

**Influence of Enclosure Management Systems
on Rangeland Rehabilitation in Chepareria,
West Pokot County, Kenya**

BY

Wairore, John Ndung'u (B.Sc.)

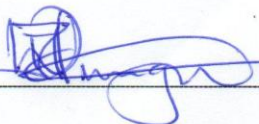
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the requirements for award of the Degree of Master of Science in Range
Management in the Department of Land Resource Management and
Agricultural Technology (LARMAT), Faculty of Agriculture, University of
Nairobi

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DECLARATION

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

SIGNATURE:  DATE: 16/11/2015

JOHN NDUNG'U WAIRORE

A56/71014/2014

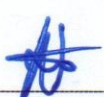
Department of Land Resource Management and Agricultural Technology, Faculty of
Agriculture, University of Nairobi.

This thesis has been submitted for examination with our approval as university supervisors:

SIGNATURE:  DATE: 16/11/2015

DR. STEPHEN M. MUREITHI

Department of Land Resource Management and Agricultural Technology, Faculty of
Agriculture, University of Nairobi.

SIGNATURE:  DATE: 16/11/2015

DR. OLIVER V. WASONGA

Department of Land Resource Management and Agricultural Technology, Faculty of
Agriculture, University of Nairobi.

DEDICATION

Dear

mama, I know how much you have sacrificed for
my education. I therefore, dedicate this thesis to
you, Esther Wamaitha Wairore.

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ACRONYMS AND ABBREVIATIONS

A.S.L	Above Sea Level
ACF	Action Against Hunger
AEZ	Agro-ecological zones
AI	Aridity Index
ANOVA	Analysis of Variance
ASALs	Arid and Semi-Arid Lands
AU	African Union
AU-IBAR	African Union- Interafrican Bureau for Animal Resources
CAN	Calcium Ammonium Phosphate
CBA	Cost Benefit Analysis
CBO	Community Based Organization
CSA	Climate-Smart Agriculture
D	Simpson's Index of dominance
DAP	Diammonium Phosphate
DCG	Drylands Coordination Group
DLDD	Desertification, Land degradation and Drought
EMG	Environmental Management Group
FAO	Food and Agricultural Organization of the United Nations
FFRI	Finnish Forest Research Institute
FGDs	Focussed group discussions
GDP	Gross Domestic Product
GEF	Global Environment Facility
GoK	Government of Kenya
H'	Shannon-Weiner Index of diversity
IBAR	Interafrican Bureau for Animal Resources
ICRAF	World Agroforestry Centre
IEBC	Independent Elections and Boundaries Commission
IGA	Income Generating Activity
ILRI	International Livestock Research Institute
ILRI	International Livestock Research Institute
KARI	Kenya Agricultural Research Institute

KIIs	Key Informant Interviews
KMC	Kenya Meat Commission
KNBS	Kenya National Bureau of Statistics
LSD	Least Significance Difference
MA	Millennium Ecosystem Assessment
MDGs	Millennium Development Goals
MFI	Microfinance Institutions
NAPs	National Action Plans
NDMA	National Drought Management Authority
NGO	Non-Governmental Organization
P	Mean annual precipitation
PET	Potential Evapotranspiration
PMC	Plantation Management Committee
RAE	Rehabilitation of Arid Environments [RAE] Trust
RAPs	Regional Action Plans
SER	Society of Ecological Restoration International
SIDA	Swedish International Development Cooperation Agency
SLU	Swedish University of Agricultural Sciences
SOC	Soil Organic Carbon
SPSS	Statistical Package for the Social Sciences
SRM	Society of Range Management
SSA	Sub-Saharan Africa
UN	United Nation
UNCCD	United Nations Convention to Combat Desertification
UNDDD	United Nations Decade for Deserts and Fight Against Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
Vi-AF	NGO Vi Agroforestry
Vi-TPP	NGO Vi Agroforestry tree planting project
WISP	World Initiative for Sustainable Pastoralism
WOCAT	World Overview of Conservation Approaches and Technologies

FOREWORD

The chapters in this thesis are structured as papers and have been submitted to peer-review journals. I would like to apologize to the reader for the inconvenience caused by the repetition of some sections dictated by this mode of presentation.

ABSTRACT

The establishment of enclosures has been recognized as an effective strategy for the rehabilitation of degraded rangelands in sub-Saharan Africa (SSA). While numerous approaches to restore degraded rangelands have failed, the continuous adoption and adaptation of enclosures in Chepareria, a ward in West Pokot County in Kenya indicates the success of enclosures as a management tool for the restoration and rehabilitation of degraded areas in the arid and semi-arid landscapes of East Africa. There are two main forms of enclosures namely communal and private enclosures found in East African rangelands. However, most studies and research have focused on communal enclosures within pastoral and agro-pastoral areas of Africa. With increasing adoption and adaptation of private enclosures, the influence of enclosure management systems within private enclosures is not well understood. This study aimed to assess the influence of private enclosure management regimes on rangeland rehabilitation and was conducted in Chepareria ward, West Pokot County, Kenya.

The specific objectives of the study were to (a) characterize enclosure management regimes and identify reasons for their continued establishment among agro-pastoralists; (b) assess the impacts of enclosure age and management on herbaceous layer characteristics and woody species density; and (c) assess the benefits derived from rehabilitating degraded semi-arid rangelands through private enclosures. The study area was divided administratively into three locations namely: Ywalateke, Chepkopegh and Morpus. Socio-economic data were collected using a questionnaire, focus group discussions and key informant interviews. Ecological data were collected randomly at six points in each of the three identified enclosure management systems. Sampling was carried out at the peak of both the wet (August) and dry (January) seasons in 2014-2015. Secondary data were obtained from the Kenya National Bureau of Statistics (KNBS), Independent Elections and Boundaries Commission (IEBC), National Drought Management Authority (NDMA), and West Pokot County Integrated Development Plan (CIDP) 2013-2017.

Enclosures were mainly established to demarcate boundaries, provide grazing reserves, enable proper land management, and facilitate crop cultivation in a pastoral set-up and to restore degraded land. Agro-pastoral households in Chepareria were diversifying their livelihood and income sources beyond the conventional livestock and crop production activities. Although livestock production was still the main source of livelihood, we found that

it was supplemented by other land use and income generating activities such as trade, wage labour, employment, agroforestry and cultivation (crops, fruits, or hay). In terms of management, there were livestock and crop-based enclosure management regimes whose adoption was mainly influenced by agroecological zonation, land tenure, number of livestock and household income. The dominance of livestock-based management regimes in the semi-arid rangelands indicated that enclosures were mostly established to provide livestock grazing reserves and enable pastoralists to cope with drought. On the other hand, the presence of crop dominated regimes on the wetter regions pointed to the increasing recognition and uptake of alternative land use and livelihood strategies in order to diversify household income.

This study showed that vegetation attributes were mostly influenced by enclosure management ($p \leq 0.005$) while enclosure age was not significant. Among the different management regimes, grazing dominated (GD) regime had the highest aboveground biomass ($688.2 \pm 860.7 \text{ kg DM ha}^{-1}$) and plant species cover while cultivation dominated (CD) regimes exhibited average biomass production and lower density of woody species due to clearance and deforestation for the establishment of crop and pasture fields. Contractual grazing (CG) regimes were characterized by severe overgrazing, high species dominance, lower plant species cover and low herbaceous aboveground biomass production.

The qualitative benefits derived from the establishment of private enclosures included dry-season grazing reserves, healthier livestock, improved livestock productivity, better livestock management, food security, reduced animal losses, ecosystem services, land ownership, independence and improved standard of living. Quantitative benefits were manifested through various enclosure enterprise combinations, income generating activities and diverse marketable products from enclosures. They included sale of livestock and livestock products, maize, wood cutting, grass cutting, contractual grazing, grass seeds, poultry, fruits and honey, among others. There was a positive correlation between enclosure income and enclosure age (years) and acreage (ha). The increased reliance on enclosure tangible (quantitative) benefits underpins the rapidly changing reasons for enclosing communal land from environmental conservation to diversification and economic benefits over time.

Overall, private enclosures have the potential of contributing to resilience building or offer pathways towards resilience building in dryland ecosystems and communities as attested from

the reasons for enclosure establishment, utilization and benefits reported in this study. This study concluded that private enclosures offer a framework for additional flexibility in land use, pasture, livestock management and the uptake of other income generating activities. By promoting effective and sustainable management of formerly degraded rangelands, private enclosures have emerged as an effective tool for the rehabilitation of degraded grazing lands. However, proper and appropriate management of enclosed areas will be critical to foster successful restoration of degraded rangelands. The thesis further, pin-points areas of research and offers suggestions on how the success of private enclosures in the restoration of degraded rangelands in East Africa can be improved.

Keywords: Drylands, enclosures, land degradation, rangeland restoration and rehabilitation, West Pokot

CHAPTER ONE

General Introduction

1.1. Land degradation and restoration in arid and semi-arid rangelands

Drylands- arid, semi-arid and dry sub-humid zones- occur on every continent except in the Antarctica. Drylands cover about 41% of the globe's land area (MA, 2005) and are home to more than 2 billion people (Reynolds et al., 2007), 90% of whom live in developing countries (UNEP, 2007). In Africa, drylands make up 43% of the land area and are inhabited by approximately 268 million people representing 40% of the continent's population (AU-IBAR, 2012). It is estimated that up to 50 million pastoralists and 200 million agro-pastoralists live and derive their livelihoods from drylands in West and East Africa (De Jode, 2009). Drylands cover about 82% of the total land surface in Kenya (Pratt & Gwynne, 1977; GoK, 1997; Herlocker, 1999; Kiriro, 2003; Nyariki et al., 2005), supporting more than 30% of the country's population, and over 60% of the country's livestock population (RoK, 2002). Although drylands have supported livelihoods for thousands of years, they have previously been perceived to be of low significance (AU-IBAR, 2012). However, due to their vastness there is growing recognition of their importance in global food security and other associated needs by dryland and non-dryland inhabitants (Mortimore, 2009). While drylands have significant potential for socio-economic development, spiral issues of desertification, land degradation, deforestation which are exacerbated by climatic variability and change, and fragmentation are rampant (FAO, 2010).

The major environmental issues facing drylands in the 21st century are desertification, land degradation and drought (DLDD) as cited by the United Nations Convention to Combat Desertification (UNCCD, 2012). Drought and desertification are coherently interlinked to land degradation and are of great concern today (Kahsay, 2004; Nyssen et al., 2004). Land degradation results in the loss of ecosystem services hence undermining the sustainability of both natural and managed ecosystems. This endangers the rural livelihoods and the population at large (World Bank, 2006). Reports by UNCCD (2012) indicate that approximately 24% of the global land is degrading, of which 20-25% is rangeland. A quarter of the world's agricultural land is also estimated to be highly degraded, some of which is irreversible (FAO, 2011a).

Land degradation is manifested in various ways ranging from desertification, soil erosion to waterlogging, and affects one out of every three people on earth in at least one way or the other (FAO, 2011b; Braun et al., 2012). Land degradation and desertification is more severe in sub-Saharan Africa (SSA) (United Nations, 2011) with an estimated 75% of Africa's drylands affected by moderate to high degree (Olukoye and Kinyamario, 2009). Anthropogenic influences namely, overgrazing and invaders species are classified as the primary driving forces for rangeland degradation (WISP, 2008; Li et al., 2011). About two thirds (2/3) of Africa's productive land area is affected by land degradation (UNCCD, 2013). According to the United Nations Environment Programme (UNEP) about 30% of Kenya is affected by severe to very severe land degradation (UNEP, 2002). Approximately a third (1/3) of Kenya's population directly depends on the land that is being degraded (Bai and Dent., 2006). Specifically, studies in Kenya by Meyerhoff (1991), de Groot et al. (1992), Onyando et al. (2005), Johansson and Svensson (2002), Mureithi (2012) and Wasonga (2009) in Baringo; and Makokha et al. (1999), Kitalyi et al. (2002) and Nangulu (2009) in West Pokot have shown that most arid and semi-arid lands (ASALs) are undergoing land degradation.

Recognition of the potential benefits of drylands to local, regional and global populations; risks of dryland degradation to human well-being and the fact that dryland degradation costs developing countries approximately 4-8% of their national gross domestic product (GDP) every year (United Nations, 2011) has necessitated efforts to combat land degradation in drylands. This is vital to ensuring sustainable development, and long-term productivity of arid and semi-arid lands (ASALs) (UNCCD, 2012). The formation of the UNCCD in 1994 to combat desertification was a response to the continuous deterioration of dryland environments (UNCCD, 2012). Even with the formation of the UNCCD, land degradation in the drylands remains an important issue on the international front. The launch of TerrAfrica in 2005; the DESIRE project in 2007; the formation of the United Nations Decade for Deserts and Fight Against Desertification (UNDDD) in 2010; increased calls for committed efforts to address DLDD in 2011 by the UN General Assembly; and calls for Zero Net Land Degradation during the Rio+20 summit in 2012 underlines the commitment of the international community in combating desertification and land degradation in drylands globally. Eswaran et al. (2001) pointed out that land degradation will remain an imperative global issue in the 21st century due to its adverse impacts on agricultural productivity, the

environment, food security and the quality of life. True to these sentiments, two decades since the establishment of the UNCCD, land degradation remains a critical issue on the international agenda reinforcing the concerns of Toulmin (1994) on the usefulness of a global convention to deal with the problem of land degradation.

According to Toulmin (1994), agreements reached at a global level are general in nature and do not provide the framework for the development of more-specific commitments at both national and regional levels. Recognition of this fact has not only led to the enactment of National and Regional Action Plans (NAPs and RAPs) within the UNCCD framework but also increased calls for ‘glocal Approaches’. Glocal approaches call for land degradation, biodiversity loss and climate change to be addressed locally while thinking globally (Mureithi, 2012; UNCCD, 2012). This approach seeks to turn international efforts, capital and time investments into local actions with diverse global benefits.

Continued land degradation and increased calls for “glocal” approaches in combating land degradation, biodiversity loss and climate change in rangelands; various approaches to restore and rehabilitate degraded ecosystems are being employed (RAE, 2004; Mureithi et al., 2010). Activities and measures to combat desertification are part of an integrated development of land. They seek to ensure sustainable development by implementing change in order to attain a specific economic value in drylands (Heady, 1999). This change can be in the form of rangeland rehabilitation or improvement and integrates preventing or reducing land degradation; rehabilitating partially degraded lands or reclaiming desertified land (UNCCD, 1994). Ecological restoration to rejuvenate or accelerate the reclamation and recovery of degraded rangelands in terms of health, integrity and posterity has continued to gain interest in globally. In sub-Saharan Africa, there is increasing evidence that show the commitment of community based organizations (CBOs), non-government organizations (NGOs), local and international efforts to combat land degradation in rangelands through diverse approaches and measures (UNEP/GEF, 2002; RAE, 2004). Despite many efforts to combat land degradation (Wasonga, 2009), there are only limited cases of successful rangelands rehabilitation initiatives in East African drylands (Makokha et al., 1999; RAE, 2004; Mengistu et al., 2005).

The establishment of enclosures is one of the remarkable examples of successful rangeland rehabilitation techniques in drylands. It has gained ground as an effective rangeland restoration strategy globally given its application in various countries including Ethiopia (Cleemput, 2004; Mengistu et al., 2005; Mekuria et al., 2007; Angassa and Oba, 2008; Bayene, 2009; Napier & Desta, 2011), Sudan (Behnke, 1985, 1986; Nedessa et al., 2005), Tanzania (Mwilawa et al., 2008), Somalia (Gaani et al., 2002) and China (Bauer, 2005). There is a general consensus and proof from the growing body of literature that previously communal grazing land are being divided into rangeland enclosures (Keene, 2008). Enclosures signify the *de-facto* privatization of pastoral commons by either allocating grazing commons to individual private owners or groups (Gaani et al., 2002; Beyene, 2009). In both cases, the adjudication/fragmentation of communal land for the establishment of rangeland enclosures is believed to foster a more responsible use of the land and is therefore, prevalent where communal use of rangelands has led to degradation (McCarthy et al., 2003; Keene, 2008). Though enclosures are established to meet varying objectives (Mureithi et al., 2010), their application in rangeland rehabilitation showcases enclosure as an effective and a well-known management tool for the restoration of degraded rangeland ecosystems (Verdoodt et al. 2010).

In the wake of increased land degradation and drought in Kenyan rangelands, enclosing the commons (communal land) through the establishment of communal and private enclosure has gained prominence. Example of successful rangeland restoration initiatives using private and communal enclosures in Kenya are found in West Pokot (Makokha et al., 1999; Kitalyi et al., 2002; Barklund, 2004; Nyberg et al., 2013), Baringo (Meyerhoff, 1991; De Groot et al., 1992; Mureithi et al., 2014; Wasonga, 2009; Mureithi et al., 2015; RAE, 2004), Kajiado (Macharia and Ekaya, 2005; Opiyo et al., 2011), and Turkana (Kigomo and Muturi, 2013). However, these studies have not explicitly explored private enclosure management and the impacts of enclosure management systems/regimes on rangeland rehabilitation. With increasing adoption and adaptation of private enclosures in rangeland rehabilitation in Chepareria, understanding the management regimes or systems is not only pivotal to management and utilization but is also important in understanding trends, issues and basis that inform the existing management pathways. Information gained from this study is critical in coming-up with a cost-effective private enclosure management strategy which is adaptable to various localities and cultures in SSA.

1.2. Statement of the problem

The establishment of grazing enclosures in the arid and semi-arid rangelands of sub-Saharan Africa (SSA) has gained cognizance as an important rangeland rehabilitation strategy. In Kenya, Successful rehabilitation of severely degraded semi-arid rangelands in Chepareria, West Pokot County and in Lake Baringo basin, Baringo County, Kenya using enclosures has created an upsurge of private enclosures on previously communal property regime. However, there are various key issues which need to be streamlined as this glocal approach takes root.

First, the variability of enclosure rehabilitation success in both Chepareria (Makokha et al., 1999) and Baringo (Mureithi et al., 2010; Verdoodt et al., 2010) has pointed out that individual management decisions play a vital role in promoting successful rangeland rehabilitation using enclosures. It is therefore imperative to understand applied management regimes and the utilization and management decisions within each system. Verdoodt et al (2010) observed that vegetation restoration had been rather difficult in some private enclosures denoting issues with regards to applied management regimes. This feature was attributed to differences in the condition of the range before enclosure establishment, routine management practices and an actual variation in enclosure management regimes.

Second, it has been rather difficult to interpret ecological data from enclosures in Chepareria since various management regimes applied by the individual owners have not been studied (Svanlund, 2014). It has been observed that some herders cultivate their enclosures in better seasons/years and plant crops, and graze in subsequent seasons/years. In Baringo (Verdoodt et al, 2010), differences in biomass productivity between private and communal enclosures could not be deduced solely on the available data. Therefore, it is vital to carry out a detailed characterization of management systems and their impact on herbaceous vegetation and woody species density in Chepareria rangelands.

Finally, management systems adopted by pastoral communities are defined by among others objectives and rationalities for the establishment of rangeland enclosures and the benefits that individuals derive from them. The continued establishment of rangeland enclosures in sub-Saharan Africa has been observed to be driven and sustained by a combination of factors (Behnke, 1986). However, these benefits cannot be generalized as they tend to be case-specific. More so, except for Mureithi et al. (2015), there exist few studies detailing the benefits derived from rehabilitating degraded rangelands in enclosures.

1.3. Justification

As the area under enclosure management expands, it is vital that these areas are managed accordingly (Mekuria and Veldkamp, 2011). Moghaddam (2000) and Tavakoli (2001) reiterated that the consequences of enclosure operations and management measures should be previously prospected. Yayneshet et al. (2009) stressed on the need for a management strategy which allows selectivity and careful timely utilization of enclosures. Close monitoring of the individual management actions/ decisions covers: adopted grass cutting and frequencies, inclusion of water harvesting structures, stocking density, soil seedbed preparation, and seed/planting density is necessary. Verdoodt et al. (2010) stressed that these aspects should be included in any future treatment design to examine the impacts of individual management actions/strategies on enclosure rehabilitation success.

To come up with a cost-effective enclosure management strategy which can be replicated in other regions of Sub-Saharan Africa (SSA), range enclosures should be properly managed. However, the differential success in rehabilitation success within private and communal enclosures in Chepareria (Makokha et al., 1999) calls for a study of the previously applied management processes, the soil and vegetation cover changes in order to introduce new integral management strategies.

Overall, researchers have experienced difficulty interpreting ecological data from enclosures in Chepareria (Makokha et al, 1999; Svanlund, 2014). This has been attributed to the fact that management regimes applied by individual owners have not been studied. This justifies the need to characterise management regimes in detail. This will ultimately help understand the dynamics of enclosures management and the restoration process.

Consequently, there is need to characterize enclosure management strategies and evaluate the impacts of individuals management actions on rangeland rehabilitation. This is imperative owing to the fact that a growing body of literature showcase a steady dismantling of communal grazing land while range closure is on the rise. While the need to come up with a cost-effective enclosure management strategy is imperative, this can only be successfully accomplished once enclosure management systems, their impacts on vegetation dynamics, reasons for establishment and benefits -qualitative and quantitative- derived have been thoroughly researched on and characterized.

1.4. Scope of the study

1.4.1. Objectives

Broad Objective

This study assessed the impact of enclosure management regimes on rangeland rehabilitation in Chepareria ward, West Pokot County, Kenya. The study sought to generate evidence-based information on rangeland enclosures as an approach for land rehabilitation. The findings will guide up- and out-scaling of enclosures and their management in SSA.

Specific objectives

The specific objectives of the study were to:

1. Characterize enclosure management regimes and identify reasons for their continued establishment among agro-pastoralists;
2. Determine the impacts of enclosure age and management on herbaceous layer characteristics and woody species density in Chepareria;
3. Assess the benefits derived from rehabilitating degraded semi-arid rangelands through rangeland enclosures.

1.4.2. Research hypotheses

The current study was based on the hypothesis that:

1. Pastoral households have specific objectives and rationalities for the establishment rangeland enclosures.
2. Enclosure management systems adopted by pastoral households reflect the dominant land-use systems in the area and their adoption is influenced by various factors.
3. There is an association between enclosure age and management systems and herbaceous vegetation characteristics and woody species density in Chepareria.
4. Rangeland enclosures offer various qualitative and quantitative benefits to pastoral and agro-pastoral households.

1.5. Description of the study site

1.5.1. Location and geo-physical characteristics

This study was conducted in Chepareria ward in West Pokot County, Kenya (Figure 1.1). The ward has an area of 495 Km² (IEBC, 2010) and lies between latitude 1°15' and 1°55'N; longitude 35° 7' and 35° 27' E (Maphill, 2013). It is located on the lower slopes of Kamatira hills and its southern floodplains which stretch beyond Mount Morpus on the lower side. This study was conducted in Chepareria, an area where the agroforestry and enclosures have been extensively promoted by NGO Vi Agroforestry (Vi-AF) from 1987 to 2000 (Nyberg et al., 2013).

Vi-Agroforestry (Vi-skogen) is a Swedish development organization that works to support farmers in the Lake Victoria Basin in East Africa. Through agroforestry, Vi-AF supports farmers' organisations contributing to poverty reduction, food security, increased income, increased biodiversity and climate change adaptation (viagroforestry.org).

The study was specifically conducted in three locations where NGO Vi Agroforestry was active for a long-term namely: Ywalateke, Chepkopegh and Morpus. These locations represent areas where many households adopted and continue to adopt private enclosure as a strategy for land rehabilitation (Nyberg et al., 2013). Though the area has gently undulating plains with an altitude ranging from 1200 to 1600 meters above sea level; it is surrounded by hills and mountain with peaks of up to 3000 meters (Touber, 1991).

