THE ROLE OF SOCIAL LEARNING IN LINKING KNOWLEDGE AND PRACTICE FOR REHABILITATION OF DEGRADED DRYLANDS IN NJEMPS FLATS, BARINGO COUNTY, KENYA

REBECCA NJOKI KARAYA

A Thesis Submitted to the Graduate School in Partial Fulfillment of the Requirements for Doctor of Philosophy Degree in Agricultural and Rural Innovation Studies of Egerton University

EGERTON UNIVERSITY

MAY, 2021

DECLARATION AND RECOMMENDATION

Declaration

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

Signature……. Date: ……

Rebecca Njoki Karaya

ED17/0397/13

Recommendation

This thesis has been submitted with our recommendation as university supervisors:

Signature…… Date ……

Prof. Christopher A. Onyango

Department of Agricultural Education and Extension,

Egerton University

Signature…… Date……

Prof. George Ogendi

Department of Environmental Science

Egerton University

COPYRIGHT

DEDICATION

To my husband Wellington Kigwa and our son Ian Gathungu for their encouragement and support throughout my studies. To my late mother for instilling in me the virtues of discipline and hard work. Hope I have made you proud.

ACKNOWLEDGEMENTS

This thesis is the result of the combined effort of many individuals and institutions who shared my vision and passion. My very special gratitude goes to my university supervisors, Professors Christopher Assa Onyango and George Morara Ogendi for their encouragement, technical input, guidance and mentoring throughout the research process. I am particularly indebted to them for their kindness, patience, understanding and readiness to review my numerous drafts. My sincere thanks also go to the Department of Agricultural Education and Extension, Faculty of Education and Community Studies and the Graduate School of Egerton University for creating forums for valuable critique from the examiners and colleagues which added great value to my research work. I also acknowledge RUFORUM for its financial support that enabled me to carry out my coursework in Makerere University Uganda.

My sincere appreciation also goes to members of Melita Self-Help Group, Il Chamus Ward in Baringo South, Agricultural Extension staff, KALRO Apiculture Research Institute staff at Marigat especially Mr John Duyu and Daniel Toroitich and Rehabilitation of Arid Environment Trust extension officer Francis Parkolwa for spearheading social learning in the rehabilitation of degraded dryland interventions in Il Chamus Ward. Mzee Edward Sikamoi also deserves a special mention for availing to the Community of Practice part of his degraded land to be enclosed and used as a field laboratory for experimenting and demonstration of rehabilitation practices. Most importantly, this would have been impossible without the love, patience and support of my family. Their love, encouragement and faith in me have always been a pillar of strength. Thank you all, and may God bless you richly. Finally, to God who has enabled me to do exceedingly more than I ever dreamt of be the honour and glory. Amen.

ABSTRACT

Land degradation is a major cause of decreasing yields and loss of dryland ecosystems resilience in the Kenyan drylands. One of the solutions to land degradation is the application of Sustainable Land Management (SLM) technologies. However, adoption of SLM practices in Kenyan drylands is low. This study sought to enhance adoption of SLM practices by improving farmers capacity through social learning in a Community of Practice (CoP). The study employed Participatory Action Research (PAR) design. Systematic random sampling was used to select 150 household heads from Il Chamus and Mukutani Wards in Baringo South Sub-County for the baseline survey. Five key informants were interviewed and two focus group discussions held. Thirty-five farmers from Il Chamus Ward were invited to voluntarily form a farmer's group for social learning on SLM practices. Data was collected using validated and reliability tested (Cronbach Alpha coefficient of 0.78) structured questionnaires, checklists and topic guides. Categorical, Simple and Multiple Linear Regressions were used to analyze quantitive data for making inferences. The farmers identified both natural and anthropogenic causes of land degradation and registered concern over continued land degradation. Diversification, extensification and adoption of SLM practices were some of the coping strategies used against land degradation. The study revealed significant and positive association between adoption of SLM practices and household head's level of education, household annual income, level of extension access and participation in farmer groups at R^2= 60.8, F (16,133) =13.429, p<.000). Social learning was influenced by level of participation in CoP activities (p<0.00) and formal education (p=0.040). Social learning was found to influence farmers' SLM pracices adoption behavior at R^2=53, F (1,33) = 37.3, p< 0.000. The study concluded that social learning in CoPs comprising of farmers, research and extension can be used to leverage the benefits derived from such linkages to help farmers deal with land degradation challenges. Based on the results, the researcher recommends that development agencies promote participatory research and social learning with farmer groups as CoPs to enable generation of context and location specific SLM practices in addition to building farmers competencies in their adoption. County government of Baringo should target farmer groups for capacity building and also for scaling-up success cases like the Melita group enclosure to different Wards in the County.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS AND ACRONYMS

ASAL	Arid and Semi Arid Lands
CoP	Community of Practice
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GEF	Global Envirnment Facility
GIS	Geographical Information System
GoK	Government of Kenya
ICRAF	International Centre for Research on Agro-forestry
IFAD	International Fund for Agriculture Development
IUCN	International Union for Conservation of Nature
KALRO	Kenya Agricultural and Livestock Research Organization
KNBS	Kenya National Bureau of Statistics
LULCC	Land Use and Land Cover Change
NGO	Non-Governmental Organization
NRM	Natural Resource Management
PAR	Participatory Action Research
RAE	Rehabilitation of Arid Environments
RS	Remote Sensing
SERI	Society for Ecological Restoration International
SID	Society for International Development
SL	Social Learning
SLM	Sustainable Land Management
SLT	Social Learning Theory
SSA	Sub-Sahara Africa
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNDDD	United Nations Decade for Deserts and Fight against Desertification
UNDP	United Nations Development Programme
UNFCCC	United Nations Convention on Climate Change
USAID	United States Agency for International Development

CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

Drylands occupy 41.3 percent of the earth's land surface, are home to a third of the world's population, half of the world's animals, and more than a third of global biodiversity hotspots (Nkonya & Anderson, 2014). In Africa, drylands take up 43 percent of the land surface and support 40 percent of human population while in Kenya, they cover 89 percent and support 36 percent of the population (Davies *et al*., 2012; Government of Kenya, 2016). Thus, drylands are vast and provide important ecosystem services for humanity, both directly and indirectly. Directly, drylands inhabitants make their livelihoods from wild harvesting from common resources, herding and rain-fed cultivation (Neely *et al*., 2009; United Nations Convention to Combat Desertification, 2012). Indirectly, drylands ecological services range from carbon dioxide (CO_2) sequestration to offering habitation for wild wildlife and vegetation and acting as watersheds among others (Shaoliang & Muhammad, 2011; Thornton & Herrero, 2010). Though drylands have supported livelihoods for centuries, they have in the past been viewed as having low economic significance and have been overlooked from countries' development agenda (AU-IBAR, 2012). Presently, there has been a rising appreciation of the contribution of drylands to world food security and other linked needs by the dryland and non-dryland human population (Mortimore, 2009; UNCCD, 2012).

Despite the worth of drylands environmental services, their stewardship is undermined by various factors among them land use and cover changes and overgrazing, leading to land degradation (FAO, 2010; Hobbs *et al*., 2008). Processes like expansion of cultivation and diversification of dryland use activities coupled with climatic changes have placed huge burdens on the ecological, economic and socio-cultural integrity of the drylands leading to their degradation (Hobbs *et al*., 2008). The Millennium Ecosystem Assessment report (2005) indicated that 58% of all degraded soils globally are in the drylands. United Nations (2011) noted that land degradation is most severe in Sub-Saharan Africa (SSA) drylands with approximately 75 percent of the lands affected by moderate to high degree levels of degradation. In Kenya, about 18 percent of grasslands and 42 percent of shrub land is degraded. Nkonya and Anderson (2014), noted that a third of Kenya's population directly depend on the degraded lands for their livelihoods.

Degradation of drylands manifest in the forms of decline in vegetative cover, loss of soil productivity, loss of plant and earth organisms' biodiversity and increased soil erosion (Mganga *et al*., 2015). With degradation, drylands agro-pastoral resources decline in productivity, leading to crop failure and decline in quality and loss of livestock to hunger, especially during prolonged droughts (Maitima *et al*., 2009). The above results in the decrease of household income levels, food insecurity and loss of livelihoods driving the dryland inhabitants further into poverty (Nachtergaele *et al*., 2010). This in most cases is followed by reduced resilience and adaptive capacity, increasing the vulnerability of the dryland communities to shocks from climate extremes (Geist & Lambin, 2004). According to United Nations (UN) (2011), dryland degradation cost developing countries four percent of their national Gross Domestic Product each year. International Monetary Fund (IMF) (2010), put the cost of land degradation in Kenya at about USD 390 million in 2010 which is equivalent to three percent of her annual Gross Domestic Product.

The recognition of the risks and costs of dryland degradation to local, regional and global populations have turned it into a major issue of concern in the global and local development policy agenda. The United Nation's Sustainable Development Goal (SDG) target 15.3 aimed to combat desertification, restore degraded land including land affected by desertification, drought and floods, and strive to achieve land degradation neutrality by 2030 (UNCCD & World Bank, 2016). The concern has further been translated to formation of global, regional and country initiatives aiming to combat land degradation and desertification in drylands (Mortimore, 2009; UNCCD, 2012). For example, UNCCD was established in 1994 to tackle desertification (UNCCD, 2012); TerrAfrica was established in 2005 to counter land degradation in Sub-Saharan Africa (TerrAfrica, 2009); and the United Nations Decade for Deserts and Fight against Desertification (UNDDD) was launched in 2010 to protect drylands from degradation and the more recent Mirova natural capital Land Degradation Neutrality (LDN) fund was formed in 2017 to provide funding for projects that help to achieve zero land degradation in the world.

Global agreements tend to be generic in nature and rarely provide frameworks for their adaptation to local specific action. This has led to increased calls for "glocal strategies" which advocate for land degradation to be tended locally while thinking universally (UNCCD, 2012). National and Regional Action Plans (NAPs and RAPs) within the UNCCD framework have been formed as a result with the aim of turning international efforts into

local actions with diverse global and local benefits (Wairore, 2015). For example, the Kenya Vision 2030 identified reconciliation of environmental protection in agricultural production (GoK, 2007) while the Agricultural Sector Development Strategy for 2010-2020 focused on enhancement of environmental resilience and improvement of conservation and management of natural resources (GoK, 2011).

Sustainable Land Management (SLM) is regarded as a remedy to land degradation with adoption of SLM practices being cited as having potential of upholding the capacity of land to afford essential goods and services to human populations sustainably (Liniger *et al*., 2011). Developed by research and promoted by extension, SLM practices such as soil and water conservation and integrated ecosystem management practices, seeks to increase land value and productivity with the aim of sustaining and improving livelihoods (UNCCD, 2012; UNCCD & World Bank, 2016). Even though SLM practices have the capacity to grow productivity of agro-ecosystems while preventing degradation of natural resources and creating resilience to environmental variability, their uptake is still low in SSA. For instance, FAOSTAT (2008) estimated that less than three percent of all land cultivated for crop production in SSA is under SLM practices. Along the same line, Kihiu (2016) approximated the assessed implementation rate of SLM technologies in Kenyan drylands at 14 percent.

Lack of knowledge and information on suitable SLM practices, failure to integrate relevant stakeholders and failure to acknowledge the role of traditional institutions in SLM are key factors limiting adoption in drylands (Liniger *et al*., 2011). Agricultural extension and advisory service has the role of dissemination of agricultural information, creation of awareness, training and promotion of SLM practices generated by public sector research through appropriate strategies (Kihiu, 2016; Liniger *et al*., 2011). Regrettably, little impact of extension has been noted in drylands. Attributes of dryland environments including physical environment and socio-political situation make traditional extension models inappropriate (Butcher, 1994). In recognition to this, there is increasing evidence showing communities, Non-Governmental Organisations (NGOs), research and extension advisory services in interactive and participatory efforts towards developing various SLM alternatives in drylands (Mureithi, 2012).

Since impacts of land degradation are location and context specific, implementing SLM practices does not lend itself to universal knowledge alone (Curry & Kirwan, 2014). Rather,

it requires employing different types of knowledge from scientists and advisory services as well as farmers tacit knowledge (Lampkin *et al*., 2015). The practices therefore need to be adaptable, open to innovation and responsive to new trends and opportunities in the community (Liniger *et al*., 2011). In particular, the element of social learning and collective action in collaboration with farmers where all the actors contribute expertise has received attention. Woodhill and Roling (2000), observed that social learning approach in Natural Resources Management (NRM) embodied an action-oriented thinking that focuses on participatory progressions of social change reinforced by a theoretical framework in which social processes are defined as non-linear, open ended and non-deterministic. Kilvington (2013) noted that social learning emphasizes on a dynamic and interactive research and policymaking process, involving researchers, change agents and community in context-based knowledge co-production and problem solving.

While co-production of knowledge through social learning is a central theme in sustainable NRM science, how social learning can be pursued in practice is a critical challenge to NRM practitioners (Miller *et al*., 2013). Communities of Practice (CoP) concept was suggested by Lave and Wenger (1991) as a way of reflecting and grounding social learning in locally situated practice. The notion of CoPs operationalizes social learning and associates it to social constructions and participation activities. Centred on the notions of shared meaning, mutual engagement, collective action, trust and reciprocity, CoP framework emphasises the dynamic nature of social learning and can be used to leverage innovations in complex problems like land degradation (Moschitz *et al*., 2015; Wenger, 2006). In this, learning is viewed as a process of social construction and knowledge creation and sharing rather than the process of linear knowledge transmission (Beena *et al*., 2015; Wenger *et al*., 2002).

Pretty and Hines (2001) listed factors leading to success in generation, dissemination and adoption of SLM innovations to include social capital, social learning, good linkages and working partnerships between farmers and external agencies. All are enablers present in CoPs. Therefore, application of CoP framework may offer a fresh insight into understanding social learning and functioning processes occurring within groups involved in SLM activities (Morgan, 2011; Van Buuren & Edelenbos, 2006). Of importance to this study is that CoP framework allows the eaxploration of the social processes around which platforms for social learning are formed, utilised and sustained over time (Moschitz *et al*., 2015).

Lake Baringo basin, often referred to as Njemps Flats in the Kenyan Rift Valley is a semi-arid rangeland inhabited by pastoral and agropastoral communities engaging in communal resource system management for livestock production (Verdoodt *et al*., 2010). In the last few decades, growing human population, land use and cover changes, overgrazing and droughts in combination with highly erodible soils have induced severe land degradation (Mwangi & Swallow, 2008; Verdoodt *et al*., 2010). Pastoralists in the proposed study area have also progressively lost most of their grazing land to the steady expansion of lake Baringo together with other competitive land uses such as encroaching crop farming, establishment of wildlife protection areas, mining and settlements (Odada, 2006). Mwangi and Swallow (2008) and Odhiambo (2015) noted that previous attempts to rehabilitate the land by introducing the invasive shrub *Prosopis Juliflora* by the Kenyan government failed as it suppressed all other forms of indigenous vegetation increasing vulnerability of the inhabitants to droughts and leading to concerns of biodiversity loss. It is against this background that a study to assess how social learning in communities of practice can bridge the gap between knowledge in the hands of research and extension and farmers' site-specific needs and knowledge in the rehabilitation of degraded lands in the Njemps Flats of Baringo County was undertaken.

1.2 Statement of the Problem

Njemps Flats in Baringo County is a highly degraded semi-arid ecosystem. The severity of degradation in this area has adversely impacted on the local livelihoods base for the residents who experience high levels of stock and crop loss especially at the end of a long dry season. The consequent poverty and livelihood challenges have led to logging for charcoal and wood fuel for sale and clearing of more land for agriculture as residents try to cope. This further perpetuates land degradation and poverty. Land degradation interventions in the Flats have a long history, dating back to colonial times. The interventions included culling of livestock to curb overgrazing as recommended by the Kenya Land Commission Report of 1934; implementation of soil and water conservation measures by African Land Development Board (ALDEV) in 1946; implementation of perceived best practices in rangeland management recommended by Swynnerton Commission of 1954 and the introduction of *Prosopis juliflora* in 1982 by FAO among others. Those past interventions have not borne the desired outcomes as land degradation has continued exacerbated by climatic change. The failure of the interventions to create land degradation neutrality has been attributed to research, extension and policy solutions with little or no participation from the agropastoralists thus ignoring their local experience and traditional knowledge. Community

social learning and collective action has been cited as holding great potential in rehabilitation of degraded lands. However, to bring actors together to share knowledge and collaboratively innovate for degraded land rehabilitation, a social learning platform is required. A Community of Practice (CoP) comprising of stakeholders in SLM has been cited as being useful as an interaction platform for knowledge exchange and co-innovation. For this study, a CoP comprising of research, extension and farmers was set up for social learning. This study not only focused on contributing to the solution of land degradation but also enhancing food and environmental security in the study area and by extension in Baringo County. The research also examined how theory and knowledge in the hands of research and extension can be linked with farmer's location and context-based needs and practice in the management of environmental problems.

1.3 Purpose of the Study

The aim of this study was to assess how social learning in a community of practice composed of a group of agropastoralists, researchers and extension providers could help link the scientific knowledge in the hands of extension and research with farmers site-specific needs and knowledge in generation, adaptation and adoption of sustainable land management practices in the rehabilitation of degraded land in the Njemps Flats Baringo County.

1.4 Objectives of the Study

The following specific objectives guided the study.

i. To determine land degradation drivers and indicators in the study area
ii. To assess land degradation coping strategies used by the participants in the study area
iii. To assess the determinants of sustainable land management adoption by the participants
iv. To establish a community of practice for social learning in the rehabilitation of degraded in the Njemps Flats
v. To assess factors affecting the level of social learning among members of farmer-based community of practice
vi. To assess the influence of the social learning in the community of practice on participating members' sustainable land managementpractices adoption behavior

1.5 Research Questions

The following are the research questions for the specific objectives listed above;

i. What are the drivers and indicators of land degradation in the study area?
ii. What land degradation coping strategies are used by the participants in the study area?
iii. What are the determinants of sustainable land management practices adoption in the study areas?
iv. What are the challenges of establishing and maintaining a community of practice for rehabilitation of degraded lands in the study area?
v. What are the factors affecting the level of social learning among members of farmer-based community of practice?
vi. How does social learning in community of practice influence participating members' sustainable land management practices adoption behavior?

1.6 Significance of the Study

Through the study, a community of practice for social learning in rehabilitation of degraded lands was formed. An enclosure was established which acted as a field laboratory where farmers' existing tacit knowledge was linked with new knowledge from research and extension to develop location and farmer specific SLM innovations for use in combating and rehabilitating degraded lands in Njemps Flats. The study helped farmers develop social networks with research, extension and other farmers and helped strengthen local institutions that have been cited as being important for collective action in sustainable management of the common resources.

This study also supported the move towards the attainment of land degradation neutrality and promoted biodiversity conservation in the study area by promoting adoption of SLM innovations. These are concerns of United Nations, GoK and the County Government of Baringo as captured in the SDGs, Kenya's Vision 2030 and the 2018-2022 Baringo County Intergrated development plan. The results may be used by policy makers, extension programme planners and farmer organizations to foster sustainable farming practices and enhance socio-economic development through rehabilitation of already degraded lands and prevention of degradation. This would have a positive feedback on improved food security and household level poverty reduction in Njemps Flats and other areas with similar climatic conditions. Researchers, extension and other development agencies may also apply the CoP as a framework to operationalize social learning involving multi-stakeholders to address

problems of mutual concern in natural resources management. The study came up with concrete technical, administrative, educational recommendations that may be utilized by the National Government, County Governments and agricultural stakeholders as a general model for smallholder agropastoral strategies to address land degradation.

1.7 Scope of the Study

The study was carried out in the Njemps Flats in the Il Chamus and Mukutani Wards of Baringo County from January 2019 to March 2020. It focused on identifying indicators and drivers of land degradation, assessing determinats of SLM practices adoption and evaluationg the role of social learning on adaptation and adoption of SLM practices for rehabilitation of degraded drylands. A Community of Practice (CoP) was established to act as a social learning platform bringing togethers agricultural advisory services providers and practitioners.

1.8 Assumptions of the Study

The following were the assumptions made in the study:

i. The stakeholders in Baringo South Sub-County would be willing to participate in the community of practice.
ii. That security in the area would remain stable throughout the study period.
iii. The community of practice members would be willing to participate and be dedicated to the learning programme to the end.

1.9 Limitations of the Study

The following were the limitations of the study.

i. The foremost limitation was the long length of time required to carry out PAR. The methodology entailed long and iterative processes of community discourse and action, which was evaluated at the end. The study programme time could not permit for comprehensive evaluation of SLM adoption and impact of this adoption to be done conclusively. Instead, adoption behavior which included stewardship level, SLM knowledge acquired, bonding and bridging social capital which are predictive of SLM adoption were evaluated. Since the learning platform is in place, the researcher may in future collect data for impact assessment for publication purpose.

ii. Language barrier. To counter language and cultural barriers encountered, the researcher took time to learn the basic culture of the study area inhabitants and engaged an interpreter during the data collection period.

iii. To offset the limitation posed by recollection of past events by community members on land degradation trends, GIS technique was employed to capture information on land use and land cover changes over the years, and thus complement data collected from the community using a social survey.

1.10 Operational Definition of Terms used in the Study

Communities of Practice: A collection of people who share a common interest, a collection of problems, or a passion for a subject and meet on a regular basis to further their knowledge and expertise in that field (Wenger *et al.,* 2002). This study operationalised it to mean all actors and champions who have a concern and are passionate about combating and rehabilitating degraded land and who met regularly to learn together about their area of passion and concern.

Drivers of Land degradation: These are human and natural factors that cause or promote the occurence of land degradation (Mirzabaev *et al*., 2016). Same definition is applied in this study.

Enclosure(s): Refer to areas characterized by severe degradation that are closed off from grazing and other human extractive activities for a set period of time in order to enable vegetation to regenerate (Aerts *et al*., 2009). In this study enclosures, were severely degraded areas closed off from grazing and human extractive activitieswhile advancing revegetation and construction of soil and water management structures to restore the overall ecological conditions of the areas.

Farmer: A person who cultivates land or crops or raises animals (Merriam-Webster, dictionary). In this study, a farmer refers to an individual practicing agropastoralism, mixed farming or crop farming.

Indicators of land degradation: Indicators are manifestations of a response by land to environmental and human disturbance (Mirzabaev *et al*., 2016). In this study land degradation indicators are variables which may show that land degradation has taken place or is taking place.

Innovation Adoption Behaviour: Refers to a consumer's expressed desire to adopt an innovation or the initial trial of an innovation usually leading to total adoption based on the information and perceptions the consumer has at that time (Rogers, 2003). In

this study adoption behavior is taken to mean a farmer or a household uptake and continuous use of a SLM practice or intention to use it in future.

Innovation: Anything new (idea, object, practice, process) that is put into use and creates value, whether social or economic (Maatman *et al*., 2011). In this study innovations refer to the SLM strategies generated through participatory action research and put into use by agropastoralists to enable them combat land degradation and rehabilitate degraded lands.

Land degradation: Land degradation, according to the UNCCD (2012), is characterized as the loss of a land's productive capacity, including its major uses and economic value. The same definition applies to this study.

Land Stewardship: According toVictorian Catchment Management Council and Department of Sustainability and Environment (2003), it refers to the use of a broad range of activities by landowners and resource users that seek to ensure land use matches whole of landscape capability and that landholders are rewarded for the ecosystem services they provide. In this study it refers to an inner held concern and conviction that reflects an ecological conscience that in turn produces a sense of individual and collective responsibility and an awareness of limitation of freedom of action on what can be done or cannot be done with land.

Livestock Units- A measure of heard size computed according to FAO (2005). Cattle has 0.5 units, shoats 0.1 and poultry 0.01 units. The measure is adopted for this study.

Social learning: Learning that arises when people engage one another to sharing diverse viewpoints and experiences resulting to development of a common framework of understanding that forms the basis for joint action (Schusler *et al*., 2003). In this study, social learning encompasses all the activities and interactions that members of community groups and their supporting agencies engage in to share and co-generate knowledge through processes of questioning, negotiation, experimentation and reflection leading to learning outcomes, including changes in practices and values.

Stakeholder Participation: Taking part by stakeholders in knowledge generation and dissemination for the purpose of initiating learning processes as well as the creation, sharing, and implementation of innovations (Freyer *et al.,* 2012). This study operationalized it as active involvement by stakeholders in the problem analysis, learning activities, experimenting, management and monitoring of the SLM practices.

Stakeholder: Stakeholder: A person or group with an investment, share, or interest in a company or industry. (Random House Dictionary, 2013). In this study, a stakeholder refers to an agency, organization; group or individual involved in or has an interest in combating and rehabilitating degraded drylands in Njemps Flats.

Sustainable Land Management: The adoption of land use systems that, through appropriate management practices, enables land users to exploit maximun economic and social benefits from the land while upholding and enhancing the ecological support functions of the land resources (Liniger *et al*., 2011). The same definition is applied in this study.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature relevant to the study including its theoretical basis. It highlights challenges, trends and drivers of land degradation and the strategies used by agropastoralists to rehabilitate degraded lands. The role of agricultural extension in rehabilitation of degraded drylands is explored, as well as the application of the social learning concept in Communities of Practice (CoP) to generate and disseminate Sustainable Land Management (SLM) practices for the rehabilitation of degraded drylands. The chapter ends with the theoretical and conceptual frameworks that guided this sudy.

2.2 Understanding Drylands Livelihoods and Challenges

Drylands are vast and are of great economic and social value as a key source of livelihood for millions of pastoralists and agropastoralists. Even so, they have suffered decades of neglect, marginalisation and underinvestment in proportion to their size, population and importance to global and national economies (GoK, 2016; Mortimore, 2009). Characterised by harsh climatic conditions, remoteness, marginality, low-productivity of land, weak institutions, and even conflict, dryland dwellers and their development partners face many challenges in sustainable land management (Mortimore, 2009). These challenges raise multiple concerns regarding the ability of pastoral and agropastoral systems in drylands to accommodate growing human populations within the constraints of the resources available and a changing climate (McCabe *et al*., 2010).

2.2.1 Land Use and Land Tenure in Drylands

Land use in drylands varies based on the agro-ecological conditions, social-economic conditions and the possibilities for irrigation (Davies *et al*., 2012; UN, 2011). Accordingly, land use includes nomadic pastoralism in the drier areas while in the wetter semi-arid areas and those well serviced by infrastructures a more varied economy prevails, including rain-fed and irrigated crop production, agro-pastoralism, bio-enterprise and tourism and conservation related activities (Neely *et al*., 2009). United Nations (2011), described drylands as having three chief economic functions which include; as rangelands (65%) used for pastoralism, for rain-fed and irrigated agriculture (25%) and as forest town and city sites (10%). Pastoralism dominates the economy of arid areas in SSA especially Kenya, where crop-growing capacity

is limited by low and highly unreliable rainfall, steep terrain, and very high temperatures (Rota & Sperandini 2009).

An important feature of drylands communities is collaborative and collective resource management and user rights (FAO *et al.*, 2011; Niamir-Fuller, 2005). Often collective property rights regimes exist where land is owned by national, local governments or communal groups (Meinzen-Dick & Mwangi, 2009). Communal land tenure allows for livestock mobility that helps align pastoralist livelihoods with seasonal climate variations while enabling pastoralists to manage uncertainty, risk and access a range of markets (Niamir-Fuller, 2005). This tenure system remains hotly debated in the context of resource exploitation and sustainable development (Mwangi, 2009). Nevertheless, the property regime creates a framework for exploitation of resources across agroecological boundaries hence reducing the level of vulnerability of pastoralists in marginal lands (Niamir-Fuller, 2005).

The tragedy of commons concept by Hardin (1968), entrenched claims about environmental degradation by pastoralists and paved way for dominant development policy interventions based on assumptions of damage potential of livestock grazing (Sullivan & Homewood, 2003). According to Hardin (1968), in absence of governance by some higher authority, users of common resources inevitably deplete them through over exploitation. Hence, managers must have effective hegemony over users of common resources. This exemplifies the widespread approach to the governance of common pool resources where privatization is seen as a viable alternative to collective land management arguing that it creates more responsible land management (Carson, 2013). This perception has seen African governments seek to push pastoralists into becoming full-time farmers, ranchers or small traders (Lund & Boone, 2013; Meinzen-Dick & Mwangi, 2009). Discussing privatization and fragmentation, Liniger *et al*. (2011) noted that an increased concentration of both people and livestock results to increased grazing intensification and consequently rangeland degradation. Mortimore (2009) observed that privatization of common resources often leads to rising land values, subdivision or fragmentation of inherited land, and exclusion of the poorest.

2.2.2 Land Use and Land Cover Changes in Drylands

Human alteration of the Earth's land surface is unparalleled in terms of speed, magnitude, and spatial scope. Land-use and land-cover shifts have been so pervasive that they have a direct impact on key aspects of Earth system functioning when aggregated (Lambin *et al*., 2003).

They have an effect on biotic diversity and contribute to local and regional climate change, as well as global warming and soil degradation (Foley, 2005). By altering ecosystem services, they affect the ability of biological systems to support human needs and partly influence the vulnerability of places and people to climatic, economic or socio-political agitations (Geist & Lambin, 2002). The shift in land use and cover change on the other hand, is influenced by a variety of interconnected socioeconomic, cultural, and biophysical forces that arise at local to global scales, involving feedback loops, and flow across land-use processes (Lambin & Meyfroidt, 2011).

One of the greatest drivers behind land use and cover changes globally is the expansion of crop farming which has seen natural vegetation, including natural grazing lands, declining at the expense of croplands and pastures (Lambin *et al*., 2003; Maitima *et al*., 2009). According to Reid *et al*. (2008), 35–50 percent of semi-arid and dry sub-humid rangelands have been transformed to cropland around the world, with another 2-4 percent being urban centers. Agriculture grew by 123,413 hectares in Sub-Saharan Africa from 1975 to 2000, at the cost of forests (71,325 hectares) and non-forest natural vegetation (58,894 hectares), which included woodlands and grasslands (Brink & Eva, 2009). Similar trends have been observed at individual country levels. In Benin, Bukina Faso, Guinea, Senegal, Ghana, and Togo, for example, the expansion of agricultural crop lands has come at the cost of savannas and woodlands, as well as other wild lands and protected areas, resulting in the shrinking of natural savannas as population pressures increase (Tappan *et al*., 2016). The East Africa region also followed the same trend. For example, between 1990 and 2010, land use and land cover shift in the Kagera Basin, spanning Burundi, Rwanda, Uganda, and Tanzania, showed a 15.4 percent decrease in savanna grassland (Wasige *et al.*, 2013). Another study in the same region done between 1984 and 2011, found that savanna woodlands had declined by 12.4%. (Berakhi *et al*., 2014).

Lack of strong land tenure laws among the indigenous pastoralists in dry areas may have contributed to the high conversion rates (Reid *et al*., 2009). As land scarcity in the arable areas increases in the coming decades, it is expected that land-use change from rangeland to other land uses will escalate (Lambin & Meyfroidt, 2011). Increased population pressures, mostly due to in migration, are related to a rise in human-dominated cover forms, resulting in less native grazing lands (Brink & Eva, 2009). As population increases, pressure on the available resources increases, particularly on the availabile productive land leading to a

change in agricultural production to adoption of higher value production; for instance, from native grazing to intensive crop production or modified pastures (Brink & Eva, 2009; Hamza & Iyela, 2012). In some areas though, rising population pressures have resulted in an increase in both natural and controlled herbaceous pasture crops according to Mascorro *et al*. (2014). Other human population-related pressures include the conversion of grazing land to built-up areas, as well as the widening of urban and rural residential areas (Fuchs et al., 2015).

Land use and land cover adjustments are often influenced by government policies such as national state interventions to protect native plants and maintain environmental flows (Fuchs *et al*., 2015). Increased natural vegetation, including native grasslands, has resulted from such policies. Inappropriate policies from the regulating bodies, on the other hand, have been shown to result in grazing land depletion and introduction of invasive species (Dong *et al*., 2011; Meinzen-Dick & Mwangi, 2009). Land policies that encourage the division of grazing areas and the conversion of pastoral systems to cropping systems, for example, have been shown to result in the loss and degradation of grazing lands (Dong *et al*., 2011). Land use and land cover shifts are also influenced by market forces (Hamza & Iyela, 2012). Dryland residents respond to market opportunities such as crop farming, resulting in grazing land conversion, alteration, and fragmentation (Dong *et al*., 2011). For example, low returns from pastoralism have been observed to drive livestock producers to seek alternative sources of income (Dong *et al*., 2011; Pender *et al*., 2009). In the once-marginalized drylands habitats, the introduction of new and enhanced technology and infrastructure growth also offers opportunities and new land use options (Olson *et al*., 2008).

As development opportunities change and open up the once marginalized dry lands, need for social amenities such as education and health has influenced how dryland residents perceive and use land in grazing areas with many nomadic groups adopting partial or permanent settlements as a result (Lambin *et al.,* 2003). The changing settlement patterns, according to Lind *et al*. (2016), have driven households to explore ways to mitigate risks such as droughts. An increase in settlements result in increased grazing pressure in the settled areas, which harms the pastoral and agro-pastoral ecosystems (Dong *et al*., 2011). Poverty, collapsing customary resource institutions, and a lack of understanding of traditional expertise in the management of drylands, as well as climatic change, are additional drivers of land use and land cover changes in grazing lands (Tappan *et al*., 2016).

2.2.3 GIS Supported Community Land Use and Land Cover Change Assessment

Geographic Information System (GIS) paired with Remote Sensing (RS) are commonly used to quantify, map and detect spatial-temporal dynamics of Land Use and Land Cover Change (LULCC) (Lambin, 2003, Rahman *et al*., 2011). The method involves use of satellite data in maps, aerial photographs, written records in addition to ground truthing that involves people interviews (Bruzzone, 1997; Conedera *et al*., 2007). Though it is generally agreed that GIS is an effective and robust tool in facilitating geo-spatial information retrieval, analysis, modelling and visualization, conventional GIS came under a barrage of criticism starting in the 1990s (Schuurman, 2000; Warf & Sui, 2010). The critiques who mostly hailed from human geography criticized GIScience for lacking sufficient engagement with issues of social-cultural context, relations and power and being obsessed with mechanical rationality thus actively bringing back positivism into geographic practice. (Schuurman, 2000; Sheppard, 2005; Warf & Sui, 2010).

Over time and in response to these criticisms together with engagement between the GIS scientists, social theorists and humanities scholars, GIS has evolved to include new approaches including critical GIS (Pavlovskaya, 2018; Sheppard, 2005), participatory GIS (Elwood, 2006), qualitative GIS (Cope and Elwood 2009), feminist GIS (McLafferty 2002; Pavlovskaya, 2018) ethnographic and indigenous knowledge GIS (Robbins, 2003) and open GIS (Sui, 2014). These contemporary forms of GIS, tend to move from positivism and more towards social constructivism, be more context-sensitive and be more issue-driven (Warf & Sui, 2010). Putting more emphasis on cooperation and collaboration, contemporary GIS seek more local communities' participation and accept indigenous forms of knowledge as valid and important sources of information making the approaches more sensitive to issues of access, control and ownership of spatial information (Elwood, 2006).

The use of GIS in SSA drylands face challenges of cost, need for expertise, concerns over data rights, access and use of generated information as well as difficulties in understanding the Cartesian methods of spatial representation (Attri *et al*., 2015; Chambers, 2006). In addition, LULCC caused by population increase or climatic changes might be a slow process taking years to manifest while in certain places, remote sensing is not possible as land cover phenomena could be obscured by cloud, vegetation or other physical features like hills or shadows (Maphanyane, 2018). Kathumo *et al*. (2015) noted that conventional GIS tend to be a top-down approach to LULCC detection and emphasize the production of spatial data to

facilitate official decision-making. Presently, emerging issues in dryland use and management require inclusion of local communities in the decision-making processes that may influence their lives (Adhiambo *et al*., 2017). This need can be addressed through the integration of community participatory methods with GIS and RS. Engaging communities in participatory methods offer opportunities for co-learning and coconstruction of knowledge with communities giving the researcher occasion to disseminate certain kinds of scientific knowledge in a discursive and nonformal manner (McCall & Minang, 2005).

Several researchers have studied LULCC in SSA drylands including, Rembold *et al*. (2000) regions of central and south Ethiopia, Kiage *et al*. (2007) in the Lake Baringo catchment area, Alawamy *et al*. (2020) in Al-Jabal Al-Akhdar region in Libya; Matlhodi *et al*. (2019), in the Gaborone Dam Catchment, Botswana and Mekuyie *et al*. (2018) in the Afar region of Ethiopia among others. While most of the above studies used GIS coupled with RS, our study-integrated community participatory methods with GIS and RS to capture certain trends in land use including livestock herd size and mobility, crops and livestock diversity which could not be well captured by GIS and RS alone. Burian *et al*. (2019) observed that integrating GIS with community participatory methods can effectively create community awareness on the implications of LULCC while helping decision makers appreciate the socio-economic, political and cultural reality of the local community. This integration can result to participatory learning and innovations that lead to the needed action in halting, slowing down and mitigating negative effects of LULCC including land degradation and loss of bio-diversity (Rambaldi *et al*., 2006).

2.3 Land Degradation in Drylands

Land degradation is considered as a major global environmental issue affecting pastoralists in SSA drylands that is directly linked to poverty and food security (Mureithi *et al.*, 2015). According to Bunning *et al*. (2011), land degradation is the accumulated reduction of the land's productive capacity, including its primary uses, agricultural processes, and economic value. It is manifested in the forms of impoverishment and diminution of vegetative cover, loss of biological and economic productivity, soil erosion, salinisation and deterioration in the general physical, chemical and biological properties of the soil (Mureithi, 2012). Nachtergaele *et al*., (2010) observed that land degradation inflicts the highest injury on the livelihoods and welfare of the poorest in the dryland areas of emerging countries.

With degradation of drylands, the agro-pastoral resource base is diminished and becomes less productive resulting in crop failure and quality decline or loss of livestock to hunger, especially during prolonged droughts (Maitima *et al*., 2009). The loss of livestock and crops together with a drop in value of degraded land leads to decrease of the income levels of agro-pastoralists, pushing the communities further into poverty (Maitima *et al*., 2009; Nachtergaele *et al*., 2010). In most situations, this is accompanied by loss of resilience and adaptive capability, making dryland individuals and populations more vulnerable to shocks from changing climates (Amman & Duraiappah, 2004).

2.3.1 Drivers of Dryland Degradation

Understanding the drivers of dryland degradation is a crucial component of addressing the threat. Drivers of degradation are numerous, compounded, and result from a range of different interactions over time and space (Geist & Lambin, 2004). According to Hobbs *et al*. (2008), they include related drivers, such as topography, land cover and vegetation change, poor soil and land management, as well as other underlying factors such as poverty, access to agricultural extension service, land tenure and population density (see Table 1). Concurrence of these factors in pastoralist and agropastoralists systems of SSA exacerbated by increase of extreme weather events easily amplifies the amount of land degradation and increases the need for adaptive land management and land restoration practices (Geist & Lambin, 2004).

Table 1

Drivers of Land Degradation and their Potential Cause-Effect Mechanisms

Drivers	Examples of Causality
Topography	Steep slopes make land susceptible to severe water-caused soil erosion
Land use and Land Cover Change	Changing rangelands use to irrigated farming may lead to soil salinization while clearing land for farming leads to deforestation and soil erosion
Climate	Dry and hot areas are more prone and vulnerable to wildfires, which, in turn destroys ground cover and leaves them exposed to the agents of soil erosion. Addionally, strong rainstorms lead to flooding and erosion while low, infrequent and irregular rainfall lead to erosion and salinization
Soil Erodibility	Some soils are more vulnerable to erosion than others, such as those with a high silt content.
Pest and Diseases	Pests and diseases lead to loss of bio-diversity and ground cover, loss of crop and livestock productivity
Unsustainable Land use	Land clearing, over stocking leading to overgrazing, arable farming on slopes, bush clearing by burning and soil nutrient mining lead to land degradation
Population density	High population density leads to cultivation of marginal lands
Market access	Good market availability encourages people to use sustainable land management practices. on the flip side, it can increase labor costs, making poor people less likely to use labor-intensive SLM practices
Land tenure	Insecure land tenure will encourage farmers to adopt unsustainable land management practices and discourage them from investing in sustainable land management.
Poverty	Poverty could lead to use of unsustainable land management practices plus SLM practices requires labor and capital input which may not be readily available for the poor
Agricultural Extension services	Access to agricultural advisory services builds capacity and enhances the likelihood for the adoption of SLM practices

Adapted from Mirzabaev *et al*. (2016).

2.3.2 Rehabilitation of Degraded Drylands

Rehabilitation of degraded lands is a deliberate undertaking and instigates mending of a degraded ecosystem with respect to its health, integrity and sustainability aiming at returning it to its pre-disturbance state (Mureithi *et al.*, 2015). This requisite action improves ecological capacity and economic usefulness of drylands with the aim of enhancing livelihoods of the inhabitants (Mekuria *et al*., 2007; Verdoodt *et al*., 2010). Descheemaecker *et al*. (2006) noted that rehabilitation activities aim at reducing soil loss through erosion, increasing soil water infiltration and retention while encouraging vegetation growth. This is followed by change in land microclimate with positive effects on biodiversity and land productive capacity. Ultimately, rehabilitation restores habitats and ecosystem functions and services, which translate into economic and social benefits for the local people (Beukes & Cowling, 2002).

Sustainable Land Management (SLM)technologies are generated by research and promoted by agricultural extension and advisory services as viable intervention strategies for combating land degradation and rehabilitating degraded lands (Kihiu, 2016; Liniger *et al*., 2011). The SLM practices serve to preserve and enhance ecological functions of land and create resilience and stability of ecosystem services. Yet, the up scaling of such practices in drylands remains unsatisfactory with only a few islands of good practice. For example, the estimated implementation of SLM technologies in Kenya's drylands is (14.2%), despite the diminishing productivity of these environments (Kihiu, 2016).

Several factors condition the up-take of SLM technologies and innovations among them the land features, households social and economic factors and the climatic condations of the locality. According to Pender *et al*. (2009), adoption of SLM activities is higher in high-potential or on lands with greater erodibility potential based on the soil properties and the slope of land. Where farmers were concerned about land degradation and perceived it as a factor affecting land productivity and hence their livelihoods, SLM implementation increased (Mekuria *et al*., 2007). Pender *et al*. (2009) and Shiferaw *et al*. (2009) observed that SLM practices might also be implemented as intervening measures to rehabilitate degraded lands rather than as preemptive measures. Other factors that were noted to influence adoption of SLM innovations included the level of access to extension services, access to markets, household income, education level, land tenure and human capital endowments (Gillespie *et al*., 2007; Shiferaw *et al*., 2009). Despite the numerous constraints, Liniger *et al*. (2011)

observed that, land users were willing to implement SLM practices if they offered higher net returns and reduced risks to their livelihoods and investments.

According to D'Odorico *et al*. (2012), adoption of SLM technologies for rehabilitation of degraded drylands requires identification and monitoring of early warning signs of degradation. The indicators vary from biophysical (land cover change, biodiversity, soil fertility), economic (declining crop and fodder yield) to social (population structural changes, decline in social solidarity) indicators. These points to the need for a holistic approach to SLM that takes into consideration of physical, chemical and biological status of land as well as the socio-economic status of the community. Lambins *et al*. (2003) recommended that activities aimed at sustainable management and utilisation of drylands be holistic and multidisciplinary in approach while reflecting the needs of the local people. Therefore, the primary goal of SLM should be to integrate people's coexistence with nature over time, in order to preserve ecosystem services such as provisioning, governing, social, cultural, and supporting ecosystem services (Schwilch *et al*., 2014).

