. The land subdivision and fencing has also curtailed free movements of both human and livestock (IRIN, 2009).

Competition for scarce natural resources is widely understood to be a primary cause of conflict in the region and is in part related to the inability of pastoralists to assert their land rights. Competition for space between small-scale farmers and pastoralist communities has led to frequent conflicts in Isiolo and Laikipia. In Isiolo for instance, Meru agro-pastoral groups have frequently clashed with Turkana and Borana herders along the northern grazing corridors of Meru-Isiolo border during drought seasons, leading to destruction of crops and other property, killing of livestock and sometimes human deaths. The same case scenarios is witnessed in Laikipia, where the Kikuyus farmers have frequently clashed with the neighboring Maasai herders. Land demarcation has always been blamed for frequent conflicts between grazers and pastoral communities, with the Isiolo-Meru county boundary having not been clearly demarcated by the two county governments (Selemani, 2014)

Grazing conflicts have also been blamed on breakdown of traditional law and governance system, where community elders used to weld powers over the young generation. This has led to youths taking laws into their hands, and defying elders caution when trying to acquire illegal wealth. In Samburu and Borana traditions for instance, elders used to sanction raids at designated periods and could even pray and bless the process, which is no longer the case as the elders have lost this traditional power leaving the youths to make their independent decisions (Mkutu &Marani, 2001)

The fragile grazing scenario in particular, and the pastoralism in general, has been compounded by cross-border politics for a number of decades. Vulnerable pastoral groups have been at the receiving ends when security agencies come in pursuit of armed terrorists from neibouring countries like the case of Oromo liberation Front (OLF) from Ethiopia and Al Shabaab from Somalia, both crossing to Kenya through the north and northeastern boundaries respectively. The has frequently caused the pastoral communities in northern Kenya to always seek to stay away from such scenarios even if it means migrating into other peaceful communities (IRIN, 2009).

In other areas like the Samburu, Turkana and Isiolo counties, cattle raids are indicators of politically-motivated conflicts which occur every election year. Some politicians flare-up violent conflicts pitting their ethnic communities against the others (like the case of the Samburu versus the Turkana in Isiolo), aiming to consolidate tribal votes in order to win elections (Matara, 2017).

Local and regional politicians have influenced creation new geo-political spaces in order to award friendly politicians to enable them to take control of voting numbers from their perceived friendly constituencies. This is the case of Baragoi district, a mainly Turkana and Samburu populated area. It is widely perceived that the district was curved off Samburu to create new political influence for the Turkana in order to wade away Samburu dominance (Matara, 2017).

2.3.9 Historical injustices as a catalyst to grazing conflicts

In Laikipia, and parts of Isiolo, there are many private ranches and investors which have existed since independence. As Matara (2017) reported, there is noted a growing perception, and usually a common excuse to conflicts in the times of grazing adversities in Laikipia. The common line the herders hold to is that the lands which the private ranches occupy, once belonged to the local communities, and need to be repossessed. Herders have occasionally argued that the land was once theirs, or their ancestors' but was taken away, especially when they face severe drought like witnessed in the region between 2015 and 2017. Some of the grazers found with livestock on private lands argued that they could not withstand seeing their livestock die while there was grass on private land (Caroline, 2017).

Laikipia pastoralists have lived side by side with private ranchers since before Kenyan independence, sometimes sharing the limited resources during times of drought. However, as the population increases, pastoralists stoke historical emotions dating back to pre-independence (Bond & Mkuttu, 2017). This perception backed by land fragmentation and skewed distribution, unequal resource ownership, drought and curtailed mobility, form the ingredients of illegal land invasions witnessed in the recent past. In the recent decades, the grazing lands have continued to shrink even further leaving pastoralists with little space to practice their livelihood, as a result of emergence of devolved government organs, expansion of tourism industry and the growth of local human population (Matara, 2017).

2.3.10 Pastoralists invasion of private property in Northern Kenya

Between 2015 and 2017, there was severe drought in the region that affected the residents of the Northern Kenya in a manner not witnessed in the recent past. Laikipia hit the world headlines as a result of incidences of invasion of private property by local pastoralists, some of which turned out to be fatal. The armed herders invaded tourist lodges, burned down infrastructure, and argued they were determined to take back their ancestral land. The scenario boiled over to 2017, the year of elections in Kenya usually accompanied by harsh tribal politics (Caroline, 2017).

This was not the first time that climate shocks systematically triggered violence over land rights in Northern Kenya. The chain of events is pretty straightforward: when there is no water, no grass grows and pastoralists' cattle starve to death. This puts indigenous peoples' food security and well-being directly at risk. The vast majority of the Laikipia pastoralists have therefore fallen victims of the dynamics of climate change, bad politics and population increase, leading to starvation of both human and livestock, and trapping half of the population in despair (Matara, 2017).

2.3.11 Ineffectively low fines for law breakers

In Kenya, trespassing into private property is against the law. Trespassers are prosecuted either under the criminal or civil law, both of which can lead to a maximum of two years in jail or a fine of minimum Ksh 500 (USD5) or both. They can be prosecuted under criminal law and sued in a civil case. These fines are so ineffectively low, such that grazers find it preferable to trespass into private land in search of pasture, rather than have a livestock unit worth Ksh 20,000 (USD 195) starve to death (Caroline, 2017).

2.3.12 Local politics and grazing conflicts

Kenya carries out national elections every five years. The periods of elections are so emotive that opportunist politicians find it easier to invoke historical injustices in order to endear themselves to the people to win sympathy votes from the locals (Bond & Mkuttu, 2017). In 2017, the severe drought was used as a selling point by Laikipia politicians in contest for various seats both in the local and national level governments. Scarcity of grazing resources is a common scenario in Northern Kenya, but locals argue that every election year, politicians use this excuse to flare up tension aimed at scaring away non supporters sometimes leading to evictions that are seen as not only political but also tribal (Caroline, 2017).

2.3.13 Land acquisition and development projects

The national government has initiated mega-projects in the country, some of which, like Lamu Port South Sudan Ethiopia (LAPSSET) corridor and the Kenya-Ethiopia-South-Sudan road, both cut across the Northern rangelands. These, even though they have come with huge economical expectations, have put local pastoralist under unexpected new pressure (Caroline, 2017). Other industries including extractive, mining, conservation and agricultural have simultaneously demanded more space for expansion, thus cornering pastoralist even further through loss of their grazing areas.

2.3. 14 The rationale behind conflicts resolution

Communities have different options when dealing with conflict resolution. Committees charged with the task of finding a lasting solution have to consider the nature of conflict at hand, the different approaches it will employ, and whether it will result to a better situation than before (Adan & Pkalya, 2006). In certain circumstances, conflicts can be of future benefits to the stakeholders, and viewed as a necessary condition for a better coexistence and sharing of resources between communities. It is arguable that, if conflicts nipped in the bud, these important benefits may be lost. Early intervention in a dispute, for example, could be used as a mask behind which powerful groups work to advance their own interests (Brown, Smith, Handmer & Wiseman, 1995).

As noted by Brown e*t al.* (1995) "conflict is the inevitable accompaniment of change. The challenge is therefore not to prevent conflict arising, but to identify the outcome of the conflict and the best ways to manage it." Conflict resolution therefore calls for carefully thought out and agreed approaches that will address problem for the long-term (Chandraskhan, 1997).

Conflict resolution aims at promoting better and sustainable use of resources in question to ensure their availability for the future generations. Conflicts may arise as a result of competition for the resource like water or grazing fields. This calls for the parties to come together to bring their experiences ending up with amicable solutions. Conflict resolution also presents an opportunity to discover other underlying causes of the problems and the discovery of ways to resolve them (Gleeson, 2018).

Fair and equal distribution of resources brings a feeling of recognition to the vulnerable communities. Fairness also means that the resources are utilized in a sustainable way that the future generations will be in a position to use the same natural resources in their inheritance. In cases of unfair distribution of resources conflict resolution can be used to correct the wrong and ensure equity and fairness (Adan & Pkalya, 2006).

Unwanted Consequences such as violence, deaths and migrations to unknown areas resulting to further conflicts in new areas can be avoided if all parties engage each other to fairly resolve the causal issues. To avoid feelings of resentment which may later result to revenge, it is important to consider the broader conflict management approach. This involves proactively searching and exposing the underlying causes, and collaboratively agreeing to resolve them for the long term resolution and peaceful co-existence. It will also involve the reactive approach which includes the agreed methods of negotiations, consensus, expulsion and penalties (Chandraskhan, 1997).

2.3.15 Community approaches to conflicts resolution

Communities conflicting on grazing resources have devised a number of ways of dealing with grazing conflicts. In Northern Kenya, for instance, traditional grazing plans have been in existence where every grazing community has internal rules and regulations on how they manage their pasture or any conflict arising therefrom (Adan & Pkalya, 2006). Like in the "Mountain figure approach" to conflict resolution, at the top of the community's interest are the mutual benefits for all (Brown, 1995). Communities try to ensure that confrontation experienced in the early stages of conflict is avoided, while making deliberate decisions to find out lasting solutions to the problem. Therefore, they negotiate steps of mutual interest and reach an agreement satisfactory between the conflicting parties (Brown, 1995). Conflict resolution committees are formed , which deal with the conflict at hand by taking steps from isolation and confrontation to the stages of litigation, arbitration, mediation, facilitation, conciliation, negotiation, and on to cooperation at the top (Adan & Pkalya, 2006).

2.4 Predictive Modelling

Modelling is a technique of producing predictable outcomes of an dependent variable when it is subjected to mathematical manipulations using variations of independent factors that are deemed to be associated with it. Models have been used to assess relationships between variables to give a clear understanding on the levels of agreement between the dependent and the independent variable (Colwell, Chao, Gotelli, Lin, Mao, Chazdon & Longino, 2012). For species potential distribution, models have been used to produce either mechanistic or correlative relationship between the species (Robertson, Craig, Villet & Rippley, 2003). It is a technique that has been used widely to give resource managers a clue of the trends of the natural resources in a predetermined timescale. In forestry, predictive modelling is used to produce large scale maps of forest characteristics that help in decision making on forest land management (Moiswen & Frescino, 2002).

The main purpose of modelling resource conflicts where future trends of grazing conflicts is taken as a dependent variable is to predict the most likely behaviour when it is measured against predetermined variables in order to produce a mathematical relationship. Grazing conflicts occur at some points in time, therefore their relationship with causal variables are not perfect. This makes it difficult to predict them with high certainty, hence when modelling them, it is advisable to allow some measure of uncertainty with a high level of confidence (Robertson et al, 2003).

The process of model building takes different steps. It is important to decide on the direct variables that affect the dependent variable and therefore play an important role in its future trends. These must be included as factors in the model. It is also important to consider the variables that are of moderate effects that may or may not affect the response of the dependent variable. Another consideration are those variables that are close to the dependent variable, but do not influence its response in any way. It is therefore imperative for the researcher to decide on whether to include the last two categories, as the response of the dependent variable to these factors may change with time (David, 2012).

2.5 Critique of the Existing Theories and Literature

Most of literature relating to grazing conflicts in Kenya point out that the conflicts are caused by lack of grazing resources which include limited forage and water. Researchers have argued that forage availability depends on the stocking rate engaged by the livestock keepers (Pratt & Rasmusen, 2001). However, other scholars have asserted that the livestock numbers engaged in an area matters less than the length of grazing spent in a certain grazing field. There is a believe that the longer the animals graze in an area the more depletion they cause, leading to scarcities associated with violent conflicts in Northern Kenya (Homer-Dixon, 1994).

There is tendency to argue that inter-tribal and historical injustices are a major cause of grazing conflicts in Northern Kenya. This tendency therefore raises the issue of the role played by local politics in those areas (Bond & Mkuttu, 2017). The other assertions by the literature reviewed are that lack or prolonged absence of rainfall is a major causal agent of grazing conflicts in Northern Kenya (Pamela, 2007). There is a widespread believe that livestock movements arise during droughts which is associated with grazing conflicts, whereas, grazing conflicts are seen to persist even into the wet seasons (IRIN, 2017). The causes of conflicts during the wet seasons leading to fatalities and life losses are clear indications of the limited availability of literature relating to other causal agents including the role of infrastructural expansions going on (Matara, 2017).

Key arguments found on most of the research works in the field of grazing conflicts are that forage availability is a major determinant. The community conservancies are considered most vulnerable to conflicts compared to private conservancies. It has been pointed out that privately managed conservancies are better managers of their forage supply due to proper implementation of grazing plans. However, private conservancies in Laikipia and Isiolo have in recent years been victims of deadly grazing conflicts (Caroline, 2017). The questions arising from such occurrences of violent conflicts pitting the private conservancies versus the surrounding communities revolve around other underlying causes of the conflicts rather than lack of forage and water (Selemani, 2014).

Globally, overgrazing has been acclaimed as the main driver of land degradation, leading to environmental externalities. These affect the grazing communities and others that depend on the ecosystem in other ways rather than grazing (Graegar, 1996). It has been argued that certain numbers of livestock need to graze in a determined field size for a certain period of time without exceeding any of the factors. However, degradation has been attributed to other factors such as soil types, slope orientation and prolonged periods of drought leading to depletion of ground cover (Debelko, 1996).

Literature has concentrated on major environmental effects such as soil erosion, gullying, depletion of riparian areas and loss of vegetative species. There are other ecosystem services that are lost due to overgrazing including loss of valuable cultural shrines, loss of springs leading to reduction of water-flows from the forested areas downstream and depletion of valuable species of herbal medicine. Literature has not provided the valuation criteria of such ecosystem services to both human and livestock due to their 'hidden nature' (Schindler, 1998).

There have been divergent views on the ways communities cope with grazing conflicts depending on their nature of occurrence and the consequences attributed to them. Some scholars have argued that communities have got their traditional ways of dealing with such conflicts including negotiations, mediation, arbitration and migrations. However, not much has been advanced on the consequences of such coping methods employed by the communities for instance effects of migrations on other communities (Homer-Dixon, 1994).

2.6 Conceptual Framework

A conceptual framework is an analytical tool with several variations and contexts. It is used to make conceptual distinctions and organize ideas. The use of the term conceptual framework crosses both scale of large and small theories (Ravitch, and Riggan, 2012). It is used in research to outline possible courses of action or to present a preferred approach to an idea or thought. Conceptual frameworks are a type of intermediate theory that attempt to connect to all aspects of inquiry (e.g., problem definition, purpose, literature review, methodology, data collection and analysis). Conceptual frameworks can act like maps that give coherence to empirical inquiry. Because conceptual frameworks are potentially so close to empirical inquiry, they take different forms depending upon the research question or problem (Ashley & Carney, 1999).

Frameworks have also been used to explain conflict theory and the balance necessary to reach what amounts to resolution. Within these conflicts frameworks, visible and invisible variables function under concepts of relevance. In this research, the independent variables are the key elements of the study, which include forage and water availability, cultural and political influences, livestock numbers and ground cover percentages, while the dependent variables are the grazing conflicts. Within these there are moderating and intervening variables, which includes the government's policy and laws, weather characteristics, tribalism and grazing plans. Figure 2.1 shows how objectives and variables are linking to each other in the study as per the Sustainable Livelihood Framework (Modified from Ashley & Carney, 1999):

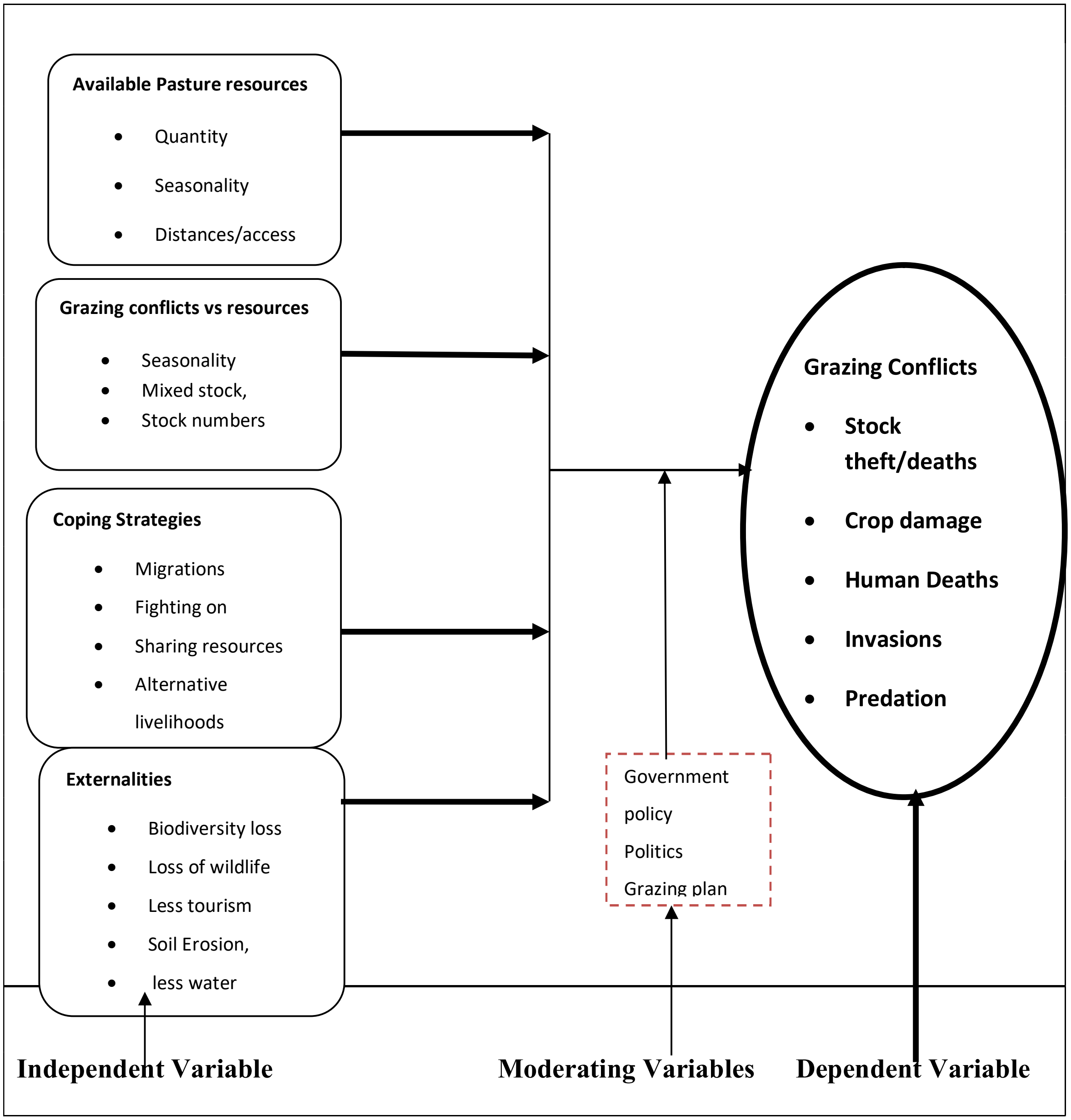


***Figure 2.1*: Conceptual Framework and study variables**

2.6.1 Summary of interrelationships between variables

The empirical review indicates that the dependent variables are linked to the presence and extent of the independent variables. From Figure 2.2, Government policy, conservancy management and grazing plans, moderates the impacts and effects of the independent variables on grazing related conflicts. For instance, where there are generally agreed and properly implemented grazing plans, there are lesser conflicts taking place like in privately-owned conservancies. The community attitudes and cultural views intervene in the resultant grazing patterns and grazing conflicts. Local politics are external factors which may influence the dependent variable (grazing conflicts) either positively or negatively.

2.6.2 Research Gaps

Documented literature shows that there is a problem of increasing grazing resource conflicts in Northern Kenya and the country in general. However, researchers do not seem to agree that grazing resource availability is the main variable determining the grazing conflicts in Northern Kenya (Matara, 2017; Selemani, 2014).

As Bond & Mkuttu (2017) argues, there are other underlying triggers of grazing conflicts in Kenya that needs to be investigated and documented. There is limited knowledge in the intricate relationship between the resource based and social economic factors triggering the actual or the purported grazing conflicts (Homer-Dixon 1994).

This research addresses the problem by studying the delicate thresholds on pasture use that trigger stock movements to neighbouring conservancies causing pasture based conflicts in Northern Kenya. It endeavors to bridge the gap by bringing out ways of predicting the grazing conflicts.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter elaborates the methods and procedures that were used in carrying out this study. It briefly describes the area, the research design and data collection and analysis. Besides the information on the use of tools for the social economic approach, it also discusses ecological methods as well as the use of Remote Sensing techniques in the multidisciplinary approach.

3.2 The Study Area

This study was undertaken in four community conservancies distributed within two counties of Northern Kenya, namely Laikipia and Isiolo. These are Ngarendare, Ilngwesi, Nasuulu and Lewa Wildlife. The two counties have almost similar geophysical and climatic characteristics and are adjacent to each other, with Laikipia bordering Isiolo to the Northwest. The two counties have experienced the worst of grazing conflicts in recent years. They are both of geo-political and economic importance, with Laikipia being the second largest tourism catchment area in Kenya after the Mara ecosystem. Isiolo is set to be a result city according to Kenya Vision 2030, to host the third largest airport in Kenya, and is going to be the central port of LAPSSET in Northern Kenya.

Both counties host the largest number of livestock in Kenya. In both counties, natural resources are communally managed, besides being the only region in Kenya where community conservancies and large-scale ranching are found adjacent to each other. Figure 3.1 shows the location of the study area on the larger North Kenya:

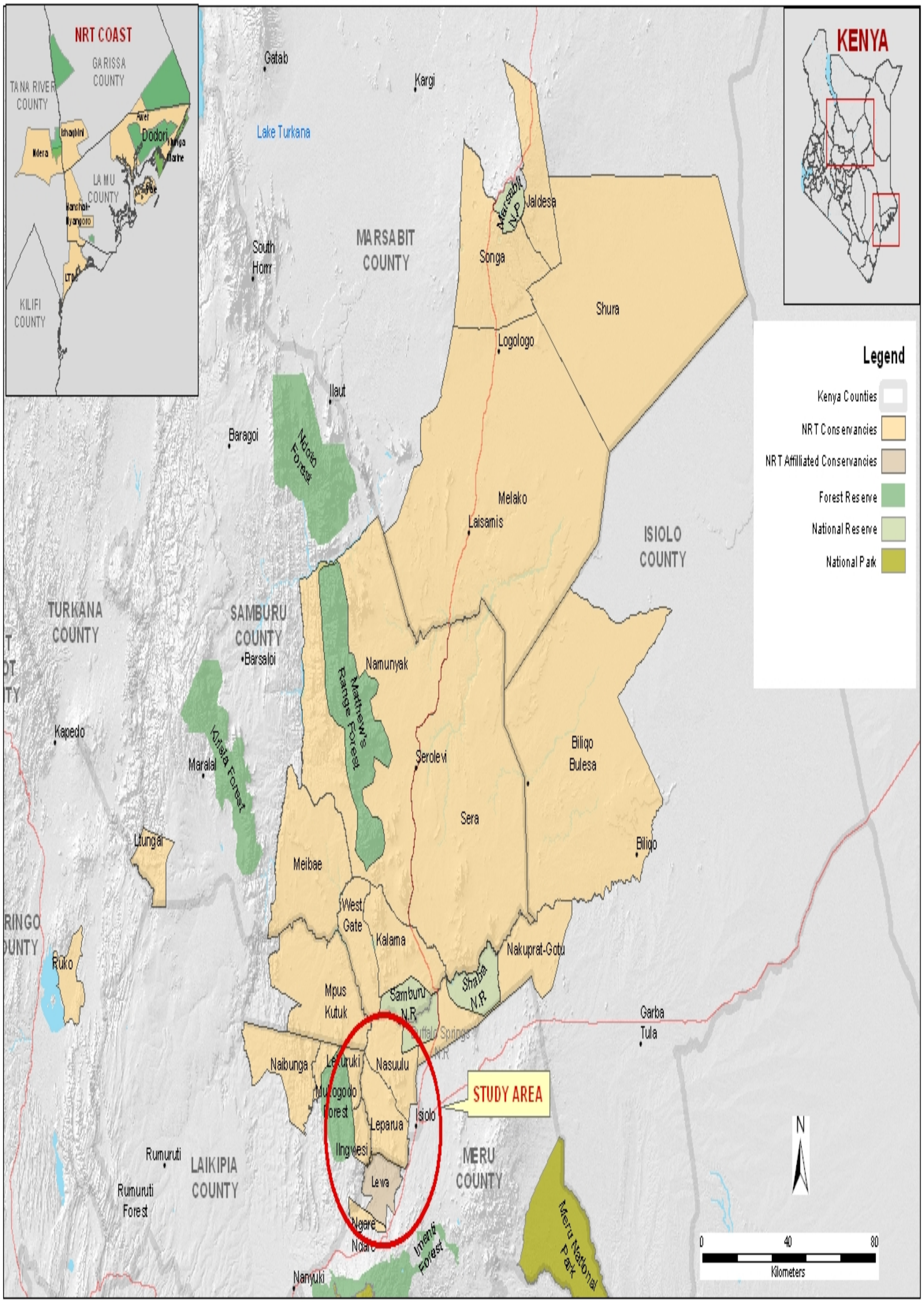


***Figure 3.1*: Map showing the study area: Source NRT GIS department**

3.2.1 Geographical location

The study was conducted in four conservancies namely Ngarendare, Ilngwesi, Lewa and Nasuulu. They are situated adjacent to each other at the boundary of Laikipia and Isiolo counties. Laikipia county lies between longitudes 36° 5' and 37° 55' East and latitudes and 1° 10' and 3° 10' South while Isiolo is at 0°21' North and 37° 35' South.

3.2.2 Soils, geology and natural vegetation

The area is dominated by varied soil types, which include Acrisols, Ferrasols, Oxisols, Luvisols, Alfisols and Lithosols, which are mainly highly fragile in nature, unfertile for meaningful crop production and are generally highly erodible. In both counties, most common vegetation are occasional bushes and shrubs of different species including acacia, cormiphora and grewia all scartered in the undulating terrain with occasional grassland areas (Lezberg, 1988).

3.2.3 Climate

Both counties are semi-arid and receive about 450 - 800mm of rainfall per year. The rainfall pattern is bimodal and starts from March until May in the long rain season and from October to December in the short rain season. Average temperatures range from 25^0 C to 29^0 C. These climatic conditions result in very low crop yields at times, and are mostly dominated by nomadic pastoralism (KNBS, 2009,).

3.2.4 Social economic activities

Both counties are situated within the Ewaso Ng'iro catchment, which is a landscape comprised of communal and trust lands, cattle ranches and private wildlife conservancies managed by both pastoralist communities and commercial enterprises, as well as agricultural plots managed by agribusinesses and smallholder farmers according to national Economic Survey of Kenya in 2009 (KNBS, 2009). The pastoralist communities have in some areas succeeded to form a pool of grazing resources known as Community Conservancies. The catchment extends from the high potential areas of Mt. Kenya and the Aberdares down across seven ASAL districts. Isiolo County has an area of 25,336km^2 and population density of 5.6km^{-2} while Laikipia, with an area of 399,227 km^2, has a density of 42.19km^{-2} (KNBS, 2009).

3.2.5 Livestock and wildlife

Laikipia and Isiolo region is a critical area as it is at the crossroads of many wildlife and livestock corridors as well as roads. Although parks and protected areas cover less than 10% of the catchment, the area is home to the greatest diversity and density of wild ungulates in East Africa outside of the Serengeti-Mara park system (Ojwang', Wargute, Saidi, Worden, Muruthi, Kanga, Ihwagi, Okita-Ouma, 2009).

The region has more than twenty species of indigenous large mammals with several endangered species. It also hosts over 6,000 elephants, and has the largest remaining population in the world of Grevy zebra and Jackson's hartebeest. It has also the largest national populations of rhinoceros and reticulated giraffe outside of protected areas (Georgiadis, 2007).

The greater Ewaso Ng'iro is an important livestock area. The camel population of Ewaso Ng'iro catchment is estimated at about 830,000 animals. As most of the catchment is arid and semi-arid shrublands and rangelands, wildlife and livestock move regularly around the catchment to find forage and water. The government of Kenya is considering a number of infrastructure investment opportunities in the area, including a railroad to Sudan and a road from Lamu to Ethiopia (the proposed Lamu Port-Southern Sudan- Ethiopia Transport (LAPSSET) Corridor project (Ericksen, Said, Leeuw, & Silvestri, 2011).

3.3 The Research Design

A research design is the combination of approaches that are used to query and obtain answers to the questions that the study seeks to investigate (Kihara, 2016). This research adopted a mixed-method approach that combined or associated both qualitative and quantitative approaches. It involved philosophical assumptions, the use of ecological, qualitative, quantitative and remote sensing approaches, and the mixing of the four approaches. Thus it was more than simply collecting and analyzing kinds of data; it also involved the use of those approaches in tandem so that the overall strength of the study was greater than either qualitative or quantitative research (Creswell & Plano- Clark, 2007).

The mixed methods design was chosen since it involves triangulation of several designs to increase validity of the outcomes, as well as compensate for the weaknesses of any one of them when used singly (Kihara, 2016). Specifically, this approach included ecological methods which involved field plots, quadrants and transect walks (Bonham, 1989; Beesom & Haucke, 1975); Social economic approaches included administration of questionnaires, interview schedules, Focus Group Discussions (FGDs), desk research, while the remote sensing methods included the use of GIS and remote sensing to analyse temporal and spatial vegetation indices and land use and land cover trends.

3.4 Target Population

Population refers to the entire group of people, events or other items of interest that the research is targeting. In this study, the population of interest included all the fifteen community and private conservancies in Isiolo and Laikipia counties in Northern Kenya. These were selected from a list of conservancies obtained from the

Northern Rangelands Trust (NRT), the umbrella organization of community conservancies in Kenya. Four conservancies were purposely selected out of the 15 within Laikipia and Isiolo counties, based on meeting basic requirements among them being official registration, availability of grazing committees, and having a defined conservancy boundary (Foley, 2018).

3.5 Sampling Frame

The sampling frame in this study included the fifteen community and private conservancies found in Isiolo and Laikipia county. The conservancies were grouped into community or private ones based on their registration, ownership and management (Research Advisors, 2006). Since most of the conservancies were spread across Northern Kenya which is a vast territory, the research restricted itself to those found in the two adjacent counties, and met the basic criteria of having a working grazing committee, legal registrations and a management system. The aim of this limitation was to ensure that homogeneity was achieved (Gatheya, Bwisa, & Kihoro, 2011). Conservancies that were covered here were Nasuulu, Ngarendare, Ilngwesi and Lewa.

3.5.1 Ecological methods

Two sites were located within each of the conservancies grazing field, and a plot of 50m x 50m set on each site. The sites were selected based as much as possible on representation of variation characteristics of entire grazing field like slope direction, forage species, vegetation growth forms and accessibility (University of Idaho, 2009). Each plot contained 50 sub-plots (quadrants) measuring 1mx1m each. To estimate available forage biomass, five quadrants were picked at random and 'clip-dry-weigh' method used to estimate the biomass levels of standing herbage (grass) in both wet and dry seasons (Henderson, 2012). A clipping frame of 0.5 m x 0.5m was placed on the subplot and all above ground grass cut using secateurs (University of Idaho, 2009; Cottam & Curtis, 1956). Figure 3.2 shows the quadrant, ground cover analysis, and measurement of standing grass biomass:

***Figure 3.2*: Grass height measurement using tape clipping frame**

The samples were put in Kirk papers, marked with dates and then oven-dried for 24 hours. The electronic oven was set at 60^0c and the samples were weighed and recorded at equilibrium moisture content (M Connell &Daniel, 2002)

To ascertain available forage biomass, regression equation: $Y = a + bx$, was used

Where**:**

Y = dry matter production (kg/ha/year or season),

x = annual or season precipitation (mm)

a = regression constant (-180 for herbs and – 400 for shrubs),

b = regression constant (6.3 for herbs and 10 for shrubs) according to the method of LeHourerou & Hoste, (1977). Data on forage biomass was collected twice i.e. dry season (February -March) and wet season at the end of the growing season (May - June).

Two transect walks were conducted between the plots to describe vegetation variability, tree and shrub density and diversity. Data on vegetation and soil characteristics was recorded on Range Condition Data Sheets (Appendix 2).

3.5.2 Rainfall variability data

Rainfall data was collected from Kenya Meteorological Department 2016 data-base where Coefficient of Variation (CV) and linier regression analysis were done to ascertain the variability over time period. Pearson Correlation Coefficient was used to find out the relationships between rainfall and grazing conflicts (Appendix 8).

3.5.3 Social survey

The survey approach focused on the resource persons, grazing committees, key informants and experts within each community conservancy and in the entire study area. Respondents were Conservancy committee members picked from each conservancy and the questionnaires administered. Four (4) focused group discussions of between 8-12 people were conducted. Key informants and experts were interviewed to clarify controversial issues in the course of research (Appendix 5). The survey data was analyzed using SPSS version 26. Results were presented in graphs, tables, and accumulation curves.

3.5.4 Remote sensing techniques

Remote sensing techniques were used which included production of Normalized Difference Vegetation Indices (NDVI) of the spatial and temporal vegetation changes and their geographical distribution within the study area (McArthur, 1972). Participatory GIS (PGIS) was used to obtain data from lay knowledge of the indigenous people to correlate with ecological and social data. The satellites imagery were produced using Quantum Geographical Information System (QGIS), which showed trends in vegetation and land-use changes.

3.6 The Sample Size and Sampling Procedure

Purposive sampling method was used to deliberately obtain four conservancies among the 15 for this research, based on the fact that they possessed the requirements of legal registration, availability of grazing committees and grazing plans, management plans and organizational structure. Purposive sampling is a more specific method which is justified when studying particularly identified and existing categories or groups (Foley, 2018)

3.6.1 Social economic sampling

Sampling is the selection of elements of a population to be included in a study. A sample is part of the entire population that exhibits the desired characteristics of the whole population, which can be picked to represent others in a study. The goodness of a sample is how well it represents the entire population. The sample size (n) was determined using the formula given by Yamane (1967) as $n=N/1+N(e^2)$,

Where:

n is the sample size,

N is the population size and

e is the allowable error at 95% confidence interval (Yamane, 1967)

Therefore, where a conservancy had committee membership of 40, at a confidence interval of 95%, the sample size (n) would be calculated thus:

N=40; e =0.05

$n=40/1+40(0.05)^2$

n=40/1+40(00025)

n=40/1+0.1

n=40/1.1; therefore sample size (n)= 36

In each of the four conservancies, similar categories of respondents were engaged. Simple random sampling was used to pick the respondents from the list of grazing committee in each conservancy to whom the questionnaire was administered. Four Focused Group Discussion composed of 8-12 people were also conducted. Table 3.1 summarizes the social economic sampling design:

Table 3.1:
Sample sizes per conservancy

Conservancy	Committee members (N)	Sample Size (n)	FGDs
Ngarendare	30	27	1
Lewa	12	11	1
Ilgwesi	26	24	1
Nasuulu	22	20	1
	90	**82**	**4**

3.7 Data Collection Instruments and Procedure

There were three types of data. The quantitative data measured from field plots and transect walks were collected using ecological methods described above (See 3.4.1), and the social survey data from the grazing committees, experts/key informants and Focused Group Discussions (FGDs) as described in 3.4.3 above. Land cover and land use data were obtained from LandSat 8 through remote sensing. The data sets that were collected in this study included rainfall, conflicts occurrence information, livestock numbers, size of the conservancy and grazing area, grazing blocks stocking rates and carrying capacities, forage biomass, vegetation data and variability, climate variability, water availability and coping strategies.

3.7.1 Pilot survey and pre-testing of instruments

A Pilot study was undertaken at Ngarendare community conservancy to provide descriptive and cross-sectional quantitative data on the current situation of the study area in terms of population distribution, vegetation characteristics, grazing regimes, and general environmental characteristics (Mugenda & Mugenda, 2003). This was undertaken separately way before the commencement of the main study. The purpose of the pilot study was to assess the reliability of the instruments to be used in the main study and make adjustments or improvements of the approaches where necessary.

3.7.2 Reliability and validity of instruments

Reliability measures the internal consistency of a set of measures which capture the degree to which they indicate the latent constructs (Hair & Ephanet, 2006). The assessment of reliability was conducted by examining the Cronbach's alpha coefficient of each construct (factor). Cronbach alpha measures how well items in a set are correlated to each other (Cronbach, 1951). Cortina (1993) recommended the reliability criterion to be higher than 0.6. The results showed that values for Cronbach's alpha for the dependent and the independent variables ranged from 0.834 to 0.908.

The highest value for reliability was established for constructs that measured Competition for resources with 5 items in the questionnaire with Cronbach's alpha coefficient of 0.908. This was followed by constructs for resource supply thresholds and livestock movements with 6 with a Cronbach alpha coefficient of 0.884, followed by constructs that measured environmental externalities with 2 items where the study established Cronbach alpha coefficient was 0.843, followed by constructs that measured forage availability and utilization with 5 items where the study established Cronbach alpha coefficient of 0.834.

The study established that all values for the questionnaire reliability measured using Cronbach's alpha coefficient were higher than 0.7 for all variables confirming their reliability. The results of the Cronbach alpha tests for the dependent and independent variable are as shown in Table 3.2:

Table 3.2:
Reliability and Validity measurement Results

Measurement Items	Items	Cronbach Alpha	Reliability Results	Inter-Item Correlation	Item-Total Correlation
Forage availability and utilization	5	0.834	Good	0.463-0.673	0.581-0.742
Water Availability and Utilization	4	0.879	Good	0.448-0.704	0.655-0.773
Resource supply thresholds and livestock numbers	6	0.884	Good	0.411-0.743	0.617-0.836
Competition for Resources	4	0.908	Excellent	0.621-0.760	0.721-0.824
Environmental Externalities and rainfall	2	0.843	Good	0.413-0.607	0.572-0.725

The study generated information on the levels of awareness, knowledge, attitude and practices (AKAP) of the population on selected topics of grazing, environment and conflicts in the specified study area. Training of research assistants and interns was conducted to ensure they understood their role in the research process and the use of different methods of data collection. Reconnaissance survey was conducted with research assistants, interns, and conservancy extension personnel to familiarize with the study area and key resource persons. To ascertain reliability of the data instruments, a pilot study was conducted in one of the conservancies prior to the main study whereby the instruments were tested to ascertain if they yielded the same result on repeated trials, and lessons learnt were used to improve the data collection techniques. The instruments were tested for validity to ensure they measured and collected data as exactly and varied as anticipated.