1.5.2. Climate

The area experiences a highly variable seasonal climate which is a characteristic of semi-arid regions in SSA. Chepareria is located on the lowlands of West Pokot County and receives about 600 mm of rainfall per annum although rainfall increases with altitude (County Government of West Pokot, 2013). The rains are bimodal with the wet seasons in March – May (long rains) and August – November (short rains) (NDMA, 2014). Temperature varies with altitude and ranges between 24°C to 30°C (County Government of West Pokot, 2013). The area has two distinct climatic conditions which affect land use and productivity (Figure 1.1).

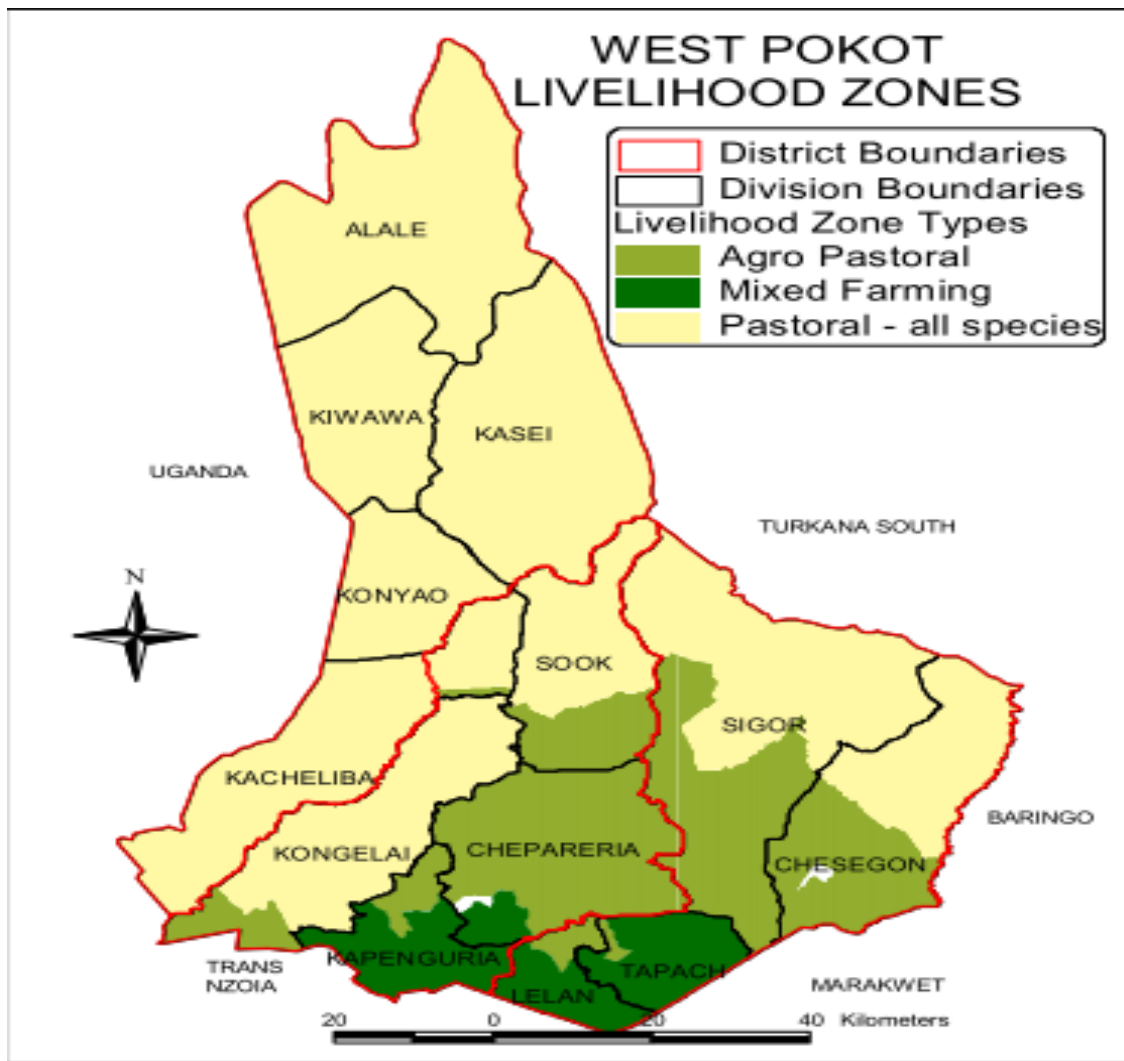


Figure 1.1 West Pokot County Livelihood Zones.

Source: Adapted from the National Drought Management Authority (NDMA) (NDMA, 2014)

1.5.3. Soils and water resources

Chepareria is primarily a metamorphic bedrock area, highly rich in ferromagnesian minerals. It is from this bedrock that rocky, moderately shallow, and well drained soils have developed (Touber, 1991). While the soils vary significantly across the study area (Sposito, 2013); the lower altitude and more semi-arid areas of Chepareria generally have fragile infertile soils (FAO, 2006). The main sources of water in the study area are rivers Muruny, Weiwei and Suam and seasonal streams (Makokha et al., 1999). There is also considerable investment in water infrastructure by the government and NGOs such as World Vision Kenya, through sinking boreholes, waterpans and dam construction.

1.5.4. Vegetation

The vegetation is steppe-like, dominated by grasslands (*Themeda triandra*, *Eragrostis superba*, *Cymbopogon validus*, *Cenchrus ciliaris* and *Cynodon dactylon*) with scattered native and exotic tree species. Common native tree species include *Acacia spp.*, *Balanites aegyptiaca*, *Kigelia africana* and *Terminalia brownii* while the exotic tree species are *Croton spp.*, *Ficus spp.*, *Grevillea robusta* and *Azadirachta indica* (Makokha et al. 1999).

1.5.5. Land-use and livelihood

The main land-use and source of livelihood in the study area is livestock keeping (Svanlund, 2014; Awino Ochieng and Vera, 2014). Sedentary agro-pastoralism is the main land-use on the lower altitude areas of Chepareria while the upper areas support mixed-farming as indicated in Figure 1.2. Though livestock is still a measure of wealth, enclosures facilitate the adoption and intensification of agriculture, particularly maize production (Makokha et al., 1999). Other cultivated crops include beans, millet and sorghum (Vi Agroforestry Survey, 2007; Wernersson, 2013; Awino Ochieng and Vera, 2014). Fruits farming, contractual grazing and pasture production are other land–use practices that are slowly gaining popularity in the study area.

Chepareria ward is inhabited by the Pokot community, a tribe with a long history of pastoralism which allowed their communal lands to recover from grazing and other natural disturbances such as drought. However, the colonialists introduced new borders thus halting their migratory lifestyle (Nangulu, 2009). Restricted mobility meant that herds were restrained in limited areas and for prolonged period thus overstocking, overgrazing and poor management of grazing resources. Changes in livestock grazing patterns led to massive land degradation in area. The term *Chepareria* was coined from the massive land degradation that rocked the area (Kitalyi et al. 2002). It is a Pokot word meaning ‘The land of the red soils’ (W. Makokha, personal communication, March, 2014). Vi-Agroforestry, with funding from the Swedish International Development Cooperation Agency (SIDA) set up a land rehabilitation program in 1987 to address the intense land degradation in the area. Working together with diverse stakeholders in Chepareria, Vi-Agroforestry introduced prolonged changes in land management through demonstration and intensive extension of agroforestry and establishment of enclosures (Makokha et al., 1999).

However, with the introduction of enclosures, the Pokot community in Chepareria is now a sedentary agro-pastoral community deriving its livelihood from crop and livestock production within individual private enclosures. Today, the study area has a population of 41, 563 persons (KNBS, 2009; IEBC, 2010). Land privatization is also taking root in the study area. Residents on the upper areas (Ywalateke) have titled deeds (private tenure) while those on the lower areas (Chepkopegh and Morpus) have allotment letters for the sub-divided group ranches. Communal land in Chepareria has significantly reduced.

1.6. Structure of the thesis

This thesis is divided into three parts. The **first part** provides an introduction into enclosure as a tool for the management of degraded rangelands. It also defines the scope of the study (objectives and research questions) and describes the study area in chapter 1. The **second part** reviews the restoration of degraded areas using enclosures in chapters 2 to 5. *Chapter 2* reviews the history, types and sources of information for the establishment of enclosures, and highlights the reasons for the adoption and adaptation of private enclosures in the semi-arid rangelands of Chepareria. *Chapters 3* assess the enclosure management regimes adopted by private enclosures in Chepareria. In *chapter 4*, the implications of enclosure age and management on herbaceous layer characteristics and woody species density in Chepareria rangeland are investigated. *Chapter 5* assesses the qualitative and quantitative benefits derived from rehabilitating degraded rangelands using private enclosures in Chepareria, West Pokot County, Kenya. The **third part** contained in *Chapter 6* provides a general discussion and conclusion from all the chapters, and provides recommendations and potential for future research.

1.7. Definition of key terms in this thesis

Agro-pastoralists are defined as livestock keepers who derive more than 25% but less than 50% of agricultural income from livestock keeping in areas with an annual rainfall range of between 400 and 600 mm and the length of the growing period is between 75 to 90 days (Morton and Meadows, 2000).

Desertification is defined as land degradation in arid, semi-arid and dry sub-humid areas attributable to diverse factors, including climatic variations and anthropogenic activities (UNCCD Art.1.a) (MA, 2005). It is a dynamic process that is observed in dry and fragile ecosystems. Desertification occurs in all continents of the world except Antarctica.

Drylands are conventionally defined in terms of water stress as areas where the ratio of mean annual precipitation (P) to potential evapotranspiration (PET), (the index of aridity) is less than 0.65 (Middleton & Thomas, 1997). Based on the aridity index (AI) values, drylands are classified into four climatic zones namely:

- Hyper-arid <0.05
- Arid 0.05-0.20
- Semi-arid 0.20-0.50
- Dry Sub-humid 0.50-0.65

Ecological restoration refers to the process of enhancing the recovery of an ecosystem that has been degraded, damaged, or destroyed (Society for Ecological Restoration International, SER, 2004).

Enclosure (s) is a well-known management tool for the restoration of degraded rangelands. According to Mekuria et al. (2011), enclosures denote areas closed from the interference of both humans and domestic animals in order to promote the natural regeneration of plants and reduce land degradation on formerly degraded communal grazing land.

Land degradation is defined as the reduction or loss of the biological or economic productivity of drylands. Bunning et al. (2011) defines land degradation as the reduction in the capacity of the land to provide ecosystem goods and services and guarantee or assure its functions over a period of time for to its beneficiaries.

Rangelands are defined as land on which native vegetation, predominantly grasses, grass-like plants, forbs, or shrubs are suitable for grazing or browsing use. It includes lands revegetated naturally or artificially to provide forage cover that is managed like natural vegetation. Rangelands encompass natural grasslands, savannah, shrublands, most deserts, tundra, alpine communities, coastal marshes and meadows (Society of Range Management, SRM, 2006).

Land Rehabilitation defines the process of returning an area of land to its former natural state after some process has resulted in its degradation or damage (Mureithi et al., 2012).

1.8. References

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CHAPTER TWO

Enclosing the Commons: Reasons for the adoption and adaptation of enclosures in the arid and semi-arid rangelands of Chepareria, Kenya

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Enclosing the Commons: Reasons for the adoption and adaptation of enclosures in the arid and semi-arid rangelands of Chepareria, Kenya

Wairore, J.N.^{1,2*}, Mureithi, S.M.^{1,2}, Wasonga, V.O.¹ and Nyberg, G.^{2,3}

¹Department of Land Resource Management and Agricultural Technology (LARMAT), University of Nairobi, P.O Box 29053-00625, Nairobi Kenya

²Triple L Research Initiative, Uppsala, Sweden

³Department of Forest Ecology and Management, Swedish University of Agricultural Sciences (SLU), 901 83 Umea, Sweden

*Corresponding author. Email: jwairore@gmail.com

Abstract

The adoption and adaptation of enclosures in the arid and semi-arid rangelands of sub-Saharan Africa is driven and sustained by a combination of factors such as tenure insecurity, pasture shortage and poor management of pastoral commons. However, reviews indicate that these factors cannot be generalized, as they tend to be case specific. A study was therefore conducted to explore the history and reasons for enclosure establishment in Chepareria, a formerly degraded communal rangeland in West Pokot. While Vi-Agroforestry Organization accounting for 52.5% was the main source of knowledge on enclosure establishment; it has now emerged that rangeland enclosures among the Pokot pastoral community existed prior to land management interventions by Vi- Agroforestry. Results indicated that enclosures were mainly established to demarcate boundaries, provide grazing reserves, enable proper/judicious land management, facilitate crop cultivation in a pastoral setup and to curb land degradation. The role of self-trigger [accounting for most of the spontaneous enclosures (73.5%)] indicates the continued establishment and expansion of areas under enclosure management as private land ownership accounting for 51.7% of enclosure tenure continues to gain momentum. While rangeland enclosures were mainly established for boundary demarcation, to alleviate pasture scarcity and enable proper management of formerly degraded areas; they have facilitated land restoration and rehabilitation by increasing flexibility in land, fodder and livestock management amongst agro-pastoralists in Chepareria over the last three decades. To ensure that rehabilitated areas do not revert to their previously degraded state; technical interventions are needed to allow for a more intensive use of rangeland resources within enclosed areas.

Keywords

Communal land; Arid and semi-arid lands; Rangeland enclosures; Rehabilitation; West Pokot County

2.1. Background

Most rangelands are caught in a spiral of desertification, land degradation and drought (DLDD), deforestation and land fragmentation (FAO 2010). DLDD have been identified as key threat to both dryland and non-dryland communities, and sustainable economic development in drylands, particularly in developing nations (UNCCD 2012, 2013), as they lead to reduced human well-being due to increased poverty and vulnerability of the affected dryland populations (MA 2005). Land degradation, in particular has led to increased food insecurity; compromised the ecosystem integrity and consequently lowered the quality of life of most dryland communities (Eswaran et al. 2001a; MA 2005; Reynolds et al. 2007).

Many attempts to rehabilitate degraded rangelands have failed (Meyerhoff 1991; de Groot et al. 1992; Wasonga 2009; Mureithi et al. 2010) as they placed more importance on the physicality and technicality of the interventions than the socio-economic and cultural needs of the people (Mureithi et al. 2010). Consequently, there have been increasing calls for holistic, multidisciplinary and integrated ecosystem approaches when rehabilitating fragile ecosystems (Harris et al. 1996; UNDP/UNCCD/UNEP 2009). Rehabilitation of degraded rangelands by enclosing the commons -enclosures- is a successful local approach in combating land degradation in rangelands and is gaining prominence (Verdoodt et al. 2010).

Enclosures refer to areas closed off from agriculture and grazing for a specified duration of time in order to allow the regeneration of vegetation (Behnke 1986). Studies in Somalia (Gaani 2002), Tanzania (Mwilawa et al. 2008), China (Bauer 2005), Sudan (Behnke 1985, 1986; Nedessa et al. 2005), Ethiopia (Mengistu et al. 2005; Mekuria et al. 2007; Keene 2008; Beyene 2009) and in Kenya (Meyerhoff 1991; Makokha et al. 1999; Mureithi et al. 2010, 2015; Opiyo et al. 2011; Kigomo and Muturi 2013; Wernersson 2013 and Svanlund 2014) all illustrate that rangeland enclosure is indeed, a well-known and successful management tool for the restoration of degraded rangelands within and beyond East Africa.

In Chepareria, a formerly communal and degraded ward in West Pokot County, enclosures were mainly established to address pasture shortage. Enclosures as a land management approach enabled individuals to properly manage land, fodder and livestock hence creating stable environment for the local pastoral community in Chepareria (Wairore et al. 2015a). Through increased flexibility in land use, pasture and livestock management, private enclosure owners have not only been able to restore degraded lands but also adopt alternative income generating activities (IGAs). These have resulted in improved standards of living amongst agro-pastoralists in the ward (Makokha et al. 1999).

While enclosures have been able to foster rangeland restoration and rehabilitation, it is now emerging that they were not specifically established for land rehabilitation, particularly in Chepareria. As a land use fragmentation/management approach, we hypothesize that enclosures were established for diverse reasons, particularly if their categories/types, time of establishment and source of information/knowledge on how to establish them vary. By drawing inference from Chepareria, this study sought to document the history of enclosures, sources of information/knowledge on enclosure establishment and explore the reasons for the enclosure movement in the formerly degraded rangelands. More importantly, we seek to identify how land use fragmentation/management through rangeland enclosures has shifted risks of degradation from previously communal rangelands to private allotments in enclosed areas. Understanding these key thematic areas is important in the upscaling of enclosures to other similar rangelands within and beyond East Africa.

2.2. Study Area

The study was conducted in Chepareria ward in West Pokot County (Figure 2.1). The ward lies between latitude $1^{\circ}15'$ and $1^{\circ}55'N$ and longitude $35^{\circ} 7'$ and $35^{\circ} 27'$ E. The region experiences a highly variable and seasonal climate as is the case with similar arid and semi-arid lands (ASALs) in Kenya. While rainfall in Chepareria increases with increasing altitude, it averages 600 mm (County Government of West Pokot 2013) and is bimodal (long rains between March and May (MAM) and the short rainy period from August to November as described by the National Drought Management Authority (NDMA 2014). The average annual temperature in Chepareria ranges from $24^{\circ}C$ to $38^{\circ}C$ (County of government of West Pokot 2013).

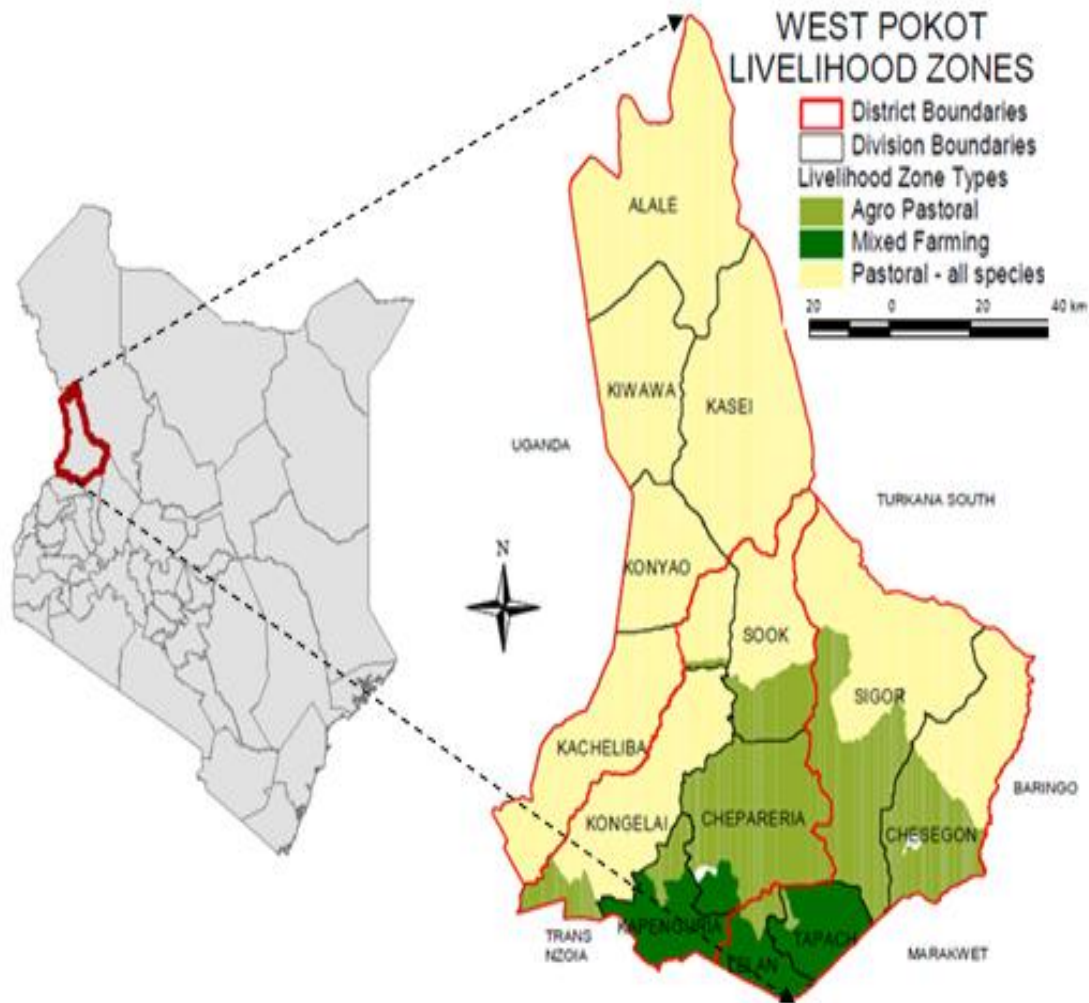


Figure 2.1 Location of West Pokot County in Kenya and inset Chepareria Ward in West Pokot County

Soils vary considerably from shallow and friable in the lowlands to deep and well-drained in the upper areas (Sposito 2013). In terms of fertility, it varies from moderate to low fertility as described by FAO (2006). The vegetation is steppe-like, though grasslands interspersed with native and exotic tree species dominate. The region is mainly inhabited by the Pokot tribe; a community with a long history of pastoral livestock keeping in Kenya. According to the Kenya National Bureau of Statistics (KNBS), the population of Chepareria ward in 2009 was 41, 563 persons (KNBS 2009).

2.3. Methods

2.3.1. Sampling design and data collection

Ywalateke, Chepkopegh and Morpus administrative locations were purposively selected for this study. The three locations represent the areas where the Non-Governmental Organization (NGO) Vi-Agroforestry (Vi-AF) conducted intensive extension on agroforestry and enclosure establishment in Chepareria. Using a checklist of more than 400 enclosure owners in each location, systematic random sampling was used to select a sample of 40 enclosure owners in each location, giving a total sample of 120 households.

A combination of data collection instruments were used in this study. A semi-structured questionnaire was used to collect data on household demographics, characteristics of selected enclosures, history, sources of information/knowledge and reasons for rangeland enclosure establishment. Five key informant interviews (KIIs) and eight focus group discussions (FGDs) were also conducted to clarify and obtain further information on responses that appeared unclear and compliment information gathered through the semi-structured questionnaire, particularly on the reasons for enclosure establishment and how they have enabled respondents address land degradation in the area. To contextualize this study, extensive literature review was also conducted to identify and relate our findings on reasons and implications of rangeland enclosures on land restoration and rehabilitation.

2.3.2. Data analysis

Qualitative data gathered from literature review, FGDs, and KIIs was compiled, organized and consolidated using summary tables into different topics addressed during this study. This information was used to interpret and clarify qualitative data collected from household interviews. The statistical package for the social sciences (SPSS) was used to analyze data collected from semi-structured questionnaires. Descriptive statistics such as means, standard deviation (SD) and percentages were used to present results on the history, categories and reasons for enclosure establishment in Chepareria. Bivariate correlation was used to determine factors influencing the choice of enclosure categories amongst enclosure owners in the area. Significant correlations were detected using Pearson's coefficient two-tailed test of significance. Information obtained from literature reviewer helped in contextualizing the study and relating our results and findings to those of previous studies.

2.4. RESULTS

2.4.1. Selected demographic and enclosure characteristics

Majority of the households interviewed were headed by males (73.3%), most of whom (42.5%) had an average age of between 36-50 years. While a majority of the respondents were married (97.5%), the 2.5% of those who are not married corresponds to the 0.8% of household headed by respondents below 20 years as indicated in Table 2.1. While a significant 56.3% of respondents have attained primary education; there remains a considerable 29.4% of household heads who have not accessed education. There was a significant negative correlation between education level attained and age of household head ($p \leq 0.01$) indicating a trend of increased access to education among younger household heads compared to their older counterparts. Though weak, the observed significant negative correlation between education level attained and gender of the household head ($p \leq 0.05$) indicates that access to education among women is still an issue in Chepareria.

In Chepareria, most households have an average family size of 7 ± 3 . The observed significant positive correlation between family size and age of household head ($p \leq 0.05$) indicates that older respondents are likely to have a larger family size compared to younger household heads. This relationship can be associated with the observed significant negative correlation between the age and education level attained by the household head. Enclosures averaged $5.01 (\pm 4.38)$ ha with an increasing trend towards formalization of land tenure as indicated by the 51.7% of enclosures under private ownership.