2.3.3 Enclosure System in the Rehabilitation of Degraded Lands

The concept of rangeland enclosure, inferring barring part of an area from grazing and other extractive activities is an old pastoral practice. Customarily, the traditional pastoralists communities set aside sections of the common pool grazing areas for dry season and restricted their access by livestock until directed by the governing elders (Mureithi *et al*., 2015). Though the areas were not fenced, traditional and customary institutions and taboos enforced the enclosures boundaries. The migration of people from high-potential areas with a different way of life, high population growth, the collapse of traditional community governance systems coupled with government policies of land subdivision and privatization have made this set aside indigenous innovation increasingly difficult, if not impossible to practice (Mureithi *et al*., 2010). The consequence, is many households with smaller herds of livestock, with no regulated grazing whereas in the past, there were less households with larger herds whose grazing was regulated by some respected traditional governance structures (Meyerhoff, 1991). This scenario tends towards the tragedy of commons set-up (Hardin, 1968; Mureithi *et al*., 2015) and ultimately leads to overgrazing, pasture confricts and severe land degradation.

Area enclosure as used presently in rehabilitation of degraded lands refers to a method of land management where livestock and human are barred from utilising an area that is characterized by severe degradation for extractive activities (Aerts *et al*., 2009). The purpose of this exclusion is to allow re-vegetation and application of SLM practices including construction of soil and water management structures (Verdoodt *et al*., 2010). Enclosures established by pastoral and agropastoral communities to facilitate grazing management and rangeland rehabilitation have potential to address food insecurity, assuage poverty and rehabilitate dryland productivity (Mekuria *et al*., 2011). Enclosures can thus be viewed as a management method for long-term dryland intensification within the context of a market-driven livestock production system and long-term dryland management (Verdoodt *et al*., 2010).

The use of communal enclosures in rehabilitation of degraded drylands and in communal land pasture management is gaining prominence given their use in various countries including Ethiopia, Tanzania and Kenya (Napier & Desta, 2011, Wairore, 2015). It is however important to learn how the enclosures are governed and the dynamics in the allocation of rights to enclose given that most drylands are common pool resources (Napier & Desta, 2011). In essence, enclosures denote the privatization of pastoral commons by their allocation to private individuals or community groups (Beyene, 2009). Mureithi *et al*. (2010) warned that enclosing common lands may benefit some people while marginalising others especially the very poor who could be locked out of the common grazing areas. This makes governance processes and communal institutions that are involved in enclosing and management of common pool land imperative for ensuring that the poor are not dispossessed of access to communal resources.

In the Njemps Flats, the communal enclosures were first established in 1982, in a community-based project in the lake Baringo basin by a charitable organization the Rehabilitation of Arid Environments (RAE) Trust. The trust aimed to work with agropastoralists residing in highly degraded drylands to achieve sustainable land management systems (Meyerhoff, 1991). Using participatory approach and in conjunction with community groups, RAE identifies severely degraded areas and selected them for rehabilitation. The process of rehabilitation started by fencing off the area, preparing the land with water harvesting structures and planting drought-resistant trees and grass species. RAE trained and capacity build the community groups on how to manage land use, with environmental

sustainability as the goal (RAE, 2010). The community groups elected field management committees who were given the mandate to regulate field use including whose livestock could graze on the fenced property and for how long (Mureithi *et al*., 2015). The grass-roots enclosure method has gained traction in the Lake Baringo Basin since the 1980s, following the successful restoration of more than 1,430 hectares of severely degraded land (RAE, 2010)

2.4 Past Rehabilitation Efforts inNjemps Flats

Numerous studies carried out in theNjemps Flats have recorded increasing trends of land degradation in the area ecosystems. Variations in the surface area and depth of Lake Baringo, loss of vegetation cover, loss of aquatic and terrestrial biodiversity, increased soil erosion, Lake Baringo water turbidity, and a general loss of ecological robustness are all signs of degradation (Odhiambo, 2015). Over the years, the inhabitants of the Njemps Flats have become increasingly vulnerable to extreme weather occurances as a consequence of pervasive droughts caused by climatic change and land degradation followed by inappropriate interventions by the state.

In the pre-colonial period, Njemps Flats was described as a lush, beautiful land of relative abundance in a desert-like environment (Thompson, 1887). Just three decades later, in 1921, the region was referred to as "an agricultural slum" (Burnett & Rowntree 1990), citing an unnamed scientist from that year. Huxley (1951) described the Njemps Flats as "*One of the saddest sights in Kenya with hardly a blade of grass left*" (Huxley, 1951) while Burnett and Rowntree (1990) described the Lake Baringo basin as "*an archetypical example of landscape degeneration*". In this narrative of the Lake Baringo Basin environmental degradation, much of the blame was put on African traditional approaches of pastoralism and crop farming (Odhiambo, 2015). For example, the Kenya Land Commission Report of 1934, stressed the connection between the alleged overstocking by the pastoralists and the great risk of desertification and suggested culling as a measure to improve range conditions (KLC, 1934). The enforced culling left the pastoralists in the area resentful towards the colonial administration (Anderson, 2002).

The African Land Development Board (ALDB) was founded in 1946 to direct development in the Arid and Semi-Arid Lands (ASAL), with a focus on water resource conservation and rangeland development (Odhiambo, 2015). This was followed in 1954 by the Swynnerton policy framework which recognised the potential of the ASALs, and aimed to harness their

potential through known and perceived best practices. The post-colonial Government of Kenya (GoK) in partnership with Food and Agricultural Organization (FAO) brought in *Prosopis juliflora* to the Njemps Flats in 1982 as an intervention to control desertification and land degradation as well as provide wood fuel (Mwangi & Swallow, 2005).

In their lawsuit against the GoK to obtain relief for damages sustained as a result of the *Prosopis juliflora* plant, the Il Chamus community argued that no consultation had been conducted priour to and during the introduction of *Prosopis juliflora* as an intervention to land degradation in the area (Charles Lekuyen Nabori and 9 others versus Attorney General and 3 others (2008) eKLR). The community quoted *Prosopis juliflora* as being fast in establishing and invasive; choking other vegetation by forming thick impenetrable bushes, clogging waterways and encouraging soil erosion by eliminating indigenous ground cover. Additionally, *Prosopis* was accused of having chemical contents that caused tooth decay in goats; creating livestock digestive problems and causing allergic reactions in humans including respiratory ailments through its pollen (Odhiambo, 2015). The Il Chamus people believed that *Prosopis juliflora* was a threat to their survival, and they demanded that it be eradicated completely. More recently, the UNDP/GEF small grants program for environment and biodiversity conservation in the Lake Bogoria, Lake Baringo landscape has funded the restoration of degraded lands in the study area through capacity and skill building in pasture development value chains, sustainable land management, and livelihoods diversification.

The actions by both colonial and post-colonial Kenyan governments were motivated by the belief that traditional pastoral and farming activities were not economically feasible and posed a danger to the environment (Odhiambo, 2015). While acknowledging that some traditional land use practices can contribute to or worsen environmental degradation, Odada (2006) and Odhiambo (2015), pointed out that some interventions like the introduction of *Prosopis juliflora* carried out in “good faith” to better the livelihoods of the local pastoralist communities also have had negative effects. Climatic change has also negatively impacted and exacerbated land degradation of the environment in the area. The past interventions have been largely centered on top–down approaches and policy solutions with little participation from agropastoralists, therefore ignoring their experience and knowledge. This has led to low or no uptake of SLM technologies and where coercion has been used farmers are left feeling resentful. This emphasizes the need for a different approach than traditional extension delivery, emphasizing all stakeholder involvement in peer learning, facilitation rather than

teaching pedagogy, and local innovation processes rather than technical transfer (Duveskog *et al.*, 2011). Social learning within a learning platform such as a community of practice can serve this role.

2.5 Agricultural Extension and Advisory Services in Drylands

In the developing countries, one of the most important roles of agricultural extension and advisory services has been to disseminate innovations developed by research organizations through effective dissemination strategies such as demonstrations, field visits, farmer meetings, and media use (Sulaiman *et al*., 2006). Extension helps farmers improve agricultural production, generate revenue, and reduce poverty by assisting them in solving problems and participating in the agricultural knowledge and information system (Christoplos *et al*., 2001). However, most of the existing extension approaches and policy solutions have largely been top–down with little or no stakeholders' participation (Reid *et al*., 2009). The lack of farmers' participation in particular ignores their context, experience and knowledge and may lead to low innovations uptake. For the most part, the needs of resource-poor rural farmers, agropastoralists, and pastoralists in SSA who work in rapidly evolving environments and contexts have largely been ignored by topdown approaches (Leeuwis, 2004).

As an effective rejoinder to the needs of their clients, agricultural extension has undergone changes and reforms since the neoliberal World Bank reforms of the 1980s (Rivera & Sulaiman, 2009). The move from a linear top-down approach to a systems approach, in which innovation is the product of a process of networking, collaborative learning, and negotiation among a diverse collection of actors, is central to extension reforms and evolution (World Bank, 2006). Wennink *et al*. (2007) credit the extension reforms to the need to find an appropriate 'mix' of public and private funding and delivery mechanisms for extension that will serve populations in varying and changing contexts. Whatever the case, the reforms have resulted in a shift from the traditional top-down extension and rural development policies and strategies towards more bottom-up approaches (Sulaiman *et al*., 2006). The new approaches are characterised by decentralisation, plurality and stakeholder participation alongside concepts of social learning and sustainable development (Rivera & Sulaiman, 2009).

The low impact of agricultural extension within the pastoral sector and the general dryland landscapes is widely recognised (Mugambi *et al*., 2012; Mosalagae, & Mogotsi, 2013; Gustafson *et al*., 2015). The attributes commonly associated with pastoral environments make

traditional extension models unsuitable for use in there (Butcher 1994). To begin with, dryland inhabitants suffer multiple-dimensional marginalisation that makes their site-specific ecosystem knowledge and aspirations to stay mostly unconsidered within expert evaluations and management strategies. Distance and topography, cultural and linguistic barriers, access to resources, and institutional exclusion all contribute to their marginalization, as they are often excluded from policy decisions that impact their livelihoods (Whitfield & Reed, 2012). This poses challenges to the twin objectives of achieving sustainable land use and improved livelihoods as shown in many interventions that have not succeeded in drylands (Mortimore *et al*., 2008; Roden *et al*., 2016). Butcher (1994) observed that the term extension is commonly used in studies involving livestock within mixed-farming systems and rarely used in pastoralism literature, where terms like development, management or administration are used even when an aspect of extension is present or implied.

Research in natural resource management and rural development currently record empirical cases including adaptive co-management (Armitage *et al*., 2008), collaborative resources management (Danielsen *et al*., 2009) and the sustainable rural livelihoods approach (Scoones, 2009) that emphasise learning, experimentation and adaptation that come along with stakeholder interaction and participation. Central to these approaches is that learning is seen to have an important role at different levels of engagement including at resource users' level, resource managers' as well as the policy-makers level (Armitage *et al*., 2008; Berkes, 2009). The methods borrow insights from adult learning and are seen as having potential to trigger transformative behavior change in relation to environmental issues that some have dubbed social learning (Romina, 2014). Social learning, according to Tabara and Pahl-Wostl (2007), has become a useful interpretive framework for understanding and managing environmental problems in natural resource assessment and management.

2.6 Social Learning and Natural Resources Management

Since the 1990s, a variety of scholars have focused on Social Learning (SL), and it has emerged as normative goal in natural resource management and policy (Ison *et al*., 2011; Muro & Jeffrey2008; Pahl-Wostl et al., 2007; Reed *et al*., 2010; Scholz et al., 2014; Woodhill & Roling 1998). Social learning improves socio-ecological systems' resilience, and thus their ability to adapt to and act on change (Pahl-Wostl & Hare, 2004). Furthermore, social learning is expected to resolve the complexities of natural resource management, facilitate behavioral change, and encourage collective action (Muro & Jeffrey, 2008; Pahl-Wostl, 2006). The

central interest of this study was social learning, how it is facilitated through interactive settings within participatory processes, how it brings transformation in resource management and how it can be measured.

2.6.1 Origin and Definition of Social Learning

Bandura (1977), a psychologist, coined the word "social learning" to describe a theory of learning focused on observation of others and their social interactions within a community. To explain learning by observation of individuals, Bandura's Social Learning Theory (SLT) merged behavioristic reinforcement and cognitive psychology (Kilvington, 2013). The key aspects of observational learning according to Pahl-Wostl (2006) are attending to behaviour, remembering it as a probable model and playing out how it may work in different situations (Pahl-Wostl 2006). If the behavior of the model corresponds to the individuals' situation in terms of interests, values, experiences and goals, then the behavior of the model is imitated. According to this theory, learners have power to influence their own learning in new circumstances by controlling the environment around them whether that environment is obligatory, selected or constructed (Bandura, 1999). Bandura's SLT assumed an iterative feedback between the learners and their environment, the learner changing the environment, and these changes affecting the learner in return (Reed *et al*., 2010).

In this context, social learning can be viewed as a process of conforming to previously established and socially appropriate societal roles and practices (learning to fit), as well as a positive process in which new knowledge is created in and encouraged by a social framework (Morgan, 2011). Participating in social learning processes thus require modeling and observation, which helps to match the individual learner's identity with that of the community. According to Lindkvist (2005), identifying with a group may help create grounds for building trust, exchange relationships, and loyalty to the group while also establishing boundaries for reasonable individual behavior.

Since Bandura's (1977) SLT, the notion of SL, has been picked by numerous researchers and developed into diverse SLTs in psychology, sociology, criminology and natural resources management among others (Lave &Wenger, 1991; Muro & Jeffrey 2008; Pahl-Wostl, 2006; Webler *et al*., 1995). Authors in above disciplines conceptualise SL as a process of social change in which people learn from one another in ways that can benefit the wider social-ecological systems (Muro & Jeffrey 2008; Pahl-Wostl 2006). This conceptualization is

however criticised for ignoring theoretical advancements in the education and psychology literature and thus, there remains little consensus or clarity over the conceptual basis of social learning (Fazey *et al*., 2007). Reed *et al*. (2010) noted that SL as a concept is frequently confused with the conditions or methods necessary to facilitate it such as stakeholder participation. In reviewing literature on social learning theories Blackmore (2007), noted that SL is likely to be interpreted and defined according to the different disciplinary traditions and theoretical heritage.

Social learning is thought to have an effect on both the social and decision-making processes, resulting in the generation of new information, technological, and social skills (Woodhill, 2004). It is seen as encouraging people to share and focus on their own experiences, thoughts, and beliefs with others, resulting in a shared understanding of the system or issue (Keen *et al*., 2005). Through the process of social learning, stakeholders create consensus and decide on joint actions based on a common view of the situation (Webler *et al*., 1995). Participants in social learning, according to Schusler *et al*. (2003), can sometimes exchange incorrect technical knowledge or create negative views of others. This erroneous learning has the potential to sabotage interpersonal relationships. More powerful interests which co-opt the less powerful, as is common in deliberative processes, where certain parties' values and interests are consciously or unknowingly subordinated to those of more powerful, articulate, or persuasive actors (Holmes & Scoones, 2000). This research used Schusler *et al*. (2003) concept of social learning, which states that it happens when people interact with one another, sharing different viewpoints and experiences in order to establish a shared context of understanding and a foundation for joint action.

2.6.2 Social Learning in Natural Resource Management

Natural Resource Management (NRM) challenges come in many forms including competing land use, water allocation, and consumption of non-renewables; or pressures on systems, typified by degradation, biodiversity loss, or climate change (Pahl-Wostl & Hare, 2004). Furthermore, the increase in population confronts declining resources, amplifying the pressure on managing natural resources sustainably. Managing social-ecological systems in a sustainable way for human well being, necessitates a thorough understanding of these systems in all of their complexities (Medema *et al*., 2014). Kilvington (2013), noted that central to NRM challenges solutions is an increased capacity by stakeholders to learn and adapt their way through the problem situations.

The conventional approach of coping with NRM challenges is through top-down, command and control management controlled by state actors and based on hierarchical technological and sectoral solutions (Pahl-Wostl *et al*., 2008). For the most part this approach has been ineffective, in supporting the need for practical stakeholders' participation in social-ecological system management (Rammel *et al*., 2007). Accordingly, new approaches that lean towards an integrated resource management have emerged since the 1990s (Pahl-Wostl *et al*., 2011). These new approaches aim to ensure that knowledge, inspirations and interests of all stakeholders (local and regional) are considered when generating NRM innovations (Jiggins & Visser, 2016). The approaches see stakeholder participation as an answer to the need for flexible decision making in NRM by embracing a multiplicity of knowledge instead of relying exclusively on experts (Pahl-Wostl *et al*., 2011; Reed, 2008). This paradigm shift implies an approach to learning that supports managing systems at different levels from farmers, policy makers and other development agencies.

Social learning in NRM is such an approach. Since the 1990s, social learning has been championed as a framework that supports evaluation and consideration of the knowledge management needs in environmental management (Pahl-Wostl, 2006; Muro & Jeffrey, 2008). It denotes a group process whereby knowledge is co-created and shared between diverse stakeholders with different experiences and opinions on NRM. As such, it conveys the manner in which people learn and need to learn in order to gain insight into, predict, and control the way their actions affect the natural and human domains. It is based on citizen input, social responsibility and knowledge building (Muro & Jeffrey 2008). Social learning in NRM thus builds upon existing relationships, creates new ones and transforms adversarial ones thus enhancing stake-holders' capacity for joint action (Greenwood & Levin 1998). As a result, socio-ecological systems' resilience and capacity to adapt to and act on change are improved (Pahl-Wostl & Hare, 2004). Woodhill and Roling (2000) noted that social learning approach in NRM represents an action-oriented philosophy that focus on participatory processes of social change, which are undefined non-linear and non-deterministic.

Social learning outcomes in NRM include knowledge creation and sharing, conviction to take action, changes in attitude and changes in relational dimensions (Pahl-Wostl 2015). According to Muro and Jeffrey (2008), researchers and practitioners emphasized learning approaches that promote a democratic environment, open discussions, small group work, and

facilitation. In support, Woodhill and Roling (2000), noted the participatory processes of coordination, intermediation, dialogue and collaboration as being central to social learning. The processes described above allow for collaborative and collective learning, allowing participants to change their fundamental beliefs, behaviors, and values, resulting in changes in socio-ecological relationships (Muro & Jeffrey, 2008). Webler *et al*. (1995) noted that the critical point of social learning in a participatory environment, is when the group transforms from a series of individuals each pursuing their own private interests to a community characterised by a mutual resolve and oriented toward shared collective interests.

2.6.3 Collective Agency, Stewardship and Social Learning

The capacity of an actor to imagine options and make meaningful decisions based on those options is known as agency (Alsop & Heinsohn, 2005). The definition of human agency is based on the notion of a human agent who acts and affects change, and whose accomplishments can be measured against his or her own ideals and goals (Sen, 1999). People are partly the products of their environment but by selecting, constructing and transforming their environmental conditions, they are also producers of their own environments (Bandura, 2000).

Human agency involves a self-directed process, which involves individuals' construction of their world (Duveskog, 2011). It encompasses observable action in the exercise of choice in decision-making, protest, lobbying, bargaining and negotiation as well as the meaning, motivation and purpose that individuals bring to their actions (Duveskog, 2011). People, on the other hand, do not live-in individual self-sufficiency, and many of the results they pursue need interdependent and collaborative efforts (Bandura, 2000). As a result, people must work together to accomplish goals that they could not achieve on their own. According to Bandura (2000), a group's ability to achieve desired common objectives is a product of its members' shared skills as well as the interactive, coordinative, and synergistic dynamics of their transactions. This is collective agency.

Central to collective agency of smallholder farmers, pastoralists and agropastoralists are farmer and community organisations. Farmers and community organisations have the ability to leverage collective agency. They do so by providing a platform for joint learning and action which enlarges members field of access to ideas and information and enhance members capabilities to make choices (Duveskog, 2011). At the same time, the organizations

strengthen members capacities for planning, decision-making, collective action and expand their ties to other networks and resources. Bonding, bridging and linking social capital developed in farmers and community organizations facilitates collective action for mutual benefit and is a core element of an extension strategy aimed at poverty alleviation through the organization and participation of farmers and rural people (Pahl-Wostl & Hare, 2004).

According to Folke *et al*. (2005), social networks and learning communities like farmer organisations may contribute to social-ecological resilience through fostering flexibility, diversity, innovation, and responsiveness among actors. Ahn and Ostrom (2008) added that under the right state of organization, communities could sustainably manage their common property to create public good. These findings presented a counterpoint to Hardin's (1968) tragedy of the commons, a classic environmental theory, which assumed that without regulations, individuals would always act in their self-interest, leading to environmental degradation (Baugh *et al*., 2015). One condition that can lead to sustainable management of common property is the development of ecosystem stewardship.

Ecosystem stewardship is a concerted approach to a wide range of activities aimed at ensuring that land use corresponds to landscape capability and that landowners are compensated for the ecosystem services they provide (Victorian Catchment Management Council and Department of Sustainability and Environment, 2003). It describes goals, principles and actions that aim to achieve sustainability in natural resource management, contribute to conservation priorities, and curb environmental degradation (Nelle, 2011). According to Adger (2006), ecosystem stewardship aims to reduce vulnerability to environmental changes, fostering resilience in the face of uncertainties and transforming from undesirable trajectories like environmental degradation. Lertzman (2009), noted that ecosystem stewardship exemplifies characteristics like voluntary participation and moral-ethical standings that engender care and shared responsibility. It also puts emphasis on activities that assure inter-generational benefits, collaborations and linkages for sustainable land resource use.

Individuals can be stewards on their own or at a collective level where one places greater value on cooperation (Putten *et al*., 2014). Where personal normative values are shared by others, and collective goals overlap, there is a likelihood of individuals acting in the interests of achieving the collective objectives (Mills & Keast, 2010). However, individuals' options

and actions are shaped by factors including their capacity, values, and community setting. Stewardship practices may involve a group of individuals actively invoved in conserving and restoring nature, as well as instances of partnerships in which practitioners and scientists co-produce expertise with community members (Clark & Dickson, 2003). An understanding of cross-scale interactions and constructive ways of creating synergies across knowledge systems then become essential (Folke *et al*., 2005).

In encouraging and promoting the application of social learning, participatory learning platforms and networks need to be formed where individuals can meet, interact, learn collaboratively, make collective decisions and engage in collective action (Keen *et al*, 2005). The Communities of Practice (CoP) paradigm is one way of grounding and operationalizing social learning that is closely linked to social structure and situated in practice (Lave & Wenger, 1991). Communities of Practice offer platforms where people actively engage, learn together, share experiences and information about common concern hence increasing individual and collective agency and stewardship.

2.6.4 Measuring Social Learning

Social learning, as a recent notion in natural resources management, has been extensively studied as an outcome or phenomenon of problem-solving processes (Scholz *et al*., 2014; Tàbara & Pahl-Wostl, 2007). But rarely have authors looked at measuring of social learning as an outcome of community engagement in facilitated intervention to a common problem (Schusler *et al*., 2003). Instead, recent approaches to assessing social learning, concentrate on cognitive learning while ignoring the social-relational aspects of learning (Scholz *et al*., 2014).

According to Reed *et al*. (2010) and Scholz *et al.* (2014), social learning occurs if the following conditions are met; (i) people concerned have changed their understanding; (ii) this shift extends beyond the person and occurs within wider social units or communities of practice; (iii) this change occurs through social interactions and processes between actors within a social network; and (iv) convergent learning takes place, referring to an increase in mutual understanding (Reed *et al*., 2010). To measure whether or not social learning took place, Scholz *et al*. (2014) proposed the following metrics: (i) change in mental models (practical and interpersonal); (ii) impact of practical and interpersonal outcomes in the wider context, and (iii) increased similarity between mental models. While evaluating social

learning in UK flood risk management. Benson *et al*. (2016), used the following indicators; acquisition of new knowledge; change in understanding the issues of concern; development of trust; development of network and collective agreement on management of the issue of concern. Based on Scholz *et al*. (2014) and Benson *et al*. (2016) the researcher developed indicators to measure social learning.

2.7 Communities of Practice as Platforms for Social Learning

Knowledge networks are the social infrastructure that supports social learning (Phelps *et al*., 2012). An individual's ability to engage in social learning activities such as the generation, access and spreading of knowledge and information can be either impended or aided by the structure of the network and the individual's position in that network (Hoffman *et al*., 2015). The Communities of Practice (CoP) paradigm is one way of modeling and operationalising information networks for social learning that are relevant to social structure and situated practice (Lave & Wenger, 1991).

2.7.1 Understanding Communities of Practice

A Community of Practice (CoP) is defined as a group of people who share a concern, a set of problems, or a passion for a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis (Wenger, 2006). CoPs are characterised by mutual learning, shared practice and joint exploration of ideas during group interactions (Blankenship & Ruona, 2008). Therefore, learning within CoPs is a result of consistent participation in a social world where people are continuously interacting with one another to share practice and understanding in order to produce new knowledge (Oreszczyn *et al*., 2010). Constant interaction among members results in formation of bonds and practices that serve to create a communal identity resulting in trust and social capital (Morgan, 2011).

Successful CoPs provides platforms that create opportunities for regular interactions among members (Beena, 2013). Morgan (2011) defines a CoP as a linking and information-sharing structure that operationalises social learning by connecting it to the interaction of knowledge, experience, practice, and social structures. Learning is thus perceived as a social creation and information sharing mechanism, rather than a linear knowledge transfer process. In CoPs, knowledge is created, shared, systematized, revised, and passed on within and among participants (Wenger, 2006).

A combination of three defining elements constitutes a CoP distinguishing it from other groups (Cundill *et al*., 2015; Wenger *et al*., 2009). These three three dimensions include domain, community and practice (Wenger, 1998). The Communities of Practice theory of social learning therefore focus on the interaction between the three dimensions. Snyder and Wenger (2010) noted that the effectiveness of a CoP as a social learning system depended on its strength in all three structural dimensions. The three dimensions according to Wenger *et al*. (2002) are; (i) domain of interest which constitutes a field of knowledge or a common problem that gives members a sense of joint enterprise and brings them together to learn, (ii) community that forms as a result of members shared interactions and engagements that bind members together into a social entity, (iii) practice in which members develop capability by developing a shared repertoire and resources such as tools, documents, procedures, lexis, symbols, artefacts that symbolize their collected knowledge. Consequently, CoP members organize around a shared domain of interest, mutually engage in joint activities around the shared domain and are practitioners actively experimenting and testing ideas usually through shared resources (Cundill *et al*., 2015).

According to Wenger (2006), communities may develop their practice through experimentation, problem solving, requests for information, coordination and building synergy, discussing developments, mapping knowledge and identifying gaps. In this case, CoPs, mediates learning by opening up new communicative spaces and networks in which democratic inquiry and knowledge sharing can take place among divergent actors (Pimbert, 2002). Developing this sort of shared practice takes time, trust, and sustained interaction (Cundill *et al*., 2015). More recently, Wenger *et al*. (2015), proposed that different communities of practice may also come together to form larger "landscapes of practice" which have the potential to serve as loci for social learning and innovation.

Application of CoPs concept to social learning in multi-stakeholder platforms offers a fresh insight into understanding the learning processes, functioning and logic of the platforms (Morgan, 2011). A study on the applicability of CoPs in agricultural value chains partnerships noted that CoPs can work as catalyst of diverse interests to create solutions to common problems. They benefit agricultural stakeholders by acting as magnets to attract funding, scouting emerging opportunities and by being hubs to create, capture, document and deploy knowledge (Value chain partnership, 2011). TerrAfrica (2009) proposed establishment of common pool of knowledge platforms like CoPs, related to SLM

technologies and approaches for adoption and successful up scaling. Communities of practice in SLM differs from other learning networks in that they provide participants with opportunities for learning directly in the field and from SLM protagonists and practitioners of the best practices and innovative approaches (Cundill *et al*., 2015). Together stakeholders adapt SLM practices to the practitioner's context through joint experimentation and practice (Folke *et al*., 2005).

Like all human interactions, Wenger *et al*. (2002) warned about CoPs downsides. He noted that CoPs reflects strengths, weaknesses and complex inter relationships of human behavior. As such they can hoard knowledge, limit innovations and hold outsiders hostage to their expertise. Close knit CoPs, can become exclusive and inward focused with rigid and impermeable boundaries creating a barrier to outsiders and new ideas, leading to social and cultural exclusion. Recognizing the downsides of CoPs helps in managing their shortcomings (Wenger *et al*., 2002). The participatory action research approach in this study therefore seeks to make a link between the generation of SLM innovations by research and agropastoralists practice in situations of active intervention to create change.

2.7.2 Applying CoPs Framework to Farmer Groups

The last two decades have seen many innovative methods designed for small-scale farmers and agropastoralists capacity building in developing countries in terms of institutional set-ups and methods (Fayssea *et al*., 2012). The approaches and methods were mainly built on the criticism of the linear transfer of technology model and aimed to highlight farmers' knowledge and the need to involve them in multi-stakeholder innovation partnerships (Hall, 2009). Farmer group-based learning approaches in agriculture if implemented properly can be an effective means of building farmer competencies and networking (Schad *et al*., 2010; Fayssea *et al*., 2012).

While underscoring the standing of farmer groups in learning, Schad *et al*. (2010) added that groups provide space for mutual learning, improve analytical skills, support networking and gain recognition of input suppliers, marketing outlets and knowledge providers. Thus, groups are acknowledged as being key in agricultural innovation by locating and mobilizing information, resources and influence necessary to advance better household welfare and community services (Leeuwis, 2004). Extension approaches building on this paradigm underscore the significance of farmer participation in innovation development and adaptation.

Emphasizing the importance of social networks for agropastoralists and farmers' learning, Matuschke (2008) noted that such networks and local social structures ought to be taken into consideration when designing activities aimed at supporting knowledge acquisition and sharing.

Farmers' grassroot organizations have grown in popularity in recent years, particularly in terms of providing services to their members and managing natural resources (Mercoiret *et al*., 2006). Building farmers' capacity in partnership with existing local community organisations may be a way to address the problem of farmers' empowerment in natural resources management. With recent policy developments in the agriculture sector, vocalizing the place of farmers within the wide networks of knowledge and the role of socially facilitated generation and use of knowledge has become crucial (Morgan, 2011). These developments have seen farmers' groups emerge as significant organisations serving the information and learning needs of members. According to Mercoiret *et al*. (2006), farmers' organisations can support farmer learning and innovation processes in three main ways. First as a space for exchange to consolidate and disseminate farmers' know-how and innovations; second by setting up specific support mechanisms for learning activities and third by participating in the characterisation and monitoring of the activities of research and extension organisations.

The ability of community groups to fulfill their mandate is contingent on their ability to design themselves as social learning structures that promote long term learning and viable networks (Beena, 2013). Typically, learning in farmer and community groups is an issue of engaging in and contributing to the activities, conversations, reflections and other personal interactions form the basis of learning. Beena (2013) noted that, participatory processes adopted in groups are important in pooling skills, knowledge, experience and other resources from multiple partners. In addition, participatory processes allow for collective identification of problems, planning, and implementing research and development activities that are context and location specific (Akinnagbe & Ajayi, 2010). The interactions in the organisations also promote bonding through which members develop a sense of identity and build social capital. Beena (2013), noted collective engagement and member's connections as being essential components for effective functioning and collective learning in groups. Largely, the two are dependent on identity and social capital.

Collective action among agropastoralists in rangelands can take several forms at various scales, including informal support networks between neighbors, community-based self-help groups, and formal cooperatives (Baden 2013; Pretty & Ward 2001). Although collective action by a clearly defined communities is often more identifiable and therefore more likely to have long-lasting consequences (Ostrom 1990), CoPs can also take the form of more informal, fluid, and versatile grassroot organizations like farmer groups, which have the advantage of being sensitive to the diverse and changing needs of those involved (Pandolfelli *et al*., 2008; Pretty & Ward 2001).

This conceptualization of learning within agropastoral and farmers groups aligns closely with notions of CoPs which are entities that grow out of convergent interplay of mutual engagement, shared practices and strong interpersonal ties (Wenger *et al*., 2002). Learning in CoPs is seen as an ongoing practice resulting from the participation and contribution of members to community collective activities. Communities of practice have since evolved into a foundation for a viewpoint on knowing and learning that guides efforts to develop learning systems at all levels, from local communities to organisations, alliances, and collaborations (Wenger *et al*., 2002). Figure 1 shows a framework of community groups and their supporting agencies coming together to form a CoP in restoration of degraded drylands.

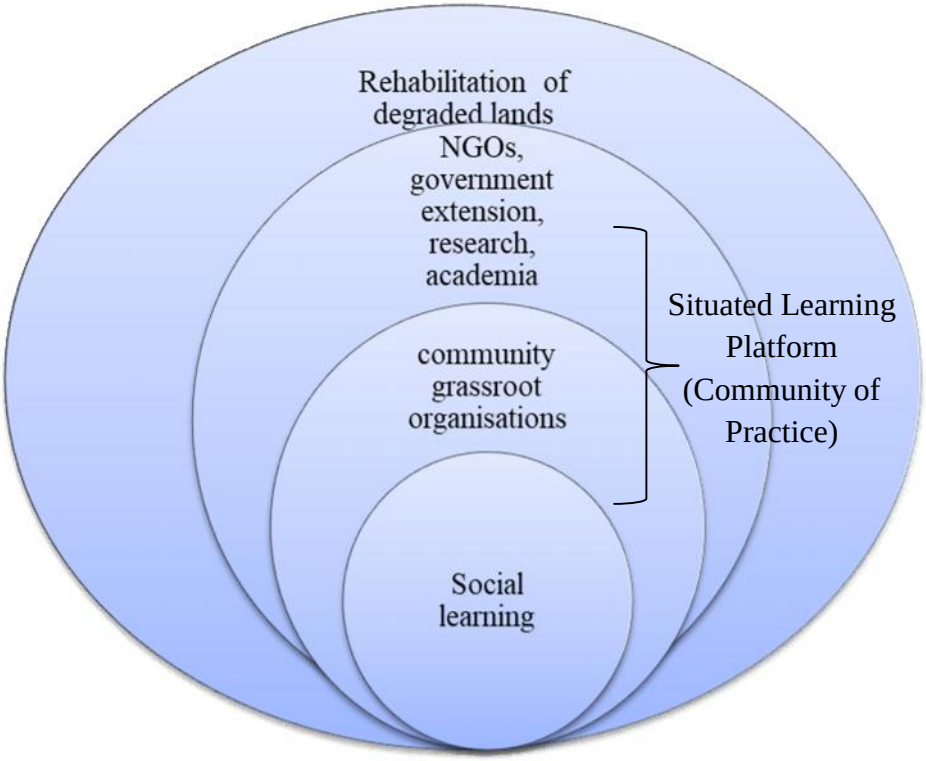

Figure 1. *Community Groups and their Supporting Agencies (adapted and modified from World Agroforestry Centre, 2017).*

The application of CoP concept to farmer groups in drylands practicing restoration of degraded lands using enclosures approach in Njemps Flats in Baringo County, Kenya enabled the researcher gain a comprehensive understanding about how learning occurs within community and farmers groups in collaboration with other actors. Such understanding is useful in identifying the logic and significance of community and farmer groups in the generation and dissemination of agricultural information and innovations (Morgan, 2011; Van Burren & Edelephos, 2006). In this study social learning was seen as a means of leveraging community groups as learning and innovation platforms for creation of context specific innovations and options for combating and rehabilitating degraded drylands and by so doing promoting integration of human livelihoods and environmental stewardship.

2.8 Addressing Research Gap in Social Learning in Sustainable Land Management

Despite the efforts and investments in SLM practices in the Njemps flats, adoption of the practices remains low and land degradation continues unabated. Lack of understanding of the the root causes have often led to efforts and interventions being wrongly focused on addressing the visible symptoms rather than attacking the site-specific drivers of land degradation (Liniger *et al*., 2011). The researcher sought to address this gap through identification of site-specific causes, indicators and effects of land degradation in the Njemps flats to ensure that efforts are directed in the right direction. In addition, there exists a gap between what research and extension see as suitable and essential and what the farmers are prepared to practice in their fields. Given that SLM practices are location specific, then farmers participation in generation of the technologies is critical (Adger, 2003). An approach that ensures knowledge, aspirations and interests of practitioners are integrated into SLM an innovation is needed if desired impacts are to be achieved (Jiggins & Visser, 2016). Social learning in natural resources management has been touted as such a method (Reed *et al*., 2010).

Literature reveals that more has been written about the meaning of social learning, or whether social learning has occurred in any given situation, than about the ‘how to’ of social learning (Kilvington, 2013; Scholz *et al*., 2014). Through the establishment of a community of practice, to serve as a nucleus for social learning and catalyse actions in rehabilitation of degraded land. The researcher sought to understand and document the process and the realities of voluntary participation and social learning involving farmers as practitioners, research and extension.

2.9 Theoretical Framework

A theoretical framework provides a lens that frames and shapes what the researcher looks at and includes in a study and how the research is conducted (Mertz & Anfara 2006). This study built on the theoretical perspectives of Wenger's social theory of learning in communities of practice (Wenger, 1998) and the Theory of Change (TOC) as proposed by Weiss (1995).

2.9.1 Theory of Social Learning in Communities of Practice

The theory of social learning by Wenger (1998) veers from Albert Bandura's 1977 social learning theory, based on the idea that individuals learn from observing and modeling the behaviours, attitudes and emotional reactions of others. While Bandura's theory is rooted in the traditional behavioral psychologist approach, Wenger's social learning theory leans towards the constructivist theories where learning is a product of the process of interaction between individuals and social actors with different types of knowledge and experiences (Morgan, 2011; Moschitz *et al*., 2015). In this theory, learning is conceived as a process of social construction wherein knowledge is shared and co-created within exchanges in social networks, and not transferred by experts (Morgan, 2011; Saether, 2010). Thus, social learning can be described as learning that is social in nature, embedded in a social context and is influenced by social structures within the particular social unit or community.

According to Wenger (1998), social learning, allows social units to learn and become critically knowledgeable about their situations through collective problematisation and reflection. It creates changes in widespread awareness and in how people see their isolated interests linked with the shared interests of their fellow citizens. This enables individuals to overcome tendencies to pursue egoistic objectives before collective ones (Kilvington, 2013). This observation agrees with Ahn and Ostrom (2008), who argued that under the right conditions, communities can learn, work and together manage sustainably their common property to create public good. It also offers a counterpoint to Hardin's (1968) tragedy of the common's theory, which argued that without regulations, individuals always act in self-interest, leading to environmental degradation. In collective action, individual goals and interests do not necessarily become peripheral but rather individuals build cognition about their interdependence and appreciate the reciprocity mechanisms that exist when they form collectives with shared interests, values and objectives that may make the achievement of their goals and interests faster.

While social learning has been linked to the efforts of rural farmers and their supporting agencies to learn and develop agricultural innovations (Spielman *et al*., 2011) how it is implemented in practice nevertheless remains a daunting challenge (Miller *et al*., 2013). Lave and Wenger (1991) proposed Communities of Practice (CoP) as an approach of grounding and operationalising social learning in locally situated practice. According to Wenger *et al*. (2011), communities of practice are formed by people who engage in a process of collective learning in a shared domain of human endeavor. Through communities of practice, learning is commonly viewed as a process of social construction and knowledge sharing, rather than linear knowledge transfer (Morgan, 2011).

Owing to the interaction processes in CoPs, members can establish a common identity and understand their common interests and problems (Oreszczyn *et al*., 2010). This enlightment subsequently stimulates collective knowledge production, learning and innovation (Angelle, 2008). A CoP thus serves as the social infrastructure or the social institution that mediates social learning within a network of different actors (Phelps *et al*., 2012). Morgan (2011), views a CoPs as providing platforms where practice is developed and pursued, meaning and enterprise negotiated and membership roles developed and defined through various forms of engagement and participation. Wenger (1998) proposed four components of social learning in communities of practice to include, learning as belonging in a community, learning as becoming with constructing identity, learning as experience through the negotiation of meaning, and learning as doing through engagement in shared practice (Figure 2). According to Snyder and Wenger (2010), social learning in CoPs can develop practice through problem solving while continuously reflecting on how and why of the working approaches and then using these insights to guide future actions.

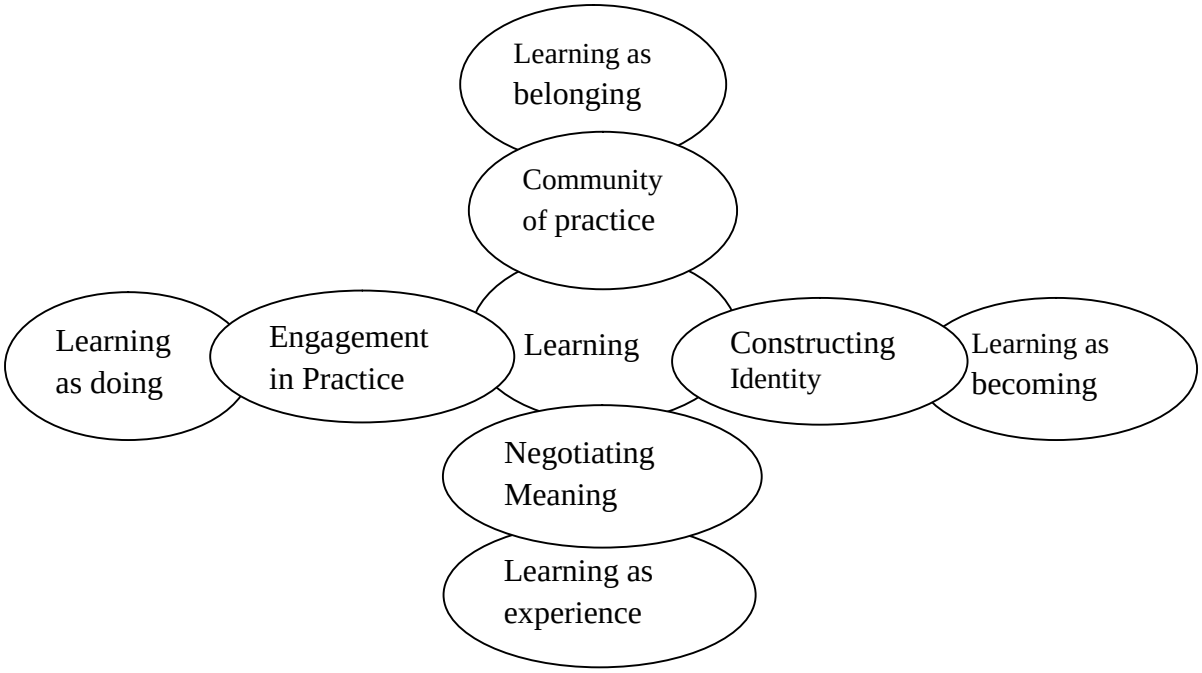

Figure 2. Components of Social Theory of Learning in Communities of Practice (Wenger, 1998)

Wenger (2002) also noted differential levels of participation in CoPs including core, active and peripheral members. The core group members are highly active, providing leadership and ensuring that the CoP has legitimacy, whereas the active members participate regularly and identifies with the CoP. The peripherals who form the majority participate little in CoP's activities but learn by observing activities in the core and active groups and might implement what they learn (Wenger *et al*., 2002). An individual's ability to engage in social learning activities such as the generation, access and spreading of knowledge can either be impeded or enabled depending on the arrangements of the social network and the individual's position within the network (Hoffman *et al*., 2015).

2.9.2 Theory of Change

Theory of Change (ToC) is a monitoring, evaluation and learning framework that intergrates indicators of progress in research along with indicators of change by providing links between activities, outcomes, impact and contexts of an intervention (De Silva *et al*., 2014; Weiss, 1995). It offers a detailed narrative explanation of an intervention impact pathway and how changes are projected to happen, based on assumptions made by stakeholders (Thornton *et al*., 2017). In consequence, ToC aids in exploring and defining desired change in a given context and the roles played by different actors and organizations while fulfilling the

functions of strategic planning, communication, accountability and learning (Stein & Valters, 2012; Valters, 2015). According to De Silva *et al*. (2014), the utility of a ToC is in its ability to demonstrate progress on the achievement of outcomes, thus providing evidence and indicators that the intervention was effective. For this reason, the outcomes in ToC must be coupled with indicators that operationalize and make them understandable in concrete, observable and measurable terms (Thornton *et al*., 2017).