3.7.3 Questionnaires

To ascertain the occurrence of past and present grazing conflicts, community coping methods and the environmental changes on the bio-physical environment and community livelihoods through time, structured questionnaires were administered to the grazing committees. The questionnaires were structured to capture as varied data as possible, and presented in the local languages through an informed interpreter. Respondents were randomly picked from the members list of the grazing committees in each of the 4 conservancies and sample size determined using the formula according to Yammane, (1967). Questionnaires containing both closed and open-ended questions were administered to the respondents to provide crucial and unbiased information to form the quantitative data (See appendix 3& 4). Table 3.3 shows the response rates:

Table 3.3:
Response rates

Conservancy	No of questionnaires	Response	Rate
Ngarendare	27	22	80
Nasuulu	22	16	76
Ilngwesi	25	21	84
Lewa	12	12	100
Total	**85**	**71**	**83**

From Table 3.3 it shows that non response rate was only 15% which was of low significance to the study. According to Babbie (2008) a response rate of over 70% is considered to be very good. This is also confirmed by Bryman & Cramer, (2005).

The response rate was determined by the percentage of questionnaires which were actually filled in and returned. A total of 85 open and closed-ended questionnaires were distributed to committee members selected from each conservancy, with a total of 83% response rate. The return rate per conservancy was 80% for Ngarendare forest, and 76% for Nasuulu , 84% for Ilngwesi and 100% for Lewa.

3.7.4 Focus group discussions (FGDs)

Qualitative data was collected through 4 Focus Group Discussions comprising of 8 to 12 people. The FGDs checklist and interview-guides were used to guide the discussions. The focus group discussions were carried out with the conservancy board members and management followed by discussion with the key informants to generate detailed past and current information regarding trends in grazing conflicts and bio-physical environment. Interviews with key stakeholders and experts like the District Agricultural and Livestock officers, Social Development officers, Lewa Research department and NRT rangelands team yielded qualitative data. In this regard, varying views, opinions, perceptions, attitudes, beliefs and experiences, on the community grazing and environmental knowledge were generated to determine the perspective of different groups on grazing and conflicts in the study area which was validated by the experimental results (see appendix 4, 5, &6).

3.7.5 Ethical considerations

For ethical reasons, the Research Assistants first enlightened each respondent on the objectives of the study and the need for them to participate in it, associated risks, envisioned benefits and confidentiality measure. Permission to undertake research was sought from and granted by the relevant institutions at National Council of Science Technology and Innovation (NACOSTI), Kenya Methodist University and relevant government agencies and were issued to the respondents as evidence of the study as an academic exercise (see annex 1).

3.8 Ecological Sampling

Simple random sampling was used to locate two plots at each conservancy map using grid coordinates and depending on the general orientation or slope of the conservancy (Ashish, 2012; Herlocker, 1992). Each plot measured 50m by 50m, and five samples were obtained from each plot using a 0.5m x0.5m grid quadrant thrown randomly on the plot in both seasons. The purpose of using a quadrant was to enable comparable samples to be obtained from areas of consistent size and shape (Ashish, 2012). Visual observation was used to estimate the basal coverage, bare ground percentages, and mean grass height measured. In each conservancy there were 4 transect walks between the experimental plots, two in the wet and dry seasons respectively (Fahey Jr., Collins, Mertens, & Moser, 1994). Table 3.4 shows a summary of the ecological sampling procedure:

Table 3.4:
Ecological sampling procedure

Conservancy	Plots	Subplots	Transect walks
Ngarendare	2	10	4
Lewa	2	10	4
Ilngwesi	2	10	4
Nasuulu	2	10	4
Total	**8**	**40**	**16**

Table 3.4 shows that there were two field plots each containing five subplots, and 4 transect walks per conservancy.

3.8.1 Ecological techniques for pasture assessment

The available pasture resources in the four conservancies were determined through forage analysis using Clip, Dry and Weigh method for forageable grass during the dry and wet seasons as described by Ashish (2012). A 0.5 m x 0.5m wire frame was used to obtain the clippings from the quadrants. To achieve high level of accuracy in assessing the amount of forage in a pasture, five samples from each plot were clipped and weighed using a gram scale. The samples were obtained both in the dry and wet seasons to ensure that they represented the variation within the pasture sites as well as the seasonality of the study area (University of Idaho, 2009).

3.9 Remote Sensing Analysis

GIS Techniques were used to undertake spatial analysis in the bio-physical environmental characteristics in the study area. In particular, remote sensing was used to obtain land-use and land-cover images from 1997 to 2017. Quantum GIS was used to produce spatial overlays of vegetation utilization. Landsat 8, a satellite sensor which has the latest calibrations of Near Infra red light of 5 and Red light of 4, was used to calculate Normalised Difference Vegetation Index (NDVI). As confirmed by other scholars of vegetation trends and food security like Smith, et al, 2004, this index was used as a metric of measure to interpret and compare vegetation health and forage trends in the study area over time. The overall aim was to establish trends of environmental externalities associated with community grazing as a land-use practice and correlate the resultant data to grazing conflicts.

Participatory Geographical Information System (PGIS) was used for extracting indigenous knowledge and perceptions regarding environmental problems resulting from community grazing methods. This was done to enable the researcher to assess the relationship between bio-physical environmental changes (externalities) and grazing conflicts in the study area, an approach also engaged by De Shrebinin, (2002).

3.10 Data Analysis

Three types of data were analysed by various methods. The data from the field plots was analyzed using ecological methods described above to yield insights into the variations of the available forage matter and its seasonality on different conservancies in order to ascertain different thresholds of resource supply per conservancy. Data from the social surveys was analysed using SPSS version 26 to yield information on peoples' perceptions of the causes, effects, and management of grazing conflicts, community copping ways and environmental externalities (Bryman & Cramer, 2005) while data from remote sensing was analysed using appropriate GIS techniques and software described above.

3.10.1 The social survey data

The social survey data was edited for completeness and consistency and analyzed using SPSS. All questionnaire-based data was cleaned, coded and entered into SPSS for analysis. Analysis centered on cross-tabulation and correlation in order to ascertain the perceived relationships between the dependent and independent variables. Critical reading of the data sources was done in order to pick out relevant information relating to the created themes and sub-themes (Babbie, 2008) This information was later described to give meaning in line with the objectives addressed by the study, and its correlation with remote sensing and ecological data established. Descriptive statistics such as frequency counts, means, percentages, variance and standard deviations were computed for all quantitative data, and results were presented using frequency distributed tables, regression graphs, bar and line graphs(Babbie, 1994)

The relationship between the dependent and independent variables was determined using ordinary least squares (OLS). The Spearman correlation coefficient (r) was used to test the linear relationship between the dependent and independent variables. The value of r ranges between -1 to 1 where a negative value signifies a week relationship and a positive value signifies a positive or strong relationship between the dependent and independent variables. This coefficient is significant where $P<0.05$ and $P<0.01$ for 95% or 99% co-efficient levels respectively. The coefficient of determination (R^2) and F-statistics are then computed to ascertain the goodness of fit of the model, where $p<0.05$ and R^2 of above 0.75 are considered fit for the model.

3.10.2 Ecological data analysis

Data from field plots was analyzed using various methods. Available forage was calculated from weights of oven-dried biomass. Tables of quantities and graphs were used to present the data. Transect walks (appendix 7) were used to capture the range characteristics using the Range Condition Field Form for analysis of environmental externalities. This was done through walking between one plot location to another and a check list of observations and images taken such as land-use, vegetation cover and degradation, elevations, animal species, grass types, tree species etc. To calculate the total forage biomass production per conservancy, the median rainfall figures were used and subjected to regression analysis as developed by LeHourerou and Hoste (1977), (modified for the conditions in Northern Kenya and separated for herbs and shrubs) a: $Y = a + bx$ Where:

Y = dry matter production (kg/ha/year or season),

x = annual or season precipitation (mm)

a = regression constant (-180 for herbs and – 400 for shrubs),

b = Intercept (6.3 for herbs and 10 for shrubs) (LeHourerou & Hoste 1977).

This information triangulated to connect with the responses from the social survey and the results from the remote sensing techniques to support various conclusions from the study as well as yield elements of the conflicts predicting model.

3.10.3 Remote sensing data analysis

Analysis of GIS data involved acquisition of satellite images for the region of interest and processing them using GIS standard procedure. In particular, to analyze the environmental changes, QGIS 2.1.4 software was used to produce rasta images of land-use changes of the study area from LandSat 8 sensor which were overlayed to produce trends of NDVI, classify land-cover and land-use and to produce forage utilization levels (Smith et al, 2004).

Desk review was conducted with narrative correlation being used to corroborate the remote data results with social and ecological data. In order to assess the relationship between trends in grazing resource availability and conflicts thereof, NDVI was used as the remote proxy to track and obtain accurate, current and detailed information on how the status of the bio-physical environment had changed over- time. It was calculated as ratio of the difference between the Near Infrared (NIR) and Red to Near infrared plus red thus: NDVI= (NIR-Red) ÷ (NIR+Red) which varies between -1 to 1, with -1 to 0 indicating no life vegetation, 0 to 0.5 indicating presence of less healthy vegetation and 0.5 to 1 indicating very healthy vegetation (GisGeography, 2018).

The final outputs were land-use classes and NDVI images and a table of quantities of predicted changes in the amount of land under grazing, seasonal swamps, wetland vegetation, shrub land and settlement.

3.10.4 The model summary

The study variables were analysed using multiple regression and each level of contribution to the grazing conflict ascertained. Their relationships to the grazing conflicts were presented in a Wald's statistics table showing their levels of significance. These factors were fitted in a logistics model predicting the grazing conflicts in Northern Kenya. Figure 3.3 shows how the variables were interconnected:

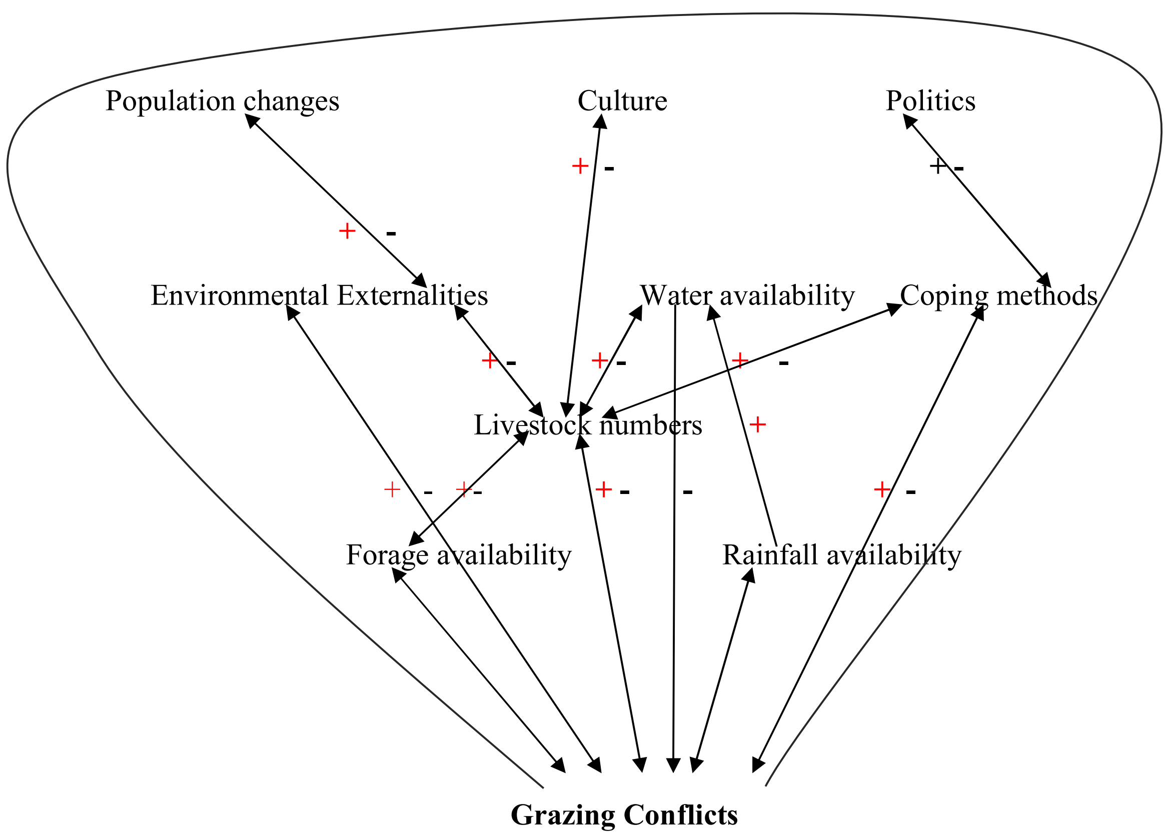


Figure 3.3**: Interrelationship between dependent and independent variables**

3.11 Operationalization of Variables

Operationalization of variables is the construction of actual, concrete measurement techniques or the creation of "operation" that will result in the desired measurements. It is the development or choice of specific procedures (operations) that will result in representing the concepts of interest. Table 3.5 shows the relationship among variables and their objectives:

Table 3.5:

Operationalization of variables

Objective	Type of Variable	Measurement scale	Research Instrument	Data collection	Method of analysis and Testing
To evaluate seasonality of pasture resources for livestock in Northern Kenya	Dependent	Nominal scores	Quadrant plots Subplots	Quantitative, Table of quantities	Regression equation, Correlation coefficient,
To determine the relationship between pasture resources and occurrence of grazing conflicts in Northern Kenya	Dependent	Nominal, Ordinal,	Quadrants plots , GIS Maps, Transect walks	Quantitative Table of quantities	Regression equation, correlation coefficient QGIS
To develop a predictive model for grazing resources and grazing conflicts in Northern Kenya	Dependent	Ordinal	Questionnaires, FGD, Transect walks	Descriptive, Frequency tables, Factor component scores,	SPSS IBM 26
To predict community coping methods under limiting grazing resources in Northern Kenya	Dependent	Ordinal	Questionnaires, GIS Maps, PGIS, FGD Rainfall data	Descriptive, Frequency tables,	Quantitative and qualitative (Observations, SPSS, Desk review and Literature), QGIS

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter presents the results, findings and discussions on the study. The results are categorized to create meaning and aid in the discussions as per the research objectives. Each of the objectives is described under the themes of social survey, ecological survey or remote sensing where their complementarities and correlations are shown.

4.2 Evaluating the Seasonality of Pasture Resources on Conservancies

In this objective, the study used ecological and remote sensing approaches to find and analyse the available forage (grass biomass) for livestock in four conservancies.

4.2.1 Ecological evaluation of available forage

The study sought to answer the research question: "What is the availability of grazing resources in different seasons of the year on the community conservancies of Northern Kenya?" Forage data was collected using ecological methods that included plots, quadrants, cut-dry-weigh methods and transect walks (Fahey Jr et al, 1994)**.** The results were presented as available forage biomass as shown on Table 4.1:

Table 4.1:

Available forage: Quadrat Plots Assessment

Site		Point 1(gm)	Point 2(gm)	Point 3(gm)	Point 4(gm)	Point 5(gm)	Total(gm)	Average (gm)
Lewa 1	Raw	77	96	76	98	157	504	100.8
	Dry	68.4	92.0	74.2	89.9	145.4	470.1	94.0
	Dff	8.51	3.9	1.7	8.0	11.6	33.8	6.7
Lewa 2	Raw	36	103	117	82	113	451	90.2
	Dry	33.71	95.4	106.5	77.7	107.8	421.0	84.2
	Dff	2.3	7.6	10.5	4.3	5.2	30.0	6.0
Ngare 1	Raw	25	51	25	27	26	154	30.8
	Dry	23.1	43.0	21.0	22.7	23.5	133.4	26.7
	Dff	1.89	7.992	3.95	4.26	2.45	20.56	4.11
Ngare 2	Raw	30	32	28	37	39	127	25.4
	Dry	24.5	24.911	24.39	30.46	30.03	118.80	23.76
	Dff	5.3	7.08	3.60	6.53	9.04	8.19	1.64
Ilngwesi1	Raw	11	9	6	6	7	6	9
	Dry	5.5	5.4	3.5	3.8	3.8	3.5	4.1
	Dff	5.5	3.6	2.5	2.2	3.2	2.5	4.9
Ilngwesi2	Raw	7	11	11	5	8	5	5
	Dry	3.1	4.3	4.0	3	4.0	3.1	3.3
	Dff	3.9	6.7	7.0	2.0	4.0	1.9	1.7
Nasuulu1	Raw	8	7	9	8	8	7	11
	Dry	4.5	4.0	4.5	4.5	4.2	3.8	6
	Dff	3.5	3.0	3.5	3.5	3.8	3.2	5
Nasuulu2	Raw	6	6	7	7	7	5	6
	Dry	3.0	3.1	3.1	3.0	3.2	2.7	2.8
	Dff	3	2.9	3.9	4	3.8	2.3	3.2

It was found that Lewa Widlife Conservancy had the highest grass forage per ha than other conservancies. This could be attributed to the fact that bieng a private conservation area, it was more protected and had better management of the available forage biomass. Overall, the grass heights at Lewa were the highest, followed by Ngarendare. At Nasuulu and Ilngwesi, the above ground grass material was almost minimal possing a challenge of measurement during the dry season.

It could also be seen and deduced that during the dry season, most community conservancies were faced with dwidling forage availability leaving most of livestock to migrate to further areas where they could find grass. It also meant that the productivity of the conservancy varied in the dry season with other factors, which was consistent with the findings of Fahey Jr., et al, (1994).

4.2.2 Remote analysis of available forage in the conservancies

NDVI was used as the remote proxy to evaluate available forage both in the dry and wet seasons to produce time series results of forage utilisation and other browsable materials. Figure 4.1 shows the results of annual forage availability on the study area as depicted through Normalised Difference Vegetation Index:

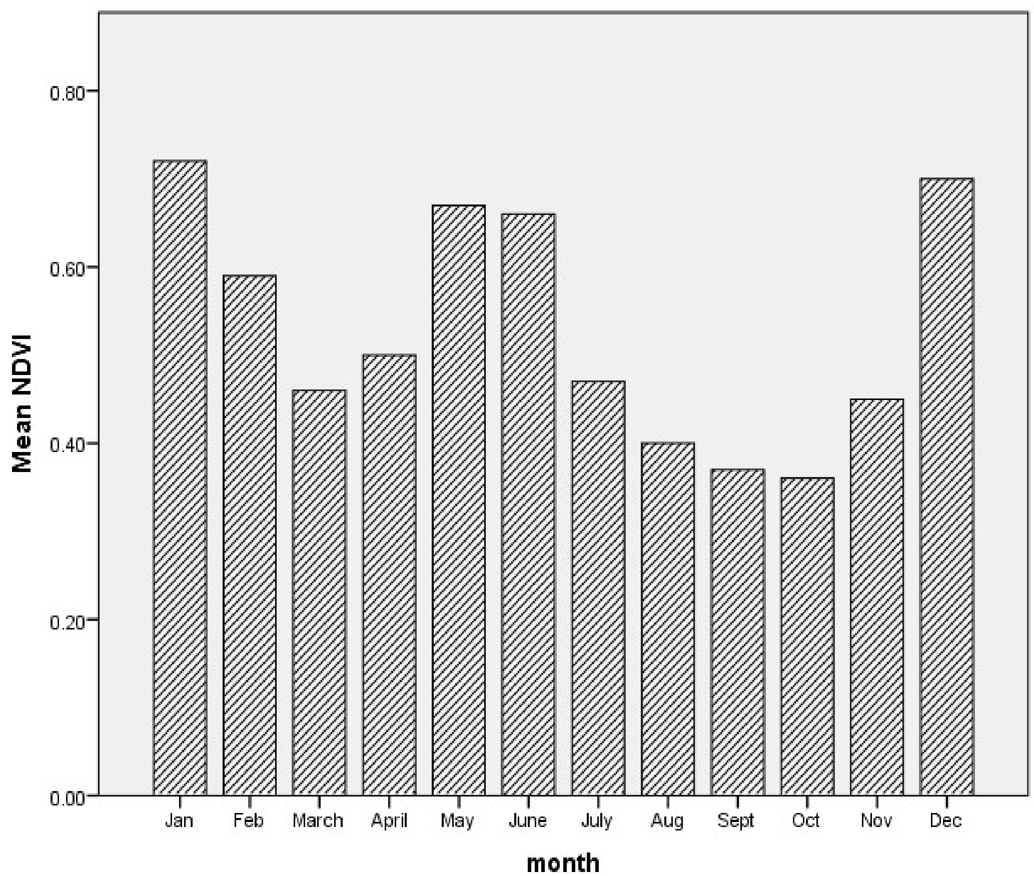


Figure 4.1 **: Mean annual forage availability**

From Figure 4.1 it can be seen that there were two main seasons of improved vegetation vigour between December and January, and April-June respectively. This is attributed to seasonal rainfall patterns of November- December and April-June.

In terms of forage availability per conservancy, Lewa had the highet average of life vegetion in both seasons.This could be attributed to forage management plans, grazing rotations and paddocking that enabled the conservancy to retain more stock of grass and other browsable material as compared to commuity conservancies, where grazing plans were sometimes disregarded especially during dry or drought season as also observed by Karla, (2017). Ilngwesi and Nasuulu were mostly shrublands and most part of the year, livestock depended on shrubs and browsable herbs. Figure 4.2, shows MODIS time series model of available utilizable forage on Ilngwesi:

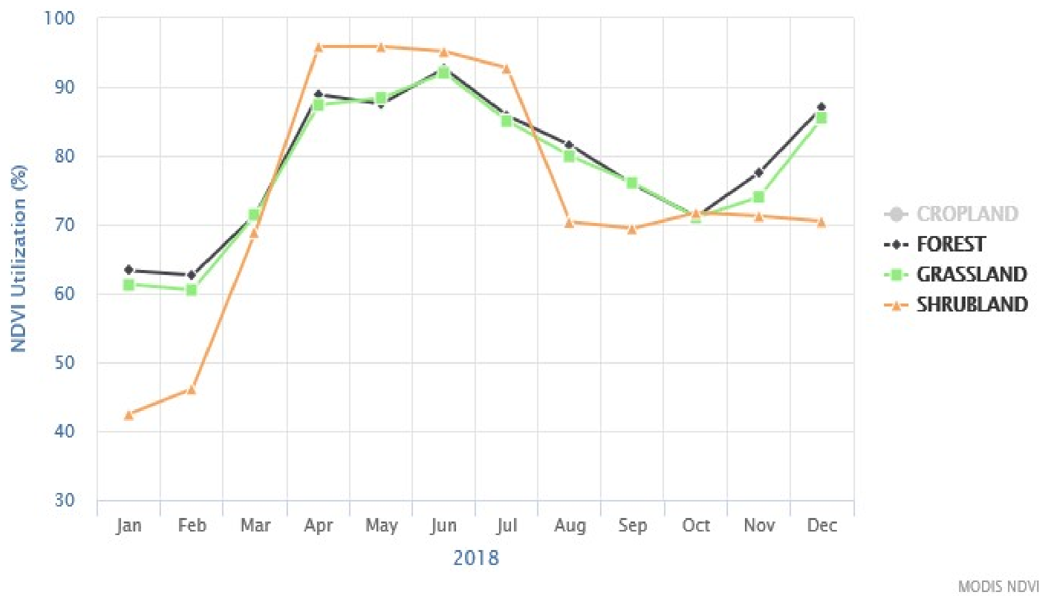


Figure 4.2: **Annual utilizable forage on Ilngwesi 2018**

From the figure, it can be seen that on Ilngwesi conservancy, most parts of the year, livestock depends on shrub browsing as compared to other sources of forage. It also shows that from the month of June, there is general decline in available forage. It means that grass as a source of browse is generally suppressed and less utilizable in most parts of the year. The model predicts that January to February had the lowest availability of utilizable browse, and this confirms the results from social data and ecological evaluation of available forage which showed that was the period when pastoralist were most vulnerable and when most migrations and conflicts were predicted. Rutagwenda and Wanyoike, (1994) observed that there was general decline in forage during the dry season in the same area of study. It also showed that there were no utilizable croplands as a source of forage on Ilngwesi as compared with Ngarendare as seen in Figure 4.3:

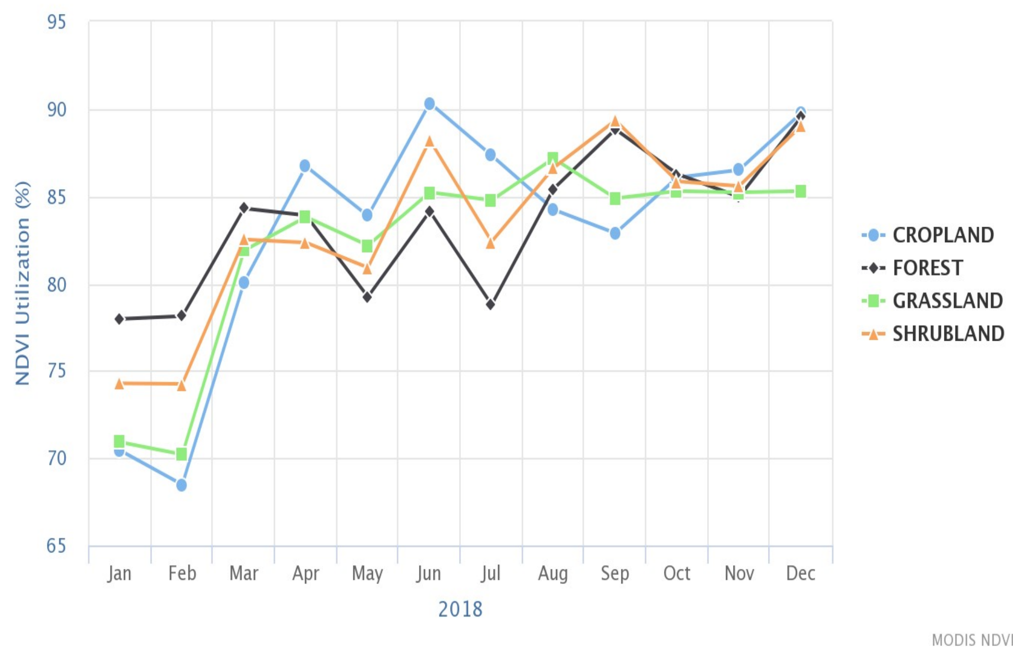


***Figure 4.3*: Annual utilizable forage on Ngarendare conservancy 2018**

Figure 4.3 shows Ngarendare conservancy had more grazers depending on forest and croplands as sources of browse for their livestock between January and July. It shows that there was general decline in availability of browse between the months of June and August and January to February. The figure predicts more stable forage between February and May around the Ngarendare conservancy.

The figure also helps to deduce that there could occur competition for grazing resources in scarce periods causing general dietary overlap among the browsing species as observed by Rutagwenda and Wanyoike (1994). This means, therefore, that sheep, goats and cattle are forced to depend on similar browse species or plant parts thus compounding species competition for browse during those periods. In all community conservancies, January and February are predicted to have the least availability of utilizable forage as also found in Nasuulu conservancy as seen in the Figure 4.4:

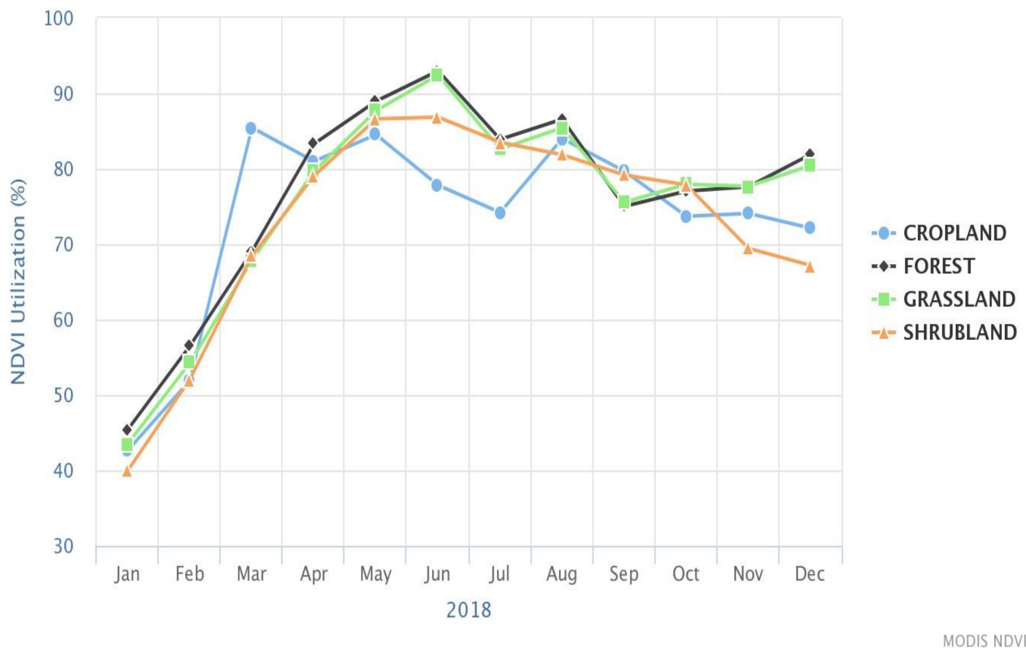


***Figure 4.4*: Annual utilizable forage on Nasuulu conservancy 2018**

From figure 4.4, it is evident that Nasuulu grazers depend on grass lands and shrub-lands for grazing most parts of the year. Crop land is quite unstable and less utilized compared to other sources of forage in the conservancy. Figure 4.5 shows overall utilizable forage situation per conservancy in both wet and dry seasons.

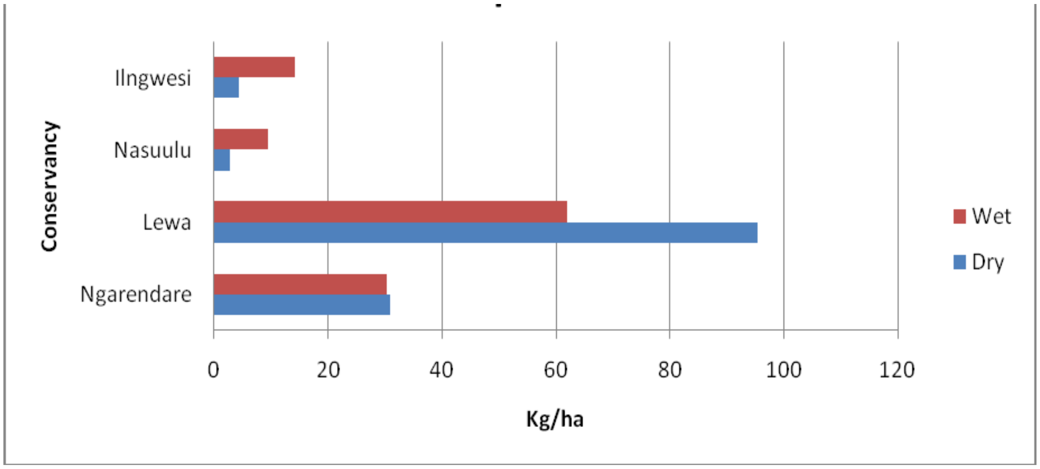


***Figure 4.5*: Utilizable forage per conservancy in wet and dry seasons**

The results from the evaluation of seasonal availability of forage implies that there was a significance difference between the four conservancies in terms of forage availability in the dry and wet seasons with highest being on Lewa while lowest in the community conservancies. These supports Maleko and Koipapi (2015), who observed that after the wet season, there was general positive response by forage greenness with new emerging plants cover forming the common utilizable browse. Nasuulu and Ilngwesi showed minimal forage in terms of browsable grass, implying that trees and shrubs were the most available browsable biomass in the dry season.

4.2.3 Seasonality of rainfall and pasture availability versus grazing conflicts

The study sought to find out how the variability of rainfall seasons affected region's environmental resilience leading to grazing conflicts in Northern Kenya. It analysed long term rainfall data obtained from the Kenya Meteorological Department and came up with trends of long term average monthly precipitation in the study area for the last 20 years as shown in Figure 4.6:

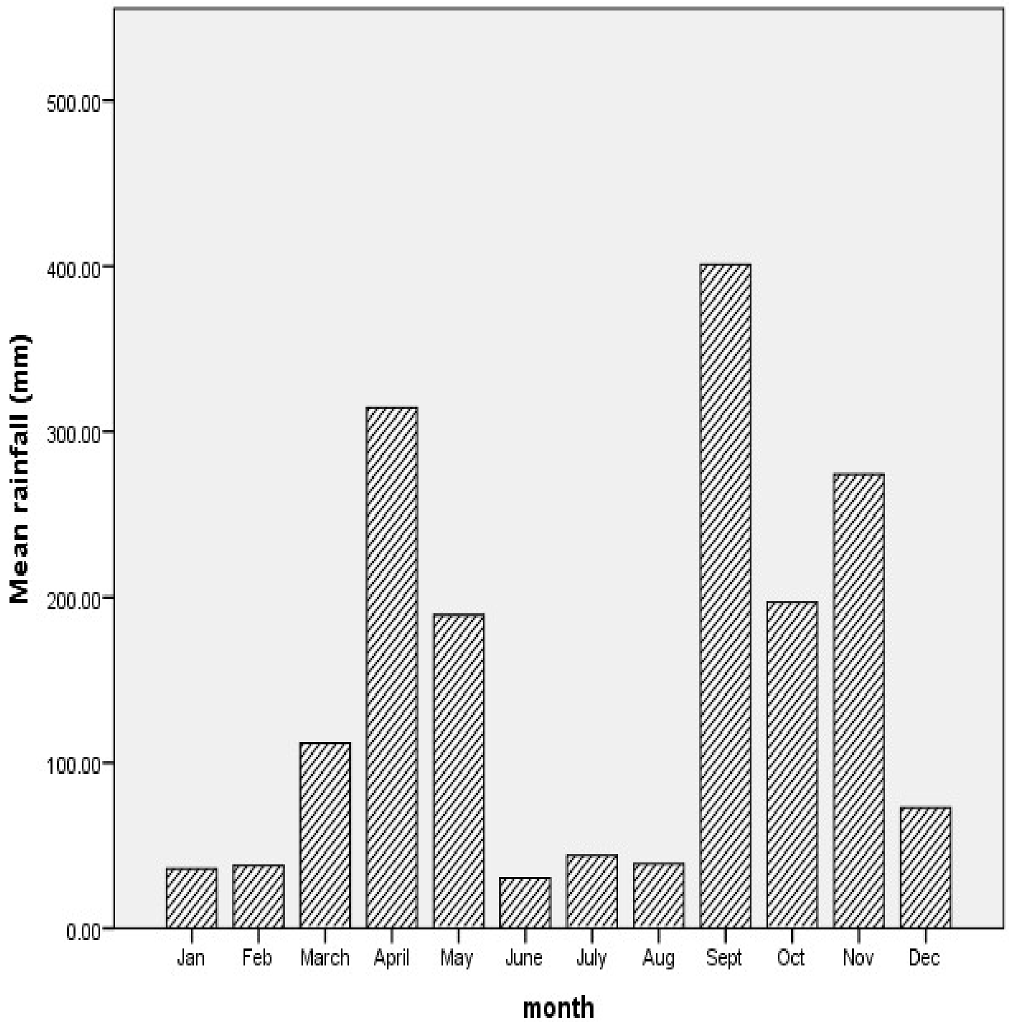


Figure 4.6: **Long-term Average Monthly Rainfall Trends**

By analyzing long term rainfall data, it was possible to establish the seasonal variation of the area covered by these conservancies. The analysis of the total amount of precipitation produced by means or central tendency per month, while standard deviation showed seasonal variations of rainfall. This helped to understand the rainfall trends over the last 20 years in the study area.

From Figure 4.6, it could be seen that there were two wet seasons from April to May and September to November. Two dry seasons were also distinct occuring from June to September and December to February. This was found to be consistent with the results of forage availalbility as discused in 4.2. This further coresponds with the social survey data where respondents cited the March-May period with high access to water and forage and other grazing resources, while June to October were cited as the most vulnerable with less grazing resources and prone to grazing conflicts. However, the results also found that on community conservancies, grazing conflicts occured in both seasons as shown in Figure 4.7:

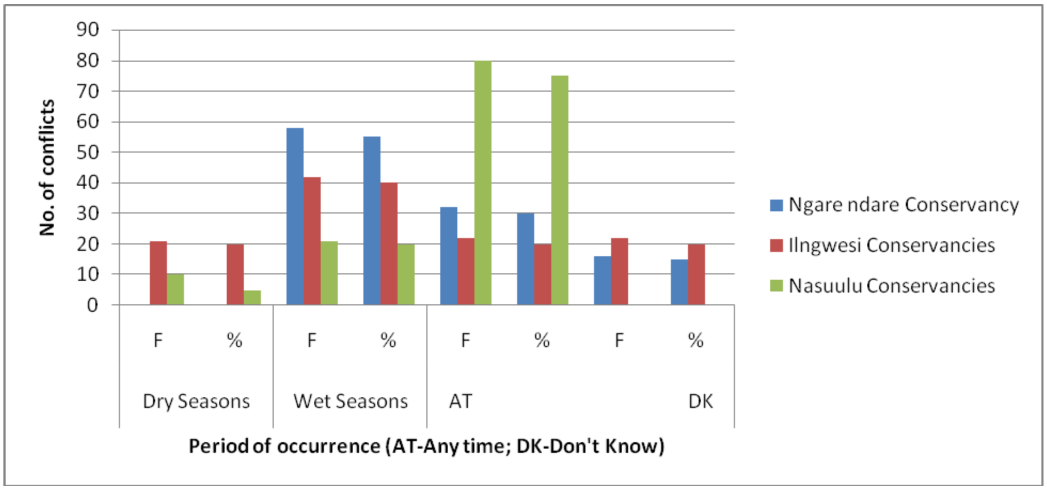


***Figure 4.7*: Seasonality of Grazing Conflicts**

From Figure 4.7, conflicts occuring in the wet seasons were attributed to competition for grazing resources, which occurs immedaitely after new green vegetation emerges, as communities want to feed their animals. This is believed to be the period to feed the cattle for weight gain to make them recover from the effects of drought and lack of forage in the just-ended dry season. The results also show that in some more vulnerable conservancies, conflicts occured any time (AT) of the year like in the case of Nasuulu. This was attributed to general lack of forage througout the year, and pastoralists are always restless searching for browsable forage and water. A sizeable number responded that they did not know (DK) when grazing conflcits occur.