Table 2.1 Selected demographic and enclosure characteristics of sampled households in Chepareria

		%	Mean (SD)
Household head			
Gender	Male	73.3	
	Female	26.7	
Age (years)	0-20	0.8	
	21-35	36.7	
	36-50	42.5	
	50+	20.0	
Marital status	Single	2.5	
	Married	97.5	
Education level attained	None	29.4	
	Primary	56.3	
	Secondary	8.4	
	Post-Secondary	5.9	
Average family size (SD)			7 (3)
Enclosure			
Average enclosure area (SD)	Ha		5.01 (4.38)
Enclosure tenure	Private	51.7	
	Communal	48.3	

2.4.2. History, categories of enclosures and sources of knowledge on enclosure establishment in Chepareria

In order to understand how individuals gain access to the land to enclose, the aged respondents indicated that enclosures existed even before the colonial period. Due to their migratory nature, these enclosures would be abandoned and new ones established in the next settlement area. During the colonial era, grazing regulations which partitioned the Pokot grazing lands into sections were instituted by the administrators. Later, these areas were divided into group ranches under the group ranch management system in a bid to control livestock diseases. Owing to their migratory lifestyle, the Pokots were not in favour of this management system.

After Kenya gained her independence in 1963, the instituted group ranch committees were not able to regulate grazing like during the colonial times and the scheme was poorly coordinated hence overstocking and land degradation. Since most individuals were not satisfied with the group ranch operations, the land enclosure movement easily received support of group ranch committee members, especially after witnessing the initial results of the project in demonstration sites set in schools and churches. This was followed by community discussions around 1990-1993 which sought to strengthen the resolution of group ranch members to demarcate the group ranches into individual land parcels. However, this did not happen until 1997, when several group ranches passed a resolution to wind up group ranches in favour of individual land holdings. Informal group ranch subdivisions in Chepareria were hastily conducted and completed. Through these subdivisions, individuals were given rights to use their land holding which represented some *de facto* degree of ownership. As of today, the process of adjudication is still on-going. While there exists legal technicality of survey and registration of individual title deeds among group ranch members; there is proof that this is happening as evidenced by the 51.7% of respondents who already have titled deeds as indicated in Table 2.1.

Most of the enclosures were established after technical interventions in land management by Vi-AF which started in 1987 as evidenced by 89.2% of the sampled enclosures which were established in the last 30 years (Table 2.2). However, 10.8% of the enclosures were established prior to Vi-AF land management intervention in 1987 as indicated in Table 2.2. The age of enclosure (years since effective protection) was significantly correlated to the age of household head ($p \leq 0.01$), and in turn influenced the category and acreage (ha) of enclosures ($p \leq 0.01$) established in Chepareria.

Table 2.2 Age distribution of enclosures establishment in Chepareria

		Count	Percent
Enclosure Age	< 10	45	37.5
	11 – 20	42	35.0
	21 – 30	20	16.7
	31+	13	10.8
	Total	120	100.0

There exist three categories of enclosures namely: Enclosures identified and sponsored by Vi-AF (10%); Enclosures identified by farmers, elders or the community but assisted by Vi-AF (16.5%) and Enclosures initiated without Vi-AF assistance-spontaneous enclosures (73.5%) as indicated in Figure 2.2. The existing significant negative correlation between enclosure category and age of enclosure and household head ($p \leq 0.01$) indicates a trend of increasing establishment of spontaneous enclosures, particularly among the younger generation over recent years.

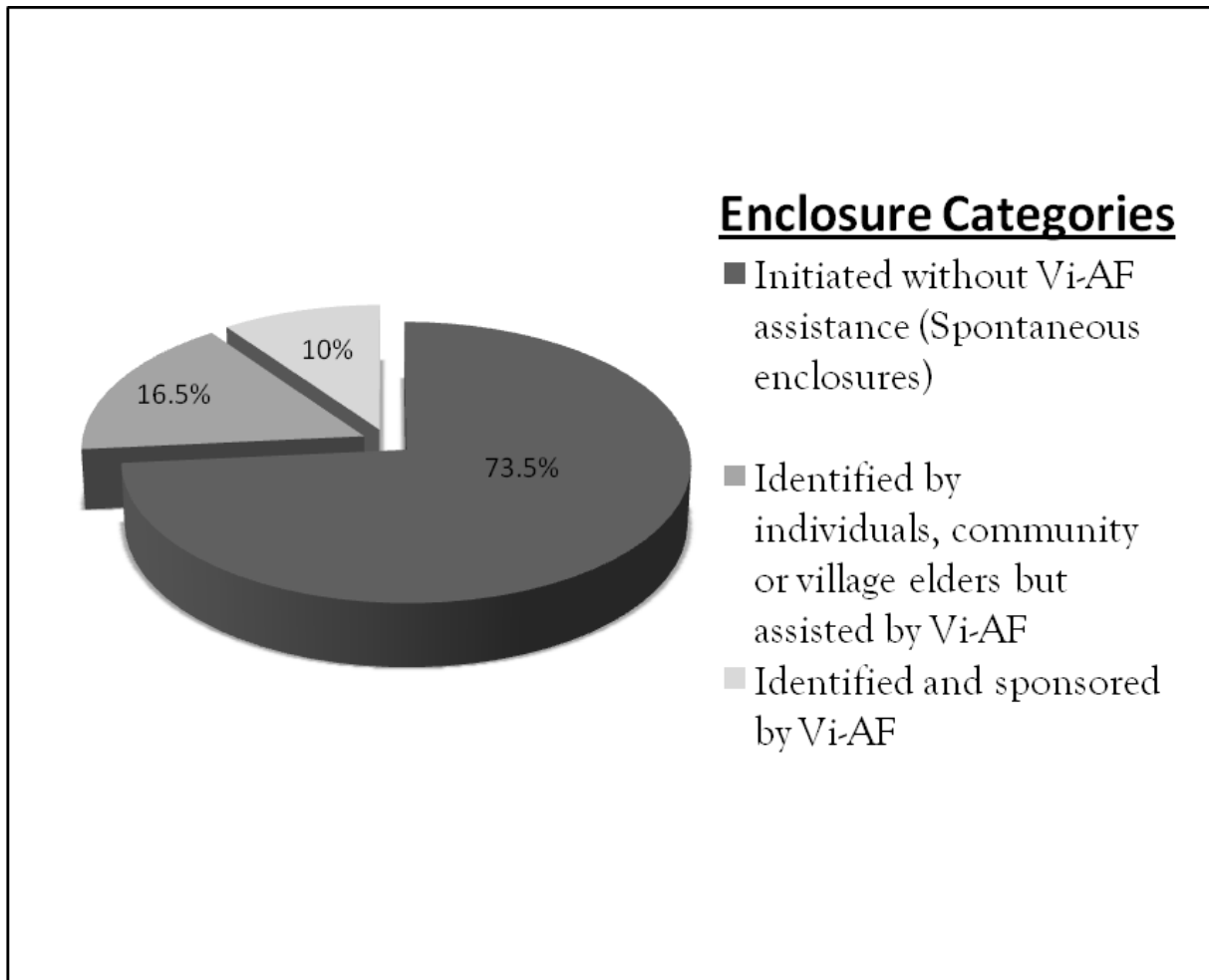


Figure 2.2 Enclosure categories owned by sampled households in Chepareria

Vi-AF was the main source of knowledge and information on enclosure establishment as indicated by (52.5%) of respondents who benefitted from the Vi-Tree Planting Project (Vi-TTP). Neighbours/community (27.5%), local leaders (22.5%) and parents (15.8%) were other common techniques of knowledge and information sharing on enclosure establishment in Chepareria. Other included field visits, government extension officers and other NGOs accounting for 2.5, 2.5 and 0.8% respectively as indicated in Table 2.3.

Table 2.3 Sources of information on enclosure establishment and management in Chepareria

		Responses	
		N=120	%
Sources of information/knowledge on how to establish enclosures	Vi Agroforestry	63	52.5
	Neighbours/community members	33	27.5
	Local leaders	27	22.5
	Parents	19	15.8
	Government extension officers	3	2.5
	Field visits	3	2.5
	Other NGOs	1	0.8

2.4.3. Reasons for enclosure establishment and sources of enclosure information

Results indicated that enclosures were mainly established for boundary demarcation owing to underlying tenure insecurity, preserve and properly manage livestock pasture and in order to properly manage land at 70.8, 65.0 and 52.5% respectively. With increasing adoption of agriculture, enclosures were also established to facilitate crop production (31.7%) either for subsistence or for sale. Being a previously degraded area; enclosures were also established to curb land degradation (26.7%) and gain diverse environmental/ ecosystem benefits and services (14.2%) as indicated in Table 2.4.

Table 2.4 Reasons for enclosure establishment in Chepareria

		Responses	
		N=120	%
Boundary demarcation/tenure insecurity		85	70.8
Preserve pasture		78	65.0
Proper/judicious land management		63	52.5
Enable crop production		38	31.7
Curb land degradation		32	26.7
Gain environmental benefits		17	14.2

2.5. DISCUSSION

2.5.1. History of enclosures in Chepareria

Rangeland enclosures in Chepareria existed even before interventions by Vi-AF through their Vi-TPP project which involved intensive extension on enclosure establishment and agroforestry. Our results indicated that although Vi-AF started operations in 1987, enclosures in Chepareria were established as early as 1967. This feature is supported by the fact that there are more than 10.8% of enclosures which were established before 1987 as indicated in Table 2.2. Similar results have been reported by Makokha et al. (1999) who observed that the Pokot people were using customary enclosures before the Vi-AF Project. According to Makokha et al. (1999) customary enclosures were mainly used for calves, milk cows and sick animals and for the cultivation of millet and sorghum, and these small areas were mainly enclosed with thorny branches. Due to their migratory lifestyle, these enclosures would be abandoned and new ones established in their next settlement area.

Makokha et al. (1999) recounts that the introduction of the group ranch management systems by the colonial administration changed the Pokot way of life (traditional system); in its place, this system confined animals to restricted areas in the name of disease control (Nangulu 2009). Previous studies indicated that this system was poorly coordinated (management), eventually leading to overstocking, overgrazing and land degradation (Makokha et al. 1999). It is then that Vi-AF through their Vi-TPP project started conducting intensive extension on enclosure establishment using demonstration sites in schools and churches, with an aim to address pasture scarcity and create stable environments for the local pastoral community (Kitalyi et al. 2002). Under the project, individuals were encouraged to use live-fences to control stocking density and enhance rotational grazing, plant trees and carry out grass reseeding (Svanlund 2014). Initially, the project worked in churches and schools which acted as demonstration plots. Once the project obtained the go-ahead from its members, the most degraded areas were selected and rehabilitation measures established.

Originally, the Vi-TPP worked on a top-down approach during the introductory years. However, successful rehabilitation of the demonstration plots saw more individuals interested in enclosing their land hence the transition towards demand-driven rangeland rehabilitation (Makokha et al. 1999).

The transition from the establishment of demonstration plots on public land to the establishment of spontaneous enclosures is estimated to have taken about seven years (1987-1994). Thereafter, Vi-AF conducted intensive extension on enclosures between 1995 and 2001 before phasing out the project in 2002. Enclosure categories were found to be significantly correlated to the age of household head ($p \leq 0.01$) with older households having older enclosures and which are likely to have been established or supported by Vi-AF.

2.5.2. Enclosure categories

Enclosures identified and sponsored by the project were established using the top-down approach due to the fact that the local community did not have confidence in the project and the results of the project were not definite. Similar results were reported by Makokha et al. (1999) who observes that under this enclosure category, a Plantation Management Committee (PMC) consisting of community members, local administration and project staff was constituted to ensure that the community was adequately informed of the project activities which were undertaken to the latter. Therefore, this enclosure category accounts for only 10% (Figure 2.2) of the enclosures and they served to introduce and convince the community that the technique being proposed was effective and worthwhile to adopt.

Enclosures identified by individuals, elders or the community but assisted by the project were established where a village elder or any other member of the community approached the project for assistance. If the request was accepted, the project would convene a *baraza* (a deliberation or reflection meeting held by a collective group of a people of wisdom) in which its role in the project would be discussed. Under this engagement, the community members would fence off the stipulated land while the project would hire casual labourers to prepare micro-catchments, plant tree seedlings and grass seeds. According to Makokha et al. (1999), individual owners of these lands were expected to take care of the enclosures for a minimum of three (3) years before allowing animals into the enclosure.

Enclosures initiated without Vi-AF assistance (spontaneous enclosures) were established after individuals witnessed successful rehabilitation of degraded lands in demonstration plots and improved enclosures in their locality. Previous studies in Chepareria have reported that Labour needs were met by family members or neighbours under the *sikom* - Pokot communal labour system in which the community assists one of its own to undertake a specific task which requires more labour than the family can provide-system (Makokha et

al. 1999). Fencing in this enclosure category was mainly achieved using dead branches cut from *Acacia nilotica*, although a few individuals planted live fences using sisal or euphorbia during the wet season.

It has been observed in previous studies that the transition from the establishment of enclosures in demonstration plots to the spontaneous enclosures took roughly 7 years after which Vi-AF was less active in the area (Makokha et al. 1999). Therefore, this category accounts for over half of the enclosure types in Chepareria (73.5 %) given that most enclosures were established after this period. Besides in Chepareria, the establishment of spontaneous enclosures has also been found to be on the increase in Lake Baringo Basin as described in previous studies by Mureithi et al. (2010) in Baringo County, Kenya. Generally, the proliferation of spontaneous enclosures indicates the success of Vi-AF land management approach in the rehabilitation of degraded rangelands in the area.

2.5.3. Sources of information on enclosure establishment

Vi-AF through their intensive extension on agroforestry and enclosure establishment accounted for 52.5% and was the main source of knowledge and information on enclosure establishment. Through observation or association with the project, individuals gained knowledge on how to establish rangeland enclosures and manage them as a land management approach.

Individuals also learnt how to establish enclosures by adopting what their neighbours were doing. Many of those who were not convinced by the Vi-TTP would later establish enclosures after witnessing the transformative ecological change within enclosed areas. These households hugely relied on the advice of their neighbours and community members when enclosing their individual farms. The role of local leaders and local level administrators was significant in not only technology extension but also in advising community members within their jurisdiction on how to enclose degraded areas. This is very crucial given that it's local leaders who were charged with the role of land demarcation and also served in the land committees.

Parents, as custodians of knowledge on enclosure establishment accounted for 15.8% of the various sources of knowledge/information. By training a new generation of enclosure owners and managers, parents have passed on knowledge on enclosure establishment and management to their children either through hands-on involvement or observation. When

their children inherit land, they are then able to use this knowledge when establishing their own enclosures. Other enclosure owners acquired knowledge from government extension officers, attending field or farm visits in other areas and through other NGOs as indicated in Table 2.3.

2.5.4. Reasons for enclosure establishment in Chepareria

There are combinations of factors which are attributable to the establishment of rangeland enclosures in sub-Saharan Africa (SSA). Previous studies by Forester (2002) and Behnke (1986) in Ethiopia and Sudan respectively have shown that there are diverse objectives for the establishment of rangeland enclosures in drylands. Our findings in Chepareria rangelands indicated that enclosures were established for:

Boundary demarcation

The enclosure movement in Chepareria was initiated by pastoralists to address pasture scarcity in the area and create stable environment for the local pastoral community. Similar results have been reported by Graham (1988) who observed that enclosures in East African rangelands are in some instances, initiated by pastoralists owing to the perception that good land is becoming scarce. Increased land degradation in Chepareria not only reduced the available good land but also increased pasture scarcity among the Pokot pastoral community.

While studies by Graham (1988) and McCarthy et al. (2003) have reported that rangeland enclosures in SSA are prevalent where privatization supported by the state or planners is believed to encourage a more responsible and rational use of the rangelands; we reiterate that the establishment of enclosures in Chepareria was driven the local pastoral community. In Chepareria, policies favouring the group ranch management system were highly disliked by the community; particularly after the exit of colonialists as the group ranch system was poorly coordinated hence leading to overgrazing and land degradation as cited by Makokha et al. (1999). With increasing evidence of the restorative success of rangeland enclosures within the demonstration sites, enclosures were increasingly established in order to lay claim to a demarcated area hence grazing rights. Similar findings were reported by Graham (1988).

The winding up of group ranch management in favour of individual landholdings created the impetus for increasing establishment of rangeland enclosures as a form of land

ownership in Chepareria. According to Makokha et al. (1999) individual landholdings created some degree of land independence and ownership of enclosed areas in Chepareria. Similar results have been reported by Saxer (2014). Our studies found that the observed success of rangeland enclosures in addressing pasture scarcity, restricted access to enclosed areas and a reduction of the available communal land, increasing establishment of enclosures to own land was also driven by the fact that the largest share of people were putting up fences because other people were putting up fences. Chances that those who did not enclose land would be left out in communal lands easily accessible by others or get the poor lands owing to allocation bias informed the spontaneous establishment of enclosures for boundary demarcation and land ownership.

Increasing tenure insecurity owing to spontaneous enclosure establishment, restricted access to enclosed areas and a shrinking resource base for pastoralists (communal land) saw more individuals interested in securing and managing private grazing and farming areas for various household needs. This could only be feasible if individuals had some form of *de facto* rights on the land hence the need for clarity on boundaries. In a previous study in Chepareria, Makokha et al. (1999) observed that the recognition of group ranch representatives as owners of the land as provided under Section 287 of the Land (Group Representative) Act allowed for all members of a group ranch to have an equal and undivided share of the ranch and any other group resource. It is against this background that private enclosures were developed and are still being developed as some land is still held under the group ranch/communal tenure regime in Chepareria as indicated in Table 2.1.

Pasture preservation

The Pokot community being a predominant pastoral community, rangeland enclosures in Chepareria were mainly established to address pasture scarcity in the area. The establishment of enclosures was seen a viable approach to enhance land management and create stable environments for the local pastoral community. Similar results have been reported by Makokha et al. (1999) who observed that pasture enclosures were established in order to provide grazing reserves during the dry season as communal grazing and livestock migration decreased. More so, similar findings were observed in Chepareria by Wairore et al. (2015a) who observed that rangeland enclosures in Chepareria have fostered increased flexibility in land use, fodder and livestock management hence enabling individuals to control grazing

throughout the year. Previous findings by Desta et al. (2013) and Wairore et al. (2015b) in Ethiopia and Kenya respectively have reported that through various enclosure management regimes, individuals are able to maximize on land use, ensure flexibility and provide fall-back options in the face of climate change impacts such as drought.

In the Cantabrian Mountains of Spain, similar results have been reported by Álvarez-Martínez et al. (2013) who observed that through increased flexibility in land, fodder and livestock management, rangeland enclosures are increasingly being used to manage livestock and control biomass. Using enclosures, individuals in Chepareria have been able to preserve natural pasture within their fields for dry season grazing. In the event that this reserve pasture is not required, individuals can choose to cut-and-carry this fodder and store it as hay. Similar findings have been observed in Ethiopia by Kindeya (Desta et al. 2013) who observed that the grazing reserves or protected pasture enables individuals to maintain livestock productivity during the dry season.

On the other hand, those with large enclosures also allow others, particularly those with small enclosed areas and large herds to graze in their fields at a fee in what is commonly termed as contractual grazing. Previous studies in Kenya and Ethiopia have reported contractual grazing as common practice amongst enclosure owners in East Africa (Makokha et al. 1999; Keene 2008, Beyene 2006, 2011; Mureithi 2015), one which would not be possible if the rangelands were still held communally (Keene 2008; Beyene 2010). Besides natural pasture, artificial reseeding involving the cultivation of high-yielding grass varieties such as *Chloris gayana* was also prominent, particularly in the wetter regions of Chepareria. Fodder production enables enclosure owners and by extension other community members to cope with drought since excess fodder can always be sold to those in need. The grass can also be cut and stored as hay and used as fodder in case of drought.

More so, crop residues are rarely sold but are stored to be used during the dry season or even drought. Previous studies in Ethiopia by Kamara et al. (2015), Abule et al. (2005) and Desta et al. (2013) have observed that the preserved pasture or fodder also provides strategic grazing fields for the lactating stock during the dry season, the young stock or is used for fattening bulls.

Proper/judicious land management

The establishment of enclosures was also observed to be due to an inherent need to manage and utilize land as individuals saw fit. Increased land degradation and pasture scarcity was attributed to increased overuse and mismanagement of the *free-for-all* communal fields in Chepareria. To fully exploit the land, individuals felt that they could better manage the vast lands if they were demarcated and boundaries established. Following the exit of the colonialists and the subsequent failure of the highly disliked group ranch management system, individuals seized this opportunity to wind up the group ranch management which was poorly coordinated in favour of individual landholdings; one which they had some degree of ownership, independence and control.

Previous studies amongst enclosures owners in Somaliland by Gaani (2002) and in Ethiopia by Keene (2008) and McCarthy et al. (2003) have shown that individuals felt that they could better utilize and manage the land if they owned it. However, in some instances as indicated by research findings by Keene (2008), the allocation of grazing commons to individual private holders is also common when the state believes or assumes that privatization through individualization will encourage a more responsible use of the land. While the elements of individual willingness and government support for the establishment of enclosures in the study area are evident; the bottom line here lies in the realization that, by establishing enclosures, individuals not only have independence in land management and utilization but also gain the accruing land use/management benefits as observed by Saxer (2014) in Chepareria.

Crop production

The significance of farming as a factor for the establishment of enclosures reiterates previous findings by BurnSilver (2007) and Galvin (2009) in East African rangelands who observed that cultivation agriculture is gaining popularity and spread among East African pastoralists today. Consequently, pastoralists cultivate where rain-fed or irrigated agriculture is a possibility. In Chepareria, two arguments can be made on the need to enclose land for farming. In the wetter regions, rain-fed agriculture is a major possibility as observed in the characterization of enclosure management systems in Chepareria by Wairore et al. (2015b). In these areas, market-oriented agriculture enables individuals to not only derive income but also produce diverse enclosure marketable products. In the lower altitude areas, agriculture is done on a subsistence basis.

Secondly, previous studies on enclosures in the area by Makokha et al. (1999), Wernersson (2013) and Karmebäck (2014) observed and reported that enclosures have reduced herding needs in amongst enclosure owners hence individuals have more time for cultivation. These findings are consistent with those of Galvin et al. (2002) which describe that the increasing human population coupled with a relatively constant livestock population have encouraged individuals to diversify their income streams. Consequently, the need for cultivation/crop farming is not due to a decline in benefits derived from the livestock enterprise or the need to lease out land to outsiders perceived to have better farming skills as stated in previous studies by Hogg (1997), Gebre (2004) and Ayalew (2009).

Curbing land degradation

The successful rehabilitation of the most degraded areas in the demonstration plots set up in schools and churches made more individuals interested in enclosing their land as they associated enclosures with rangeland restoration. While rangeland enclosures were not specifically established to curb land degradation in Chepareria; enclosures have increased flexibility in the management of land use, fodder and livestock hence enabling households to not only eke a living, diversify sources of livelihood but also address land degradation.

Our findings are similar to those of studies in Somalia which indicated that individuals still fence off most degraded areas within their own enclosures in order to protect them from indiscriminate use (Gaani 2002) while in Ethiopia, it is being done to curb land degradation (Forester 2002; WOCAT 2003; Nedessa et al. 2005; Napier and Desta 2011).

Diverse ecosystem services and environmental benefits

In Chepareria, the establishment of enclosures helped reduce communal use, regulate grazing and enhanced proper management of the enclosed areas which has fostered the recovery of formerly degraded lands. Increased vegetation cover has helped increase soil cover thus reducing losses of soil moisture through evapotranspiration. Increased soil cover has also been essential in facilitating improved water infiltration while reducing soil erosion. Increased litter deposition and carbon sequestration have also improved fertility hence increased productivity. Agroforestry practices have helped regulate the hydrological cycle, reduce wind and water soil erosion through their root binding action and increased rainfall induction.