The theory requires the participation of stakeholders to model desired outcomes and impacts they hope to achieve as well as the roadmaps through which they expect to arrive at them and is modified throughout the intervention in an ongoing process of reflection and learning (James, 2011; Valters, 2015). According to Klerkx *et al*. (2010), research and development approaches based on ToC have the potential to address need for learning as a critical element of innovation in sustainable development complex problems. Learning in ToC approaches is manifested in changes in knowledge, attitudes, skills and practices in a wide assortment of stakeholders including development practitioners, extension services providers, farmers and policymakers. Thornton *et al*. (2017), explains that ToC, has no single definition and no set methodology but, allows flexibility and innovativeness according to the needs of the user or implementer.

According to Stein and Valters (2012), ToC is a useful approach for interventions in a research setting like PAR because it allows for the understanding of the multiple causal pathways and feedback loops which better reflect the reality of how interventions achieve their impact. In this study, CoP gave actors involved in rehabilitating degraded drylands in theNjemps Flats a platform to learn together as they diagnosed problems, planned on action, mobilized and allocated resources and identified success indicators and outcomes. This participation ensured successful implementation of planned activities and achievement of the desired change which is rehabilitation of degraded land indicated by improved knowledge and skills on SLM practices and adoption of SLM practices. Figure 3 provides an example of how different components might be illustrated in a ToC map.

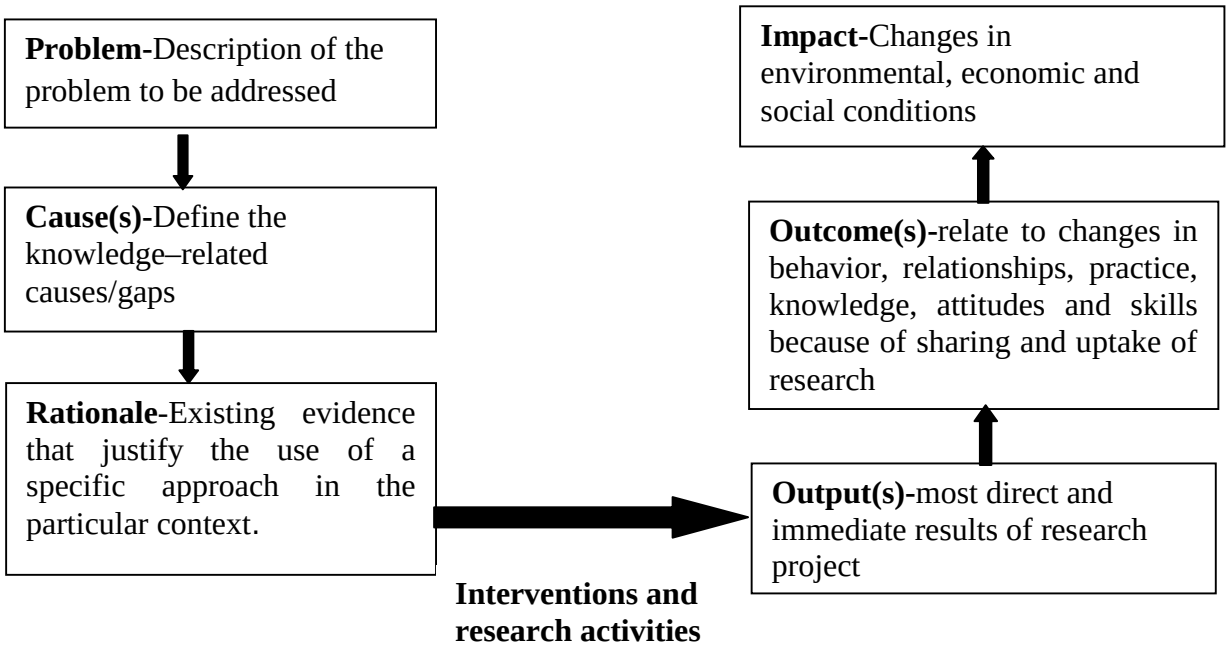

Figure 3. Example Theory of Change framework; Source: Adapted from Thornton et al. (2017).

2.10 Conceptual Framework

The study assumed that social learning in a community of practice would lead to change in community SLM practices knowledge and skills, raise concern over environmental degradation, strengthen environmental stewardship and build stronger collective and individual agency. These would in turn be translated into attitude change resulting into change in collective and individual behaviour leading to rehabilitation of degraded land and a move towards land degradation neutrality in the Njemps Flats. The final expected result would be more pasture available for livestock, less pasture conflicts, increased crop production, more household income and food security. In addition, participation in CoP activities and interaction among stakeholders was expected to result in new social networks being created and old ones being improved. Such networks were expected to build farmers' capacity and capabilities for adoption of SLM strategies through knowledge sharing and pooling of resources.

Figure 4 shows the interaction between the study's variables. The independent variable in the framework is social learning while rehabilitation of degraded land is the dependent variable. Moderator variables including gender and education level of household head, farm size, land

tenure, farm enterprises and household income were built into the study. Figure 4 is the Conceptual Framework of the study.

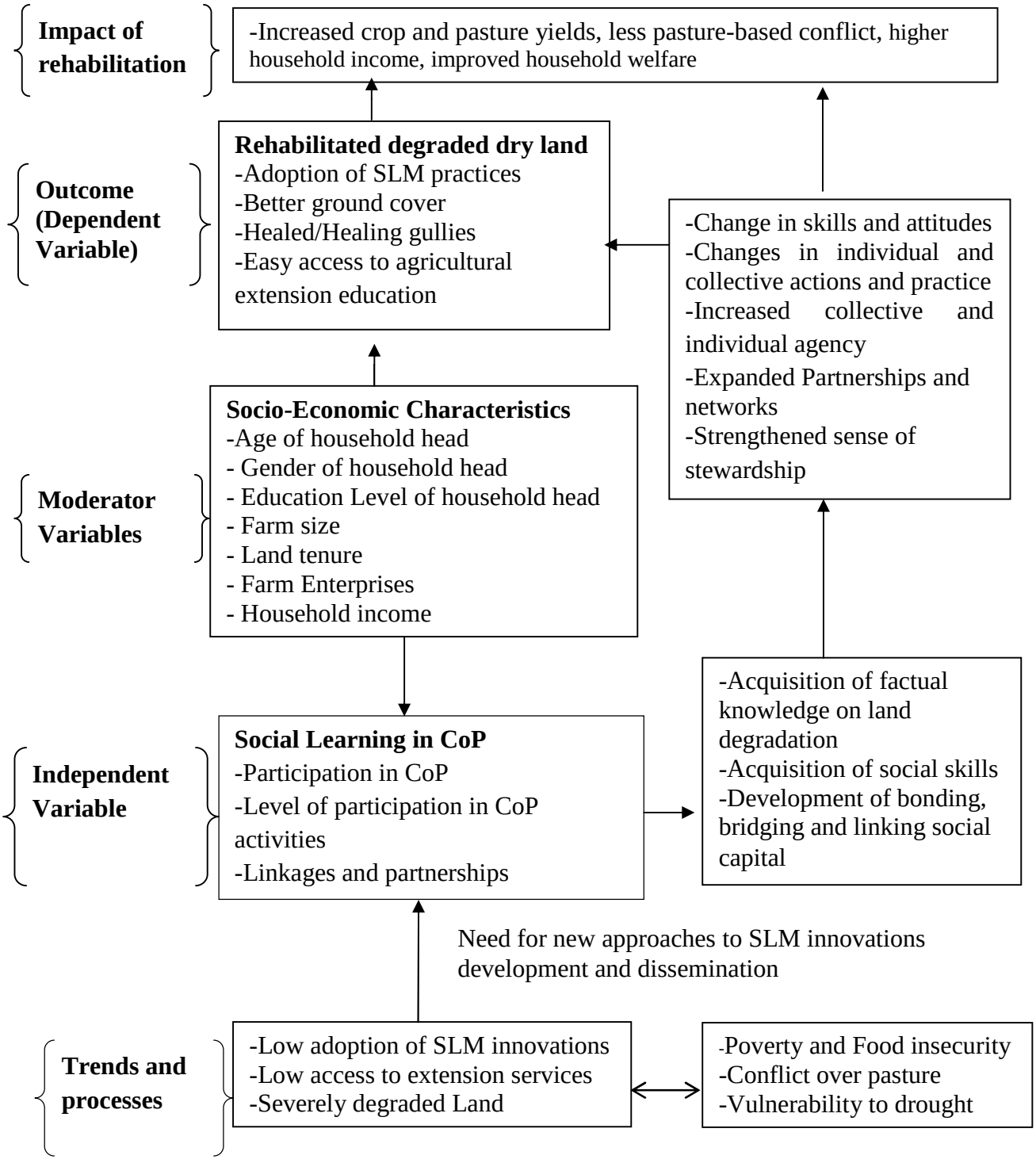

Figure 4. A Conceptual Framework for the Study

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the research philosophy, design and data collecting tools adopted for study. It also describes the study area, gives the target population, sample size determination, sampling procedure, instrumentation and how data was collected and analysed.

3.2 Research Philosophical Paradigm for the Study

Research philosophical paradigm is a set of beliefs, practices and assumptions that regulate enquiry by providing lenses, frames and procedures through which research is done (Lincoln *et al*., 2011). These are either axiological related to values and beliefs, ontological related to the perception of reality of nature or epistemological and linked to nature of production and dissemination of knowledge (Creswell, 2009). Based on researchers' view about the enquiry process, Saunders *et al*. (2009) identified research philosophical paradigms to include positivism, constructivism (interpretivism) and pragmatism. Positivism assumes existence of one reality which can be validated through the senses and advocates for rationality, objectivity, prediction and control in research (Creswell, 2009). On the other hand, constructivism assumes multiple realities for any phenomenon, relies on participants view as much as possible and adopts a stance that every individual perceives, interpret and experience a phenomenon of interest from one own point and context (Collis & Hussey, 2014).

While both positivism and constructivism are on opposite ends of ontology and epistemology continuum, numerous research questions fall in between calling for modification and a shift of the researcher's assumption to a new position on the continuum (Collis & Hussey, 2014). This in between philosophical stance is called pragmatism. Pragmatics can combine both, positivist and interpretivism positions within the scope of a single research according to need and nature of the research question (Lincoln *et al*., 2011). It allows researchers freedom to employ multiple sources and methods of data collection, focus on the practical implications of the research, and emphasize on the importance of conducting research that best addresses the research problem (Saunders *et al*., 2009). In the current study the researcher adopted the pragmatic paradigm employing mixed methods amenable to quantitive and qualitative analysis.

3.3 Research Design

The study employed the Participatory Action Research (PAR) design. MackDonald (2012) defined PAR as social research done by a team that incorporates an action researcher and members of an organization, community, or network who are looking to improve the participants' condition. According to Reason and Bradbury (2008), the researchers and participants identify a problem or circumstance that needs to be addressed, and then conduct research that uses their skills and resources to prompt appropriate action while emphasizing on collective inquiry and experimentation grounded in their experience and social history. Researchers and participants both reflect on and learn from this action before moving on to the next phase of study, action, or reflection (Kindon *et al*., 2007). Together they develop context-specific methods to facilitate the cycles including the adaptation of traditional social science methods like semi-structured interviews for surveys, focus groups and Geographic Information Systems (GIS). Methods that focus on dialogue, storytelling and collective action like participatory diagramming and mapping allow researchers and participants to explore issues and relationships regarding the issue of interest (Kindon *et al*., 2007).

The starting point of PAR is therefore a researcher joining with an individual or group of people who are concerned about their situation (Lingard *et al*., 2008). The traditional social science approach, in which an outside researcher sets the agenda, chooses the questions to be asked, and conducts the interview or questionnaire survey for later study, is challenged by PAR. In so doing, PAR emphasizes shared learning, shared knowledge, and flexible yet structured collaborative analysis (Kemmis & Mc Taggart, 2007) which are all elements of social learning. The use of PAR is therefore consistent with an intervention-based approach where the focus is action to improve a situation and learning and knowledge generation is a conscious effort (Reason & Bradbury, 2008).

3.4 Location of the Study

The study was conducted in the Southwestern basin of Lake Baringo commonly referred to as the Njemps Flats in the two administrative Wards of Il Chamus and Mukutani in Baringo South Sub-County. The area is a semi-arid rangeland inhabited by the Il Chamus a Maa speaking small indigenous tribe with a population of about 35,000 people (Kenya National Bureau of Statistics (KNBS), 2015). The Il Chamus are primarily a pastoralist tribe that has steadly transitioned from nomadic to sedentary and agropastoral livelihoods in the last few decades (Little, 2016). Other livelihood activities are, wage labour, fishing, small-scale

trading and charcoal burning (Mureithi *et al*., 2015). The poverty incidence in the area is high with over 50% of the people living below poverty line (Kenya National Bureau of Statistics (KNBS), 2015). Poverty in the area is aggravated by severe droughts and floods, colonization by invasive species, low access to agricultural assets, education, extension services and insecurity (Odada *et al*., 2006). The area has a small but growing immigrant population from other parts of Kenya practicing irrigated farming within the wetlands and in the government-sponsored Pekerra irrigation scheme.

Njemps Flats lies in the agro-ecological zone VI between 0°45′ and 0°15′N latitude; 35°45′ and 36°30′E longitude. Rainfall received in the area is low and erratic ranging from 300 mm to 700 mm annually spread over two seasons and experiences hot and dry periods with an annual mean temperature above 30^{o}C with maximum temparatures of 35^{o}C (Kiage *et al*., 2007). The dominant soils in the Njemps Flats are generally shallow silt loam to clay loam, with low organic matter (Johansson & Svensson, 2002). The main sources of water in the area are rivers Pekerra, Molo and Endao (seasonal), which drain into Lake Baringo. The vegetation in the area is dominated by acacia woodland and the invasive *Prosopis juliflora* (80%) seasonally flooded grassland (15%), shrub grassland (5%) and the permanent Loboi swamp and covered by *Cyperus papyrus* (Verdoodt *et al*., 2010). Intensive grazing pressure, highly erodible soils and erratic rainfall, have led to large-scale disappearance of annual and perennial grasses leaving the ground bare and severely degraded particularly during droughts (Mureithi *et al*., 2015). Figure 5 shows Map of the study area.

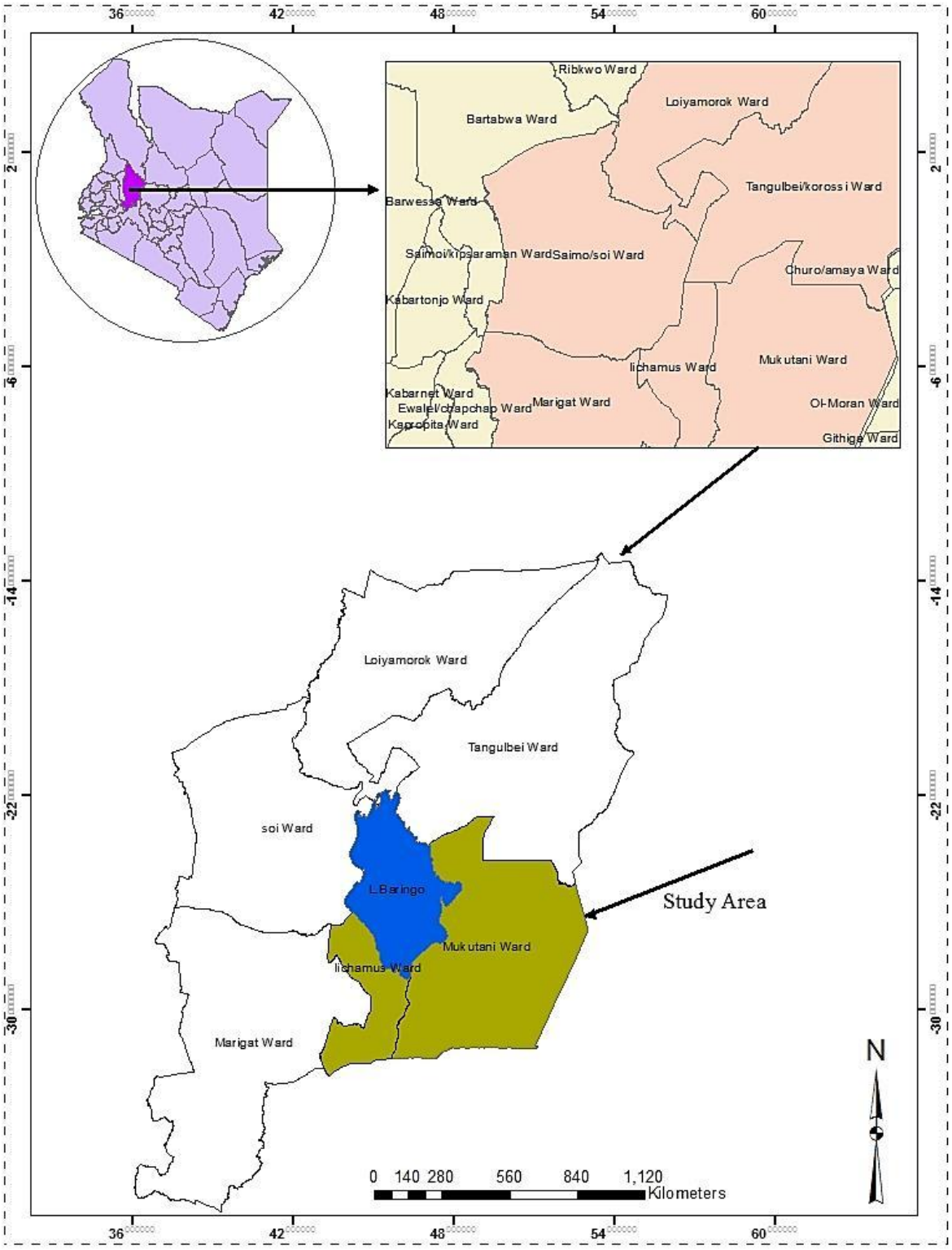

Figure 5. Map of the Study Area

3.5 Target Population

The target population comprised of 4557 households in Mukutani and Il Chamus Wards of Baringo South Sub County (Kenya National Bureau of Statistics (KNBS) and Society for

International Development (SID), 2013). These are smallholder households engaging mainly in livestock keeping and growing of diverse crops on small scale. The farmers were targeted because they are the SLM practices adopting units and effective training and learning is reflected in their transformation in terms of knowledge gained, attitude change and adoption. In addition, institutions working in the area in the fields of agriculture and natural resources management were also targeted as stakeholders for collaboration in the community of practice. Those institutions included Kenya Agricultural and Livestock Research Organisation (KARLO) Ministry of Agriculture Baringo South Sub-County, Egerton University's Dryland Research Training & Ecotourism Centre at Chemeron, and local NGOs. These institutions were targeted because they are involved in identification of SLM needs, generation of SLM practices, dissemination of SLM information and capacity building in SLM.

3.6 Sampling Procedure and Sample Size

Il Chamus and Mukutani Wards were purposively selected for the study due to the prevailing and persistent land degradation and the resulting food insecurity. A sample of 150 household heads were interviewed for the study. The sample size was arrived at using Nassiuma (2000) formula indicated below.

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

Where:

n = is the sample size

N = is the known population of Il Chamus and Mukutani Wards

e = is the error margin of (3%)

C = is the coefficient of variation (30%)

The sample size based on this formula was:

$$n = \frac{4557 * 0.3^2}{[0.3^2 + (4557-1)\,0.03^2]} = 100$$

Fifty respondents were added to the sample making it 150 to cater for possible non-response which could arise when a targeted respondent fail to respond to particular items which would be a threat to internal validity (Moore, 2000; University of Reading Statistical Centre, 2000).

Systematic random sampling was done for the sample where every 3rd household head was interviewed by the researcher with the help of trained enumerators.

Table 2

Participating Households' Heads Per Ward

Ward	Households	% Sample Contribution	Households Heads
Il Chamus	2901	63.6	95
Mukutani	1656	36.4	55
Total	4557	100	150

Two gender separated Focus Group Discussions (FGDs) each consisting of 10 participants were conducted targeting residents from Il Chamus and Mukutani Wards who had lived in the area for more than thirty years of their adult lives. This was done to help capture trends in land use and land degradation. Snowballing was used to select FGDs participants starting with three local community elders suggested by ward extension officers, who then directed the researcher to other three suitable participants who in turn suggested other residents and so on. Seven key informants were purposefully sampled from experts in agriculture, environmental conservation institutions, and NGOs working in the area, research and community leaders who have first hand knowledge on land degradation and livelihoods in the area.

For the CoP establishment, invitation was made in Il Chamus Ward during baseline survey for interested individuals to join and form a group which would jointly with research and extension form a community of practice and provide a space for social learning in SLM practices. Forty-five community members showed interest but only thirty-five turned up for group meeting. Melita Group as named by the community participants was formed with thirty-five active members and registered as a self-help group by the Ministry of Gender and Social Services. In this case Il Chamus Ward was purposively selected for CoP formation because it was more accessible and relatively stable in terms of security, suffered more land degradation challenges and the inhabitants were more sedentary than Mukutani Ward (Baringo South Sub County Agricultural Extension Officer, 2018). For evaluation of the influence of social learning all the thirty-five members of Melita self-help group were interviewed. Kathuri and Pals (1993) recommended a minimum of 30 cases for each subgroup in a survey. Table 3 presents a summary of all the participants in the study.

Table 3

Summary of Respondents

Target Group	Number of respondents
Agropastoralists (Household heads survey)	150
Female residents of more than 30 years (FGD 1)	10
Male residents of more than 30 years (FGD 2)	10
Key informant	7
Melita self-help Group	35
Sub County Extension	2
KALRO	1
RAE	1
Total	**214**

3.7 Instrumentation

Being a participatory action research, data was collected in series starting with a household baseline survey and ending with evaluation of the community of practice platform. The study employed multiple instruments for the purposes of data collection because no single method of data collection is perfect in itself (Reason and Bradbury, 2008). Three data collection tools were used for the study.

3.7.1 Data Collection Instruments

Three researcher developed instruments were used to collect data. The first was a semi-structured questionnaire (Appendix A) used to interview household heads for baseline survey. This consisted of five sections (i-v). The first section (i) looked at respondents' socio-economic data, section (ii) land use and cover change in the area, section (iii) land degradation indicators, drivers and SLM practices used in the study area (iv) collected data on effects of participation in farmer groups on adption of SLM practices and section (v) obtained data on the use of enclosures in the rehabilitation of degraded lands.

The second instrument (Appendix B) was a focus group discussion guide which had four sections. Section (i) collected data on drivers and effects of land use and land cover change, section (ii) covered land degradation indicators, drivers and effects (iii) looked at combating land degradation and rehabilitation degraded lands while (iv) looked at supporting agencies of rehabilitation of degraded lands in the study area.

The final instrument used was a structured questionnaire used to evaluate the level of social learning in the CoP, influence of the level of participation in the CoP activities on social learning and the influence of social learning in CoPs on SLM knowledge acquisition, farmers SLM practices adoption behaviour, environmental stewardship, collective agency, networks and other benefits of the CoP to the participating individuals and their households.

The instruments were chosen due to their appropriateness for collection of the desired data. Fraenkel and Wallen (2000), described questionnaires as being ideal for surveys due to their efficiency and low cost in preparation and administration. Focus group discussion guides have also been noted for providing rich data with enormous potential for comparison which help understand the phenomena under study in depth and across a variety of contexts, particulary where many factors are potentially important (Barbour, 2008; Yin, 2009).

3.7.2 Validity

Validity is the extent to which results gotten from the analyzed data actually represent the phenomenon being studied (Fraenkel & Wallen, 2000). To ensure content and face validity and to accurately measure the variables of interest in the study, each of the items in the instruments were discussed with the supervisors. The researcher gave attention to each study objective to ensure they were fully addressed by the items contained in the instruments. The researcher also incorporated comments and suggestions from the oral examination of the proposal at department and faculty levels, to ensure that the instruments yielded valid data from which appropriate, meaningful and useful inferences could be made.

3.7.3 Reliability

Reliability is a measure of the degree to which a research instrument yields consistent results after repeated trials (Fraenkel & Wallen, 2000). To ensure reliability, a pilot study was done on a sample of 30 agropastoralists from Mogotio Sub County in Baringo County. The area lies in the same agro-ecological zone and residents are agropastoralists experiencing same livelihood challenges as people in theNjemps Flats. Yin (2009), proposed an equivalent of 10-20 percent of the sample size for a pilot study making a sample of 30 appropriate.

The reliability of the instruments was estimated using Cronbach's Alpha Coefficient which is a measure of internal consistency. According to Mugenda and Mugenda (1999), use of Cronbach's Alpha Coefficient reduces the time required to compute a reliability coefficient

like in other methods and results in a lower estimate of reliability which avoids erroneous conclusions. Cronbach's Alpha Coefficient was found to be suitable for the study because it requires a one-test administration and it is the best for items with Likert scale (Tavakol & Dennick, 2011). A reliability coefficient of 0.78 was obtained. This according to Trochim (2006) is acceptable as it is above the threshold of 0.7 for social studies such as the current one. Outcome from piloting the instruments was used to address deficiencies and ambiguities present in the instruments. For qualitative data, Patton (2002) advises researchers to engage participants throughout the research and data collection process as a means to guarantee reliability and appropriate dissemination. Through participatory action research this study engaged the research participants in data collection, as well as using them to corroborate the findings as a way of ensuring reliability (Yin, 2009).

Reliability of GIS data was done through *accuracy assessment for land use classification using* Kappa Coefficients (Khat). Classification accuracy indicates the extent to which the resulting image classification conforms to the truth (Foody, 2002). As further observed by Foody, two pertinent questions as regards land use mapping accuracy may ensue. First is the extent to which each group in a classification is correctly located in the original map and Second, is whether the boundaries demarcating the groups are validly located. Overall accuracy is determined by dividing the sum of all properly classified pixels found along the central diagonal, by the total number of reference pixels. It shows an overall result of the number of the tabular error matrix. Anderson *et al*. (1976) suggested that the minimum overall accuracy should not be less than 85%. Comparatively, the overall accuracy for the year 1980, 1995 and 2019 was 98.6, 99.2 and 99.1%, respectively. Further, Kappa Coefficients (Khat) were calculated by comparing the number of pixels in each cell in the confusion matrix with the possibility to distribute pixels as a random variable, thus measures the accuracy for each classification as it accounts for all the elements in the matrix rather than diagonal elements. In the current study, this was attained by measuring the agreement between the classification map and reference data. Results showed 0.83, 0.81, 0.80 for the overall classification of the year 1980, 1995 and 2019, respectively. According to Lea and Curtis (2010), a Kappa statistic greater than 0.8 depicts a strong assessment and good accuracy.

3.8 Data Collection Procedures

The researcher obtained necessary approval from the Graduate School of Egerton University and the National Commission for Science, Technology and Innovation (NACOSTI). Data collection started with the household head interviews in the baseline survey to identify land degradation trends in the study area. All interviews were face to face and done in the interviewee's homes. This helped in capturing verbal and non-verbal cues including body language which enabled the interviewer to control the interview and keep it focused thus collecting relevant data (Fraenkel & Wallen, 2000). The language of communication was mainly the local language used by the Il Chamus community and Kiswahili in cases where the respondent was competent in the use of Kiswahili language. Trained enumerators, knowledgeable in the local language and culture assisted in data collection.

Focus group discussion participants drawn from Il Chamus and Mukutani Wards were contacted and dates and venues for the discussions set. Participatory methods of engagement like Problem trees, ranking, Venn diagrams and causal loop diagrams were used in FGDs to better capture trends and processes on land use and land degradation. In addition, the participatory methods helped capture information on the challenges, opportunities and benefits of adopting SLM practices in the Njemps Flats. For the evaluation of the CoP, questionnaires were administered during a group meeting. A brainstorming session facilitated by extension and research officers conversant with the local knowledge was done to look into the challenges of participating and sustainability of the CoP. The data was recorded and ranked by the CoP members.

3.9 Data Analysis Procedures

The researcher applied both descriptive and inferential statistics to analyse qualitative and quantitative data collected during the study. Descriptive statistics included frequencies, means, standard deviations and percentages. Inferential statistics included ordinal, simple and multiple linear regressions. The Statistical Package for Social Sciences (SPSS) version 25 was used to aid in data capture and analysis. All the inferential statistical tests were interpreted using a five percent significance level. Table 4 gives a summary of the data analysis as well as methods used to analyse each research question as shown in the following sub-section.

3.9.1 Analysis of Research Question One

What are the drivers and indicators of land degradation in the study area?

Data from household heads interviews identifying drivers and indicators of land degradation was analysed using percentages and frequencies. In focus group discussion the researcher employed voting to rank drivers of land degradation in order of importance. Geographical Information System (GIS) land use and land cover detection analysis used Landsat Imageries and administrative boundaries of Baringo county. Landsat images for the three periods 1980, 1995 and 2019 were used and consisted of multispectral data acquired by Landsat satellite. Consequently, QGIS software, version 2.14.19 was used for spatial analysis. Image preprocessing analysis included pan sharpening of Landsat imageries to achieve a 15 m resolution. Further, image classification was done using maximum likelihood algorithm and further determining percentage land use changes over the study periods.

3.9.2 Analysis of Research Question Two

What land degradation coping strategies are used by the participants in the study area?

Effects of land degradation as reported by the respondents and the strategies to cope was analysed using percentages and frequencies.

3.9.3 Analysis of Research Question Three

What are the determinants of sustainable land management practices adoption in the study areas?

Farmers listed the SLM practices they applied in their farm to combat degradation and rehabilitate degraded portions in their farms. The number of practices adopted by households ranged from 0-6 reflecting no adoption to high adoption levels. A categorical regression analysis was done to determine how different variables influenced the level of adoption of SLM practices. By assigning numerical values to the groups, this regression quantifies categorical data, resulting in an optimal linear regression equation for the transformed variables (International Business Machines (IBM), corporation knowledge centre, 2021). The regression model is presented as;

$$Y=a+b_1x_1+\ldots\ldots b_nx_n$$

Where:

Y=independent valuable (Level of SLM practices adoption

a is a constant

b_1 (1....n) are model parameters

X_1 (1....n) are independent variables (age in years, farm size in acres, level of education, household size, livestock units, extension access and group participation.

3.9.4 Analysis of Research Question Four

What are the challenges of establishing and maintaining a community of practice for rehabilitation of degraded lands in the study area?

Stakeholders' analysis was done to identify key actors and determine their interests, capacities and likely influence to the the success of the CoP. Stakeholder analysis not only helps identify the interests but also helps avoid to potential conflicts that could jeopardize the initiative at different stages of stakeholder engagement (Golder, 2005). A problem tree was developed jointly with members of the CoP to analyse drivers and impacts of land degradation to Njemps community livelihoods and provide a pictorial representation of the main problems, along with their causes and effects (Overseas Development Institute, 2009). The analysis, was part of social learning, and was done to help integrate stakeholders' different mental maps into a single visual representation while at the same time identifying knowledge gaps. Malard *et al*. (2015) noted that participation in the problem-root analysis allowed stakeholders to gain deeper knowledge of socio-ecological systems in which they live and to identify key leverage points for effective and sustainable interventions.

Multi-Criteria Analysis (MCA) was used to select the most suitable pasture grass for reseeding the degraded land after the construction of soil and water conservation measures. Multi-Criteria Analysis evaluates options based on a number of different criteria (Bartolini & Viaggi, 2010). The MCA analysis was conducted in the CoP with the assistance of a research officer from KALRO who was also a co-opted member of the CoP, and was based on a detailed review of the most appropriate parameters that the decision-makers could use to select the best reseeding pasture grass. Through the MCA the participants categorised and ranked the different grass options according to predetermined characteristics collectively agreed upon. Each criterion was given same weight. Members were given ten pebbles representing ten marks to distribute to the traits based on the level of importance attached to that trait. One could fail to vote for a trait that they didn't deem important or even cast all the votes for one they deemed very important. The weighted total of the different parameters, as well as the decision-makers' preferences, were used to rank promising and feasible reseeding options.

3.9.5 Analysis of Research Question Five

What are the factors affecting the level of social learning among members of farmer-based community of practice?

To measure whether or not social learning has taken place, Scholz *et al*. (2014) proposed the following indicators: (i) change in mental models (practical and interpersonal), (ii) impact of practical and interpersonal outcomes in the wider context and (iii) increased similarity between mental models. While evaluating social learning in UK flood risk management (Benson, Lorenzoni and Cook (2016), used the following indicators; acquisition of new knowledge; change in understanding the issues of concern; development of trust; development of network and collective agreement on management of the issue of concern. Borrowing from Scholz *et al*. (2014) and Benson *et al*. (2016) the researcher developed four indicators including knowlegde acquired in SLM practices, environmental stewardship developed, bonding social capital developed and linking and bridging social capital gained measure social learning in the context of rehabilitation of degraded rangelands in the Njemps Flats.

The indicators were measured by responding to a series of items that were measured using a three-point likert scale. The mean scores of responses to the items measuring knowlegde acquired in SLM technologies, environmental stewardship developed, bonding social capital gained and linking and bridging social capital were computed to give knowlegde acquired index (KAI), environmental stewardship index (ESI), bonding social capital index (BSI) and linking and bridging social capital index (LBI) respectively. Social learning index (SLI) was computed by adding the four indicators' indices.

$$SLI=KAI + ESI+ BSI+ LBI$$

Where; SLI. KAI, ESI and BSI is social learning, knowlegde acquired index, environmental stewardship, bonding social capital and linking and bridging social capital respectively.

To anlyse factors affecting social learning, a Multiple Linear Regression in the form of $y = a+b_1x_1+b_2x_2+b_3x_3$ was used. In the model, $x_1 \ldots\ldots x_2$ represent the specific factors affecting the level of social learning which included age, level of formal education, holding CoP leadership positions and level of participation in CoP activities.

3.9.6 Analysis of Research Question Six

How does social learning in community of practice influence participating members' sustainable land management practices adoption behavior?

A number of items were used to predict the likelihood of the farmer to adopt SLM practices. The mean of the item answers formed the Adoption behaviour index. A Simple Linear Regression was used to test the influence of social learning on the farmers' SLM adoption behaviour.

Table 4

Data Analysis Summary

Reaserch Question	Independent variable	Dependent variable	Statistical Tests/ Qualitative tools
What are the drivers and indicators of land degradation in the study area	Land degradation	Degradation Indicators	Frequencies, Percentages
What land degradation coping strategies are used by the participants in the study area?	Land degradation	Coping strategies	Percentages Frequencies
What are the determinants of sustainable land management practices adoption in the study areas?	Adoption determinants	SLM practices adoption	Categorical regression, Chi-Squire
What are the challenges of establishing and maintaining a community of practice for rehabilitation of degraded lands in the study area?	Challenges of establishing CoP	Etablishing and maintaining CoP	Frequencies, Problem tree MCA
What are the factors affecting the level of social learning among members of farmer-based community of practice?	Factors affecting social learning	Level of social Learning	Multiple Linear regression
How does social learning in community of practice influence participating members' sustainable land management practices adoption behavior	Social Learning	SLM adoption behaviour	Linear regression,

CHAPTER FOUR
RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the results and discussion of the study with reference to the research objectives as stated in chapter one. The study investigated the effect of social learning in a community of practice on adoption of SLM strategies in the rehabilitation of degraded drylands in the Njemps Flats Baringo County. Based on a random sample of 150 households, data was collected on demographic information, crop and livestock enterprises, indicators and drivers of land degradation and factors determining adoption of SLM strategies. A Community of Practice (CoP) was created to act as a platform for engaging farmers, research and extension actors in social learning on degraded dryland rehabilitation practices and innovations.

4.2 Household Demographic Characteristics

This section presents demographic characteristics of the respondents including gender, age, and education level of the household head, land size, family size, land use and household income. Descriptive statistics including means, standard deviation and percentages were used to anayse data on the socio-economic characteristics of the study participants. The analysed data was presented using tables and charts and is discussed in this section.

4.2.1 Age of the Household Head

The age categories of the agropastoralists household heads in the study are presented in figure 6.

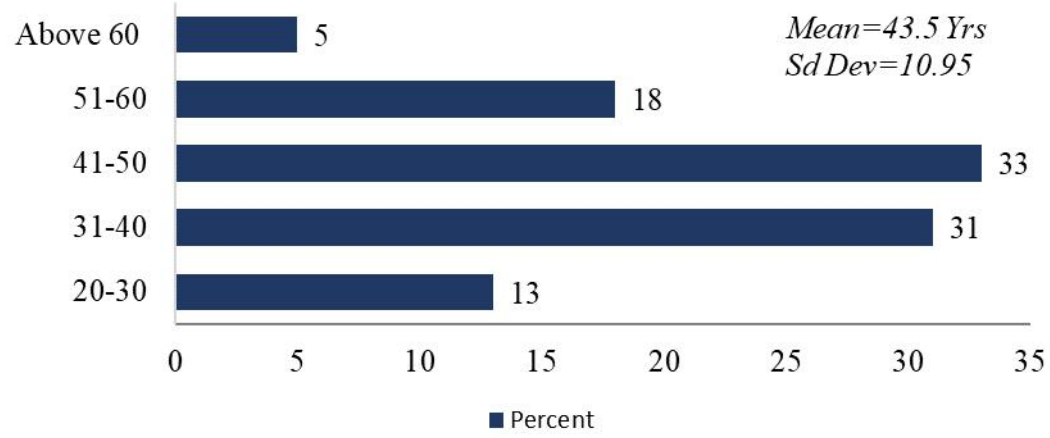

Figure 6. Age of the household heads

Sixty-four percent of the household heads in the study were in the age category between 31 and 50 years, which may be considered as the prime age for productivity. Mean age of the household heads was 43.5 years (SD=10.95 years). Age has been found to influence adoption of agricultural innovations. Sebatta *et al*. (2014) found positive relationship between age and farmer market participation, with older farmers selling higher proportions of their produce to the market. Similarly, in a study related to improving information and communication for smallholder farmers in Kenya, FARM Africa (2004) reported that older farmers were less inclined to adopt new innovations compared to younger farmers.

4.2.2 Gender of the Surveyed Household Heads

The household head is mainly responsible for the economic wellbeing of the household. Figure 7 presents the surveyed household heads in relation to gender.

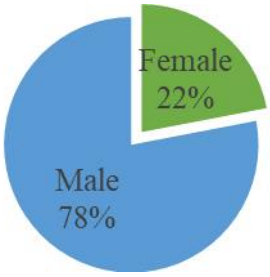

Figure 7. Gender of the surveyed household heads

In the study area male-headed households were found to be more frequent (78%) than female-headed households (22%). The results compare well to the Kenya National Bureau of Statistics (KNBS) which put the figure of female headed families at 23 percent in the region (KNBS, 2009). The figures do not consider delegate heads defined by World Bank as wives whose husbands are often away and who, as a result, bear a significant but not complete share of household obligation (World Bank, 2008). The figure is particularly important in a patriarchal society (such as the Kalenjin community in the area), where men make the majority of decisions. According to Flato *et al*. (2017), female headed households relative to male headed households have limited access to protective social networks, education attainment (FAO, 2014) assets and services (Kassie *et al*., 2014) as well as market outlets for their farm produce (Sebatta *et al*., 2014) all which have been found to affect adoption of SLM innovations. The gender of the household head has an impact on how resources are used and allocated to different needs within the household (Kamau *et al*., 2014).

4.2.3 Education Level of the Household Head

The results in figure 8 indicated that majority of the respondents had at least some leve of formal education. Only five percent of the household heads had tertiary education. Twenty-eight percent of household heads had no formal education while 26% had achieved secondary education.

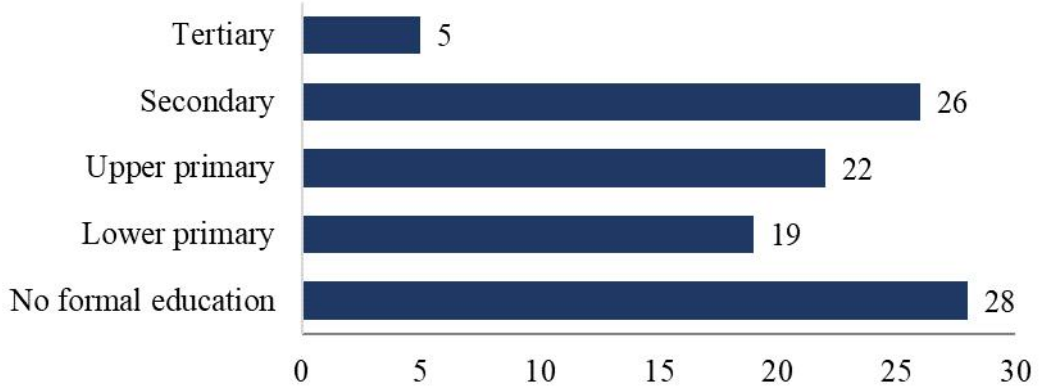

Figure 8. Households' heads level of formal Education

Education level was considered an important aspect in the study because it is instrumental to sourcing and enabling understanding of information on agricultural technologies and practices, forming social networks and entering in contractual agreements that collectively contribute towards farmers' empowerment. Several studies have found literacy and numeracy to correlate with the attainment and utilization of appropriate agricultural technologies (Kumar & Mitals, 2000). The findings in the study indicate low literacy level with 28% of sample having no formal education while respondents with secondary education and above were 31 percent. The study literacy figures compare with those of Baringo County as reported by KNBS (2013) which reported that 36% of household heads in the county had no formal education, 48%, had primary level education while 16 % had secondary school education and above.

There exists empirical evidence of a clear link between farmer education and development including household economic outcomes, not only in developing countries but all over the world (Brown & Duguid, 2000). According to the literature, there is a strong connection between educational attainment, personal empowerment to escape poverty, access to appropriate and adequate information, and making of informed choices (Balakrishnan 2000; World Bank 2008). Nyangaka *et al*. (2009) noted that farmers with higher levels of education tend to be more efficient in agricultural production. The better performance could be attributed to better interpretation and hence response to new information and improved

technology than their counterparts with lower education. A study on smallholder potato farmers in Uganda revealed that farmers' ability to produce and sell more in a market was highly and positively related to their education levels (Sebatta *et al*., 2014).

4.2.4 Household Size

In the study, household size was assumed to influence adoption of SLM practices since it may determine agricultural labour availability. The mean household size was reported at 7 (SD=3). Figure 9 shows the percentage distribution of respondents according to their household size.

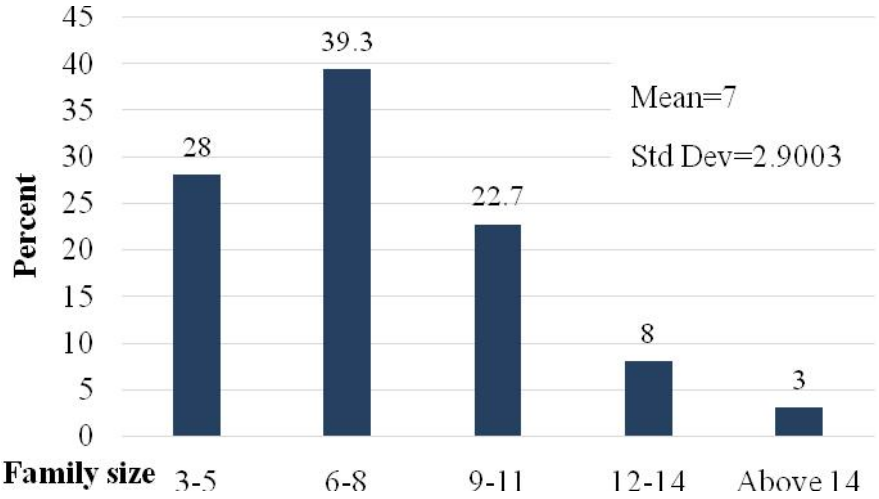

Figure 9. Family size of the sampled households

Thirty-nine percent (39%) of the participating households reported having between six and eight household members with a mean household size of seven. The 2009 census put the average household size in Baringo county to be at five persons (KNBS, 2009). Though larger households could indicate availability of unpaid labor for adoption of labor-intensive SLM practices (Gillespie *et al*., 2007), Kihiu (2013) found bigger household size reduced the probability of SLM practices adoption in rangelands. KNBS and SID (2013), noted that, big households had a higher dependency ratio especially in populations with a child rich structure. Baringo County has a child rich population structure with high dependency ratio where 0-14-year-olds constitute 49% of the total population. Brown and Duguid (2000) cautioned that higher dependency ratio in a household may lead to less income committed towards agricultural innovations hence compromising SLM practices uptake.