4.2.4 Predicting forage occurrence and grazing conflicts using remote sensing

As described in section 3.5, this study used remote sensing techniques to ascertain the availability of forage in order to enable correlation of this with the results from other methods engaged in this study to predict grazing conflicts in Northern Kenya. MODIS 250m resolution was used to produce maps of normalized difference vegetation indices for Ngarendare, Ilngwesi, Nasuulu and Lewa for January and April 2017, and the results are as shown in Figure 4.8 and 4.9:

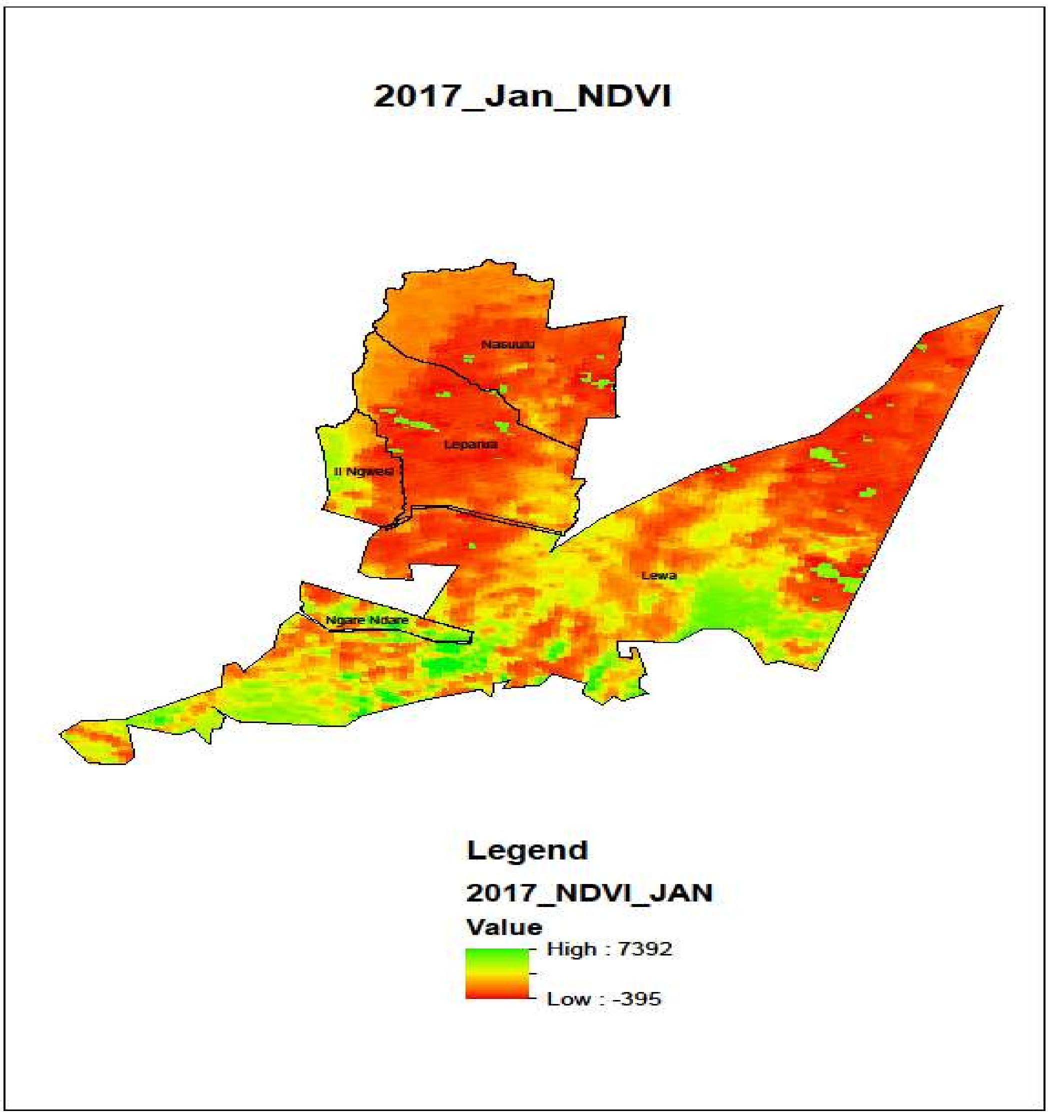


Figure 4.8 **: NDVI map for January 2017**

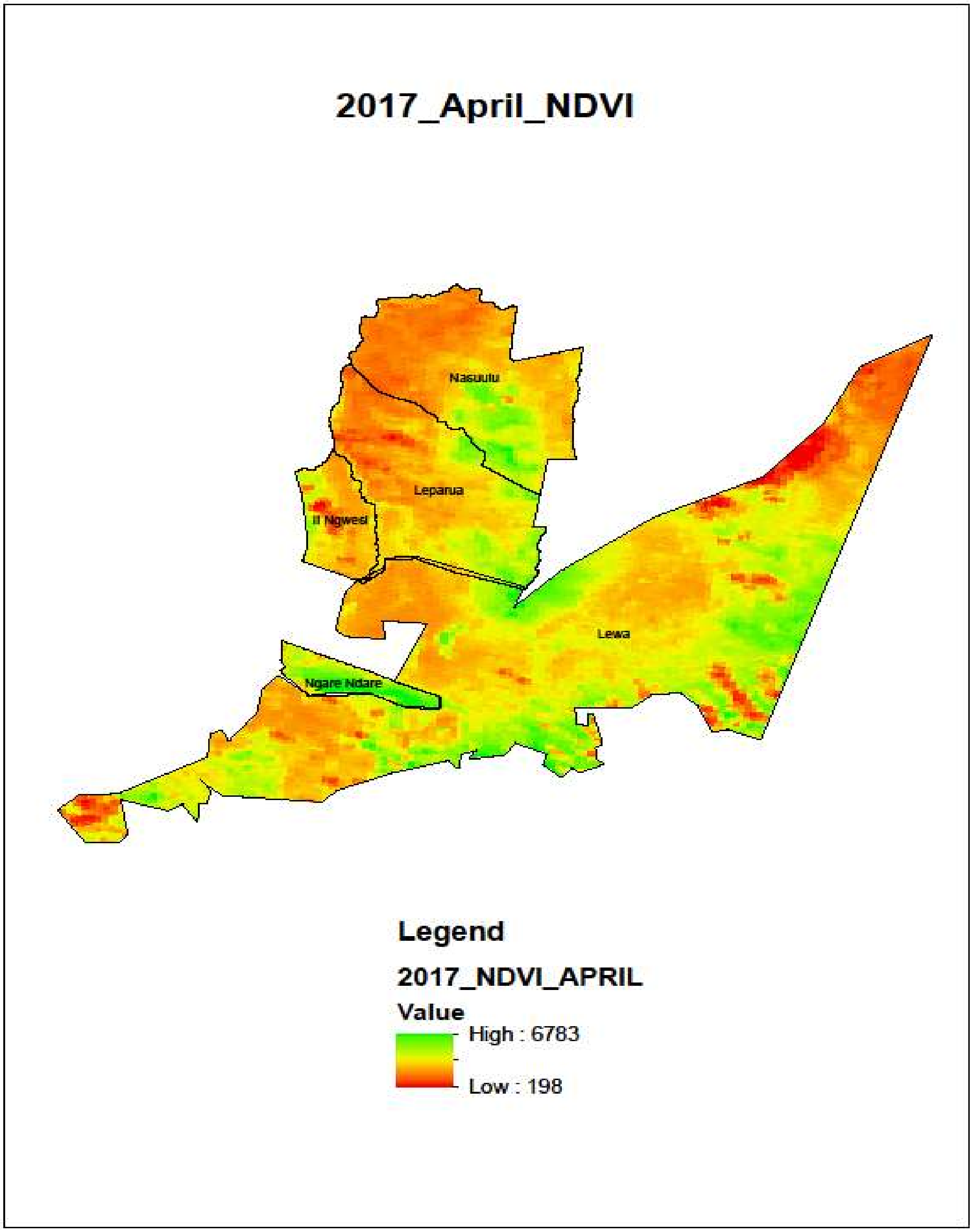


Figure 4.9 **: NDVI map for April 2017**

Figure 4.8 shows that January 2017 had the most brownness, with a low index of -0.39 compared to April (Fig 4.9) of the same year which had a low index of 0.19 on larger areas to the North. Comparing the greenness of the two months, January exhibited the highest (0.73) while April had 0.67. This could be as result of many areas of the North only depend on the November-December rains while April-May rains are mostly insufficient for meaningful vegetation recovery. This means that there is minimal ground coverage in both rain seasons and therefore scarcity of forage, predicting that most livestock would move to greener areas South of the region during that period. This results to various conflicts ranging from destruction of crop lands, invasion of private ranches and interference of grazing plans of other conservancies as ascertained from the social study.

In January, Nasuulu, Ilngwesi, and the surrounding areas display large portions of bare grounds or dead vegetation, with Lewa displaying its increasing bareness on its North-eastern tip towards Isiolo compared to April. This confirms the results of dry season forage analysis which showed the period of January to March as the most constrained in terms of grazing resource availability in all conservancies and also being the period when highest number of grazing conflicts occur in the region.

As seen in figure 4.8, there was widespread greenness in most areas after the April short rains. This indicates that there was presence of live vegetation as a result of the rains. This therefore supports the data collected on forage availability in the conservancies which showed April to May having the highest values. It could be derived that Lewa and Ngarendare have the highest ground cover as was depicted by the greenness of the two conservancies meaning they had more available forage while Ilngwesi and Nasuulu had the lowest available forage compared to other conservancies. This as well corresponds with the results of rainfall seasonality of the study area which showed April to May with the highest mean rainfall.

4.2.5 Predicting rainfall occurrence and forage availability using remote sensing

Precipitation trends of the study area were compared to NDVI to monitor their relationship in order to ascertain spatial and temporal predictions of the occurrence of browsable vegetation. The Table 4.2 shows the NDVI versus precipitation trends for the previous 17 years taken at stations in both Laikipia and Isiolo:

Table 4.2:

Trends of the longterm precipittion vesus the NDVI

Station name	NDVI 2001-2017	Precipitation(mm)
Archers Post-Isiolo	0.1996	29.75
Isiolo-Isiolo	0.3755	57.94
Rumuruti-Laikipia	0.3915	49.61
Loldaiga Hills – Barrier	0.5021	52.36
Laikipia Airbase	0.4794	47.75
Average	**0.3892**	**47.482**

The Table 4.2 shows that most of the areas under the study maintained a 17-year NDVI range of between 0.1 to 0.5 avareaging 0.35 on the more drier areas and 0.5 on the higher and more potential regions. The average NDVI and rainfall trends for the 17 year period in Isiolo and Laikipia were 0.39 and 47.5mm respectively. Most stations in Liakipia had a higher rainfall and NDVI averages than Isiolo. This infers that in most parts of Isiolo, there was likelihood of most livestock traversing the region towards Laikipia in search of pasture. This was the case mostly observed around Ingwesi conservancy, which lies on transit route of Isiolo-Leparua to the greater Laikipia. This route has always been the centre of grazing conflicts between the Borana, Turkanas and Somalis from Isiolo versus the Maasai in Laikipia. Therefore, as Inbody (2003) reported, remote tecnology can be used as a form of early warning system considering the vegetation trends in the region. The trends could be further summarised in the graph of longterm precipition versus NDVI in both Laikipia and Isiolo counties as shown in Figure 4.10:

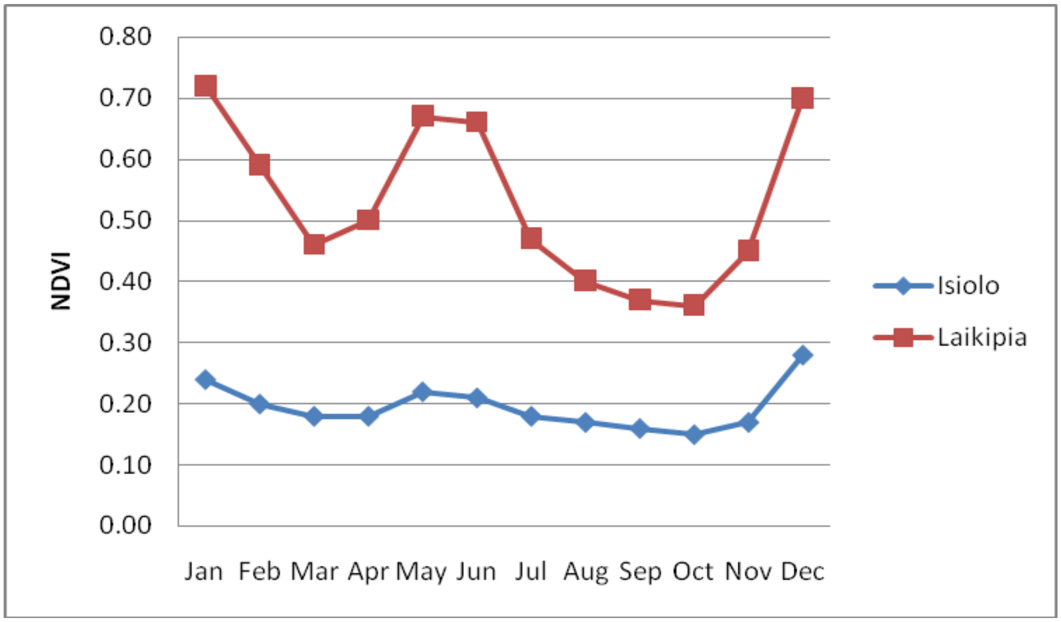


***Figure 4.10*: Monthly NDVI in Laikipia and Isiolo**

From Figure 4.10, the results show that Laikipia had higher average forage availability with the highest levels and most stable forage indices occuring in the period between April and July compared to Isiolo. This confirms the results of the ecological and social data which showed the same period having the highest levels of forage availalbility and less incidences of grazing conflicts respectively. This therefore means that NDVI can be used as a vegetation proxy to predict forage availability, livestock movements and resultant grazing conflicts in the study area.

4.2.8 Forage biomass availability using spatial vegetation distribution

NDVI was used to monitor and track the trends in the changes of vegetation indices in the study area to produce a graphical summary as shown in Figure 4.11:

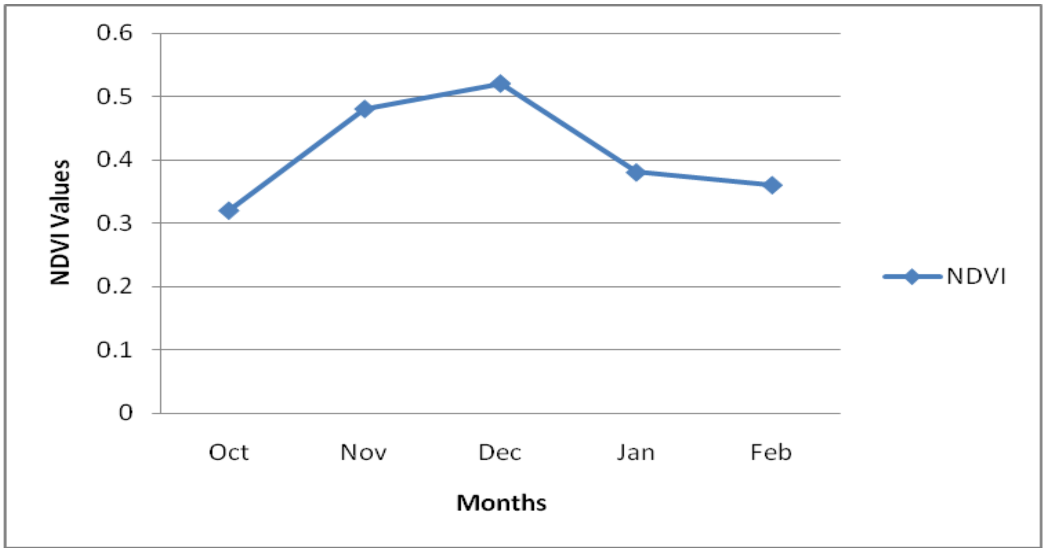


***Figure 4.11*: NDVI values in the dry and wet seasons**

Figure 4.11 shows the trends of vegetation indices between October-2017 and February 2018, which were used to predict future occurences of life browse as summarised. It shows the highest vegetation vigour occurring in the months of November to December, before it starts declining in the months of January and February. This is supported by the social survey data where respondents indicated that those were the most strained months of forage availability. Further analysis of NDVI versus precipitation is as shown in figure 4.12:

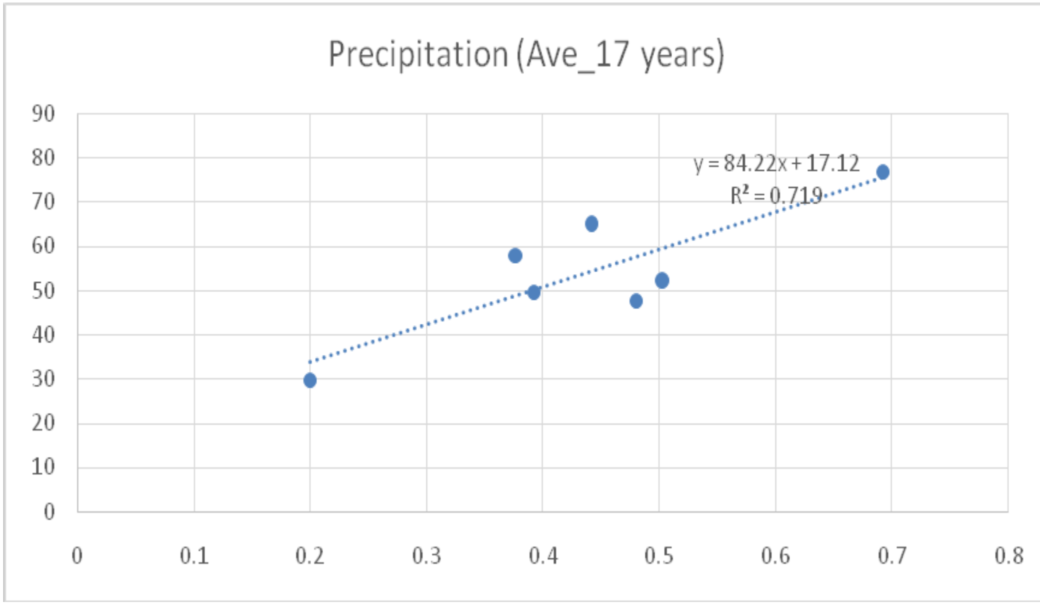


***Figure. 4.12*: The Longterm precipitation versus NDVI**

From Figure 4.12, it can be seen that NDVI and the precipitation have a R^2 of 0.719 implying that the rainfall characteristics determines 72 % variability of forage availability in the study area. Therefore, this means that rainfall can be used as reliable predictor of forage and other vegetation characteristics in the region.

4.2.9 Forage species availability and diversity

The study identified varieties of herbaceaus species including grass, sedges, shrubs, trees from the plots and transect walks where the varieties and types were visually identified. As observed by Vrachnakis, (2015), some of the rangelands herbs, shrubs and trees provide the most vital nutrition during the dry seasons or times of forage scarcity. In dry season, animals mostly depend on shrubs and herbs for forage, as evidenced by the edging of shrubs and short trees at Ilngwesi and Nasuulu as seen in Figure 4.13:

***Figure 4.13*: Heavily browsed *Grewia similis* spp at Ilngwesi**

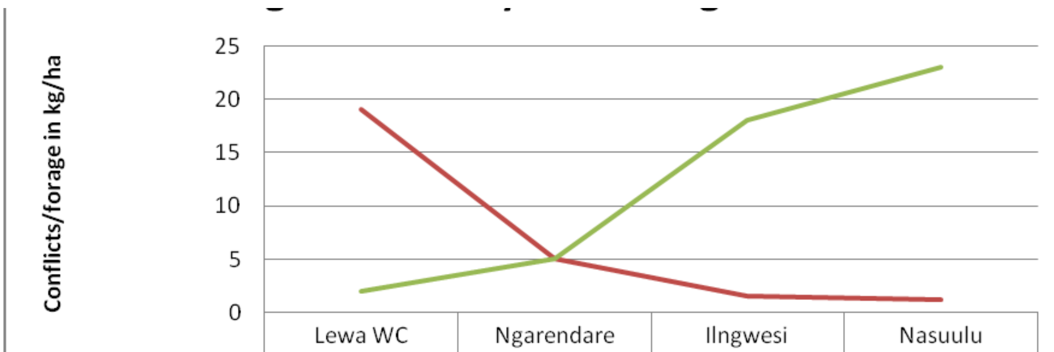
Figure 4.13 shows that during harder times of the year with less grass , livestock depend on forageable shrubs and herbs. There were heavily browsed shrubs, especially *Grewia spp* commonly found on Ilngwesi and Nasuulu observed during the transect walks. At the beginning of the wet season, most of ground is bare (NDVI<1) as seen at Nasuulu in Figure 4.14:

***Figure 4.14*: Wet season ground cover at Nasuulu**

Figure 4.14 shows that at Nasuulu, most parts of the conservancy has minimal ground cover largely exhibiting bare soils and rocks from varous types of soil erosion. After the wet season, the sprouting grass is immediately browsed with no time to cover the ground leaving exposed soils as confirmed during the group discusions.

4.3 Relationship between Grazing Resource Availability and Grazing Conflicts

The study analysed availability of grazing forage versus incidences of grazing conflicts in order to establish how they correlate with each other. Figure 4.15 shows the trends of grazing conflicts and occurrence of pasture:



	Lewa WC	Ngarendare	Ilngwesi	Nasuulu
Forage biomas	19.1	5.1	1.5	1.2
Conflicts	2	5	18	23

Figure 4.15**: Trends of grazing conflicts and occurrence of pasture**

From Figure 4.15, it can be seen that the conservancies with the highest availability of forage have the lowest cases of grazing conflicts and vise versa. Nasuulu and Ilngwesi conservancies have higher numbers of grazing conflicts while Lewa showed the lowest number of occurences followed by Ngarendare.

According to Craig, (2017), drought has been costantly blamed as the main cause of grazing conflicts on conservancies. Lack of forageable materials in most parts of the year at Nasuulu and Ilngwesi was attributed to prolonged drought, therefore the results supported observations that grazing conflicts was associated with lack of forage and prolonged drought on conservancies. Figure 4.16 shows correlation between number of occurences of grazing conflicts with forage availbility in the study area:

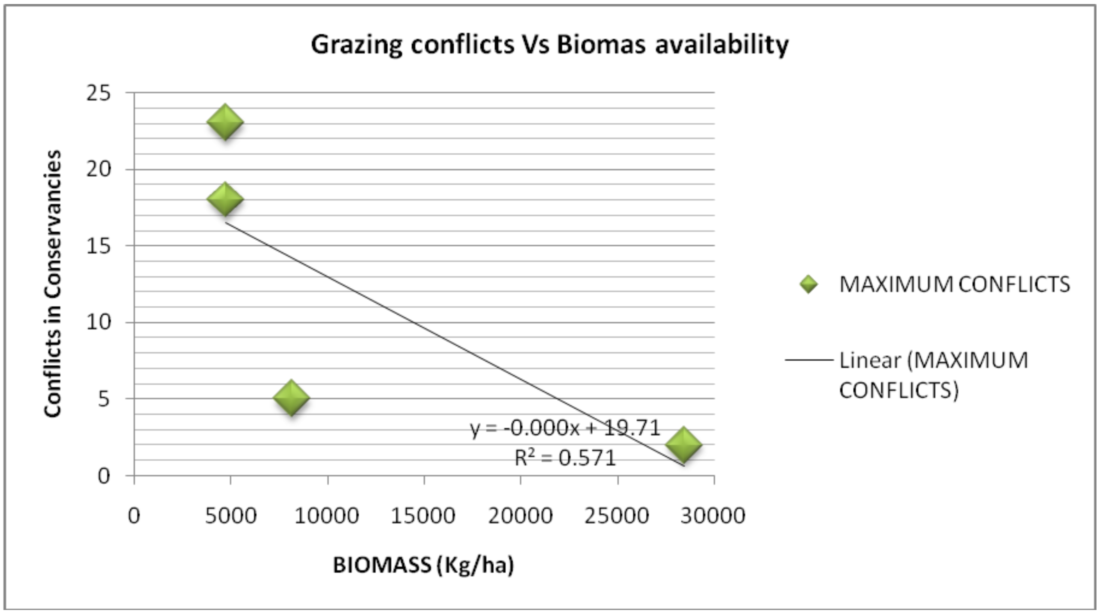


Figure 4.16**: Grazing conflicts versus forage availability**

The results as seen in Figure 4.16 showed that forage availability and grazing conflicts had a correlation gradient of R^2 =0.57, which tells that forage availability determined 57% of grazing conflict in the study area all other factors remaining constant. It can further be seen that as the forage increased, conflicts decreased. Therefore, the study found out that there was a positive relation between reduction of forage and increase of grazing conflicts in the study area as shown in Figure 4.17:

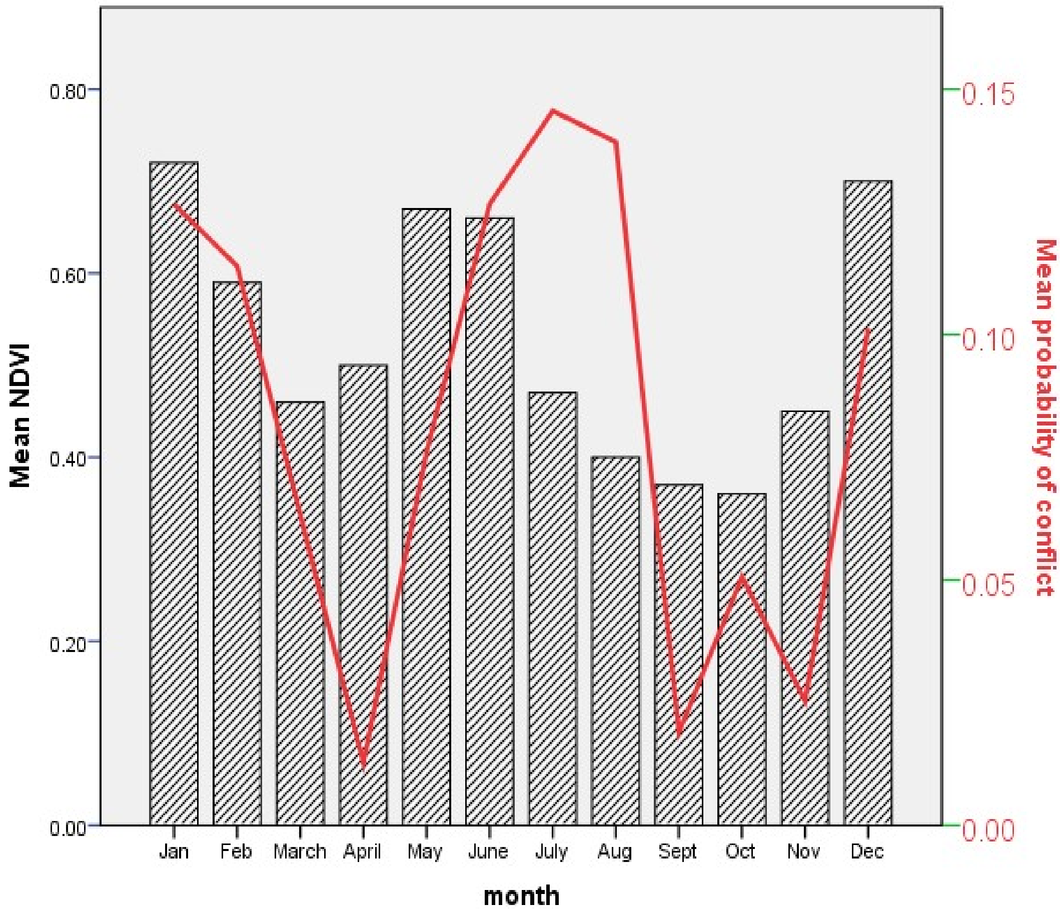


Figure 4.17: **Correlation between forage availability and grazing conflicts**

From Figure 4.17, it can be deduced that forage availability is a good predictor of grazing conflicts whereby during the wet season, pastoralists want to restock their lost livestock, stolking cattle rustling and related conflicts. The present study supported these findings where it was found that during drought, conflicts occur as a result of competition for forage as also observed by IRIN, (2009).

The annual occurence of grazing conflicts and availability of utilizable forage can be shown on mothly time series. As figure 4.17 shows, it can be deduced that most conflicts occurrences in the period between May and July, and a recurrence was witnessed between December and February. These are the periods of general forage boom in the region immediately after the rains as depicted by seasonal NDVI (see Fig 4.10 & 4.11). The results support the assertion that during the periods of forage availability, there are high conflicts resulting from the rush to restock.

Periods between July and November are the most peaceful months of the year, while they were also the periods with the lowest amount of rainfall. This could be attributed to the fact that most pastoralists had moved to other areas due to scarcity of grazing resources, or most stock had died or got exchanged. These findings are consistent with those of Pkalya, Muhamud & Masinde, (2003), in which they found that seasonal occurrences of grazing conflicts in Northern Kenya are most common in the periods between December and February but slightly disagrees with their findings on July to September. The findings also concurs with IRIN, (2009), whereby respondents asserted that during droughts there were less conflicts due to cattle rustling since there was nowhere to take stolen stock.

4.3.1 Probability of grazing conflicts in relation to rainfall

The study also sought to find out the relationship between the rainfall availability and the grazing conflicts in the study areas. The relationship between precipitation and probability of occurrence of grazing conflicts is as shown in the Figure 4.18:

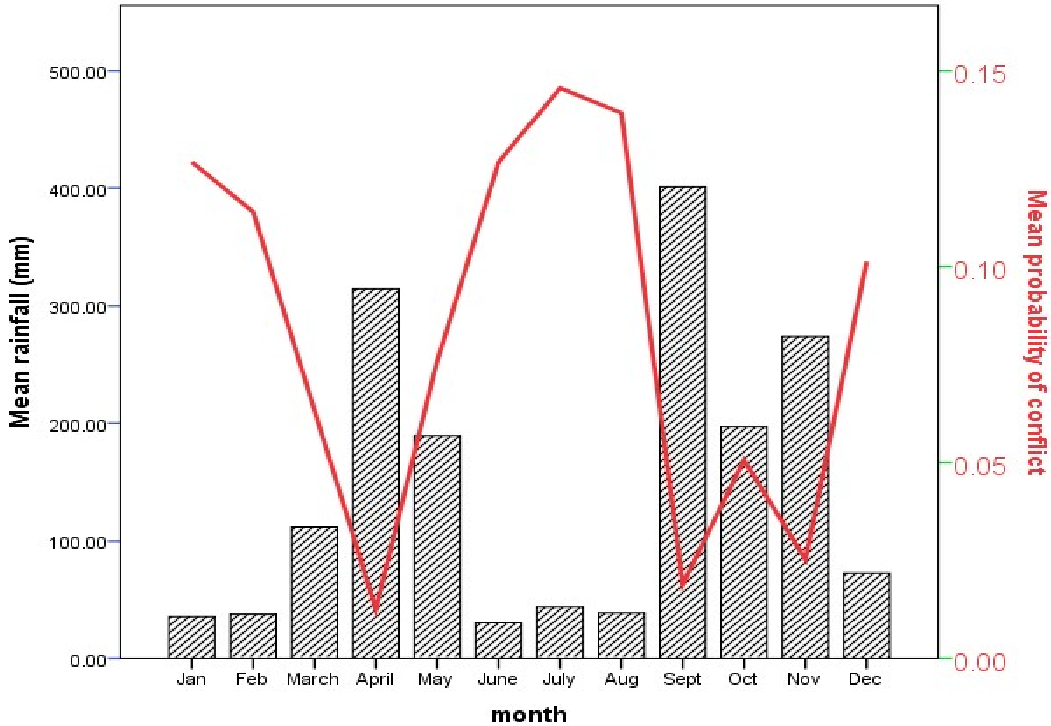


***Figure 4.18*: The trend of precipitation and probability of grazing conflicts**

From Figure 4.18, it was apparent that there was an established trend of grazing conflicts rising immediately after March-April rains as found out in the previous results (see Fig 4.17). The probability of grazing conflicts increased from May to August, with July having overall highest probability in the year. This implied that precipitation was a key predictor of grazing conflicts in the study area and the most likely periods of experiencing the grazing conflicts were the months of January to March and June-Septmeber. This was clearly supported by the results of social survey data from the grazing committees and the group discussions. Conflicts occuring immedately after the short rains were supported by the findings that this was the period when pastoralists needed to replace livestock after long periods of drought.

4.3.2 Predicting grazing conflicts per season

The study found out that there was a seasonal trend of occurrence of grazing conflicts in the study area. Figure 4.19 shows the mean probability of occurrence of grazing conflicts in the wet and dry dry seasons:

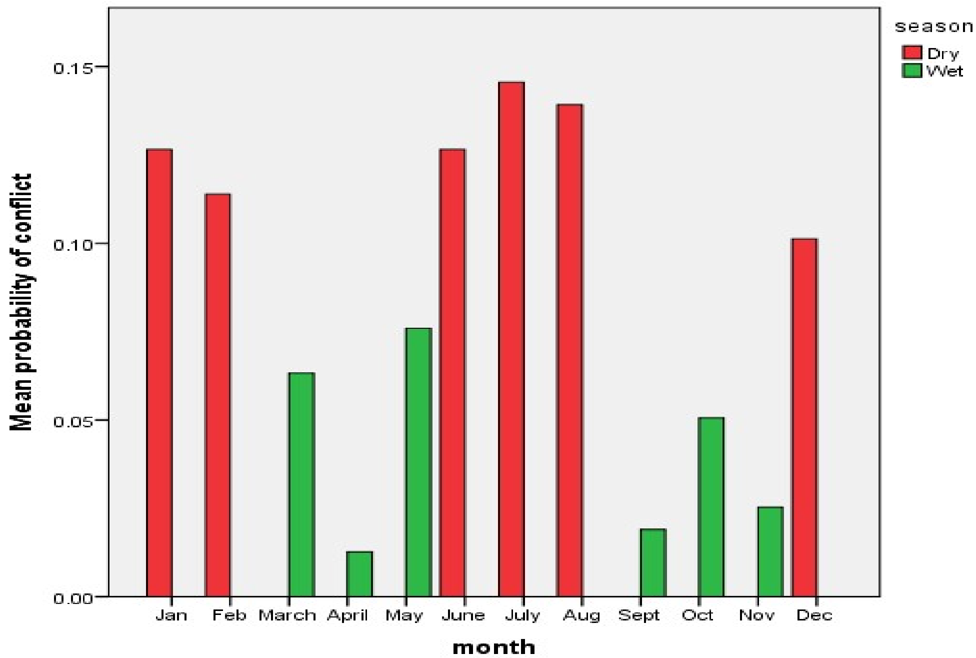


Figure 4.19**: Probability of occurrence of grazing conflicts per season**

From the results in Figure 4.19, the highest numbers of grazing conflicts are likely to occur during the dry season compared to those occuring during the wet season. This shows that the more scarce the grazing resources, the higher the possibility of conflicts occurrence. The results showed that there were grazing conflicts occuring in the wet season as well. From the group discusions, the occurrence of conflicts in the wet season, though not as many as witnessed during the dry season, was attributed to grazers taking advantage of the rains and the emerging forage to replace the livestock that died during the dry season. They also noted that morans like to acquire livestock wealth immediately after the rains since there was grass, therefore the increase in cases of cattle rustling between neighbouring clans and other communities during the wet season. The discussions also noted that increase in conflict incidences could be as a result of high market prices witnessed after the wet season as more people wished to acquire livestock since there was forage to feed and fatten them for sale, thereby increasing the market prices. Therefore, the study concluded that seasons can be taken as a good predictor of grazing conflicts in the study area.

4.3.3 Determining the resource thresholds triggering livestock movements

The study sought to find out from the respondents their level of awareness of what resource levels in the conservancies lead to various grazing conflicts. The results were ascertained through responses to questions on water availability and access, and then corroborated with the outcomes of focused group discussions. This was further correlated with the results from proximity to water, precipitation, forage availability and their overall relationship to grazing conflicts.

4.3.3(a) Distances to water points

Information from the data analysed was that most of community members indicated that grazers cover long distances to and from watering points. The results are as shown on Table 4.3:

Table 4.3:

Access to and availability of water in the study area

Distance(in Km)From Water Point Per Conservancy	0-5Km		0-10Km		Over10Km			
Statistics	Fq	%	Fq	%	Fq	%		
Ngarendare	22	100	0	0	0	0		
Lewa	12	100						
Ilngwesi	16	80	3	12	2	8		
Nasuulu	10	80	3	14	3	14		
Types of water sources	**Springs**		**Wells**		**Dams**		**Others**	
Statistics	Fq	%	Fq	%	Fq	%	Fq	%
Lewa	12	100			10	83		
Ngarendare	16	58	0	0	7	25	5	19
Ilngwesi	5	20	10	40	5	20	5	20
Nasuulu	4	20	8	40	4	20	4	20

On average, it was found that most herders cover over 5Km searching for water for their stock during dry seasons, while there was a notable difference in Ngarendare and Lewa where the number of kilometers to watering point was shorter in the range of less than 5 Km return.