Previous studies have reported that enclosure owners benefit from various ecosystem services including improved water infiltration and retention, soil fertility, shade and erosion control (Wasonga et al. 2011; Mureithi et al. 2010; Svanlund 2014). In fact, previous studies in Ethiopia have reported that ecological change is a key reason for the establishment of enclosures (Keene, 2008). As an integrated landscape approach, enclosures offer various environmental benefits such as soil stability, improved hydrological cycles, nutrients recharge and exchange and carbon sequestration on a landscape level (Scherr et al. 2012).

2.5.5. Rangeland enclosure tradeoffs- Have they shifted risks of land degradation from communal rangelands to private allotments?

While enclosures were not mainly established for land rehabilitation but to address pasture scarcity in Chepareria; the rapid ecological change witnessed within enclosed areas has proven that enclosures can be used as a management tool for the restoration of degraded rangelands. Similar results have been reported by numerous previous studies in SSA (Mekuria et al. 2007; Mureithi et al. 2010; Verdoodt et al. 2010; Mekuria and Veldkamp 2011; Mekuria and Aynekulu 2013).

Ecological restoration in the formerly degraded communal rangelands has been fostered by increased flexibility in land, fodder and livestock management as observed by Wairore et al. (2015b). While enclosures have been able to address land degradation, they have also reduced available communal land, increased land-based conflict within individual allotments, commoditized land, and created wealth stratification amongst households as observed in previous studies by Wairore et al. (2015a) in Chepareria. Ecologically, enclosures have significantly shifted risks of degradation from communal rangelands to private allotments by reducing available communal land hence restricting grazing to enclosed areas. Where grazing and intensive use of rangeland is not appropriately regulated; risks of land degradation within enclosed areas will be significantly high over time.

2.6. CONCLUSION

Rangeland enclosures in Chepareria existed long before land management interventions by Vi-AF. While enclosures were mainly established for boundary demarcation, alleviate pasture scarcity and foster proper land management; they have increased flexibility in land use, fodder and livestock management enabling households to restore degraded areas over time

and benefit from various ecosystem and environmental services. If the use and upscaling of rangeland enclosures is to be successful; technical interventions will have to be made to allow a more intensive use of rangeland resources. If this is not done, there are chances that land use fragmentation and management through enclosures will shift risks of degradation from previously communal rangelands to private allotments established through the enclosure movement.

2.8. REFERENCES

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CHAPTER THREE

Characterization of enclosure management regimes and factors influencing their choice among agropastoralists in North-Western Kenya

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Characterization of enclosure management regimes and factors influencing their choice among agropastoralists in North-Western Kenya

Wairore, J.N.^{1,2*}, Mureithi, S.M.^{1,2}, Wasonga, O.V.¹ and Nyberg, G.^{2,3}

¹Department of Land Resource Management and Agricultural Technology (LARMAT), University of Nairobi, P.O Box 29053-00625, Nairobi Kenya

²Triple L Research Initiative, Uppsala, Sweden

³Department of Forest Ecology and Management, Swedish University of Agricultural Sciences (SLU), 901 83 Umea, Sweden

*Corresponding author. Email: jwairore@gmail.com

Abstract

The enclosure system is an increasingly popular approach for land rehabilitation among communities inhabiting the arid and semi-arid lands in Africa. However, the mixed results associated with its adoption by households' calls for an in-depth understanding of the management regimes. This study was conducted in Chepareria ward in West Pokot County to characterize enclosure management regimes and determine factors which influence their choice among agropastoralists in Chepareria. Enclosures in were mainly used for livestock-based agropastoralism (78.3%) while crop-based agropastoralism accounts for 21.7%. The dominance of livestock-based enclosure management regimes indicates that livestock production is still the mainstay of agropastoralists in Chepareria while diversification of land use is common where rain-fed agriculture allows as evidenced by the adoption of crop-based enclosure regimes in the wetter regions. The choice of management regimes was mainly influenced by agroecological zonation and land tenure ($p \leq 0.01$), number of livestock owned and household income ($p \leq 0.05$). Enclosures were mainly established to alleviate pasture scarcity and create stable environments for the local Pokot pastoral community by restoring degraded rangelands. Enclosure management systems enable enclosure owners to maximize on land use, increase flexibility and provide fall-back options, particularly the adoption of alternative income generating activities amongst enclosure owners in Chepareria. Enclosure owners may continue to diversify or intensify enclosure management regimes as influenced by agroecological zonation, land tenure, number of livestock owned and household income.

Keywords

Agropastoralists; Enclosure; Rangelands; Rehabilitation; Triple L; West Pokot

3.1. Background

The use of enclosures is an increasingly popular approach for rehabilitating degraded lands in Africa. Land degradation remain, however, a key environmental concern globally, especially in the drylands which cover about 41% of the land area globally (MA 2005), 43% in Africa (AU-IBAR 2012) and 85% in Kenya (Kirui and Mirzabaev 2014). Drylands are home to more than two billion people in the world (Reynolds et al. 2007a); 90 percent of who live in developing countries (UNEP 2007). In Kenya, a county where up to a third of the its population directly depends on land that is already degraded or in the process (Bai and Dent 2006); the need to address land degradation in rangelands cannot be underestimated.

Previous attempts to rehabilitate/restore degraded rangelands globally (MA 2005; AU-AIBAR 2012) and in Kenya (Mureithi et al. 2010) have failed. However, enclosures have emerged as a successful management tool for the rehabilitation of degraded rangelands as evidenced by studies in East Africa (Behnke 1986; Gaani 2002; Nedessa et al. 2005; Mekuria et al. 2007; Keene 2008; Mwilawa et al. 2008; Beyene 2010) and in Kenya (Kitalyi et al. 2002; Wasonga 2009; Verdoodt et al. 2009, 2010, 2013; Mureithi et al. 2010; Opiyo et al. 2011; Kigomo and Muturi 2013).

In a bid to address land degradation as an emerging ecological and socio-economic challenge in Chepareria, Vi-Agroforestry (Vi-AF) organization conducted intensive extension on agroforestry and enclosure establishment in Chepareria (Makokha et al. 1999). The continuous adoption and adaptation of private enclosures since they were first introduced in 1987 was influenced by several factors, among them increasing land degradation and drought which resulted in general scarcity of good grazing (Makokha et al. 1999). Private enclosures were established to address land degradation by providing flexibility in land, fodder and livestock management including the adoption of alternative income generating activities (Wairore 2014)

Despite the general success of enclosure in rangeland rehabilitation, the variability of rehabilitation success in Chepareria (Makokha et al. 1999) and in Baringo rangelands (Verdoodt et al. 2010) has pointed out that individual management decisions play a critical role in promoting successful rangeland rehabilitation. There are observed difficulties in managing enclosed areas in Chepareria (Makokha et al. 1999), restoring vegetation in some private enclosures with lower biomass in Baringo (Verdoodt et al. 2010) and interpreting

already collected data on soil organic carbon (SOC) in Chepareria (Svanlund 2014) due to limited understanding of applied management systems. These difficulties have raised pertinent questions on the possibilities of presently rehabilitated rangelands reverting to their previously degraded state due to inappropriate private enclosure management systems.

A few studies have documented the management of private enclosures (Mureithi et al. 2010; Verdoodt et al. 2010). While these studies outlined the utilization of communal and private enclosures in the Lake Baringo Basin; there are increasing calls for further investigation on the applied past and present management systems of private enclosures in Chepareria (Svanlund 2014). More so, limited information exists on factors influencing the choice of enclosure management regimes/systems. In exploring enclosure management regimes and factors influencing their choice, we reiterate the concerns of Keene (2008) in questioning what could right holders do with their enclosures.

This chapter therefore seeks to characterize enclosure management regimes and identify factors which influence their choice among agropastoralists. This information will enable interpretation of already collected enclosure data, and may also be used as a guide to identify areas of action in decision making, management and the development of appropriate and productive enclosure management strategies to ensure that enclosed areas in Chepareria do not revert to their previously degraded state.

3.2. Study Area

The study site is located in Chepareria ward within latitude $1^{\circ}15'$ and $1^{\circ}55'N$; longitude $35^{\circ}7'$ to $35^{\circ}27'$ E in North-Western Kenya (Figure 3.1). The area has gently undulating plains surrounded by mountain ranges with peaks of up to 3000 meters. Rainfall in Chepareria averages 600 mm per year. According to the National Drought Management Authority (NDMA), Chepareria has a bimodal rainfall pattern, with a long rainy period between March and May and short rainy period from August to November (NDMA 2014). The average annual temperature in West Pokot County ranges from $15^{\circ}C$ to $30^{\circ}C$ in the highlands and $24^{\circ}C$ to $38^{\circ}C$ in the lowlands (County Government of West Pokot 2013).



Figure 3.1 Location of West Pokot County in Kenya

The soil types vary from shallow and friable in the lowlands to deep, well-drained, reddish brown sandy loams in the upper regions of Chepareria (Sposito 2013) while soil fertility varies from low to moderate (FAO 2006). The vegetation is mainly steppe-like, dominated by grasslands and interspersed native and exotic tree species. Some of the dominant native tree species include *Terminalia brownie*, *Balanites aegyptiaca*, and *Kigelia africana* among others while the introduced tree species include *Croton Spp.* *Azadidirachta indica*, *Grevillea robusta* and *Ficus Spp.* (Svanlund 2014).

According to the Kenya National Bureau of Statistics (KNBS), the population of Chepareria ward is approximately 42,000 persons (KNBS 2009). The Pokot community is the dominant tribe in the study area. Though originally a pastoral community, they have diversified into other forms of production to meet livelihood needs. There is a great variation in rainfall received (total amount and distribution) within the area influencing livelihood zones as indicated in Figure 3.2. Ywalateke location which is on the higher areas of Chepareria is mainly a mixed farming area while the lower areas of Chepkopegh and Morpus locations are agro-pastoral livelihood zones (Figure 3.2).

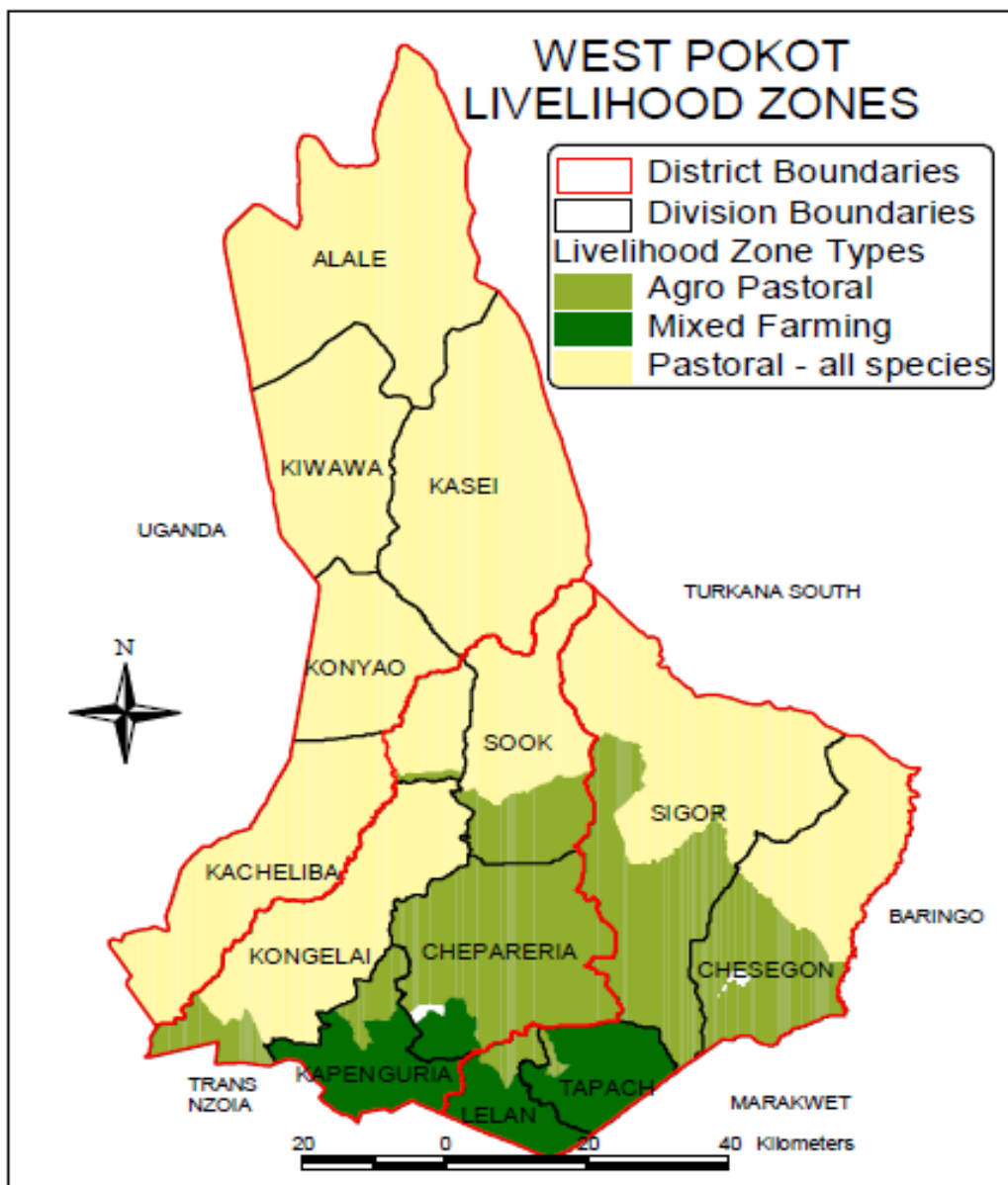


Figure 3. 2 West Pokot County livelihood zones
 Source: Drought Early Warning Bulletin – West Pokot County (NDMA 2014)

3.3. Enclosures in Chepareria

Many dryland areas in sub-Saharan Africa (SSA) have a history of overgrazing and land degradation resulting in low productivity, frequent droughts, conflicts over resources and marginalization (economic and political) of pastoral communities (Opiyo et al. 2011). The use of enclosures as a management tool for the rehabilitation of degraded rangelands in Chepareria and the Lake Baringo Basin has proven that it is a successful restoration approach/technique in drylands (Makokha et al. 1999; Mureithi et al. 2010). In Chepareria, enclosures were mainly established for land rehabilitation, fodder production, land and livestock management (Kitalyi et al. 2002).

Since 1987 when the enclosure were first introduced by Vi-AF to address land degradation and increase fodder production in Chepareria, the use of enclosures as a management tool has been high. By offering flexibility in fodder, land and livestock management; residents have not only been able to reduce land degradation but have also witnessed a transformation in livelihoods, land use and agricultural production systems (Wairore et al. 2014). Due to the continuous adoption and adaptation of enclosures witnessed in the ward, enclosures are now the dominant form of land management; one which is fostering agricultural systems diversification in the area.

3.4. Methods

3.4.1. Data collection

Purposive sampling was used to select Chepareria ward for this study. This is an area where NGO Vi Agroforestry conducted intensive extension on agroforestry and enclosure establishment in West Pokot County. The study was conducted in the three locations of Chepareria where Vi Agroforestry was active namely; Ywalateke, Chepkopegh and Morpus.

Using a checklist of more than 400 enclosures owners in each location, systematic random sampling was used to select 40 enclosures owners in each of the three locations in Chepareria ward to attain a sample of 120 households. A semi-structured questionnaire was used to collect data on household demographics, age of enclosure since establishment, the number and size of enclosure, enclosure income, enclosure management practices/regimes, enclosure ownership and distance from enclosure to tarmac and Chepareria market.

Focus group discussions (FGDs) and key informant interviews (KIIs) were used to complement the information gathered through the semi-structured questionnaire. Five KIIs and eight FGDs were conducted to clarify and give more insights on aspects of enclosure management, ownership/tenure, size and reasons for enclosure establishment. Literature review was used to contextualize the study while observation was critical in identifying the stated management systems.

3.4.2. Data analysis

The collected data were analysed using the Statistical Package for the Social Sciences (SPSS). Descriptive statistics were used to determine the applied enclosure management systems/regimes. The results were presented in forms of percentages, means/averages and standard deviations (SD). Further, Bivariate correlations were done to determine factors influencing the choice of enclosure management regimes amongst agro-pastoralists in the study area. The Pearson's coefficient two-tailed test of significance was used to detect significant correlations between enclosure management systems and the various hypothesized factors.

3.4.3. Description of factors hypothesized to influence the choice of enclosure management regimes

Agroecological zonation (AEZ). The humid and wet regions will support rain-fed agriculture hence crop-based enclosure regimes while the drier areas are more likely to support livestock-based management regimes. Agroecological zonation is hypothesized to have a negative effect on enclosure regimes.

Land tenure. Individuals with title deeds are more likely to adopt crop-based regimes while those still operating under the Group ranch scheme have livestock-based management system. Formalization of land tenure is hypothesised to encourage diversification in management regimes.

Age of household head (years). The age of the household head (HH) influences their access to education. It is therefore likely that age of household head will negatively influence management regimes in that the younger enclosure owners, in this case youths (18-35 years) will adopt improved and productive management regimes in a bid to diversify income derived from enclosure use.

Education level of household head. Education is an important entry point for the empowerment of pastoral communities. In enclosure management, the education level of pastoral households may be significant in identifying appropriate enclosure management systems for sustainable land management. Education plays a significant role in influencing household income, technology adoption and the socio-economic status of the family as a whole (Ejigu et al. 2009) and is hypothesized to positively influence enclosure regimes.

Livestock owned. The number of livestock in a household is likely to positively influence applied enclosure management regimes or systems. This hypothesis is likely to hold if there is a positive significant correlation between the number of livestock owned and total household income. Households with large herds will practice livestock-based agropastoralism while those with smaller herds are likely to adopt enclosure regimes with complementary or subsistence land use practices.

Enclosure acreage (ha). Households with large enclosure sizes are likely to practice livestock-based agropastoralism due to adequacy of pasture, particularly during the dry season. They are also likely to diversify income by engaging in other income generating land use options such as contractual grazing. On the other hand, those with smaller enclosures are likely to practice crop-based agropastoralism where rains permit. In areas with poor rainfall, they are likely to practice livestock dominated regimes with complementary crop and fodder production to supplement livestock pasture, particularly during critical grazing periods.

Distance to market (km). Households with proximity to markets are more likely to adopt market oriented production practices compared to households located far from such markets. It is hypothesized that distance to market will negatively influence enclosure regimes with those closer to the market practising market-oriented livestock or crop-dominated production practices.

Household income (US\$). It is hypothesized that rich households are more likely inclined to practice diverse land use practices than the poor since agropastoralists in the former do not find sufficient feeds for their large herds in times of grazing scarcity. Since this research was conducted in 2014, household income was determined based on the preceding year-2013.

3.5. Results

3.5.1. Household and enclosure characteristics of the sampled population

Most (73.3%) of the household interviewed were headed by males. The majority (42.5%) of the respondents were aged between 36 and 50 years. The respondents under 36 years made 37.5%, while those over 50 years made 20% of the sample. The majority of the respondents (56.3%) had attained basic primary education, while 8.4% had attained secondary education. Only 5.9% has attained post-secondary education. However, education is still a challenge as 29.4% of the respondents had not gone through formal education. The household had an average family size of 7 ± 3 (\pm SD).

The enclosure survey showed that 51.7% of respondents formally own the enclosed areas through title deeds or allotment letters. On the other hand, 48.3% of the respondents informally own land which is still held under the group ranch scheme. Most enclosures were established 16 years ago and have an average acreage of 5.01 ha. Other characteristics of sampled enclosures in Chepareria are indicated in Table 3.1.

Table 3.1 Characteristics of selected enclosures in Chepareria

Enclosure characteristics	Minimum	Maximum	Mean (SD)
Age (years)	0	47	16.17(10.98)
Distance to tarmac (km)	0	13.5	3.92(3.58)
Distance to market (km)	1	22	9.19(4.09)
Acreage (Ha)	0.4	24.38	5.01(4.38)
Number of livestock owned	1	42	7.85(7)
*Household income (US\$)	92.59	6273.15	1046.10(995.68)

*Exchange rate as at Dec. 31, 2013 was 1US\$ 86.40

3.5.2. Enclosure management regimes

Across the study area, livestock-based regimes were found to accounts for 78.3% while Crop-based regimes accounted for 21.7% of the sampled enclosures. Within the Livestock-based regimes: Grazing and cultivation; Grazing, cultivation and contractual grazing; and Grazing, cultivation and fodder production were found to accounts for 60, 13.3 and 5%, respectively. On the other hand, the crop-based agropastoralism was comprised of crop dominated Cultivation and grazing (21.7%) enclosure regime.

Although the introduction of enclosures has led to reduced migration with livestock and more sedentary lifestyles, the results shows that livestock production is still the mainstay of most agropastoral households in Chepareria as evidenced by the dominance of the Livestock-based enclosure regimes in Table 3.2.

Table 3. 2 Enclosure management regimes and practices in Chepareria

Location/Site	Frequency of enclosure management regime (%)					
	Livestock-based agropastoralism			Total	Crop-based agropastoralism	
	Grazing and cultivation	Grazing, cultivation and contractual grazing	Grazing cultivation and fodder production		Cultivation and grazing	Total
Ywalateke	30	13.3	13.3	56.6	43.4	43.4
Chepkopegh	66.7	15	3.3	85	15	15
Morpus	76.7	10	0	86.7	13.3	13.3
Average Chepareria ward	60	13.3	5	78.3	21.7	21.7

On location basis, Chepkopegh (85.0%) and Morpus (86.7%) locations were dominated by Livestock-based management regimes while crop-based enclosure regimes only accounted for 15 and 13.3%, respectively. Grazing, farming and contractual grazing regime was higher in Chepkopegh compared to Morpus at 15.1 and 10% respectively while Grazing and farming was higher in Morpus (76.7%) compared to 66.7% in Cheptiangwa. As opposed to the previous two locations, Ywalateke location was a mixed-farming area with livestock and crop-based management systems accounting for 56.7% and 43.3%, respectively. Farming and grazing regime accounted for the highest enclosure management system at 43.4% compared to Grazing and farming at 30%. Farming, grazing and fodder production and Grazing, cultivation and contractual grazing were practised equally in Ywalateke at 13.3% (Table 3.2).

3.5.3. Factors influencing the choice of enclosure management regimes

Of the eight factors hypothesized to influence the choice of enclosure management regimes among agropastoralists in Chepareria; only four factors (number of livestock owned, household income, agroecological zonation and land tenure) were significant as indicated in Table 3.3. A significant positive correlation exists between enclosure management systems and household income ($p \leq 0.05$) and number of livestock owned ($p \leq 0.05$).

On the other hand, a significant negative correlation between enclosure regimes and agroecological zonation ($p \leq 0.01$) and land tenure ($p \leq 0.01$) was detected.

Table 3.3 Factors influencing the choice of enclosure management regimes in Chepareria

Variables	Grazing and cultivation (N=72)	Grazing, cultivation and contractual grazing (N=16)	Grazing, Cultivation, and fodder/grass seeds production (N=6)	Cultivation and Grazing (N=26)	Mean	Pearson Correlation	Sig. (2-tailed)
No. of livestock owned	7.43	9.43	15.00	6.48	7.85	0.209	0.024*
Enclosure acreage (ha)	4.99	7.59	7.08	3.02	5.01	0.147	0.109
Distance to Market (km)	9.56	10.22	6.50	8.19	9.19	-0.11	0.22
Household income (US\$)	899.55	1145.33	1808.64	1214.90	1046.10	0.214	0.019*
Agroecological zone						-0.348	0.000**
Land tenure						-0.234	0.010**
Age of household head						0.064	0.486
Education level of the household head						0.068	0.461

Exchange rate as at Dec. 31, 2013 was 1US\$ - 86.40.