4.2.5 Land Tenure and Land Size

Land tenure in the Njemps Flats is characterized by hybridity. In theory, the land is under the group ranch but in reality, the land is informally owned by individual households who are recognized by the rest of the community and operate it as individual land (Key informant 2). They can sell or rent it out. Only the rivers and grazing land around lake Baringo is communal. The Constitution of Kenya categorizes land tenure into community land, public land and private land (GoK, 2013). Rohss (2017) separated the privately owned land in the Njemps Flats into "active" and "dormant". He noted that although owned by someone and demarcated by occasional stones or poles, dormant land can and is used by the community for extractive purposes. This was supported in the two FGDs where the discussants noted that crop production was not done on such land. Where land is enclosed, its use is restricted to the owner. The researcher sought to determine the preferred mode of land ownership by the participants. The result is presented in Table 5.

Table 5

Preferred Mode and Reasons of Land Ownership and Management

Preferred ownership	Reasons	Percent
Individual (72%)	Better land management hence higher yields	33
	Freedom to invest	9
	Higher production	24
	Less land conflicts	15
	Tenure security	19
Integrated (28.7%)	Access to watering points and common grazing areas	63
	Better management of common resources	21
	Inclusive management of common natural resources	16
Communal (1.3%)	Fear of losing communal grazing land	100

None of the respondents reported land as being communally owned, despite being aware that their land title was held by a community ranch. When asked on the preferred mode of land management, 72% of the respondents preferred individual land management with formal documentation of land and issuance of title deed. Only two (1%) of the respondents preferred communal land governance while 29% preferred a hybrid of communal and individual management with forests and riverine being managed communally. The reasons for integrated management were given as; easy access to watering points and common grazing

areas by the lake (63%), better management of common resources (21%) and inclusive management of common natural resources (16%). Reasons for individual land ownership and management included; better land management (33%), freedom to invest (9%), higher production (24%) less land conflicts (15%) and tenure security (19%). In a study on management of natural resources in the Njemps Flats, Rohss (2017) noted that even though aware of the 2010 constitution provision for communal land ownership, the community in the Njemps Flats rejected it as inappropriate for "modern times" arguing that true communal tenure does not exist in the Njemps since group ranches have been informally sub-divided.

The size of farm owned by the farmers is an important asset in that it determines the farming system that can be applied and output that can be obtained from the land. A majority of the households (74.7 %) owned farms that were below 2.05 Ha while 17 percent of the households owned between 2.1 to 2.8 Ha. Only 3 percent of the responding households owned farms that are above 4.05 Ha. The average household land holding of the sampled households was 1.8 Ha. This is below the county land holding average size of 2.4 Ha (GOK, 2013). Some households (30%) had ownership to more than one parcel of land. This was mostly caused by insecurity where people bought parcels in neighbouring locations, they considered more secure to build homes but still continued to operate on the other parcels. Expansion of Lake Baringo also displaced some residents forcing them to move away to higher areas even though they continued laying claim to lands near the lake as reported by FGD 2. The distance between the homestead parcel to the other parcels averaged 25 Kilometers. Figure 10 shows the frequency distribution of the respondents' natural capital according to their average land holdings.

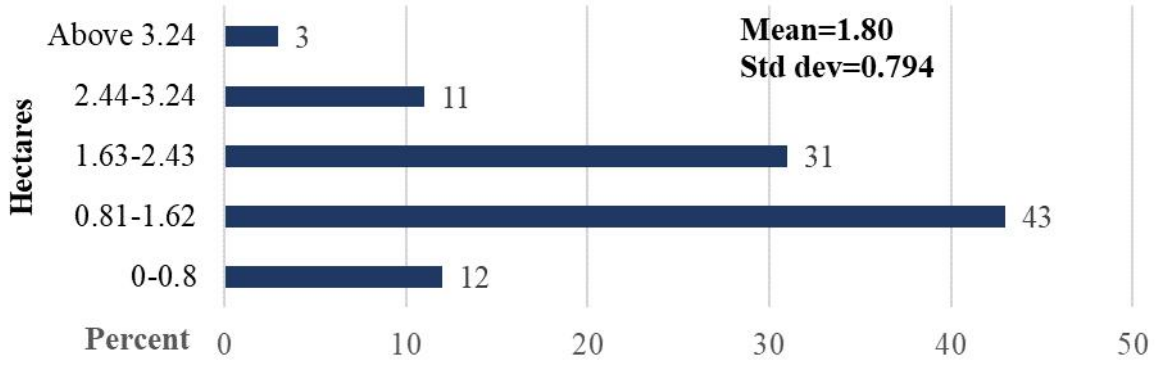

Figure 10. Surveyed households average land size in hectares

If the land is effectively used, which includes the use of appropriate farm practices and inputs, an increase in farm size can improve productivity (Tolno *et al.,* 2016). Since it provides the farmer with productive asset, farm size is a direct positive predictor of productivity. Farmers with larger land holdings produce and sell more of their produce than those with smaller land holdings, and are projected to gain more from economies of scale (Sebatta *et al.,* 2014).

4.2.6 Livestock Enterprises

The residents of the Njemps Flats are agropastoralists with their main form of livelihood being livestock (Little, 1981; Mureithi *et al*., 2013). Five different types of livestock were kept by the participating households, which included; Cattle, sheep, goats, chicken, and bees. The type and number of animals kept by the respondents is given in Table 6.

Table 6

Type and Number of Livestock Kept by the Respondents

Livestock	Number of Animals				
	None Percent	1-10 Percent	11-20 Percent	21-30 Percent	Above 30 Percent
Cattle	10	60.5	23	4.7	1.8
Sheep	36	41	17.4	4.6	1
Goats	6.4	34	35	16.6	8
Chicken	42	22	23	11	2
Bee hives	78	22	0	0	0

(N=150)

A majority (93.6 %) of the respondents kept goats, followed by cattle by 90 %, sheep 64% and chicken at 58 %. Only 22 percent of the households practiced beekeeping. Livestock ownership is known to influence households' food access and availability. According to FAO (2006), livestock is an asset that is widely owned by rural households in developing countries and performs a crucial role as a contributor of income generation and hence food accessibility and improvement of the household purchasing power in terms of food. Christoplos *et al*. (2001) cited livestock as an important means of asset accumulation, in form of savings and as insurance when there is need for immediate cash. The production and sale of livestock products such as eggs cushions the family against shocks such as crop failure brought about by drought. It also has a positive impact on the diet of family by providing protein. A study

carried out in Ghana revealed that ruminants contribute about 36 percent to annual household income of farmers in rural Ghana, and served as a source of insurance against crop failure and poor performance from other non-farm ventures (Naminse, 2011). Perez *et al*. (2015) found livestock sales to represent the main income source and an important drought-coping mechanism for many agro-pastoralists in the drylands of East and West African countries.

4.2.7 Crop Enterprises in the Study Area

The most prevalent crops grown by the respondents, included maize, beans, green grams, sorghum, millet and water melon. The area allocated for each crop and the frequency of the farmers growing the crop is given in Table 7.

Table 7

Types of Crops Grown by the Participating Households in Hectarage

Crops	Hectarage under various crops			
	None (%)	Below 0.2 (%)	0.21-0.5 (%)	Above 0.52 (%)
Maize	7	64	24	5
Beans	28	61	11	0
Water melon	55	29	12	4
Sorghum	70	30	0	0
Millet	63	37	0	0
Green grams	50	45	4	0
Kales/vegetables	73	27	0	0
Cowpeas	44	34	22	0
Tomatoes	70	27	3	0

(N=150)

The majority of the farmers grew maize (64%) and beans (61%) on an area of less than 0.2 hectare. Most of the participating households (61 %) had total crop land of 0.8 Ha and below with a mean of 0.84 and a standard deviation of 0.45.

Diversification of crops was observed. According to Mutekwa (2009), crop diversification improved household food security in arid areas since different crops are affected differently by the same climatic conditions. Diversification can also be a strategy to enhance the welfare of low-income agropastoralist households by mitigating environmental risks, employment creation and conservation of biodiversity (FAO, 2013). The possibility of interruption in

insect and diseases cycles, differential utilization of resources and drought tolerance by different crops make the diversified system more preferable compared to the monocrop production system (Mutekwa, 2009).

4.2.8 Household Annual Income

Respondents were asked for information on the amount and sources of their household income in order to determine the differences that existed within the different households in the study area. The income received by agropastoralist households is critical because it decides the investments and agricultural technologies that can be implemented. The sources and the amount of annual income earned by the households are summarized in Table 8.

Table 8

Sources and Amounts of Approximated Annual Income by percentage

Income sources	Income categories (KShs)				
	None	<50,000	50,001-100,000	100,001-150,000	>150,001
Crops	35	63	6	3	2
Livestock	13	67	21	5	3
Salary	100	0	1	0	8
Small scale business	97	11	0	0	0
Charcoal	80	29	0	0	0
Remittances from Relatives	104	5	0	0	0

(N=150)

Six separate sources of income were reported by the respondents. These sources could be divided into two broad categories: farm income and non-farm income. Farm income included earnings from cattle, vegetables, and charcoal, while non-farm income included earnings from employment, small businesses, and relatives. All surveyed families had some form of farm income with livestock earning more money than crops.

More than half of the participating households (52%) reported earning an income less than 30,000 Ksh annually. This translates to an average of 2,500 Ksh monthly income and 83.3 Ksh daily which is below a dollar. The standard deviation of household incomes was very large for the sample indicating wide income gaps between the wealthy and the poor in the

community. Figure 11 presents surveyed households average Annual Income in Kenyan Shillings.

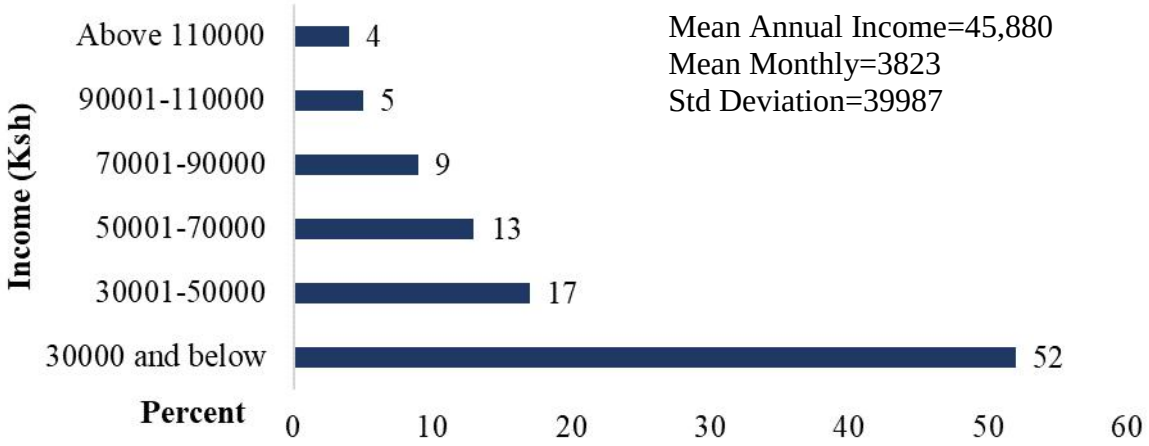

Figure 11. Surveyed Households average Annual Income in Kenyan Shillings.

The data is in line with Kenya National Bureau of statistics (2014), statistics on poverty in Baringo county. KNBS (2014), reported the Human Development Index (HDI) a composite statistic of life expectancy, education, and income per capita indicators, of Baringo county at 0.510 slightly lower than the national average (0.520) and human poverty index at 31% percent compared to the national level at 29%. The poverty incidence was reported at 52% against 45% nationally and with the county contributing two percent to the national poverty index (KNBS, 2014).

According to Liniger *et al*. (2011), wealthy households are more likely to adopt sustainable land management strategies since they require capital investment. Diiro (2013), reported off-farm earnings to have a positive influence on agricultural innovation adoption by providing farmers with capital for purchasing inputs. From the FGD results, labour provided by family members and food produced and consumed within the households was largely considered free and not costed. This could lead to misleading perception on the household wealth and income.

4.2.9 Access to Agricultural Extension and Credit

Agricultural extension and advisory services is aimed at improving agricultural productivity and raising output by providing information on technologies, good production practices and

methods, types of crops and by motivating farmers and helping them overcome their constraints. Table 9 shows extension services and credit access by the respondents.

Table 9

The Perceived Status of Extension and Credit Services Access by the Household Heads

S/No	Service Access status	Category	Percent
1	Extension services	Level of Access	
		very low	23
		Low	31
		Moderate	29
		High	12
		very high	5
2	Accessed Credit	Loan Source	
	(37%)	Farmer groups	45
		Farmers SACCO	32
		Micro finance	14
		Commercial banks	6
3	No access to credit	Reason for Non-Access	
	(63%)	Lack of collateral	39
		Lack of information	31
		Non-Group membership	18
		Fear of defaulting reprisals	12

Fifty-four percent (54%) of the participating household heads reported low to very low access to extension services as compared to seventeen percent who reported high to very high access while twenty-nine percent reported moderate access. Since extension ensures delivery of relevant innovations, knowledge and builds capacity to adopt improved agricultural technologies, it is expected that participants with higher access to extension services would have higher adoption of SLM technologies.

In order to determine access to credit, respondents were asked if they had obtained a loan for agricultural development within the last five years. Majority of the respondents (63%) had never obtained a loan for agricultural development in the preceding 5 years. Of the households that had obtained loans, 45% had obtained loans from farmers'groups, 32% from

farmers SACCO, fourteen percent from micro-finance and 6 percent from commercial banks. Respondents who had not obtained loans cited lack of collateral (39%), lack of information (31%), non-membership to groups (18%) and fear of defaulting reprisals (12%) as the reasons for not accessing loans.

Credit is assumed to empower farmers to demand and access technologies that require initial capital investment. A study by the Ministry of Gender and Social Services on women enterprise fund revealed that the women committed 80 percent of the money advanced to them for livestock farming and crop production among other agricultural activities (Omwenga, 2012). Mirzabaev *et al*. (2016) found credit to be a key underlying factor in SLM adoption in Central Asia and that improved credit facilities enhanced poor rural households' capacity to invest in SLM practices. Pender *et al*. (2009) reported that the interplay between poverty and low access to credit markets prevented farmers from investing in costly, but in the long-term profitable, SLM technologies. In a government funded project in Niger, farmers who received livestock-based credit increased herd sizes which led to overgrazing and consequent soil erosion by water and wind. In a similar project in the same country, farmers who received awareness and training on climate change and its consequencies, fodder production and grazing management in addition to livestock-based credit had higher adoption of SLM practices (Moussa *et al*., 2016). These results point to the need of coupling credit and training for adoption of SLM strategies.

4.3 Land Degradation Drivers and Indicators in the Study Area

The First objective of the study aimed to assess the indicators and causal factors driving land degradation in the study area. Numerous studies carried out in the Lake Baringo basin observe increasing trends of degradation in this environment which span back several decades earlier (Odada *et al*., 2006; Odhiambo, 2015). Understanding the dynamics and the paths of degradation in the area is critical in the design of sustainable rangeland use. Numerous factors, as discussed and presented have been shown to lead to the degradation in the area. Finally, the indicators of land degradation have also been presented and discussed in this section.

4.3.1 Length of Residence in the Area for the Survey Respondents

The study sought to find out from the respondents the number of years they had resided in the area and practiced agropastoralism. Responses are presented in Figure 12.

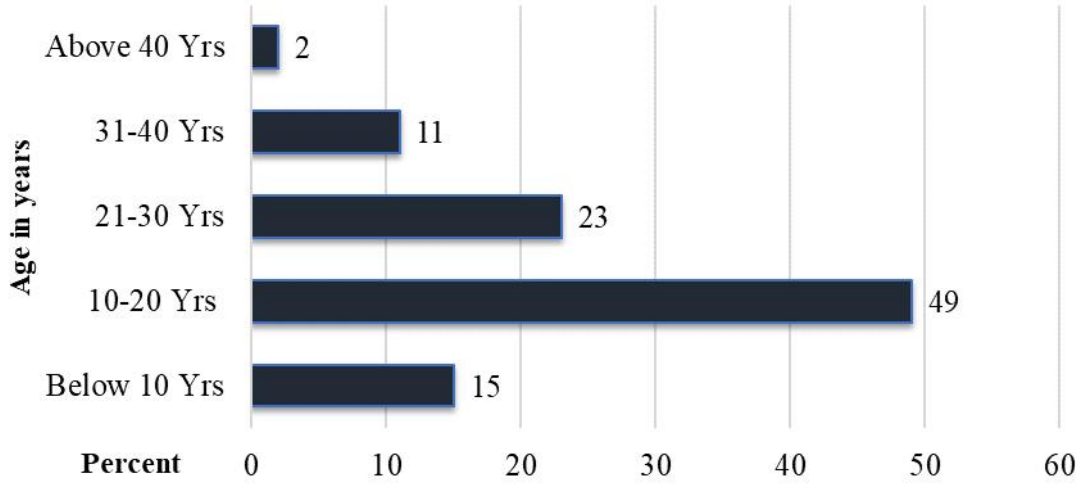

Figure 12. Duration of the surveyed Household heads residence in the study area

Fourty-nine percent (49%) of the total respondents had resided in the area for 10-20 years, 23% for a period between 21-30 years, 11% for 31-40 years and only 2 percent of the respondents had lived in the area for over 40 years. The numbers show that a bigger percentage of the participants had been in the location for long indicating accumulated knowledge through experience and observation on drivers, challenges, trends and dynamics of land degradation in the area. Farming experience has been noted to affect adoption of agricultural innovations. In a study done in Uganda, Ainembabazi and Mugisha (2014) found general farming experience referring to the time a farmer has spent in the farming occupation to have a positive but insignificant relationship with adoption of agricultural technology. In contrast Zeweld *et al*. (2018) found farming experience in Ethiopia to influence positively and significantly farmers' decision to implement agroforestry systems, crop rotation with legumes and to negatively influence adoption of compost which was linked to age and labour requirements.

4.3.2 Community Perception on Land Degradation

Ninety-seven percent (97%) of the respondents from the household survey perceived land degradation as an issue of concern that threatened local community livelihoods. The study findings are consistent with findings by Bayard and Jolly (2007), who reported farmers' awareness of land degradation and its connection to food insecurity in Haiti. The awareness towards land degradation can be positively related to both severity of and susceptibility of the land to degradation as is the case of the Njemps Flats and the extent of its impact on their livelihoods (Bayard & Jolly, 2007). This suggests that awareness and concern towards land

degradation would lead farmers to putting in place coping strategies or being open to introduction of SLM strategies by extension agencies.

4.3.3 Indicators of Land Degradation

Indicators of land degradation as reported by the study participants included invasive species (69%), gullies and rills (61%) and loss of ground cover (57%) among others (Table 10).

Table 10

Indicators of Land Degradation in the Study Area

Indicator of degradation	Frequency	Percent
Invasive species / Bush encroachment	104	69
Gullies and rills	92	61
Loss of ground cover	86	57
Low crop yields and stunted crops	57	38
Flooding of lake Baringo	39	26
Livestock trails	29	19

N=150

The study confirms results of a previous study done in Kibwezi, a semi-arid area in Southern Eastern Kenya (Mganga *et al*., 2015) where change in vegetation, exemplified by the increase in woody species and fast disappearance of indigenous forage grass species, loss of soil fertility and soil erosion were cited as the main indicators of land degradation in the area. Along the same line, Maitima *et al*. (2009) and Flintan (2011) recorded bare ground, gullies, sand storms, encroachment of woody plants, presence of succulent unpalatable forbs in the rainy seasons at the expense of palatable grasses as indicators of land degradation in the Kenyan drylands. Figure 13 presents records of land degradation indicators in the Njemps Flats.

Figure 13. Land degradation indicators in the Njemps Flats.

A: Livestock trails; B-Lake Baringo floods; C-Dust storm; D-Gullies (Pictures A, B, C-Courtesy of Francis of RAE; Picture D taken by Ian Kigwa in February, 2019*).*

In a study on vulnerability, litigation and resilience building in the Baringo Lowlands of Kenya, Odhiambo (2015) reported manifestation of land degradation in the area to be changes in lake surface area and depth, loss of vegetation cover including trees and pasture grasses, loss of marine biodiversity, increased soil erosion and sedimentation, water turbidity, changes in precipitation, and loss of ecological robustness. Lake Baringo depth fluctuated from an average of 8 meters between 1969 and 1972 to a low of 1.7 meters in 2003, according to Odada et al. (2006). It reached a maximum depth of 3.5m at its deepest points in 2006, with an average depth of 2.5m, and reaching a maximum of 3.5m at its deepest points. Likewise, the lake surface area was also revealed to have a general decreasing trend with 219 km^2 in 1976, 136 km^2 in 1986, 114 km^2 in 1995, and 108 km^2 in 2001, projecting a 50 percent reduction in surface area by 2025 based on the trends at the time (Onyando 2002; Odada *et al*., 2006). Deviating from the reported trends of the three decades between 1976 to

2001, a sudden surge and expansion in lake levels was noticed between 2011 and 2013 with floods being reported (Onywere *et al*., 2014).

4.3.4 Land Degradation Drivers

The study participants cited drivers of land degradation in the area to include prolonged droughts (70%), invasive shrubs (67%), over grazing (45%), loose soils (36%) deforestation (31%) Poor crop production practices (29%) and erosion of traditions and customs governing communal grazing land (21%) as shown in Table 11.

Table 11

Causes of Land Degradation in the Study Area

Cause of land degradation	Frequency	Respondents (%)
Prolonged droughts	105	70
Invasive Shrubs	101	67
Over grazing	68	45
Loose soils	54	36
Deforestation and land clearing	47	31
Poor crop production practices	44	29
Erosion of customs governing land	32	21

The study participants were able to recognize environmental degradation in their area and attribute it to some factors both natural and anthropogenic. Results from this study clearly show that natural (prolonged droughts, invasive species) and anthropogenic factors (overgrazing, poor farming practices, deforestation, erosion of customs governing land) were the main causes of land degradation in the Njemps Flats This agrees with Reynolds *et al*. (2007) who described land degradation as a complex phenomenon triggered by the interplay of environmental, economic and social factors. The results confirmed that prolonged drought as a result of climatic change is a major factor in inducing land degradation in the semi-arid drylands (Mwang'ombe *et al*., 2011). Overstocking was also identified as an anthropogenic cause of rangeland degradation (Reynolds *et al*., 2007). The invasive species *Prosopis juliflora* which was a government intervention against land degradation was also cited as a source of degradation. During FGD, *Prosopis* was cited as spreading fast and being invasive; choking other plants by forming dense bushes; obstructing waterways and enabling soil erosion by eliminating alternative ground cover. The general opinion by the FDG participants

was that *Prosopis* was damaging to their livelihoods and should be completely eradicated. Figure 14 shows invasive species *Prosopis juliflora* and *Opuntia elatior* in the study area.

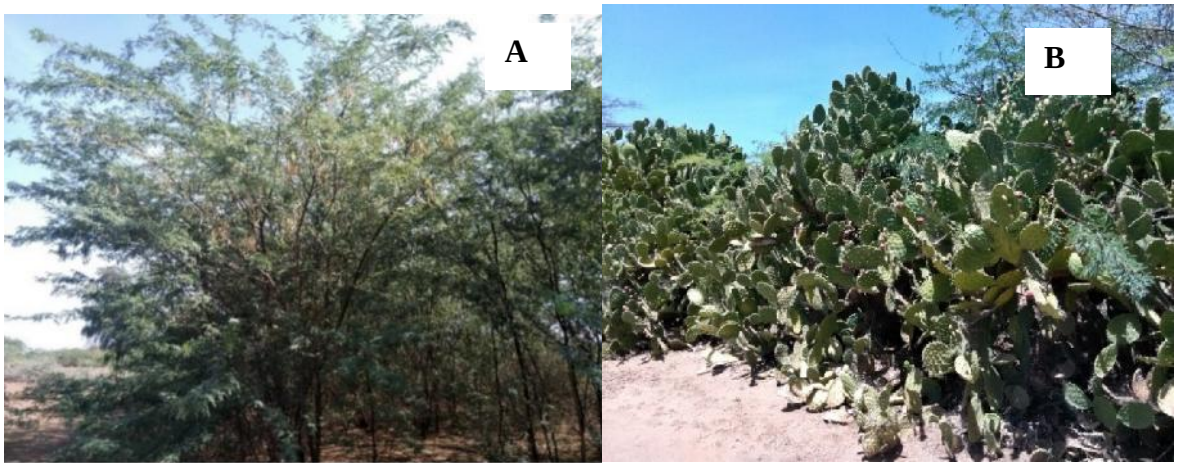

Figure 14. Invasive plants in the study area

Prosopis juliflora (A) and *Opuntia elatior* (B). Photo by Rebecca Karaya February, 2019

The results are in line with studies done in Kenyan rangelands at different times which identified increase in human population and hence increase in number of households and livestock leading to overgrazing (Burian *et al*., 2019; Mwagore, 2003) disregard for indigenous knowledge and customary rangeland management strategies; recurring droughts (Harding & Devisscher, 2009) and soil and terrain characteristics (Flintan, 2011). In Kibwezi, agropastoralists attributed land degradation to frequent droughts and low amounts of rainfall, overgrazing, and unsustainable harvesting of trees for fuelwood production in that order (Mganga *et al*., 2015).

In a study done in Kushinga Ward, Zimbabwe, farmers identified the major causes of soil erosion in the area to be cultivation of steep slopes and stream banks, population pressure and overgrazing (Manjoro, 2006). In Ethiopia, Birhanu (2014) listed cases of land degradation as a result of expansion of agricultural land for growing crops, repeated cultivation, removal of residuals and dungs, single cropping, expansion of infrastructure, droughts, increasing population, deforestation, low technology adoption, insufficient access to extension services and political unrest and civil wars. In Mexican ASALs an assessment on drivers of land degradation cited persistent droughts, turning grasslands to crop lands and overgrazing as the main drivers of land degradation (Manzano *et al*., 2000). The study results confirm that human-induced land degradation is prevalent in the semi-arid drylands (Mganga *et al*., 2015;

Mwang'ombe *et al*., 2011) and that climate change and desertification are synegestically connected to land degradation in the ASALs (UNCCD, 2012).

It is evident from the literature and also from the above findings on the drivers of land degradation that a significant portion of the established drivers of dryland degradation are related to changes in land use and land cover. Changes in land use and land cover are linked to the loss of natural grazing areas, restricted livestock mobility, and limited access to pastoral opportunities, all of which are important for long-term rangeland management. (Flintan, 2011; Foley *et al*., 2005; Maitima *et al*., 2009). Section 4.3.5 looks at community-GIS assisted land use and land cover changes tassessment in the period between 1980 to 2019.

4.3.5 Land Use and Cover Change as a Driver of Land Degradation

The study sought to assess trends, related causes and effects of land use and land cover changes in the Njemps as related to land degradation. Data to assess land use and land cover change was collected through two gender separated focus group discussions that targeted elderly people who had lived in the area practicing pastoralism or agropastoralism for the last 30 years, Seven Key informants including a pastor, research representative from KALRO, a government agriculture extensionist, an NGO extension officer (RAE), local chief, a village elder and a local teacher. Further, semi-structured interviews were conducted with 150 household heads to gather more information on land use and cover change in the study area. To corroborate community data landsat satellite images supported by GIS, were used and three maps were generated to capture land use and cover trends in the years 1980, 1995 and 2019.

The results from these two data collection measures revealed that massive land use and cover change had been observed in the area in the last three decades. From the household interviews, majority of the respondents (89 %) reported having observed land use and cover changes in the area during time of their residence in the area. The average percentage change of the different land use and cover changes was discussed in the focus group discussion and consensus achieved through voting. The land use changes were classified into three categories for the purpose of this study. The categories were; change in practice, change in livestock population and change in land cover.

4.3.5.1 Change in Practice

Major characteristic of changed agricultural practices that were identified during survey and focus group discussion included increase in enclosures and subsequent habitat fragmentation, change in cropping systems in terms of acreage and diversification and decrease in seasonal migration of livestock in search of pasture. Figure 15, shows change in agricultural practices.

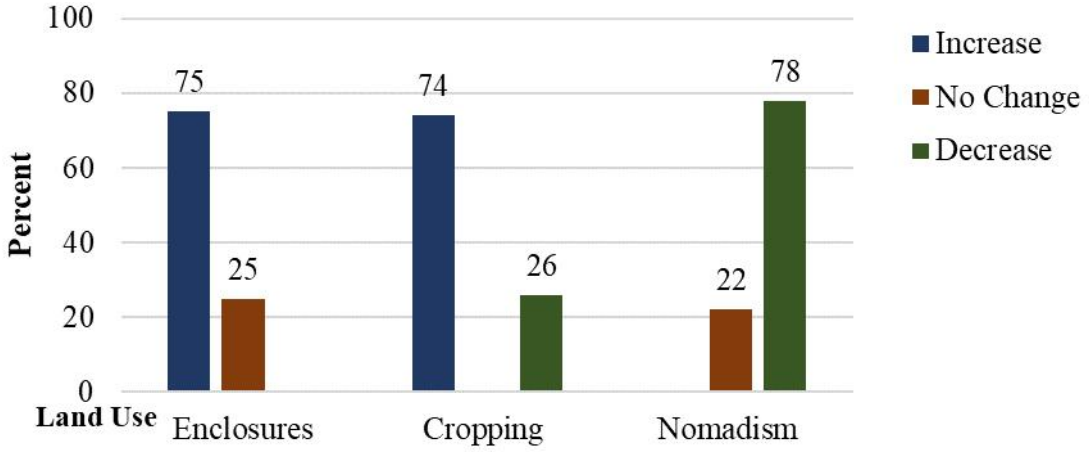

Figure 15. Change in Agricultural practices in the study area as reported by the respondents

i. Enclosures

Majority (75%) of the participants reported that enclosures had increased while 25% felt that the enclosures had remained the same. Reasons for more establishment of fences included; to facilitate crop production mentioned by 43%, allow pasture conservation (27%), facilitate rehabilitation of degraded land (19%) and to mark boundaries (11%). According to Mureithi *et al*. (2015), enclosures enable livestock improvement, facilitate pasture conservation and generally allow for agricultural and livelihood diversification which is relevant to enhanced food security. In West Pokot, enclosing land enabled individuals to properly manage land, fodder and livestock while aiding in combating land degradation (Wairore *et al*., 2015). In Ethiopia, enclosures have been used successfully as a management tool for the restoration of degraded rangelands (Beyene 2009; Mekuria *et al*., 2007).

ii. Area Under Crops

The area under crop production also increased significantly with focused group discussants agreeing that it had increased by over 50 percent in the last 30 years. The relative frequency of the main crop types changed over time with maize increasing and millet and sorghum decreasing. Majority (74%) of the survey respondents reported increase in crop acreage while

26 percent reported decrease. The increase in cropland was supported by GIS analysis done for the years 1980, 1995 and 2019 as indicated in the Figures 16.

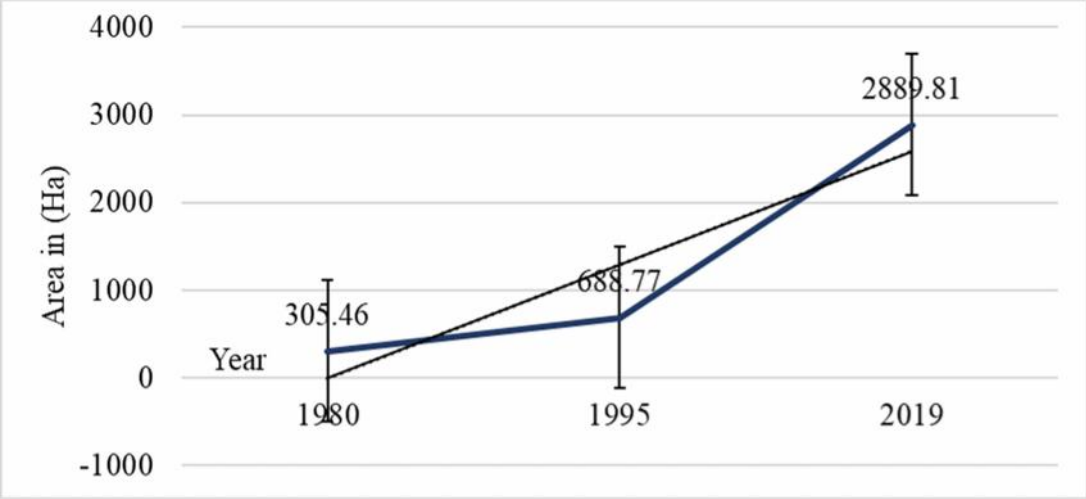

Figure 16. GIS analysis of change in crop production area from 1980 to 2019

Various farmers stated the most important explanation for increased crop acreage and diversification as; the need to compensate for lower livestock herd sizes household (57%), bigger and ready market due to expansion of Marigat and Nakuru towns (51%), improved agricultural knowledge and technology including mechanization (46%) and increased sedentarisation (34%). Twenty-six percent (26%) of the farmers mostly those bordering Lake Baringo in the areas of Salabani and Ngambo reported decrease in crop land caused by the expansion of the lake. The expansion and flooding of the lake caused displacement of the riparian residents and livestock when the flooding water overtook residential, agricultural and grazing land (FGD 1&2).

A study done by Onywere *et al*. (2014) between 2011 and 2013, recorded a general increase in water levels trend among lakes within the Eastern African Rift Valley. In the same period Lake Baringo area under water expanded from 143.6 Km² in January 2010 to a high of 231.6 Km² in September 2013 indicating 61.3% net increase in the area under water (Onywere *et al*., 2014). This was also supported by GIS mapping during this study which indicated that the water body expanded from 13471.92 Ha in 1980 to 16929.54 Ha reported in 2019.

In general, the crop land had increased at the expense of natural grassland. The results are consistent with those of FAO (2013) who decried the decline of grazing lands in Africa from 84 percent to 78 percent of agricultural area between 1961 and 2011 (FAOSTAT Database). The decline was cited to be relatively large in Eastern Africa and Western Africa, with

declines of 8.88 percent and 8.59 percent, respectively (FAO, 2013). Similarly, in agreement with the study, Brink & Eva (2009) reported agricultural land in East African drylands to have increased dramatically over the period 1975-2000 by at least 123,413 ha at the expense of forests (71,325 ha) and natural grassland vegetation (58,894 ha). A study done by Wasige *et al*. (2013) noted land use and land cover changes in Kagera Basin, spanning across Burundi, Rwanda, Uganda, and Tanzania between 1901 and 2010, indicating a decline in savanna natural grassland by 15.4% between 1901 and 2010 while cultivated land increased considerably. In contrast South Africa, reported expansion of grasslands in 1988 to 2006 with a decline in the cultivated areas (Niedertscheider *et al*., 2012).

iii. Nomadism

Nomadism as a land use type decreased over the years. The FGD discussants conceded that nomadism had declined by 90% while 78% of the survey respondents indicated a decrease and twenty-two percent reported no change. Figure 17 presents reasons for decline in nomadism as cited by the respondents.

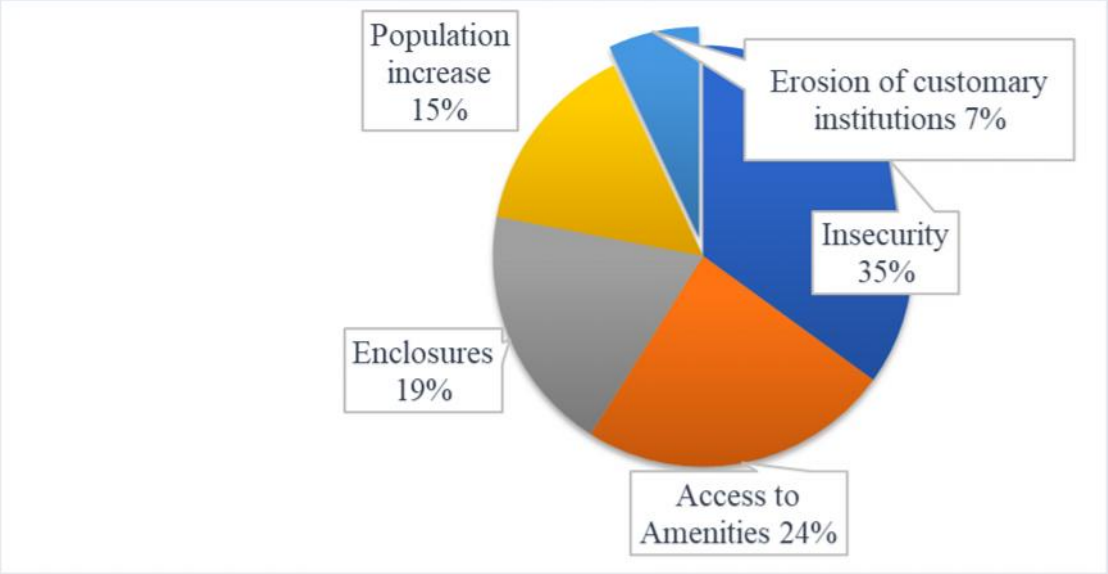

Figure 17. Reasons for decline in nomadism as reported by the respondents

The respondents cited the drivers of sedentarisation as; insecurity (35%), desire to access modern social facilities (24%), move towards privatization of land use and enclosures (19%), population increase (15%) and erosion of customary institutions governing land (7%). Different studies in Kenya showed altered land holding systems implying sedentarisation, fragmentation and privatization of previously communally owned land as leading to land use and cover changes (Flintan, 2011; GOK, 2012). A study done in South Sudan recorded

insecurity as a major contributing factor to loss of livestock mobility (Kebebew *et al*., 2001) while Lind *et al*. (2016) reported evidence showing that conflict is a life-defining factor in the region driving herding strategies and migration. The same conclusion was drawn in studies done in Turkana and Karamoja where security concerns were found to drive herding strategies including migration (Pike, 2004; Stites *et al*., 2014) and was also cited in Borana as a cause of people exiting pastoralism (Desta *et al*., 2008). Orindi *et al*. (2007) noted that decreased mobility due to insecurity exacerbates the unsustainable use of the range areas, with pastoralists to concentrating in some areas thought to be secure, leaving other pastures unused and causing with livestock to become more subject to diseases.

The overall impact of privatization, sedentarisation and other land use changes is facilitated by trade-offs at the household level. While a shift to mixed agro-pastoralist systems may for example increase average yearly production in a good year it may on the other hand increase drought vulnerability and make land prone to degradation (Delgado *et al*., 2018). Land use change may also increase inequalities between rich and poor households as noted by Mureithi *et al*. (2013) in regard to enclosing of communal land. The tradeoffs are better understood and evaluated by community members. Nonetheless, decisions about natural resource management are often taken at supra-regional levels, with little to no community participation (Behnke & Kerven, 2013). One such policy is the encouragement of sedentarisation and privatization by many governments in SSA after independence to stimulate agricultural production and facilitate an easier administration of rural areas (Eriksen & Silva, 2009).

4.3.5.2 Change in Livestock Population

Data obtained from the study baseline survey and supported by focus group discussion indicate that there was significant decline in livestock population between 1975-2018. The general declining trend in livestock population as discussed and voted for by the focus group discussants is presented in figure18.

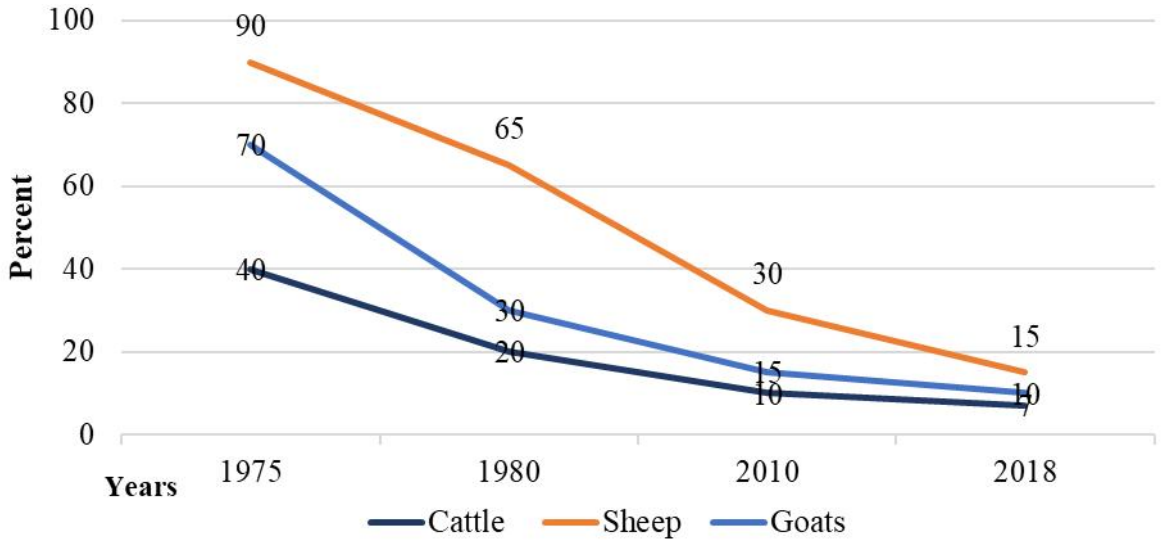

Figure 18. Livestock population trend in the study area from 1975 to 2018 (FGD analysis)

The biggest decline was attributed to the 1978-1980 drought which killed over 50 percent of livestock in the study area (FGD 2). This is supported by Little (1981), who reported 49% of stock deaths in the 1979-1980 period in the Njemps. Further, Little reported the cattle deaths related to east coast fever at 49%, while 40% was caused by lack of pasture and a further 11% was as a result of trypanosomiasis and other diseases. Little attributed goats' deaths to an outbreak of Contagious Caprine Pleuropneumonia (CCPP) between 1978-1979.

The survey respondents supported the declining trend of livestock population. Figure 19 presents the results from the household survey on livestock change in the study area.

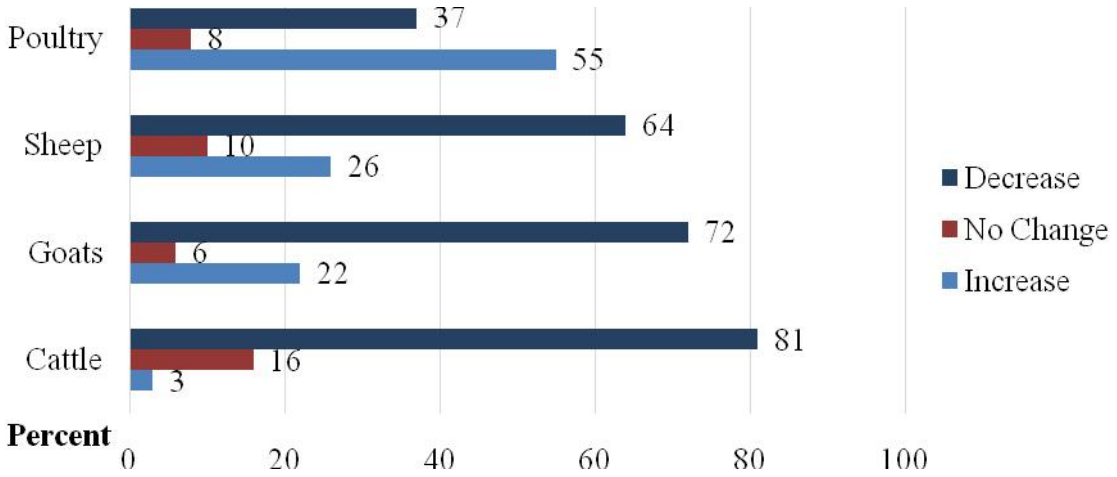

Figure 19. Change in livestock population in the study area

Majority of the survey respondents agreed to a general decline in livestock (81% for cattle, 72% for goats, 64% for sheep) apart for poultry where 55 percent indicated an increase. Drought was indicated as the main cause of livestock decline (73%) followed by pests and diseases (61%), *prosopis* invasion leading to depletion of grass pasture and livestock death (56%), increased family expenses due to health and education (49%), decrease in nomadism due to insecurity and privatization of land use (38%) and livestock improvement (25%). Innovations in husbandry were the introduction of poultry which was viewed as a woman's livestock and whose whose population increased over the years and improvement of livestock breeds cited as a reason for decline of livestock in the study area. Little (1981) noted difficulty in distinguishing drought and disease as discrete causal factors of cattle deaths in ASALs since they are habitually closely related. Poor nutrition caused by drought would usually amplify an animal's susceptibility to disease, significantly increasing mortality rate particularly where grazing is inadequate.