On the other hand, Ilngwesi and Nasuulu had fewer options of types of watering points with Ngarendare having more options to choose from comprising of springs, rivers and dams. Numbers of water points were more for the Ngarendare and Lewa with a total of 15 water points while there were fewer for Ilngwesi and Nasuulu conservancies.

It was found that in some conservancies, surface and rain water was harvested and stored in water pans and permanent earth dams. Water was also extracted from streams and boreholes. In Ngarendare forest, water was distributed to several watering points within short walking distances for livestock and wildlife to access. The distribution of watering points in the conservancy reduced walking distance for livestock and avoided vegetation damage and land degradation, especially soil erosion, due to land trampling by large concentrations of animals.

However, holding of livestock on a small area for longer periods leads to degradation and other externalities, if grazing plans are not applied and practiced, as evidenced by some sections of the Ngarendare forest where degradation occurs around watering points due to animal crowding. This is in line with the findings by Maleko and Koipapi (2015) where they found that the time spent by livestock on a grazing unit determines degradation and eventual productivity capacity of the land.

The study found that on average, most of conservancies had access to water within a distance of 0-5 km; however for some, their water was situated longer than 10 km, the distances seemed not to differ significantly from one conservancy to another as shown by chi-square statistics on the Figure 4.20:

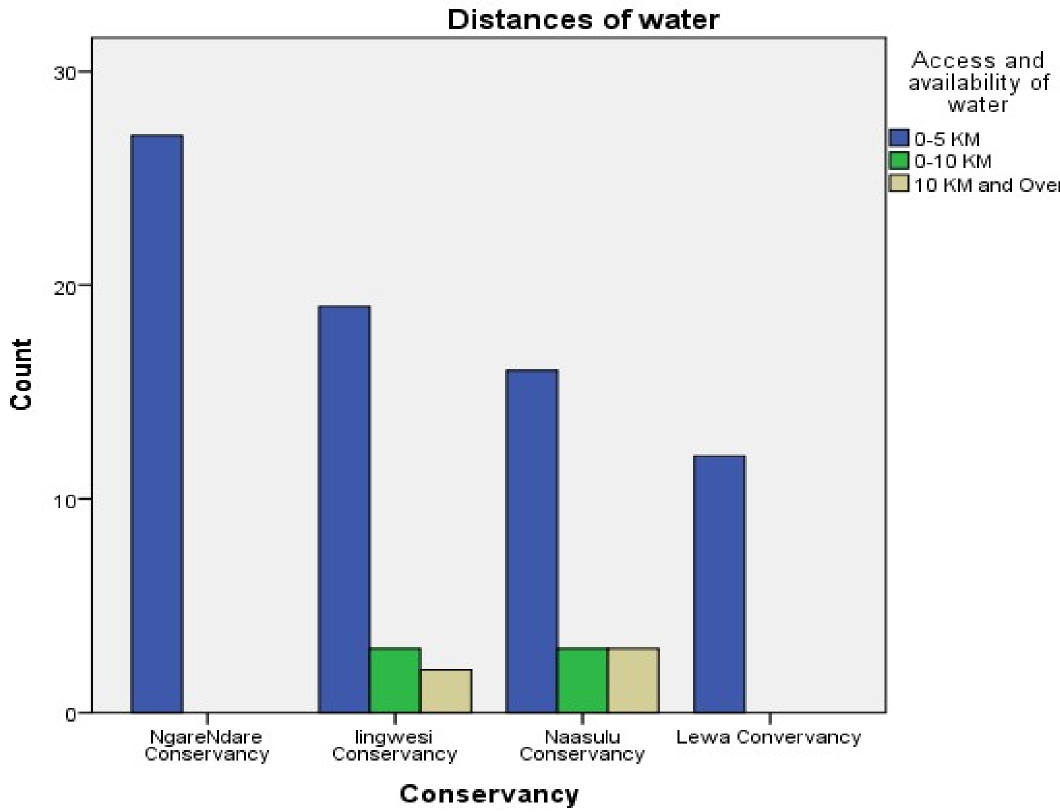


Figure 4.20**: Responses on the access to water per conservancy**

From the results, it can be seen that Ngarendare and Lewa had most of their grazers accessing water within 0-5km distance. It further shows that Ilngwesi and Nasuulu part of their grazers accessing water within 10km and longer, meaning that there was widespread movement of livestock within and outside their conservancy most of the year. This widespread movement of livestock in search of water and other resources has been widely associated with emergence of grazing conflicts as reported by IRIN, (2011). Table 4.4 shows analysis of differences among conservancies on access to water:

Table 4.4:

Access to water: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.337[a]	6	.079
Likelihood Ratio	15.260	6	.018
Linear-by-Linear Association	1.159	1	.282
N of Valid Cases	85		

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .71.

The study therefore rejected the null hypothesis and concluded that there was no significance difference on distances to water between conservancies and therefore the variables were independent of each other.

4.3.6 Types of water sources

In order to find out what formed the most reliable sources of water in the conservancies throughout the year, the respondents were asked to name the types of water sources they relied on. Table 4.5 shows the results of the cross-tabulation of the responses:

Table 4.5:

Types of water sources

			types of water sources				
			Springs	Wells	Dams	Others	TOTAL
Conservancy	Ngarendare	Count	10	0	7	5	22
		% within Conservancy	57.1%	0.0%	25.0%	17.9%	100.0 %
	Ilngwesi	Count	5	8	5	3	21
		% within Conservancy	23.1%	38.5%	19.2%	19.2%	100.0 %
	Nasuulu	Count	3	5	4	4	16
		% within Conservancy	18.2%	31.8%	22.7%	27.3%	100.0 %
	Lewa	Count	12	0	10	0	22
		% within Conservancy	54.5%	0.0%	45.5%	0.0%	100.0 %
Total		Count	38	17	27	16	98
		% within Conservancy	38.8%	17.3%	27.6%	16.3	100.0 %

The study found that types of water sources varied significantly between different conservancies. Springs were mostly found in Lewa and Ngarendare, while wells were mostly found in Ilngwesi and Nasuulu. Dams were found in all the four conservancies. The study also found that other types of water sources were also found within conservancies. When further analysed with Chi-square test, the types of water sources available differed significantly across the four conservancies with a chi-square p value = 0.000 as shown in Table 4.6:

Table 4.6:

Types of water points: Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	34.763[a]	9	.000
Likelihood Ratio	44.553	9	.000
Linear-by-Linear Association	.823	1	.364

N of Valid Cases	98

a. 8 cells (50.0%) have expected count less than 5. The minimum expected count is 3.59.

Further analysis on the types of water sources indicated that every conservancy had the four types of water sources referred in the study. It showed springs were most prominent, followed by dams, then wells in that order. Others included those accessed through water selling points, common cattle troughs and storage tanks. On conservancy level, Ngarendare relied mostly on spring water emanating from the forest, while Lewa had both springs and dams as the prominent types. Ilngwesi and Nasuulu had springs, dams, wells and other sources.

4.3.7 Competition for forage and stocking rates

This included obtaining information about livestock data and methods of stock grouping/grazing per conservancy. The aim was to find out the communities' perception on the effects of various types of livestock grazed, competition, stock numbers and their consequences on the grazing resources (See appendix 10). The study therefore established the perception about competition for limited grazing resources in their conservancies among different types of stock. Table 4.7 shows the responses on stock competition, livestock numbers and overstocking:

Table 4.7:

Stock numbers and competition per conservancy

Estimation of the Number of Cattle	**0-1000**		**1000-5000**		**5000 And Above**	
Statistics	Fq	%	Fq	%	Fq	%
Ngarendare	27	100	0	0	0	0
Ilngwesi	20	80	5	20	0	0
Nasuulu	17	80	4	20	0	0
Lewa	12	100	0	0	0	0
Total	76	89	9	11	0	0
Whether Conservancies Mixed the Goat and Sheep	**Yes**		**No**		**Sometimes**	

Statistics	Fq	%	Fq	%	Fq	%
Ngarendare	18	70	4	15	5	16
Ilngwesi	25	100	0	0	0	0
Nasuulu	21	100	0	0	0	0
Lewa	0	0	12	100	0	0
Total	64	75	16	18	5	6
Whether there was Overstocking	**Yes**		**No**		**Sometimes**	
Statistics	Fq	%	Fq	%	Fq	%
Ngarendare	3	10	15	55	8	33
Ilngwesi	10	40	10	40	5	20
Nasuulu	10	48	5	20	6	29
Lewa	0	0	12	100	0	0
Total	23	27	42	49	19	22

From the findings in Table 4.7, most respondents (89 %) indicated their conservancy sometimes held above 1000 cattle and sheep while only 11% estimated the number to be below 1000. This was supported by the focus group discussion held at Ilngwesi on 07-02-2017 where most members indicated observing large numbers of livestock from time to time in their conservancies. These movements of large populations of livestock from other areas increased competition for resources leading to various forms of conflicts within the conservancies, and the results were agreeing with the findings of Bonneau, (2013).

The study also found that stocks were grazed separately in most areas of the study, where 84% indicated that shoats and cattle were normally separated while only 15.8% indicated that they were grazed together as seen in appendix 10. Rutagwenda and Wanyoike (1994) concurs that mixing browsing species have significant effects on the availability of forage. The study found that 84 % of the respondents indicated that overstocking led to overgrazing in their conservancy while 26% indicated that it did not, which tends to support the findings of Brannstrom & Sumpter (2005) who found that clustering of groups of livestock species leads to overgrazing and depletion of certain vegetation species.

At Ngarendare forest, 55% felt there was no overstocking while over 33 % felt there was. Further, 40% and 70% felt there were negative effects of overstocking for Ilngwesi and Nasuulu respectively. Lewa indicated no overstocking as the livestock numbers were controlled within the existing grazing blocks.

As seen on Table 4.7, it was found that most members of conservancies acknowledged about existence of competition between shoats and cattle as indicated by 68.4% of respondents. However, 26% indicated that competition did not exist while 5.3% indicated they did not know. The grazing coordinator at Nasuulu conservancy concurred that there was competition for browse between shoats and cattle since the shoats browse faster on the newly germinated herbs unlike cattle. Therefore, cattle migrated away immediately after the short rains in search of pasture. This was observed at Ilngwesi, as it was reported that there were over 5000 shoats in the conservancy after the short rains, as compared to the dry period when there were about 1000. These results support the findings of the study in Northern Kenya by Taylor (2015).

While explaining that during droughts all neighborhoods experience pasture scarcity and it is only inside the private conservancies that pasture remains compared to community grazing areas like group ranches, conflicts arise since everyone competes for the limited resource. This was partly due to the fact that grazing in the conservancy was well planned and it was therefore the only fall-back resource area after other pasture was depleted. Similar findings have been obtained by Rutagwenda & Waithaka (1994), Taylor (2015); O'Connor, Bilal & Joahannes, (2015).

It was found that conflicts arose because there was disagreement between grazers and grazing plan committee about areas to graze. Sometimes the Laikipia Maasai complained of invasions by other neighbouring grazers especially morans from Samburu community. The categorized responses on livestock populations were further analysed and Figure 4.21 shows results of estimated livestock numbers per conservancy:

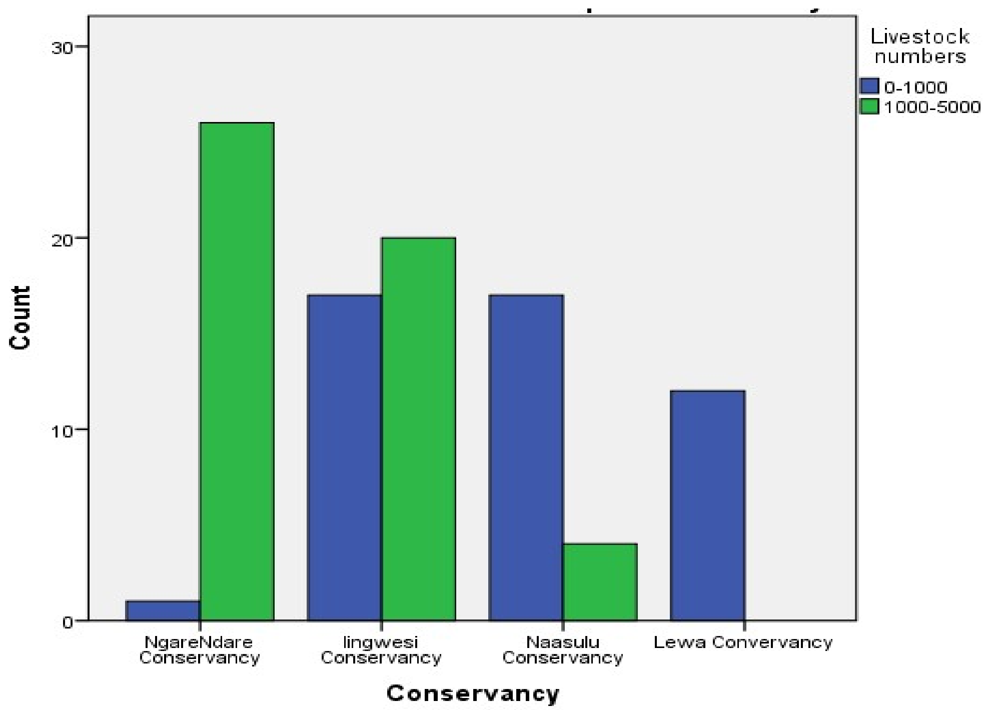


Figure 4.21: **Estimated Livestock numbers per conservancy**

From the results, Ngarendare conservancy contained the biggest number of livestock, followed by Ilngwesi, and Nasuulu then finally Lewa had the least number of livestock. In the group discussions, it was pointed out that during drought periods, most grazers moved with their livestock southwards towards Ngarendare and Lewa, and sometimes into the Mt. Kenya forest. Therefore during the time of this study, the large numbers of livestock witnessed at Ngarendare could have come from surrounding areas like Ilngwesi and Leparua, Lekuruki and Nasuulu. The results were compared across the conservancies to find out whether there were significant differences, and the findings were as shown in Table 4: 8:

Table 4.8:

Livestock numbers per conservancy: Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	43.388[a]	3	.000
Likelihood Ratio	54.324	3	.000
Linear-by-Linear Association	41.838	1	.000
N of Valid Cases	97		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.81.

The results show that there were statistically significant differences on stocking rates per conservancy as shown by chi-square <0.05.

4.3.8 Methods of grazing practiced by the communities

The study also enquired about the methods of grazing prevalent on the conservancies. This was aimed at finding out whether the communities mixed shoats and the larger stock (cattle) in order to make conclusions on the competition between species. The results of the cross tabulation of the frequency of responses for this question are as shown in Figure 4.22:

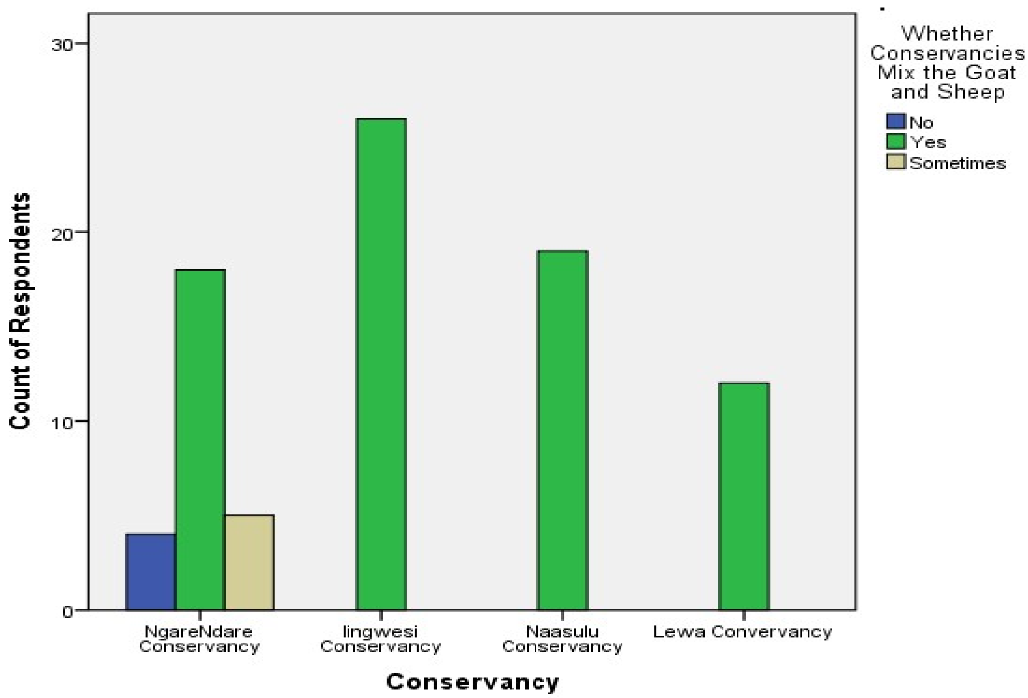


Figure 4.22: **Mixing of livestock per conservancy**

From the figure 4.22, it can be seen that most respondents asserted that their conservancies mixed all types of livestock in the same grazing set up. This means there was competition for forage between goats, sheep and cattle. This study did not interrogate the levels of competition between different types of livestock and their effects on available forage, though it was brought up in the focused group discussions that there exists competition for grass between different species of cattle. When analyzed per conservancy, the results showed that Ilngwesi had the highest response to where the communities mixed their livestock, followed by Nasuulu, Ngarendare and Lewa in that order. From the results of the frequency counts, the study found out that all conservancies mixed goat and sheep and that there was no significant differences on their responses as shown in Table 4.9.

Table 4.9:

Mixing of stock per conservancy: Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	21.280[a]	6	.092
Likelihood Ratio	22.832	6	.001
Linear-by-Linear Association	.144	1	.704
N of Valid Cases	84		

a. 8 cells (66.7%) have expected count less than 5. The minimum expected count is .57.

4.3.9 Environmental externalities due to grazing and their effects on grazing conflicts

The study sought to find out environment trends for the previous twenty years in the study area, how these trends were related to grazing and how the people percieved the changes and their consequencies. The results showed that the majority (53%) of the community members had witnessed negative trends in environmental changes. This was attributed to overgrazing as attested by the majority (56%) of the respondents who said that overstocking causes negative environmental changes in their conservancies. This opinion was supported by the majority in the focused group discusions and later confirmed by key informants. Table 4.10 shows the responses on perceptions of environmental externailities as contributed by grazing per conservancy:

Table 4.10:

Responses on perception of effect of grazing on the environment

Perception of Members of Conservancies on environmental changes in recent years	Positive		Negative		No Change		Do not know	
Statistics	**Fq**	**%**	**Fq**	**%**	**Fq**	**%**	**Fq**	**%**
Ngarendare	9	40	10	44	3	15	0	0
Ilngwesi	9	43	10	48	1	5	0	0
Lewa	2	17	8	66	2	17	0	0
Nasuulu	5	32	9	38	1	6	1	6
Total	25	36	37	53	7	10	1	1
Opinion of members of conservancy on whether grazing contributed to environmental changes in the conservancies								
Statistics	**Fq**	**%**	**Fq**	**%**	**Fq**	**%**	**Fq**	**%**
Ngarendare	8	37	13	59	1	4	0	0
Ilngwesi	10	48	9	43	2	10	0	0
Lewa	5	41	3	25	4	33	0	0
Nasuulu	5	32	4	24	3	20	3	20
Total	28	40	29	41	10	14	3	4
Whether there were effects of overstocking on the environment								
Statistics	**F**	**%**	**F**	**%**	**F**	**%**	**F**	**%**
Ngarendare	0	0	14	63	5	22	3	14
Ilngwesi	5	24	10	52	3	14	2	10
Lewa	3	25	9	75	0	0	0	0
Nasuulu	1	4	6	40	6	40	3	18
Total	9	12	39	56	14	20	8	11

These results were further tested on chi-square to find out whether there were differences between conservancies and the results showed P 0.06> 0.05, meaning there was no significant differences of these opinions between conservancies as shown in Table 4.11:

Table 4.11:

Perception on the environmental changes: Chi-Square Tests

	Value	Df	Asymp. Sig.(2-sided)
Pearson Chi-Square	23.043[a]	9	.006
Likelihood Ratio	29.689	9	.000
Linear-by-Linear Association	1.720	1	.190
N of Valid Cases	83		

a. 10 cells (62.5%) have expected count less than 5. The minimum expected count is 1.16.

The results showed that there were significant differences in the communities' perception of the environmental changes per conservancies. At Ngarendare, the majority of the respondents had observed negative changes on their conservancy, followed by Ilngwesi, Nasuulu and finally Lewa respectively. Sections of the communities felt there were no changes observed, which was most prominent on Ngarendare and Nasuulu (See appendix 13). According to Mulinge Gicheru, Muriithi, Maingi, Kihiu, Kirui & Mirzabaev, (2015), the observed loss of land value due to degradation leads to economic loss of animal products in the rangelands, resulting to endemic poverty witnessed among Kenyan pastoral communities (Homer-Dixon, 1991, 1994).

4.3.10 Environmental externalities and land-use changes over time

The aim was to apply ecological and remote sensing techniques to find out the trends of environmental changes that had occurred in the area over time and which had affected grazing conflicts (Hormer-Dixon, 1991; 1994). Ecological procedure involved visual ground cover observations and transect walks, comparing ground foliar coverage, ground bareness, erosion evidences and general range conditions to make conclusions on its water infiltration, degradation and productivity. This was recorded in Range Condition

Field Form (Appendix 2). The data was analyzed to make comparisons of forage productivity and other environmental conditions among the conservancies with the control to compare forage availability on conservancies. Table 4.12 shows the results of the ground cover percentages mainly composed of standing biomass of different grass species:

Table 4.12:
Ground cover analysis

Nasuulu			**Ngare ndare**		
Points	% ground cover	% bare ground	Points	% ground cover	% bare ground
Averages	23.4	86	Average	54	56
1	2	98	1	20	80
2	40	85	2	40	60
3	30	95	3	38	62
4	40	60	4	75	25
5	5	95	5	90	1

Lewa			**Ilngwesi**		
Points	% ground cover	% bare ground	Points	% ground cover	% bare ground
Average	82	18	Average	5.5	96
1	95	5	1	14	86
2	98	2	2	5	95
3	80	20	3	0	100
4	90	10	4	5	95
5	65	35	5	4	96

From Table 4.12 it can be seen that during the dry season, Lewa had 82 % ground cover followed by Ngarendare with 54% basal ground cover. Nasuulu had 23.4 % while Ilngwesi had the lowest with 6% basal ground cover. This therefore shows that the environmental externalities were more severe to Ilngwesi, Nasuulu, Ngarendare and Lewa in that declining order (see Annex2). It therefore can be cited as the reason for existence or lack of forageable biomass per conservancy and partly confirms the reason why livestock have to move from one conservancy to another in search of pasture during dry season. The Transect walks showed more pronounced range conditions, with Nasuulu and Ilngwesi exhibiting more open tracks, basal soil, sheet and gully erosions, while Ngarendare and Lewa exhibited less of these. This can be attributed to extent of roaming by livestock, stock numbers, grazing plan management and the amount of precipitation received per conservancy.

4.3.11 Trends of the environmental changes in the study area

The study used remote sensing to obtain land-sat maps in order to compare environmental changes that have occurred in recent years. The aim was to obtain data to support the conclusions on the prediction of grazing conflicts and inform the buildup of the predicting model. Land use maps of the study area for 1990 and 2014 were obtained using MODIS 250m resolution to compare NDVI trends between the two time periods. Figure 4.23 shows the NDVI landuse map of 1990 as analysed with colour bar -1 to 1:

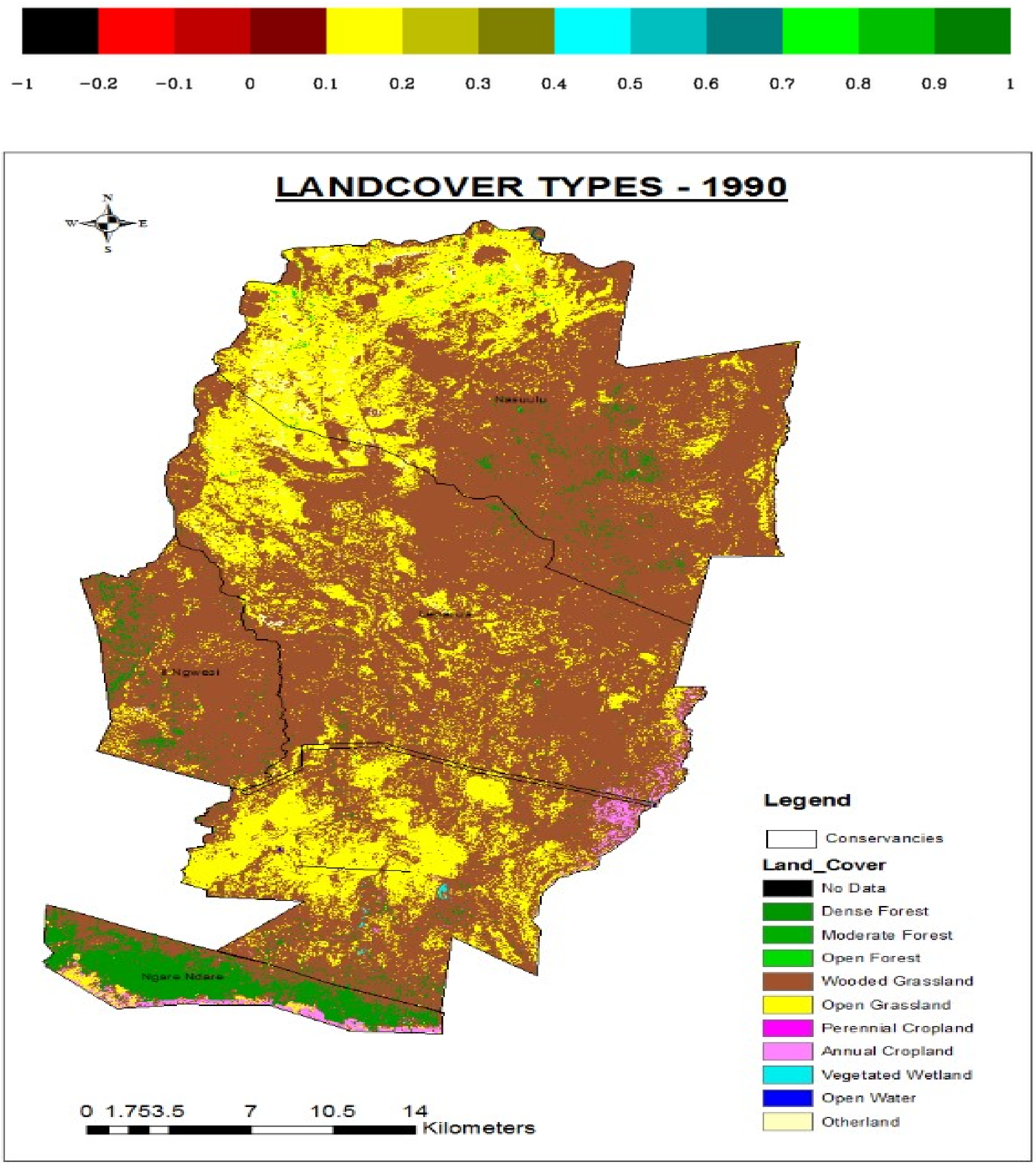


***Figure 4.23*: 1990 Spatial land-use map**

From Figure 4.23, the appearance of the vegetation index and landuse changes on the study area in 1990 can be deduced. It shows that Nasuulu, (far North), was mostly composed of wooded grasslands (central to Northeast of conservancy), which was rapidly transisting to open grassslands (Northwest). There were few patches of open forests (central), which is today seen as evidence of dry acacia rangeland.

Ilngwesi conservancy in 1990 portrayed more wooded grasslands (yellowish-brown resolution) and almost balanced amounts of open forests and open grasslands. A closer look shows a tendency of transition from wooded grasslands to open grasslands (less browning to more yellowing) from Southwest towards Northwest as seen in figure 4.27.

Lewa in 1990 showed a resolution of more wooded grasslands to open grasslands (less browning to yellowing). There were patches of open forests between the boundary with Ngarendare forest, and vegetated wetlands (dams or gullies), while evidence of annual croplands existed on its Northwestern tip boundary with Leparua (probably along Ngarenight river). However, as seen in figure 4.27, in 2014, there was a balance between wooded and open grasslands with the latter more on the Eastern and the North-eastern boundary of Lewa as compared to 1990s. This can be attributed to the fact that Lewa converted from Livestock ranching to wildlife conservation, giving way to a growing populations of elephants and other ungulates, with different foraging characteristics than livestock. Figure 4.24 shows the satelite landuse imagery of the study area in 2014:

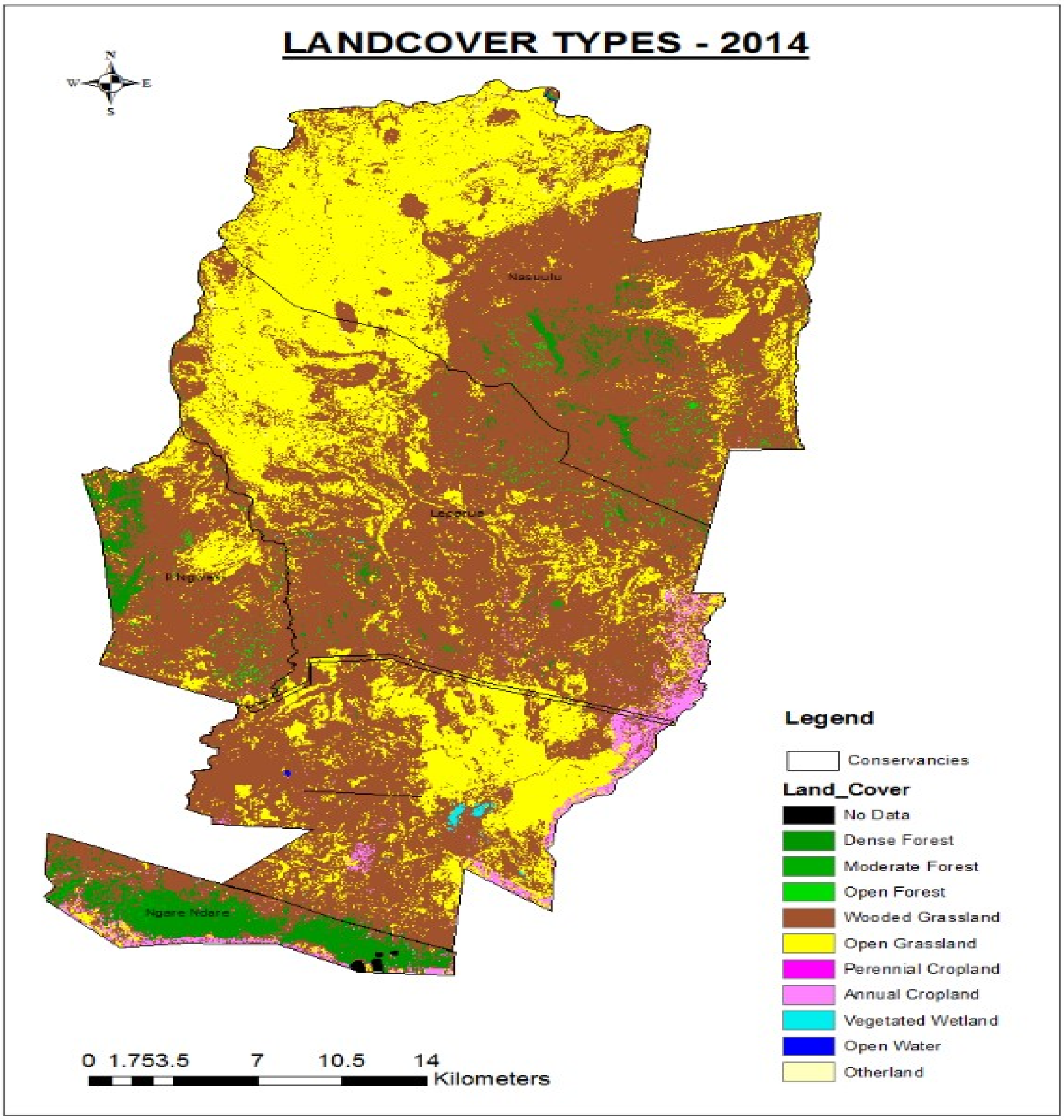


Figure 4.24: **2014 spatial land-use map**

In 2014, it shows more than 50% of the land use had transisted from wooded grasslands to open grasslands as seen on the North and Northwest (boundary with Samburu) showing intense yellowing resolution. On its central region, a more hilly area, evidence of open forest (greener patches) existed compared to 1990s. This could be attributed to gains through creation of community conservancy which implemented more controlled grazing plans.

At Ilngwesi, in 2014, more open grasslands had taken over from the North towards the centre of the conservancy. More open forests had taken up the Western and some parts of the Eastern to South-eastern of the conservancy as shown by intense greening patches. This could be due to establishment and adherence to grazing blocks advocated by the conservancy management. Ilngwesi Consevancy, however, portrayed an almost equal amount of wooded and open grasslands, with more open grasslands to the Northwest, a situation that has significantly changed today.

In 1990s, there were fewer settlements along the Lewa Eastern boundary, whereas farming population increased towards the turn of the millennium. More water sources were accessible through drilling of boreholes and pipelines leading to more settlements and farming activities. The patches of vegetated wetlands to the South had disappeared, with two key wetlands developing on its central area. These are most likely the manmade dams. At the same time, Ngarendare forest portrayed a resolution index of moderate to dense forest, with its Northern boundary showing transition from moderate forest to open grasslands along its boundary with Lewa. Its southern boundery showed evidence of transition from moderate forest to a mixture of annual/perenial croplands mainly due to increased farming.

In 2014, more conversion of dense forests to open and wooded forest was taking place on its Northern boundary tending to the South, while the perennial/annual croplands had not changed significantly. The spread of open grasslands/woodlands could be partly attributed to increasing livestock population especially during drought times, coupled with doubling populations of wildlife (especially elephants) in the forest since 1990.

4.3.13 Quantitative spatial and temporal landuse changes

Table 4.13 shows the analysis of the quantitative land use changes that had occurred between 1990 and 2016 as derived from analysis of satellite imagery which was produced from Lands at 8 on the study area:

Table 4.13: ***A summary of land use changes per vegetation class***

Value	Land cover	Area – 1990 (ha)	Area – 2016 (ha)	Change (ha)	(+/-)
1	No Data	0.99	81.54	80.55	+
2	Dense Forest	4174.29	3792.15	-382.14	-
3	Moderate Forest	40.32	165.06	124.14	+
4	Open Forest	160.38	687.06	526.68	+
5	Wooded Grassland	69937.65	62657.01	-7280.64	-
6	Open Grassland	25699.68	32199.66	6499.98	+
7	Perennial Cropland	3.24	20.52	17.28	+
8	Annual Cropland	895.05	1753.11	858.06	+
9	Vegetated Wetland	32.67	98.91	66.24	+
10	Open Water	10.35	13.86	3.51	+
11	Other land	728.73	214.47	-514.26	-

From Table 4.13 it can be seen that dense forest had decreased by 382 ha, while the wooded grasslands had also reduced by 7280.6 ha and was rapidly being converted to open grasslands. This phenomenon could be partly attributed to increasing livestock numbers, as well as increasing population of elephants and other ungulates. We postulated that due to previous incidences of poaching in the 1990s, and increased better security in the recent past, some parts of Laikipia and Isiolo had become the refuge for elephants and other larger mammals. There had also been establishment of private wildlife conservancies, further assuring elephants and browsers of better security. This had on the other hand put pressure on the woodlands and forests to transit to open grass lands.

The annual cropping system had increased by 858 ha reducing land for livestock keeping and wildlife conservation. This would explain the emergence of human wildlife conflicts within the larger Laikipia-Samburu region. Besides, perennial cropping had increased slightly by 17 ha. This could be attributed to adoption/change of livelihood from pastoralism to small-scale agriculture as seen taking place at Leparua on the Northern border with Lewa, or due to settlement of farming communities in previously pastoral areas. This trend predicts that the future of both livelihoods would be a key factor of conflicts.

Taking into account that grazing in the study area mostly took place on open forest, wooded grasslands and open grasslands (Class 4, 5&6 respectively), the analysis showed a negative trend, indicating that land cover and browsable forage have continuously reduced over the years. This led to migration from one class to the next, e.g. to class 3 (moderate forest) or class 7 (perennial cropland). This seeking of other grazing areas further compounds the grazing conflicts when it involves the larger and small scale farmers in the Laikipia and Isiolo counties especially in times of rainfall failure or drought (Natalie, 2018).

In the social survey, overgrazing was cited as having contributed to the negative environmental changes in the conservancies in the previous 20 years. As shown in Figure 4.26, the opinion of members of conservancies concerning how the grazing plans assisted in reducing grazing conflicts was equally divided where half indicated that it did while another half indicated it did not. Competition for forage was therefore a key factor in predicting future occurrence of grazing conflicts.