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

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

3.6. Discussion

3.6.1. Enclosure management regimes/systems

Enclosure management regimes showcase the various possible combinations of production practices carried out by individual enclosure owners on rehabilitated land. The presence of different enclosure regimes in the formerly degraded lands provided enclosure owners in Chepareria with the opportunity to enhance flexibility in fodder production, land and livestock management. This enabled them to ensure that restored areas do not revert to their previously degraded state, optimize on land-use and diversify livelihoods to cushion households from various climatic and market shocks.

Enclosure management regimes integrate various land use options or enterprises as enclosure owners attempt to optimize and diversify on land use, increase flexibility and provide fall-back options. Livestock-based management regimes are livestock dominated systems whose main objective is to support livestock production. They also integrated other complementary or subsistence land use practices to either support livestock production or were carried out for sustenance.

On the other hand, crop-based regimes were cultivation dominated management systems whose main goal was to produce food crops for own consumption or for sale. Similarly, they also integrated other complementary or subsistence land use practices.

Livestock-based enclosure management systems

Variations observed across the locations in the adoption of Grazing and cultivation enclosure management system can be attributed to climatic differences across the study area. Morpus and Chepkopegh locations occur on the drier, low altitude regions of Chepareria (Agroecological Zone (AEZ V), while Ywalateke location which is on the lower slopes of Kamatira hills occurs in AEZ IV. Climate variability and rainfall unpredictability impedes crop cultivation within the study area, except in Ywalateke location which is humid and receives more rainfall. Grazing and cultivation management regime was practiced by more enclosure owners in the drier locations of Chepareria namely: Chepkopegh (66.7%) and Morpus (76.7%) as indicated in Table 3.2.

The dominance of this enclosure regime in the drier areas of Chepareria was supported by previous studies which have observed that well managed livestock production is more adapted, economically and environmentally efficient in drylands (ILRI 2006; UNDP 2006; Neely et al. 2009). It also requires limited capital investment (Kandagor 2005). In Ywalateke, stable climate and higher rainfall in the mixed farming livelihood zone (Figure 3.2) enabled individuals to engage in intensive livestock and crop-based regimes hence it is only practised by 30% of Ywalateke residents.

The Grazing, cultivation and contractual grazing management regime indicated that pastoralists' are looking for possibilities to diversify their income as observed by Fratkin (2001). Contractual grazing represents a grazing arrangement between households with relatively few animals and those who are better off during the dry season hence creating access options to pasture for such households and income for the poor households (Beyene 2006, 2011). This enclosure regime reaffirms observations in previous studies which indicated that contractual grazing presents a new form of income generation amongst enclosure owners, one which would be impossible if the entire range was held communally (Keene 2008; Beyene 2010).

Chepkopegh location had the highest percentage of enclosure owners who lease grazing at 15% owing to the high potential of livestock production in the area. This was due to pasture availability owing to favourable climate for pasture production and the large enclosure sizes coupled with the recent developments such as the investments in a meat processing plant by the Kenya Meat Commission (KMC). Intensification of crop-based enclosure regimes such as maize production in Ywalateke had reduced the amount of land available for livestock-based regimes. Consequently, there is increasing demand for additional pasture which translates into high prices for contractual grazing. This tended to tempt some individuals into demarcating some parts of their enclosure for leasing out hence practiced by 13.3% of the residents in the location. Morpus location located on the lowlands of Chepareria is in AEZ V. Since the region is dry with erratic rainfall, most individuals choose to maintain pasture for dry-season grazing hence land use integrating contractual grazing was practiced by only 10% enclosure owners in this location.

Grazing, cultivation and fodder production management regime integrated rearing of improved breeds, cultivation of maize and beans, and cultivation of high-yielding grass varieties. This regime had been necessitated by two factors: (1) reducing availability of natural pasture due to increasing uptake of crop-based regimes in the wetter regions of Chepareria, and (2) intensification in livestock production (through improved breeds) and ready market for livestock marketable products, particularly milk. These factors necessitated households to practice fodder production in order to ensure sufficiency/stability in pasture availability and stability in milk production.

The regime was therefore prevalent in Ywalateke location (13.3%) located on the wetter regions of Chepareria. Notably, it was lowly practised in the drier areas of Chepareria by only 3.3 and 0% in Chepkopegh and Morpus locations. Under proper management it is possible to optimize Chepkopegh and Morpus locations in zone V to this regime. However, rainfall and inadequate finances to invest in capital intensive practices such as irrigation are key limiting factors hindering enclosure owners in the locations from practising it. Our results are similar to findings in previous studies which indicated that fodder production in enclosures not only enables enclosure owners to stock fodder for use during the dry season (Gaani et al. 2002; Desta et al. 2013; WOCAT 2013) but also presents opportunities for enclosure owners to earn income from sale of hay or grass seeds from the enclosure (Napier and Desta 2011).

Crop-based enclosure management regimes

Cultivation and grazing enclosure regime integrated intensive production of market-oriented crops and rearing of improved livestock breeds. Commonly cultivated crops within this regime included maize and beans. Individuals practising this regime tend to keep improved breeds which have higher productivity, particularly for milk and higher demand in the market due to their productivity (milk and meat). Pasture availability for those inhabiting the wetter regions of Chepareria (Ywalateke) supports livestock production in this regime.

This coupled with supplemental livestock feeds from crop residues maintains the production of livestock even during the dry period. It was therefore common in Ywalateke location (43.4%), which is a mixed farming livelihood zone (Figure 3.2) and can support rain-fed agriculture. The increasing practise of this regime in the wetter regions of Chepareria reaffirms the observation of others (BurnSilver 2007; Galvin 2009). They all reported increasing adoption of crop cultivation amongst pastoralists in East Africa who inhabit areas that can support ran-fed production.

3.6.2. Factors influencing the choice of enclosure management regimes in Chepareria

In Chepareria, enclosures were established to provide dry-season grazing reserves (Makokha et al. 1999; Kitalyi et al. 2002). Initially, enclosures were only used as dry-season fodder reserves while livestock were grazed in the open range during the rainy season. However, the continuous establishment of enclosures has reduced the available communal land hence restricting livestock grazing within individual enclosures only. With reduced communal and individual land holdings, the need to diversify and complement sources of household livelihood, particularly from land use amongst enclosure owners is gaining momentum.

While the dominance of livestock-based management regimes in our study reaffirms previous studies which report that enclosures in African rangelands were mainly established for livestock grazing (Gaani et al. 2002; Nedessa et al. 2005; Flintan 2011; Napier and Desta 2011; Desta et al. 2013); we have also observed agricultural diversification of land use among enclosure owners to include crop cultivation, contractual grazing and fodder/grass seeds production.

Agroecological zonation

The upper altitude areas with wetter climates supports more of rain-fed dependent production practices hence the higher proportion of crop-based agropastoralism management system in Ywalateke. On the other hand, livestock-based agropastoralism regimes dominate as you go down the rainfall gradient. Variable and unpredictable rainfall in arid and semi-arid lands (ASALs) of sub-Saharan Africa (SSA) continues to curtail meaningful crop-production through rain-fed agriculture. The dominance of crop-based enclosure management regimes in the wetter regions of Chepareria supports and reinforces observations in previous studies that reported increasing adoption of crop farming among East African pastoralists inhabiting areas that support rain-fed agriculture (BurnSilver 2007; Galvin 2009; Flintan 2011).

Land tenure

Land ownership or lack thereof influences how individuals use their land. In Ethiopia, enclosure establishment through rangeland privatisation by the state has been found to foster proper management and use of rangelands (McCarthy et al. 2003; Keene 2008; Napier and Desta 2011). It also offers independence in land management and utilization of enclosures in Somaliland (Gaani et al. 2002); and allow enclosure owners to practice what they wish with their land (independence) and gain the accruing benefits as is the case in Chepareria, West Pokot (Saxer 2014).

While most individuals in Ywalateke have title deeds those on the lower altitude areas (Chepkopegh and Morpus) still operate under the Group ranch system although land boundaries are delineated and they have allotment letters/numbers (Saxer 2014). Enclosure owners in Ywalateke are significantly practising crop-based management regimes compared to those in Chepkopegh and Morpus although livestock-based management regimes tend to predominate.

Livestock owned

Households with large herd sizes are likely to adopt Livestock-based management regimes in place of crop-based regimes. This can be explained by the underlying positive correlation between the number of livestock owned by a household and its income.

Household income

The observed positive correlation between enclosure management regimes and household income can be explained by the underlying correlation between household income and number of livestock owned. The rich households are more likely inclined to diversify land use options and by extension management regimes than the poor do since the former do not find sufficient feed for their large herds during the dry season. Wealth stratification not only influences enclosure regimes but also the decision to enclose land (Beyene 2010).

3.7. Conclusion

Enclosures were mainly established to address land degradation in Chepareria. However, the continuous adoption and adaptation of enclosures has also enabled agricultural diversification amongst enclosure owners as evidenced by the four enclosure management regimes identified. The dominance of livestock-based enclosure management regimes indicates that livestock production is still the mainstay of agropastoralists in Chepareria. More so, enclosure owners are increasingly engaging in crop-based enclosure regimes where and when rain-fed agriculture is possible for subsistence or for sale to satisfy existing market needs.

Since enclosure management regimes enables individuals to maximize on land use, increase flexibility and provide fall-back options; enclosure owners in Chepareria may continue to diversify or intensify enclosure management regimes. However, agroecological zonation, land tenure, number of livestock owned and household income are significant factors which will continue to influence the choice of management regimes among agropastoralists in the area. To ensure that restored areas in enclosures do not revert to their previously degraded state, there is a need for research to be conducted to identify the impacts of enclosure management regimes/systems on rangeland rehabilitation in Chepareria.

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CHAPTER FOUR

Impacts of enclosure age and management on herbaceous layer characteristics and woody species density in Northwestern Kenya

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Impacts of enclosure age and management on herbaceous layer characteristics and woody species density in Northwestern Kenya

John WAIRORE^{1,2*}, Stephen MUREITHI^{1,2}, Oliver WASONGA², Gert NYBERG^{2,3}

¹Department of Land Resource Management and Agricultural Technology (LARMAT), University of Nairobi, P.O Box 29053-00625, Nairobi, Kenya

²Triple L Research Initiative, Uppsala, Sweden

³Department of Forest Ecology and Management, Swedish University of Agricultural Sciences (SLU), 901 83 Umea, Sweden

*Corresponding author. (J. Wairore). E-mail address: jwairore@gmail.com

Abstract

This chapter assessed the impacts of enclosure age and management on the restoration of degraded rangelands by examining their effects on selected vegetation attributes between (open rangeland and enclosures) and within enclosures (management systems) in Chepareria drylands. Although the effect of enclosure age was insignificant, there were significant differences with respect to climatic seasons, enclosure establishment and applied management systems. Herbaceous species cover, diversity, aboveground biomass and woody species density were higher in enclosures than in the open rangelands. Among the different management regimes, grazing dominated (GD) regimes had the highest aboveground biomass ($688.2 \pm 860.7 \text{ kg DMha}^{-1}$) and plant species cover while cultivation dominated (CD) regimes exhibited low density of woody species ($2084 \pm 1517 \text{ plants ha}^{-1}$) due bush clearing practices common in cultivation systems. Contractual grazing (CG) regimes were characterized by low herbaceous species cover, high species dominance, lower species diversity and low herbaceous aboveground biomass indicating very high grazing densities. While vegetation attributes were mostly influenced by management, the large variability observed within management systems indicates variations in the intensity and success of enclosure management. This suggests there is room for improvement in management, particularly with regards to applied livestock grazing densities/intensities in rangeland enclosures.

Keywords: Herbaceous layer characteristics; land use change; enclosures; rangeland restoration; arid and semi-arid lands (ASALs); West Pokot

4.1. Introduction

In the wake of increased land degradation in Kenya's rangelands due to various anthropogenic influences (WISP, 2008; Li et al., 2011), various approaches to rehabilitate and restore degraded ecosystems are being employed (UNEP/GEF, 2002; RAE, 2004; Mureithi et al., 2010). Rehabilitation and restoration approaches seek to restore dryland's ecosystem services which have been lost due to land degradation through positive change in the interaction between people and ecosystems (MA, 2005). In Chepareria, a ward in the northwestern rangelands of Kenya, communities started to establish rangeland enclosures to restore degraded communal grazing lands about three decades ago (Makokha et al., 1999; Kitalyi et al., 2002). Initially, the inception of enclosures was driven by the need to address rampant land degradation in the area (Makokha et al. 1999; Kitalyi et al., 2002). Today, the continuous establishment of enclosures in the area is attributed to various factors including tenure insecurity, pasture scarcity and for judicious land management, among others (Wairore et al., 2015a). Besides West Pokot, enclosure have emerged as an effective management tool for the rehabilitation of degraded rangelands in other parts of the country as evidenced in various studies (RAE, 2004; Macharia and Ekaya, 2005; Wasonga, 2009; Verdoodt et al., 2010; Opiyo et al., 2011; Mureithi, 2012; Kigomo and Muturi, 2013).

Previously, enclosure management has been found to have an effect on the restoration of degraded semi-arid rangelands in Chepareria and in the Lake Baringo Basin in Kenya (Makokha et al., 1999; Verdoodt et al., 2013). Various case studies conducted in Chepareria have attributed the observed variations in herbaceous standing biomass (Makokha et al., 1999) and soil organic carbon (Svanlund, 2014) to the applied past and present enclosure management systems. In Lake Baringo Basin, there were observed difficulties restoring vegetation in some of the private enclosures which recorded lower aboveground biomass (Verdoodt et al., 2009, 2010). According to Verdoodt et al. (2013), the absence of empirical data on the applied enclosure management systems hampered interpretation of the restoration rate and success in enclosed areas. In this regard, there have been increasing calls for studies and treatment designs to focus on revealing the impacts of enclosure management systems and operations on rangeland restoration and rehabilitation in sub-Saharan Africa (SSA) (Moghaddam, 2000; Verdoodt et al., 2010, 2013; Svanlund, 2014).

Despite the fact that enclosures were started in Chepareria for almost three decades, empirical evidence on the effectiveness of private enclosures in restoring vegetation are lacking. Particularly, a clear understanding of the influences of enclosure management and age on herbaceous species cover, abundance, richness, dominance, diversity and aboveground biomass production in private enclosures is needed for tailoring effective management. This study assesses the impacts of enclosure age and management on herbaceous layer characteristics and woody species density in Chepareria, West Pokot County, Kenya. The study focussed on plant species cover (grasses and forbs), composition (relative abundance, richness and diversity), herbaceous aboveground biomass and density of woody species across enclosures of different ages and management regimes/systems.

4.2. Materials and methods

4.2.1. Study area

Chepareria Ward is located in Northwestern Kenya ($1^{\circ}15'$ - $1^{\circ}55'$ N and $35^{\circ}7'$ - $35^{\circ}27'$ E) in the lowland arid and semi-arid rangelands of West Pokot County (Figure 4.1). Average annual rainfall averages 600 mm per year (County Government of West Pokot, 2013). The rains are bimodal with two rainy seasons between March and May (long rains) and August and November (short rains) with dry seasons in between (National Drought Management Authority, NDMA, 2014). The average annual temperature in West Pokot County ranges between 24°C to 38°C (County Government of West Pokot, 2013). The altitude in Chepareria ranges between 1200 – 1600 m above sea level, although the area is surrounded by hills and mountains with peaks of up to 3000 m (Touber, 1991).

The soils vary significantly from rocky, moderately shallow to well drained soils (Sposito, 2013). Soil fertility also varies with parts of the lower altitude and drier regions of Chepareria having fragile and infertile soils (FAO, 2006). The vegetation is mainly acacia bushland with scattered native and exotic tree species.

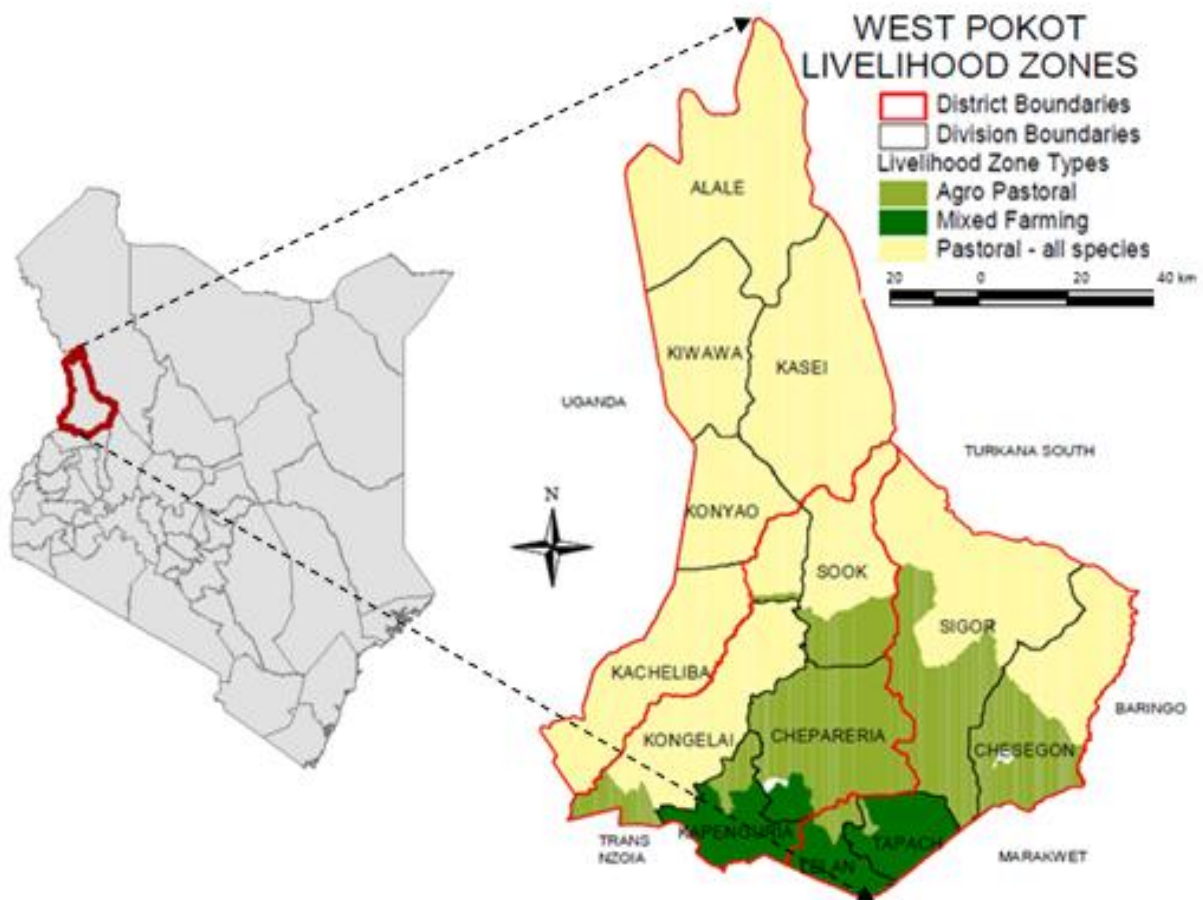


Figure 4.1. Location of West Pokot County in Kenya and to the right the main livelihood zones in West Pokot with Chepareria Ward inset (Source: National Drought Management Authority (NDMA, 2014)

4.2.2. Enclosure description and sampling

An enclosure refers to an area which is closed off from agriculture and grazing for a specified duration of time in order to allow natural or artificial regeneration of vegetation (Behnke, 1986). Before protection, the communal grazing lands in Chepareria were severely degraded supporting sparse unpalatable vegetation with little grazing value (Makokha et al., 1999). In a bid to provide stable conditions for the local pastoral community, Vi-Agroforestry (Vi-AF) embarked on a land rehabilitation programme that conducted in-depth extension on agroforestry and enclosure establishment in the area (Kitalyi et al., 2002). Initially, the project started by setting up demonstration plots in schools and churches before they received the go-ahead from the community to establish enclosures in the most degraded areas in private land. Upon witnessing vegetation regeneration and land restoration in the formerly

degraded sites, individuals started volunteering portions of their land for rehabilitation activities while others (with knowledge and experience from the project) started spontaneously establishing their own enclosures (Makokha et al., 1999).

The study was conducted in three administrative locations within Chepareria ward namely; Ywalateke, Chepkopegh and Morpus. These locations were selected due to their extensive enclosure system and the continued enclosure establishment witnessed in the areas to-date. A list of enclosures established since 1987 was obtained from Vi-Agroforestry and local administrators and grouped into three broad categories based on years since effective protection. From this, three age categories with age categories 0 – 10, 10 – 20, and ≥ 20 years were identified. Next, enclosures within the identified age brackets were visited to understand their utilization and management systems. The classification of enclosure management systems was informed by previous studies conducted to characterize enclosure management regimes/systems among agro-pastoralists in Chepareria by Wairore et al. (2015b).

Three key enclosure management systems were identified namely: Grazing dominated (GD); Cultivation dominated (CD) and Contractual grazing (CG) where individuals allowed others to graze on their enclosed land at a fee as observed by Wairore et al. (2015b). From each management system and age category, two enclosures were randomly selected for sampling of herbaceous species and woody vegetation. This was then replicated in each of the three selected locations in Chepareria to give 18 sampling enclosures per location ($n=18$, $3 \times 2 \times 3$) and 54 sampling enclosures in Chepareria ward ($n=54$, 18×3). Two reference sites per location for comparison purposes, herein referred to as open rangelands were randomly chosen from open communal grazing areas adjacent to enclosures and which were subjected to year round grazing by livestock giving a total of eight sampling points for comparison purposes ($n=6$, 2×3).

4.2.3. Vegetation sampling

To assess herbaceous species cover, relative abundance, aboveground herbaceous biomass, and diversity in rangeland enclosures and reference (open rangeland) areas, point-to-line transect method was used. Vegetation sampling was carried out at the peak of the wet (August) and dry (January) seasons in the 2014-2015 study period. Six 0.5 x 0.5 m quadrats laid at intervals of 10 m were placed along 60 m transect lines laid 5 m away from the boundaries to avoid edge effects. The herbaceous layer aboveground biomass was estimated

using the destructive method as described by T'Mannetje and Jones (2000). Grass and forb materials rooted within each quadrat were clipped at 2 cm above the ground level (clipping at grazing-height to give a more applicable measure of forage biomass) and their fresh biomass immediately weighed using to determine their aboveground fresh biomass and later oven-dried to a constant weight at 70 °C for 48 hours. Aboveground biomass production was expressed in kg ha⁻¹ on dry matter basis. Herbaceous layer (grasses and forbs) plant cover (Eq. 1) and relative abundance (Eq. 2) were assessed using the point-to-line transect technique (Brady et al., 1995). The density of woody species was assessed using the point-centred quarter method (PCQM) (Cottam and Curtis, 1956). Species dominance and diversity were computed using the Simpson's Index (D) (Eq. 3) and Shannon-Weiner Index (H') (Eq. 4) (Krebs, 1999). The following equations were used:

Percent cover of functional groups

$$\text{cover of life-form A (\%)} = \left(\frac{\text{no of hits of life-form A}}{\text{total no of hits}} \right) \times 100 \dots\dots\dots [1]$$

Relative abundance of functional groups

$$\text{relative abundance of functional group A (\%)} = \left(\frac{\text{no of hits of functional group A}}{\text{total no of hits of all species}} \right) \times 100 \dots\dots\dots [2]$$

Simpson's Index (D) of Dominance

$$D = - \sum \left[\left(\frac{ni(ni-1)}{N(N-1)} \right) \right] \dots\dots\dots [3]$$

Where: ni= number of each species (the ith species); N= total number of individual for the site

Shannon-Weiner index (H') of Diversity

$$H' = - \sum \left[\left(\frac{ni}{N} \right) \times \ln \left(\frac{ni}{N} \right) \right] \dots\dots\dots [4]$$

Where: ni= number of each species (the ith species); N= total number of individual for the site; ln= the natural log of the number

The determination of species dominance (D) was important in determining if establishment and management of enclosed areas positively affected the ecosystem. Species richness was computed as the total number of species per plot (Polley et al., 2005).