4.3.5.3 Land Cover Change

Changes in land use and land cover in drylands result in grazing lands being converted, modified, or fragmented, with significant ecological, social, cultural, and economic implications (Kihiu, 2013). Figure 20 shows land cover change in the study area.

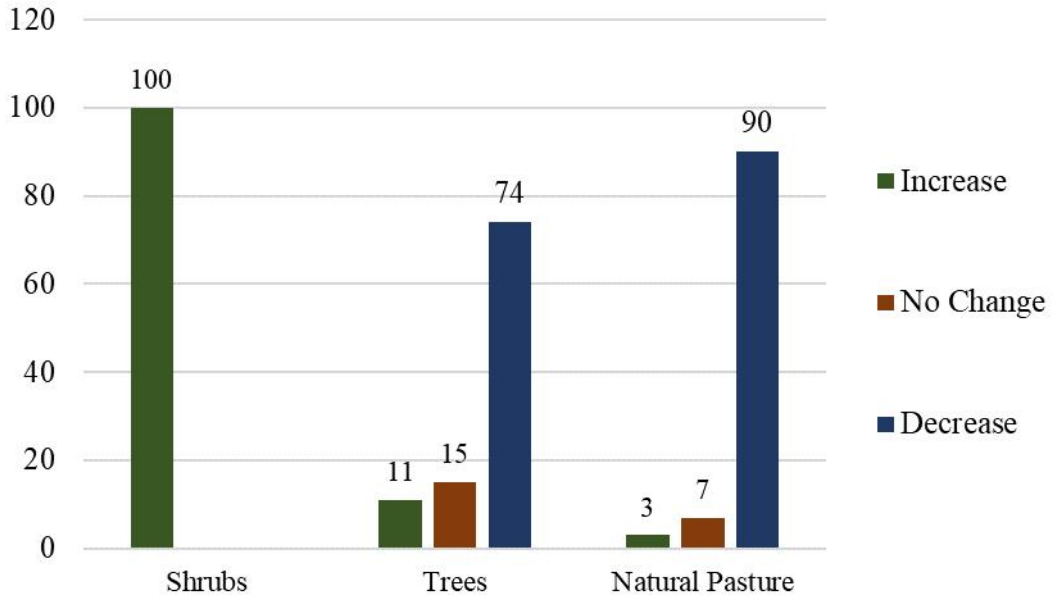

Figure 20. Land cover change as reported by the survey respondents

All focus group discussants and survey respondents cited the introduction of *Prosopis juliflora* as the main cause of increase in shrub in the area. The invasive species was introduced in the study area in 1982, due to land degradation concerns (FGD 1). As reported by key informants, *Prosopis juliflora* was introduced by the Government of Kenya through the Ministry of Agriculture, the Ministry of Environment and Natural Resources in conjunction with the Food and Agricultural Organization (FAO.) under a partnership agreement. Andersson (2005), reported that the shrub was introduced as a forestry tree for the purpose of controlling land degradation, reducing desertification and ensuring self-sufficiency in wood while making the land more habitable as part of the Fuel wood Afforestation Extension Project in the early 1982. Ng'ambo location in Il Chamus ward was the initial planting site and represents the highest density of *Prosopis juliflora* currently (FGD 1*).* GIS analysis revealed that the area under shrub increased progressively by 15,000 Ha since the introduction of *Prosopis juliflora* in 1982. It was however not possible to separate between the different types of shrubs in the study area from the GIS data and therefore the data was used as a corroboration of the community collected data. Figure 21 presents the GIS analysis on area under shrub since 1980.

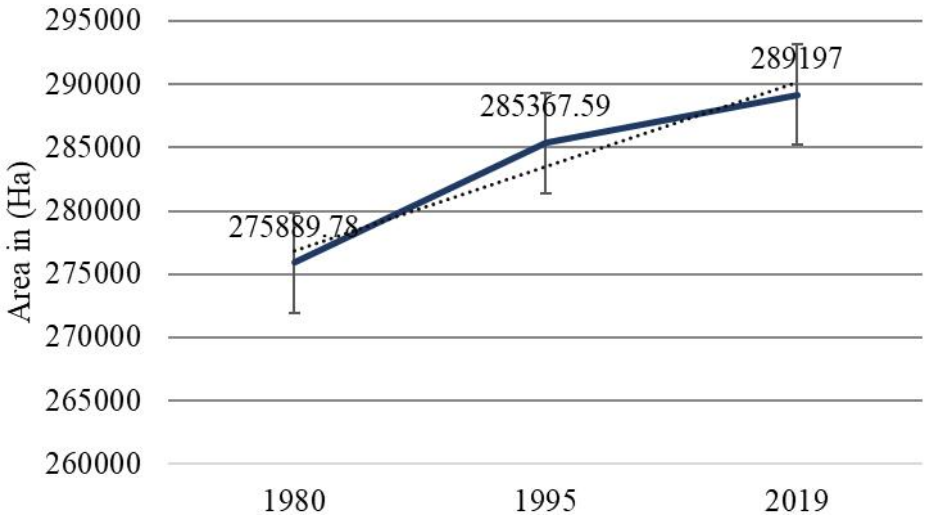

Figure 21. GIS data on change in Area covered by shrubs from1980 to 2019

The survey respondents identified *prosopis* as the main cause of decrease in natural grass pastures (66%) and indigenous trees (48%). In both FGD sessions the discussants showed awareness of *prosopis* positive attributes which they cited as fodder for livestock, nectar for honey, wind breaks and provision of wood for construction and charcoal. Before introduction of *prosopis*, strong winds would blow off roofs from houses and carry sand that would blind

livestock (FGD 1). However, on the negative side, the discussants considered *Prosopis juliflora* to be highly invasive; shading out other plants, eliminating natural grass cover, having chemical that causes tooth decay in livestock and causing lameness in livestock and humans through thorn injuries and causing respiratory allergies in humans. Majority of the respondents perceived *Prosopis* to be damaging to their livelihoods and called for its total elimination. The findings are consistent with those of Mwangi and Swallow (2005) and Kahi *et al*. (2009) who reported *Prosopis juliflora* as being alellopathic in leading to low biomass production of herbaceous plant species under the *prosopis* canopies or their total elimination. Mwangi and Swallow (2005) reported elimination of indigenous trees and pasture grasses in the Njemps flats due to *Prosopis* invasion.

Comparable trends of declining grazing lands have been reported in Burkina Faso, between the years 1975 and 2000, where savanna grasslands declined from 59.8% to 51.6% of the land area, Niger, where grazing lands decreased by 16.2%, Togo by 10%, Mauritania by 30%, and in Benin by 10.4% (Tappan and Cushing, 2013). In Ethiopia, agropastoralists were reported to have lost over 700,000 hectares of natural grazing land to *prosopis* (Admasu, 2008) while agropastoralists in Namibia had lost over 26 million hectares to bush encroachment by 2014 (Mlunga & Gschwender, 2015). Contrarily to the above trend, a study done in South Africa found grasslands to have increased between 1988 and 2006 mainly due to rehabilitation efforts (Niedertscheider *et al*., 2012) while Brink and Eva (2009) found no significant grassland changes in the Karoo-Namib and Kalahari regions between the years 1975 and 2000.

On forested land, majority (74%) of the respondents reported tree decrease, 15% reported no change while 11 percent reported an increase in forested land. Same trend was observed in natural grassland pastures where 90% of the respondents reported a decrease. The reported changes in forest and grassland were supported by GIS data presented in figure 22.

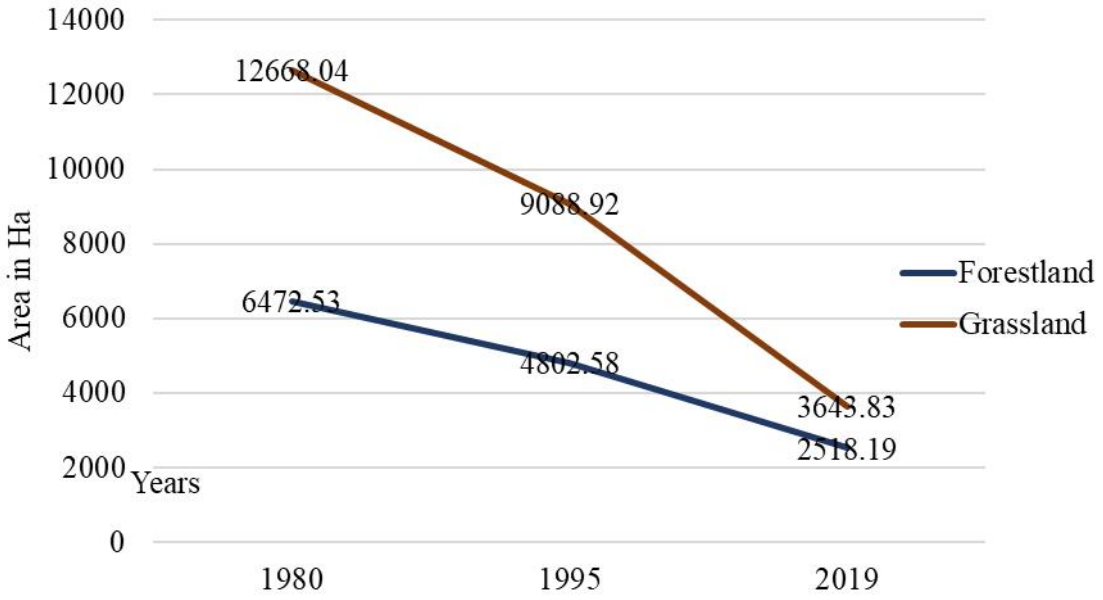

Figure 22. GIS data on Forested and grassland cover in the study area from 1980 to 2019

Conversion of communal grasslands used for grazing to other forms of land use as reported by this study has led to limited mobility of livestock and has increased grazing pressure of livestock in confined areas. This has had negative impacts on the sustenance of the ecosystems, leading to overgrazing and subsequent productivity losses and land degradation. Less grazing areas and less productivity is likely to have negative impacts on incomes as well as increase the vulnerability of rural households to the variable climate and droughts characterizing the area. Davies and Bennett (2007) noted that while crop farming provided an alternative to pastoralism, especially in the areas near Lake Baringo and permanent river Pekerra, conversion of grassland to agriculture rendered communal pastoralists vulnerable to the ecological climate variability of rangelands resulting in larger livelihood impacts. Kihiu (2013), noted that opportunity costs of disrupting the traditional operations of rangelands are at times overlooked, while the benefits may be overstated. The study results indicate that land use change may have far-reaching side effects on other drivers of rangeland degradation and consequently on rural livelihoods.

The study also sought to corroborate community data using landsat satellite images and supported by GIS, to draw a map for land use and cover in the years 1980, 1995 and 2019. Figures 23, 24 and 25 show land use and land cover in the study area for the years 1980, 1995 and 2019 respectively while Table 12 presents a summary of land use and cover change in the study area from 1980 to 2019.

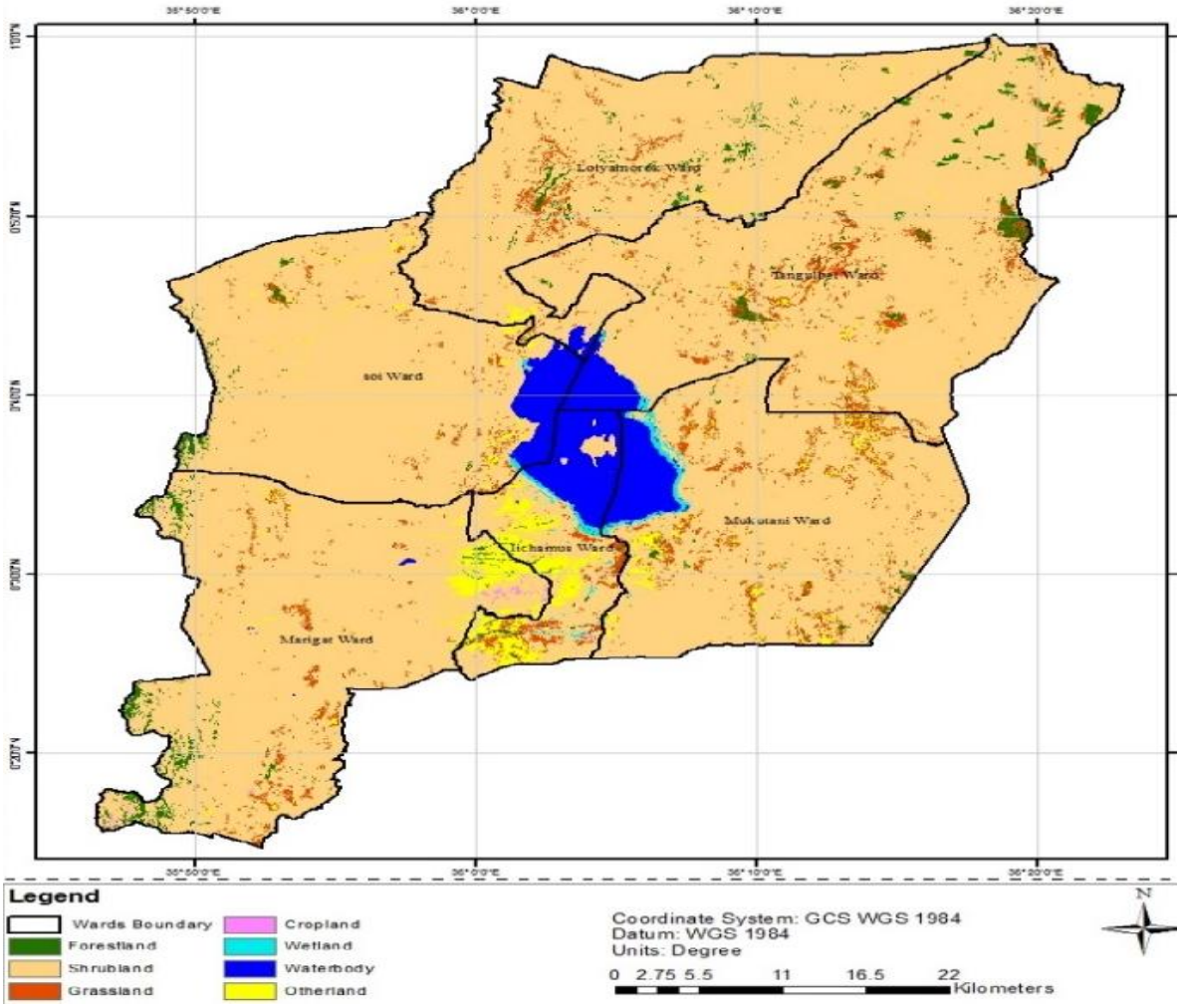

Figure 23. Map of Land use and land cover in the study area in 1980

Based on household survey, focus group discussion and personal observation, the existing land cover in the area included cropland, natural grass land, shrub/bush land and forested land. The 1980 map for land use and cover in the study area (Figure 23), which acted as a baseline for comparison of land use and cover change for the period between 1980 and 2019 showed that shrubland was the main land cover accounting for 86.6 % of the landscape, followed by grassland at four percent, forested land at two percent, wetland (0.4 %) and crop land (0.2%).

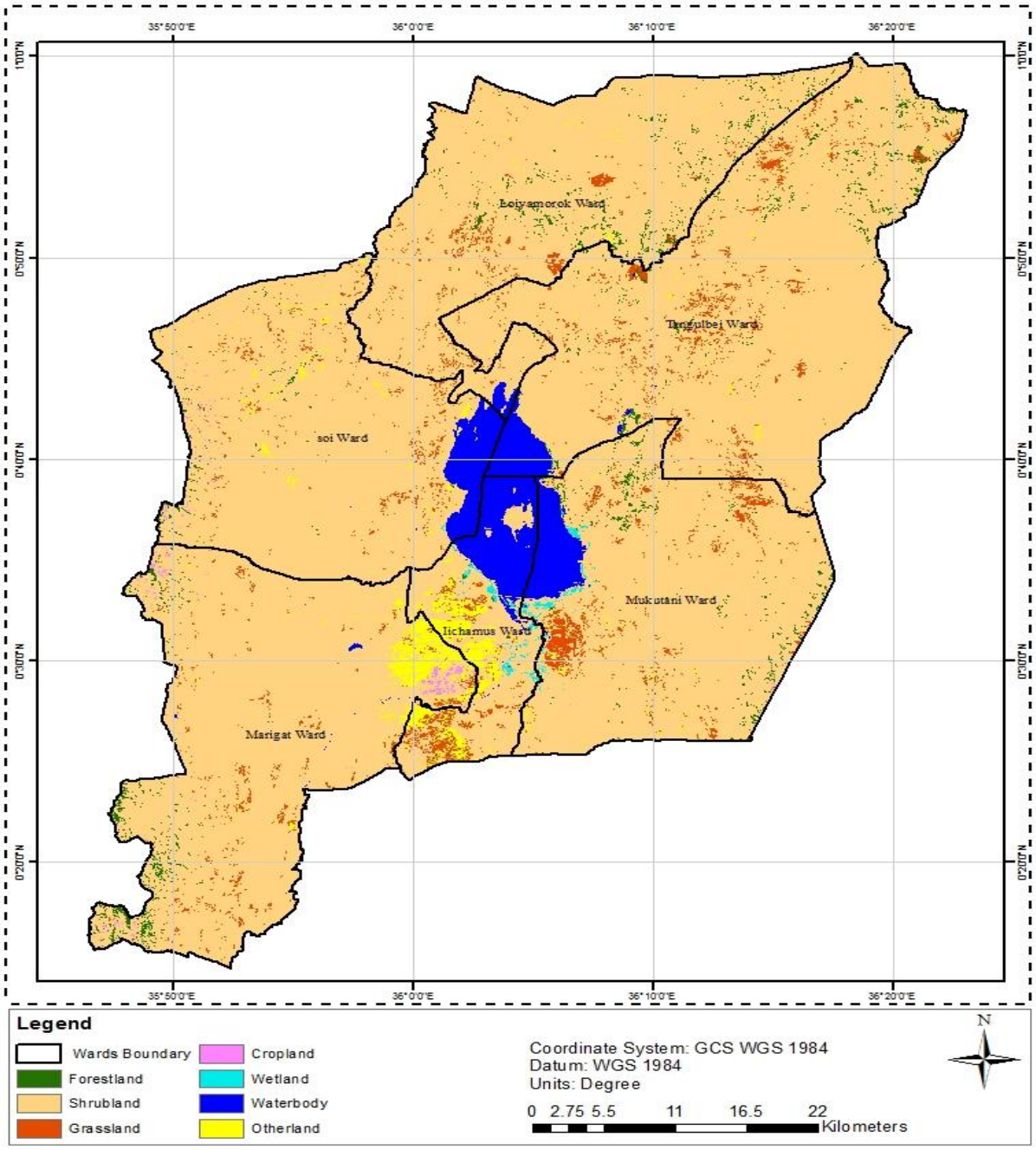

Figure 24. Land use and land cover in the study area in 1995

In 1995 shrubland increased by three percent from 275889.8 Ha to 285367.6 Ha (Figure 24). This is attributed to the spread of *Prosopis juliflora* introduced in the area in 1982 by the GoK in collaboration with FAO. Area under Lake Baringo decreased by approximately 458 Ha between 1980 and 1995. Similar trend was observed in all Lakes in East African Rift Valley (Onywere *et al*., 2014). Onyando (2002) and Odada *et al*. (2006) reported a general decreasing trend from 219 Km^2 in 1976 to 136 Km^2 in 1986 then 114 Km^2 in 1995, and 108

Km^2 in 2001. Differing from this general trend, a sudden surge in lake levels was noticed between 2011 and 2013 (Onywere *et al*., 2014). Other land covers that decreased as shown in figure 25 and Table 12 included grassland, forested land and wetlands. Another increase was observed in crop land which doubled from 370.5Ha to 788.8 Ha an increase of over 50 prcent. The increase of cropland at the expense of grassland and forested land is a global trend (FAO, 2013).

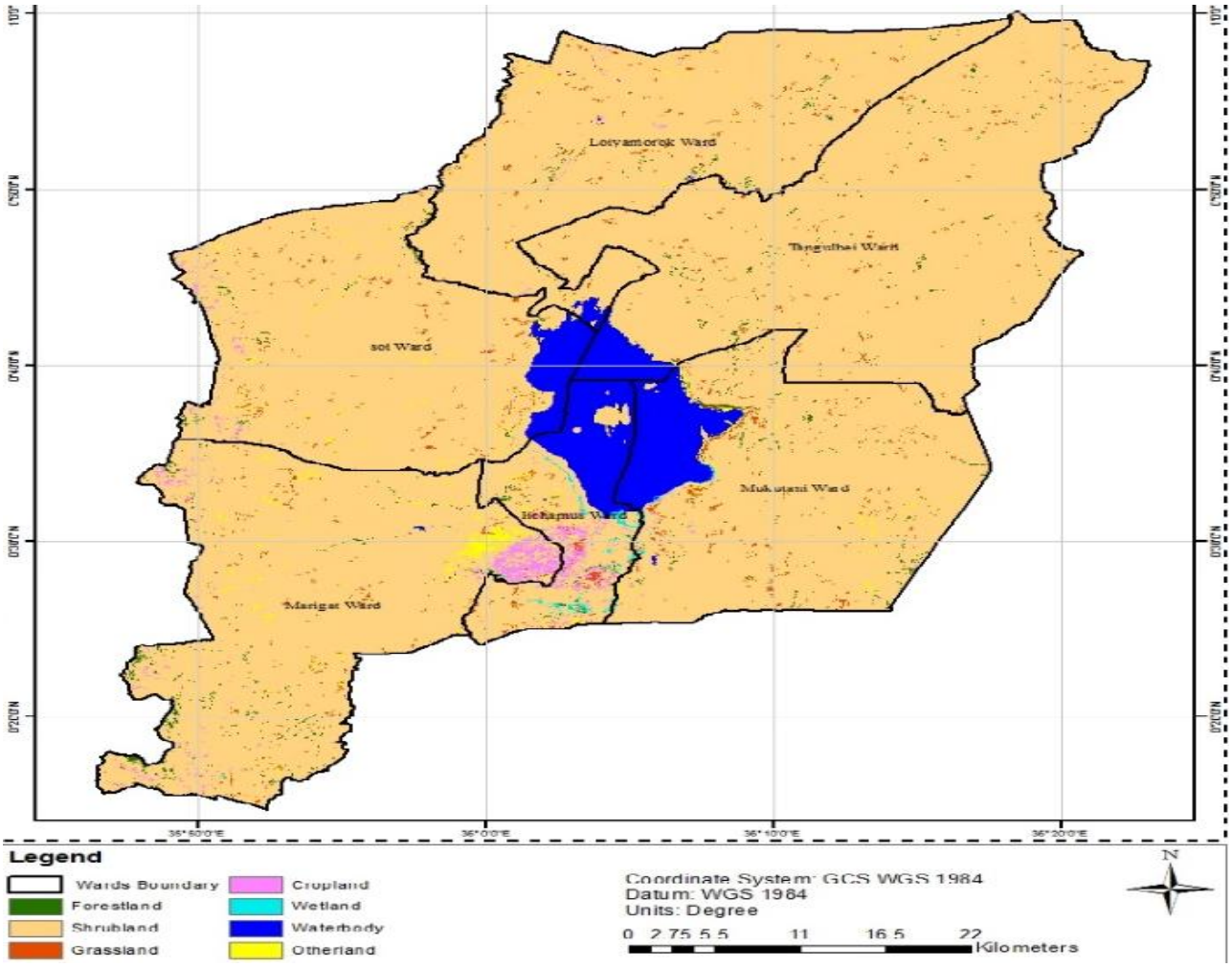

Figure 25. Map on Land use and land cover in the study area in 2019

The 2019 land use and land cover map showed more growth in shrub land albeit by only a small percentage (1%), expansion of Lake Baringo by 3915.9 Ha (1.4 %), decrease in grassland and forested land. Area under wetland didn't show any significant change. The area under cropland grew significantly from 788.8 Ha to 2889.8 Ha. The farmers near the lake decried the expansion of the lake which they reported as having eaten into their farming land.

Table 12 presents a summary of land use and cover change in the study area between 1980 and 2019.

Table 12

Summary of Land Use and Cover Types in the Njemps Flats in 1980 to 2019

Year	1980		1995		2019	
Land cover type	Area in (ha)	Area in %	Area in (ha)	Area in %	Area in (ha)	Area in %
Shrubland	275889.8	86.6	285367.6	89.6	289197	90.8
Waterbody	13471.9	4.2	13013.6	3.9	16929.5	5.3
Grassland	12668	4.0	9088.9	2.9	3643.8	1.1
Other land	8357.7	2.6	4881.3	1.5	2724.2	0.8
Forestland	6472.5	2.0	4802.6	1.5	2518.3	0.8
Wetland	1397	0.4	689.5	0.2	659.6	0.2
Cropland	370.5	0.2	788.8	0.4	2889.8	1.0
Total Area	318562.3	100	318562.29	100	318562.3	100

The summary shows progressive increase in shrubland at the expense of natural pasture and indigenous trees between the period 1980 to 2019, general expansion of Lake Baringo, and a decrease in wet land. During the same period, crop areas increased by over 50 percent. The above implies that the increase in the cropped area was mainly from natural grasslands. The expansion of cropped land and the introduction of the invasive *Prosopis juliflora* has been major driving forces behind land use and land cover changes in this area during the period 1980-2019. Globally, crop lands have expanded at the cost of natural grasslands (Maitima *et al*., 2009).

4.4 Coping with Effects of Land degradation

The second objective aimed at assessing the strategies used by the respondents to cope with the effects of land degradation in the study area. In order to effectively understand the coping strategies, it was found imperative to understand the effects of land degradation as observed and understood by the residents of the Njemps Flats.

4.4.1 Effects of Land Degradation

To understand the effects of land degradation, the respondents were asked to state how land degradation had affected their livelihoods. The results were tabulated and presented in table 13.

Table 13

Effects of Land Degradation on the Study Area

Effects of land degradation	Participants	Percentage
Increased drought and water scarcity	95	63
Low crop and livestock production	88	59
Loss of indigenous grasses and shrubs	80	53
Loss of settlement, grazing and agriculture land	66	44
Increase in human and livestock diseases	54	36
Destruction of Infrastructure	44	29

Sixty three percent (63%) of them reported an increase in droughts and water scarcity as the biggest effect followed by low crop and livestock production (59%) loss of indigenous grasses and shrubs (53%), loss of grazing and agriculture land (42%), increase in human and livestock diseases (37%), Loss of settlement, grazing and agriculture land (25%) and destruction of infrastructure (18%).

Results from numerous related studies are consistent with those of the current study. For example, Duraiappah *et al*. (2000) and Maitima *et al*. (2009) observed that range degradation makes agro-pastoral resources yield less, ensuing in loss of livestock to hunger or quality decline, especially during persistent droughts effecting community livelihoods adversely. Flintan (2011) estimated cattle mortality during severe drought to be as high as 3 million cattle in Kenya ASALs, leading to losses of about a billion dollar. Pastoralists' income levels fall as a result of the loss of livestock and a decline in the value of degraded land, driving the communities deeper into poverty (Duraiappah et al., 2000). As rangeland productivity declines, pastoral populations become more vulnerable to shocks from changing climates (Amman & Duraiappah, 2004). Loss of coping mechanisms during droughts, leads to a high loss of human life and large humanitarian aid costs, which can exceed $4.0 million (Flintan, 2011).

A study done in Ethiopia listed the following as effects of land degradation; decrease of livestock in both quantity and quality, pushing up unemployment rate and out-migration; increased conflict between pastoralists and agropastoralists (Birhanu, 2014). Hurni (2000) reported degradation as a cause for food malnutrition in Ethiopia as it reduced crop production by ten to twenty percent. Loss of grazing land to degradation coupled with population increase leads to competition and conflict over the limited and declining dryland resources (Maitima *et al*., 2009). Rangeland degradation was also reported by the respondents to have negative effects on biodiversity reported by the respondents as loss of indigenous grasses and shrubs. This is supported by Maitima *et al*. (2009) who reported rangeland degradation as having strong negative effects on biodiversity with severe soil erosion decreasing plant species numbers. Maitima also reported intensification which is a coping strategy to degradation effects as leading to a decline in indigenous plants over time with subsequent negative consequences on the ecological function of rangelands. The results shown in table 13 underline the urgent need to promote adoption of SLM management practices in the study area.

4.4.2 Strategies for Coping with Effects of Land Degradation

The respondents in this study reported a number of possible adaptive responses available to deal with land degradation in the study area. These included adoption of various SLM practices, livelihood diversification, extensification as well as behavioural responses such as migration and building of social capital through participation in farmer groups (Figure 26).

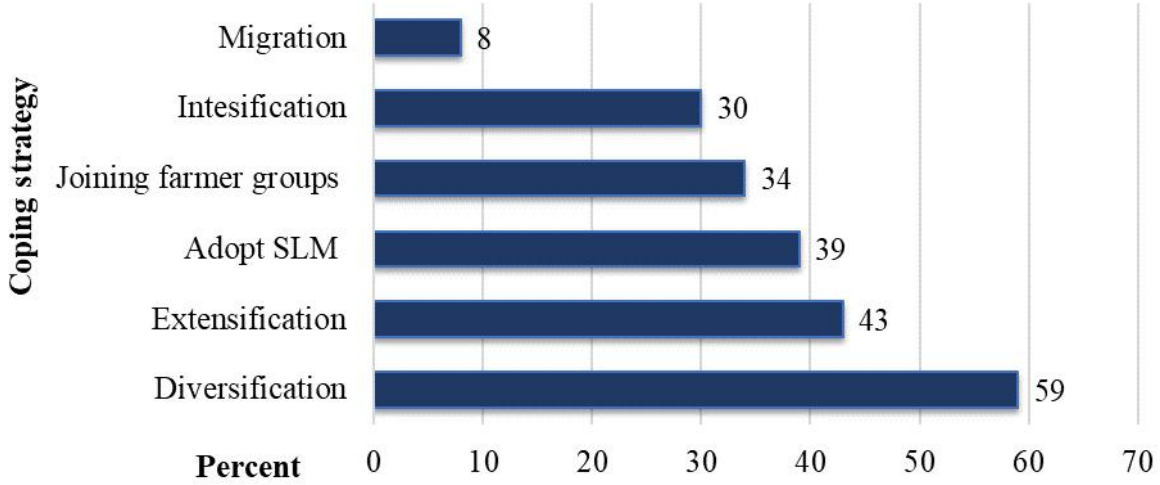

Figure 26. Land degradation coping Strategies used by households in the study area

Diversification was reported by the majority (59%) of the respondents and involved charcoal burning, keeping kiosks, planting different crops as a way of creating resilience and engaging in motorcycle transportation commonly referred to as bodaboda. The community was allowed charcoal burning by the court in 2008 in their case against the government as a way of reducing the invasive shrub *prosopis* and improving their livelihood (FGD 1). Other coping strategies included, extensification (43%) which involved opening more lands for planting and keeping more livestock; adoption of SLM practices (39%); joining farmer groups (34%); intensification (30%); which included investing in more farm inputs for disease control, soil fertility and livestock upgrading and migration to rent land in irrigation scheme (8%).

Other studies carried elsewhere revealed results which are consistent with the current study. For example, adaptive strategies to meet family needs, under the context of soil erosion and increasing population pressure, smallholder farmers in northern Laos were reported as intensification, shortening of the fallow period, and crop diversification (Lestrelin & Giordano, 2006). In the case of pastoralists in Mali, adaptive strategies such as transhumance, forage conservation and destocking were reported (Dembele, 2006). Other coping strategies that have been used to cope with or to reverse degradation processes reported by various studies include; afforestation and mechanical practices to fix dunes stonewall terrace construction to reduce runoff and erosion and to preserve soil moisture (Dembele, 2006) agroforestry practices (Nyaga *et al*., 2015) and the use of enclosures (Mureithi *et al*., 2013).

4.4.3 Factors Affecting Choice of the Coping Strategies

The respondents were asked to indicate factors they considered while selecting land degradation coping strategies. Table 14 shows factors affecting choice of the coping strategies as reported by the respondents.

Table 14

Factors affecting choice of coping strategy (N=150)

Factors affecting choice of coping strategy	Frequency	Percentage
Perceived potential benefits	94	63
Availability of resources	77	51
Severity of degradation	62	42
Access knowledge access and skills	56	37

The choice of the coping strategies as reported by the respondents depended on perceived potential benefits from application of the strategies (63%), availability of resources for the strategy including labour (51%), the severity of degradation (42%) and access to knowledge and skills (37%). Leutlwetse (2006) observed that adoption of coping strategies depended on household characteristics such as education, age and number of family members. Eswaran *et al*. (2001) however cautioned that conservation practices are to a large extent site and context specific, and care should be taken when selecting suitable strategy to use. In addition, Moges and Holden (2007) noted that though in many situations, land users pocessed a fair amount of knowledge on causative factors and strategies to reverse degradation, they nevertheless, prioritized survival and immediate family needs at the expense of taking action on combating land degradation. This could explain why activities like charcoal burning and opening more pasture land for crop farming were preferred coping strategies against effects of land degradation in the study area.

4.5 Determinants of Adoption of Sustainable Land Management Practices in the Njemps Flats

This section deals with objective three which assessed the factors determining the adoption of SLM practices in the study area. The adoption of SLM practices in Kenyan rangelands has remained low with only a few islands of good practice in spite of the deteriorating productivity of the ecosystems (ASDP, 2013; Kihiu, 2016). This low adoption necessitated the documentation of factors that determine their implementation among rural households in drylands as the third objective of the study. The SLM practices used by the households of the respondents, levels and sources of SLM knowledge and the challenges of adopting SLM practices were documented as reported by respondents and discussed in the ensuing section.

4.5.1 Level and Sources of Knowledge on Sustainable Land Management Practices

To understand farmers' level of knowledge of existing SLM practices, they were required to indicate their perceived knowledge level on a Likert scale and also indicate the sources of the information and training. Table 15 and Figure 24 presents their responses respectively.

Table 15

Level of Knowledge on SLM Practices by the Survey Participants

Knowledge Level	Frequency	Percent
Low	103	68.7
Moderate	33	22
High	14	9.3
Total	150	100.0

Majority (68.7%) of the respondents reported low level of knowledge in SLM practices. Only 9.3 percent of the respondents perceived themselves as having high level knowledge on SLM practices. The low level of knowledge in SLM practices could be linked to the low adoption of SLM in the study area. This is supported by Gupta *et al*. (2009) and Mirzabaev (2013) who indicated lack of farmers' awareness or training in the use of appropriate SLM practices, and the lack of adaptation of practices to local conditions as major constraints in adoption of SLM practices.

The major sources of knowledge and information on SLM technologies were neighbors (54%), farmer groups (32%), public extension (27%), agrochemical dealers (23%) and NGOs (19%). Figure 27 presents the sources of information in SLM technologies as reported by the respondents.

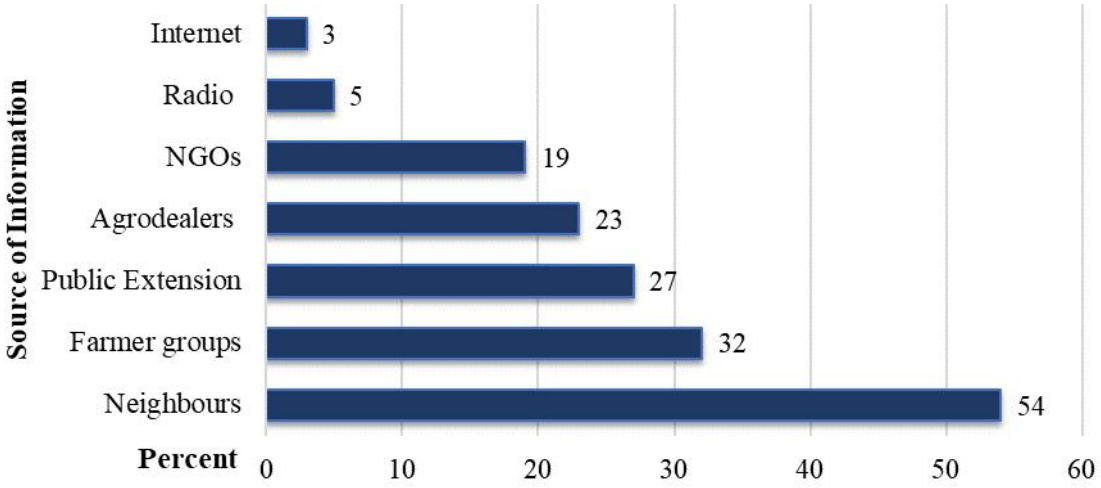

Figure 27. Source of SLM Knowledge and information as reported by the respondents

The fact that neighbors and farmer groups were reported to play a major role in the diffusion and adoption of SLM technologies points to the importance of farmers participation and

collaboration when developing and adapting the SLM practices to their localities and context. The study findings are supported by Bwambale (2015), who found farmers to be most important source of information for erosion control measures (49.1%), animal manures (27.7%), and inorganic fertilizers (43.2%). Chambers and Leach (1989) and Ramisch (2004) noted that farmers groups are a source of indigenous knowledge and technologies, and therefore must be involved in technology development and adoption research. Similarly, Ekoja (2003) reported the most important sources of agricultural information in Nigeria to include extension agents, neighbors, other farmers, opinion leaders and organized groups in that order. Lu *et al*. (2002) concluded that farmer groups, neighbors and family members can be used as a leverage for poor farmers who were more likely to get information about new technologies through them as compared to the rich farmers who had better access to government extension, NGOs agents and programs.

A country wide household survey done in Kenya by ASDP in 2013 reported major sources of knowledge and extension on SLM technologies to be agro-dealers, followed by government extension officers, farmer groups, co-operatives and NGOs in that order (Mulinge *et al*., 2016). Schipper *et al*. (2014) noted the important role played by the NGOs and farmer groups in disseminating agricultural information in rural agricultural communities especially where government extension services are scarce. Mulinge *et al*. (2016) noted that access to a local NGOs increased the log count of the number of SLM technologies adopted by thirty-three percent (33%).

4.5.2 Sustainable Land Management Practices used by the Participants' Households

The respondents were asked to indicate the SLM practices they use to combat degradation and rehabilitate degraded land. The SLM practices are presented in figure 28.

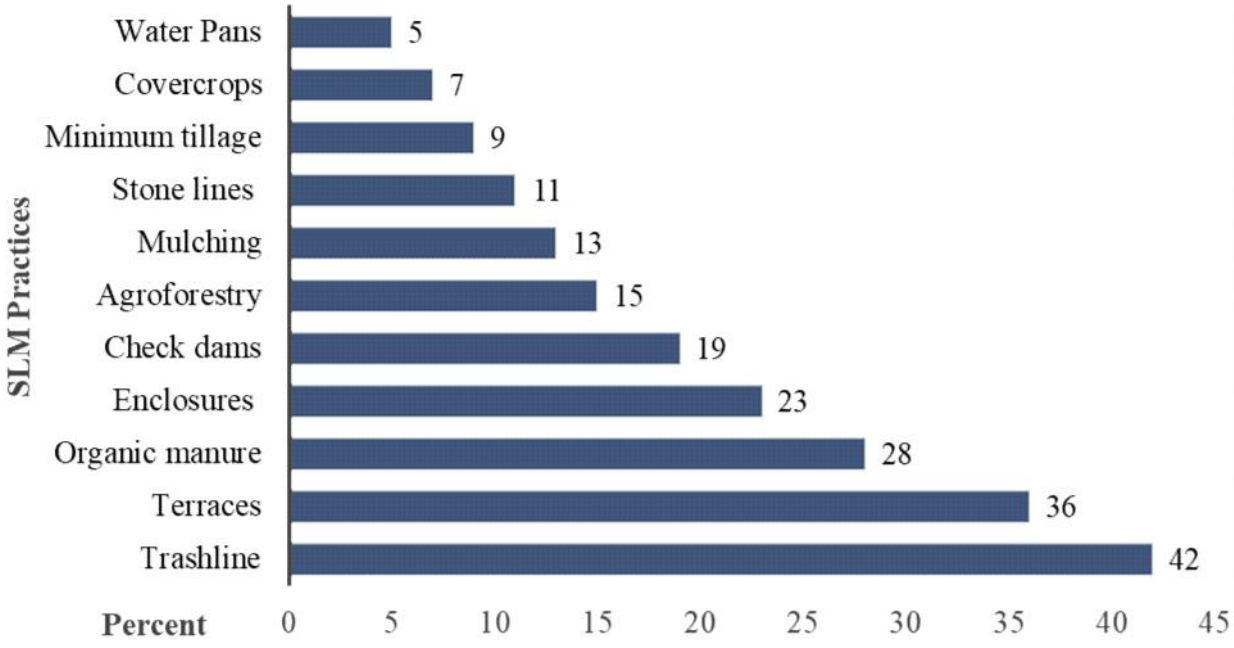

Figure 28. SLM Practices used by households in the study area

The SLM practices used in the study area mainly fell in the categories of soil-water management and soil fertility management practices. The soil and water management practices included trash lines (42%), terraces (36%), Enclosures (23%) check dams (19%), mulching (13%), stone lines (11%), minimum tillage (9%), cover crops (7%) and water pans (5%) while soil fertility management practices included the use of organic manure (28%) and agroforestry (15%).

There is abundant empirical evidence that show adoption of SLM technologies leads to better livelihood outcomes with each adopted SLM technology increasing monetary value of per capita food consumption by 3 percent for the agricultural households in SSA (Kassie *et al*., 2008; Mirzabaev, 2014). A study by Kassie *et al*. (2008) in Northern Ethiopia, reported that farm plots treated with stone terraces experienced significant increment in yields while farmers who used stone bunds recorded higher crop yields than those who did not. Kaumbutho *et al*. (2008) showed that maize yield increased in Kenya with the use of *Velvet Bean* cover crop while Branca *et al*. (2011) reported increase in maize yields in Brazil with the use of cover crops.

Adopting organic manure was found to have positive effects on crop yields. In Kenya, maize yields increased by 100 percent with the use of manure (Branca *et al.*, 2011), while millet

yields increased by 75-195 percent and groundnut by 100-200 percent in Senegal (Parrot *et al*., 2002). Cases of crop yield increase have also been reported from Latin America where adoption of organic fertilization led to increases in maize and wheat yields by between 198-250 percent (Altieri, 2001). Place *et al*. (2003) reported that between 86 percent and 91 percent of farmers in semi-arid and semi-humid zones east of Nairobi used manure. Farmers in the study area though, avoided using farmyard organic manure in their land because it led to spread of *Prosopis juliflora*. According to focus group discussants, *Prosopis juliflora* seeds that have gone through digestive system of livestock became highly viable and germinated easily thus spreading the invasive shrub. Figure 29 presents some of the SLM practices used by the study participants.

Figure 29. SLM practices used by the study participants.
A-Posts and sticks Check dam; B-Trash used to fill a small gulley; C-Stone terrace; D-Ox-bow bunds; Photos by Francis Pakolwa (RAE) February 2019

Further analysis of the adoption of SLM practices revealed that most adopter farmers adopted more than one type of practice at a time. Twenty-two percent (22%) of the surveyed households adopted a combination of two types of practices while 19% adopted three

different practices. Only three percent of the households reported using six SLM practices which was the highest number practices reported. (Figure 30).