4.4 Predicting Community Coping Methods Under Limited Resource Regimes

This objective sought to find out how communities in Northern Kenya who experienced grazing conflicts in the wake of limited grazing resources, were likely to deal with them. The results were as discussed below:

4.4.1 Occurrences of grazing conflicts in conservancies

According to the findings from the analysis of the data about grazing conflicts in the 4 conservancies which included Ngarendare, Nasuulu and Ilngwesi as well as Lewa which was the control, it was clear that grazing conflicts varied depending on number of incidences, frequencies, severity once they occurred. Figure 4.25 shows the average number of occurrences of grazing conflicts per month per conservancy between 2016 and 2017:

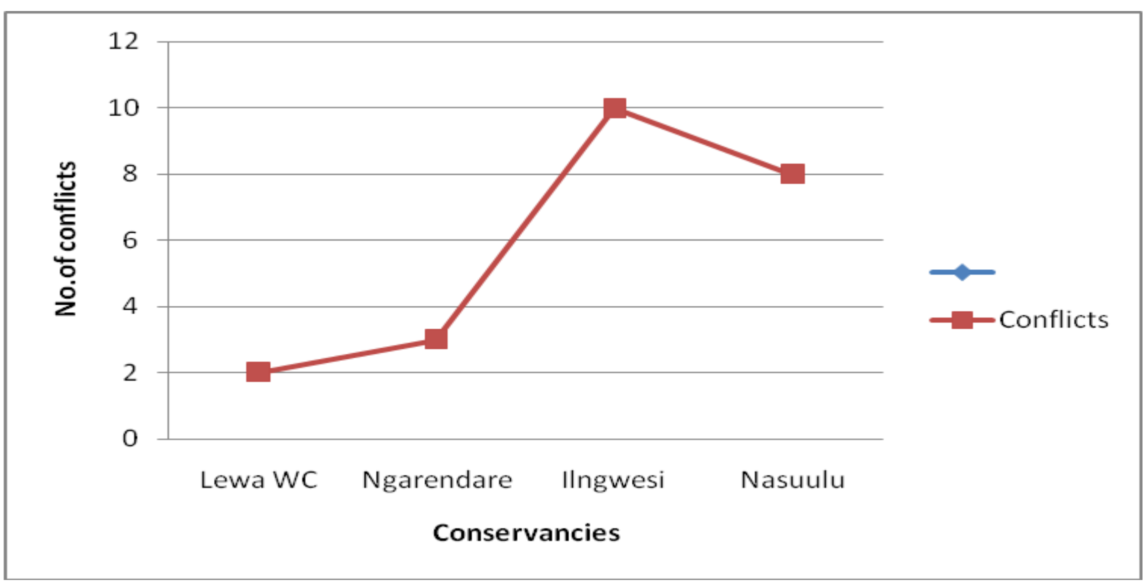


***Figure 4.25*: Number of incidences of grazing conflicts per conservancy**

From Figure 4.25, it can be seen that there were minimal incidences of grazing conflicts on Lewa conservancy being privately owned since no livestock from outside ventured to graze inside the conservancies unless under prior arrangement with the owner. However, on community owned conservancies, Ngarendare had the lowest number of incidences averaging 3 per month, while about 10 were reported for Ilngwesi and about 8 for Nasuulu respectively.

4.4.2 Perception on causes of conflicts on conservancies

The respondents were asked to name what they thought were the causes of grazing conflicts on their conservancies. Table 4.14 shows the responses on perceived causes of grazing conflicts on community and private conservancies:

Table 4.14:

Perception on causes of grazing conflicts

Causes of Conflicts		Conservancy Ngarendare	Ilngwesi	Nasuulu	Lewa	Total
Lack of Pasture	Count	11	8	3	5	27
	% within Conservancy	51.2%	40.6%	19.2%	40.0%	38.9%
Lack of Water	Count	0	6	3	3	12
	% within Conservancy	0.0%	29.4%	20.3%	28.0%	17.0%
Lack or Disregard to Grazing Plans	Count	6	3	6	4	19
	% within Conservancy	24.4%	15.1%	36.7%	32.0%	27.2%
Other causes	Count	5	3	4	0	12
	% within Conservancy	22.7%	14.9%	25%	0.0%	17.1%
	Count	22	20	16	12	
	% within Conservancy	100.0%	100.0%	100.0%	100.0%	100.0%

The study found that the major causes of conflicts in the four conservancies were lack of pasture as witnessed by 38.9% of the responses. This was followed by disregard to grazing plans at 27.2% while over 17% of the conflicts were caused by other factors that the respondents did not know or name. These factors could be like clan or tribal wars, moranisms or urge to restock in good pasture seasons. Lack of access to water in most times of the year was also cited as a cause of conflicts standing at 17%.

The results show that at Ilngwesi and Ngarendare forest, the biggest cause of grazing conflicts was lack of pasture. It also shows that Lewa and Ngarendate forest had fewer or no conflicts arising as a result of lack of water on the conservancies. However, Ilngwesi and Nasuulu have communities facing conflicts as a result of lack of water. The results show that lack or disregard to grazing plans was playing a suignificant role in what the communities percieved as causes of grazing conflicts. This was most prominent at Nasuulu and Ilngwesi conservancies. To find out whether there were comparable significant differences between conservancies, the responses were run on a chi-square test and the results were as shown in Table 4.15:

Table 4.15:
Perception on causes of grazing conflicts: Chi-Square Tests

	Value	df	Asymp. Sig. (2sided)
Pearson Chi-Square	53.270[a]	9	.000
Likelihood Ratio	67.763	9	.000
Linear-by-Linear Association	5.739	1	.017
No of Valid Cases	386		

a. 1 cells (6.2%) have expected count less than 5. The minimum expected count is 4.73.

The differences between the perceived causes of conflicts in the four conservancies were significant as can be seen in Table 4.15. This means that the causes of grazing conflicts observed by the respondents largely depended on characteristics of individual conservancy.

4.4.3 Perception on seasonality of grazing conflicts

The study sought to find out perceptions of communities on the periods of high ferequency occurence of grazing conflicts in their areas. The purpose of this question was to yeild results to correlate with the findings of other approaches in this study. Table 4.16 shows responses on percieved seasonality of grazing conflicts in the study area:

Table 4.16:

Perception on the seasonality of conflicts occurence

Conservancy		Periods when conflicts Occur			
		Dry Seasons	Wet Seasons	Any Time	Don't Know
Ngarendare Conservancy	Count	0	12	7	3
	% within Conservancy	0.0%	55.0%	30.0%	15.0%
Ilngwesi Conservancy	Count	4	8	4	4
	% within Conservancy	20.0%	40.0%	20.0%	20.0%
Nasuulu Conservancy	Count	1	3	12	0
	% within Conservancy	5.0%	15.0%	80.0%	0.0%
Lewa conservancy	Count	6	3	3	0
	% within Conservancy	50.0%	25.0%	25.0%	0.0%
Total	Count	9	26	26	10
	% within Conservancy	13.0%	37.1%	37.1%	9.8%

From the results, the majority of the respondents (37%) experienced grazing conflicts any time of the year. Similar number also experienced them during the wet seasons of the year. On further analysis of the responses per conservancy however, it was established that in Nasuulu the majority of grazing conflicts (80%) occurred any time of the year, while at Ngarendare and Ilngwesi it was established that they occurred in the wet-season. In Lewa, most conflicts occurred (50%) in dry seasons.

These responses were further analysed to ascertain whether there were significant differences on the seasonality of occurrences per conservancy. Table 4.17 shows the results of chi-square analysis:

Table 417:

Seasonality of grazing conflicts: Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	143.113[a]	12	.000
Likelihood Ratio	146.125	12	.000
Linear-by-Linear Association	.514	1	.474
N of Valid Cases	348		

a. 6 cells (30.0%) have expected count less than 5. The minimum expected count is .09.

The chi-square statistics shows that the periodic differences between seasons that conflicts occur in the four conservancies could differ significantly with P value < 0.05.

4.4.4 Likely conflicts resolutions strategies

The study sought to answer research question: "What coping methods are communities in Northern Kenya likely to engage in mitigating and resolving grazing conflicts". It was found out that communities had devised internal ways of dealing with grazing conflicts. Table 4.18 shows the commonest methods engaged by the communities:

Table 4.18:

Communities Coping with and resolving conflicts

Methods of coping with & Resolving Conflicts		Conservancy				Total
		Ngarendare	Ilngwesi	Nasuulu	Lewa	
Negotiation	Count	0	7	3	6	16
	% within Conservancy	0.0%	38.3%	19.2%	41%	23.3%
Fighting	Count	11	6	3	3	23
	% within Conservancy	51.2%	28.9%	20.3%	29.0%	33%
Arbitration	Count	5	3	6	0	14
	% within Conservancy	24.4%	13.4%	36.7%	0.0%	20%
Migration	Count	5	4	4	3	16
	% within Conservancy	24.4%	19.5%	23.7%	29.0%	23%
Total	Count	22	20	16	12	70
	% within Conservancy	100.0%	100.0%	100.0%	100.0%	100.0%

The results showed that most grazing conflicts were resolved through fighting on as indicated by 33%, while negotiations followed by 23.3% of respondents, next by arbitrations as indicated by 20.3%. Migration to other areas of the two counties was used as a method of resolving or avoiding conflicts as indicated by 23.3%.

The members of conservancies said that they did negotiate with invaders, sometimes sending chiefs to arbitrate and other times, ejecting unruly groups from within or outside their conservancy when fighting escalated. Elders were sometimes involved in negotiations as grazing committees and communities deliberated on the way forward.

During the group discussions, committees sometimes enforced grazing plans and by-laws by rationing the available pasture throughout the year and by creating grazing blocks within conservancies. As observed by Otinda (2017), some conservancies like

Ngarendare and Lewa had adopted technology and remote sensing to track grass and monitor livestock population changes (Rouse, Haas, Schell & Deering, 1973). These included spatial monitoring and research tools (SMART). However, methods of resolving conflicts were found to differ significantly from one conservancy to another, as shown in Table 4.19:

Table 4.19:
Coping with and resolving conflicts: Chi-Square Tests

	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	65.008[a]	9	.000
Likelihood Ratio	80.019	9	.000
Linear-by-Linear Association	.331	1	.565
N of Valid Cases	398		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.01.

The results showed statistics with p value <0.05. This meant that methods of resolving and coping with grazing conflicts were significantly different among the conservancies. The responses were further analysed to produce the results per conservancy as shown in the Figure 4.26:

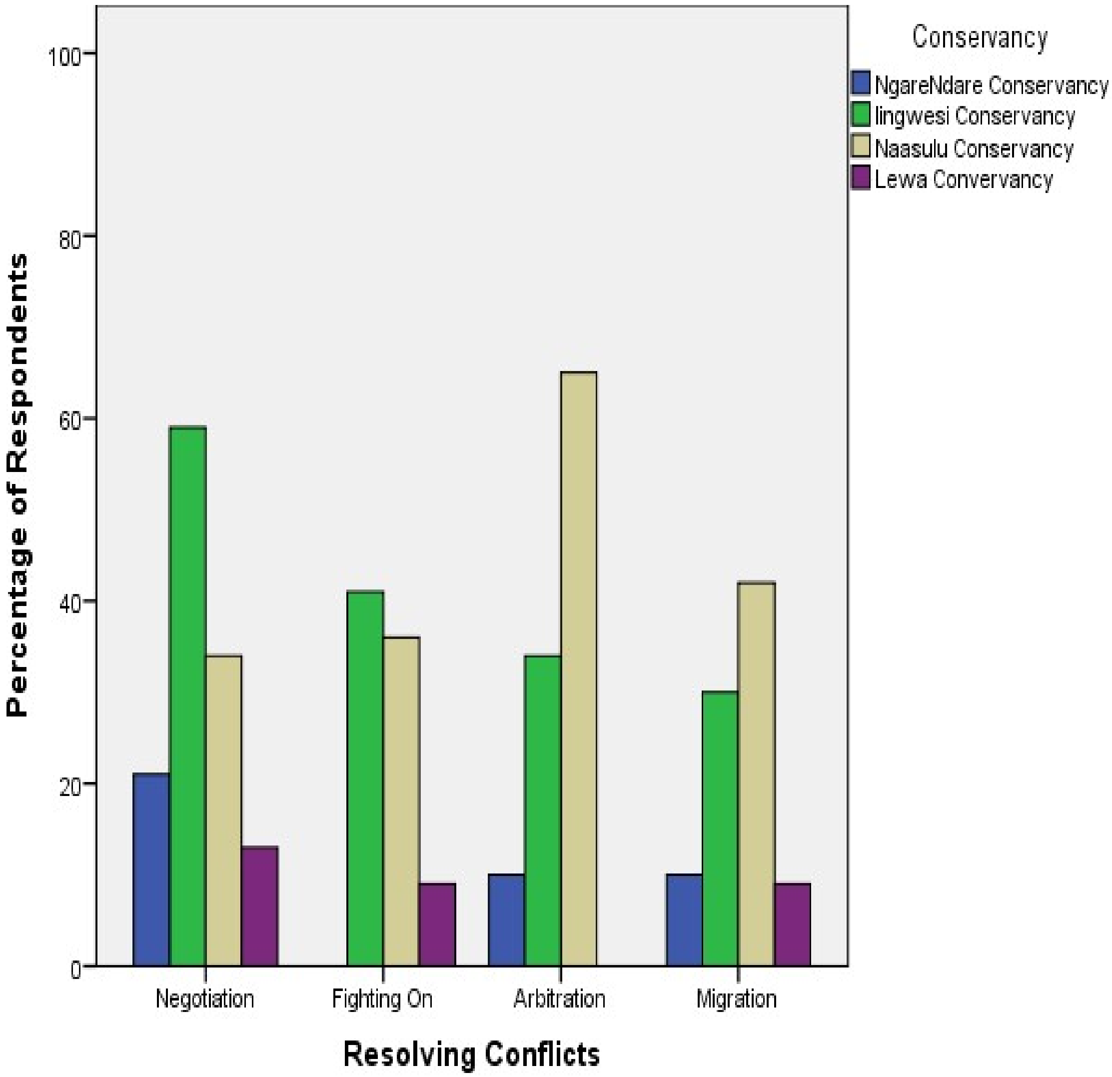


Figure 4.26**: Coping with and resolving conflicts per conservancy**

From the above results, arbitration was the most applied method of resolving conflicts, where the group discussions held that council of elders from both sides of the conflicting groups were engaged to resolve the conflict. At Ilngwesi, negotiation with the conflicting communities was the most common method of resolving, where the elders and the administration brought the conflicting sides together. At Nasuulu, arbitration was the most used method, while migration and fighting on with the invading grazers were the very last options of coping with grazing conflicts in all conservancies.

4.5 Developing Model for Predicting Grazing Conflicts in Northern Kenya

From the results of the various variables discussed above, this study was able to develop a conflict predicting model basing on binomial logistic regression (often referred to simply as logistic regression). The relationship between independent variables namely; precipitation, forage availability and utilization, access to water, livestock numbers, competition for resources, environmental externalities and the dependent variable which was probability of grazing conflicts, were analysed using Multiple Linear Regression. Multiple linear regression was used because it is a non-parametric regression analysis in which the predictors do not take a predetermined form but are constructed according to information derived from the data collected (Gravetter, & Wallnau, 2000).

Multiple Linear regression model was also used to determine the overall fit (variance explained) of the model and the relative contribution of each of the predictors to the total variance explained (Pallant, 2007; Manuel 2011). From existing literature and as applied in this study, Multiple Linear Regression equation took the following form:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \ldots\ldots\ldots\ldots\ldots + \varepsilon$$

In this study, there were five independent variables which were under investigations to predict the dependent variable (Y). These were:

Y = Probability of Grazing Conflicts in the Conservancies

β_0 = Constant variable

X_1 = Annual Precipitation

X_2 = Forage Availability and Utilization

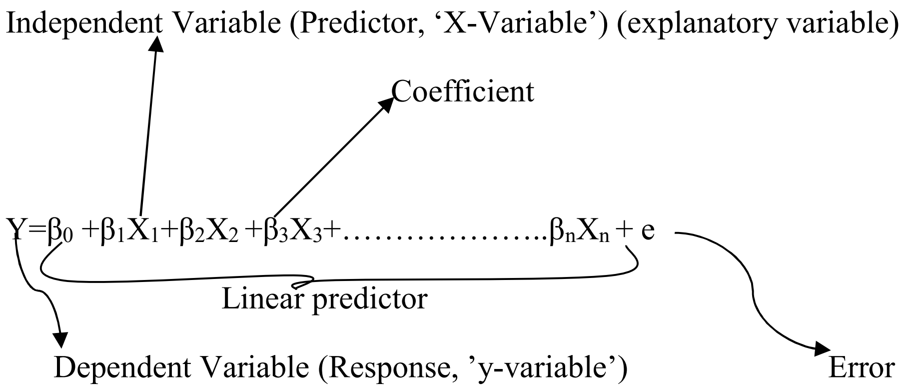
X_3 = Competition for Resources

X_4 = Livestock numbers

X_5 = Water Availability and Access

ε = Error term

The equation was further interpreted as follows:



(Adopted from Manuel, 2011).

4.5.1 Testing assumptions of the multiple regression model

In statistical analysis, all tests assume some certain characteristic about the data, also known as assumptions. Violation of these assumptions changes the conclusion of the research and interpretation of the results. These steps were taken to prove that the data used obeyed the expectations or assumptions of the research (Lani, 2018). Before undertaking multiple linear regressions, the data was subjected to checks of assumptions of normality, linearity, homoscedasticity, and absence of multicollinearity in order to make valid inferences.

4.5.2 Normality of the data

This was the first step taken to proof that the data complied with the requirements of normality. It aimed at checking the distribution of the variables and data which were utilized in the analysis. Many statistical methods assume that the distribution of scores on the dependent variable is normal, which means upon running the data it is expected that it will yield a symmetrical, bell-shaped curve histogram, which shows the greatest frequency of scores in the middle (smaller frequencies towards the extremes) (Gravetter & Wallnau, 2000). This assumption was checked by fitting a histogram to produce a normal curve and then subjected to Q-Q-also called Kolmogorov-Smirnof test, with the dependent variable being Incidences of grazing conflicts, and the results were as shown in Figure 4.27:

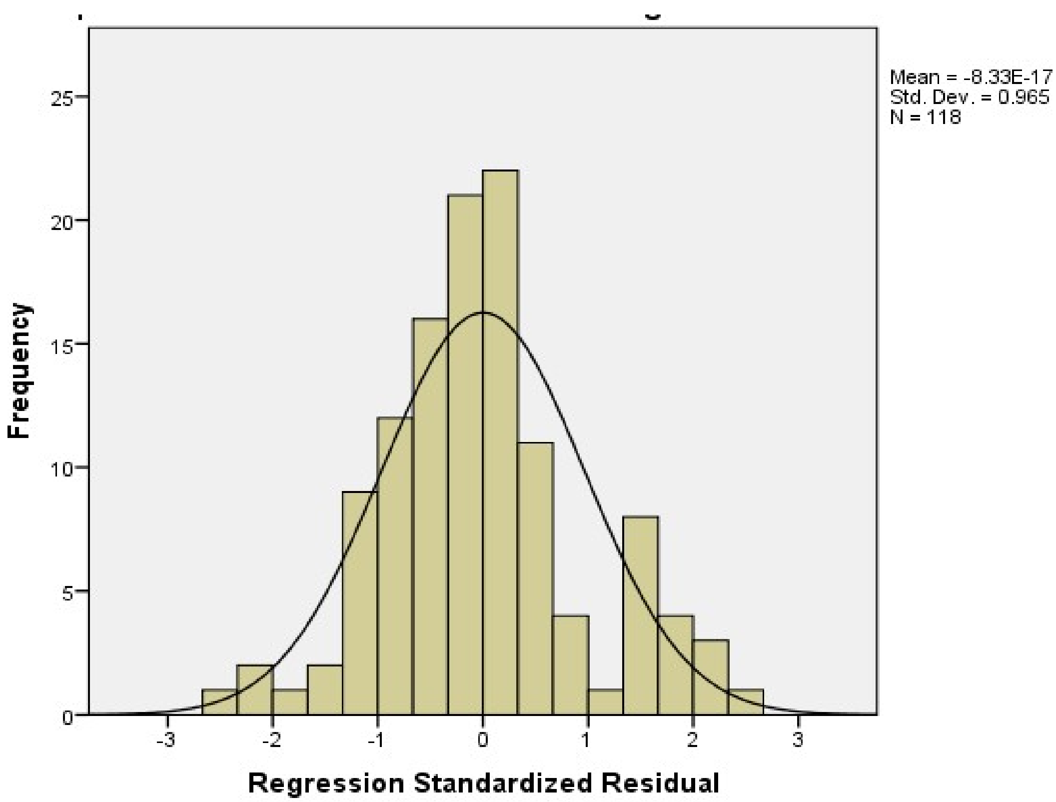


***Figure 4.27*: Normality test: Distribution of data**

A histogram or residuals of the data shown in Figure 4.27 shows that the result of the data produced a symmetrical, bell-shaped curve, which shows the greatest frequency of scores in the middle. This means that the assumption of normality of data was met, and the data was fit for subsequent analysis. A P.P plot was also used to test the normality curve as shown in the Figure 4.28:

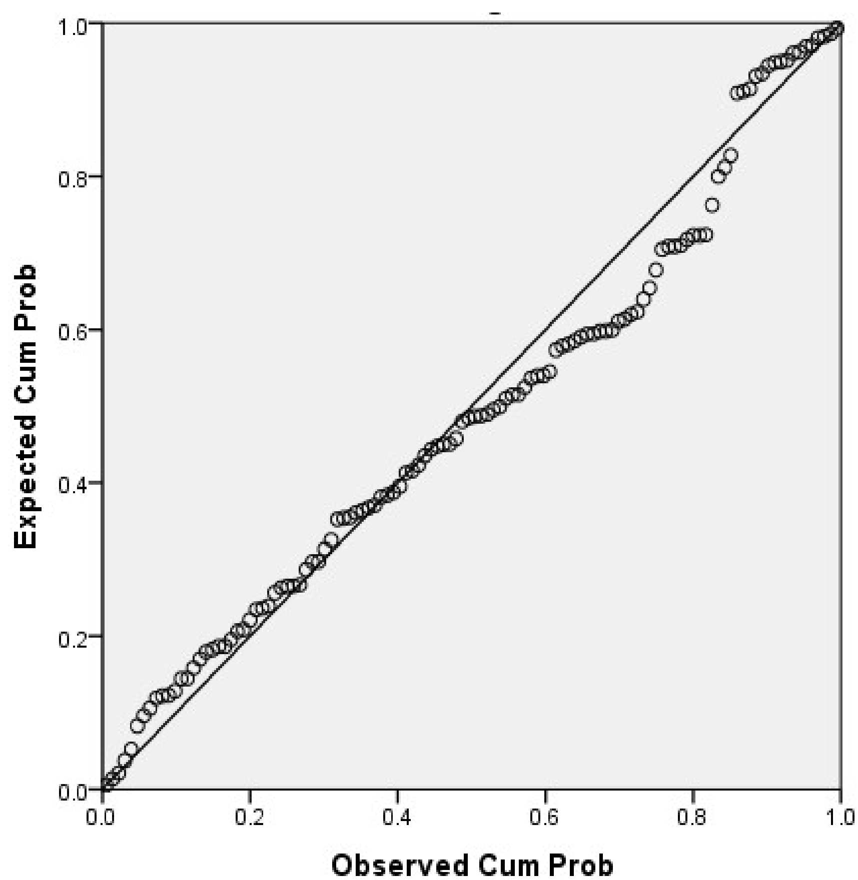


***Figure 4.28*: Normal standardized residual plot**

From Figure 4.28, it is observed that normality was met by the pattern of the scores with a goodness of fit test-line fitted in the middle of the data. Normality is achieved where there is most of the data falling near the fitness line which implies the data follows a normal distribution. The residuals are simply the error terms, or the differences between the observed value of the dependent variable and the predicted value (Kraemer, 2006).

4.5.3 Test of homoscedasticity assumptions

This test assumes that the variance of error terms are similar across the values of the independent variables. A plot of standardized residuals versus predicted values can show whether points are equally distributed across all values of the independent variables. The scatter diagram should not necessarily produce a clear pattern, but if there is a cone-shaped pattern, the data is heteroscedastic (Lani, 2018). Figure 4.29 shows the results of homoscedasticity test with dependent variable being incidences of grazing conflicts:

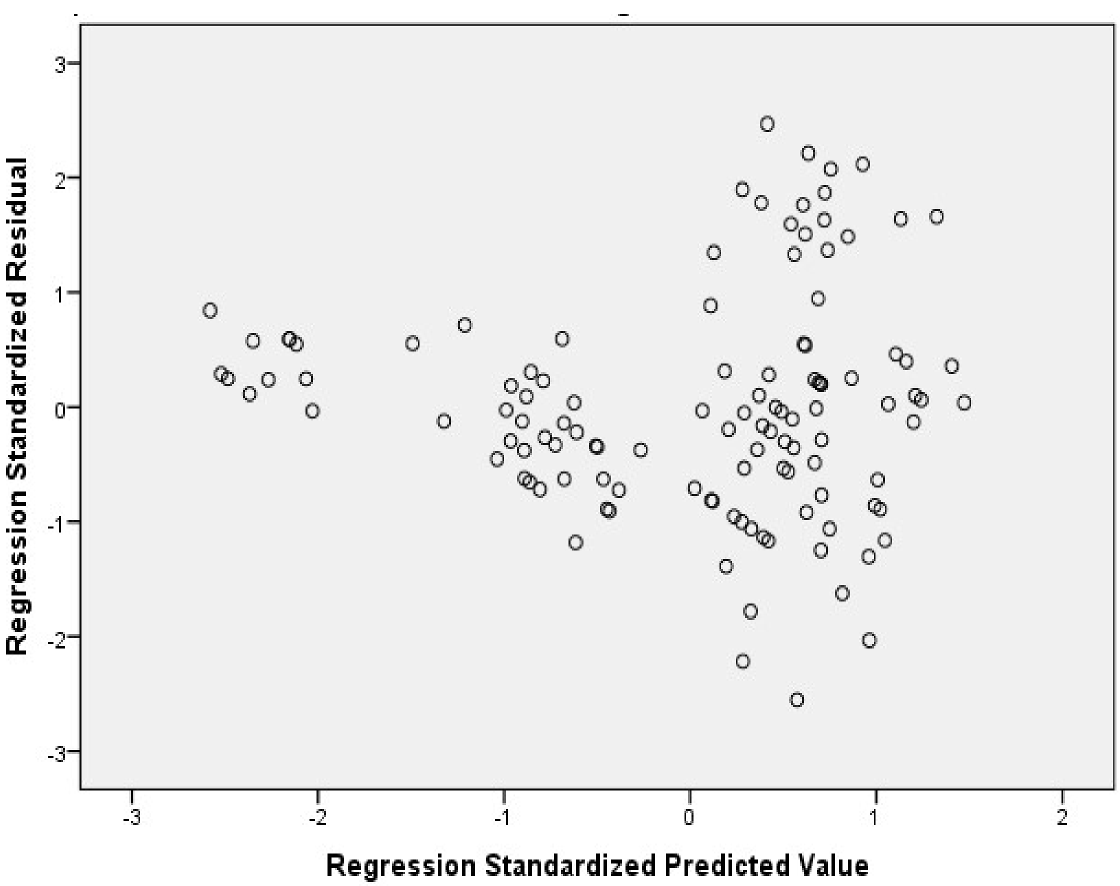


Figure 4.29: **Scatter Plot Incidences of grazing conflicts in the conservancies**

From figure 4.29, the results does not have an obvious pattern, there are points equally distributed above and below zero on the X axis, and to the left and right of zero on the Y axis. The data showed a narrow distribution on the left of the scatter, and a wide one on the right, producing a cone shaped pattern. Therefore, this shows that data used for multiple regression was well distributed above and below zero indicating no homoscedasticity, therefore the errors between observed and predicted values (i.e., the residuals of the regression) are normally distributed.

4.5.4 Test of multicollinearity of variables

Multicollinearity occurs when the independent variables are too highly correlated with each other (Lani, 2018). Multiple linear regression assumes that there is no multicollinearity in the data. This means that the independent variables are not highly correlated with each other. Where the independent variables are highly correlated, it can lead to skewed or misleading results when a researcher or analyst attempts to determine how well each independent variable can be used most effectively to predict or understand the dependent variable in a statistical model.

In general, multicollinearity can lead to wider confidence intervals and less reliable probability values (P values) for the independent variables. This assumption was tested using Pearson Correlation matrix and Variance Inflation Factor (VIF).

4.5.4 (a) Pearson correlation matrix

Pearson Correlation matrix assumes that the magnitude of correlation coefficient among all independent variables should not exceed 0.8. Table 4.20 shows the results of the Pearson's correlation matrix of the independent variables:

Table 4.20:
Pearson's correlation matrix of variables

Correlations

		GC	FO	RN	COM	WT	STC
GC	Pearson Correlation	1					
	Sig. (2-tailed)						
	N	226					
FO	Pearson Correlation	.000	1				
	Sig. (2-tailed)	.099					
	N	226	226				
RN	Pearson Correlation	.076	.077	1			
	Sig. (2-tailed)	.255	.250				
	N	226	226	226			
COM	Pearson Correlation	.076	.077	1.000**	1		
	Sig. (2-tailed)	.255	.250	.000			
	N	226	226	226	226		
WT	Pearson Correlation	-.317**	-.193**	-.293**	-.293**	1	
	Sig. (2-tailed)	.000	.004	.000	.000		
	N	224	224	224	224	224	
STC	Pearson Correlation	-.213**	.170*	.318**	.318**	.272**	1
	Sig. (2-tailed)	.001	.010	.000	.000	.000	
	N	226	226	226	226	224	226

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

From Table 4.20, it can be seen that the data set had no issues of multicollinearity as shown in correlation matrix. The correlation matrix indicated there were no significant linearly correlated combinations of variables (no value greater than 0.8). A correlation of 1.00 means that two variables are perfectly correlated; a correlation of 0.00 means there is absolutely no correlation. The cells in the matrix above, where the correlation is 1.00, shows the correlation of an independent variable with itself – we would expect a perfectly correlated relationship. What is most important are the numbers below 1.00 correlations. The first column shows dependent variable, "Incidences of Grazing Conflicts". Going down the column, row by row, it is noted that each of the independent variables was strongly correlated with the dependent variable, indicating that they were all strong predictors of grazing conflict. However it was noted that all of independent variables were not highly correlated with one another (Cortina, 1993).

4.5.4 (b)Variance inflation factor (VIF)

The VIFs of linear regression indicate the degree that the variances in the regression estimates are increased due to multicollinearity. VIF values higher than 10 indicate that multicollinearity exists. Table 4.21 shows the results of the Variance inflation factor of the variables:

Table 4.21:
Variance Inflation Factor

Model		Collinearity Statistics	
		Tolerance	VIF
1	(Constant)		
	Annual Precipitation	0.805	1.242
	Competition for Resources	0.809	1.236
	Forage Availability	0.969	1.032
	Livestock numbers	0.975	1.026
	Access to water	0.588	1.701
	Environmental Externalities	0.592	1.696
2	(Constant)		
	Annual Precipitation	0.761	1.315
	Competition for Resources	0.788	1.273
	Forage Availability	0.957	1.044
	Livestock numbers	0.919	1.088

Access to water	0.556	1.798
Environmental Externalities	0.563	1.775
Other Factors: politics	0.893	1.123
Other Factors: culture	0.861	1.162

The results showed that the values were below 10 for all the variables, indicating that the assumption was met. The deduction from the analysis was that the data met all assumptions expected for multiple regression which included normality, linearity, homoscedasticity, and absence of multicollinearity in order to make valid inferences from multiple regressions and could therefore be used to build the model.

4.5.5 Regression Model.

Regression analysis in this study was used in coming up with a model for predicting grazing conflicts in conservancies. The predictors or independent variables (precipitation, forage availability, access to water, livestock numbers and competition for resources) were regressed with the probabilities of grazing conflicts. The result of the analysis were presented in the model summary, analysis of variance tests, and summary of coefficients.

4.5.5 (a) Model Summary

Regression model which provided information about the regression line's ability to account for the total variation in the dependent variable was summarized. This demonstrates whether the observed y-values are highly dispersed around the regression line. Thus, a regression model 'explains' proportion of the dependent variable's total variation. If the regression line is not completely horizontal (i.e. if the b coefficient is different from 0), then some of the total variance is accounted for by the regression line.

This part of the variance is measured as the sum of squared differences between the respondents' predicted dependent variable values and the overall mean divided by the number of respondents.

In order to achieve a representative percentage of variances of the predictor variables that is fully manifested by the resultant regression equation, the figures of independent variable were divided by the total variance of dependent variables. The end results was a R square R^2 which lied between 0 and 1 (Hayes, 2019).

4.5.5(a) Univariate regression model and testing of hypothesis

Th predictors (independent variables) were regressed univariately against the dependent variable to provide information on the ability of the model to account for the effects of independent variable on the variations in the dependent variable. This variation was measured by R^2 (R Square), which varies between 0 and 100% or 0-1. R squared is coefficient of determination which indicates the variation in the dependent variable due to changes in a single independent variable (Mugenda & Mugenda, 2004). The model was presented as follows:

i) ***Effects of forage availability on grazing conflicts: Model Summary***

To check the effectiveness of the model on predicting how availability forage affects grazing conflicts, the variables were regressed against the dependent variable, and the results are as shown in Table 4.24:

Table 4.24 :

Forage availability: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.982[d]	.965	.946	3.99137

a. Predictors: (Constant), Forage Biomass

The forage model showed that the value of R^2 as 0.965, which meant that 96.5% of the total variance in grazing conflicts in conservancies could be accounted for by a change in forage availability.

One-way (univariate) Analysis of Variance (ANOVA) provided information about levels of variability within the regression model which formed the basis for hypothesis testing using P-value at 95.0% confidence interval (0.05). The P was used to decide whether forage availability had statistically significant predictive capability to influence grazing conflicts in conservancies and the results are as shown in Table 4.25:

Table 4.25:

Forage Availability ANOVA

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	33.564	1	33.564	78.107	.031[b]
	Residual	2007.311	126	15.931		
	Total	2040.875	127			

a. Dependent Variable: Grazing conflicts

b. Predictors: (Constant), Forage

The results in Table 4.25 showed that the effect of forage availability on grazing conflicts was significant, F(1,130)=78.107, p .031<.050). Therefore, the study rejected the null hypothesis and concluded that there was a significant relationship between forage availability and grazing conflicts.

The beta coefficient and t-test were examined which showed the degree of change in the dependent variable for every 1-unit of change in the predictor variable (Cortina, 1993). The findings are as shown in Table 4.26:

Table 4.26:

Forage Availability: Beta Coefficient

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
3	(Constant)	9.044	4.356		2.076	.041
	Forage availability	.676	.109	.729	3.699	.010

The study established that availability of forage biomass was significant at p value <0.05 holding all factors constant. Unit increase or decrease in forage led to an increase or decrease of conflicts by 73% (Beta = 0.729; t =3.699, p=0.010<.05). The study therefore rejected the null hypothesis and concluded that forage availability had a significant positive influence on grazing conflicts on Northern Kenya.

ii) Effects of competition for resources on grazing conflicts

Competition for grazing resources was regressed against the grazing conflicts to find out whether the model accounted for any variations in the dependent variable. The results were as shown in Table 4.27.

Table 4.27:

Competition for resources: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	.522[a]	.449	.042	3.91337

a. Predictors: (Constant), Competition

The findings in Table 4.27 shows the value of R^2 as 0.449, which meant that 45 % of the total variance in grazing conflicts could be accounted for by competition for resources.

ANOVA on competition factor provided information about levels of variability within the regression model which formed the basis for hypothesis testing. Table 4.28 shows the anova results of competition analysis against the dependent variable:

Table 4.28 :

Competition for resources: Anova

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	101.475	1	101.475	16.626	.041[b]
1	Residual	1960.248	128	15.314		
	Total	2061.723	129			

a. Dependent Variable: Grazing conflicts

b. Predictors: (Constant), Competition

Table 4.28 shows a one-way analysis of variance effects of competition on grazing conflicts was partially significant, F(1,130)=16.626, p .041>.050). Therefore the null hypothesis was rejected and study concluded that there was positive relationship between grazing conflicts and competition for grazing resources.

The beta coefficient and t-test was examined which is the degree of change in the outcome variable for every 1-unit of change in the competition for resources. The findings were as shown in Table 4.29:

Table: 4.29:

Competition for resources: Beta Coefficient

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
2	(Constant)	10.180	1.936		5.259	.00
	Competition	.066	.204	.012	.323	.77

The study established that competition for resources was not significant. Holding all factors to constant, a unit increase or decrease of competition for resources would lead to an increase or decrease of grazing conflicts by 1.2%. This shows that competition for resources had no major effects on the independent variable.

iii) Effects of Access to water on grazing conflicts

The study aimed to find out the effects of access to water on grazing conflicts, which provided information on its ability to account for the variation in the dependent variable. The findings were presented in Table 4.30.

Table 4.30:

Effect of access to water on grazing Conflicts

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	.699[a]	.489	.479	7.66463

a. Predictors: (Constant), Annual; Precipitation

From the findings, the value of R^2 is 0.489 which meant that 48.9% of the total variance in grazing conflicts in conservancies could be accounted for by change of availability and access to water.

ANOVA on access to water provided information about levels of variability within the regression model which formed the basis of hypothesis testing. The results were as shown in the Table 4.31:

Table 4.31:

Access to water: ANOVA

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	666.007	1	666.007	70.12	.040[b]
	Residual	1395.716	128	10.904		
	Total	2061.723	129			

a. Dependent Variable: Grazing conflicts

b. Predictors: (Constant), Access to water

The Anova showed that the effect of distances to water on grazing conflicts was significant, $F(1,130)=70.12$, p $.040<.050$). Therefore the study rejected the null hypothesis and concluded that there was a significant relationship between availability and access to water and grazing conflicts.

The beta coefficient and t-test were also examined to show the degree of change in the dependent variable for every unit of change of the predictor variable (independent). The findings were as shown in Table 4.32:

Table 4.32:

Access to water: Beta Coefficient

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.517	3.096		3.074	.023
	Distance to water	.587	.162	.800	4.800	.025

The study established that the distance to water were significant at p value <0.05 holding all factors to constant zero, unit increase or decrease in distance would lead to an increase or decrease of conflicts by 80%. Therefore this means that effects of access to water on grazing conflicts is highly significant.

iv) Effects of stocking rate on grazing conflicts

Univariate regression was ran on the effects of stocking (livestock numbers) on grazing conflicts and the results were as shown in table 4.33:

Table 4.33:

Effects of stocking rates: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of
1	.448[a]	.201	.159	4.70016

a. Predictors: (Constant), Stock Rate

The results show the value of R^2 as 0.201, which means that 20.1% of the total variance in grazing conflicts in conservancies could be attributed to changes in stock rate.