4.2.4. Data analysis

Statistical analyses were performed to test the influence of enclosure age and management on plant species cover, abundance, richness, dominance, diversity, herbaceous aboveground biomass and woody species density using two-way analysis of variance (ANOVA) in a randomized block design (RBD). Locations were used as random blocking factors to mask the climatic and pedological differences between locations hence illuminate the effect of enclosure management on selected vegetation attributes. Mean comparisons were made using the Fisher's Protected Least Significance Difference (LSD) test with $p \leq 0.05$. Two-way ANOVA was also used to test whether there is an interaction between the two main independent variables: age and enclosure management. All the analyses were conducted using GenStat 15th edition program.

4.3. Results

4.3.1. Herbaceous species abundance and woody species density

The relative abundance of herbaceous species was significantly different during the wet and dry seasons (annual grasses: $p \leq 0.004$; perennial grasses: $p \leq 0.001$; forbs: $p \leq 0.001$) and between management systems (annual grasses: $p \leq 0.001$; perennial grasses: $p \leq 0.001$). There were no significant differences in species abundance among the different enclosure ages. In general, the relative abundance of forbs (Table 4.1) was higher than that of annuals and perennials in both the wet and dry seasons. In terms of management, the relative abundance of annual grasses was significantly higher in the open rangeland compared to the enclosed areas. The relative abundance of annual grasses was significantly higher in CD when compared to GD and CG management systems. On the contrary, the abundance of perennial grasses was significantly lower in the open rangeland compared to enclosed areas while there were no significant differences within enclosure management systems.

Woody species density was affected by management ($p \leq 0.011$) and was higher in the enclosed areas than in the adjacent open rangeland. The Fisher's protected LSD test revealed that there was no significant difference in the density of woody species between the open rangeland and CD regime. Similarly, there was no significant difference in the density of woody species among the management regimes except between GD (3841 ± 3846 plants ha^{-1}) and CD (2084 ± 1517 plants ha^{-1}).

Table 4. 1 Effects of enclosure management and age on various vegetation attributes (Mean \pm SD) in Chepareria, Kenya

Vegetation	Communal grazing lands		Private Enclosures		
			Enclosure Management		
Attributes	^a Open rangeland	^b Grazing dominated (GD)	^b Cultivation dominated (CD)	^b Contractual grazing (CG)	
Cover (%)					
Bare ground	75.28 \pm 18.23 b	54.40 \pm 18.02 a	65.33 \pm 15.43 b	65.69 \pm 16.37 b	0.001
Annual grasses	13.72 \pm 10.49b	9.86 \pm 5.76b	10.53 \pm 4.73b	5.66 \pm 3.15a	0.001
Perennial grasses	2 \pm 1.30a	14.17 \pm 7.0c	8.90 \pm 4.84b	12.18 \pm 8.9bc	0.001
Forbs	8.99 \pm 6.48a	22.33 \pm 12.19b	14.80 \pm 9.6a	16.44 \pm 10.14ab	0.001
Relative Abundance (%)					
Annual grasses	56 \pm 5.61c	22.73 \pm 9.68a	32.87 \pm 11.66b	20.21 \pm 14.46a	0.001
Perennial grasses	9.1 \pm 2.34a	33.35 \pm 14.03b	26.63 \pm 9.10b	31.04 \pm 17.46b	0.001
Forbs	37.15 \pm 3.68	44.43 \pm 13.20	40.5 \pm 15.50	45.06 \pm 15.79	0.18
Species					
Richness	13.62 \pm 6.12	16.54 \pm 6.57	17.08 \pm 7.85	15.62 \pm 7.32	0.065
Dominance	0.44 \pm 0.03 b	0.41 \pm 0.05 ab	0.39 \pm 0.05a	0.44 \pm 0.06 b	0.012
Diversity	1.83 \pm 0.09 a	1.97 \pm 0.18 bc	2.038 \pm 0.15c	1.88 \pm 0.20 ab	0.004
Herbaceous aboveground Biomass (kg DM ha ⁻¹)	60 \pm 64.14 a	688.2 \pm 860.7 b	444.4 \pm 587.0ab	272.3 \pm 418.6 a	0.034
Wood species density (ha ⁻¹)	816a	3841 \pm 3846 c	2084 \pm 1517ab	3271 \pm 1625 bc	0.011

Means calculated from: ^an=6; ^b=18; P, Probability (significance detected at $p < 0.05$, highly significant at $p < 0.01$); SD, Standard Deviation; Means with different letters are significantly different.

4.3.2. Vegetation cover

Herbaceous species cover was highly influenced by enclosure management systems ($p \leq 0.001$). Of the three enclosure management regimes, GD regime recorded significantly lower bare ground cover while a significantly lower annual grasses cover was observed across CG management systems (Table 4.1). A significant difference in perennial grasses cover was observed between the open range and private enclosures. GD and CD management systems were significantly different in perennial grasses and forbs cover (Table 4.1).

4.3.3. Herbaceous aboveground biomass production

Herbaceous aboveground biomass differed across seasons (Figure 4.2) and enclosure management systems (Figure 4.3). The mean herbaceous biomass measured in the enclosed areas ($468 \text{ kg DM ha}^{-1}$) during both the wet and dry seasons was more than four times that of the adjacent open rangelands (60 kg DM ha^{-1}) (Figure 4.2). GD regime had the highest aboveground biomass ($688 \text{ kg DM ha}^{-1}$) and was significantly different from CD and CG management systems and communal grazing lands in the open rangeland (Figure 4.3).

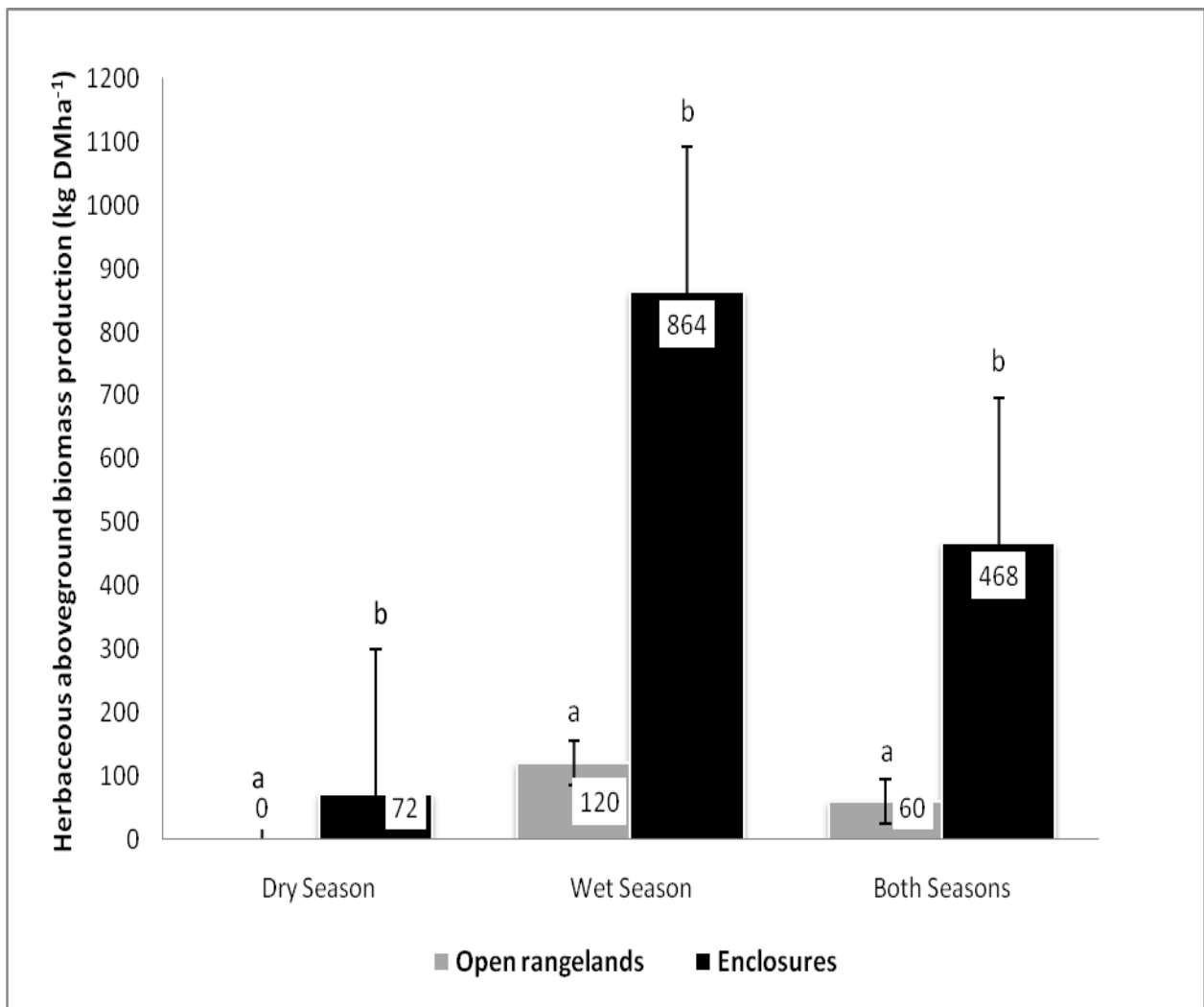


Figure 4.2. Effect of season and enclosure on mean (\pm SE) herbaceous aboveground biomass production (kg DMha^{-1}) of rangelands in Chepareria. Means are indicated within the bars, means with different letters within each sampled season are significantly different

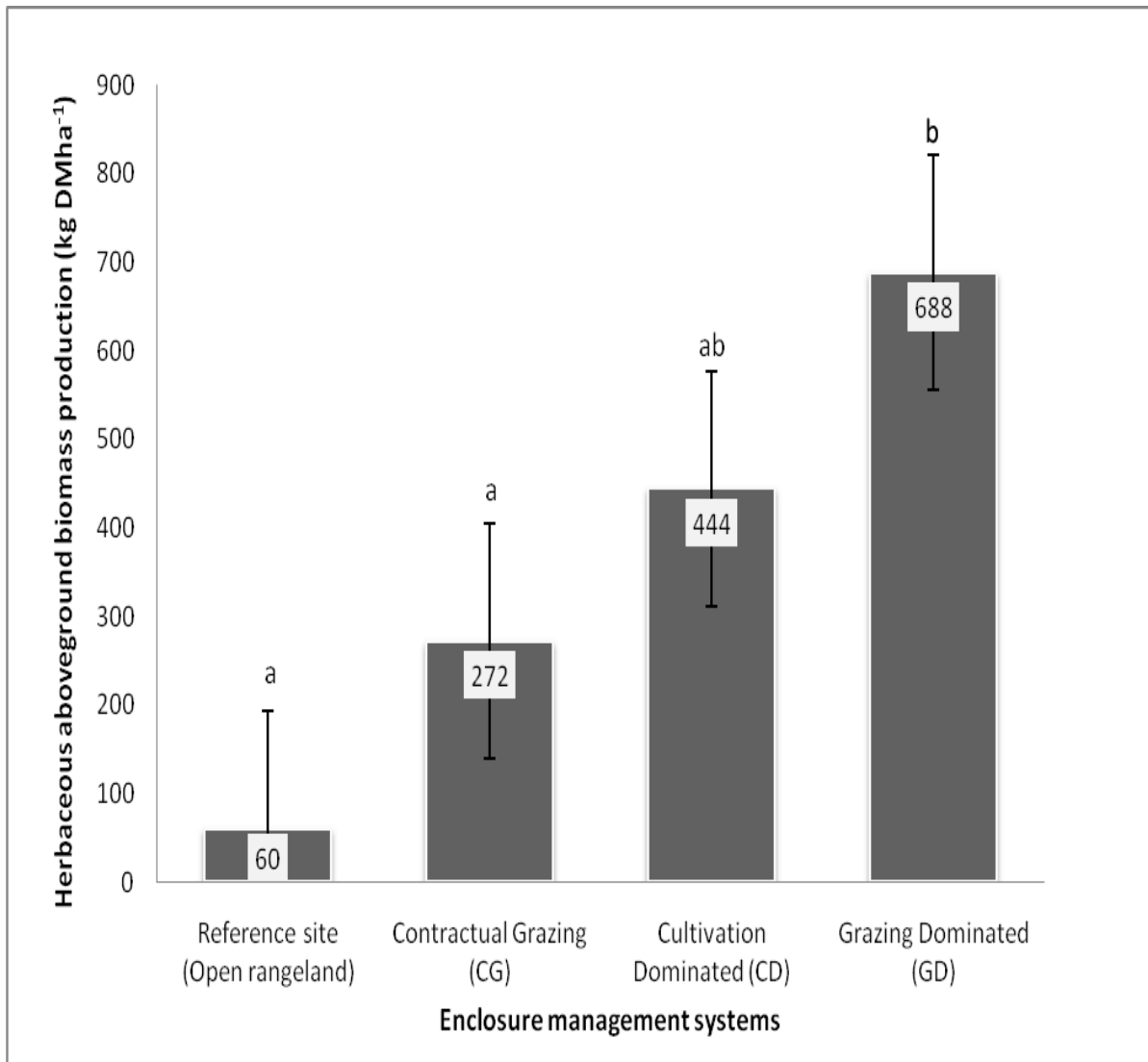


Figure 4.3. Effects of management systems on mean (\pm SE) herbage aboveground biomass production (kg DMha⁻¹) of enclosures in Chepareria (seasons combined); Means are indicated within the bars, management systems with different letters are significantly different

4.3.4. Plant species dominance, richness and diversity

Herbage species dominance was not significantly different between enclosures and open rangelands except between the communal grazing lands and CD management system. In terms of enclosure management, only CD and CG management systems were significantly different ($p \leq 0.001$) in herbage species dominance. This can be attributed to the significance difference in species diversity observed the two enclosure management systems as indicated in Table 4.1. Across the management systems (open rangelands, CG, GD and CD) species dominance reduced with increasing herbage species richness and diversity.

Species richness showed a significant difference ($p \leq 0.001$) between the wet and dry season, and the number of species recorded during the wet season was more than twice those recorded during the dry season. Species richness was significantly lower in the dry season but did not vary with management and age. Herbaceous species diversity was influenced by season ($p \leq 0.005$) and higher species diversity was recorded during the wet season compared to the dry season. Enclosed areas were more diverse than the open rangelands ($p \leq 0.005$). Within management systems, the lowest species diversity was recorded in CG regime which was significantly different from CD regimes which recorded the highest species diversity (Table 4.1). Overall, herbaceous species diversity increased with increasing species richness and decreasing species dominance.

4.4. Discussion

4.4.1. Herbaceous species abundance and woody species density

The significantly different annual and perennial grass species relative abundance between the open rangeland and enclosed areas is as a result of livestock grazing and human interference leading to overgrazing and rangeland overutilization. The end result is the higher degree of rangeland degradation in open rangelands as evidenced by the dominance of annual grass species, forbs and the higher bare ground cover compared to the higher dominance of perennial grasses in the enclosed areas. Similar results have been observed by Mekuria and Veldkamp (2012) in Tigray, Ethiopia. The dominance of annuals and forbs within communal grazing areas in the open rangelands indicates year-round grazing as observed in the Lake Baringo Basin of Kenya by Verdoodt et al. (2010). High grazing intensities leads to overgrazing of preferred and palatable species in the open rangeland and undergrazing of less palatable ones or emergence of grazing tolerant species, which then end up dominating the rangeland. Previous studies have observed similar results where high grazing densities in communal rangelands impose negative effects on vegetation cover thus eliminating the desirable and palatable species and giving rise to an increase in invader or increaser species, particularly forbs (Hosseinzadeh et al., 2010).

The density of woody species measured in the open rangelands was lower than that recorded in enclosed areas. In fact, the woody species density measured inside enclosures was more than twice that of adjacent open rangelands. These observations were attributed to overgrazing and heavy browsing, a common feature within the communal grazing lands of

African rangelands. These results are consistent with findings in northern Ethiopia which reported hampered rates of woody species recruitment in the heavily browsed and trampled communal grazing areas in SSA (Yayneshet et al., 2009 Mekuria and Veldkamp, 2012). Similarly, previous experimental studies reported severely limited woody species recruitment in communal grazing rangelands, particularly due to among other factors, seedling predation by medium-sized browsers (Moe et al., 2009) and hampered rate of shrub recruitment due to ungulate browsing in East African rangelands (Augustine and McNaughton, 2004). Within management systems, the immense need to clear trees and shrubs for the establishment of crop and pasture fields, particularly where land preparation is mechanized explains for the lower woody species density observed in the CD management regimes.

4.4.2. Vegetation cover

Enclosed areas had more plant species cover compared to the open rangeland indicating the impacts of high grazing densities on rangeland vegetation and the role of enclosures in rangeland restoration. Similar findings were reported by Hosseinzadeh et al. (2010) who observed that grazing intensities and animal transit within the communal grazing areas led to reduced vegetation cover and increased bare ground. The significantly higher perennial species cover in the enclosures compared to open rangelands indicates improved productivity of desirable species within enclosed areas compared to those in the open rangelands. This improved productivity is evidenced by the significantly higher perennial species cover and has previously been reported to indicate recovery of previously degraded areas as observed by Verdoodt et al. (2010) in Baringo County. Within enclosure management regimes, regulated grazing in GD regimes, particularly through paddocking accounted for the observed lower bare ground cover. Year round overgrazing recounted in CG regimes accounted for the higher bare ground cover and significantly annual grass species cover. GD and CG were not significantly different in perennial grass species and forbs cover reiterating the effect of livestock grazing on vegetation dynamics in rangelands. However, GD and CG exhibited significantly differential annual grass species and bare ground cover which can be attributed to the high grazing densities observed in the latter.

4.4.3. Herbaceous aboveground biomass production

Observed seasonal and site variations in herbaceous standing biomass in Chepareria supports observations of spatial and temporal variations in aboveground biomass production for non-equilibrium systems African rangelands (Ellis and Swift, 1988). Interestingly, there was no aboveground biomass recorded within communal grazing areas during the dry season. This supports observations in Table 4.1 that indicated higher annual grasses and forbs abundance. Since most of the herbage in the open rangeland were either ephemerals or annual grasses, they tend to “live fast” in response to rain, grow to maturity and complete their life cycle “die young” before the rains stop. This is described as an adaptation in the drylands, where you get more short-lived species as it becomes drier, and when water is not limiting, you find more perennials (IALC, undated).

Overall, enclosures in Chepareria had significantly higher aboveground biomass supporting observations in previous studies that indicated higher aboveground standing biomass in enclosed areas (Muchiru et al., 2009; Hosseinzadeh et al., 2010; Verdoodt et al., 2010). This reiterates findings by Álvarez-Martínez et al. (2013) in the Spanish Cantabrian Mountains which reported that enclosures are not only used to manage livestock but also as a strategy to control biomass. The heavy grazing densities in open rangelands and CG fields must have reduced the aboveground herbaceous biomass production hence the significant mean difference with GD regime. This supports observations that high grazing densities for extended time periods may reduce the productivity of the grazing resource in rangelands (Keya, 1998).

In terms of management, GD regime had the highest standing crop (688.2 ± 860.7 kg ha⁻¹) pointing to grass cutting and grazing strategies that seek to ensure pasture availability for their main source of livelihood and income. On the other hand, CG fields were constantly overgrazed hence ranked lowest in herbaceous standing biomass (272.3 ± 418.6 kg ha⁻¹) among the three enclosure management regimes.

4.4.4. Species richness and diversity

Rangeland enclosures had higher herbaceous species diversity compared to the adjacent communal grazing areas. These results support observations in previous studies which lower species diversity in open rangelands reiterating that disturbance, be it from livestock or

humans influences species diversity (Cumming, 1982). Our results of higher species diversity in enclosed areas have also been observed in Ethiopia (Aerts et al., 2006; Yayneshet et al., 2009; Mekuria and Veldkamp, 2012) and in Kenya (Oba et al., 2001). Overall, Mekuria and Veldkamp, (2012) indicated that increased species diversity in enclosure areas is one of the indicators of successful rangeland restoration in the formerly degraded communal grazing lands.

Enclosed areas recorded higher herbaceous species diversity compared to adjacent open areas which is consistent with findings that protected areas tend to develop higher plant species diversity compared to areas subjected to heavy grazing (Yayneshet et al., 2009). Areas with high grazing pressure, in the open rangelands and CG fields had developed significantly lower species diversity compared to GD and CD management regimes. Interestingly, enclosure age did not influence species diversity in Chepareria rangelands. These results are inconsistent with findings from other studies which reported that species diversity varied with years since effective protection-enclosure age (Oba et al., 2001; Asefa et al., 2003; Abebe et al., 2006). Various propositions can be made to explain these observations. We propose that the age classes (0 - 10; 10 - 20; ≥ 20) used were too large such that the differences were masked. Possibly, if we had smaller age classes (0 - 5 and 5 - 10 etc.) we could have seen significant differences. Similarly, plant species cover, abundance, richness and diversity are determined by a variety of factors besides years of protection, management systems and grazing pressure. Previous studies have shown that other factors such as precipitation, edaphic, environmental variables and site factors usually interact with grazing to determine species cover, abundance, richness or diversity (Milchunas and Lauenroth, 1993; Olff and Ritchie, 1998).

Although differences between management regimes were highly significant there were very large variability, i.e. $stdev > mean$ values, within respective management regimes. This does indicate that there is considerable variation in management intensity and success, suggesting that there is room for substantial improvement in management.

4.5. Conclusions

This study reiterates that climate/season and grazing management are the main drivers of plant community structure and changes in ASALs. By increasing flexibility in livestock and pasture management, enclosures have fostered rangeland restoration as evidenced by the

significantly higher herbaceous species cover, relative species abundance, dominance, aboveground biomass and woody species density in rangeland enclosures compared to reference sites in communal grazing lands. Within management regimes, the role of enclosures in not only managing livestock but also controlling herbaceous biomass production is evident. However, the large variability observed within management systems/regimes indicates variations in enclosure management intensity and success. This indicates that there is room for improvement in the management of rangeland enclosures, particularly with regards to applied livestock grazing densities/intensities.

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CHAPTER FIVE

Benefits Derived from Rehabilitating A Degraded Semi-Arid Rangeland in Private Enclosures In West Pokot County, Kenya

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Benefits derived from rehabilitating a degraded semi-arid rangeland in private enclosures in West Pokot County, Kenya

John N.Wairore^{1,2*}, Stephen M.Mureithi^{1,2}, Oliver V. Wasonga¹, Gert Nyberg^{2,3}

¹University of Nairobi, Department of Land Resources Management and Agricultural Technology, P.O Box 29053, 00625 Nairobi, Kenya

²Triple L Research Initiative, Uppsala, Sweden

³Swedish University of Agricultural Sciences (SLU), Department of Forest Ecology and Management, 901 83 Umea, Sweden

*Corresponding author's e-mail: jwairore@gmail.com

ABSTRACT

Rehabilitating degraded rangelands using enclosures offers various benefits to agro-pastoral households. However, enclosure benefits cannot be generalized as there are variations across dryland ecosystems and societies. This study assessed the qualitative and quantitative benefits derived from rehabilitating degraded rangelands using private enclosures in Chepareria, West Pokot County, Kenya. Dry-season grazing reserves, healthier livestock, improved livestock productivity, easier livestock management, food security, reduced animal losses, ecosystem services, land ownership, independence and improved standard of living were the main qualitative benefits from private enclosures identified. Quantitative benefits were manifested through various enclosure enterprise combinations, sale of enclosure marketable products and adoption of alternative income generating activities. They included the sale of livestock and livestock products, maize, wood cutting, grass cuttings, contractual grazing, grass seeds, poultry products, fruits and honey, among others. Livestock production directly accounts for 42.4% of the total enclosure income and is the main source of livelihood in Chepareria. There was a significant trend of increasing total enclosure income with enclosure acreage ($p \leq 0.05$) while enclosure age was insignificant. Enclosures cushion households against climatic shocks such as drought by providing additional flexibility in land, fodder, livestock management and the uptake of various income generating activities. We conclude that enclosures have the potential of contributing to resilience as attested from the benefits reported in this study. However, private enclosure tradeoffs such income differentiation, reduced communal land and conflict have implications on how the ecological and socio-economic aspects may be impacted as the establishment of private enclosures in Chepareria continues.