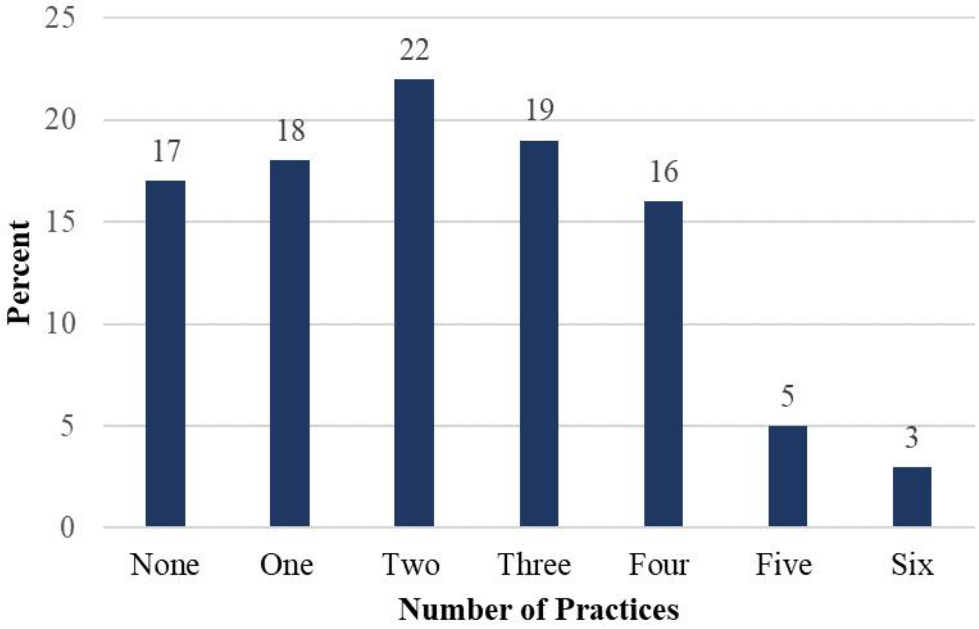

Figure 30. Number of SLM practices used by the Respondents

The combination of the SLM practices adopted depended on the farm enterprises, physical conditions of the farm and households' social economic factors. For example, farmers who planted pasture created oxbow bunds to slow down runoff and improve water infiltration. These findings are in line with those of Mganga et al. (2015) who reported that farmers combined various SLM practices to rehabilitate degraded fields in Kibwezi Kenya. According Schwilch *et al.* (2014), farmers' decision to combine various SLM practices is founded on farmers' short and long-term goals of improved soil fertility management coupled with economic viability, and social acceptability. A study on adoption of integrated soil fertility management practices in Malawi and Tanzania reported farmers used one to six practices with an average of two practices in Malawi and one practice in Tanzania. The determinants for the number of practices adopted included plot factors, biophysical factors, benefits of adoption, social economic factors and demographic factors (Kirui, 2016). In the survey, the household heads were also asked to indicate the challenges they faced in adoption of SLM technologies. Those are presented in Table 16.

Table 16

Challenges Associated with the Use of SLM Practices in the Study Area (N=150)

Challenge	Frequency	Percentage
Lack of capital/High cost of SLM practices	95	63
Lack of knowledge and skills	89	59
Shortage of labour	56	37
Climatic variation	50	33
Insecurity of land tenure	9	6

Majority of the respondents (63%) cited high cost of SLM technologies as the main challenge in implementing SLM followed by lack of knowledge and skills (59%), lack of labour (37%), climate variation (33%) and insecure tenure (6%). The findings concur with a nationalwide survey by Mulinge *et al.* (2016) who reported the most important constraints in the adoption of SLM technologies in Kenya to be their high cost of implementation and lack of information and expertise in their proper application. Kihiu (2016), observed that though SLM practices are conceptually simple, their adoption is surrounded by many constraints embedded within the stakeholder levels of policy makers, technocrats and households.

4.5.3 Determinants of Using Sustainable Land Management Practices

To further analyse factors determining adoption of SLM practices, regression analysis for categorical data with optimal scaling was run using Statistical Package for Social Sciences version 25. Table 17 presents the results of the categorical regression between adoption of SLM practices and moderator variables namely; Level of formal education of the HH, age of the HH, gender of the HH, Level of extension access by HH, farm size, household annual income, livestock units and participation in farmer groups.

Table 17

Results of the Categorical Regression Between Adoption of SLM Practices

	Standardized Coefficients		Df	F	Sig.
	Beta	Bootstrap (1,000) Estimate of Std. Error			
Family size	0.091	0.150	1	0.362	0.548
Level of formal education	0.185	0.100	3	3.450	**0.019**
Level of extension Access	0.513	0.068	2	56.382	**0.000**
Household annual income	0.183	0.065	3	8.080	**0.002**
Livestock Units	-0.069	0.079	1	0.779	0.379
Age of Household Head	-0.078	0.173	2	0.204	0.652
Group Participation	0.173	0.068	1	6.567	**0.000**
Land Size Categories	0.063	0.102	2	0.382	0.683
Gender of respondent	-0.016	0.073	1	0.048	0.827

The results of the regression indicated that the model explained 60.8% of the variance and that the model was a significant predictor of SLM practices adoption F (16,133) =13.429, p<.000). From the model, four socio-economic household characteristics significantly predicted adoption of SLM practices by the participating households. The following factors had coefficients that indicated significant influence on the dependent variable; household head's level of education (**0.019),** total annual income (**0.002**), level of extension access (**0.000**) and participation in farmer groups (**0.000**). All the significant factors had positive influence on adoption of SLM practices. The other coefficients were not significantly different from zero.

The study found household head level of formal education to be positively associated with adoption of SLM practices (P=0.019**)** with households whose heads had higher educational levels more likely to adopt SLM practices than those with lower. This suggests that education enabled farmers to access and interpret agricultural information correctly. This finding is supported by Gillespie *et al*. (2007) who found education likely to enhance the perception of degradation being a problem as well as increase access to information on available SLM technologies.

Total annual income was found to influence adoption of SLM practices positively at P=0.002 with households having higher annual income adopting more SLM Practices. This suggests that households with low level of income and high poverty levels are likely to have lower SLM practices especially those that have a monetary requirement. Liniger *et al.* (2011), reported that adoption of SLM innovations in rangelands, involved investments in improved grassland management, such as pasture establishment, bush encroachment protection, rotational grazing, tree planting, and soil conservation initiatives. As a result, the ability of a household to invest in the practices will have a significant influence on their adoption (Gillespie *et al.*, 2010).

Access to agricultural extension services had a positive impact on SLM adoption (P=0.000). A key factor restricting the adoption of SLM activities, according to Shiferaw *et al.* (2009), is a lack of knowledge on the possible benefits, costs, and risks associated with land degradation or SLM adoption. Analyzing household surveys from Central Asia, Mirzabaev *et al*. (2015) also found access to extension information and participation in farmer groups to be key underlying factors influencing SLM adoption. In a comparative study done in Malawi and Tanzania access to extension increased probability of SLM adoption by 13.7 and 14 percent respectively, while membership in farmer organizations increased probability of SLM adoption by 7.2 and 9.8 percent in the two countries respectively (Kirui, 2016). Liniger *et al.* (2011) found that access to extension services had a positive impact on SLM adoption, especially where extension was linked to increased knowledge of land degradation issues. The findings highlight the importance of information, training and creation of awareness on on the effect of degradation on pastoral livelihoods. Farmers were observed to adopt more SLM practices when they perceived tt degradation as a key factor affecting the productivity of their land and also their livelihoods.

Participation in farmers groups was found to positively influence adoption of SLM technologies (P=0.000). Groups are relevant in SLM adoption because they can serve as conduits for financial transfers that can help farmers overcome credit constraints, provide information about new technology, and foster farmer cooperation so that costs and benefits can be shared (Karaya *et al.*, 2013). Some SLM technologies are labor intensive, and one of the main reasons for the success of conservation activities in Machakos, particularly terracing, has been recorded as the pooling of labor among group members on a reciprocal and rotating basis (Kamar, 2001). This positive impact could mean that farmer groups or

associations are important for disseminating agricultural extension messages and providing information about new technology, as well as facilitating farmer cooperation. This would enable group members to benefit from economies of scale while linking them to governmental and non-governmental development agencies. Further discussion on the effect of farmer group participation on SLM practices adoption follows in section 4.5.4

4.5.4 Effect of Participating in Farmer Groups on Adoption of SLM Practices

The study sought to assess how participation in farmers groups affected the level of adoption of SLM practices. Seventy-nine respondents were members to farmer groups (52.7%) or had an adult household member participating in the groups while seventy-one (47.3%) of respondents did not have an adult household member belonging to farmer groups.

4.5.4.1 Reasons for Joining Farmer Groups

Individuals joined the groups on their own initiatives, though a few were required to join in order to profit from donor-funded projects. It was expected that people joining groups voluntarily would result in a high level of participation in group activities. Table 18 presents reasons for farmers joining and participating in groups.

Table 18

Reasons for Joining Groups (N=79)

Reason	Frequency	Percent
To access credit and funding	50	63
To enhance access to extension services	38	48
Social capital and emergency help	36	45
Acess benefits from communal enclosures	19	24
Market acess	10	13
Access shared labour	6	8

Motivation for joining and remaining in groups was shown to be related to the services provided by the groups. The respondents cited the availability or the potential availability of the following services as their motivation to join and remain in their groups: credit and funding mentioned (63%) extension services (48%), social capital and help during emergencies (45%) and access to benefits from communal enclosures (24%) among others.

Benefits of participation whether social, economic, capacity building or otherwise may be instrumental to the participants' household adoption of SLM practices (Liniger *et al*., 2011). It is therefore assumed that an increase in the level of participation of household members in groups would be reflected in an increase in adoption of SLM innovations. Kariuki and Place (2006) noted that collective action promotes low-cost access to information, thereby stimulating technology distribution and adoption, reduces marketing costs, lowers input costs, facilitates labor sharing, and acts as informal insurance to members. As a result, groups are seen as an appealing tool for finding and mobilizing the knowledge, money, and power needed to improve household welfare and community services (Korching & Allen, 2004). Consequently, most community and agricultural development agencies have looked to those organizations for help in transforming community structures, harnessing community capital, and enhancing agricultural development (Njoku *et al*., 2009).).

4.5.4.2 Influence of Group Participation on the Level of Household SLM Adoption

The study sought to assess how participation in farmer groups influenced the level of adoption of SLM practices. The household heads were asked to indicate the SLM practices used in their farms which were then categorized as non-adoption, low adoption (1and 2 practices), moderate (3 and 4 practices) and high adoption (5 and 6 practices). Figure 31 presents level of SLM adoption based on group participation.

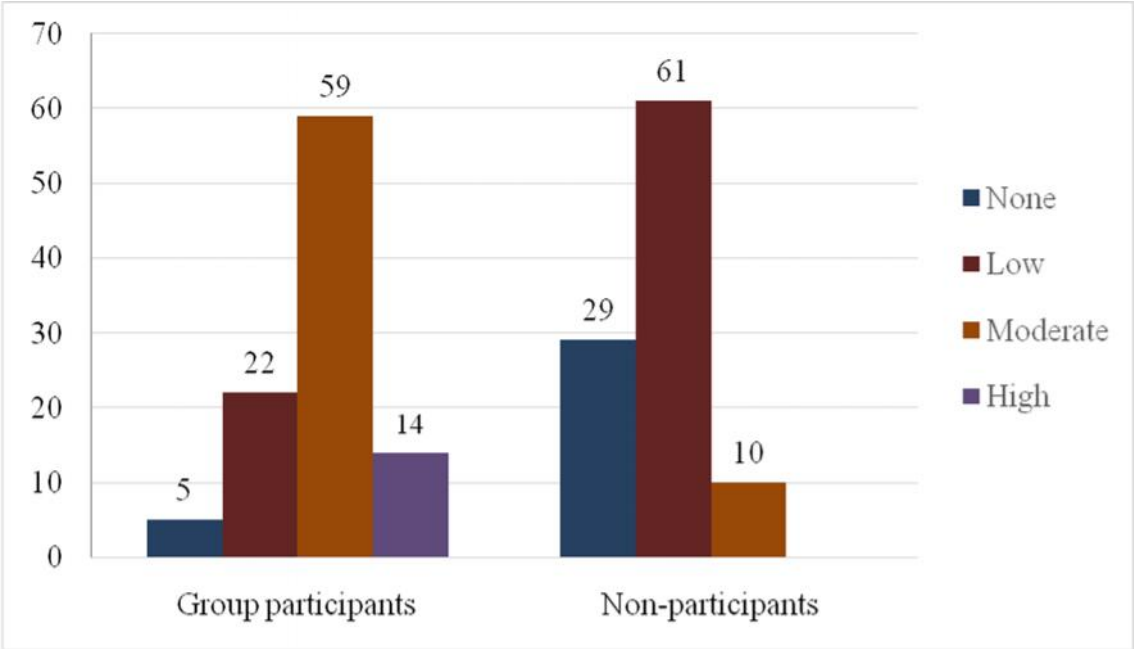

Figure 31. Level of SLM adoption based on group participation.

Group participants generally adopted more SLM practices than non-participants. Only 5 percent of group participants had not adopted any SLM practice compared to 29 percent in non-group participants category. The observed higher adoption levels in group participants could be attributed to higher access to labour through labour sharing in groups, access to information on SLM technology and more access to credit through groups than non- group members.

A Chi-squire test of independence was performed to examine the influence of group participation on the level of adoption of SLM practices. The relationship between group participation and level of adoption of SLM practices was found to be significant at X^2 (3, N=150=62.209, P=0.000). The households with adult members participating in farmer groups had a higher level of SLM practices adoption than the households with no adult member participating in farmer groups. Cramer's V coefficient was used to calculate the magnitude of the relationship between the two variables. The Cramer's V was found to be 0.649 indicating a strong influence of group participation on farmers' levels of SLM practices adoption (Kotrlik *et al*., 2011). Table 19 presents the Chi- squire test analysis for group participation and level of SLM practices adoption.

Table 19

Chi-Squire Tests for Group Participation and SLM Practices Adoption

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	63.209	3	.000
Likelihood Ratio	72.351	3	.000
Linear-by-Linear Association	54.858	1	.000
N of Valid Cases	150		

The study revealed that group participants had significantly higher SLM practices adoption score than non-group participants. This could be due to the fact that most SLM practices required labour, capital and knowledge to construct which is available in groups (Deressa *et al*., 2008). Liniger *et al*. (2011) indicated that the primary reasons for low adoption of SLM practices in SSA included lack of information and knowledge on SLM options, lack of financial resources and labor constraints. A country-wide household survey done in Kenya by ASDP in 2013 reported farmer groups and farmer co-operatives to be major sources of knowledge and extension on SLM technologies (Mulinge *et al*., 2016). The study reported

that access to to agricultural cooperatives and farmer groups increased the log count of the number of SLM technologies adopted by 21.5 percent. Similar results were reported by Teklewold *et al*. (2013) pointing to the importance of building capacity of farmer groups in sustainable land management.

4.5.4.3 Effect of Group Partinerships on the Level of Household SLM Adoption

A group's ability to build constructive partnerships and collaborations with the wider agricultural and development agencies increases their success in the provision of services to its members (Beena, 2013). The study explored the agencies partnering with the different groups and the benefits the farmers got from these partnerships. Out of the 79 respondents who were members to groups, 41 were in groups with no partnerships while 38 were in groups with partnerships. Some of the agencies that the groups had formed partnerships with included government agencies (Ministry of agriculture, Kenya agricultural and Livestock Research Organisation, Kenya Seed Company, Kerio Valley Development Authority) and Non-Governmental Organisations (Rehabilitation of arid environments trust, World vision, Norwegian church aid). Benefits obtained from partnerships were in form of resources support and included extension information; startup assets, market, grants, agricultural technology, training and capacity building, agricultural inputs and food aid.

A Chi-Squire test of independence was performed to examine the effect of groups partnering with development agencies on the numbers of SLM practices that members adopted. The effect of partinering was found to be positive and significant at X^2 (3, N=79=13.147, P=0.004). Group members whose groups formed linkages with other development agencies were more likely to adopt more SLM practices. Cramer's V coefficient was used to calculate the magnitude of the effect of group partinering with outside agencies on the level of SLM adoption. The Cramer's V was found to be 0.408 indicating a strong effect of group partinerships on the members level of SLM practices adoption (Kotrlik *et al*., 2011). Table 20 presents the Chi- squire test analysis for group partinerships and the level of SLM practices adoption.

Table 20

Group Partinerships and the Level of Members SLM Practices Adoption

	Value	Df	Asymptotic Significance (2-sided)
Pearson Chi-Square	13.147	3	0.004
Likelihood Ratio	15.255	3	0.002
Linear-by-Linear Association	12.855	1	0.000
N of Valid Cases	79		

Further analysis, showed that the mean of SLM practices by farmers whose groups had formed partinerships was higher at 3.216 practices than for farmers from groups without partnerships who reported 2.286. In addition, standard deviation for farmers with group partinerships was lower at 0.78652 compared to farmers from groups without partnerships (0.99125). The results could imply that the benefits of the partnerships increased the level of enabling factors associated with SLM adoption to members or that groups with visionary and innovative leaders were more likely to have partners. Figure 32 shows the effect of group forming partinerships and the number of SLM practices adopted by group members.

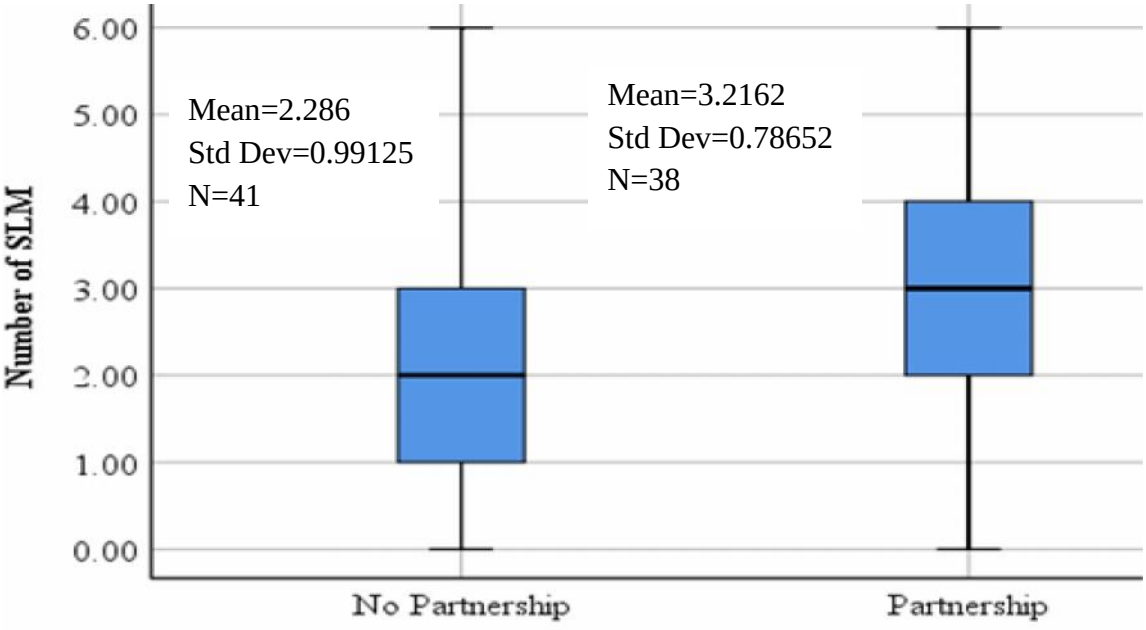

Figure 32. Effect of group partnerships on number of SLM practices adopted by households

The findings of the study concur with those of Amudavi (2005), who reported that service accessible through farmers groups particularly through partnerships with actors increase benefits of such groups to members by promoting mutual learning and increasing utilization of new technologies. Karaya *et al*. (2013) noted that the capacity of a group to carry out its function may depend on the group's relationships with state and other external agencies.

Amudavi (2005) also described group-partner relationships as providing a platform for resources and learning with regard to technology adoption. Participation in grassroot organisations has been found to influence adoption of SLM practices positively by enabling households to establish social networks leading to higher access to information labour and capital (Amudavi, 2005; Karaya *et al*., 2013).

4.6 Establishing a Community of Practice for Rehabilitation of Degraded Land

This section presents results for the fourth objective which was stated as;

To establish a Community of Practice for social learning in the rehabilitation of degraded in the Njemps Flats

4.6.1 Intiation of the Community of Practice

The process of CoP initiation started by analysis of institutional stakeholders considered to have significant influence on the success of rehabilitation of degraded land in the smallholder agropastoralists systems in the Njemps Flats and inviting them to an inception meeting to enlist their support, participation and to scope out on how to establish a functional and sustainable CoP in rehabilitation of degraded rangelands. Stakeholder analysis, according to Golder (2005), aids in identifying the interests of all stakeholders who may influence or be influenced by a project; possible conflicts or threats that may jeopardize the initiative; resources and relationships that can be created by various participating groups at various stages; and stakeholder involvement strategies. The identified institutional stakeholders included local community leaders, researchers from KALRO, Baringo County extension officers, and NGOs representatives.

Community members who were the most important stakeholders to the CoP were invited to voluntarily join and form a farmers group during the baseline survey interviews and focus group discussions in the Il Chamus Ward. Thirty-five community members accepted the invitation to form the group which they named Melita farmers group. Members democratically elected an inaugural committee and registered as a self-help group under the Ministry of Gender and Social Services thus creating identity and order in the loose network. Table 21 shows the social demographics of Melita self help group members.

Table 21

Social Demographic Characteristics of Melita Self Group Members (N=35)

S. No	Characteristic	Category	Frequency	Percent
1.	Gender	Male	9	26
		Female	26	74
2.	Age	20-29	10	28
		30-39	13	37
		40-49	7	20
		50-59	3	9
		Above 60	2	6
3.	Formal Education	No formal Education	7	20
		Lower Primary	12	34
		Upper Primary	9	26
		Secondary	5	14
		Above Secondary	2	6
4.	Reasons for joining group	Income generating projects	17	48
		Social capital	7	20
		Extension access	18	51
		To pool resources	7	19

After the election, the leadership positions were described. The Chairperson was in charge of convening and chairing meetings as well as resource mobilization. The secretary was supposed to be the keeper of all papers, minutes, and project documents. The treasurer was supposed to be in charge of the money. By-laws were drawn by the members and stipulated norms and expectations of being a member to Melita group. Two researchers from KALRO Marigat, one extension officer from RAE Trust, one extension officer from the county Ministry of Agriculture, Livestock and Fisheries were invited to collaborate with the farmers to form Melita CoP for rehabilitation of degraded land. While still members of the CoP, the extension officers from county government and RAE, researchers from KALRO would serve the brokerage role and as SLM champions in the group. The RAE Agricultural Extension Officer and KALRO researcher were coopted into the CoP committee to spearhead linkages with other stakeholders and to facilitate learning and sharing of information on rehabilitation of degraded land. A workshop for Melita CoP members was then held in which common

challenges and needs were identified and roles defined. Table 22 presents the CoP member entities.

Table 22

The Melita Cop Member Entities.

Member	Attributes	Interest	Resources/Roles
Melita self-help group	Agropastoralists	Learning about SLM and Pasture production	Labour, Land, Inputs
KALRO Marigat	Public research	Adaption of SLM practices to local context	Technical capacity inputs and research
County Extension	Public extension	Promote SLM Practices	Technical support
RAE	Local NGO	Rehabilitation of degraded community land	Capacity building
PhD Fellow	Academic research	Social learning	Research, capacity building

4.6.2 Applying a Community of Practice Framework to Melita Farmers Group

This study used the concepts of Community of Practice (CoP) theory as a lens of social learning systems, to explore how to provide practical insights into transforming individual learning into social learning, and the structure considerations that would support this in a farmers' group.

4.6.2.1 Identifying the Domain of Interest for Melita Community of Practice

The first structural dimension of Communuties of Practice is the domain of interest (Wenger *et al*., 2002). The domain is the mutual knowledge that gives the community credibility and separates it from a simple social network that is primarily concerned with cozy interpersonal relationships and friendships (Wenger *et al*., 2002). According to Triste et al. (2018), domain offers the group's coherence and identity, as well as the group's very reason for being and the aim of participant interactions. A well-defined domain of knowledge inspires CoP members to participate and contribute, guides their learning and gives meaning to their actions.

The process of domain identification was done through a series of field meetings and a workshop. During baseline survey, the researcher was able to establish a draw factor bringing together the agropastoralists, extension and research in the area. The domain emanated from

the needs and the area of concern of the actors which in this case was sustainable land management as a result of the rampant land degradation in the area. The farmers identified and prioritized the main constraints to agropastoralism in the area as land degradation and pervasive droughts, which in turn led to low pasture and low crop yields. The baseline also collected information on community's pastoral and agrarian practices, perception on land degradation, challenges of rehabilitating degraded lands and knowledge needs for the rehabilitation of degraded lands and then used the synthesis of these interviews to trigger discussion.

Farmers were able to identify various drivers of land degradation as has been discussed earlier in this docuument. During the construction of the problem tree, farmers recognized low access to agricultural extension services, as a major factor contributing to land degradation. According to Wenger *et al*. (2002) in CoPs, a common subject of interest or a common problem to solve often becomes the basis for the formation of a network of individuals leading to increased interactions and knowledge sharing on the topic of interest. The farmers were interested in building their competencies in SLM with the aim of rehabilitating degraded lands and combating land degradation in their area. The CoP fostered the specific interpretation of sustainability by discussing social, economic, and ecological effects of degradation and narrowing to the specific area of rehabilitation of degraded land using SLM practices. The specificity of this domain was crucial for coalescing a community with overlapping interests, focusing its learning activities, and attracting collaborators and sponsors.

It is notable that, 92% of the respondents indicated concern over land degradation during baseline survey and that this concern inspired them to participate in the CoP when invited to by the researcher. The Agircultural extension officers from Ministry of Agriculture and research officers from KARLO, as well as other development partners also had commitment to the joint domain due to their training and careers and this was reflected in their willingness to participate in the CoP and facilitate learning when called upon. They were responsible for assisting the farmers in developing proper practice and adaption of those practices to local needs and conditions. They also maintained a knowledge database, lessons from past mistakes and tools and methods of learning.

Majority (77%) of the farmers indicated that the CoP's domain and objectives were made clear from the start and included action research and learning driven by the study principal investigator PhD student and other collaborators. They were therefore aware of the CoP intended activities and their roles in those activities. This contributed to the realized value creation as they applied knowledge generated during the action research cycle and the activities were clearly of interest to them. According to Wenger (2002), the domain of a CoP is where the researcher or knowledge intermediary can locate the notion of productive and meaningful conversations and is a distinguishing criterion of CoPs from other forms of organizations. In a study done in Denmark, Madsen and Noe (2012), found that when organic farmers participated in domain identification, they were more motivated to participate in CoP activities. The KALRO researcher helped in domain identification by facilitating problem analysis using a problem tree and voting on the various SLM practices to be used (Figure 33).

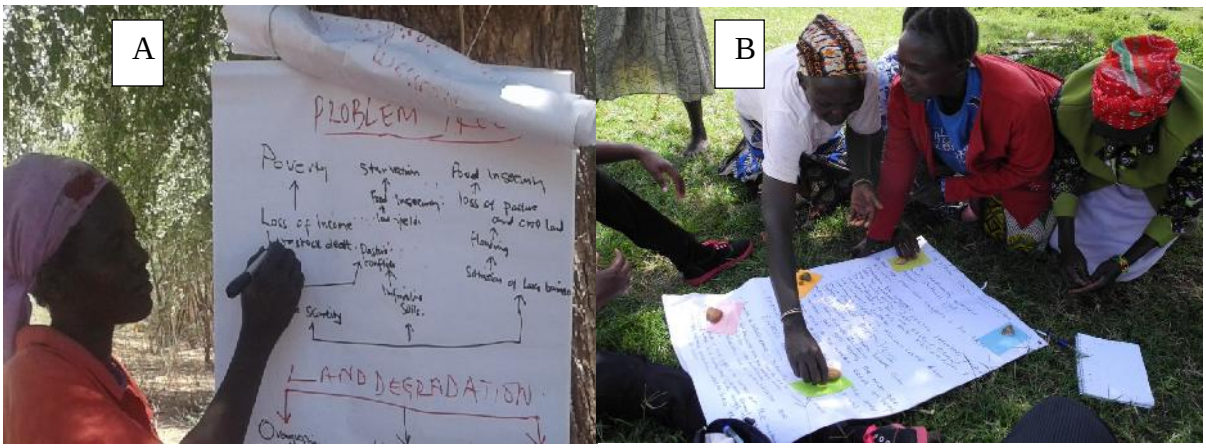

Figure 33. A Members involved in domain identification activities

A; Member leading group in constructing a problem tree; B; members voting on causes and effects of land degradation -Photographs by Mr Duyu of KALRO, Marigat.

For clarity and legibility, the Problem Tree generated from the discussion with the farmers was digitized as presented in Figure 34.

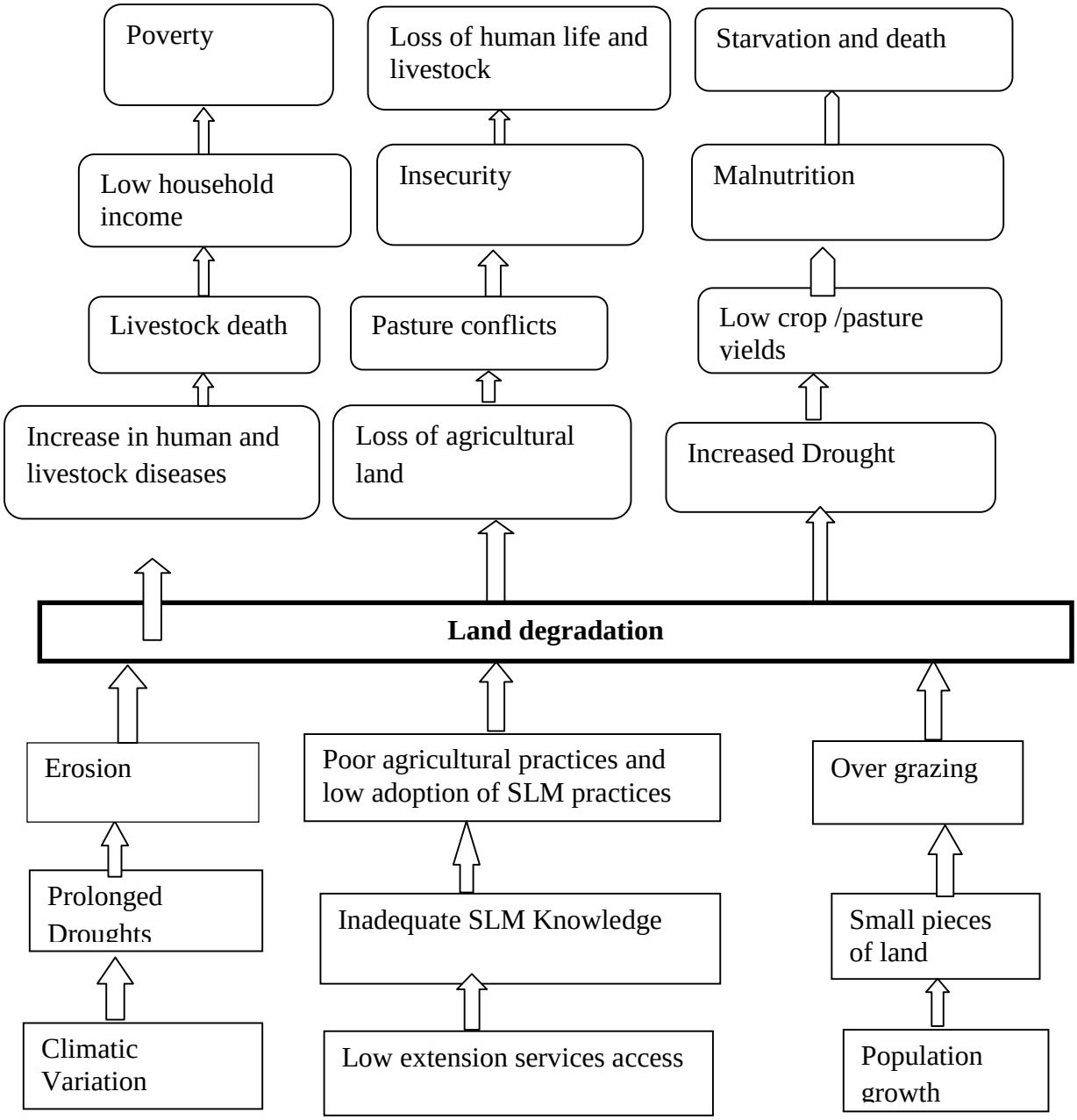

Figure 34. Problem tree on land degradation as discussed by Melita CoP

4.6.2.2 Melita Group as a Community

The second dimension is the community which Wenger (2002) noted as being critical for effective knowledge development and sharing since it fosters interactions and relationships, based on mutual respect and trust. Wenger *et al*. (2002) and Beena (2013) observed that once members create an identity, they start viewing their issues and interests as communal concerns and a community starts to establish. Through electing their own leaders who they knew from the local community, trust is built and the relationship formed though a shared agenda providing stimulus for action (Beena, 2013).

In this study, majority (68%) of the participants spoke about sharing learning experiences with other CoP participants, and with others outside the group including family members, friends and members of other groups they had membership to. This suggests that groups can facilitate building of a competent human resource that can be used to disseminate knowledge and skills in SLM and in rehabilitation of degraded lands. The study results support the findings of Dolinska *et al*. (2018) whose study showed that farmers in group learning developed confidence about their capacity to carry out soil management activities without external guidance and taught those activities to group members and friends outside the group. Table 23 shows level of members' participation in various group activities.

Table 23

Levels of Melita Group Members Participation in Group Activities (N=35)

Activity	Participation Level in Group Activities (%)		
	Low	Moderate	High
Attendance of group meetings	7	19	74
Planning and decision making	16	24	60
Field days	4	26	70
Sharing information with group members	12	23	65
Making group contributions on time	9	36	55
Facilitating trials and demonstrations	24	31	45
Sharing knowledge outside the group	16	33	51

Most of the group activities were well attended by group members with more than half of the participants recording high level of participation. Hearn and White (2009) and Beena (2013) noted that attendance to group events is important in instilling rhythm to a community's growth and are significant for providing for members' interactions. In a study on farmer producer groups in Western Australia, Beena *et al*. (2015) noted that group activities helped members engage in collaborative learning and knowledge sharing that in turn met individual and group knowledge goals while creating an increased cycle of participation and members' interaction. Hearn and White (2009) noted that people frequently have different levels of interest in the community depending on their needs which influences the extent of their involvement in community activities. Based on the level of involvement, Wenger (2000) categorized members within a community into three categories of core, active or passive.

4.6.2.3 Identifying the Practice (Negotiating a Joint Enterprise)

In contrast to more structured policies and procedures that represent how work should be done, the word practice implies information action, suggesting how individuals actually conduct their jobs on a day-to-day basis (Reed *et al*., 2010). The tacit and explicit information that the group generates, communicates, and retains as a result of joint activities among CoP participants is referred to as practice (Triste *et al.,* 2018). These could include a set of ideas, language or information, processes and more tangible outputs, like tools or documents (Wenger *et al*., 2002). According to Morgan (2011) the practice of a CoP includes purposeful action and knowing, physical and mental activity, the practical and the theoretical, and this distinguishes a community of practice from other community networks.

During domain identification, farmers had pointed out the lack of technical support and low access to sources of information that could potentially improve their agricultural productivity and soil and water management in the area. Still, the farmers had noted too that the value of knowledge ultimately depended on their ability to put it into practice which was usually limited by lack of capital and labour. The Baringo county extension officer recommended participation in farmers group like Melita to help pool resources to solve such problems. In an attempt to co-produce transformative knowledge in sustainable land management frequent meetings by farmer group members, facilitated workshops and field days were held. In those sessions, participants had opportunities to interact with each other and with experts to reflect on theory and apply SLM knowledge practically in the enclosed field. Figure 35, shows members of Melita community of practice carrying out various activities.

Figure 35. Farmers participating in group activities.

A: Farmers preparing indigenous tree nursery; B: Farmers learning about Bee keeping.

Photos by Rebecca Karaya

On the joint enterprise, the group chose to use enclosure approach to learn SLM practices in the rehabilitation of degraded land. Enclosure approach is endogenous to pastoralism systems in Kenya and had been used by RAE successfully in the neighboring villages, to rehabilitate degraded rangeland. In enclosure approach, severely degraded land is identified and fenced, seedbed prepared and water harvesting structures constructed followed by reseeding with indigenous grass species alongside planting a variety of drought resistant indigenous and exotic tree species while working and learning with the community groups to carefully manage land use, with environmental sustainability as the goal (RAE, 2010). This is integrated with other income generating activities for the farmers group like bee keeping, harvesting and selling of grass seeds, cattle fattening and pasture conservation (Mureithi *et al*., 2010).

In the RAE initiated enclosures, the right to enclose part of communal land was given by Elders in a Baraza in which chiefs, village headmen participated after application by the enclosing groups supported by RAE (FGD 1). Due to the high level of degradation, there was no opposition and the community viewed the RAE established enclosures as an experiment for rehabilitation and restoration of degraded lands at its inception (Rohss, 2018). However, no communal enclosure was established after 2004 since virtually all communal land had been informally subdivided and privatized with all land belonging to individuals even when not in use (Key informant 3, FGD 1). Melita CoP approached a village elder with a large field

which was severely degraded and requested its use for learning purpose. After signing agreement with the land owner to use the land for five years, the group set out to establish an enclosure on the degraded land and started rehabilitation activities. Weekly meetings, field days and workshops were used as routine components of the group activities in an attempt to encourage learning, teamwork and adoption of SLM practices. Initiating knowledge sharing was reported as a way of galvanising support for CoP and while generating further interest by members leading to success and sustainability of the CoP (Wenger *et al*., 2002).

Enclosure establishment started by fencing five acres of land using *Prosopis juliflora* branches, followed by ploughing to break the surface crust and loosen the soil for seed germination and increase in rain-water percolation, construction of water harvesting structures (semi-circular bunds) and re-seeding. The benefits expected by Melita self-help group members from participating in the CoP and using enclosure to rehabilitate degraded land included income from sale of various commodities from the enclosure which included fattened livestock, cut grass for thatch, fodder or hay, grass seed, renting dry season grazing and Bee-keeping products which was incorporated to take advantage of the flowering pasture grass. Figure 36 shows steps in establishment of enclosures and some of the benefits accrued through rehabilitating degraded land in the study area.

Figure 36. Enclosure approach to rehabilitation of degraded drylands

A: Severely degraded field; B Melita group members preparing the field for rehabilitation; C and D, same field after rehabilitation. Inset, Pasture Conservation. Photos by Rebecca Karaya

In a facilitated discussion by researchers from KALRO, the members considered three indigenous grass species namely African foxtail grass/Buffel grass (*Cenchrus ciliaris*), Maasai love grass (*Eragrostis superba*) and Bush rye grass (*Enteropogon macrostachyus*), for possible reseeding. The choice of the three grasses was based on what the farmers have been using in the area and expert advice from research and extension. Using Multiple Criteria Analysis (MCA) farmers voted to re-seed with *Cenchrus ciliaris*. The members agreed on the traits they wanted in the re-seeding grass before-hand and through simple majority voting weighted them on a scale of 3 depending on perceived importance of that trait. The traits included, drought tolerance, fast setting after planting, ability to regenerate after harvesting, tolerance to termites, amount of leaf biomass, not easy to be up-rooted by cattle during

grazing (strong rooting system) and can withstand heavy grazing pressure. Table 24 shows the MCA and the ranking done.

Table 24

MCA of Indigenous Pasture Grass Used for Rehabilitation of Degraded Land

Traits	Weight	*C. ciliaris*	*E. macrostachyus*	*E. superba*
Fast setting after planting	1	2	1	3
Drought tolerance	3	3	2	1
Ability to regenerate when it rains	3	3	3	2
Termite tolerance	2	3	1	2
Strong rooting system	1	2	1	3
Leaf biomass	3	2	3	1
Ability to withstand heavy grazing	3	2	1	3
Other products (bee keeping, seeds for sale)	2	3	1	2
Total/Rank		52(1)	37 (3)	38 (2)

Cenchrus ciliaris is an indigenous vigorous perennial, tufted and sometimes spreading grass species. *Cenchrus* has easy establishment, is drought tolerant, is able to withstand grazing pressure, fire and has ability to proliferate itself and produce an output of viable seeds which can be easily harvested (Mganga *et al*., 2015). The grass grows in a wide range of soils, is drought resistant, and some ecotypes can withstand temperatures as low as -10 degrees Celsius and as high as 46.5 degrees Celsius (Arshad *et al*., 2007). By branching established tillers or developing new tillers, the species may take advantage of both low and high rainfall levels (Visser *et al*., 2008). The grass is also highly tolerant of grazing strain, which may be due to the grass's various types of tiller growth or its extensive deep-rooted system, which can reach a depth of two metres.

The farmers determined *Cenchrus ciliaris* as the most suitable grass species for reseeding in their enclosure because of its fast establishment, fast regeneration of the stubble during rains, its prolificacy in seed production which could be harvested for sale and its termite resistance nature. The farmers also found it useful when integrating bee keeping with pasture production since it is well loved by bees and produces high quality honey (Melita group discussion). According to Wenger (2000) and Morgan (2011), the continual development and

maintenance of a shared collection of procedures, techniques, shortcuts, jargon, tools, documents, symbols, actions and concepts developed in CoP interactions provide a powerful binding force to maintain mutual engagement by the group members. Leeuwis and Aarts (2011) argued that in building shared repertoire, a discursive space that provide linkage between the space of thinking with the space of doing is created. In this space, actors negotiate the construction of their world through competing storylines.

The continuous debates allow members of the CoP to negotiate which options are accepted as locally possible, justify their choices and construct arguments. This is important in generating location and context specific SLM practices. Wenger (2000) reported negotiating of meaning as one of the fundamental processes in communities of practice and discourse as well as an important part of a shared repertoire of a CoP. As Klerkx *et al*. (2010) argued that in the study of innovation process, "telling a good story" is essential and learning communities should be taken into account as spaces of discourse production. For this reason, CoPs and other learning communities are perceived as repositories of knowledge generation, knowledge sharing and knowledge creation within organization (Brown & Duguid, 2000) and are proposed to be the most promising sources of innovation (Wenger & Snyder, 2002). Pesch (2015) cautioned that discursive fixation inside learning communities can be too strong, up to preventing discursive fields from changing and derailing enterprise.

The blend of the three dimensions (domain, community and practice) allows a CoP to jointly manage, create, disseminate and accumulate knowledge. The domain provides a common focus; community supports and builds relationships that enable learning; and practice grounds the learning and knowledge in what people do (Briard & Carter, 2013). Table 25 summarizes the three dimensions as applied to Melita farmers group and its collaborators.

Table 25

Cop Dimensions Displayed in Melita Group

Dimension	Indicators
Domain	• Identifying area of concern (SLM)
	• Analysis of broad domain and establishing causal-effect relationships
	• Narrowing the domain to rehabilitation of degraded land
	• Setting clear objectives
Community	• Personal invitation by researcher
	• Setting up CoP Workshops
	• Election of governing committee and developing a constitution
	• Formal regular meetings, field days and workshops
	• Informal intermittent interactions between members
Practice	• Identifying degraded land in the community
	• Negotiating with the owner to use the land for learning purpose
	• Enclosing and implementing SLM practices with input from research
	• Tacit and indigenous knowledge shared on pasture production
	• Diverse views on communal land management
	• Integrating bee keeping with pasture production
	• Documenting group activities

Melita self help group was examined in terms of the three dimensions of CoP which include, domain, community and practice (Wenger, 2000). The domain consisted of developing an understanding around the area of sustainable land management through rehabilitation of degraded lands. The interactions and mutual engagements emphasized on commonalities and helps in defining identity for the members (Reed *et al*., 2010). Though interaction between members facilitates mutual engagement and a common understanding, there is also the potential for the formation of differentiated communities within the main community due to disputed concepts or percepations in domains like SLM (Morgan, 2011). This may affect how farmers learn from, and with each other. Social learning processes may, therefore, also expose dissent and conflicting views (Morgan, 2011). Facilitation, rules that are agreed upon by all members and good leadership may lower the risk of disputes.