ANOVA on effects of stocking rates provided information about levels of variability within the model which formed the basis for hypothesis testing using P-value at 95.0% confidence interval. The results were as shown on Table 4.34:

Table 4.34 :

Stocking rates: ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	1155.305	11	105.028	24.754	.025[b]
1	Residual	4595.040	208	22.092		
	Total	5750.345	219			

a. Dependent Variable: Grazing Conflicts

b. Predictors: (Constant), stock rate

A one-way analysis of variance showed that the effect of stocking rate on grazing conflicts was significant, $F(1,130)=24.754$, p .025<.050). Therefore, the study rejected the null hypothesis and concluded that there was a significant relationship between stocking rate and grazing conflicts.

The beta coefficient and t-test were examined to show degree of change in the outcome variable for every 1-unit change in the predictor variable. The results are as shown in Table 4.35:

Table 4.35:

Stocking Rate: Beta coefficient

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T
		B	Std. Error	Beta	
1	(Constant)	18.865	2.495		7.561
	Stock rate	.282	.523	.559	.0540

The study found that stocking rates varied the grazing conflicts significantly, with all factors to constant zero, a unit increase or decrease in stock rate led to an increase or decrease of conflicts by 56% (Beta = 0.559; t =3.699, p=0.054).

v) Effect of Annual Precipitation on Grazing Conflicts: Model Summary

Univariate regression on the effects of precipitation on grazing conflicts were analysed and the results were as shown on tables 4.36.

Table 4.36:
Effects of precipitation on grazing conflicts

Model	R	R Square	Adjusted R Square	Std. Error of the
1	.919[a]	.844	.829	1.66463

a. Predictors: (Constant), Annual; Precipitation

The findings showed R^2 as 0.844, which means that 88.4 % of the total variance in grazing conflicts in conservancies could be accounted for by change in annual precipitation.

Analysis of Variance (ANOVA) provided information about levels of variability within the regression model which formed the basis for hypothesis testing using P value at 95.0% confidence interval (0.05). The P -was used to decide whether the annual precipitation had statistically significant predictive capability to influence grazing conflicts in conservancies at 95.0% confidence interval. The results are as shown on Table 4.37:

Table 4.37:

Precipitation ANOVA

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	666.007	1	666.007	61.079	.010[b]
1	Residual	1395.716	128	10.904		
	Total	2061.723	129			

a. Dependent Variable: Grazing conflicts
b. Predictors: (Constant), Precipitation

One-way analysis of variance showed that the effect of precipitation on conflicts was significant, $F(1,130)=61.079$, p .010<.050). The study therefore rejected the null hypothesis and concluded that there was a positive relationship between precipitation and grazing conflicts in the area. The beta coefficient and t-test were examined which showed the degree of change in the outcome variable for every 1-unit of change in the predictor variable. The findings are as shown in Table 4.38:

Table 4.38:
Precipitation: Beta Coefficient

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.517	3.096		3.074	.023
	Precipitation	.487	.162	.727	2.538	.022

The study established that precipitation was significant at p value <0.05 holding all factors to zero, a unit increase or decrease precipitation led to an increase or decrease of conflicts by 73% (Beta = 0.727; t =2.538, p=0.022 <.05). This meant that precipitation could predict 73% of the grazing conflicts in the area.

vi) Effect of other factors on Grazing Conflicts

Table 4.39 shows prediction model for the overall effects of other factors on the occurrence of grazing conflicts in the study area:

Table 4.39:

Effects of other factors on Grazing Conflicts

Model Summary

Model	R	R^2	Adjusted R Square	Std. Error of
1	.492	.242	.229	1.66463

a. Predictors: (Constant), other factors

The findings showed the value of R^2 as 0.242, which meant that 24% of the total variance in grazing conflicts in conservancies could be accounted for by change in other factors. These factors included local politics, tribalism, cultural practices like moranism, cattle rustling and other crimes. ANOVA provided information about levels of variability within the regression model and the results were as shown in Table 4.40.

Table 4.40:

Other Factors: ANOVA

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	666.007	1	666.007	70.00	.040[b]
1	Residual	1395.716	128	10.904		
	Total	2061.723	129			

a. Dependent Variable: Grazing conflicts

b. Predictors: (Constant), Other factors

A one-way analysis of variance showed that the effects of other factors on conflicts was significant, $F(1,130)=70.00$, p $.040<.050$). This showed that there was a positive relationship between other factors and grazing conflicts.

The beta coefficient and t-test were examined and the results are as shown in Table 4.41.

Table 4.41:

Other factors: Beta Coefficient

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.517	3.096		3.074	.023
	Precipitations	.487	.162	.727	2.538	.022

The study established that the other factors were significant and that holding all factors to constant zero, a unit increase or decrease in Other Factors would lead to an increase or decrease of grazing conflicts by 73%. This showed the model fitted well for predicting the effects of other factors on grazing conflicts in the study area. Therefore, in univariate analysis taking a model of shape $Y=X_1+e$, gave a better meaning of how individual variable predicted grazing conflicts.

4.5.5 (b) Multivariate analysis of variables

Table 4.42 shows the model summary of multivariate results when the variables are analysed together:

Table 4.42:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	.348[a]	.121	.105	4.85199

a. Predictors: (Constant), STC(Stocking rate), FO(Forage), COM(Competition), WT(Water access)

From Table 4.22, if the R-Square value is 0.121, then it means there is a perfect fit, whereas R-Square value 0 indicates that there is no relationship between Independent Variable (IV) & he Dependent Variable (DV).

From Table 4.22, if the R-Square value is 0.121 it meant there was a relationship and the model fitted the summary, whereas R-Square value 0 indicated that there is no relationship between Independent Variable (IV) & the Dependent Variable (DV).

From the results of multivariate analysis with results of R^2 being 0.121, the model shows that a total of 12.1% of variance in grazing conflicts in the area are accounted for by the model. However, some effects of the independent variables are generally compressed under the multivariate analysis, meaning that the predictors could show very little effect on the predicted variable. Overall, it still showed the model provided a good fit in predicting grazing conflicts in the conservancies. The results of the Analysis of Variance (Anova) output were shown in the Table 4.43:

Table 4.43:

ANOVA[a]

Model		Sum of Squares	Df	Mean Square	F	Sig.
	Regression	708.322	4	177.080	7.522	.000[b]
1	Residual	5155.660	219	23.542		
	Total	5863.982	223			

a. Dependent Variable: GC(Grazing Conflicts)

b. Predictors: (Constant), STC(Stocking rate), FO(Forage), COM (Competition), WT(Water access)

From Table 4.43 output is the F-test. The linear regression's F-test has the null hypothesis that the model explains zero variance in the dependent variable (in other words $R^2 = 0$). The F-test is highly significant, thus indicating that the model explains a significant amount of the variance in the dependent variable.

From the ANOVA, the overall p-value was equal to .000 which was less than 0.05. The results indicated that the overall regression model was found to be valid and significant in predicting grazing conflicts at 95% confidence level. Summarizing the model and ANOVA shows that a significant regression equation was found where $F(4, 219) = 7.522$, $p < .001$), with an R^2 of .000. This means that the independent variables under investigation (Forage, Water availability, Stocking rate and Competition for resources) were good predictors of grazing conflicts, indicating a model of shape $Y= \beta_0 -\beta_1X_1 + \beta_2X_2 -\beta_3X_{3-} \beta_3X_3 +e$

From the above results, therefore, it was possible to express the significance levels of the variables to the grazing conflicts resulting from the multivariate analysis as shown in Figure 4.30:

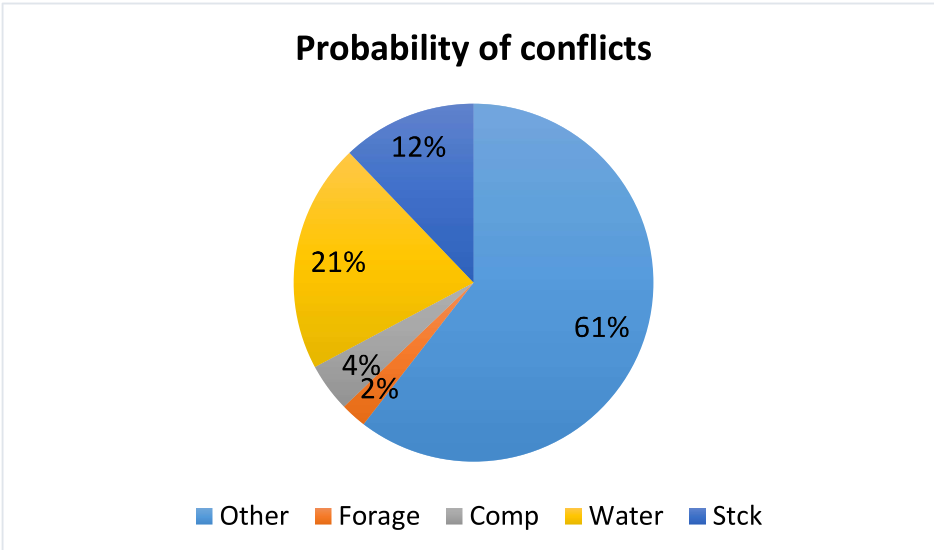


Figure 4.30**: Significance of variables to conflicts predicting model.**

From Figure 4.30, it can be seen that other factors had bigger weight in causing conflicts. This calls for further research to find out roles played by cultural practices, believes and politics. Other hidden causes may be responsible for a bigger chunk of causal agents, like moranism, cattle rustling for wealth creation and tribal conflicts retaliations.

4.5.5 (c) Testing of Hypothesis: Beta Coefficients

Beta Coefficient gives the size of the effect that a predicting variable is having on the dependent variable, and the sign on the coefficient (positive or negative) gives the direction of the effect. In regression with a single independent variable, the coefficient tells how much the dependent variable is expected to increase (if the coefficient is positive) or decrease (if the coefficient is negative) when that independent variable increases by one. Table 4.24 shows the effect of the dependent variables on the independent variable:

Table 4.24:

The Beta Coefficients of independent variables

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	13.081	1.282		10.204	.000
	FO	-.163	.416	-.026	-.391	.696
	COM	.286	.385	.055	.741	.459
	WT	-1.080	.308	-.263	-3.507	.001
	STC	-.738	.359	-.155	-2.053	.041

a. Dependent Variable: GC(Grazing Conflicts); FO(Forage);COM (Competition); WT(Water access); STC(Stocking rate)

Results of the multiple linear regression indicated that constant factors had collective significant effects of (F (13.08, 1.28) = 10.438, $p < .05$), with an R^2 of .000 in the model for predicting grazing conflicts. This meant that other factors not considered in this study had very significant influence on the dependent variable.

When individual predictors were examined mutivariate, it was found that forage availability had (Beta = -0.026; t = -3.91, p = .696). In this case, the study failed to reject the null hypothesis and concluded that forage availability had no significant influence on grazing conflicts. Competition for resources, which had a Beta coefficient of = 0.055; t = 0.741 p = .459), seems insignificant in influencing grazing conflicts.

Water availability (Beta = -0.263; t = -3.507, p = .001) was found to influence grazing conflicts significantly. Here, the study rejected the null hypothesis, and concluded that water availability and access had a positive influence on grazing conflicts in the area. Same case applied to livestock numbers (stocking rate), which was found to be significant (Beta = 0.155; t = -2.053, p = .041).

This results showed that biggest influencers of grazing conflicts were water availability at a significant level of 0.001 and stocking rate at 0.041. In both cases the study rejected the null hypothesis meaning that there existed strong relationship between the two variables and the independent variable. Rainfall became insignificant when regressed among other predictors. This meant that although in the analysis it seemed insignificant, it influenced the overall effects of all other predictors. The study therefore fails to reject the null hypothesis and concludes that there is no significant difference between rainfall and grazing conflicts.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Here, the conclusions on the study and recommendations for further study are presented. The conclusions and recommendations are arranged as per the objectives of the study.

5.1.1 Summary of findings

From the results shown in the previous sections, it was apparent that community conservancies had far less available forage both in the dry and wet seasons. Results found that forage had positive influence on grazing conflicts. This was the same case with water access, precipitation, stocking rates and other factors not considered in this study. It was also clear that in the study area, water availability was very low while communities had very few options for water access. The private conservancies were better managed, with resources well allocated therefore experiencing minimal competition between stocks. Most environmental externalities observed during the transect walks could be associated with stocking rates. Degradation was increasing on the group ranches and community conservancies which was as a result of high stocking rates on the conservancies. Therefore, the study concluded that most of the grazing conflicts experienced were as a result of search for pasture, water and other grazing resources. When analysed multivariate, stocking rates and access to water were found to be significantly contributing to variations of grazing conflicts while rainfall patterns was found to have little influence on grazing conflicts when analysed multivariate, although theoretically, all grazing resources depended on it.

5.1.2 Evaluation of seasonality of pasture resources for livestock in the study area.

From the findings, the limited resources scenario meant that more stock scrambled for dwindling pasture and water resources therefore causing competition which lead to grazing conflicts and other environmental externalities. The big stock was migrating away immediately after the short rains, leaving sheep and goats to browse longer on the ground liter and perennial shrubs. This study therefore contributes to theory in espousing which and how grazing resources, environmental and human factors contribute to grazing conflicts in Kenya.

5.1.3 Seasonal pasture resources and occurrence of grazing conflicts

Basing on the responses, it was clear that the months of June to October were the hardest periods of grazing in the study area. The rainfall patterns for the previous twenty five years showed a declining trend, while the vegetation indices supported the conclusion that the area was depressed most of the seasons as far as forage availability was concerned. The study concluded that there was a relationship between pasture occurrence and grazing conflicts. Therefore, the predictive model developed had the effects of rainfall/precipitation and levels of ground cover/forage as the integral parts of what triggered livestock movements and the resultant grazing conflicts in Northern Kenya. This study will be beneficial to grazers and other decision makers in the sector when it comes to planning grazing based on seasonal pasture occurrence to avoid conflicts in the area.

5.1.4 Predictive model for grazing conflicts in Northern Kenya.

From the findings and the results of the analyzed data, the study was able to come up with a new model to predict grazing conflicts in Northern Kenya. From the model, the results showed that forage and water access, stocking rates and precipitation were strong predictors of grazing conflicts in Northern Kenya communities.

This study is among the first ones in Kenya, to apply grazing resources to come with a conflicts predicting model in the pastoral world. It adds to the body of knowledge in the field of conflicts predictions and their resolutions.

5.1.5 Predicting community coping methods under limited resource supply regimes

From the findings, it was clear that the community conservancies faced conflicts due to lack of or strained availability of pasture and other grazing resources. Overstocking was generally accepted as the main cause of pasture scarcity which made the communities to venture as far as possible outside their counties looking for pasture and water. The communities were likely to trespass to and invade other neighboring conservancies or communities by those who were migrating to search for pasture.

It also concludes that acquisition and implementation of grazing plans were likely methods to be engaged into assisting the communities to plan and utilize their pasture. Indigenous lay knowledge supported that historically, the communities were able to use negotiation as a means of seeking lasting solutions. However, this approach needed to be structured to include other stakeholders, government institutions and other assistance providers.

The livestock off-take programme being implemented by the NRT and the Government were seen as the best ways of assisting the communities during hard times of drought. However, it had not worked as expected for the benefit of households and the environment, owing to cultural-economic factors. While the NRT and Government offer a slightly higher price for the stock in order to boost their livelihood during the drought season, cultural factors conspired against this gesture, where morans got more stock at cheaper prices or through raids from far conservancies, hence ending up increasing the stocking rates in their conservancies.

5.2 Recommendations

In this section, the researcher recommends approaches that can lead to mitigation of grazing conflicts in Northern Kenya. Therefore, there is recommendation for further studies, management actions, policy change and social economic approaches.

5.2.1 Recommendations for further studies

This study recommends that further study be done on the browse forage provided by trees and shrubs in the study area. Further research on more resilient, fast growing and more grazable grass, browsable herbs, shrubs and trees is recommended. It is also recommended that a study be undertaken to ascertain the percentage of the hard fibrous matter seen on the ground and how livestock utilize them.

The study recommends further research on underlying social-political issues enhancing grazing conflicts in the study area. A study should be carried out to predict mortality of livestock and wildlife as a result of grazing conflicts. There should be further research on the effects of fencing and wildlife/livestock coexistence in the study area.

The study recommends further research on competition for pasture and water resources between different species of livestock and wildlife in order to advise the grazers, stakeholders and policy developers on stocking under limited resources. In every further studies undertaken, there should be flow-back of research findings to inform future policy, interventions, modifications or models developed in the field of grazing conflicts and their resolutions

5.2.2 Recommendation for social economic support

The community could benefit from sand dams which the county governments of Laikipia and Isiolo could provide to ease access to water and reduce grazing conflicts. Lewa has already installed a number of dams, an initiative that could be replicated to community conservancies. The study also recommends the expansion of the women and youth enterprise support programmes currently under donors and Government agencies to reach as many households as possible to stabilize them financially in order to stem migrations and increase incomes. More boreholes need to be surveyed and drilled at Nasuulu and Ilngwesi. Communities through their conservancies should diversify their source of livelihood by adopting alternative occupations rather than overdependence on grazing.

5.2.3 Management approaches

The study observed that although some private conservancies had grass sharing programmes with the surrounding pastoralists, they still kept high accumulation of grass biomass which was a huge risk for dry season fires. Therefore, more aggressive utilization including selling of the grass biomass to other communities is highly recommended. The study also recommends cutting and carrying excess grass to be stored in nearby homesteads, to form forage stock for dry seasons, thus helping the conservancies alleviate dry season fires.

5.2.4 Policy and administrative approaches

From the results, the study recommends the use of local administration in negotiation processes to make them more inclusive and authentic and results or agreements enforceable. It also recommends a diversification of economic activities in the study area, where Government and other stakeholders can support water programmes like dams and small scale irrigation. More livestock off-take programmes need to be entrenched as a policy of the national and county governments. The study also recommends that capacity building on the people of the two counties be enhanced to understand how their land is getting lost overtime to degradation as a result of over grazing.

REFERENCES

Abdile, A., (2017). Ethnic Contest and Electoral Violence in Northern Kenya. International Crisis Group. https://www.crisisgroup.org/africa/horn-africa/kenya/ethnic-contest-and-electoral-violence-Northern-kenya

Adan, M. & R. Pkalya (2006). The Concept Peace Committee. A Snapshot Analysis of the Concept Peace Committee in Relation to Peacebuilding Initiatives in Kenya., PracticalAction. Retrieved from :http://unpan1.un.org/intradoc/groups/public/documents/UN/UNPAN032127.pdf

Aksnes, D. L. & Egge, J. K., (1991). A theoretical model for nutrient uptake in phytoplankton.

Andrés, J.P & Diego. P., (2009). Environmental externalities and efficiency measurement. Journal of Environmental Management. Vol. 90, Issue 11, August 2009, Pages 3332- 3339. Retrieved from https://www.sciencedirect.com/science/article/pii/S0301479709001650

Ashley, C., & Carney.D., (1999); Sustainable livelihood: Lessons from early experience. London: Department for international Development. 55PP.

Ashish, M., (2012). Ecological Study Sampling Techniques In Field Ecology Quadrat, Pitfall, &Transect At Murti & Gorumara. Retrieved from http://caluniv.academia.edu/AshishMondal

Ayana, A., & Adugna, T., (2006). The effects of physical environment on the condition of rangelands in Borana. In: Tropical Grasslands., Vol 40 (1):33-39.March 2006.

Babbie, E.R., (2008) . The Basics of Social Research Fourth. (4th) Edition. Paperback. Retrieved from: https://www.amazon.com/Earl-R-Babbie-Basics-Research/dp/B004HM6X9O

Babbie, E.R., (1992). *The Practice of Social Research.* Retrieved from https://books.google.co.ke/books/about/The_practice_of_social_research.html?id=CBG2AAAAIAAJ&redir_esc=y. 01-02-2018

Barzilai, G., (2003). Communities and Law: Politics and Cultures of Legal Identities. Ann Arbor: University of Michigan Press

Beesom, S.L., & Haucke, H., (1975). A comparison of four distance sampling techniques in South Texas live oak mottes. *Journal of Range Management* 28:142-144.

Begon, M., Townsed TR., Harper JL., (2006). *Ecology: From Individual to Ecosystems. University of Liverpool*. Blackwell Publishing Ltd.

Berger, D J., (1993). Wildlife Extension: Participatory Conservation by the Maasai of Kenya. Nairobi: African Centre for Technology Studies (ACTS).

Berryman, A., (1997). *"Intraspecific Competition"*. Retrieved from classes. entom.wsu.edu. *Retrieved 11-11-2016.*

Berliner, D., Kioko, J., (2000). The effect of long-term mowing and ungulate exclusion on grass species composition and soil nutrient status on the Athi-Kapiti plains, central Kenya. *Journal of Range Forage Science*, 16(2–3): 62–70. Retrieved from *www.oalib.com/paper/3154670*

Botha, J O., (1999). A resource management plan for the Lewa Wildlife Conservancy in the Meru District of the central highlands of Kenya. MSc. Thesis: University of Pretoria. South Africa.

Bond, J., & Mkuttu. K., (2017). Behind the conflict in central Kenya that's costing lives and hitting tourism**.** Retrieved from**:** http://theconversation.com/behind-the-conflict-in-central-kenya-thats-costing-lives-and-hitting-tourism-72423

Bonham, C.D., (1989). *Measurements for terrestrial vegetation*. John Wiley Sons, New York. Pp.159-164.

Bonneau, P., (2013). Drought and Internal Displacements of Pastoralists in Northern Kenya in 2012: An Assessment. Retrieved from: http://labos.ulg.ac.be/hugo/wp-content/uploads/sites/38/2017/11/The-State-of-Environmental-Migration-2013-101-116.pdf

Brännström, A. & Sumpter, D.J.T., (2005). *"The role of competition and clustering in population dynamics"* (PDF). Proceedings of the Royal Society of London B: Biological Sciences, 275:2065-2072.

Bransby, D. & Tainton, N. M., (1977). *The disc pasture meter: possible implication in grazing management*. Proceedings of Grassland Society of South Africa, 12: 115–118.

Breman, H., (2016). *Maximum carrying capacity of Malian grasslands.* Retrieved from http://www.fao.org/library/library-home/en/.

Brian, E. G., (2005). A General Model of Natural Resource Conflicts: the Case of International Freshwater Disputes. Keene State College in New Hampshire, USA. Retrieved from: https://www.sav.sk/journals/uploads/02061008Green.pdf

Briske, D.D. & Richards,.J.H., (1995). Plant responses to defoliation: a physiological, morphological and demographic evaluation. In: Bedunah, D.J. & R.E. Sosebee.Wildland plants: physiological ecology and developmental morphology. Society for Range Management, Denver, Colorado. p. 635-710

Brown, V.A., Smith D.I., Handmer J., Wiseman .R., (1995). Risks and opportunities: managing environmental conflict and change / https://www.bing.com/search?q=risks+and+opportunities+%3A+managing+environmental+conflict+and+change&form=EDGEAR&qs=PF&cvid=0e12352e801b4e18abd2d8a26ef9cb43&cc=US&setlang=en-US

Bryman, A. & Cramer, D., (2005). *Quantitative Data Analysis with SPSS 12 and 13: A Guide for Social Scientists*. Routledge 27 Church Road, Hove, East Sussex, BN3 2FA.

Burnsilver, S., Mwangi, E., (2007). Beyond group ranch subdivision: collective action for Livestock mobility, ecological viability, and livelihoods. Washington DC: International Food Policy Research Institute.

Butler, C. K., & Gates, S. (2012). African range wars: Climate, conflict, and property rights. *Journal of Peace Research*, 49(1), 23-34. Retrieved from *jpr.sagepub.com/content/49/1/23.abstrac.* November 2016.

Campbell, D., Gichohi H, Mwangi A, *et al*. (2000). *Land use conflict in Kajiado District, Kenya*. Land use Policy, 17: 337–348.

Caroline, W., (2017, April 10th). Kenyan herders flout trespassing law as conflict over grazing heats up. Thomson Reuters Foundation. Retrieved from https://af.reuters.com/article/topNews/idAFKBN17C0QN-OZATP

Chandraskhan, D., (1997). Proceedings: Electronic Conference Addressing natural resource Conflicts through community Forestry. Jan-May 1996 Rome. FAO, Forestry Department. Forests, Trees and People Programme. Community Forestry Unit, Conflicts Management Series. Pp195

Chebet, C., (2013, Dec, 28th). Overgrazing and climate Change fuel wetlands depletion. Standard Digital. Retrieved from; https://www.standadrdmedia.co.ke/article/2001264330/overgrazing-and-climate-change-fuel-wetlands-depletion

Chirichella, R., & Apollonio. M., & Rory P., (2014). Competition between domestic and wild ungulates. ResearchGate: https://www.researchgate.net/publication/286373611_Competition_between_domestic_and_wild_Ungulates accessed 13-08-2018

Clark, C. W., (1973). The Economics of Overexploitation. Science 181, p. 630-634.

Clarke, K. C. (1986). Recent trends in Geographic Information System research

GeoProcessing, vol. 3, no. 1, pp. 1-16.

Cottam, G., & Curtis. J.T., (1956). The use of distance measure in phytosociological sampling. *Ecology* 37:451-460.

Colwell, R. K., Chao, A., Gotelli, N. J., Lin, S.-Y., Mao, C. X., Chazdon, R. L. , & Longino J. T., (2012). Models and estimators linking individual-based and sample-based rarefaction, extrapolation, and comparison of assemblages. *Journal of Plant Ecology* **5**:3-21.

Cornelia, H., & Elisabeth H., (2014). Pastoralism and conflict – two sides of a coin? Journal of Rural21. November 2014 ISBN / Resource ID: Rural21-Vol:48-Nr:4/2014-Article:5https://www.togev.de/fileadmin/gfx/Presse/Artikel_Publikationen/rural21 Pastoral_conflict_c.heine-2014.pdf

Cortina, B., (1993*). "Coefficients Alpha, Beta, Omega, and the glb: Comments on Sijtsma". Psychometrika. **74** (1): 145–154. doi:10.1007/s11336-008-9102-z.*

Craig, J., (2017, Feb, 17th). Drought Blamed for Conflict in Kenya From Illegal Grazing. In VOA. https://www.voanews.com/a/drought-blamed-for-conflict-in-kenya-from-illegal-grazing/3725769.html Accessed 12-08-2018

Creswell, J.W; Plano-Clark, (2007). Designing and Conducting Mixed Method Research. Vol.2 2nd Ed.

Cronbach, L., (1951). Coefficient alpha and the internal structure of tests. Psychometrika, 22(3) 297-33s

Dabelko, G. D., (1996). The Environment and Conflict in the Third World: Examining Linkage, Context and Policy. Occasional Paper No. 12. Harrison Program on the Future Global Agenda.

David, A. D., (2012): Introduction to Predictive Modeling with Examples. Statistics and Data Analysis. Paper 337-2012, N. Carolina State U., Raleigh, NC 1.

Davidson, D. J., (1999). Implementing the Endangered Species Act on Private Land in the Coastal Redwoods: A Political-Sociological Analysis of Environmental Bureaucracies. Madison, University of Wisconsin.

Davis, M.A., Grime, J.P., Thompson, K. (2000). Fluctuating resources in plant communities: a general theory of invasibility. Journal of Ecology 88, 528–534.

DenBerg, V., Rossing, W., & Grasman, J. (2006). "Contest and Scramble Competition and the Carry-Over Effect in Globodera spp. In Potato-Based Crop Rotations Using an Extended Ricker Model". Journal of Nematology, 38(2):210-220.

De Sherbinin, A., (2003).Frontiers in the Application of Sub-National Data in PDE Research. Prepared for 2003 Open Meeting of the Human Dimensions of Global Environmental Change Research Community Montreal, Canada 16-18 October

2003. Retrieved from http://sedac.ciesin.columbia.edu/openmtg/docs/desherbinin.pdf

Droop, M. R., (1970). Vitamin B12 and marine ecology: *Marine Ecology Progress Series*, 20:629–636.doi:10.1007/BF01609935.. *ink.springer.com/article/10.1007/BF01609935.*

Droop, M. R., (1973). Some thoughts on nutrient limitation in algae. *Journal of Phycology*.

Ducobu.H., Huisman.J., Jonker. R.R., Mur. L.R., (1998). Competition between phytoclorophite and Cyanobacterium under various phosphorous regimes. Coparison with Droop Model. J.Phyco 34: 467-476 Retrieved from: https://books.google.co.ke/books

Ericksen, P.J., Said, M.Y., Leeuw, J. de, Silvestri, S., Zaibet, L., Kifugo, S.C., Sijmons, K., Kinoti, J., Ng'ang'a, L., Landsberg, F. and Stickler, M. (2011). Mapping and valuing ecosystem services in the Ewaso Ng'iro Watershed. Nairobi, Kenya: ILRI.

Ericksen, S., Aldunce, P., Bahinipati, S.C.,D'almeida M .R., Molefe, J.I., Nhemachena, C., (2011). When not every response to climate change is a good one: Identifying principles for sustainable adaptation. *Journal of Climate and Development*, Vol. 3, Issue 1, 2011.

Evgeni, M. F., Michael J., McDonald, J., David Van Dyken., Katya. K., Gregory. I. L, & Michael M. D., (2015). Crowded growth leads to the spontaneous evolution of semi stable coexistence in laboratory yeast populations. *PNAS 2015 112 (36) 11306-11311.*

FAO., (1990). Section 1. Module 6. Range Resource Evaluation. http://www.fao.org/Wairdocs/ILRI/x5469E/x5469e09.htm

Fahey, G.C,Jr. Collins. M., Mertens, D.R., & Moser. L.E., (1994). Forage Quality, Evaluation, and Utilization. Based on the National Conference on Forage Quality, Evaluation, and Utilization held at the University of Nebraska, Lincoln, on 13-15 April 1994. Retrieved from: https://dl.sciencesocieties.org/publications/books/pdfs/acsesspublicati/foragequalityev/frontmatter?noSSO=1&t=6

Foley, B., (2018).Purposive Sampling 101. Retrieved from: https://www.surveygizmo.com/resources/blog/purposive-sampling-101/Sampling 10

Francis, E.O., Wasonga O., Schilling. J., Mureithi. S.M., (2012). Resource –based conflicts in drought-prone Northwest Kenya: The drivers, and mitigation mechanism. Wudpecker Journal of Agricultultural Research. Vol.1 (II).PP 442-453. Dec 2012

Frost, R.*,(2019)* Carrying Capacity and Stocking Rate. Global Range. https://globalrangelands.org/topics/uses-range-and-pasture-lands/carrying-capacity-and-stocking-rate. *Montana State University. Accessed 12-08-2018*

Galt, D., Molinar F, Navarro J, Joseph. J., & Holecheck. J., (2000). Grazing capacity and stocking rate. Rangelands, 22(6): 7–11.

Gandhi, G.M., S. Parthiban., N. Thumulu., A. Christy., (2015) NDVI: Vegetation Change Detection Using Remote Sensing and GIS- A case study of Vallore District. Procedia Computer Science. Vol. 5. Pp.1199-1210

Gathenya, J., Bwisa, H., & Kihoro, J., (2011). Interaction between women entrepreneurs' age and education on business dynamics in small and medium enterprises in Kenya. International Journal of Business and Social Science, 2(5).

Georgiadis, N., & Cooper, R., (2007). Development of a Forest Certification Standard Compatible with PEFC and FSC's Management Requirements. A Case Study from Greece. Forestry, 80, 113-135. http://dx.doi.org/10.1093/forestry/cpm004

GisGeography (2018). How to create NDVI Maps in ArchGis. https://gisgeography.com/how-to-ndvi-maps.arcgis. accessed July 2018

Gleeson, P., (2018). Five Approaches to Conflict Resolution. Retrieved from: https://smallbusiness.chron.com/five-approaches-conflict-resolution-21360.html

GoK, (2008). Kenya Vision 2030. Retrieved from: https://vision2030.go.ke/about-vision-2030/

Græger, N., (1996). Environmental Security? Journal of Peace Research 33(1), p. 109-116

Graham, O., (1989). A land divided: The impact of ranching on a pastoral society. The Ecologist, 19 (5): 184–185.

Gravetter, F.J. & Wallnau, L.B., (2000). Statistics for the Behavioural Sciences. West Publishing Company. # 5th ed.

Hair, J.F., & Ephanet, J., (2006). Assessment of Reliability. In: Psychometric Theory (2nd ed.). New York: McGraw-Hill.

Havstad, K.M., Debra, P.C, Brown, J.R., Skaggs, R.,(2007). Ecological services to and from rangelands of the United States. Retrieved from:

https://www.researchgate.net/publication/222814728_Ecological_services_to_and_from_rangelands_of_the_United_States

Henderson, P.A., (2012). Ecological Methods. Pisces Conservation Ltd, Hampshire, England DOI:10.1002/9780470015902.a0003271.pub2.Retrievedfrom http://www.els.net/WileyCDA/ElsArticle/refId-a0003271.html

Herlocker, D.J., (1992). Survey Method for Classification of Range Condition.(Range Monitoring Series No.1).In: Shaaban. B & Dierk.W (edt). Range management Handbook of Kenya Vol III .7. Ministry of Livestock Development. Range Management Division. Nairobi. Kenya.

Herlocker, D. J., H.J. Dirschil, & G. Frame., (1993). Grasslands of East Africa. In 'Natural Ecosystems: eastern hemisphere and resume. Ecosystems of the World. 8B'9Ed.R.TCoupland) (Elsevier: Amsterdam).

Heying, (2004). Scramble Competition. Retrieved from: https://en.wikipedia.org/wiki/Scramble_competition

Hickman, K. R., D. C. Hartnett, R. C. Cochran, C. E. Owensby., (2004). Grazing management effects on plant species diversity in tall grass prairie. Journal of Range Management 57:58- 65.

Holechek, J. L., R. D. Pieper, and C. H. Herbel., (2001). Range Management Principles And Practices. 4th Ed. Upper Saddle River, Nj, Usa: Prentice Hall. 587 P.

Holme, A. McR., Burnside, D.G. and Mitchell, A.A., (1987). The development of a system for monitoring trend in range condition in the arid shrublands of Western Australia. Australian Rangeland Journal 9:14-20. Cross Ref.

Homer-Dixon, T. F., (1994). Environmental Scarcities and Violent Conflict: Evidence from Cases. International Security 19(1), p. 5-40.

Homer-Dixon, T. F., (1991). On the Threshold: Environmental Changes as Causes of Acute Conflict. International Security 16(2), p. 76-116.

Houreld, K., (2017). Drought stokes battle for pastures in Kenya's Northern regions. Thomson Reuters. https://reliefweb.int/report/kenya/drought-stokes-battle-pastures-kenyas-Northern-regions Accessed 13-08-2018.

IRIN., (December, 18th, 2009). KENYA: "What drives conflicts in Northern Kenya". *The Inside Story*. (IRIN News). https://www.globalsecurity.org/military/library/news/2009/12/mil-091218-irin01.htm.

IRIN., (September 13th, 2011). Movements of livestock in search of water and pasture. KENYA: What's new on the drought. (IRIN News). Accessed 26-11-2018.

https://desertification.wordpress.com/2011/09/13/dropught-conflicts-over-resources-and-movements-of-livestock-in-search-of-water-and-pasture-irin-news/

IISD, CDC & Saferworld. (2009). *Climate change and conflict: Lessons from community conservancies in Northern Kenya.* Retrieved from*: https://www.iisd.org/library/climate-change-and-conflict-lessons-community-conservancies-northern-kenya*

Inbody, R.D., (2003). *The Livestock Early Warning System (LEWS): Blending technology and the human dimension to support grazing decisions. ARIDLANDS Newsletter, No 53.*

Jatzold, R.,(1995). Climatology of Northern and North East Kenya. In Range Management Handbook of Kenya Vol.11. Ministry of Livestock and Marketing.

Juma, F., (2015). Pastoralists Map Grazing Lands for Survival and Security in Northern Kenya. Reliefweb. https://reliefweb.int/report/kenya/pastoralists-map-grazing-lands-survival-and-security-Northern-kenya Accessed 12-08-2018.

Karla, A. H., (2017). Evaluation of forage production in South Dakota. Retrieved from: https://www.thepublicopinion.com/news/farming/evaluation-of-forage-production-in-south-dakota/article_57966926-6e0d-11e7-9a53-83686d1f5924.html

Kaye-Zwiebel, E., & E. King. (2014). Kenyan pastoralist societies in transition: Varying perceptions of the value of ecosystem services. Ecology and Society: 19 (3). 17.

Kihara, M.P., (2017). Influence of strategy implementation on the performance of manufacturing small and medium firms in Kenya. Retrieved from: https://scholar.google.com/citations

Kimiti K.S., (2016). Rangeland resource dynamics and their implications for pastoral livelihoods in Amboseli ecosystem, Kenya. http://erepository.uonbi.ac.ke:8080/handle/11295/24532 UoN

KNBS., (2009). Kenya National Population Census. GOK

KNBS,(2009). Economic Survery 2009. Retrieved from: https://www.knbs.or.ke/download/economic-survey-2009-3/

Kgomotso. H.M., (2005). Documenting indigenous knowledge systems in Africa: prospects and challenges. African Journals Online. *ESARBICA Journal* Vol. 24 2005: 63-73. Retrieved from: https://www.ajol.info/index.php/esarjo/article/view/30996

Kraemer, H. C., (2006). Correlation coefficients in medical research: from product moment correlation to the odds ratio. Statistical Methods in Medical Research, 15: 525–545

Kristie, M., & Lori.H., (2018). Sustainable Rangelands Ecosystem Goods and Services.. Consortium for Science, Policy, and Outcomes, Arizona State University . Retrieved from: http://sustainable.rangelands.org/pdf/Ecosystem_Goods_Services.pdf

Lani, J.,(2018). Assumptions of Multiple Linear Regression. Retrieved from https://www.statisticssolutions.com/assumptions-of-multiple-linear-regression/.