Key Words: Ecosystem services; Kenya; Land degradation; Livelihoods; Rangeland rehabilitation

5.1. INTRODUCTION

Land degradation reduces the capacity of the drylands to provide essential ecosystem services (Irwin & Ranganathan, 2007; Mekuria & Veldkamp, 2011). Land degradation, particularly on soils, the worst hit component of land degradation (Brevik *et al.*, 2015), deprives the soil of organic matter, hence reducing soil fertility and productivity in drylands (FAO, 2004). This increases food insecurity and poverty, thereby posing serious threats to livelihoods and biodiversity in drylands (Reynolds *et al.*, 2007). Therefore, combating land degradation is essential to guarantee sustainable and long-term productivity in the semi-arid environments. The establishment of enclosures is a common rangeland rehabilitation strategy in semi-arid regions of sub-Saharan Africa (SSA). Though there are few cases of successful rehabilitation initiatives in East Africa (Mureithi *et al.*, 2010); the successful restoration of degraded rangelands using enclosures in Chepareria and the lake Baringo Basin has created an impetus for increased enclosure establishment (Makokha *et al.*, 1999; Verdoodt *et al.*, 2010; Mureithi *et al.*, 2015).

Past research on enclosure benefits provides information on the qualitative benefits derived from restoring degraded rangelands in the arid and semi-arid lands (ASALs) of Baringo in Kenya and Alaba in Southern Ethiopia respectively (WOCAT, 2003; Mureithi *et al.*, 2015). Across the various studies and research projects, private benefits derived from enclosures were observed to continually attract individuals into establishing enclosures (Barklund, 2004; Bauer, 2005; Keene, 2008, Verdoodt *et al.*, 2010; Bayene, 2010; Napier & Desta, 2011). While these benefits have contributed to the spontaneous adoption and adaptation of rangeland enclosures in the region; variations exist across case studies with regards to the incentives and drivers for the establishment of rangeland enclosures (Behnke, 1985; Behnke, 1986). The observed variations influence the reasons and benefits derived from the establishment of enclosures by households. It is hence fundamental to understand the benefits derived by enclosure owners in the Northwestern rangelands of West Pokot County in Kenya.

Despite evidence of increased demarcation of common property grazing commons as communal range enclosures tend to gain momentum (Kamara *et al.*, 2004; Keene, 2008); there are limited studies on the benefits of rehabilitating degraded rangelands through private enclosures. Most studies on the benefits of enclosures have predominantly focused on the

qualitative benefits derived from rehabilitated rangelands in private and communal enclosures (Kitalyi *et al.*, 2002; WOCAT, 2003; Beyene, 2009), particularly on biophysical parameters such as soil carbon, vegetation cover and biodiversity. However, except for Mureithi *et al.* (2015) who assessed quantitative benefits derived from rehabilitating a degraded semi-arid rangeland in communal and private enclosures, studies on economic benefits are rare. Particularly, Mureithi *et al.* (2015) called for a need to assess the quantitative benefits derived from rehabilitating degraded rangelands in private enclosures.

This study assessed the benefits-qualitative and quantitative-of private enclosure establishment in Chepareria ward, West Pokot County in Kenya. It also sought to understand the socio-economic reasons for the continued expansion of private enclosures in order to contribute to the development of a cost-effective private enclosure management and utilization strategy. This is critical if scaling up/out of private enclosures is to take place in rangelands with similar ecological/ climatic conditions in SSA.

5.2. MATERIALS AND METHODS

5.2.1. Study area

Chepareria, a ward in West Pokot County (Figure 5.1), is situated in the northwestern rangelands of Kenya between latitude 1°15' and 1°55'N; longitude 35° 7' to 35° 27' E. The ward is located at the lower edge of the Kamatira hills and its Southern floodplains stretching far and beyond Mount Morpus. The area is gently undulating plain with an altitude range of 1200-1600 meters above sea level, and is surrounded with hills, ridges and plateaus with peaks of up to 3000 meters (Touber, 1991).

Chepareria ward experiences a profoundly seasonal climate common in most arid and semi-arid regions of SSA. Rainfall in Chepareria averages 600 mm per year, although it varies with altitude, hence influencing livelihood zones as indicated in Figure 5.1. According to the National Drought Management Authority (NDMA), Chepareria has a bimodal rainfall pattern, with a long rainy period between March and May (MAM) and short rainy period from August to November (NDMA 2014). The average annual temperature in West Pokot County ranges from 15°C to 30°C in the highlands and 24°C to 38°C in the lowlands (County Government of West Pokot 2013).

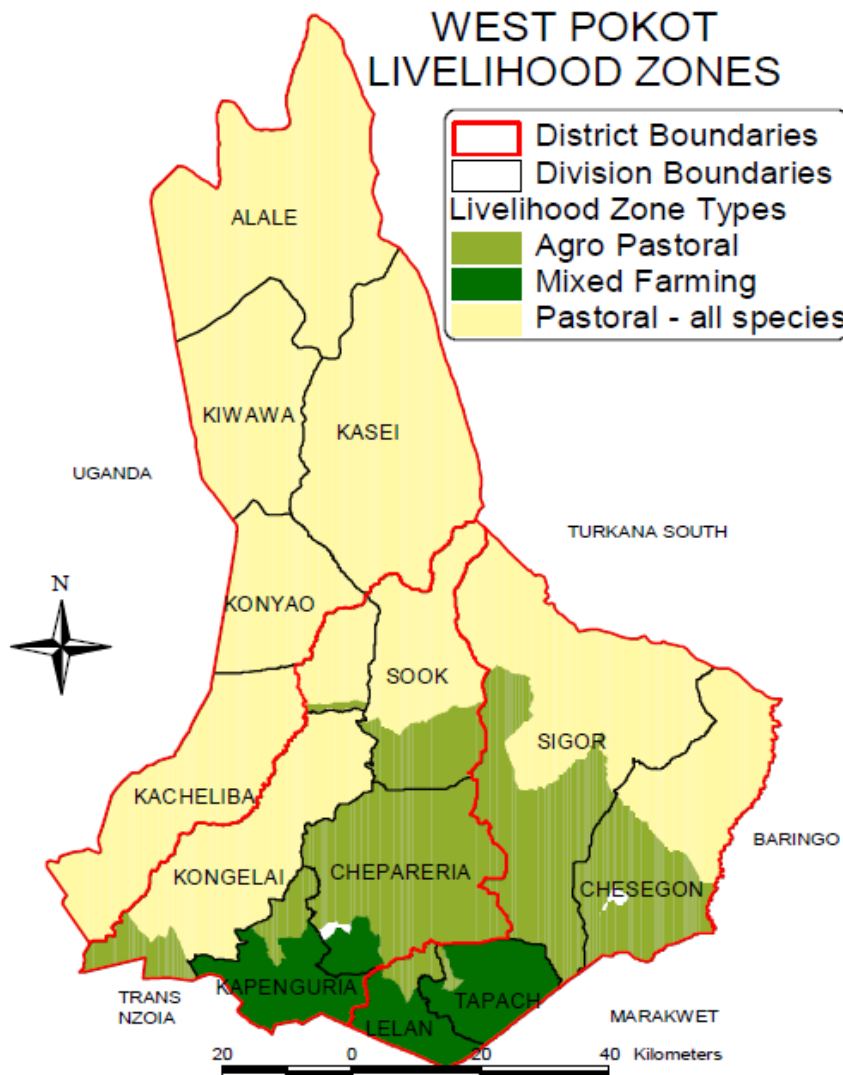


Figure 5.1. Location and livelihood zones of Chepareria ward in West Pokot County, Kenya (Source: National Drought Management Authority (NDMA, 2014))

Chepareria is primarily a metamorphic bedrock area, rich in ferromagnesian minerals. It is from this bedrock that rocky, moderately shallow, and well drained soils have developed (Touber, 1991; Sposito, 2013). Soils vary significantly across the study area with the lower altitude and more semi-arid areas of Chepareria generally having fragile infertile soils (FAO, 2006). Generally, the vegetation is steppe-like, dominated by grasslands with scattered native and exotic tree species.

Chepareria ward covers an area of almost 495 km², has a population of about 41,563 people, and is mainly inhabited by the Pokot ethnic group with a long history of nomadic pastoralism as cited by the Kenya National Bureau of statistics (KNBS) (KNBS, 2009). Traditionally, the Pokot moved with their animals from one area to another in accordance

with the seasons. This allowed their land to recover from grazing and other natural disturbances such as drought. However, the colonialists introduced border restrictions thus halting their migratory lifestyle (Nangulu, 2009). Restricted mobility meant that herds were restrained in limited areas and for prolonged period, thus leading to overstocking, overgrazing and poor management of natural resources. Changes in livestock grazing patterns led to massive land degradation in Chepareria. The NGO Vi-Agroforestry (Vi-AF) set up a land rehabilitation program in 1987 to address land degradation in the area. Working together with diverse stakeholders in Chepareria, Vi-AF introduced sustained changes in land management by establishing enclosures, starting with churches and schools as demonstration sites.

5.2.2. Sampling and data collection

Systematic random sampling method was used to select the locations and enclosure households to be sampled. Households to be sampled were selected based on their administrative location within the ward and the years since effective protection. Three locations, namely Ywalateke, Chepkopegh and Morpus were selected for this study. These locations represent areas where Vi-AF conducted intensive extension on enclosure establishment and agroforestry in Chepareria from 1987 to 1994. The extensive establishment of enclosure in these locations was informed by stable security, high population density and a high extent of land degradation. Systematic random sampling was used to sample forty (40) enclosure owners from each of the three administrative locations based on a checklist of more than 400 enclosure owners provided by the local administrators in each location. Some of the general characteristics of sampled enclosures are indicated in Table 5.1.

A total of 120 semi-structured interviews, five key informant interviews (KIIs), and eight focus group discussion (FGDs) were conducted to collect data on the study subject. Qualitative benefits were captured using semi-structured interviews, KIIs and FGDs while quantitative benefits were only captured using a semi-structured questionnaire.

Table 5.1. General characterisation of the selected enclosures

Variable	Classification	Sampled
Age (years)	≤10	45
	10.01 – 20	42
	20.01 – 30	33
Acreage (ha)	≤5	72
	5.01 – 10	30
	10.01 – 15	12
	15+	6
Administrative location	Ywalateke	40
	Chepkopegh	40
	Morpus	40

5.2.3. Data analysis

Data analysis combined both qualitative and quantitative approaches. First, field-notes were revised and similar information consolidated with the help of summary tables. This was important in identifying themes and concepts from the rich individual and group narratives. This information was then used to verify and confirm data collected using household semi-structured interviews, KIIs and FGDs. From all the data collected, the results were grouped into two distinct categories; the quantitative benefits [products/services that have immediate, tangible economic value or return] and qualitative benefits [improve the well-being/welfare of the individual household, community or society, but cannot be converted immediately into monetary value].

5.3. RESULTS

Private enclosure owners in Chepareria do not maintain utilization or sales records of the marketable products (goods or services) derived from their enclosures. Quantitative benefits from private enclosures were restricted to the preceding year–2013. This was necessary to reduce recall bias when quantifying such benefits from households. Due to their descriptive and intangible nature, private enclosure qualitative benefits were not time-bound.

5.3.1. Qualitative benefits

Private enclosure owners in Chepareria indicated to have benefitted greatly from the establishment of enclosures. Enclosure of previously communal rangelands had given them flexibility to engage in crop farming hence increase food production. With recurrent droughts and feeds shortage, private enclosures have given individuals increased flexibility in the management and usage of livestock pasture. They indicated that enclosures enabled them to preserve pasture for dry-season grazing hence reduced animal losses. Private enclosures have provided the framework for increased pasture availability, reduced livestock migration and easier livestock management. Consequently, individuals indicated improved livestock health and productivity (milk and meat). The increased need for land ownership has also been cited as a key reason for the establishment of private enclosures. Respondents indicated that enclosures have enabled them own land which they can manage appropriately and derived land use benefits. Within the formerly degraded rangeland, proper land management fostered by land ownership has been instrumental in addressing land degradation and increasing ecosystem/environmental services such as vegetation cover and reduced soil erosion. Individuals indicate that vegetation cover has greatly increased compared to other neighbouring areas without enclosures. The respondents indicated improved standards of living as they have diversified their livelihoods to include additional income generating activities (IGAs). This was attributed to increased flexibility in pasture and livestock management. Private enclosures have fostered changes in gender roles with both men and women, highlighting that they had time for alternative tasks and IGAs besides their traditional gender roles. Qualitative benefits derived from rehabilitating degraded rangelands using private enclosures in Chepareria are broadly classified under livestock production, crop production, land ownership and management, ecological change and environmental benefits and income diversification as well as improved living standards as indicated in Table 5.2.

Table 5.2. Reported qualitative benefits derived from rehabilitated rangelands in private enclosures in Chepareria

	Responses	(N=120)	%
Livestock production	Reserve grazing pasture	100	83.3
	Healthier livestock	81	67.5
	Improved livestock productivity	61	50.8
	Easier livestock management	53	44.2
	Reduced animal losses	48	40.0
Crop production	Enable farming	57	47.5
Land ownership and independence in land use	Land ownership	44	36.7
	Independence	36	30.0
Ecosystem/environmental services	Environmental conservation/benefits	34	28.3
Income diversification and improved living standards	Improved living standards	30	25.0

5.3.2. Quantitative benefits

Quantitative benefits derived from enclosures were classified based on various enterprises and IGAs supported by enclosures. These IGAs provide various enclosure marketable products which generate income and benefit streams. Some of the identified enclosure marketable products as per the IGA are indicated in Table 3. The resultant economic benefits of private enclosures were ranked based on their proportionate contribution to total enclosure income (Table 5.3). The total enclosure income increases with increasing enclosure age (years) and the enclosure area in hectares (ha) as indicated in Figure 5.2. The mean and standard deviations (SD) of enclosures varies across the three locations, ranging from 4.32 ± 4.54 , 5.62 ± 4.81 , and 4.50 ± 3.09 in Ywalateke, Chepkopegh and Morpus respectively. Average total enclosure income per hectare in the three locations ranged from US\$ 225.72 (± 157.27) in Ywalateke, US\$ 217.44 (± 204.06) in Chepkopegh and US\$ 170.06 (± 147.65) in Morpus. Interestingly, while Chepkopegh had the highest total enclosure income among the three locations; it ranked second on a per hectare basis. This can be attributed to the large enclosure sizes (ha) in the location.

Table 5.3. Quantitative enclosure benefits for selected households (HHs) in US\$ for 2013

Enclosure Enterprise	Income Generating Activity	Enclosure Marketable product sold	% of HHs which recorded sales in 2013	Average sold	^a Average sales price	Total enclosure income	Total enclosure income Per IGA	Total enclosure enterprise income	Enterprise income as a proportion of the Total enclosure income (%)	Enclosure enterprise income rank based on proportionate contribution to Total enclosure income
Livestock production	Livestock	Cattle (no.)	85.8	3	191.9	575.7				
		Shoats (no.)	86.7	11	37.4	411.4	987.1			
	Livestock products	Milk (litres)	15	327	0.3	98.1	98.1	1085.2	42.4	1
Crop production	Crop farming	Maize grains (bags)	34.2	16	36.1	577.6				
		Crop residue	0.8	-	-	23.1 ^b				
		Vegetables	2.5	-	-	28.5 ^b	629.2	629.2	24.6	2
Fodder and pasture production	Grass cutting	Thatching grass (backloads)	10.8	25	1.3	32.5				
		Hay (bales)	3.3	63	2.1	132.3	164.8			
	Contractual grazing	Pasture (ha)	12.5	7	19.3	135.1	135.1			
	Grass seeds harvesting	Grass seeds (kg)	1.7	37	1.7	62.9	62.9	362.8	14.2	3
Agroforestry	Wood Cutting	Firewood (backloads)	3.3	80	1.2	96				
		Fencing posts (no.)	0.8	-	-	92.6 ^b				
		Building poles (no.)	2.5	101	1.1	111.1				
		Charcoal (bags)	9.2	12	4.8	57.6	357.3	357.3	14.0	4
Poultry Keeping	Poultry production	Poultry (no.)	74.2	16	3.8	60.8	60.8	60.8	2.4	5
Fruits production	Fruits farming	Fruits	9.2	-	-	45.1 ^b	45.1	45.1	1.8	6
Bee Keeping	Bee keeping	Unpurified honey	0.8	-	-	19.7 ^b	19.7	19.7	0.8	7
Total			100					2560.1	100	

^aApproximate minimum sales price in US\$ at farm gate; Exchange rate as at Dec. 31, 2013 was 1US\$- 86.40. ^bUsed where the quantity sold and average sales price could not be determined.

NB. Quantitative enclosure benefits were only computed for those households that engaged in the indicated IGAs.

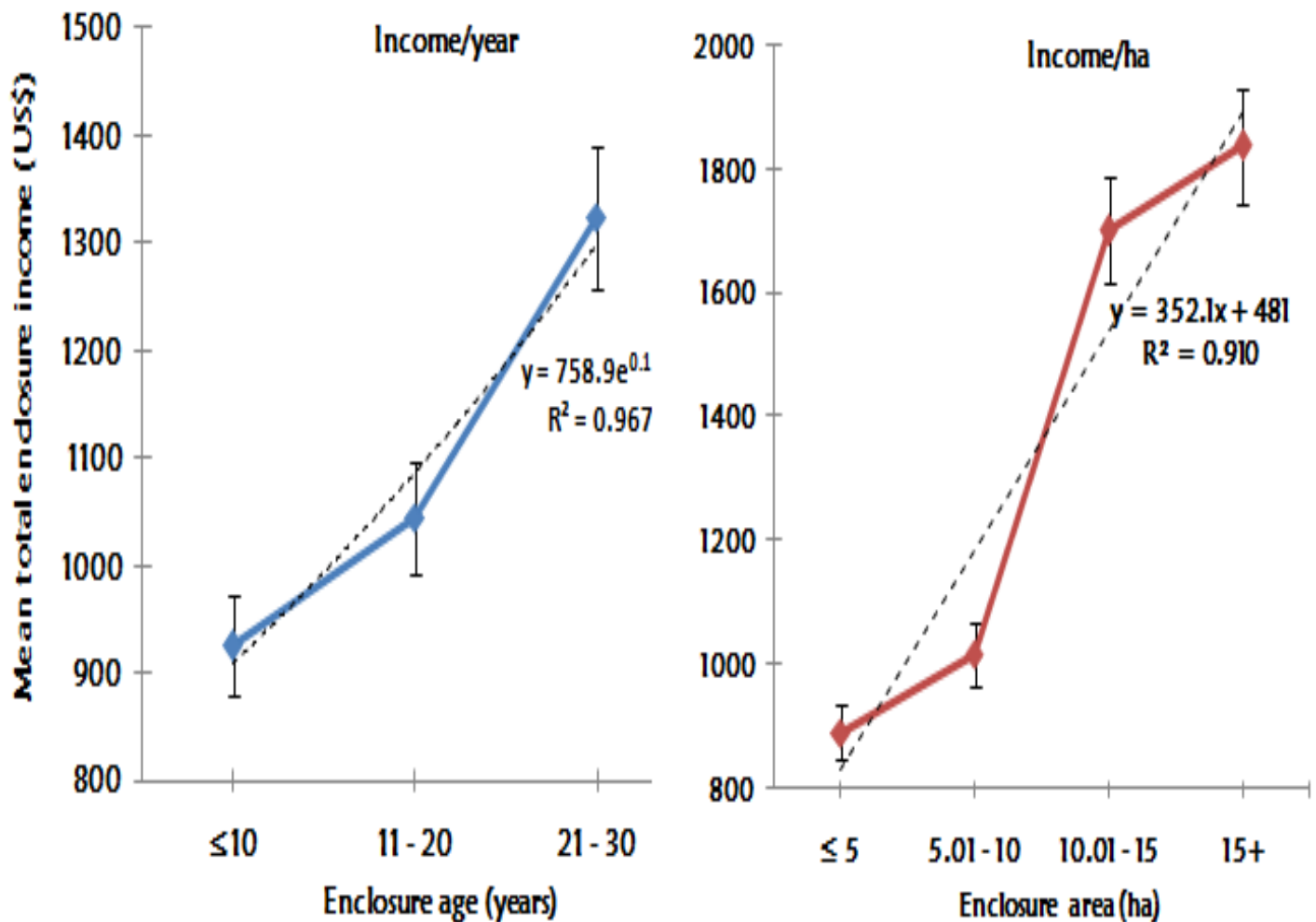


Figure 5.2. Effect of enclosure age and area on mean total enclosure income in Chepareria

5.4. Discussion

Livestock production

Previous studies have shown that enclosures are used to control grazing (Shang *et al.*, 2014), provide vital dry-season fodder reserve (Gaani *et al.*, 2002; Bayene, 2009; Desta *et al.*, 2013; Mureithi *et al.*, 2015) and where the grazing pressure is moderated, they can be used to restore degraded rangelands (Mekuria & Aynekulu, 2013; Papanastasis *et al.*, 2015). The reserved feeds are essential during the long dry season, especially for the lactating stock which is the core breeding stock (Kamara *et al.*, 2004; Abule *et al.*, 2005; Angassa & Oba, 2008; Keene, 2008; Desta *et al.*, 2013).

The availability of pasture throughout the year amongst enclosure owners in Chepareria has not only reduced the loss of animals but also enabled livestock improvement. Key informants indicated that enclosure owners have healthier and more productive animals in Chepareria due to pasture availability. Healthy animals have higher fertility and production rates, hence there is higher calving, lambing and kidding rates, which generally lead to faster herd building among individual households. Improved health can also be associated with reduced migration and movement needs of the animal as pasture is readily available. Enclosures in Somalia were found to be exclusively used for fattening livestock for export (Gaani *et al.*, 2002). Animals with access to good feeds provide more milk, lactate longer and are able to maintain their body condition.

Similar findings have been reported by Makokha *et al.* (1999) and Gaani *et al.* (2002) who observed that livestock within enclosure households are of better body condition and attain higher live-weight in shorter periods. Such animals have higher demand and fetch more money in the market. To ensure that overgrazing does not occur, most respondents indicated that they regulate grazing and animal densities within their enclosures. More importantly, those with smaller enclosures or large herd sizes tend to hire grazing lands from those who practice contractual grazing in the area. This, coupled with maintenance of grazing reserves and the use of crop residue as livestock feed helps avoid overgrazing and loss of livestock during the dry season or even drought.

More significantly, enclosures are facilitating easier livestock management as individuals can easily graze their livestock within paddocks on a rotational basis during the dry and wet seasons. In developed countries where the rate of vegetation is very fast after land abandonment, previous studies have shown that enclosures are not only used to manage the livestock but also as an alternative strategy to control biomass (Álvarez-Martínez *et al.*, 2013). Consequently, herding labour requirements have reduced as it is easier to monitor and manage livestock and pasture compared to grazing on the open range. This has influenced gender roles, hence enabling men to take part in other IGAs such as agriculture, businesses or casual jobs while enabling more children to attend school (Karmebäck, 2014). Particularly, her study indicated that the workload of women has increased under the private enclosure land management approach. Both men and women are increasingly engaged in alternative IGAs such as small-scale business. This has increased women's participation in decision-making, though they are still excluded from various traditionally male-dominated spheres, particularly financial control and leadership.