Farmers are associated by what they learn and practice together. Their activities are centred on practical farming, land management, marketing and accessing of agricultural information and knowledge. The activities lead to formulation of shared resources such as language, routines, sensibilities, artefacts, tools, stories, and styles refered to as joint repertore (Wenger, 2000). Building competency involves access to this repertoire. Learning about and experimenting with SLM practices for rehabilitation of degraded land led to creation of new repertoires of practice driven by community demands and needs (Morgan, 2011). These drivers are explored during domain identification and analysis leading to new repertoires of practice developed during group interactions and activities. These collections provide a powerful binding force to maintain mutual engagement and increased sustainability of groups (Reed *et al*., 2010).

4.6.3 Action Research within Melita Community of Practice

As previously mentioned, diagnosis and solution-oriented discussions were done in workshops and group discussions on how land degradation problems are experienced, understood and tackled by farmers, individually and collectively. The CoP members jointly identified potential options for rehabilitating degraded land with the enclosure approach which involved construction of soil and water conservation measures, reseeding with indigenous pasture grasses and planting indigenous trees. The above involved repeated joint planning, action and reflection all which are part of ParticipatoryAction Research (PAR). The various phases in the enclosure establishment which included, problem diagnosis, action planning, implementation, evaluation and learning are summarized in Figure 37.

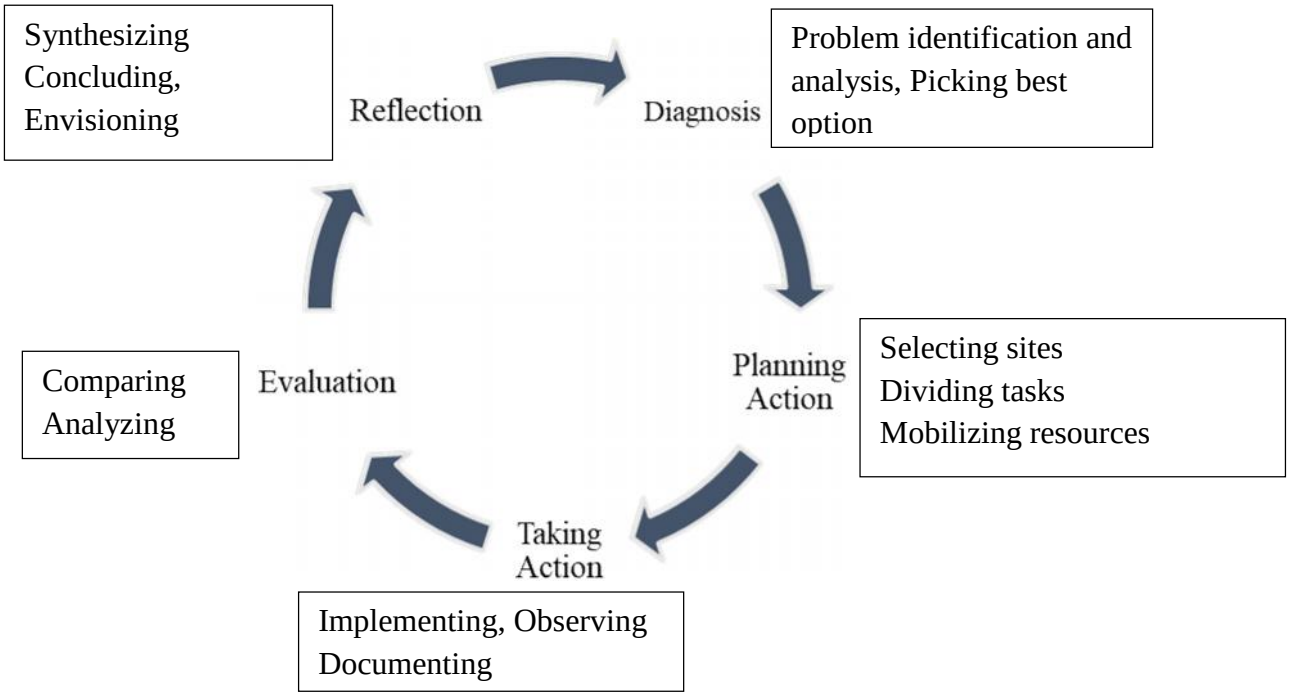

Figure 37. Action Research cycle for the study. Adapted from Andersson (2014) and based on field work 2019-2020

Action research required the researcher to take on multiple roles. While being a 'reflective scientist', the researcher was also intermediary who brought the actors together and helped negotiate the different roles and responsibilities in order to balance and integrate different outlooks and interests, as well as being facilitator of the joint learning process (Pohl *et al*., 2010). When the researcher was not able to be in the area during the research cycle, the RAE extension officer and researcher from KALRO took over the role of learning facilitators, and were involved in all phases of the process to assist the group. This greatly aided the researcher to maintain contact with the group and stay informed about the process. In this way, action research permitted the researcher to act as a change agent while at the same time assuming benefits related to the role of an insider and experience the reality of the practitioner in their day-to-day work as demonstrated by Stringer (2010).

The groups implemented, managed and documented the rehabilitation activities and still maintained interactions even in the absence of researchers. The recurrent engagement with the same groups over a longer period of time made it possible to form a collaborative team and helped understand the social dynamics within the group while creating trust and

openness. Andersson (2014) noted that for action research to be meaningful for those involved, it required sustained participation and involvement through the whole cycle. Participatory action research as a form of enquiry allowed the CoP members to link theory to practice in situations of active intervention to generate change (Bray *et al*., 2000).

Reporting on their experience as members of the CoP, the farmers described being exposed to the messages of researchers and extension officers which they reported as having a profound effect on their understanding of land degradation and their role as stewards of the environment. This understanding is expected to be linked to change in land management leading to higher adoption of SLM practices (Vankeerberghen & Stassart, 2016). Farmers cited field experimentation as having helped them with creating general rules for local adaptation of sustainable farming practices, and also setting them aside from the other farmers thus creating cohesion and giving a sense of community. They acknowledged the relevance of the training which they reported would lead to more informed decisions and improved practices resulting to rehabilitation of degraded lands.

The interaction and communication between farmers and researchers were perceived as good and open by the farmers though they worried about its continuation and sustainablity after the end of the research cycle. The farmers felt that they were well involved in all the field experiments and played a central role in the knowledge creation process. Close involvement in activities done in the group experimental field such as the selection of indigenous pasture grass for reseeding, implementing SLM practices, managing the pasture grass, harvesting and marketing changed the farmer's perspective and encouraged the farmers to also consider adoption of SLM practices in their individual farms. Pointing to the need of good and open communication during action research, Triste et al. (2018) in a study done in Flanders reported farmers concerns at not being involved in, or being fully informed about the research activities in a project, which made them feel that their data were exploited without any meaningful benefit to them.

4.6.4 Challenges of Establishing and Sustaining a Community of Practice

Assessment of the challenges of establishing and sustaining a community of practice for the rehabilitation of degraded lands in the Njemps Flats was attained through careful and continuous observation and documentation during the study period which lasted for fourteen months. This was followed by a workshop attended by members of the CoP where

brainstorming and nominal group discussion methods were used to come up with the challenges while ensuring active participation by all participants (Jones, 2007). The group was divided into three sub-groups of eight people and each group discussed and brainstormed on the challenges of establishing and sustaining a CoP. Sub-county extension officer, RAE extension officer and KALRO research officer facilitated the three groups. The identified and agreed upon challenges by each sub-group were then reported in the plenary session for joint discussion among all group participants. The ideas were recorded in a flip chart to allow everyone to understand and consider their importance as the discussions progressed. Himanen *et al.* (2016) noted that brainstorming session allows for immediate feedback and raising of novel, differing or supporting perspectives. The main challenges observed during the study period and also reported during the workshop included:

(i) Cost of facilitation-members feared that learning interaction with the researchers and extension would not continue after the study period due to lack of facilitation for transport and other costs.

(ii) Leadership in terms of commitment, transparency and personal interests versus group interests.

(iii) Keeping members interested and motivated in the CoP and therefore maintaining consistent participation.

The CoP learning platform establishment and sustainability requires commitment of all members to achieve its goals. Inconsistent participation from some members was observed especially in certain activities that were deemed as not benefiting them directly. It was also noted that sustaining a CoP comes with some costs both financial and in kind. Members noted a need to have a budget to organize group activities, platform where members were expected to pay for their expenses through monthly contributions. Leadership was also encouraged to fundraise from other stakeholders in environmental conservation. There were fears that after the completion and exit of the research project that was largely shouldering the cost of facilitation the CoP would not be sustained.

As reported by Wenger (2000), CoPs in rural agriculture do not require heavy institutional infrastructures, though members need time and space to collaborate and learn. The CoPs mostly

self-organize, and flourish when their learning fits with their social, environmental and economic context which can be assured under good leadership. Tarmizi *et al*. (2006) cited challenges of establishing and sustaining communities of practice to include facilitation and leadership. Dolinsika et al. (2018) reported that farmers who worked alone felt restricted in their access to new information, while members of CoP indicated that their conversations were sterile after they lost their external sources of knowledge while working with farmers in Tunisia. Farmers who belonged to groups with higher research and extension facilitation had more access to diverse sources of knowledge, and they valued their participation in the CoPs highly. This indicates that the intersection of horizontal interaction within farmers' CoPs and external interactions of its representatives with other actors, such as study and extension, is the most fertile ground for innovation.

4.7 Factors Affecting the Level of Social Learning Among Members of Melita CoP

The fifth objective of the study sought to determine factors affecting the level of social learning among the members of the CoP. This is discussed in the section that follows.

Melita group served as a social learning platform that brought together farmers, academia, research and extension to learn and innovate on rehabilitation of degraded land. The expected outcome of this learning was a joint understanding of the problem, agreement on the solution and progressive implementation of the solution. A multiple linear regression was performed to test for factors influencing the level of social learning. The results are presented in table Table 26.

Table 26

Multiple Regression Results on Factors Influencing the Level of Social Learning.

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	4.196	1.002		4.188	0.000
Age of respondent	0.021	0.015	0.127	1.359	0.184
Marital Status	-0.439	0.450	-0.093	-0.976	0.337
Formal education level	0.424	0.197	0.216	2.151	**0.040**
Participation CoP activities	1.949	0.225	0.796	8.669	**0.000**

Results of Multiple Linear Regression Between Moderator Variables and Social Learning

The results indicated that the regression model was a significant predictor of social learning at F (4, 25.7) = (25.4, p = .000). The B values indicated that as formal education increases by one unit, level of social learning increased by 0.424 units. Similarly, if the level of participation in CoP activities increased by one unit, level of social learning increased by 1.949 units. The R^2 for the model is 0.77 which implies that 77% of the variation in social learning in Melita group can be explained by the variables listed above. Two factors had coefficients indicating significant influence on the dependent variable. They were level of participation in group activities (0.000) and respondents' level of formal education (0.040). The Changes in these variables would lead to positive changes in the dependent variable. Age and marital status of the respondents did not influence the level of social learning significantly.

The results are supported by Mostert (2003) who observed that public participation promotes social learning if all parties take part in a constructive dialogue and collective action. While studying CoPs in dairy farming in Flanders in Belgium and Northern Ireland, Triste *et al*. (2018) noted that farmers in CoPs who participated in experimentation and had interactions with extension advisors and researchers felt honored and perceived participation as useful, interesting, fun, and even exceeding expectations. According to Cofré-Bravo *et al*. (2019) participation in group activities enables farmers to access formal research-based knowledge, innovative experiences, knowledge and financial resources access and openined opportunities for diversifying forms of production.

In the case of social learning, farmers with higher levels of formal education are expected to be open to formimg new networks and confident in seeking and sharing information with other farmers. A study by Karaya *et al*. (2013) reported formal education as being important in sourcing of agricultural information, forming social networks and entering in contractual agreements that collectively contribute towards farmer's empowerment. Similarly, World Bank (2009) reported existence of a link between education level, personal empowerment to escape poverty, possession of appropriate information and making informed choices on adoption of agricultural innovations.

4.8 The Influence of Social Learning on Farmers Adoption Behaviour

The sixth objective sought to assess how social learning in a Community of Practice influenced participants' household adoption behaviour.

A simple regression was used to predict the likelihood of the farmers to adopt (adoption behaviour) based on their level of social learning scores. Farmers' adoption behaviour was measured as an index of self-rating questions on the relevancy of the training, intention to adopt, increased awareness on the need to adopt and ongoing adoption of SLM practices learnt in the CoP. Table 27 presents the Anova summary on the influence of social learning on adoption behaviour.

Table 27

Anova Results on Influence of Social Learning on Adoption Behaviour.

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	282.202	1	282.202	37.29	0.000[b]
	Residual	250.148	33	7.580		
	Total	532.350	34			

Social learning level explained a significan amount of variance in the likelihood to adopt SLM practices at F (1,33) = 37.3 =0.000, R^2=0.53. The regression coefficient is (B=1.5, 95% indicating that an increase in one unit of social learning on average led to an inceease in the likelihood to adopt SLM practices by 1.5 units. Table 28 presents the simple regression results on the influence of social learning on adoption behavior.

Table 28

Simple Regression Results on the Influence of Social Learning on Adoption Behavior

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-2.472	2.691		-0.919	0.365
Social learning	1.549	0.254	0.728	6.102	0.000

The findings are supported by Krzywoszynska (2018), who reported that social learning in community of practice comprising of researchers and soil-focused agronomic advisors led to adoption of sustainable soil practices in England. Similarly, Phuong *et al*. (2019) reported social learning in CoPs to have contributed to transforming farmers perspectives, habits and mindsets on climate change adaptation leading to adoption of appropriate adaptation strategies in Vietnam. Krzywoszynska (2018 further noted that CoP members became champions of sustainable soil practices using and referring to scientific experts in the CoP and narratives to inspire, justify and legitimise sustainable soil management as a valid way of

farming sustainably. This affirms the important role that experts play in communities of practice as contributors to meaning-creation in social learning.

Adoption of SLM practices is only likely to take root if farmers consider them appropriate and consistent with their context and location specific conditions (Shiferaw *et al*., 2009). Thus, introducing new SLM technology and knowledge to farmers is as important as localising such knowledge by proposing modifications, advancements or improvements assembled from local practical application. Social learning in a community of practice comprising of research and extension in a participatory action research setting was found to influence SLM adoption positively. Furthermore, scientific inquiry through participatory action research supported the social processes of learning within the CoP leading to localised learning on SLM practices.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This Chapter presents a summary of the study, its key findings and conclusions made from it. It also highlights on the recommendations for rehabilitation of degraded lands as well as recommendations for further research.

5.2 Summary of the Study

The study sought to analyse and document how farmers are affected, respond to, cope with and shape change in their everyday lives in relation to land degradation, particularly in the form of collective action and learning in farmer groups supported by research and extension. Drawing on the concept of communities of practice, the study explored the processes of social learning and collective action by smallholder agropastoralists organised in a group to pool resources, learn together and manage communal resources. The aim of the study was to contribute to finding solutions to the challenges that restrict sustainable rangeland management in ways that rehabilitate degraded lands and stop degradation, with possible positive feedbacks on ecosystem services such as ecological, social, cultural, and economic services, as well as improve agropastoral livelihoods in the Njemps Flats.

The study adopted Participatory action research design. Systematic random sampling was used to select 150 agropastoralists to participate in a baseline survey while thirty-five farmers from Il Chamus Ward, Salabani village were invited to voluntarily form a CoP to collectively learn and implement the SLM practices in a common field. The CoP also acted as an interaction platform between research, extension and the agropastoralists and the space for social learning. Two research officers from KALRO, one extension officer from County government of Baringo, an NGO extension officer from RAE and the PhD fellow facilitated and learnt together with the farmers. The community was established to support learning-by-doing, reflection and adaptation as key elements of capacity building in rehabilitation of degraded land. Social learning was measured on the basis of capacity build (trainings, trials and experiments), environmental stewardship (concern, willingness to act) and SLM knowledge aquired (new SLM practices, new knowledge on old practices, confidence in implementation).

Data collection was done in the period between January 2019 and March 2020 using structured questionnaires, checklists and topic guides. Descriptive and inferential statistics including categorical, multiple and simple regression were used for data analysis whereas qualitative data was obtained and synthesized through problem tree analysis, stakeholder analysis and multiple criteria analysis.

The results indicated that residents in the study area were aware and concerned about land degradation and were able to identfy both natural and anthropogenic factors causing land degradation. Prolonged drought, over grazing, invasive shrubs, deforestation, poor agricultural practices and erosion of traditions and customs governing communal grazing land were cited as the main causal factors of land degradation. Gullies, lack of ground cover, livestock trails and lake flooding were quoted as indicators of land degradation. The obstacles hindering adoption of SLM practices included limited knowledge on the SLM practices, high cost of SLM practices implementation, while the consequences of degraded rangelands were cited as declining capacity to sustain livestock and crops, progressive loss of biodiversity and human displacement.

The study concluded that adoption of SLM practices was significantly and positively influenced by participation of agropastoralists in grassroot farmer organisations and those members whose groups partnered with development agencies like extension and NGOs had higher adoption levels of SLM practices than those without partnerships. The CoP was found to be effective in bringing together actors to enhance stakeholder networking and collaboration for joint innovation and investment towards achievement of a common goal. It also allowed for tapping of resources and expertise held by various stakeholders to address rehabilitation of degraded communal land collaboratively. Social learning in a community of practice was found to influence adoption behavior measured by continuing adoption and the likelihood to adopt SLM practices in future.

Challenges of establishing and sustaining a Community of Practice were reported and observed by members as: (i) facilitation in terms of cost and expertise after the study period, (ii) leadership in terms of commitment, transparency and personal interests versus group interests, and (iii) keeping members interested in the CoP and therefore maintaining consistent participation. There were fears that after the completion and exit of the research project that was largely shouldering the cost of facilitation, the CoP would not be sustained.

Presence of income generating activities like bee keeping and sale of pasture, election of good leadership, a constituition developed by members and collaboration with extension and research were seen by members as factors that would ensure the group sustainability and so were implemented.

From these findings, key policy implications can be drawn. Firstly, SLM practices adoption among dryland rural households is likely to be facilitated by policies that promote raising awareness of the effects of dryland degradation and the various SLM options/technologies available to combat the degradation. Information on possible SLM options is likely to increase adoption among rural rangeland households, as it will enable them to tailor techniques to their specific socioeconomic circumstances. A possible approach to achieve this is through the expansion of extension services and creation of social learning platforms in drylands. Policies facilitating institutional capacity building of extension services on innovative SLM practices are also likely to enhance SLM adoption. Furthermore, policy action empowering livestock producers to participate in high-value product markets is also likely to increase economic incentives in adopting SLM practices especially where a monetary cost is implicated.

5.3 Conclusions

The following specific conclusions were drawn from the study;

i. Land degradation is a persistent problem in the Njemps Flats and even though farmers perceive it as a threat to their livelihoods and identify its drivers and even effects, adoption of SLM technologies is low in the area.
ii. Households employed various coping mechanisms in response to land degradation among them adoption of SLM practices, diversification and opening up of more land for crop production.
iii. Determinants of SLM practices adoption included, access to extension services, participation in farmer groups, annual income and level of formal education.
iv. Challenges of bearing the operation overheads of communities of practice were observed together with low level of ownership by participating stakeholders. This was likely to bear on the sustainability of the CoPs after the action research cycle ended.
v. The level of participation in CoP activities and formal education level influenced the level of social learning positively.

vi. The study showed that social learning in a CoP has positive influence on the probability of households adopting SLM practices thereforeCoPs present a viable option to foster sustainable management practices in semi-arid grazing lands in addition to being a vehicle for research and advisory services interventions.

5.4 Recommendations

Based on the conclusions, the following are the recommendations of the study.

a) To extension and research stakeholdes

i. There is need for researchers to engage in participatory action research and joint innovation through effective collaborative linkages with farmers and other stakeholders in learning platforms such as communities of practice with the view of making technology generation consumer led. This would ensure generation of context and location specific technologies.

ii. Extension providers need to employ methods that go beyond simple information sharing to methods that include problem identification to evaluation and monitoring. This would ensure that farmers understand and contribute to their own problems' solutions through long-life experiences and at the same time develop sense of ownership to developed technologies and practices.

b) To policy makers

i. The County government of Baringo should target farmer groups with funds, training and policies that connect them with other agricultural institutions in order scale-up locally proven and successful SLM strategies and practices within the County.

ii. The National government of Kenya in conjuction with the County governments should ensure policies that improve the existing extension services in the counties by bridging capacity gaps of the officers through regular re-tooling courses to make them more responsive to the emerging problems associated with sustainable land management.

c) To farmers and community groups

i. Farmer groups and community organisations should have clearly formulated cost and benefit sharing mechanisms between members of groups so as to keep farmers motivated in participating and staying in the groups.

ii. To ensure sustainability of natural resource management initiatives, groups should put in place innovative and complementing income generating activities.

iii. Farmer groups are encouraged to form linkages and collaborations with other development agencies in order to leverage resources and services accessible through such partinerships.

5.5 Recommendations for Further Research

The challenges of how to sustainably maintain drylands' capacity to provide goods and services are growing, particularly in the face of population growth, climate change, and desertification. This study offers some insights into how to address some of the obstacles that limit sustainable dryland practices leading to land degradation. However, a few gaps still exist that could form a basis for future research.

Firstly, future adoption studies need to consider the roles of short-term and long-term farmers' motivations to adoption of SLM practices as well as the extent to which farmers' participation in diversified social networks facilitate adoption of specific SLM practices and technologies. This could inform development of targeted SLM practices and enhance adoption among households. In addition, while the study has provided some insight in understanding the impact of social learning in communities of practice on the adoption of SLM practices, it does generate additional research questions in terms of how the various pedagogical aspects of the learning processes within CoP create change leading to adoption. Particularly the tools and methods used to bring out experiences among participants and which tools and methods potentially play much greater roles in fostering learning and reflection.

The collective nature of learning in the CoPs and collective change in environmental stewardship as a result of the learning process needs additional research. Such research could take into consideration the extent to which learning facilitators also undergo their own transformative learning journey alongside the participants that they serve and to what extent their transformation in terms of change in worldviews, perspectives and attitude impact on participants as is expected to happen in Participatory action research. A big challenge to farmer organisations in developing countries is how to ensure financial sustainability and good governance. Therefore, an important area for further research would be to investigate what specific policy frameworks and institutional support that can inspire and allow forms of collective action and learning that is likely to benefit the vulnerable especially women and the poor.

REFERENCES

Adger, W.N. (2006). Vulnerability. *Global Environmental Change*, 16(3), 268-281.

Adhiambo, M., Kironchi, G., Mureithi, S., & Kathumo, M. (2017). Assessing land use and land cover change using participatory geographical information system (PGIS) approach in Nguruman Sub-catchment, Kajiado north Sub county, Kenya. *Journal of Geography and Regional Planning*, *10*(8), 219–228.

https://doi.org/10.5897/JGRP2016.0606

Adler, P. S. & Kwon, S.W. (2002). Social capital: Prospects for a new concept. *Academy of Management Review*, *27*(2), 17–40.

Admasu, D. (2008). Invasive plants and food security: The case of Prosopis juliflora in the Afar region of Ethiopia. *FARM-Africa, IUCN*. *https:/www.farmafrica.org> downloads.*

Aerts, R., Nyssen, J., & Mitiku, H. (2009). On the difference between "exclosures" and "enclosures" in ecology and the environment. *Journal of Arid Environments 73*(8), 762–763.

Ahn, K., & Ostrom, E. (2008). Social capital and collective action. In Castiglione, D., Van Deth, J.W., Wolleb, G. (Eds.), *The Handbook of Social Capital*. Pages 70–100. Oxford University Press.

Ainembabazi, J., & Mugisha, J. (2014). The Role of Farming Experience on the Adoption of Agricultural Technologies: Evidence fromSmallholder Farmers in Uganda. *The Journal of Development Studies*, *50*(5), 666-679, DOI:10.1080/00220388.2013. 874556

Akinnabe, O., & Ajaayi, A.R. (2010). Challenges of farmer extension approaches in Nigeria. *World Journal of Agricultural Science*, *6*(4), 353-359.

Alawamy, J. S., Balasundram, S. K., Hanif, A. H., & Sung, C. B. (2020). Detecting and analyzing land use and land cover changes in the region of Al-Jabal Al-Akhdar, Libya using time-series landsat data from 1985 to 2017. *Sustainability*, *12*(11), 4490. https://doi.org/10.3390/su12114490

Alsop, R., & Heinsohn, N. (2005). *Measuring empowerment in practice: Structuring analysis and framing indicators.* The World Bank.

Amman, H.M., & Duraiappah, A.K. (2004). Land Tenure and Conflict Resolution: A Game Theoretic Approach in the Narok District in Kenya. *Environment and Development Economics*, *9*(1):383–407.

Amudavi, D. (2005). *Exploring the effects of farmer community group participation on rural livelihoods*. SAGA Cornell University, Ithaca.

Anderson, D.M. (2002). *Eroding the commons: The politics of ecology in Baringo, Kenya, 1890s-1963*. Oxford: James Currey.

Anderson, R., Hardy, E., Roach, T., & Witmer, E. (1976). A land use and land cover classification system for use with remote sensor data. *Geological Survey Professional Paper 964*

Andersson, E. (2014). *Fertile grounds? Collective strategies and the political ecology of soil management in Uganda*. Albemarle County: Embracing our value of stewardship, retrieved from: http://www.albemarle.org.

Angelle, P. S. (2008). Communities of practice promote shared learning for organizational success. *Middle School Journal, 39*(5), 52.

Armitage, D., Marschke, M., & Plummer, R. (2008). Adaptive co-management and the paradox of learning. *Global Environmental Change 18*: 86–98.

Arshad, M., Ashraf, Y., Ahamad, M., & Zaman, F (2007). Morpho-genetic variability potential of *Cenchrus ciliaris* l., from Cholistan Desert, Pakistan. *Pakstan Journal for Botany*, 39(5), 1481-1488, 2007.

Attri, P., Chaudhry, S., & Sharma, S. (2015). Remote sensing and GIS based approach for LULC change detection: A review. *International Journal of Current Engineering and Technology*, *5*(5), 3126–3137.

AU-IBAR (African Union – Interafrican Bureau for Animal Resources). (2012). *Rational Use of Rangelands and Fodder Crop Development in Africa.* AU-IBAR, Nairobi. www.au-ibar.org/component/jdownloads/finish/46-mg/907africa

Ayantunde, A., deLeeuw, J., Turner, M., & Said. M. (2011). Challenges of assessing the sustainability of (agro)-pastoral systems. *Livestock Science 139*, 30–43.

Balakrishnan, R. (2000). Widening gaps in technology development and technology transfer to support rural women. *In Editor-in-Chief. ed. Human resources in agriculture and rural development*. pp. 81-91. Rome, Food and Agriculture Organization.

Bandura, A. (2000). Exercise of human agency through collective efficacy. *Journal of American Psychology, 9*(3), 456-478.

Bandura, A. (1977). *Social Learning Theory*. Prentice Hall, Englewood Cliffs, United States.

Barbour, R. (2008). *Introducing Qualitative Research: A Student Guide to the Graft of Doing Qualitative Research*. London: Sage.

Bartolini, F., & Viagi D. (2010). Recent Developments in Multi-Criteria Evaluation of Regulations. *Presentation during the 2nd MoniQA International Conference*, Krakow.

Baugh, T., Stek, W., & Leet, K. (2015). Environmental Education and Community Stewardship: Strengthening and Expanding the National fish and wildlife foundation's Conservation Stewardship portfolio. *Environmental Leadership Strategies Organisation*. http://www.environmentalleadershipstrategies.com

Bayard, B., & Jolly, C. (2007). Environmental perceptions and behavioral change of hillside farmers: the case of Haiti. *Journal of Caribbean Agro-Economic Society. 7* (1), 122-138.

Beena, A, W., Matthew, T., & Kadambot, H. (2015). Strengthening the performance of farming system groups: perspectives from a Communities of Practice framework application. *International Journal of Sustainable Development and World Ecology, 4*(2), 25-39.

Beena, A, W. (2013). *A study of emergence, evolution and role of grower groups in western Australia.* PhD Thesis. University of Perth.

Behnke, R., & Kerven, C. (2013). Counting the costs: replacing pastoralism with irrigated agriculture in the Awash valley, north-eastern Ethiopia (IIED Climate Change Working Paper no. 4). London: International Institute for Environment and Development.

Benson, D., Lorenzoni, I., & Cook, H (2016). Evaluating social learning in England flood risk management: An 'individual-community interaction' perspective. *Environmental Science and Policy*, 55(2), 326-334. http://dx.doi.org/10.1016/j.envsci.2015.05.013

Berakhi. O., Oyana. J., & Adu-Prah., S, (2014). Land use and land cover change and its implications in Kagera river basin, East Africa. *African Geographical Review 34*(3):1-23. http//.doi10.1080/19376812.2014.912140

Berkes, F. (2009). Evolution of co-management: Role of knowledge generation, bridging organizations and social learning, *Journal of Environmental Management, 90*(5), 1692–1702.

Bestelmeyer, T., Okin, S., Duniway, M., & Archer, R. (2015). Desertification, land use, and the transformation of global drylands. *Frontiers in Ecology and the Environment, 13*(1), 28–36.

Beukes, P.C., & Cowling, R.M. (2003). Evaluation of Restoration Techniques for the Succulent Karoo, South Africa. *Restoration Ecology*, *11*(1): 308-316.

Beyene, J. (2009). Exploring incentives for rangeland enclosures among pastoral and agropastoral households in eastern Ethiopia. *Global Environmental Change, 19*(5): 494-502. https://doi.org/10.1016/j.gloenvcha.2009.07.002

Birhanu, A. (2014). Environmental Degradation and Management in Ethiopian Highlands: Review of Lessons Learned, *International Journal of Environmental Protection and Policy*. Vol. 2, No. 1, 2014, pp. 24-34. doi: 10.11648/j.ijepp.20140201.14

Blackmore, C. (2007). What kinds of knowledge, knowing and learning are required for addressing resource dilemmas? A theoretical overview. *Environmental Science and Policy, 10* (6), 512–525.

Blankenship, S., & Ruona, W. (2008). *Professional Learning Communities and Communities of Practice: A Comparison of Models*, Literature Review. University of Georgia.

Bodin, O. & Crona, B. (2009). The role of social networks in natural resource governance: What relational patterns make a difference: What relational patterns make a difference? *Global Environmental Change, 19*(3), 366-374.

Branca, G., Lipper, L., Neves, N., Lopa, D., & Mwanjioka, I. (2011). Payments for watershed services supporting sustainable agricultural development in Tanzania. *Journal of Environment and Development 20*(3), 278–302. doi:10.1177/1070496511415645

Brauch, H.G., & Spring, U.O. (2009). Securitizing the Ground Grounding Security UNCCD Issue Paper NO. 2. Secretariat of the United Nations Convention to Combat Desertification, Bonn.

Bray, J., Lee, A., Smith, L., & Yorks, L. (eds.) (2000). *Collaborative Inquiry in Practice: Action, Reflection, and Making Meaning*. Thousand Oaks, CA: Sage.

Briard, S., & Carter, C. (2013). *Communities of Practice and Communities of Interest: Definitions and Evaluation Consideration*. The Ontario Centre of Excellence for Child and Youth Mental Health.

Brink, A.B., & Eva, H.D. (2009). Monitoring 25 years of land cover change dynamics in Africa: A sample based remote sensing approach. *Applied Geography*, *29*(4), 501–512. https://doi.org/10.1016/j.apgeog.2008.10.004

Brown J, & Duguid P. (2000). *The Social Life of Information*. Boston: Harvard Business School Press

Bruzzone, L. S. (1997). An iterative technique for the detection of land-cover transitions in multi-temporal remote-sensing images. *IEEE Transactions on Geosciences and Remote Sensing*, *35*(4), 858–867.

Bunning, S., McDonagh, J., & Rioux, J. (2011). Land degradation assessment in drylands. Manual for local level assessment of land degradation and sustainable land management. Part 1. *Planning and methodological approach, analysis and reporting*. FAO, Rome, p.163.

Burian, A., Karaya, R., Wernersson, J. E., Egberth, M., Lokorwa, B., & Nyberg, G. (2019). A community-based evaluation of population growth and agro-pastoralist resilience in Sub-Saharan drylands. *Environmental Science & Policy*, *92*(3), 323–330. https://doi.org/10.1016/j.envsci.2018.10.021

Burnett, G.W., & Rowntree, K.M. (1990). Agriculture, research and tourism in the landscape of Lake Baringo, Kenya. *Landscape and Urban Planning*, *19* (1990), 159-172.

Butcher, C. (1994). Nomadic pastoralism and extension: A review of the literature. *Pastoral Development Network, Network paper 37,* Overseas Development Institute.

Bwambale, N. (2015). Farmers' Knowledge, Perceptions, and Socioeconomic Factors Influencing Decision Making for Integrated Soil Fertility Management Practices in Masaka and Rakai Districts, Central Uganda. *Graduate Theses and Dissertations*. 15231.https://lib.dr.iastate.edu/etd/15231

Carson (2013). *Governance, Agency and Autonomy*. Centre of stateless society.

Chambers, R., & Leach, M. (1989). Trees as savings and security for the rural poor. *World Development*, 17(3), 329-342.

Christoplos, I., Farrington, J., & Kidd, A. (2001). Extension, Poverty and Vulnerability: Inception Report of a Study for the Neuchatel Initiative. *Working Paper 144*. Overseas Development Institute.

Clark, W. C., & N. M. Dickson. (2003). Sustainability science: the emerging research program. *Proceedings of the National Academy of Sciences*, USA 100:8059–8061.

Cofré-Bravo, G., Klerkx, L., & Engle, A (2019). Combinations of bonding, bridging, and linking social capital for farm innovation: How farmers configure different support networks. *Journal of Rural Studies,* 69, 53-64 https://doi.org/10.1016/j.jrurstud. 2019.04.004

Coleman, J. (1988). Social capital in the creation of human capital. *Journal of Sociology* 94, 95-120

Collis, J., & Hussey, R. (2014). *Business Research: A Practical Guide for Undergraduate and Postgraduate Students.* 4th edition, Palgrave Macmillan, p.54

Chambers, R. (2006). Participatory mapping and geographic information systems: Whose map? Who is empowered and who disempowered? Who gains and who loses? *The*

Electronic Journal of Information Systems in Developing Countries, *25*(1), 1–11. https://doi.org/10.1002/j.1681-4835.2006.tb00163.x

Conedera, M., Stefano, V., Christophe, N., Meurer, M., & Krebs, P. (2007). Using toponymy to reconstruct past land use: A case study of 'Brusada' (Burn) in Southern Switzerland. *Journal of Historical Geography*, *33*(4), 729–748. https://doi.org/10.1016/j.jhg.2006.11.002

Conroy, R.M. (2016). *Sample Size Handbook*. Royal College of Surgeons, Ireland. www.rcsi.ie/files/research/docs/2016 0811111051

Cope, M., and Elwood, S. (eds.). (2009). *Qualititive GIS: A mixed methods Approach*. Los Angeles, CA. SAGE doi:10.4135/9780857024541

Creswell, J., W. (2009). *Research Design: Qualitative, Quantitative, and Mixed Methods Approach*. 3rd edition. Thousand Oaks: Sage.

Cundill, G., Roux, D., & Parker, J. (2015). Nurturing communities of practice for transdisciplinary research. *Ecology and Society, 20*(2), 22-30.

Curry, N., & Kirwan, J. (2014). The Role of Tacit Knowledge in Developing Networks for Sustainable Agriculture. *Sociol Ruralis, 54*, 341–361.

D'Odorico, P., Bhattachan, A., Davis, K., Ravi, S., & Runyan, C. (2012). Global desertification: drivers and feedbacks, *Advances in Water Resources*, 51, s 326-344, https://doi.org/10.1016/j.advwatres.2012.01.013

Dalice, A. (2010). *The Sampling issues in Quantitative Research*. Egitim Danismanligi Ve Arastivmalari Ilatism Hizmatlari Tic. Ltd.

Danielsen, F., Burgess, N.D., Balmford, A., Donald, P.F., Funder, M., Jones, J.P.G., Alviola, P., Balete, D.S., Blomley, T., Brashares, J., Child, B., Enghoff, M., Fjeldsa, J., Holt, S., Hübertz, H., Jensen, A.E., Jensen, P.M., Massao, J., Mendoza, M.M., Ngaga, Y., Poulsen, M.K., Rueda, R., Sam, M., Skielboe, T., Stuart-Hill, G., Topp-Jørgensen, E., & Yonten, D. (2009). Local participation in natural resource monitoring: a characterization of approaches. *Conservation Biology,* 2(3), 31-42.

Danish International Development Agency (DANIDA). (2004). *Farmer empowerment: experiences, lessons learned and ways forward.* Volume 1: technical papers, Danida.

Davies, J., & Bennett, R. (2007). Livelihood adaptation to risk: Constraints and opportunities for pastoral development in Ethiopia's Afar region. *The Journal of Development Studies, 43(3),* 490-511. https://doi.org/10.1080/00220380701204422

Davies, J., Poulsen, L., Schulte-Herbrüggen, B., Mackinnon, K., Crawhall, N., Henwood, W. D., Dudley, N., Smith, J., & Gudka, M. (2012). Conserving dryland biodiversity. International Union for Conservation of Nature. IUCN. www.iucn.org/publications

De Silva, M. J., Breuer, E., Lee, L., Asher, L., Chowdhary, N., Lund, C., & Patel, V. (2014). Theory of Change: a theory-driven approach to enhance the Medical Research Council's framework for complex interventions. *Trials*, *15*(1), 267.

Delgado, C., Rosegrant, M., Steinfeld, H., Ehui, S., & Curbois, C. (2018). Livestock to 2020. The Next Food Revolution. Food, Agriculture and Environment Discussion Paper 28.

Dembele, Y. (2006). *Land degradation and its Impact on livelihood on Malian semi-arid zone, Nara. No. 2006180852.* Master of Science Thesis Submitted to Universitetet for milj-og biovitenskap.

Deressa, T. T., R. M. Hassan, C. Ringler, T. Alemu., & Yesuf, M. (2008). Analysis of the Determinants of Farmers' Choice of Adaptation Methods and Perceptions of Climate Change in the Nile Basin of Ethiopia. IFPRI Discussion Paper No. 798 (Washington, DC: International Food Policy Research Institute.

Descheemaecker, K., Nyssen, J., Rossi, J., Poesen, J., Haile, M., Raes, D., Muys, B., Moeyersons J. & Deckers J. (2006). Sediment deposition and pedogenesis in exclosures in the Tigray highlands Ethiopia. *Geoderma, 132*, 291-314.

Desta, S., Berhanu, W., Gebru, G., & Amosha, D. (2008). *Pastoral Drop-out Study in Selected Weredas of Borana Zone, Oromia Regional State*. Care International ethiopia.

Diiro, G. M. (2013). Impact of off-farm income on agricultural technology adoption intensity and productivity: Evidence from rural maize farmers in Uganda. Working paper 11, *International Food Policy Research Institute*. http://www.ifpri.org/sites/default/files/publications/usspwp11.pdf.

Dolinska, A., Oates, N., Ludi, E., & d'Aquino P. (2018). Engaging Farmers in a Research Project: Lessons Learned from Implementing the Community of Practice Concept in Innovation Platforms in Irrigated Schemes in Tunisia, Mozambique and Ethiopia. *Irrigation and Drainage*, 69 (1) 38-48. https://doi.org/10.1002/ird.2222

Dong, S., Wen, L., Liu, S., Zhang, X., Lassoie, J., Yi, S., Li, X., Li, J., & Li, Y. (2011). Vulnerability of worldwide pastoralism to global changes and interdisciplinary strategies for sustainable pastoralism. *Ecology and Society*, *16*(2), 10. https://doi.org/10.5751/ES-04093-160210

Duraiappah, A.K., Ikiara, G., Manundu, M., Nyangena, W., & Rueben, R. (2000). Land Tenure, Land Use, Environmental Degradation and Conflict Resolution: A PASIR Analysis for the Narok District, Kenya. *CREED Working Paper 33*, IIED.

Duveskog, D., Friis-Hansen, E., & Taylor, E. W. (2011). Farmer Field School in rural Kenya: A transformative learning experience. *Journal of Development Studies* 47(10): 1529-1544.

Elwood, S. (2006). Critical issues in participatory GIS: Deconstructions, reconstructions, and new research directions. *Transactions in GIS, 10*(5), 693 708.https://doi.org/10.1111/j.1467-9671.2006.01023

Ekoja, I. (2005). Farmers' Access to Agricultural Information in Nigeria. *Bulletin of the American Society for Information Science and Technology 29*(6):21 – 23 DOI: 10.1002/bult.293

Ensor, J., & Harvey, B. (2015). Social learning and climate change adaptation: evidence for international development practice. *Wiley Interdisciplinary Reviews: Climate Change*. John Wiley & Sons, Inc., 6(5): pp. 509–522.

Eriksen, S., & Silva, J. A. (2009). The vulnerability context of a savanna area in Mozambique: Household drought coping strategies and responses to economic change. *Environmental Science & Policy*, *12*(1), 33–52. https://doi.org/10.1016/j.envsci.2008.10.007

FAOSTAT, (2008). *Agricultural statistics*. Available at http://faostat.fao.org.

Faysse, N., Taher, S., & Errahj, M. (2012). Local farmers' organisations: a space for peer-to-peer learning? The case of milk collection cooperatives in Morocco. *Journal of Agricultural Education and Extension*, Taylor & Francis (Routledge), pp.285-299.

Fazey, L., Fazey, A.; Fischer, J; Sherren, K; Warren, J; Noss, R.; & Dovers, S., (2007). Adaptive capacity and learning to learn as leverage for social-ecological resilience *Frontiers in Ecology and the Environment 5*: 375–80. https://doi.org/10.1890/1540-9295(2007)5[375:ACALTL]2.0.CO;2

Fisher, R. (2013). A gentleman's handshake: The role of social capital and trust in transforming information into useable knowledge *Journal of Rural Studies., 31* (2013), pp.13-22 https://doi.org/10.1016/j.jrurstud.2013.02.006

Flato M., Muttarak R., &Pelser A. (2017). Women, weather and woes: The Triangular Dynamics of Female-Headed Households, Economic Variability and Climate Variability in South Africa. *World Development, 90, 41-62.* https://doi.org/10.1016/ j.worlddev.2016.08.015

Flintan, F. (2011). *Broken lands: Broken lives? Causes, processes and impacts of land fragmentation in the rangelands of Ethiopia, Kenya and Uganda.* Nairobi: Regional Learning and Advocacy Programme (REGLAP).

Foley, J. A., DeFries, G. P., Asner., C, Barford, G., Bonan, S. R., Carpenter, F. S., Chapin, M. T. Coe, G. C., Daily. H. K., Gibbs, J. H., Helkowski, T., Holloway, E. A., Howard, C. J., Kucharik, C., Monfreda, J. A., Patz, I. C., Prentice, N., & Snyder, P. K. (2005). Global consequences of land use. *Science, 309,* 570–574. http://dx.doi.org/10.1126/science.1111772

Folke, C., Hahn, T., Olsson, P., & Norberg, J. (2005). Adaptive governance of social-ecological systems. *Annual Review of Environment and Resources, 30,* 441–473.

Food and Agricultural Organization (2014). *Identifying the "family farm". An informal discussion of the concepts and definitions*. FAO.

Food and Agriculture Organization of the United Nations, FAOSTAT database (FAOSTAT). (2013). http://fao stat3.fao.org/home/E

Food and Agricultural Organisation. (2006). FAO World Reference Base for Soil Resources. *Food and Agriculture Organization of the United Nations*.

Food and Agricultural Organisation, Mountain Partnership Secretariat, UNCCD, SDC & CDE., (2011). *Highlands and Drylands– mountains, a source of resilience in arid regions.* Technical report, Published by FAO, UNCCD, Mountain Partnership, Swiss Agency for Development and Cooperation, and CDE, with the support of an international group of experts. FAO.

Foody, M. (2002). Status of land cover classification accuracy assessment. *Remote Sensing of Environment, 80*(2002), 185–201.