Lalampaa, P.K., Wasonga O.V., Njoka.J., Rubenstein.D., (2016).). Effects of holistic grazing management on milk production, weight gain, and visitation to grazing areas by livestock and wildlife in Laikipia County, Kenya. ResearchGate.

Laws of Kenya, (2012). Land (Group Representative) Act Cap 287.Rev 2012.National Council for Law Reporting. Retrieved from: https://www.kenyalaws.org

Le Heoroeu & Hoste, (1977). "Rangeland Production and Annual Rainfall Relations in the Mediterranean Basin and in the African Sahelo-Sudanian Zone". In: Journal of Range Management. 30 (3). May 1977.

Lezberg, S., (1988). Political ecology and resource management: An examination of response to soil erosion in Machakos District, Kenya. M.A. thesis, Clark University, Worcester, MA.

Luis, F.M., Celaya, R.R., Benavides, R., Juaregui, B.M., Garcia, U., & Sofia, A., Garcia, R.R., Rodrigues, M. A., Osoro, K., (2013). "Foraging behaviour of domestic herbivore species grazing on heathlands associated with improved pasture areas''. Livestock Science, vol.155 (2013) 373–383. doi:10.1016/j.livsci.2013.05.007.

Lovel .A., ,(2012). Six steps for calculating pasture carrying capacity. In Grainnews. Cattleman's corner https://www.grainews.ca/2012/06/05/six-steps-for-calculating-pasture-carrying-capacity/ Accessed 12-08-2018

MacArthur, R.H., (1972). Geographical Ecology: Patterns in the Distribution of Species. Harper & Row, New York, NY. 269pp.

Maleko, D.D., & Koipapi. M.L., (2015). Opportunities and constraints for overcoming dry season livestock feed shortages in communal semi-arid rangelands of Northern Tanzania: A case of Longido District. Department of Animal Science and Production, Sokoine University of Agriculture. Retrieved from: *http://www.lrrd.org/lrrd27/4/male27070.html*

Manley,W.A., R. H. Hart, M. J. Samuel, M. A. Smith, J. W. Waggoner, Jr. and J. T., (1997). Vegetation, Cattle, and Economic Responses to Grazing Strategies and

Pressures. Society of Range Management. *Journal of Range Management*. Vol. 50, No. 6 (Nov., 1997), pp. 638-64.

Manuel, R.P., (2011). A new theory in multiple linear regression. Retrieved From: https://www.researchgate.net/publication/279181297_A_new_theory_in_multiple_linear_regression

Matara, E., (2017). *Competition for political power fuelling ranch invasions; In: The Daily Nation. Tuesday, February, 2017. Retrieved from: https://www.nation.co.ke/counties/laikipia/competition-political-power-fuelling-ranch-invasions-laikipia/1183290-3804092-eyai8z/index.html*

McConnell, R.L & C.A. Daniel., (2002). Environmental Issues. Measuring, Analyzing and Evaluating Carrying Capacity. In '*Sustainable Scale Project'. Retrived from:* www.worldcat.org/title/environmental-issues-measuring-analyzing.../47044847.

Mganga, K.Z., N.K. Musimba., M.Nyariki., M. Nyangito., &W. Mwangombe., (2013).The Choice of Grass Species to combat desertification in semi-arid Kenyan Rangelands. Grass Forage Science

Mica, E., P.S.Wesley, N. Silva-Send & A.M. Boudrias, (2017). The Role of Social Influences on Pro-Environment Behaviors in the San Diego Region. The New York Academy of Medicine 2017. Published online: 6 March 2017 #. Retrieved from:https://www.psychologytoday.com/sites/default/files/juh_estrada_2017.pdf.

Michelle, D., (2014). Working paper: Grazing and cross-border conflict between the two Sudans. Retrieved from http://www.thebrokeronline.eu/News/Working-paper-Grazing-and-cross-border-conflict-between-the-two-Sudans2

Mkutu, K., and Marani, M.,(2001, June). "The role of civic leaders in the mitigation of cattle-rustling and small arms: The case of Laikipia and Samburu", (African Peace Forum: Nairobi, 2001). Retrieved from: https://www.saferworld.org.uk/downloadfile.php?filepath=downloads/pubdocs/WebLaikipia.pdf

Moisen, G.G., Tracey S., & Frescino. T.S., (2002). Comparing five modelling techniques for predicting forest characteristics: Ecological Modelling 157 (2002) 209 /225. https://www.fs.fed.us/rm/pubs_other/rmrs_2002_moisen_g001.pdf

Montana State University, (1993). Range and Pasture Records: Determining Carrying Capacity and Stocking Rates for Range and Pasture in North Dakota (R1810). Retrieved from www.ag.ndsu.edu/pubs/ansci/range/r1810.pdf.

Mouldi, G., (2014). Grazing intensity effect on the vegetation in desert rangelands of Southern Tunisia. *Journal of Arid Lands* Vol. 6, Issue 3,pp 324-333

Morgan, R. P C., (1995). Soil Erosion and Conservation, 2nd ed. Essex: Longman Group.

MoyaLarano, J., El-Sayyid, T., &Fox, C. (2007).“Smaller beetles are better scramble competitors at cooler temperatures”. Biol Lett. 22; 3(5): 475-478. Noor Ali, (2017, March 19th).

Mugenda, O.,& Mugenda. A., (2003). Research Methods-Quantitative and Qualitative Approaches. Nairobi. ACT Press

Mulinge. W., Gicheru.P.,Muriithi. F., Maingi. P., Kihiu. E., Kirui., Mirzabaev.A., (2015) Economics of Land Degradation and Improvement in Kenya. Retrived from: https://link.springer.com/chapter/10.1007/978-3-319-19168-3_16

Murray, M., & Brow.,D.,(1993). Niche Separation of Grazing Ungulates in the Serengeti: An Experimental Test. In Jopuirnal of Animal Ecology. Retrieved from: https://www.researchgate.net/publication/272553621_Niche_Separation_of_Grazing_Ungulates_in_the_Serengeti_An_Experimental_Test

Natalie, W., (2018). What Is a Drought? *In LiveScience*. Accessed September 28, 2018 06:06pm

National Drought Mitigation Centre (NDMC): *Grazing Pressure & Stocking Rate*. University of Nebrasca at Lincoln. Accessed 07-11-2016.

Ng'ethe, J. C.,(1993). Group ranch concept and practice in Kenya with special emphasis on Kajiado District. University of Nairobi. http//www.fao.org/Wairdocs/ILRI/x5485E/x5485e0t.htm. Accessed 12-08-2018

Njagi,. D., (2016). Conservatio News. Retrieved from: https://news.mongabay.com/by/david-njagi/

Noor, A., (2017, March 19th). “Kenya Clashes Over Grazing Leaves 10 Dead in Drought-Hit North”. USNEWS. Retrieved from https://www.usnews.com/news/world/articles/2017-03-19/kenya-clashes-over-grazing-leaves-10-dead-in-drought-hit-North.

Northern Rangelands Trust (NRT), (2006). Community Conservancies: Formation, staffing and their operations.

O’Connor, D.A., Bilal. B., & Joahannes B.F., (2015). Foraging ecologies of giraffe (*Giraffa camelopardalis reticulata*) and camels (*Camelus dromedarius*) in Northern Kenya: effects of habitat structure and possibilities for competition? Retrieved from: https://onlinelibrary.wiley.com/doi/full/10.1111/aje.12204

Odongo, W., (2016). "*Hotter, Dreir than Usual Weather Comimg"*. In: Daily Nation Aug, 18, 2016. https://www.nation.co.ke/news/Hotter-drier-than-usual-weather-coming/1056-3348562-d4a798z/index.html

Ogutu, J., Hans-Peter, P., Said, M.Y., Ojwang, G.O., Njino W.L., 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): e0163249. https://doi.org/10.1371/journal.pone.0163249

Ojwang, G.O., Wargute. P.W., Said. M.Y., Worden. J.S., Zeke. D., Muruthi. P., Kanga. E., Ihwagi. F.,& Okita-Ouma. B., (2017). Wildlife Migratory Corridors and Dispersal Areas: Kenya Rangelands and Coastal Terrestrial Ecosystems

Okinda, B., (2018). Experts Bet on Technology to Tackle Hunger. In: Daily Nation. Jan 18, 2018. Retrieved from: https://www.pressreader.com/kenya/daily-nation-kenya/20180126/281771334618920.

Okumu W., (2014). A Delicate Balance. Conflict over Ltungai Conservancy: A Case of Fatal Competition over Grazing Land and Water among the Samburu and Pokot in North-western Kenya.

Onyango, M.C., (2011). Estimation of the carrying capacity and stocking rate of cattle and sheep in Konza, Kenya: a systems analysis approach. UoN http://erepository.uonbi.ac.ke:8080/handle/11295/24532.

Opiyo, E.O., Wasonga. V.O., Schilling J., & Mureithi. M., (2012). Resource-based conflicts in drought-prone Northwestern Kenya: The drivers and mitigation. Wudpecker Journal of Agricultural Research Vol. 1(11), pp. 442 - 453, December 2012 Available online at http://www.wudpeckerresearchjournals.org

Osvaldo, E. S., Laura K. H., & Martin. R.A., (2017). Rangelands Ecosystem Services: Nature's Supply and Humans' Demand. Retrieved from https://link.springer.com/chapter/10.1007/978-3-319-46709-2_14

Otinda., B., (2017). Pastoralists Turn to Apps to find Grazing Fields. Daily Nation. Retrieved from https://www.nation.co.ke/health/pastoralists-turn-to-apps

Otieno, R., (2018, June, 19th). Rapid desertification in Kenya threatening livelihood. Standard Digital. Retrieved from: http://www.standardmedia.co.ke/lifestyle/article/2000086318/rapid-desertification-desertification-in-kenya-threatening-livelihood

Oudtshoorn, F. V., (1992). Guide to Grasses of South Africa. Pretoria: Briza Publications.

Overseas Development Institute (ODI)., (2009). Pastoralists Vulnerability in the Horn of Africa: Exploring Political marginalization, donors' policies and cross-border issue. Lit. Rev.

Pallant, J., (2007). SPSS Survival Manual 3rd Edition. New York, NY: McGraw Hill Open University Press.

Peter, A.V., & Mark.W., (2002). Predicting Plant species response to grazing. *Journal of Applied Ecology*. British Ecological Society.

Pkalya, R, Adan.M, Masinde. I., (2003). Conflict in Northern Kenya: A focus on the internally displaced conflict victims in Northern Kenya. *Retrieved from: https://practicalaction.org/conflict-in-Northern-kenya*

Pratt, M., & Rasmusen A.G., (2001). Calculating Available Forage. Range Management Fact Sheet. Utah State University Extension. Electronic Publishing. Retrieved from: http://www.wyoextension.org/werawater/region8/PDFs/range3.pdf

Pratt, D.J. & M.D. Gwinne (1977). *Rangelands management and ecology in east Africa*. London: Hodder & Stoughton, 310pp

Price, D., (1998). Of Population and False Hope: Malthus and His Legacy. Population and Environment: A Journal of Interdisciplinary Studies 19(3), p. 205-19.

Rambaldi, G., (2010). Participatory Three-dimensional Modelling: Guiding Principles and Applications, 2010 edition CTA, Wageningen, The Netherlands.

Ravitch, S.M., and Riggan, M., (2012). Reason & rigor: How Conceptual Frameworks Guide Research. London: Sage

Robertson, P.M., Craig I. P., Martin H. Villet M.H., & Ripley. B.S (2003), Comparing models for predicting species' potential distributions: a case study using correlative and mechanistic predictive modelling techniques, *Ecological Modelling*, 10.1016/S0304-3800(03)00028-0, **164**, 2-3, (153-167), (2003).

Rouse, J. W., R. H. Haas, J. A. Schell, and D. W. Deering (1973). Monitoring vegetation systems in the Great Plains with ERTS, Third ERTS Symposium, NASA SP-351 I, 309- 317. Cross Ref.

Rutagwenda, .T., & Wanyoike. M.,(1994). Seasonal changes in livestock diets in a semi-arid environment in Northern Kenya. Department of Animal Production, Faculty of Veterinary Medicine, University of Nairobi, Kenya. Retrieved from: http://www.fao.org/wairdocs/ilri/x5519b/x5519b09.htm

Sala, O.E., Yahdijan.L., Havstard. K., Aguar. M.R.,(2017). Rangeland Ecosystem Services: Nature's Supply and Human's Demand. Retrieved from: https://link.springer.com/chapter/10.1007/978-3-319-46709_14

Savory, A.,(2015). What is Holistic Planned Grazing. https://www.savory.global/wp-content/uploads/2017/02/about-holistic-planned-grazing.pdf

Schnaiber, A., & Gould, K., (1994). Environment and Society: The Enduring Conflict. https://www.researchgate.net/publication/239970499_Environment_and_Society_The_Enduring_Conflict

Schnaiberg , A., & Gould , K.A., (2000) *Environment and society: The enduring conflict*.

West Caldwell, NJ, USA: Blackburn Press.

Schneider & Cooper, (2003). Business Research Methods (7th ed.)

Schindler, D. W., (1998). "Replication versus Realism: The Need for Ecosystem-Scale Experiments". *Ecosystems*. **1** (4):323–334. doi:10.1007/s100219900026. JSTOR 3658915

Seleman, I. S., (2014). Communal rangelands management and challenges underpinning pastoral mobility in Tanzania: a review. Department of Animal Science and Production, Sokoine University of Agriculture

Sharov, A., (1997). "*11.1 Intra-specific Competition*". ma.utexas.edu. Retrieved 08th Nov 2016, Stuth, J., Angerer, Kaitho J., Zander, K., Jama, A., Heath, C., Bucher, J., Hamilton, W., Conner,

Skarpe, C. (1992). Dynamics of Savanna Ecosystems. *Journal of Vegetation Science* 3(3): 293–300.

Smith, W.B., P.D. Miles, J.S. Vissage, & S.A. Pugh (2004). Forest resources of the United States, 2002. USDA Forest Service. http://ncrs.fs.fed.us/pubs/gtr/gtr_nc241.pdf

Sterner, W., & elser. J.J., (2002). Ecological Stoichiometry: The Biology of Elements from Molecules to Biosphere. Forward by Vitousek P. Princeton University Press. Retrieved from https://press.princeton.edu/titles/7434.html

Taylor, R. L., (2015). Battle of the Kenyan Herbivores: Resource Competition between Native and Domesticated Animals. Retrieved from: https://nature.berkeley.edu/classes/es196/projects/2015final/TaylorR_2015.pdf

Trainer, T., (1998). Our Unsustainable Society: Basic Causes, Interconnections, and Solutions. In Dobkowski, M. N., & Wallimann, I. The Coming Age of Scarcity:

Preventing Mass Death and Genocide in the Twenty-First Century. Syracuse, New York, Syracuse University Press. p. 83-100

The Research Advisors, (2006). The required Sample Size: Sample size table. Retrieved from http://research-advisors.com/tools/SampleSize.htm.

Thurow, T. L., & Herlocker, D.J. (1993). Range Management Handbook of Kenya, Volume III, 5. Users Guide for the Range Management. Ministry of Agriculture, Livestock development and Marketing, Range Management Division/ Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), Nairobi.

Thurow, T. L., (1991). Hydrology and erosion. Pages 141–150 in Grazing Management: An Ecological Perspective. R. K. Heitschmidt and J. W. Stuth, ed. Timber Press, Portland, OR.

Thomson Reuters Foundation, (2006). Kenya: Clashes over water, pasture kill 40 in east Africa. Accessed 27-09-2018. https://reliefweb.int/report/kenya/kenya-clashes-over-water-pasture-kill-40-east-africa

Tilman, D., (1990). Mechanisms of plant competition for nutrients: the elements of a Predictive Theory of competition. In: Grace, J.B., Tilman, D. (Eds.), Perspectives on Plant Competition. Academic Press, San Diego, CA, 484pp.

Tilman, D., (1982). Resource Competition and Community Structure. Princeton University Press, Princeton, NJ, 296pp.

Trollope, W., (1990). Development of a technique for assessing veld` condition in the Kruger National Park using key grass species. Journal of Grassland Society of South Africa, 7(1): 46–51.

Trollope, W., &Trollope, A., (1999). Report of assessment of range condition and the fire of the savanna vegetation on the LEWA Downs Wildlife Conservancy, Kenya-1998. Alice: University of Fort Hare.

Tong, W., Richard. T., & Seong C.P., (2016). Evaluation of Continuous and Multipaddock Grazing on Vegetation and Livestock Performance—a Modeling Approach. Rangeland Ecology & Management. Volume 69, Issue 6, November 2016, Pages 457-464. https://doi.org/10.1016/j.rama.2016.07.003. https://www.sciencedirect.com/science/article/pii/S1550742416300495

University of Idaho, (2009). Direct Measures of Biomass. In: Principles of Vegetation Measurement & Assessment and Ecological Monitoring & Analysis. Accessed 02-01-2019 https://www.webpages.uidaho.edu/veg_measure/Modules/Lessons/Module%207(Biomass&Utilization)/7_3_Direct%20Methods.htm

USDA , (1996). Prescribed Grazing: Practice Introduction. Natural Resources Conservation Service – practice code 528. Accessed Nov 2016.

USDA , (1997). NRCS National Range and Pasture Handbook. Retrieved from https://www.**nrcs**.usda.gov/wps/portal/**nrcs**/detail/**national**/landuse/**rangepasture**/?cid...

US Fish & Wildlife Service, (2009). Managing Invasive Plants. Concepts, Principles and Practices. U.S Fish &Wildlife Service. https://www.fws.gov/invisives.

Veit, P., (2011). *Rise and fall of Group Ranches in Kenya.* Focus on Land in Africa. *Brief.*

Voice of America, (2017, Feb.15th). Drought blamed for Conflicts in Kenya from illegal grazing. Knowledge by lane. News from Kenya. Accessed Thursday, Aug., 2018. www.knowledgebylane.co.ke/drought-blamed-for-conflict.

Volterra, V., (1926). Variations and Fluctuations of the Number of Individuals in Animal Species Living Together. In: R. N. Chapman (Ed.), Animal Ecology (pp. 31-113). New York: McGraw-Hill.

Vrachnakis., M., (2015). Important grasses, legumes, herbs, fodder trees and shrubs. Hellenic Academic E-books. Retrieved from https://repository.kallipos.gr/handle/11419/1198?locale=en

Wafula, O., (2010). Resources and border disputes in Eastern Africa. Journal of Eastern Africa Studies. Vol 4, issue 2. Pg 279-297 | Received 28 Sep 2009, Published online: 28 Jun 2010 . https://doi.org/10.1080/17531055.2010.487338

Warren, S.D., Thurrow. T.I., Blackburn. W.H., & Garza.N.E., (1986). The Influence of Livestock Trampling under Intensive Rotation Grazing on Soil Hydrologic Characteristics. Journal of Range Management 39(0), November 1996 Retrieved from: https://journals.uair.arizona.edu/index.php/jrm/article/viewFile/8049/7661

Western, D., & Wright R. M., (1994). The background to community based conservation. In: Western D, Wright R M. Natural Connections: Perspectives in Community-based Conservation. Washington DC: Island Press, 1–14.

Wilson, S.D., Tilman, D., (1991). Components of plant competition along an experimental gradient of nitrogen availability. Ecology 72, 1050–1065.

Yamane, T., (1967). Statistics, an introductory analysis. 2nd ed. New York. Happer and Row. Pg 8

APPENDICES

Appendix 1: Experimental Blocks: Ground cover analysis

Points	% ground cover	%bare ground	Average crown cover %	Grass ht(cm)	Tree density (78)	Tree dbh	Shrub density (196)	Grass sample collected	Cut wgt	Dry Wgt
			4.7/ha	4.27/ha	0.78/ha	16	1.96			
1	2	98	7	1	I	12	ii	0	0	0
2	40	85	4	3.5	I	34	Iii	0	0	0
3	30	95	3	5	I	21	ii	0	0	0
4	40	60	3	3	I	12	0	0	0	0
5	40	95	3.5	4.2	0	8	I, ii	0	0	0
6	50	50	8	4	0	8	iii	0	0	0
7	20	80	3.3	7	I	21	i	0	0	0
8	40	60	5	6	I	12	i	0	0	0
9	10	90	4.6	5	I	11	0	0	0	0
10	5	95	3.3	4	0	20	0	0	0	0

Appendix 2: Range Condition Field Form

Conservancy----------------------plot----------------------date------------------------ Recorder-----------------------------

1. **Subcomponent ratings**

Soil **Herb** **woody**

Erosion----------- Growth form---------- Hedging----------

Surface trails---------- Vigour-------------------- Vigour---------------

Crust----------- Composition-------------- composition--------

Litter----------------

2. **Component ratings (Average of subcomponents)**

Soil (Mark only A or B)

A. Erosion and/surface crust exceed 1.5) : mark highest ratings**------------(IIA)**

B. Otherwise average the subcomponent ratings-----------------

Herb

Woody

3. **Mean component ratings--------------------- (III)**

Final Range condition rating* (the highest of the two ratings IIA or III

Other notes

Ratings

0.00-0.56 (Good)

0.56-1.55 (Fair)

1.56-2.55 (Poor)

2.56-3.00 (Very poor). (Pratt D.J. &M.D. Gwinne 1977).

Appendix 3: Questionnaire

Questionnaire No.	Date	Name	Position	Conservancy

A) Forage availability and utilization:

1. How can you describe the type of grazing regime in your conservancy

a) Mixed regime ☐ b)Single species Regime ☐ c) Don't know ☐

2. If your answer in 1 above is:
   a) Please name species in the regime…………………………………………………
   b) Please name the species in the regime………………………………………………

3. a) How many times/seasons in a year does your conservancy receive rainfall
   1x ☐ 2x ☐ More than 2x ☐

b) Please name the time periods when you receive rains in a year in your conservancy
   1x……………………………………………….
   2x……………………………………………….
   More than 2x……………………………………
   Don't know………… ☐

4. How can you rate the pasture availability in your conservancy throughout the year
   a) Enough ☐ b) Satisfactory ☐ c) Non available ☐
   b) Please explain your answer in 4a above
   ……………………………………………………………………………………
   ……………………………………………………………………………………
   ……………………………………………………………………………………

B) Resource supply thresholds and Livestock movements

5. a) Does your conservancy have a grazing plan Yes ☐ No. ☐

   b) If your answer in 5 above is yes, who runs the grazing plan:
   i) The grazing committee……. ☐
   ii) The community…………………………… ☐
   iii) The manager………………………………………….. ☐
   iv) Do not know …………………………………………………… ☐

6. a) Is water available in your conservancy…..Yes ……… ☐
No……….. ☐
c) How long do your livestock travel to get water…< 1km ☐
……………<5km……… ☐ > 5km ☐ Don't know ☐
d) Is available water enough for your livestock..Yes ☐ No ☐ Don't know ☐
e) How is water available: Stream/river ☐ Well/borehole ☐ Dam ☐ Other ☐

7. a) Are you aware of grazing conflicts in your conservancy? Yes ☐ No ☐

b) How can you rate the grazing conflicts in your conservancy?

i) Very Frequent.. .. ☐ ii) Frequent …. ☐ iii) Not frequent….. ☐

8. a) What period of the year do your conservancy experience grazing conflicts…………………

b) Please explain your answer in 7a above

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

9. a) What do you think are the causes of the grazing conflicts in your conservancy

i) Lack of pasture ☐ ii) Lack of Grazing plan ☐
iii) Lack of water ☐ iv) other ☐ Don't know ☐

b) Please explain briefly your answer in 8a above

…………………………………………………………………………………………
…………………………………………………………………………………………
…………………………………………………………………………………………

10. How do you resolve grazing conflicts in your conservancy?

i) Negotiation ☐ ii) Arbitration ☐

iii) Fighting on ☐ iv) Migration ☐

10. Do you experience conflicts from other conservancies i) Yes ☐ ii)No ☐

11a) If your answer in the 10 above is Yes, Please explain how you deal with such a conflict………………………………………………………………………………
………..…………………………………………………………………………………

b) When in the year does such conflicts occur………………………………

12. How do members of your conservancy cope with grazing problems in your conservancy?

i) Adhering to grazing plan ☐ ii) Migrations to other areas ☐

iii) Reducing livestock ☐ iv) Don't know……☐

C) Competition for resources

13. a) Can you estimate the number of cattle and sheep available in your conservancy

i) <1000 ☐ ii) 1000-5000 ☐ iii) >5000 ☐ iv) Don't know ☐

b) Are both cattle and sheep grazed together or separated. i) Together ☐ ii) separated ☐

c) Does overstocking affect your grazing in the conservancy i)Yes.☐ ii) No ☐ iii) Don't Know ☐

d) How do you perceive competition for pasture between sheep and cattle a) Exists

i) exists ☐ ii) Does not exist ☐ ii) Do Not know ☐

e) Does stocking both sheep and cattle affect availability of pasture in your area

i)Yes…… ☐ ii)No……☐ iii)Don't know…… ☐

D) Environmental externalities

14. a) How do you perceive environmental changes in your conservancy in the last 20 years

i) No changes ☐ ii) Positive change ☐ ii) Negative change ☐

b) Please explain your answer in 12a above

……………………………………………………………………………………………

……………………………………………………………………………………………

c) In your opinion, do you think grazing contributes to the above mentioned changes in your conservancies? ……….Yes ☐ No ☐

Please explain your answer
………………………………………………………………………………………………
………………………………………………………………………………………………

c) Please can you tick any effect environmental changes you recognize in your area

Loss of soil …. ☐ Loss of trees and shrubs …….. ☐

Loss of grass … ☐ Loss of water……….. ☐

Loss of livestock ☐ Loss of wildlife….. ☐

Don't know… ☐

d) In your opinion do the environmental changes affect grazing positively or negatively:

i) Positively ☐ Negatively.. ☐ Don't know….. ☐

Appendix 4: Questionnaire on the Grazing Conflicts on Lewa Range Coordinators

Name…………………………..
…………………………………………………………………………..

Company/Organisation……………… ……………………..

Department…………………………………………………….

Position in the Organisation………………………………………..

Date of Interview…………………………………

a) Grazing conflicts

What time/s of the year does the conservancy experience grazing conflicts.

How many number of grazing conflicts did the conservancy experience in the last 24 months

i) 0-5 ii) 5-10 10-20 iii) 50>.

How did/do you resolve grazing conflicts between the conservancy and the grazers

b) Access to water

Does the conservancy experience water scarcity? ☐ ☐
Yes…………………………No………………………

Which times of the year does the conservancy experience water scarcity Please categorize the scarcity times with 1 being the best and 3 being the worst:

i) Jan-March………………ii) April-June…………………ii) Jul-Sept………………Oct-Dec

In the grade of 1 to 5, with 5 being the biggest/most, please categorize the main sources of water in the conservancy

i) Springs
ii) Wells
iii) Dams
iv) Any other

Competition

In your opinion, how do you view species completion for pasture/forage Grazing Plan

Does the conservancy have a grazing plan……

Yes.☐….No…☐………………………Don't know…☐…………..

Is the grazing plan adhered to…………………..
Yes..☐……………No.☐…….Sometimes..☐………Don't know.☐..

Who are the most violators of the grazing plan…..

Conservancy..☐…………None.☐……………………..Don't Know.☐

Signed …………………………………… Date………………………………

Appendix 5: Guidelines for the Focused Groups Discussion (FGDs)

1. What are grazing conflicts as perceived in your conservancy
2. How often do the grazing conflicts occur within your conservancy
3. What has been known to be the causes of conflicts on grazing in the conservancies
4. When do most of the grazing conflicts occur around and inside the conservancies
5. How do you intervenes in the resolutions of the grazing conflicts
6. Who else intervenes in the grazing conflicts
7. Who are the perpetrators by the conservancy members or the outsiders
8. How has grazing affected the environmental conditions in your conservancies
9. What are the notable losses as a result of overgrazing in the conservancy over time
10. How does grazing sheep and cattle affect each other in the same areas
11. Is there grazing plan in the conservancy
12. What are the actual benefits witnessed through grazing plan
13. If you may remember before time of Kenya's independence what would you say was the state of the environment in terms of the following elements:
    a) Grass cover
    b) Vegetation cover
    c) Water availability
    d) Number and quality of natural springs, rivers, streams and wetlands
    e) Number and types of birds and wildlife

14. How often are you involved in meetings on grazing issues with other stakeholders in the District? Please explain your answer.

Appendix 6: Interview guide for the Government, NGOs and Key informants

1. For how long have you lived and worked in this county/conservancy?

2. How do you understand grazing conflicts in this area?

3. How do the grazing conflicts occur in the county/conservancy?

2. Are you aware of any environmental challenges/problems as a result of grazing conflicts in the county?

a) Yes

b) No

3. If your answer to (2) above is yes, please list these challenges.

4. In your opinion, are there any community norms and grazing systems that are associated with frequent grazing conflicts?

a) Yes

b) No

5. If your answer to (4) above is yes, please name the norms and the management systems and explain how they relate grazing conflicts

6. How often do you involve the local community in grazing conservation programs? Please explain

7. What do you perceive as the impacts of grazing on the environment in this area?

8. What challenges do you encounter when engaging the community members in discussions on environmental conservation?

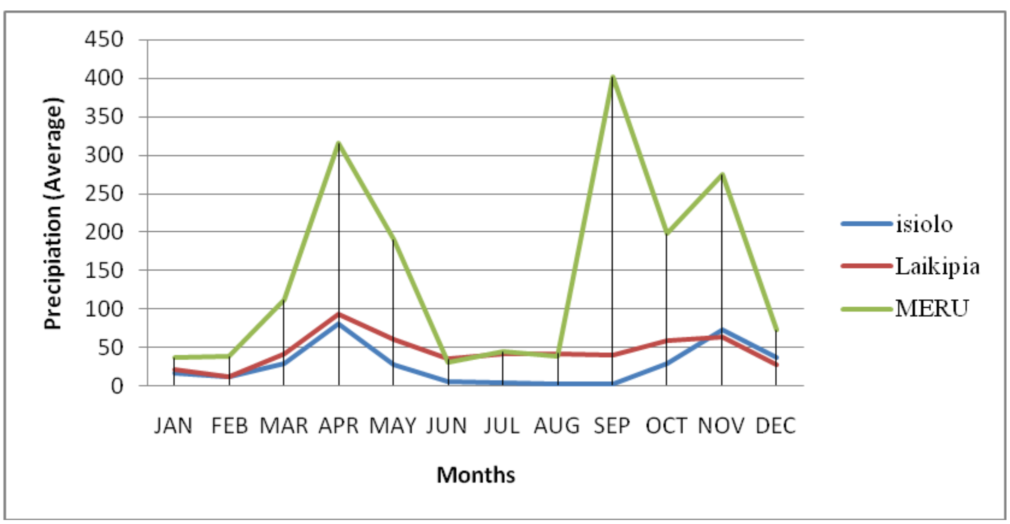
Appendix 7: Guidelines for transect walks

1. What are the key land use activities seen or found in the conservancies
2. How is the vegetation characteristics changing from one conservancy to another
3. How is the environmental degradation distributed as observed along the transect
4. What impacts of environmental degradation are observable on the environment along transect, soil erosion, gullies,
5. How is the grazing characteristics along the transect
    a) Mixed cattle and shoats
    b) Cattle only
6. Which forms the biggest portion of domestic grazing species
    a) Shoats
    b) Cattle
7. Vegetation types, ground cover, changes along the transect
8. Observable conflicts signs along the transect
9. Are there observable grazing systems/plans on the ground

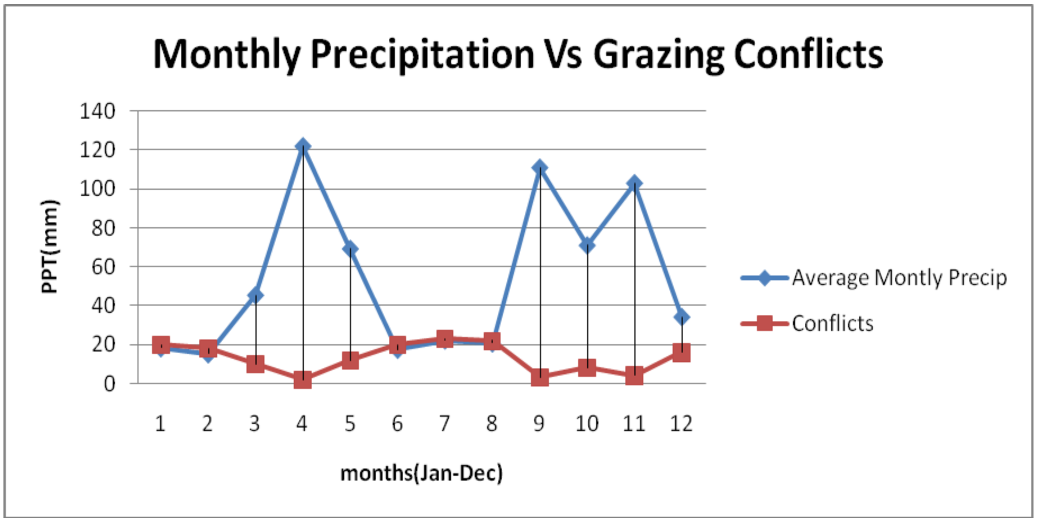
Appendix 8: The occurrences of rainfall

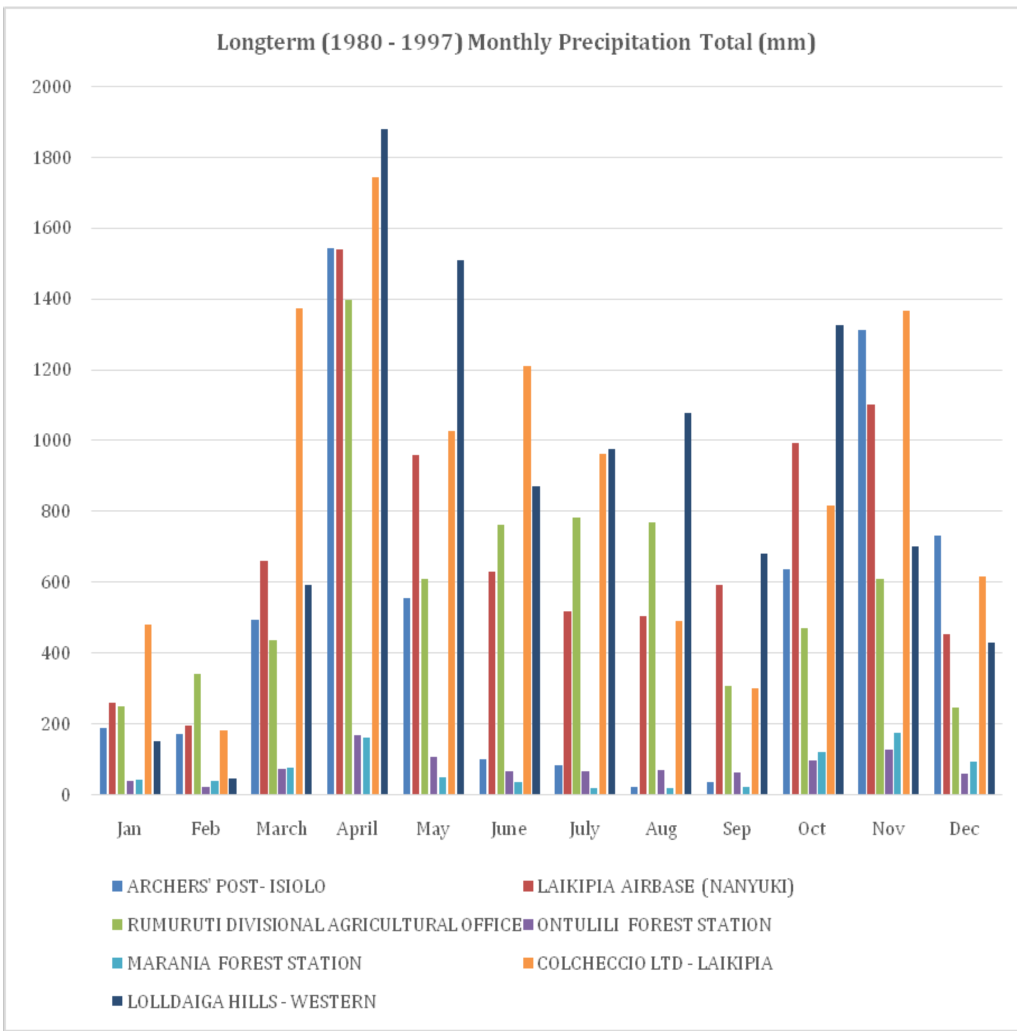
COUNTIES	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
Isiolo	16.4	11	28	80.7	27.7	5	3.7	1.8	1.7	28.4	73.1	36.2
Laikipia	21	12	42.1	92.8	60.4	34.8	41.3	42.4	39.9	58.6	63.1	28.3
Lewa	35.9	37.8	112	314.5	189.2	30.4	44.2	39	401	197	274	72.8
Conflicts	20	18	10	2	12	20	23	22	3	8	4	16
Average LT precip	73.3	61	182.1	487.9	277.3	70.2	89.3	83.2	443	284	410	137
Average Monthly Precip	18.3	15.2	45.5	122	69.3	17.5	22.3	20.8	111	71.1	103	34.3