Economically, with the exception of other sources of household income such as employment (formal and informal), business (excluding sale of enclosure marketable products), remittances and income aid; livestock production accounting for 42.4% of the total enclosure income in Chepareria ranks highest in its contribution to total enclosure income associated with enclosure land use (Table 5.3). These results are similar to findings by Mureithi *et al.* (2015) who reported that livestock production accounts for 52 – 97% of the total enclosure income, depending on utilization and management systems adopted by enclosure owners in Baringo. This study found that livestock production enterprise through the sale of livestock and livestock products ranks first in its proportionate contribution to total enclosure income and practice by households as indicated in Table 3. These results are similar to findings by Wernersson (2013) and Saxer (2014) who reported that livestock is still the main measure of wealth and source of livelihood among the agropastoral community in Chepareria.

Though surplus milk was sold, most of the milk produced was consumed within the household, hence accounting for the observed low engagement in milk trade as an income generating activity of households (15%), low sales volume (327 litres per year) and accruing average income per year. Similar findings were reported by Makokha *et al.* (1999) in Chepareria, West Pokot County.

Crop production

Being an agropastoral community, crop production is a key feature of the Pokot community in Chepareria. Enclosures have enabled individuals to effectively take part in crop production, increase acreage and intensify food production. Studies in the arid and semi-arid rangelands of East Africa have shown that crop production is a necessity of East African pastoralists today, particularly where rain-fed agriculture permits (BurnSilver, 2007; Galvin, 2009). Similar to findings in other previous studies in Chepareria (Vi Agroforestry Survey, 2007; Wernersson, 2013; Awino Ochieng and Vera, 2014), the main crops grown are maize and beans while sorghum, millet and cassava are also cultivated. Bananas and mangoes in the wetter parts of Chepareria are essential fruit foods contributing to household nutrition security. The shift towards agropastoralism, commercialized maize farming, changes in dietary habitats and food preference have been accelerated by use of enclosures.

Economically, engagement in maize, crop residue and vegetable trade is low, although crop production ranks 2nd in proportionate contribution to total enclosure income. The 34.2% of households that can sell maize are mainly from Ywalateke location which is in one the more humid areas of Chepareria. In other locations, maize production is done on subsistence basis and the harvested grains if any are consumed by the household. We are in agreement with findings by Makokha *et al.* (1999) that the sale of crop residues is not common as maize stovers are mainly stored on top of *Balanites aegyptiaca* trees as fodder for livestock during the dry season hence the low engagement in crop residue sale by enclosure owners in Chepareria.

Ecological change, environmental benefits and agroforestry income

Previous studies have reported that productivity increase, environmental benefits and the desire to address land degradation are some of the reasons for the establishment of enclosures in rangelands (Makokha *et al.*, 1999; WOCAT, 2003; Keene, 2008; Mureithi *et al.*, 2010; Wasonga *et al.*, 2011; Svanlund, 2014). The establishment of “living fences” and intensive agroforestry within the formerly degraded areas has facilitated rapid ecological change in Chepareria. The simplest indicator of the ecological benefits of rangeland enclosures is the remarkable difference of vegetation cover/regeneration and soil health inside respective of outside the fence as reported by Mureithi *et al.* (2010) and Mekuria & Aynekulu (2013) respectively. The same transformational vegetative change has been observed in Chepareria and is reported in various similar studies as cited by Kitalyi *et al.* (2002) and Svanlund (2014).

Notably, the establishment of enclosures has diverse environmental benefits both at the site and landscape levels as reported in various ecological studies. Some of these benefits reported include reduced soil erosion (Descheemaeker *et al.*, 2006b; Napier & Desta, 2011), improved soil structure (Bronick & Lal, 2005) and fertility (Descheemaeker *et al.*, 2006a; Mekuria *et al.*, 2007; Mekuria & Aynekulu, 2013), soil water balance (Mureithi *et al.*, 2010) and restored soil biodiversity (Su *et al.*, 2005), notably, the soil micro-organisms essential in soil aeration. These features when combined with other landscape benefits such as regulation of the hydrological cycle lead to improved crop, pasture and animal productivity at household level.

However, it will become difficult to sustain the above mentioned ecological change and accruing environmental benefits if associated economic benefits of resource extraction practices such as wood cutting and charcoal burning are not harnessed. According to studies by Mekuria &

Aynekulu (2013), increased vegetation cover and woody cover was observed to be one of the factors contributing to improved soil within communal enclosures in Northern Ethiopia.

Currently, agroforestry through wood products ranks fourth on proportionate contribution to total enclosure income, though it is only practiced by a combined 15.8% of households (Table 5.3) indicating the intensity of resource extraction and incentives for their extraction. Although the sales of firewood, fencing and building poles and fencing posts are considerably low; they have significant economic contributions to a few households in Chepareria. Similar findings were reported in the Lake Baringo Basin by Mureithi *et al.* (2015) who observed that wood cutting with the exception of the sale of firewood accounts for approximately 7% of the total income. Species commonly used for fuel wood, poles and posts include *Acacia hockii*, *Acacia mellifera*, *Acacia nilotica*, *Terminalia brownii*, *Kigelia africana* and *Agave sisalana*. Of the various IGAs under agroforestry, charcoal burning will have detrimental effects on the environment and climate, particularly if the practice rises above the current 9.2% adoption by households.

Land ownership and independence in land use

Studies on rangeland enclosures in Somaliland reported that enclosures signify the *de facto* privatization of pastoral commons (Gaani *et al.*, 2002), insinuating the allocation of grazing commons to individual private owners. In this case, it arises where the state, elders and the community have embraced the individualization of land tenure. This is based on the assumption that privatization will encourage a more responsible use of the land, or where communal use/management of rangelands has led to range degradation (McCarthy *et al.*, 2003; Keene, 2008).

In Chepareria, land ownership through the establishment of private enclosures has increased flexibility in land use, enhanced freedom in land management and provided a framework for the management of vast rangelands. Though there exist various communal effects due to the establishment of private enclosure such as land-based conflict, reduced communal land and increased land prices, various studies have observed that land ownership and freedom in land use and management allows individuals to exercise and explore the various benefits and opportunities presented by individual land ownership and are important to the utilization and management of enclosures (Napier & Desta, 2011; Saxer, 2014). IGAs such as contractual grazing practiced by 12.5% of the respondents showcase opportunities presented by land ownership and independence in land use.

Income diversification and improved living standards

In Ethiopia, previous studies have reported that rangeland enclosures present opportunities for income diversification (Keene, 2008) while in Kenya they are themselves a form of diversification (Mureithi *et al.*, 2015). We are in agreement with findings by Little *et al.* (2001) that multiple IGAs are carried out within enclosures. In an attempt to obtain optimal benefits from rehabilitated rangelands using private enclosures, individuals are capitalizing on the increased flexibility provided by easier livestock management, reduced livestock migration and reduced herding needs to take part in alternative forms of livelihood. Opportunities for income diversification have also been enabled by changing gender roles in Chepareria as reported by Wernersson (2013). Shifts from conventional, traditional gendered roles by men with reduced herding needs have enabled them to participate in other IGAs such as business (trade in livestock, small-scale shops) and informal jobs. Women, on the other hand have taken up entrepreneurial duties to support family income and are increasingly participating in decision-making within the household as reported by Wernersson (2013) and Karmebäck (2014).

In other studies, households with access to communal enclosures have been found to enjoy improved livelihoods owing to diversified IGAs which have enabled them to complement household income (Kitalyi *et al.*, 2002; RAE, 2004; Mureithi *et al.*, 2010; 2015). According to Wernersson (2013) individuals with enclosure in Chepareria are gaining various economic benefits which have led to improved standards of living. In Lake Baringo Basin, it was found that communal enclosure owners had improved standard of living hence reduced need for food relief amongst (Makokha *et al.*, 1999; GoK, 2007). In Chepareria, some of the new IGAs that Chepareria residents currently engage in include:

Fodder and pasture production incorporates grass cutting, grass seeds harvesting and contractual grazing. This is similar to observations amongst communal enclosures owners in Lake Baringo Basin by Mureithi *et al.* (2015). Grass seeds harvesting is normally done before grass cutting for thatching, baling or cut-and-carry. Some of the grass seed species in the study area include *Chloris gayana*, *Enteropogon macrostachyus*, *Cenchrus ciliaris*, and *Eragrostis superba*. Despite its low adoption by households, it has the potential to grow given the increasing markets and demand for grass seeds. Grass cutting, particularly for thatching grass and hay is important as sources of fodder and household thatching materials. Trade in these enclosure marketable products is practiced by 10.8 and 3.3% of respondents, respectively accounting for 6.4% of the total

enclosure income compared to 1% observed in Baringo County by Mureithi *et al.* (2015). Common grass cutting and fodder species include *Chloris gayana*, *Themeda triandra*, *Eragrostis superba*, *Cymbopogon validus*, *Cenchrus ciliaris* and *Cynodon dactylon*. Contractual grazing is a key utilization of enclosures and is practiced by 12.5% of the enclosures owners who lease out an average of 2.8 ha per year. As indicated by Makokha *et al.* (1999), those who lease out their pasture tend to be enclosure owners with more pasture than their herds can make use of. They therefore tend to have large areas of rehabilitated land and comparatively few animals. On the other hand, renting pasture is a survival strategy for herds, particularly for those households with considerably large herds and less pasture.

Poultry production is a new IGA which is rapidly gaining importance in Chepareria. Its engagement by 74.2% of the households indicated increasing recognition of the IGA's capacity to contribute to food and income generation. While the sale of poultry was common in Chepareria households to cover basic needs, the sale of eggs is minimal as they are mainly used for household consumption. This is a key area which has the capacity for expansion in Kenyan rangelands given the fact that poultry income and income from the sale of eggs have not been estimated as described by Gichuki *et al.* (2000).

Fruit farming, particularly of mangoes, bananas, guava, avocados and pawpaw was common in the wetter areas of Chepareria such as Ywalateke location. Though the uptake of this IGA both for the market and household nutrition security is rising, capacity, limited access to markets, pest and diseases are major challenges.

Bee keeping is an IGA which is lowly practiced in Chepareria despite its huge potential, thus accounting for its' dismal ranking as an enterprise and IGA. Research by Kosgei *et al.* (2011) to assess the structure, conduct and performance of honey marketing in West Pokot District, Kenya, indicated that West Pokot County has huge potential for honey production, though the practice is significantly affected by education level, quantity and existing market prices for honey produced. Due to record keeping issues; there are no data on the amount of honey collected or sales price on kilogram basis.

Effects of enclosure age, area and location on total enclosure income

Previous studies have reported varying effects of enclosure characteristics on total enclosure income (Mureithi *et al.*, 2015). Owing to the observed variations in enclosure, general characteristics such as the years since effective protection (enclosure age), enclosure area (ha) and diverse geographical location; the effect of these variables on total enclosure income was determined. Research findings by Mureithi *et al.* (2015) reported increased enclosure income with time amongst communal enclosures owners in Baringo. Similarly, our findings indicated a non-significant trend of increasing total enclosure income with time amongst private enclosure owners in Chepareria. However, this study also observed a significant trend ($p \leq 0.05$, $n=120$) of increasing mean total enclosure income with enclosure area (ha) as indicated by a strong positive coefficient of determination of 0.910 (Figure 2).

Ywalateke, Chepkopegh and Morpus locations selected for this study exhibited significantly differential total enclosure incomes ($p \leq 0.05$, $n=120$). Climatically, Ywalateke is on the higher altitude regions of Chepareria ward and receives more rainfall than Chepkopegh and Morpus locations which are on the drier lowlands of Chepareria (County Government of West Pokot, 2013; Wernersson, 2013). Similarly, the higher altitude areas (Ywalateke) have fertile soils conducive for crop production compared to Chepkopegh and Morpus on the lowlands (FAO, 2006; Sposito, 2013). In terms of enclosure area (ha), respondents in Chepkopegh have larger enclosures compared to those in Morpus and Ywalateke locations.

Owing to the observed climatic, pedological and enclosure area/size differences, Ywalateke is mainly a mixed farming area while Chepkopegh and Morpus are agropastoral livelihood zones as indicated in Figure 5.1. Crop production, mainly maize cultivation, is highly practiced in Ywalateke while livestock production has slowly shifted towards intensive livestock production. This includes rearing improved breeds and the cultivation of high-yielding grass species (Makokha *et al.*, 1999). The high agricultural potential has reduced individual area holdings (acreage) due to increased subdivision and land sales hence reduced herd sizes. While enclosure sizes in Ywalateke are lower compared to those in Chepkopegh and Morpus; the location ranks higher on an enclosure income per hectare basis due to intensified crop production and improvements in livestock production, notably through improved breeds.

Chepkopegh location is mainly a livestock production area inhabited by agro-pastoralists with large enclosure and herd sizes. The establishment of a new Kenya Meat Commission (KMC)

abattoir in the location has encouraged livestock production to include improved livestock species and cultivation of high-yielding grass species for fodder production. Crop production is practiced where rain-fed agriculture allows. Increased dependence on livestock production insinuates frequent livestock and livestock product sales, hence accounting for the observed higher mean total enclosure income in the location.

Livestock production and subsistence crop production are the main livelihoods amongst agro-pastoralists inhabiting Morpus location. Though individuals have large farm sizes, livestock improvement is slow; hence most households retain a mixed herd of adapted local breeds and their crossbreeds. Subsistence cultivation of maize and beans food crops is practiced where rain-fed agriculture allows boosting household food security. Consequently, Morpus ranks lowest among the three locations in mean total enclosure income averaging US\$ 765 as indicated in Figure 5.2.

Negative implication of enclosure establishment-private enclosure tradeoffs

With increasing individual benefits derived from private enclosures, Chepareria has witnessed the continuous adoption and adaptation of enclosures as individuals seek to maximize, particularly on the quantitative benefits derived from private enclosures. Previous studies have documented that land management approaches such as enclosures have increased sedentarization, reduced available communal land and reduced pastoral mobility. These trends may have implications on the ASAL vegetation in Kenyan rangelands (Butt, 2010). Previous studies in Chepareria have reported increased conflicts associated with trespass and encroachments into private enclosures (Makokha *et al.*, 1999; Saxer, 2014; Wernersson, 2014). According to Keene (2008), trespass in communal and private enclosures is common where individual fences allow animals to pass through. Studies by Saxer (2014) in Chepareria observed that there is a new kind of conflict where individuals are brokering and selling other peoples land, especially in Ywalateke location although they are not the legitimate owners.

While there are no individuals without land in Chepareria, land sizes vary greatly depending on once initiative and enthusiasm during registration with elders for land demarcation and ownership (Makokha *et al.*, 1999). With the observed significant correlation between enclosure income and area (ha); individuals with bigger fields can be able to generate more income if they put the land to productive use. If individuals with smaller enclosure sizes need to lease grazing pasture, they can only do this from those who have bigger fields or those without animals. Consequently, stratification is emerging in Chepareria where individuals with large enclosure sizes or quality land

are better off compared to their immediate neighbours. Previous studies by Taylor (2006) in Inner Mongolia and Mureithi (2006) in Lake Baringo Basin reported that allocation bias in favour of large herders and allocation bias in the choice of land respectively leads to income differentiation and recipe for conflict by creating the haves and the have-nots situation. Overall, increasing fragmentation and registration of formerly communal rangelands in Chepareria reiterate findings reported on a study to examine the benefits of land registration for smallholders in Ethiopia by Yami & Snyder (2015).

Finally, we observed that most of the previously communal land in Chepareria has been demarcated and enclosed hence significantly reducing available communal land. Similar findings were reported by Makokha et al. (1999) who observed that although the land may not be fenced off; it belongs to someone and individuals are not allowed to graze their livestock there. As such, during the dry season, individuals can only hire land for contractual grazing or migrate to other areas such as Kongelai or Kacheliba wards in Pokot West Sub-County; wards which are still under communal land management, hence free for all.

5.5. CONCLUSION

The main rationale for the establishment of private enclosures in Chepareria was to alleviate pasture scarcity and create stable environments for local pastoral communities by restoring degraded rangelands. Rangeland rehabilitation through private enclosures provides additional flexibility in pasture and livestock management while providing a framework for the adoption of alternative income generating activities. Qualitative and quantitative benefits derived from rehabilitated rangelands through private enclosures enable households to address food insecurity, poverty and lack of complementary livelihoods common in agro-pastoral regions. Across the study sites, dry-season grazing reserves, increased livestock productivity, easier livestock management, crop cultivation, reduced animal losses, environmental benefits, land ownership, independence and improved standard of living are some of the quantitative benefits derived from rehabilitating degraded rangelands in private enclosures. Engagement in various IGAs has helped diversify livelihood and income sources. However, livestock production is still the mainstay of agro-pastoralists in Chepareria as observed in previous studies. Furthermore, enclosures were found to facilitate crop farming and the uptake of new income generating opportunities among residents. Overall, enclosures have the potential of contributing to resilience or offer pathways towards resilience as attested from the benefits reported in this study. Because of the revealed differential effects of enclosure characteristics such as age and acreage, and the existing private enclosure

tradeoffs; there is a need to develop cost-effective enclosure management strategies. This calls for a comprehensive cost-benefit analysis of private enclosure establishment and management in order to adequately inform the out-and up-scaling of enclosure management and diversification options.

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CHAPTER SIX

General Conclusion, Scope for Future Research and Implications for Practice

Influence of enclosure management systems on rangeland rehabilitation in Chepareria, West Pokot County

6.0. General Conclusions

6.1. Establishment, utilization, management and benefits of private enclosures

The continuous adoption and adaptation of enclosures in the semi-arid rangelands of Chepareria in West Pokot County, Kenya is driven and sustained by a combination of factors. This study showed that there are three categories of enclosures in the area which have been in existence for the last 30 years. These include; enclosures identified and sponsored by Vi-AF (10%) which corresponds to enclosures with above 30 years; enclosures identified by individuals, community or village elders but assisted by Vi-AF (16.5%) which corresponds to enclosures with 21 – 30 years; and enclosures identified without Vi-AF assistance (73.5%) which corresponds to enclosures established in the last 20 years. Enclosures were mainly established to demarcate boundaries, to preserve pasture, properly/judicious manage land, enable farming and to rehabilitate degraded grazing land. A shrinking resource base (land and pasture) driven by socio-economic factors (population increase, increased market based livelihoods and demand for land), biophysical factors (land degradation), climate change, improved pasture production in demonstration plots and state support (policies) account prominently for the enclosure adoption in Chepareria. The role of self-trigger (accounting for most of the spontaneous enclosures) indicates the continued establishment, proliferation and expansion of areas under enclosure management in Chepareria. Overall, the reasons for enclosure establishment were initially driven by conservation goals at the nascent stages of the project. However, with the continued success and sustainability; the reasons for enclosure establishment have rapidly changed from conservation to economic benefits oriented.

The utilization of enclosures in Chepareria was used to classify enclosure management systems/regimes and identify categories based on the dominant land use practices within private enclosures. Results indicated that there are livestock (78.3%) and crop (21.7%) dominated regimes whose adoption is influenced by agro-ecological zonation, land tenure, number of livestock owned and household income. Livestock dominated management regimes included: Grazing and cultivation; Grazing, cultivation and contractual grazing; and Cultivation, grazing and fodder production while crop dominated regimes included Cultivation and grazing. The dominance of livestock-based management regimes in the semi-arid rangelands indicates that enclosures were mostly established to provide livestock grazing reserves and enable pastoralists to cope with droughts. On the other hand, the presence of crop dominated regimes on the wetter regions points to the increasing recognition and uptake of alternative land use and livelihood strategies in order to diversify household income. Generally, enclosure management regimes enable households to maximize on land use, increase flexibility and provide fall-back options.

To understand the influence of adopted enclosure utilization and management practices, a study was conducted to assess the impacts of identified management systems on plant species cover and composition, diversity, aboveground biomass production and woody species density. Results indicated that rangeland rehabilitation within enclosed areas in Chepareria is mostly influenced by management, which is in-turn influenced by utilization and land use practices employed by private enclosure owners. Enclosure age did not influence various vegetation attributes investigated in this study. Overall, plant species cover was higher in private enclosures than in the communal grazing lands (open range) while bare ground was higher in the open range. Open areas exhibited higher relative abundance in annuals reiterating the effects of overgrazing in communal grazing areas. Plant richness and diversity were also influenced by management and varied considerably within the various management systems. The standing crop was significantly higher in the private enclosures compared to the communal grazing areas. The density of woody species also varied significantly across management regimes and was lowest in cultivation dominated (CD) regimes due to frequent deforestation for the establishment of crops and pasture fields by agro-pastoralists. This study concludes that under appropriate management, private enclosures are effective in rehabilitating degraded rangelands in Chepareria.

Finally, the study assessed the benefits derived from rehabilitating degraded semi-arid rangelands using private enclosures. This was significant to tie the identified reasons for enclosure establishment, utilization practices and management regimes to wider household, environmental

and economic benefits. The qualitative benefits derived from private enclosures included: pasture conservation by establishing dry-season grazing reserves, healthier and improved livestock performance, easier livestock management, crop production, reduced animal losses, environmental/ecological benefits, sign for land ownership, independence in land use and improved standards of living. On the other hand, tangible (quantitative) benefits were manifested through various enclosure enterprise combinations, income generating activities and diverse marketable products from enclosures. They included sale of livestock and livestock products, maize, wood cutting, grass cuttings, contractual grazing, grass seeds, poultry products, fruits and honey among others. Qualitative and quantitative benefits derived from rehabilitated rangelands through private enclosures enable households to address food insecurity, poverty and lack of complementary livelihoods common in agro-pastoral regions. While the adoption of various IGAs has assisted diversify livelihood and income sources, livestock is still the main source of income. Overall, enclosures have the potential of contributing to resilience building against land degradation in dryland ecosystems or offer pathways towards resilience as attested from the benefits reported in this study.

6.2. Scope for Future Research

This study has concluded that private enclosures are an effective tool for the management of degraded lands. However, proper and appropriate management of enclosed areas is critical to foster successful restoration and rehabilitation of degraded rangelands. Some of the recommended areas of future research are:

- a) A detailed cost-benefit analysis (CBA) of enclosure establishment is needed to inform the management and up-scaling of areas under enclosure management.
- b) The continuous adoption and adaptation of enclosures in Chepareria has been seen to reduce the available communal land and restrict access to communal resources such as watering points and salt licks. There is need for research to focus on the consequences of enclosure establishment, the gainers and losers in this rangeland rehabilitation approach.
- c) The need for sustainable and climate resilient agricultural practices/pathways cannot be overstated in the face of climate change. In this regard, a need assessment study to focus on the adopted and potential climate-smart agricultural (CSA) practices in Chepareria should be conducted.

- d) Further research could also focus on contractual grazing, its dynamics and regulation within private enclosures in Chepareria. This study has indicated that enclosed areas under contractual grazing (CG) regimes are overgrazed, local mechanisms for its regulation are unclear, and payments options are varied.
- e) Lower herbaceous biomass production under various woody species calls for a detailed study of the choice of woody species by private enclosure owners in Chepareria to ensure that trees with allelopathic effects are avoided in pasture enclosures.
- f) With the observed continuous adoption and adaptation of enclosures in an area where livestock is still the main source of livelihood, there is need to determine and model existing grazing systems, intensities and density in private enclosures and their effect on range condition and trend within enclosed areas.

6.3. Implications for Research

In a bid to increase or maintain productivity, mitigate and adapt to climate change, agro-pastoralists in Chepareria should adopt climate-smart agriculture (CSA) practices and interventions. Some of these practices that could be adopted to make agriculture more resilient and adapted to climate change include zero tillage, conservation agriculture, fallowing, and livestock improvement among others. Additionally, the following recommendations need attention:

- a) Geo-referencing of private enclosures in Chepareria is vital to update the current database of private enclosures in Chepareria.
- b) To increase household resilience and boost income, enclosure owners in Chepareria need to adopt other livelihood activities in order to reduce pressure on natural resources. In particular, bee keeping is lowly practiced though it has the potential to contribute significantly on household income and food security.
- c) The formation of farmer groups is also essential to assist farmers in marketing their produce and demand better prices for their farm products, particularly fruits. This can also help them pool resources.
- d) Rangeland enclosures are effective in the rehabilitation of degraded rangelands in the study area and should be encouraged in similar areas in sub-Saharan Africa (SSA).