Rainfall trends



Seasonality of rainfall and conflicts in the study area

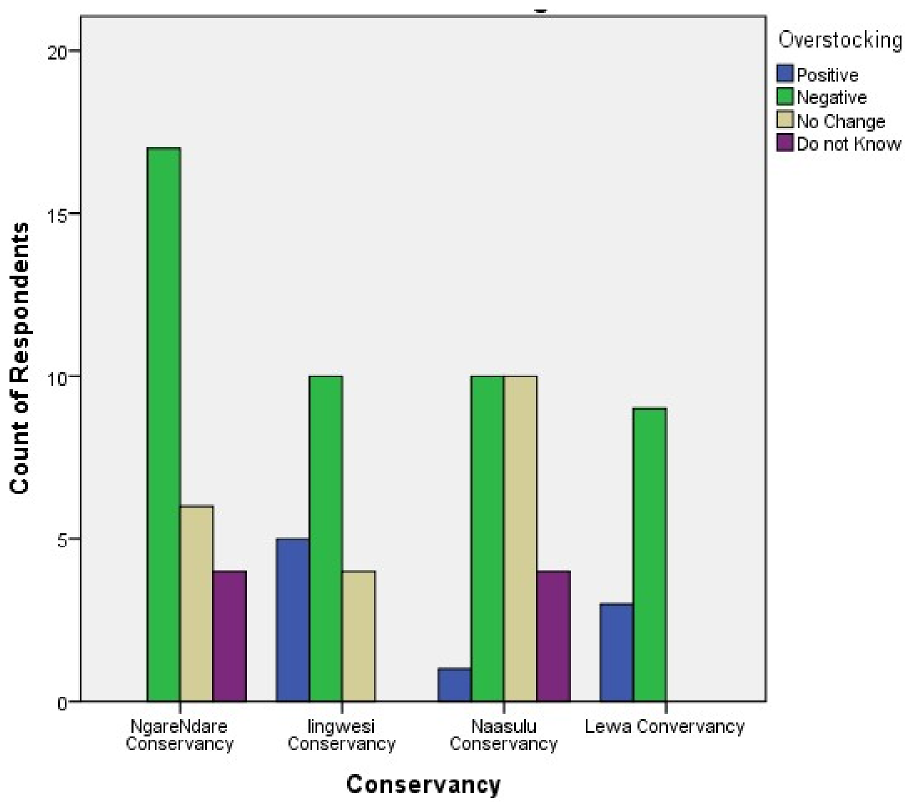




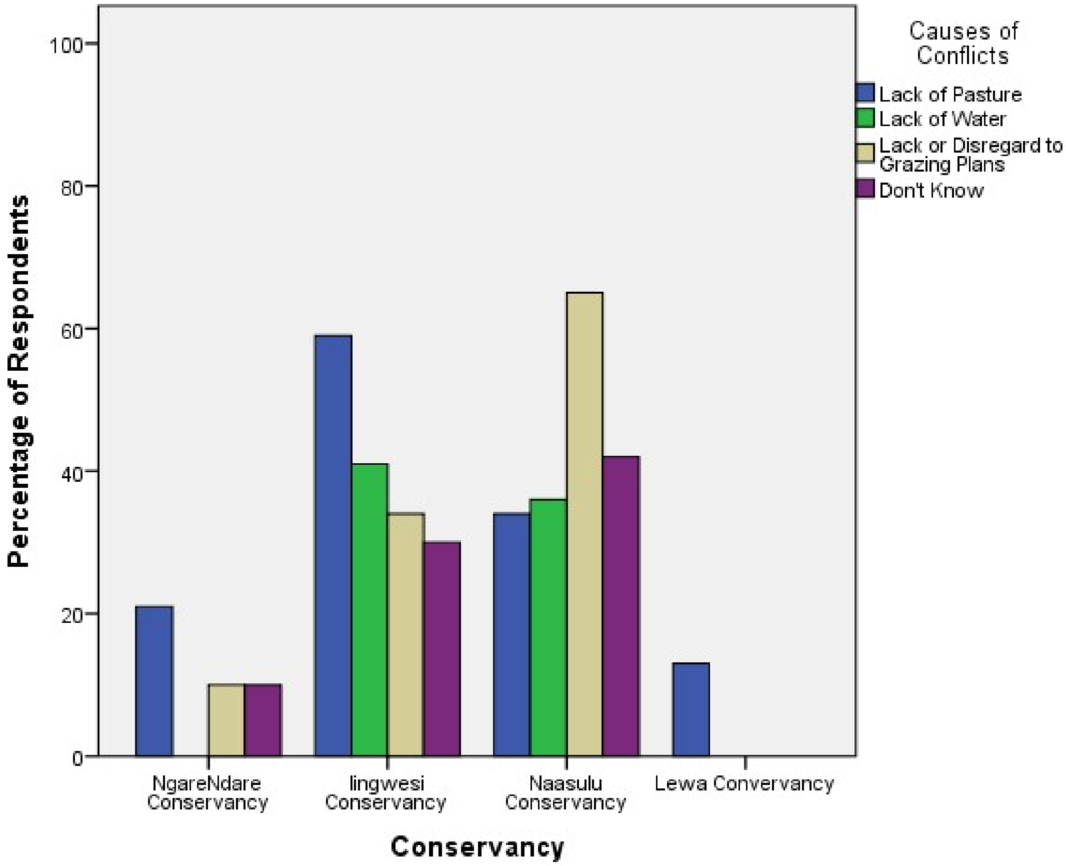
Appendix 9: Livestock numbers, Stocking rates: Cross Tabulation

			Livestock numbers		Total
			0-1000	1000-5000	
Conservancy	Ngarendare Conservancy	Count	1	21	22
		% within Conservancy	3.7%	96.3%	100.0%
	Ilngwesi Conservancy	Count	9	11	20
		% within Conservancy	45.9%	54.1%	100.0%
	Nasuulu Conservancy	Count	10	6	16
		% within Conservancy	81.0%	19.0%	100.0%
	Lewa conservancy	Count	12	0	12
		% within Conservancy	100.0%	0.0%	100.0%
Total		Count	32	38	70
		% within Conservancy	45.5%	54.5%	100.0%

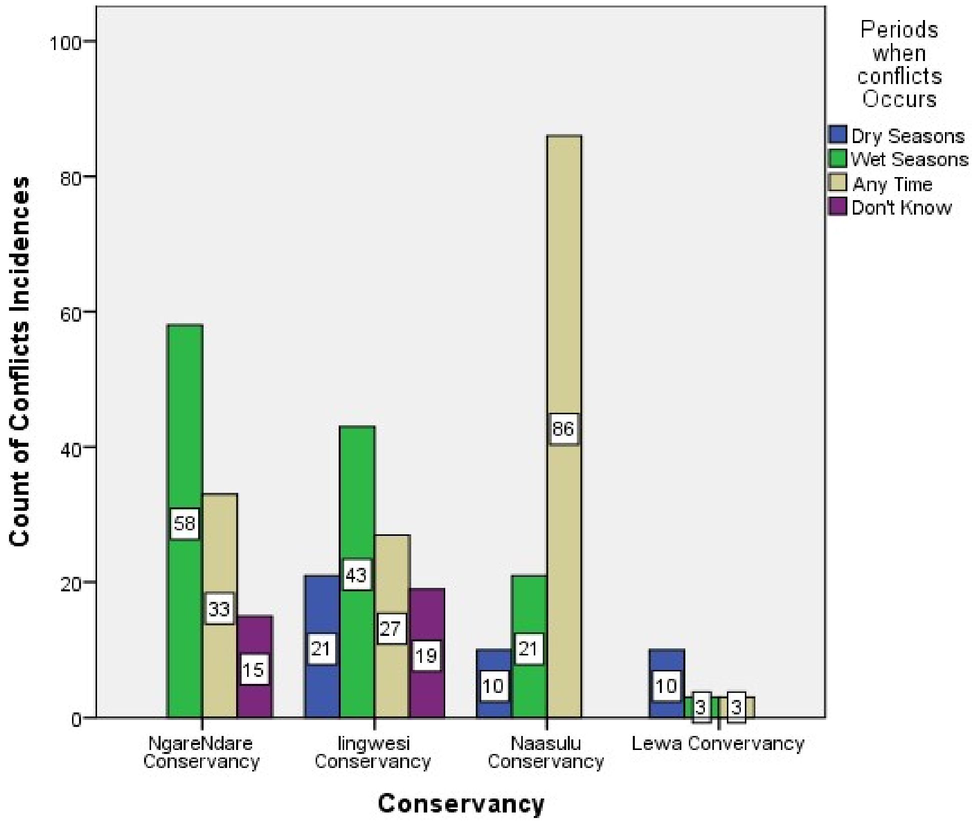
Appendix 10: Perception of community on Environmental Changes



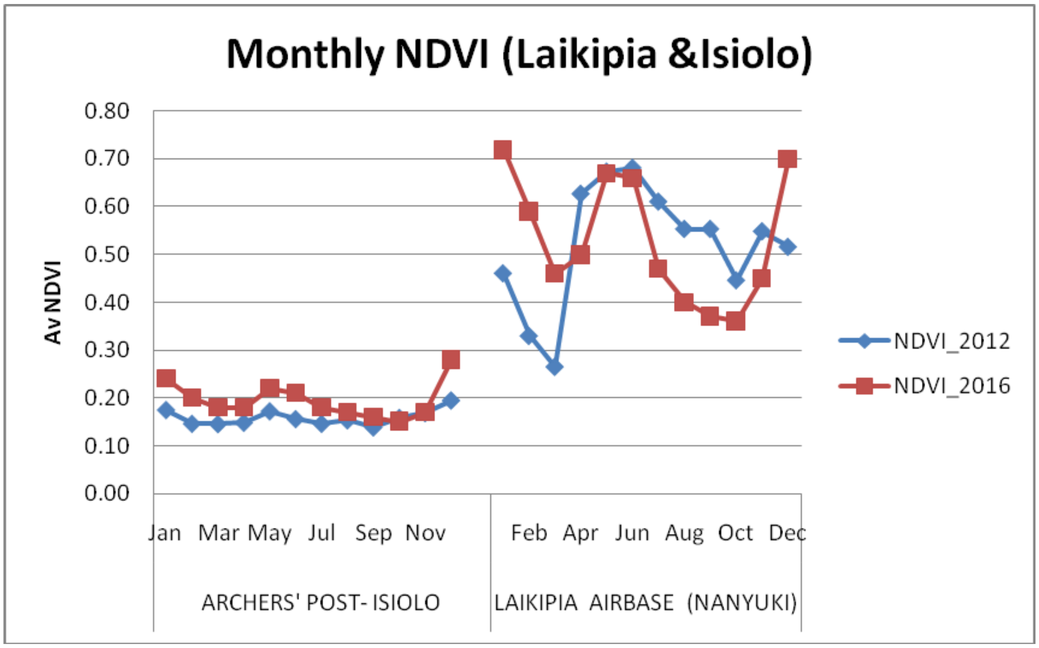
Appendix 11: Perceived causes of grazing conflicts per conservancy

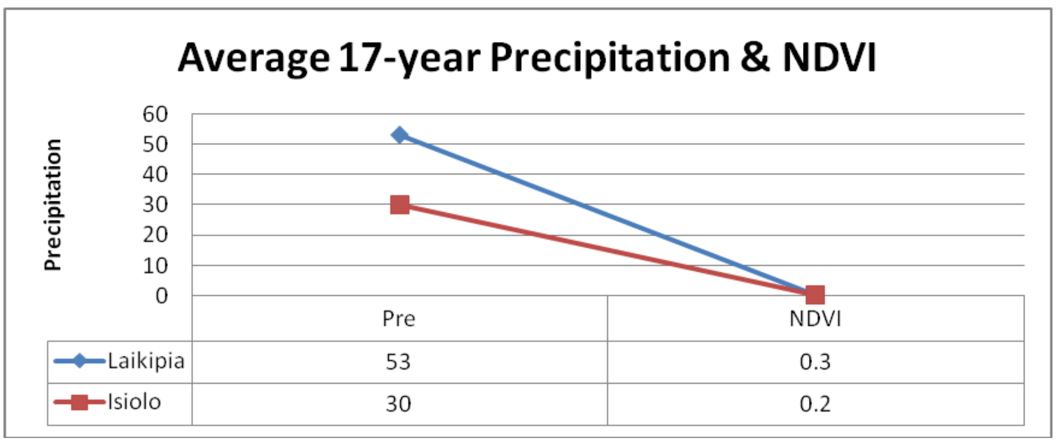


Appendix 12: Perception on the seasonality of conflicts occurrence

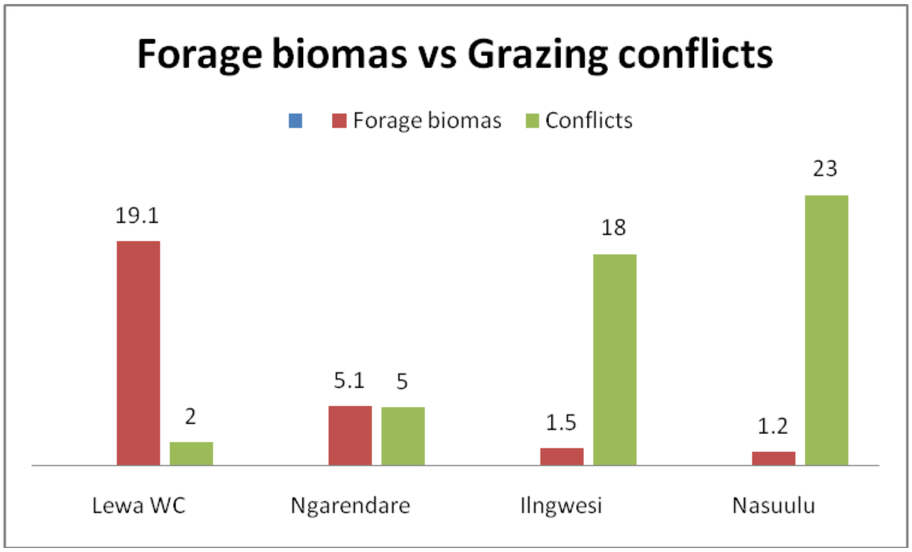


Appendix 13: Average NDVI Laikipia and Isiolo

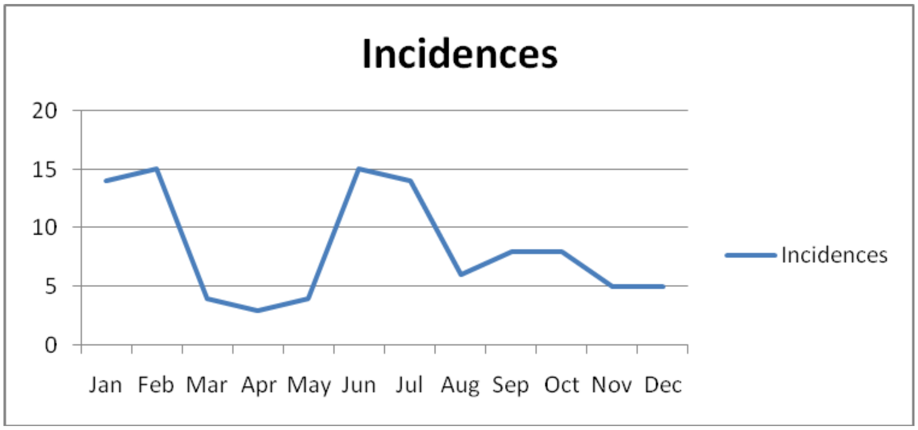




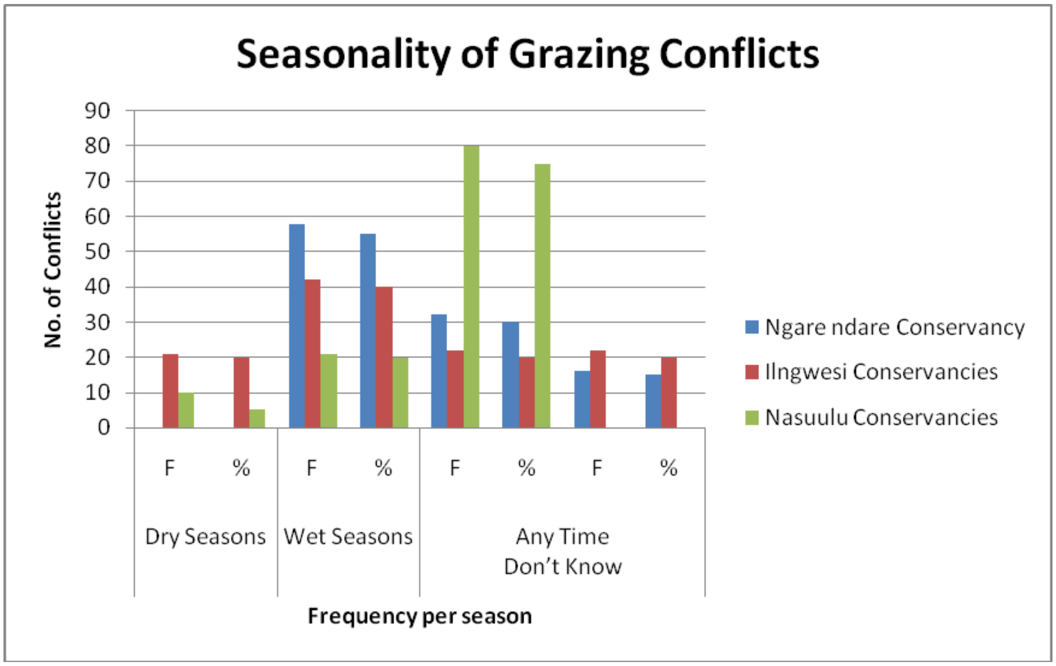
Appendix 14: Forage Vs Grazing conflicts per conservancy in 2016



Appendix 15: Incidences of grazing conflicts



Appendix 16: Average occurrences of grazing conflicts in five years



Appendix 17: Seasonality of grazing conflicts and ways of conflicts resolution

Periods When Conflicts Occurs	Dry Seasons		Wet Seasons		Any Time		Don't Know	
Conservancy	**Fq**	**%**	**Fq**	**%**	**Fq**	**%**	**Fq**	**%**
Ngarendare Conservancy	0	0.0	12	55.0	7	30.0	3	15.0
Ilngwesi Conservancies	4	20.0	8	40.0	4	20.0	4	20.0
Nasuulu Conservancies	8	50.0	3	20.0	5	30	0	0
Lewa	6	50	3	25	3	25	0	0
Causes of Conflicts	Ngarendare Conservancy		Ilngwesi Conservancy		Nasuulu Conservancy		Lewa	
	Fq	**%**	**Fq**	**%**	**Fq**	**%**	**Fq**	**%**
Lack of Pasture	13	59	9	48.0	5	30.0	7	58
Lack of Water	0	0.0	4	25	6	42.0	1	8
Lack of or disregard to Grazing Plan	5	23	3	15.0	3	20	4	33
Other causes	4	18	3	12.0	2	8	0	0
Resolving Conflicts	Ngarendare Conservancies		Ilngwesi Conservancies		Nasuulu Conservancy			
	Fq	**%**	**Fq**	**%**	**Fq**	**%**	Fq	%
Negotiation	0	0.0	58	55.0	32	30.0	7	58
Fighting On	21	20.0	42	40.0	42	40.0	0	0
Arbitration	10	5.0	21	20.0	80	75.0	7	58
Migration	10	5.0	21	20.0	80	75.0	0	0

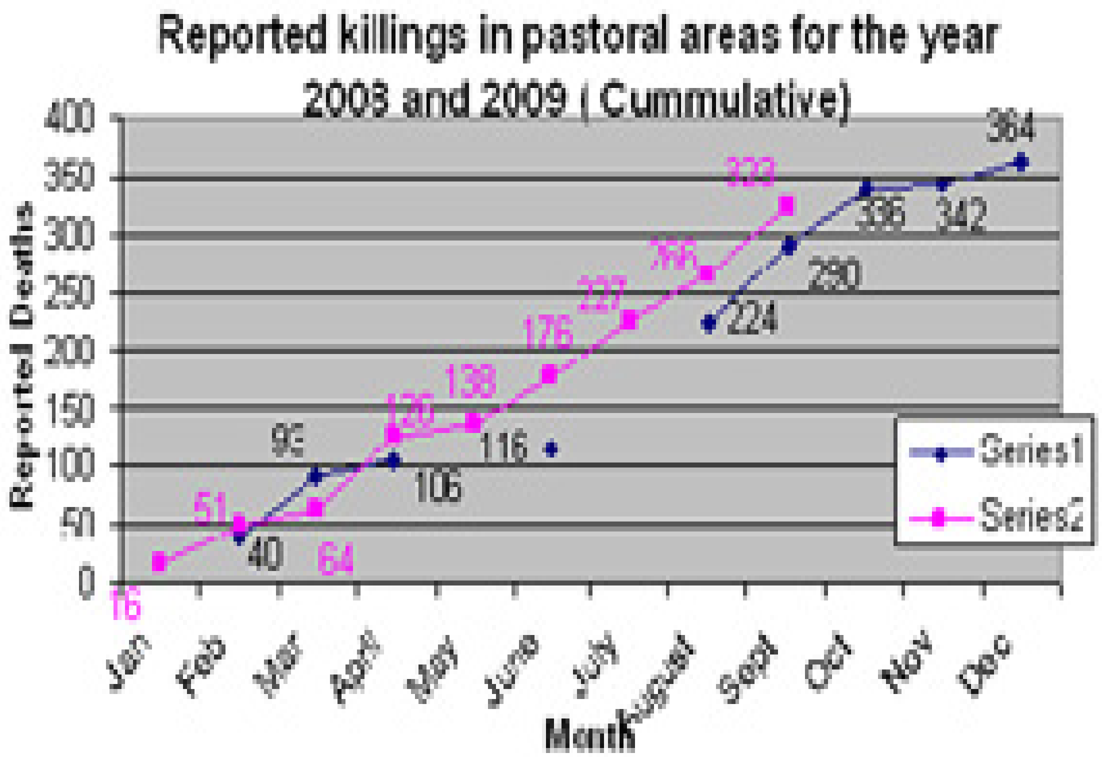
Appendix 18: Whether Conservancies mix the goat and sheep: Cross tabulation

			Whether Conservancies Mix Goat and Sheep			Total
			No	Yes	Sometimes	
Conservancy	Ngarendare Conservancy	Count	5	14	3	22
		% within Conservancy	22.8%	63.7%	13.5%	100.0%
	Ilngwesi Conservancy	Count	0	20	0	20
		% within Conservancy	0.0%	100.0%	0.0%	100.0%
	Nasuulu Conservancy	Count	0	15	0	15
		% within Conservancy	0.0%	100.0%	0.0%	100.0%
	Lewa conservancy	Count	0	12	0	12
		% within Conservancy	0.0%	100.0%	0.0%	100.0%
Total		Count	5	61	3	71
		% within Conservancy	4.8%	89.3%	6.0%	100.0%

Appendix 19: Dry Season data on grass forage

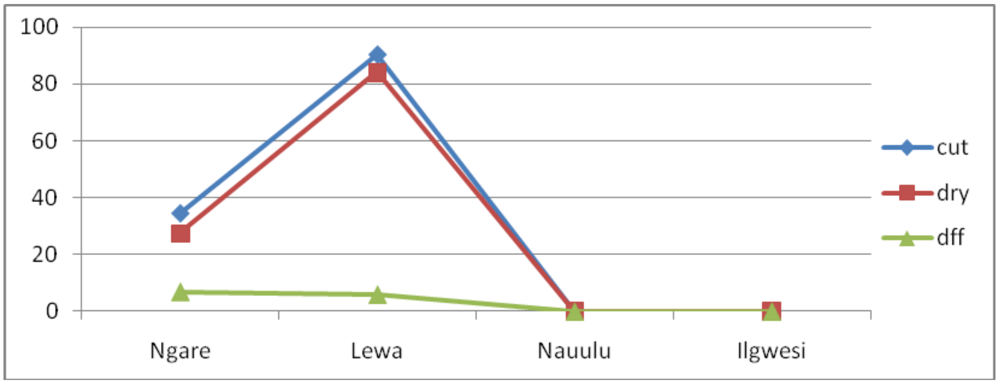
		Dry Season data on grass forage						
Site		Point 1	Point 2	Point 3	Point 4	Point 5	Total	Average
Lewa 1	Raw	68.488	92.045	74.26	89.999	145.392		
	Dry	77	96	76	98	157		
	Dff	8.512	3.955	1.74	8.001	11.608	33.816	6.7632
Lewa2	Raw	33.719	95.351	106.485	77.666	107.791		
	Dry	36	103	117	82	113		
	Dff	2.281	7.649	10.515	4.334	5.209	29.988	5.9976
Ngare 1	Dry	23.11	43.008	21.046	22.734	23.544		
	Raw	25	51	25	27	26		
	Dff	1.89	7.992	3.954	4.266	2.456	20.558	4.1116
Ngare2	Raw	0	24.911	24.393	30.468	39.036		
	Dry	0	**32**	**28**	**37**	**30**		
	Dff	0	7.089	3.607	6.532	-9.036	8.192	1.6384
Ngare3	Raw	14.651	19.742	48.61	20.688	34.09		
	Dry	17	26	62	25	44		
	Dff	2.349	6.258	13.39	4.312	9.91	36.219	7.2438
Lewa:	6.7632		Ngarendare	4.11				
	5.99			1.63				
	12.7532			7.2				
				12.94				
				4.313333				

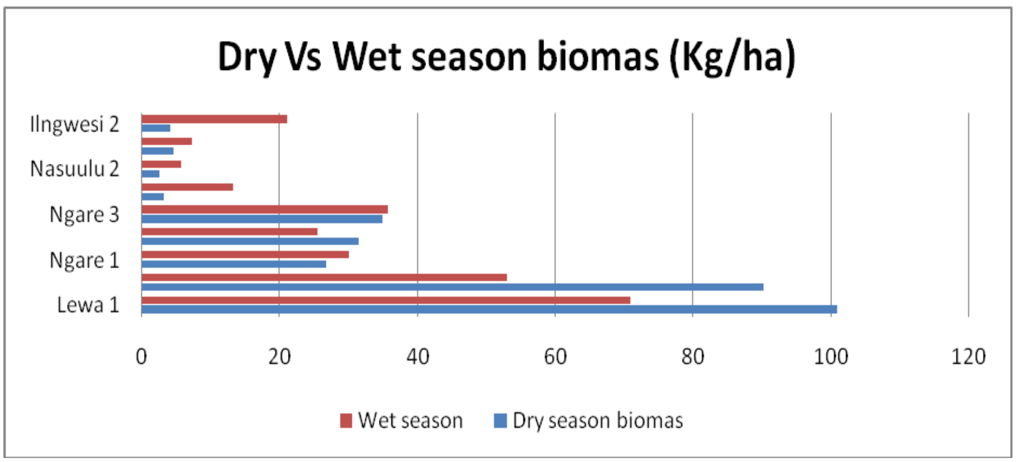
Appendix 20: Reported killings in pastoral areas

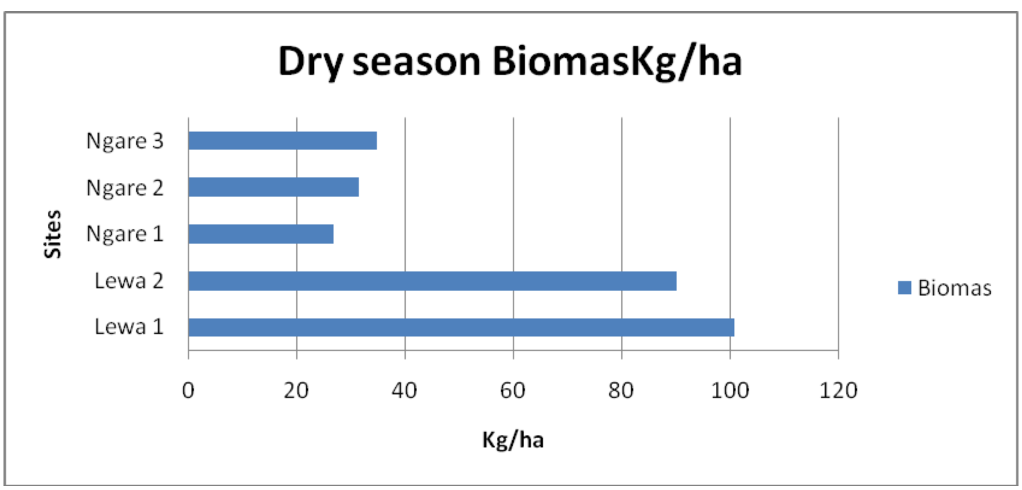


Reported killings in pastoral areas for the years 2008 – 2009. Source Photo: Kenya Humanitarian Update

Appendix 21: Dry season forage biomass per conservancy

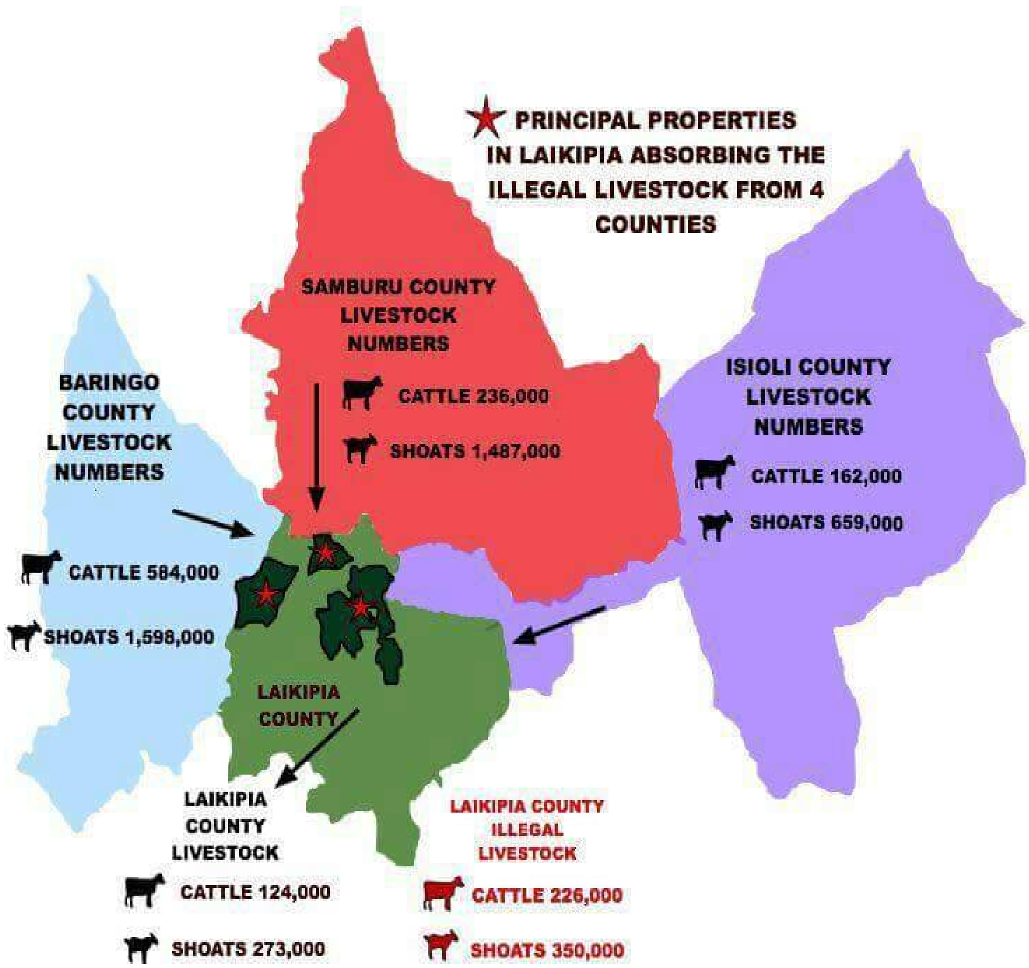






Dry season forage on Lewa and Ngarendare

Appendix 22: Average livestock numbers and movements in Laikipia & Isiolo



Source: The NDMA Isiolo

Annex 1: NACOSTI Permit

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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

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

Ref: No. **NACOSTI/P/17/61229/15835**

Date: **17th March, 2017**

Dominic Maringa Ikuathu
Kenya Methodist University
P.O. Box 267- 60200
MERU.

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Prediction of grazing conflicts based on limited resources in Northern Kenya,"*** I am pleased to inform you that you have been authorized to undertake research in **Isiolo and Laikipia Counties** for the period ending **16th March, 2018.**

You are advised to report to **the County Commissioners and the County Directors of Education, Isiolo and Laikipia Counties** before embarking on the research project.

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

BONIFACE WANYAMA
FOR: DIRECTOR-GENERAL/CEO

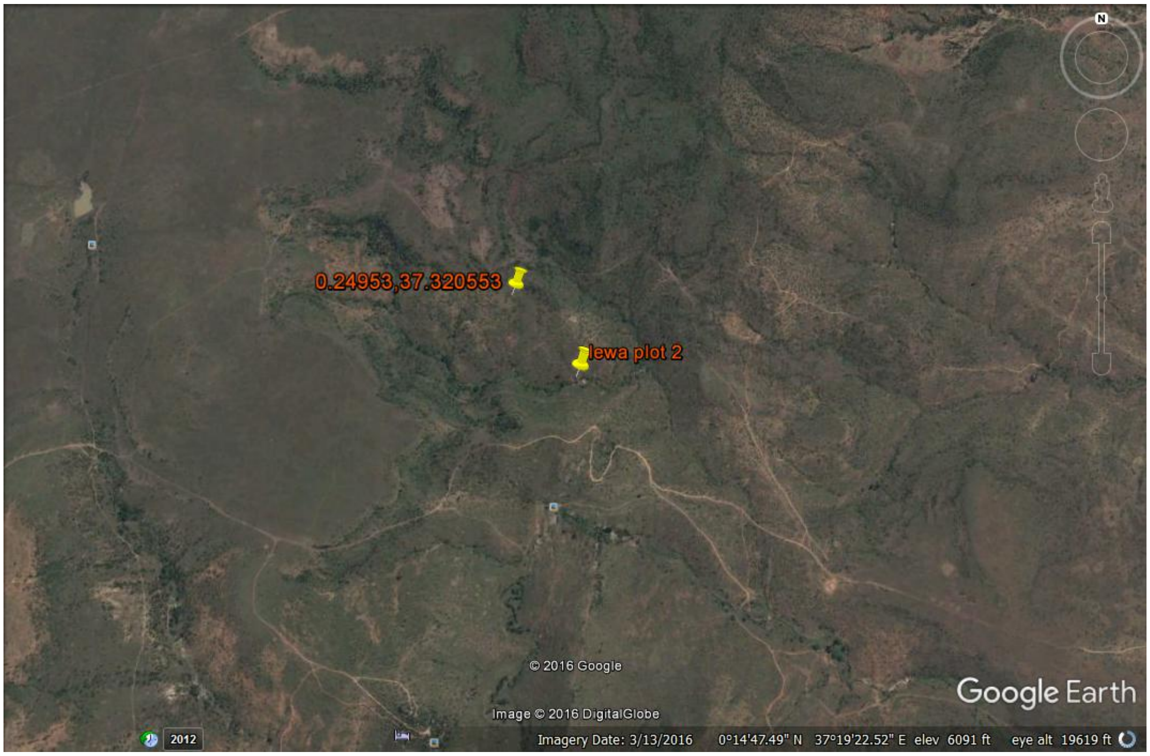
Copy to:

The County Commissioner
Isiolo County.

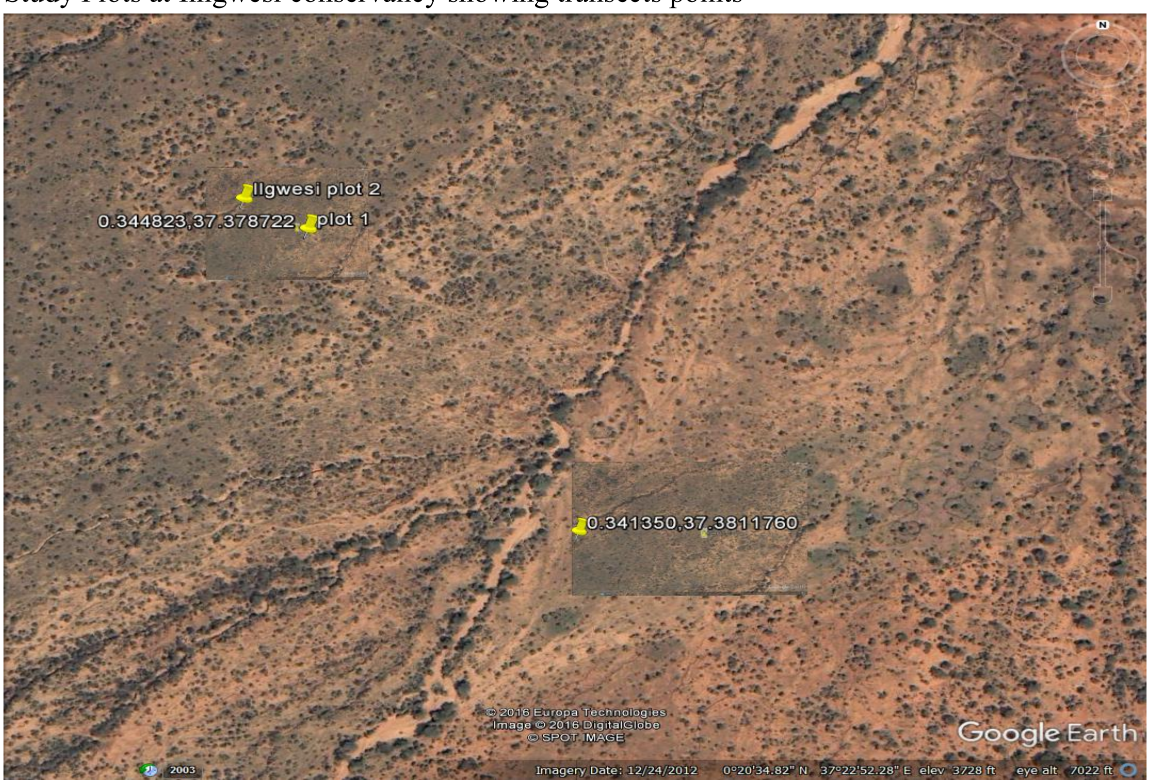
The County Director of Education
Isiolo County.

National Commission for Science, Technology and Innovation is ISO 9001:2008 Certified

Annex 2: Position of Control Plots, land map at Ilngwesi and transect points



Study Plots at Ilngwesi conservancy showing transects points



Annex 3: Some field work photos

Quadrants and grass height analysis at Ngarendare Ground cover estimation at Nasuulu-June 2017

April 2017 Abandoned boma at Ilngwesi-April 2017& hedged shrub at Nasuulu