Fraenkel, J.R., & Wallen, N.E. (2000). *How to Design and Evaluate Research in Education.* New York, NY: McGraw Hill Publishing Co.

Fuchs, R., Herold, M., Verburg, P. H., Clevers, J. G., & Eberle, J. (2015). Gross changes in reconstructions of historic land cover/use for Europe between 1900 and 2010. *Global Change Biology, 21*(1), 299–313. https://doi.org/10.1111/gcb.12714

Geist H., & Lambin, F. (2002). Proximate causes and underlying driving forces of tropical deforestation. *Bioscience, 52,* 143–150.

Geist, H. J., & Lambin, E. F. (2004). Dynamical causal patterns of desertification. *BioScience, 54*(9), 817–829.

Gibbs G. R. (2007). *Analyzing qualitative data.* In U. Flick (ED.). The sage qualitative research kit. Sage.

Gillespie, J., Kim, S., & Paudel, K. (2007). Why don't producers adopt best management practices? An analysis of the beef cattle industry. *Agricultural Economics*, *36*(1), 89-102.

Golder B. (2005). *Cross Cutting Tool Stakeholder Analysis.* Retrieved from https://intranet.panda.org/documents/folder.cmf? U folder ID=60976.

Government of Kenya (GOK). (2012). Sessional Paper No. 8 of 2012 on *National Policy for the Sustainable Development of Northern Kenya and Other Arid Lands.* Ministry of State for Development of Northern Kenya and Other Arid Lands.

Government of Kenya, (2007). *Vision 2030*. Government Printer.

Government of Kenya. (2011). *Agricultural Sector Development Support Programme–Programme Document*. Government Printer.

Government of Kenya. (2016). *National Policy for the Sustainable Development of Northern Kenya and other Arid Lands: Unlocking Our Full Potential for the Realization of the Kenya Vision 2030.* Ministry of Devolution.

Greenwood, D. J., & M. Levin. (1998*). Introduction to action research: Social research for social change*. Thousand Oaks, CA: Sage.

Gustafson. C., VanWormer, E., Kazwala. R., Makweta. A., Goodluck. P., Smith. W., & Mazet J. (2015). Educating pastoralists and extension officers on diverse livestock diseases in a changing environment in Tanzania. *Pastoralism: Research, Policy and Practice* 5:1 http://www.pastoralismjournal.com/content/5/1/1.

Hall, A. (2009). Challenges to strengthening agricultural innovation systems: Where do we go from here? *UNI-MERIT Working paper*. The Netherlands.

Hamza, I. A., & Iyela, A. (2012). Land use pattern, climate change, and its implication for food security in Ethiopia: Review. *Ethiopia Journal of Environmental Study and Management*, *5*(1), 26-31. DOI:10.4314/ ejesm.v5i.4

Hardin, G. (1968). The Tragedy of the Commons. Science 162, 1243–1248. doi:10.1126/science.162.3859.1243

Hearn, S., & White, N. (2009). *Communities of practice: linking knowledge, policy and practice.* Overseas Development Institute. https://odi.org › publications

Himanen S.J., Makinen H., Rimhanen K., & Savikko R. (2016). Engaging Farmers in Climate Change Adaptation Planning: Assessing Intercropping as a Means to Support Farm Adaptive Capacity. *Agriculture 2016, 6, 34; doi: 10.3390/agriculture6030034*.

Hoang, Q.D., Dufhues, T.B., & Buchenrieder, G. (2016). Individual social capital and access to rural services in Northern Vietnam. *International Journal of Social Economisc, 43,* 363-381. https://doi.org/10.1108/IJSE-12-2012-0234

Hobbs, N.T., Galvin, K.A., Stokes, C.J., Lackett, J.M., Ash, A.J., Boone, R.B., Reid, R., & Thornton, P.K. (2008). Fragmentation of rangelands: Implications for humans, animals, and landscapes. *Global Environmental Change, 18*, 776–785.

Hoffman, T., & Vogel, C. (2008). Climate change impacts on African Rangelands. *Rangelands, 30*(3), 12–17. https://doi.org/10.2111/1551-501X(2008)30[12:CCIOAR]2.0.CO;2

Holmes, T., & Scoones. I. (2000). Participatory environmental policy process: experiences from North and South. *IDS Working Paper 113.* Institute of Development Studies. University of Sussex. Brighton. http://www.ids.ac.uk/ids/bookshop/wp/Wp113.pdf.

Hurni, H. (2000). Assessing sustainable land management (SLM): *Agriculture, Ecosystems & Environment, 81*, 83–92

Huxley, E. (1951). *The Sorcerer's Apprentice*. Chatto and Windus, London.

International Business Machines (IBM) corporation knowlegde centre. (2021). Categorical Regression analysis. https://www.ibm.com/support/knowledgecenter

Ison, R., Collins, K., Colvin, J., Jiggins, J., Roggero, P., Seddaiu G, Steyaert, P., & Zanolla C. (2011). Sustainable catchment managing in a climate changing world: new integrative modalitites for connecting policy makers, scientists and other stakeholders. *Water Resource Management.* doi:10.1007/s11269-011-9880-4

James, C. (2011). *Theory of Change Review: A report commissioned by Comic Relief*; 2011.

Jiggins, J., & Visser, M. (2016) Escape pathways. *Outlook on Agriculture*, *45*(4), 254–258.

Johansson, J., & Svensson, J. (2002). Land degradation in the semi-arid catchment of lake Baringo, Kenya. *A minor field study of physical causes with- a Socio-economic aspect.* Earth sciences centre Göteborg university.

Jones R.W. (2007). Learning and teaching in small groups: Characteristics, benefits, problems and approaches. *Anaesthesia and Intensive Care, 35,* 587–592.

Kahi, C. H., Ngugi, R. K., Mureithi, S. M., & Ng'ethe, J. C. (2009). The canopy effects of Prosopis Juliflora (Dc.) and Acacia Tortilis (Hayne) trees on herbaceous plants species and soil physico-chemical properties in Njemps Flats, Kenya. *Tropical and Subtropical Agroecosystems, 10,* 441–449.

Kamar, M. (2001). Role of Kenyan women's groups in community-based soil and water conservation. A case study of Mwethya women's groups in Machakos. In: D.E Stott, R. H. Mohtar & G.C., Steinhardt (Eds.) *Sustaining the global farm*. Purdue University.

Kamau, W., Kimani E., & Wamue-Ngare, G. (2014). Gender relattions in utilization of Micro-finance resources among women in Kiharu Constituency, Murang'a County, Kenya. *Merit Research Journal of Art, Social Science and Humanities, 2*(7) 95-100

Karaya, R.N., Onyango, C.A., & Amudavi, D.M. (2013). Fighting hunger together: A case of women farmers' participation in women groups. A study on women groups in Kenya. *International Journal of Agricultural Management and Development 3* (3), 189-200.

Kassie M., Ndiritu S.W., & Stage J. (2014). What determines Gender Inequality in household Food Security in Kenya? *Application of Switching Treatment Regression. World Development, 56*, 153-171

Kassie, M., Pender, J., Yesuf, M., Kohlin, G., Bluffstone, R., & Mulugeta, E. (2008). Estimating returns to soil conservation adoption in the northern Ethiopian highlands. *Agricultural Economics 38*, 213-232.

Kathumo, M., Gachene, K., Okello, J., Ngigi, M., & Miruka, M. (2015). Is lower Tana River Forest complex and ecosystem under threat of total destruction? Evidence from participatory GIS. In Z. Khalif, K. Gachene, P. Gicheru, M. Mburu, & G. Gakahu (Eds.), *Sustainable land management in dry lands of Kenya; Improving land productivity through participatory research and technology transfer*. United Nations Development Programme (pp. 13-35).

Kathuri, N.J. & Pals, A.D. (1993*). Introduction to educational research*. Njoro: Egerton Education Book services.

Kaumbutho, P., & Kienzle, J. (2008). *Conservation Agriculture as Practiced in Kenya: Two Case Studies.* Food and Agriculture Organization of the United Nations.

Kebebew, F., Dsegaye, D., & Synnevag, G. (2001). Traditional Coping Strategies of the Afar and Borana Pastoralists in Response to Drought. *Drylands Coordination Group Report No. 17*.

Keen, M., Bruck, T., & Dyball, R. (2005). Social learning: a new approach to environmental management, in: M. Keen, V. Brown, R. Dyball (Eds.), *Social learning in environmental management: towards a sustainable future,* Earthscan.

Kemmis, S., & McTaggart, R. (2007). *Participatory action research*. Retrieved from www.corwin.com/upm- data/21157.

Kenya Land Commission (KLC) Report. (1934). *The National Archives*, Catalogue Reference: CAB/24/248.

Kenya National Bureau of Statistics. (2008). *Economic Survey 2008*. Herufi House, Nairobi, Kenya

Kenya National Bureau of Statistics. (2010). *The 2009 Kenya Population and Housing Census* "Counting our People for the Implementation of Vision 2030" vol 1A. Government printer.

Kenya National Bureau of Statistics & Society for International Development (2013). *Exploring inequalities in Kenya: Pulling Apart or Pooling Together? Baringo County*. KNBS and SID.

Kiage., L. M., Liu, B. K., Walker, N. D., Lam, N., & Huh, O. K. (2007). Recent land-cover/use change associated with land degradation in the Lake Baringo catchment, Kenya, East Africa: Evidence from Landsat TM and ETM+. *International Journal of Remote Sensing*, *28*(19), 4285–4309. https://doi.org/10.1080/01431160701241753

Kihiu, N. E. (2016). *Pastoral practices, economics, and institutions of sustainable rangeland management in Kenya*. (PhD Thesis). University of Bonn.

Kilvington, M. (2013). *Building capacity for social learning in environmental management.* (PhD thesis). Lincoln University.

Kindon, S., Pain, R., & Kesby, M. (2007). *Approaches and Methods- Connecting people, participation and place*. Routledge 2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Kirui, O. K. (2016). Economics of land degradation and improvement in Tanzania and Malawi. In "Economics of Land Degradation and Improvement - A Global Assessment for Sustainable Development", pp. 609-649. Springer.

Klerkx, L., Aarts, N., & Leeuwis, C. (2010). Adaptive management in agricultural innovation systems: the interactions between innovation networks and their environment. *Agriculture Systems. 102*, 390–400.

Kotrlik, J., Williams, H., & Jabor, K. (2011). Reporting and Interpreting Effect Size in Quantitative Agricultural Education Research. *Journal of Agricultural Education, 52, (1), 132–142, http/10.5032/jae.2011.01132.*

Korsching, P. F., & Allen J.C. (2004). Locality based entrepreneurship: A strategy for community economic vitality. *Community Development Journal, 3*9, 385-400.

Kreutzmann H, Abdulalishoev K, Zhaohui L., & Richter J. (2011). *Pastoralism and rangeland management in mountain areas in the context of climate and global change*. GIZ, Bonn.

Krzywoszynska, A. (2018). Making knowledge and meaning in communities of practice: What role may science play? The case of sustainable soil management in England. *Soil Use and Management*, 35, 160–168. https://doi.org/10.1111/sum.12487.

Kumar, P., & Mitals, S. (2000). Agricultural Performance and Productivity. *Final Report ICAR-ACIAR collaborative projects on equity driven trade and marketing policies and strategies for Indian Agriculture.* Indian Agricultural Research Institute.

Lambin, E. F., Geist, H. J., & Lepers, E. (2003). Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environment and Resources*, *28*(1), 205–241. https://doi.org/10.1146/annurev.energy.28.050302.105459

Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, *108*(9), 3465–3472. https://doi.org/10.1073/pnas.1100480108

Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., & Xu, J. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change*, *11*(4), 261-269.

Lampkin, N.H., Pearce, B.D., Leake, A.R., Creissen, H., Gerrard, C.L., Girling, R., & Wolfe, M.S., (2015). The role of agroecology in sustainable intensification. *Report for the Land Use Policy Group*. Organic Research Centre, Elm Farm and Game & Wildlife Conservation Trust.

Lave, J., & Wenger, E. (1991). S*ituated learning: Legitimate peripheral participation.* Cambridge University Press.

Lea, C., & Curtis, C. (2010). Thematic accuracy assessment procedures: National Park service vegetation inventory, version 2.0. Natural Resource Report NPS/2010/ NRR 2010/204. National Park Service.

Leeuwis, C. (2004). *Communication for rural innovation: rethinking agricultural extension, With Contributions from A. Van den Ban*. Blackwell Science.

Lertzman, K. (2009). The paradigm of management, management systems, and resource stewardship. *Journal of Ethnobiology, 29*(2), 339–358.

Lestrelin, G., & Giordano, M. (2006). *Upland development policy, livelihood change and land degradation: interactions from a Laotian village*. https://doi.org/10.1002/ldr.756 Wiley Online Library.

Leutlwetse, C. (2006). Farmers' perception of socio-economic constraints and coping strategies in crop production in Mopipi, Botswana. Norwegian University of Life Sciences, (MSc thesis). http://www.bio.uio.no/cees/doc/GEFIVP/gefivp3.pdf

Lincoln, Y., Lynham, A., & Guba, E. (2011). *Paradigmatic Controversies, contradictions and emerging Confluences revisited.* In the Sage Handbook of Qualitative Research. Edited by Norman K. Denzin and Yvonna S. Lincoln. Thousand Oaks: Sage Publications.

Lind. J., Wheeler. R., & Kohnstamm, R., (2016*). Changes in the drylands of Eastern Africa: A review of evidence and data and their implications for efforts to strengthening resilience.* Institute of Development Studies University of Sussex

Lindkvist, L. (2005). Knowledge Communities and Knowledge Collectivities: a typology of knowledge work in groups. *Journal of Management Studies,* 42(6), 1189-1210.

Lingard, L., Albert, M., & Levinson, W. (2008). Grounded theory, mixed methods, and action research". *British Medical Journal*, *337*(2): 567-567.

Liniger, H., Mekdaschi S., Hauert, C., & Gurtner M. (2011). *Sustainable Land Management in Practice–Guidelines and Best Practices for Sub-Saharan Africa. TerrAfrica, World Overview of Conservation Approaches and Technologies* (WOCAT) and Food and Agriculture Organization of the United Nations (FAO).

Little, P, D. (1981). The Effects of Increased Crop Production on Livestock Investments in a Semi-Arid Area: Some Examples from Baringo District, Kenya. *Working Paper No. 386.* Institute for Development Studies, University of Nairobi.

Little, P. D. (2016). A victory in theory, loss in practice: Struggles for political representation in the Lake Baringo-Bogoria Basin, Kenya. Journal of Eastern African Studies, 10:1. 189–207. doi:10.1080/17531055.2016.1138665

Lu, Y., McDonagh, J., Semalulu, O., Stocking, M., & Nkalubo S. (2005). *Bridging Research and Development in Soil Management: Matching Technical Options with Local Livelihoods*. Available from: https://www.researchgate.net/publication/266422005

Lund, C., & Boone, C. (2013). Introduction: land politics in Africa- constituting authority over territory, property and persons. *Africa, 83*(1), 1-13.

Maatman A., Wongtschowski, M., Heemskerk, W., Sellamna, N., Davis, K., Nahdy, S., Ochola, W., & Kisauzi, D. (2011). Dynamic Networks of Interactive Learning and Agricultural Research for Development. Three Critical Roles for Agricultural Advisory Services. *Conference Working Paper 11 prepared for the ASTI/IFRI-FARA conference,* Accra, Ghana.

McCall, M. K., & Minang, P. A. (2005). Assessing participatory GIS for community-based natural resource management: Claiming community forests in Cameroon. *The Geographical Journal, 171*(4), 340– 356. https://doi.org/10.1111/j.1475-4959.2005.00173.x

MacDonald, C. (2012). Understanding participatory action research: A qualitative research methodology option. *Canadian Journal of Action Research, 13*(2), 34-50.

Mc Lafferty, S. L. (2002). Mapping Women's Worlds: Knowledge, power and the bounds of GIS. *Gender, Place & Culture,* 9(3), 263–269. doi:10.1080/0966369022000003879

Madsen, M., & Noe, E (2012). Communities of practice in participatory approaches to environmental regulation. Prerequisites for implementation of environmental knowledge in agricultural context. *Environmental Science & Policy 18*, 25–33 DOI: 10.1016/j.envsci.2011.12.008

Maitima, J. M., Mugatha, S. M., Reid, R. S., Gachimbi, L. N., Majule, A., Lyaruu, H., & Mugisha, S. (2009). The linkages between land use change, land degradation and biodiversity across East Africa. *African Journal of Environmental Science and Technology, 3*(10), 310-325. Retrieved from http://www.academicjournals.org/AJEST

Malard, J., Adamowski, F., Rojas, M., Carrera, J, Gálvez, J., Monardes, H., & Melgar-Quiñonez, H. (2015). *Use of participatory system dynamics modelling to assess the sustainability of smallholder agriculture.* Written for presentation at the 2015 ASABE Annual International Meeting New Orleans, Louisiana.

Manjoro, M. (2006). "Understanding farmers: explaining soil and water conservation behavior in small-holder farmers in Southern Zimbabwe", *Journal of Sustainable Development in Africa*, 8, 239–252.

Manzano, M. G., Navar, J., Pando-Moreno, M., & Martinez, A. (2000). Overgrazing and desertification in northern Mexico: highlights on northeastern region. *Annals of Arid Zone 39*, 285–304.

Mascorro, V.S., Coops, N.C., Kurz, W.A., & Olguin, M. (2016). Attributing changes in land cover using independent disturbance datasets: a case study of the Yucatan Peninsula, Mexico. *Regional Environment change* 16, 213–228. https://doi.org/10.1007/s10113-014-0739-0

Maphanyane, J. G. (2018). Reconstruction of historical landscapes: An alternative approach to monitor land cover change. IST-Africa 2018 Conference Proceedings Paul Cunningham and Miriam Cunningham (Eds) IIMC International Information Management Corporation, 2018.

Matlhodi, B., Kenabatho, P. K., Parida, B. P., & Maphanyane, J. G. (2019). Evaluating land use and land cover change in the Gaborone Dam Catchment, Botswana, from 1984–2015 using GIS and remote sensing. *Sustainability*, *11*(19), 5174. https://doi.org/10.3390/su11195174

Matuschke, I. (2008). *Evaluating the impact of social networks in rural innovation systems*. IFPRI Discussion Paper No. 00816.

McCabe, J.T, Leslie, P.W., & DeLuca, L. (2010). Adopting cultivation to remain pastoralists: The diversification of maasai livelihoods in Northern Tanzania. *Human Ecology, 38*:321–334.

McNiff, J., & Whitehead, J. (2010). *All you need to know about action research*. London: SAGE Publications.

Medema, W., Arjen, W.A., & Adamowski, J. (2014). Multi-loop social learning for sustainable land and water governance: Towards a research agenda on the potential of virtual learning platforms. *NJAS-Wageningen Journal of Life Sciences, 69*(14): 23–38.

Meinzen-Dick, R., & Mwangi, E. (2009). Cutting the web of interests: Pitfalls of formalizing property rights. *Land Use Policy, 26*(1), 36–43. https://doi.org/10.1016/.2007.06.003

Mekuria, W., Veldkamp, E., Corre M.D. & Haile, M. (2011). Restoration of ecosystem carbon stocks following exclosure establishment in communal grazing lands in Tigray ethiopia. *Soil Science Society of America Journal, 75*(1), 246-256.

Mekuria, W., Veldkamp, E., Haile, M., Nyssen, J., Muys, B., & Gebrehiwot, K. (2007). Effectiveness of exclosures to restore degraded soils as a result of overgrazing in Tigray, Ethiopia. *Journal of Arid Environments*, *69*(2), 270–284. https://doi.org/10.1016/j. jaridenv. 2006.10.009

Mekuyie, M., Jordaan, A., & Yoseph Melka, Y. (2018). Landuse and land-cover changes and their drivers in rangeland-dependent pastoral communities in the southern Afar Region of Ethiopia. *African Journal of Range & Forage Science*, *35*(1), 33–43. https://doi.org/ 10.2989/10220119.2018.1442366

Mercoiret, M.R., Pesche, D., & Bosc, P.M. (2006). Rural producer organizations (RPOs) for pro-poor sustainable development. *World Development Report 2008: Agriculture for Development.* Report of the Paris Workshop, 30-31 October.

Mertz, N. T., & Anfara, V. A. Jr. (2006). Conclusion: Coming full circle. In Jr. V. A. Anfara & N. T. Mertz (Eds.), *Theoretical frameworks in qualitative research* (pp. 189–196). Thousand Oaks, CA: Sage

Meyerhoff, E. (1991). *Taking Stock: Changing Livelihoods in Agropastoral Community.* African Center for Technology Studies (ACTS) Press: Nairobi, Kenya and Biomass Users Network (BUN), Harare, Zimbabwe. 58 pp.

Mganga, K.Z., Musimba, N.K.R. & Nyariki, D.M. (2015). Combining Sustainable Land Management Technologies to Combat Land Degradation and Improve Rural Livelihoods in Semi-arid Lands in Kenya. *Environmental Management* 56, 1538–1548. https://doi.org/10.1007/s00267-015-0579-9

Micheels, E, T & Nolan, J, F. (2016). Examining the effects of absorptive capacity and social capital on the adoption of agricultural innovations: a Canadian Prairie case study**.** *Agriculture Systems., 145* (2016), pp 127-138 https://doi.org/10.1016/j.agsy. 2016.03.010

Middleton, N., Stringer. L., Goudie, A., & Thomas. D. (2011). *Forgotten billion: Millennium development goals achievement in the drylands.* United Nations Convention to Combat Desertification, Secretariat, Bonn, Germany

Millennium Ecosystem Assessment. (2005). *Ecosystems and human well-being: Desertification synthesis.* World Resources Institute.

Miller. R., Wiek.A., Sarewitz. D., Robinson. J., Olsson. L., Kriebel, D., & Loorbach, D. (2013). The future of sustainability science: a solutions-oriented research agenda. *Journal of Sustainability Science, 10* (6), 13-24.

Mills, D., & Keast, R. (2010). Can stewardship theory produce better stewardship of privatised water infrastructure*?* Paper presented to Doctoral Panel, IRSPM 21 XIV Conference; 7 - 9 April 2010; University of Berne, Centre of Competence for Public Management.

Mirzabaev, A., Nkonya, E., Goedecke, J., Johnson, T. & Anderson, W. (2016). *Global drivers of land degradation and improvement.* In E. Nkonya, E., A. Mirzabaev, A. & Von Braun, J. (Eds.), Economics of Land Degradation and Improvement-A Global Assessment for Sustainable Development. Springer International Publishing

Mlunga, L., & Gschwender, F. (2015). Bush encroachment, de-bushing and energy production in Namibia. In O. C. Ruppel & B. Althusmann (Eds.), *Perspectives on Energy Security and Renewable Energies in Sub-Saharan Africa. Practical Opportunities and Regulatory Challenges* (pp. 195–202). Macmillan Education Namibia.

Moges, A., & Holden, N., M. (2007). *Farmers' perceptions of soil erosion and soil fertility loss in Southern Ethiopia*. Wiley Online library. https://doi.org/10.1002/ldr.795

Moore, D.S., (2000). *The basic practice of statistics (2nd Edition).* W.H. Freeman and Company.

Morgan, S. (2011). Social learning among organic farmers and the application of the communities of practice framework. *Journal of Agricultural Education and Extension, 17* (1), 99-112.

Mortimore, M. (2009). *Dryland Opportunities: A new paradigm for people, ecosystems and development,* IUCN, Gland, Switzerland; IIED, London, UK and UNDP/DDC.

Mortimore, M., Anderson, S., Cotula, L., Faccer, K., Hesse, C., Mwangi, A., Nyangena, W., & Skinner, J., (2008). Drylands: An Economic Asset for Rural Livelihoods and Economic Growth. *Draft Report for the Dryland Challenge Paper Series of the Global Drylands Imperative*. UNDP/DDC.

Mosalagae, D., & Mogotsi, K. (2013). *Caught in a sandstorm: an assessment of pressures on communal pastoral livelihoods in the Kalahari Desert of Botswana*. Pastoralism 3: 18.

Moschitz, H., Roep, D., Brunori, G. & Tisenkopfs, T., (2015). Learning and innovation networks for sustainable agriculture: processes of co-evolution, joint reflection and facilitation. *Journal of Agricultural Education and Extension, 21*(1), 1-11. http//doi:10.1080/1389224X.2014.991111

Mostert, E. (2003). The challenge of public participation. *Water Policy, 5*(2), 179–197.

Mostert, E., Craps, M., & Pahl-Wostl, C. (2008). Social learning: the key to integrated water resources management? *Water International, 33*(3), 293–304. http//doi:10.1080/02508060802275757

Moussa, B., Nkonya, E., Meyer, S., Kato, E., Johnson, T., & Hawkins, J. (2016). Economics of land degradation and improvement in Niger. In: Nkonya E, Mirzabaev A, von Braun J, editors. *Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development*. Springer; (2014) p. 499–539.

Mugambi, J.M, Wesonga, F.D. & Ndungu, S.G. (2012). Ticks and tick-borne disease control in a pastoral and an agro-pastoral farming system in Kenya. *Livestock Research for Rural Development, 24*, 1–8.

Mugenda O.M., & Mugenda A.G. (1999). *Research Methods: Quantitative and Qualitative Approaches.* Acts Press, Nairobi.

Mulinge, W., Gicheru, P., Murithi, F., Maingi, P., Kihiu, E., Kirui, O., & Mirzabaev, A (2016). Economics of land degradation and improvement in Kenya in E. Nkonya, A.

Mirzabaev, J.von Braun (Eds.), *Economics of Land Degradation and Improvement. A Global, Assessment for Sustainable Development.* Springer-Verlag. pp.471-498,10.1007/978-3-319-19168-3_16

Mureithi S.M., Verdoodt A., Van Ranst E. (2010). Effects and Implications of Enclosures for Rehabilitating Degraded Semi-Arid Rangelands: Critical Lessons from Lake Baringo Basin, Kenya. In: Zdruli P., Pagliai M., Kapur S., Faz Cano A. (eds) Land Degradation and Desertification: Assessment, Mitigation and Remediation. *Springer, Dordrecht*. 490, 111–130. https://doi.org/10.1007/978-90-481-8657-0_9

Mureithi, S. M., Verdoodt, A., Gachene, C. K., Njoka, J. T., Wasonga, V. O., De Neve, S., Meyerhoff, E., & Van Ranst, E. (2015). Impact of enclosure management on soil properties and microbial biomass in a restored semi-arid rangeland, Kenya. *Journal of Arid Land*, *6*(5), 561–570. https://doi.org/10.1007/s40333-014-0065-x

Mureithi, S.M., Verdoodt, A., Gachene, C.K., Njoka, J.T., Wasonga, V.O., De neve, S., Meyerhoff, E. & Van ranst. E., (2015). Impact of enclosure management on soil properties and microbial biomass in a restored semi-arid rangeland, Kenya. *Journal of Arid Land*, *6*(5), 561–570.

Mureithi, SM., (2012). *Effects of enclosures and land zoning on the restoration of degraded semi-arid rangeland in Kenya*. (PhD Thesis), Ghent University, Belgium.

Muro, M., & Jeffrey, P. (2008). A critical review of the theory and application of social learning inparticipatory natural resource management processes. *Journal of Environmental Planning and Management*, *51*(3), 325–344. doi:10.1080/0964056 0801977190

Mutekwa, V.T. (2009). Climate Change Impacts and Adaptation in the Agricultural Sector: The Case of Smallholder Farmers in Zimbabwe**.** *Journal of Sustainable Development in Africa, 11(2), 237-256.*

Mwagore, D. (Ed.). (2003). *Land use in Kenya: the case for a national land-use policy*. Land reform vol. 3. Kenya Land Alliance. Nairobi: Printfast Kenya limited.

Mwang'ombe, A., Ekaya, W., Muiru, W., Wasonga, V., Mnene, W., Mong'are, P., & Chege, S. (2011). Livelihoods under climate variability and change: an analysis of the adaptive capacity of rural poor to water scarcity in Kenya's drylands. *Journal of environmental science and technology* 4 (4), 403-410.

Mwangi, E. & Swallow, B. (2005). Invasion of Prosopis juliflora and local livelihoods: Case study from the lake Baringo area of Kenya. *ICRAF Working Paper* – no. 3. Nairobi: World Agroforestry Centre.

Mwangi, E. & Swallow, B. (2008). *Prosopis juliflora* invasion and rural livelihoods in the Lake Baringo area of Kenya. *Conservation and Society, 6* (2): 130-140.

Mwangi, E. (2009). Property rights and governance of Africa's rangelands: A policy overview. *Natural Resources Forum, 33*: 160–170.

Nachtergaele, F., Petri, M., Biancalani, R., Lynden, G., & Velthuizen, H. (2010). Global land degradation information system (GLADIS). Beta version. An information database for land degradation assessment at global level. *Land degradation assessment in Drylands technical report, no. 17.* FAO.

Naminse, E.Y. (2011). *The Impact of Ruminant Production on Household Income and Food Security in Ghana*. Symposium Paper. Available online at: http://www.ifama.org/events/conferences/2011/cmsdocs/2011SymposiumDocs/330_ symposium, 20Paper.pdf

Napier, A., & Desta, S. (2011). *Review of pastoral rangeland enclosures in Ethiopia*: PLI Policy Project.

Nassiuma D. K. (2000). *Survey sampling: Theory and methods.* Egerton University Press

Neele. S. (2011) *Genuine Land Stewardship*. WWW.texas wildlife.org.

Neely, C., Bunning. S., & Wilkes, A. (2009). Review of evidence on drylands pastoral systems and climate change: Implications and opportunities for mitigation and adaptation. *Land and Water Discussion Paper 8*. FAO, Rome.

Niamir-Fuller, M. (2005). *Managing mobility in African rangelands*. In: Collective action and property rights for sustainable rangeland management. Collective action and property rights research brief, pp 5–7.

Niedertscheider, M., Gingrich, S., & Erb, K. H. (2012). Changes in land use in South Africa between 1961 and 2006: An integrated socio-ecological analysis based on the human appropriation of net primary production framework. *Regional Environmental Change, 12*(4), 715-727. https://doi.org/10.1007/s10113-012-0285-6

Njoku E., Angba, A., & Nwakwasi, R. (2009). Factors influencing role performance of community-based organization. Agricultural Development. *International NGO Journal 4 (6),* 313-317.

Nkonya, E., & Anderson, W. (2014). Exploiting provisions of land economic productivity without degrading its natural capital. *Journal of Arid Environments*, 2(12):12-14.

Nkonya, E., Anderson, W., Kato, E., Koo, J., Mirzabaev, A., Braun, J., & Meyer, S. (2016) Global Cost of Land Degradation. In Nkonya. E., Mirzabaev, A., and Braun, J. (*Editors). Economics of Land Degradation and Improvement – A Global Assessment*

for Sustainable Development. Pp 117-166. Springer International Publishing AG Switzerland is part of Springer Science Business Media (www.springer.com)

Nyaga, J., Barrios, E., Muthuri, C.W., Öborn, I., Matiru, V., & Sinclair, F.L. (2015). Evaluating factors Influencing heterogeneity in agroforestry adoption and practices within smallholder farms in Rift Valley, Kenya. *Agriculture, Ecosystems & Environment, 212*, 106- 118. https://doi.org/10.1016/j.agee.2015.06.013

Nyangaka D.O., Obare G.A., & Nguyo W. (2009). Economic Efficiency of Smallholder Irish Potato Producers in Kenya: A Case of Nyandarua North District. Contributed Paper prepared for presentation at the *International Association of Agricultural Economists' Conference, Beijing, China,* August 16-22, 2009.

Odada, E. O., Onyando, J. O., & Obudho, P. A. (2006). Lake Baringo: Addressing threatened biodiversity and livelihoods. *Lakes and Reservoirs: Research and Management, 11*(4), 287–299. https://doi.org/10.1111/j.1440-1770.2006.00309.x

Odhiambo, M., (2015). Il Chamus versus the state: Vulnerability, Litigation and Resilience Building in the Baringo Lowlands of Kenya. (PhD Thesis), Cologne University.

Ogunsumi, L.O., & Ogbusuka, G.E. (2009). Pattern of livelihood and household food security among rural dwellers: Case of women pastoralists in Oyo State of Nigeria. *African Journal of Biotechnology, 8 (23),* 6536-6541.

Olson, J. M., Misana, S., Campbell, D., Mbonile, M., & Mugisha, S. (2008). *The spatial patterns and root cause of land use change in East Africa.* LUCID Dar es Salaam. 44pp.

Omwenga, G. (2012, January, 23). Agriculture takes lead in fund usage. *The Daily Nation* p.25 Nation Media Group Ltd. Nairobi, Kenya.

Onyando, J. O. (2002). *Land cover resource maps of Lake Baringo drainage basin.* Consultancy report submitted to UNOPS.

Onywere, S.M. C. A. Shisanya, C.A., Obando, J. A., Ndubi, A. O., Masiga, D., Irura, Z., Mariita, N., & Maragia, H.O (2014). *Geospatial Extent of 2011-2013 Flooding from the Eastern African Rift Valley Lakes in Kenya and its Implication on the Ecosystems.* Papers, Kenya Soda Lakes 1084 Workshop, Kenya Wildlife Service Training Institute, Naivasha, Kenya.

Oreszczyn, S, Lane, A., & Carr, S. (2010). The role of networks of practice and webs of influencers on farmers' engagement with and learning about agricultural innovations. *Journal of Rural Studies*. *6*(13), 87-99.

Orindi, V. A., Nyong, A., & Herrero, M. (2007). Pastoral livelihood adaptation to drought and institutional interventions in Kenya. Occasional Paper in *Fighting climate change: human solidarity in a divided world.* Human Development Report Office, Occasional Paper, 54.

Overseas Development Institute (2009). *Planning Tools: Problem Tree Analysis*. https//www.odo.org>publications 525.

Pahl-Wostl**,** C**. (**2006). The importance of social learning in restoring the multifunctionality of rivers and floodplains. *Ecology and Society, 11*(1), 10.

Pahl-Wostl, C., & M. Hare. (2004). Processes of social learning in integrated resources management. *Journal of Community and Applied Social Psychology, 14*:193-206.

Pahl-Wostl, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D., & Taillieu, T. (2007). Social learning and water resources management. *Ecology and Society, 12* (2), 5.

Pandolfelli, L., R. Meinzen-Dick, and Dohrn, S., (2008). Introduction: Gender and collective action: Motivations, effectiveness and impact. *Journal of International Development 20* (1):1–11.

Patton, M.Q. (2002). *Qualitative research and evaluation methods* (3rd Ed.). Thousand Oaks, CA: Sage.

Pavlovskaya, M. (2018). Critical GIS as a tool for social transformation. *Canadian Association of Geographers, 38*(11), 2003-2020. https://doi.org/10.1111/cag.12438

Pender, J., Mirzabaev, A., & Kato, E. (2009). *Economic Analysis of Sustainable Land Management Options in Central Asia.* Final Report for the ADB. IFPRI/ICARDA, 168.

Pérez, C., Jones, E., Kristjanson, P., & Cramer, L. (2015). How resilient are farming households and communities to a changing climate in Africa? A gender-based perspective. *Global Environmental Change.* 34, 95-107 http://www.sciencedirect.com/science/article/pii/S0959378015000825.

Pesch, U. (2015). Tracing discursive space: Agency and change in sustainability transitions. *Technological Forecasting and Social Change, 90*, 379-388.

Phelps C., Heidl, R., & Wadhwa A. (2012). Knowledge, networks, and knowledge networks: A review and research agenda. *Journal of Management, 38*, 15–66.

Phuong, L. T., Tuan, T. D., & Phuc, N. T. (2019). Transformative Social Learning for Agricultural Sustainability and Climate Change Adaptation in the Vietnam Mekong Delta. *Sustainability*. 11(23), 6775. https://doi.org/10.3390/su11236775

Pickmeier, U. (2011). *Land acquisitions in Tana Delta, Kenya: (Bio) fueling local conflicts? A youth perspective.* Nijmegen, Netherlands: Radboud University.

Pike, L. (*2004*). *The Biosocial Consequences of Life on the Run: A Case Study from Turkana District, Kenya.* Human Organization: Summer 2004, Vol. 63, No. 2, pp. 221-235. https://doi.org/10.17730/humo.63.2.tpa607r9enhl7k1x

Pimbert, M.P. (2002). *Farmer Field Schools (FFS): Emerging Issues and Challenges*. A Paper prepared for the CIP-UPWARD-FAO International Workshop on Farmer Field Schools, 21-25 October 2002. Yogyakarta, Indonesia

Pohl, C., Rist, S., Zimmermann, A., Fry, P., Gurung, G., Schneider, F., Speranza, C., Kiteme, B., Boillat, S., Serrano, E., Hadorn, G., & Wiesmann, U. (2010). Researchers' roles in knowledge co-production: experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. *Sci Public Policy; 37*,267–281. doi: 10.3152/030234210X496628.

Pratt, G. (2000). Participatory action research in Johnston, R., Gregory, D., Pratt, G., & Watts, M. (eds) *The Dictionary of Human Geography*, 4th edn, Oxford: Blackwell: 574.

Pretty, J., & Chambers, R. (2003). Toward a learning paradigm: New professionalism and institutions for agriculture. In: Harris J (ed.). *Rethinking Sustainability: Power, Knowledge, and Institutions*. Ann Arbor, MI: University of Michigan Press.

Pretty, J., & Ward, H. (2001). *Social capital and Environment*. World Development, Vol. 29, No. 2, pp. 209-227. Elsevier Science Ltd.

Pretty. J., & Hines, R. (2001). Reducing Food Poverty with Sustainable Agriculture: A Summary of New Evidence. *Final Report from the "SAFE-World" (The Potential of Sustainable Agriculture to Feed the World) Research Project, University of Essex*

RAE, Rehabilitation of Arid Lands Trust. (2010). *A Factsheet*. Kampi ya Samaki, Marigat, Kenya.

Rahman, A., Kumar, S., Fazal, S., & Siddiqui, M. A. (2011). Assessment of land use/land cover change in the North-West District of Delhi using remote sensing and GIS techniques. *Journal of the Indian Society of Remote Sensing*, *40*(4), 689–697. https://doi.org/10.1007/s12524-011-0165-4

Rambaldi, G., Kyem, P. A. K., McCall, M., & Weiner, D. (2006). Participatory spatial information management and communication in developing countries. *The Electronic Journal of Information Systems in Developing Countries*, *25*(1), 1–9. https://doi.org/10.1002/j.1681-4835.2006.tb00162.x

Ramisch, J. (2004). Inequality, agro-pastoral exchanges, and soil fertility gradient in southern Mali. *Agriculture Ecosystems & Environment 105*(1-2),353-372. DOI:10.1016/j.agee.2004.02.001

Rammel, C., Stagl, S., & Wilfing, H. (2007). Managing complex adaptive systems - A co-evolutionary perspective on natural resource management. *Ecological Economics, 63*(1), 9–21.doi: 10.1016/j.ecolecon.

Random House Dictionary, (2013). *Dictionary*. Random House Inc.

Reason, P., & Bradbury, H. (2008). *The SAGE Handbook of Action Research*. London: Sage

Reed, M., Evely, A.C., Cundill, G., Fazey, R.A., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C., & Stringer, L. (2010). What is social learning? *Ecology and Society*, *15* (4).

Reid, R.S., Galvin, K.A., Kruska. R.L., (2008). *Global significance of extensive grazing lands and pastoral societies: an introduction.* See Ref. 10, pp. 1–24.

Reid, R.S., Nkedianye, D., Said, M.Y., Kaelo, D., & Neselle, M. (2009). Evolution of models to support community and policy action with science: balancing pastoral livelihoods and wildlife conservation in savannas of East Africa. Proceedings of the*National Academy of Sciences of the United States of America.*

Republic of Kenya (1965). *Sessional Paper Number 10, 1965: African Socialism and its Application to Planning in Kenya*.

Reynolds, J., Stafford, D., Lambin, E., Turner, B., Mortimore, M., Batterbury, S., Downing, T., Dowlatabadi, H., Fernandez, R., Herrick, J., Huber-Sannwald, E., Jiang, H., Leemans, R., Lynam, T., Maestre, F., Ayarza, M. & Walker, B. (2007). Global desertification: Building a science for dryland development. *Science, 316, 847–851*. (2007).

Rivera, W., & Sulaiman, R. (2009). Extension: object of reform, engine for innovation. *Outlook on Agriculture, 38*(2), 267-273.

Robbins, P. (2003). Beyond ground truth: GIS and the environmental knowledge of herders, professional foresters, and other traditional communities. *Human Ecology, 31*(2), 233–253. https://doi.org/10.1023/A:1023932829887

Rocheleau, D. E. (2008). Political ecology in the key of policy: From chains of explanation to webs of relation. *Geoforum 39*(2), 716-727.

Roden, P., Bergmann, C., Ulrich, A., & Nüsser, M. (2016). Tracing divergent livelihood pathways in the drylands: A perspective on two spatially proximate locations in Laikipia County, Kenya. *Journal of Arid Environments, 124* (16), 239-248.

Röling, N. (2003). From causes to reasons: The human dimension of agricultural sustainability. *International Journal of Agricultural Sustainability*. *1*(1), 54-65.

Romina, R. (2014). Social Learning, Natural Resource Management, and Participatory Activities: A reflection on construct development and testing. *Journal of Life Sciences, 69*(8), 15–22.

Rota, A. & Sperandini, S. (2009). *Livestock and pastoralists: Livestock thematic paper*. IFAD.

Saether, B., (2010). Agricultural extension services and rural innovation in inner Scandinavia. *Norwegian Journal of Geography*, 64(1), 1-8. http//doi10.1080/00291950903557647

Saunders, M., Lewis, P. & Thornhill, A. (2012). *Research Methods for Business Students*. 6th edition, Pearson Education Limited.

Schad, A., Roessler, R., Neef. A. & Hoffmann. V. (2010). *Enabling collaborative learning? Lessons from group-based extension in Vietnam's smallholder pig husbandry*. 9th European IFSA Symposium, 4th -7th, July, 2010. Vienna (Austria).

Schipper, E., Lisa F., Ayers, J., Reid, H., Huq, S. & Rahman, A. (eds.) (2014). *Community-Based Adaptation to Climate Change.* London: Routledge.

Scholz, G., Dewulf, A., & Pahl-Wostl, C. (2014). An analytical framework of social learning facilitated by participatory methods. *Systemic Practice and Action Research, 27*(6), 575-591. DOI:10.1007/s11213-013-9310-z

Schuurman, N. (2000). Trouble in the heartland: GIS and its critics in the 1990s. *Progress in Human Geography, 24*(4), 569–590. https://doi.org/10.1191/030913200100189111

Schusler, T.M., Decker. D, J. & Pfeffer. M.J. (2003). Social learning for collaborative natural resource management. *Society and Natural Resources, 15*, 309–326.

Schwilch, G., Liniger, H. P. & Hurni, H. (2014). Sustainable land management (SLM) practices in drylands: How do they address desertification threats? *Journal of Environmental Management, 2*(14): 54, 983–1004.

Scoones, I. (2009). Livelihood's perspectives and rural development. *Journal of Peasant Studies, 36*, (1), 171-196.

Sebatta, C., Mugisha J., Katungi E., Kashaaru A. & Kyomugisha H. (2014). Smallholder Farmers' Decision and Level of Participation in the Potato Market in Uganda. *Modern Economy, 5, 895-906.*http://dx.doi.org/10.4236/me.2014.58082.

Sen, A. (1999). *Development as Freedom*. Oxford: Oxford University Press.

Shaoliang, Y., & Muhammad, I. (2011). From Pastoral Economy to Rangeland Economy: Capturing the Multi-functionalities of Rangeland Resources. In H. Kreutzmann,

YangYong, J. Richter (Eds.), *Pastoralism and rangeland management on the Tibetan Plateau in the context of climate and global change*, 66-86. Bonn: GIZ.

Sheppard, E. (2005). Knowledge production through critical GIS: Genealogy and prospects. *Cartographica: The International Journal for Geographic Information and Geovisualization*, *40*(4), 5–21. https://doi.org/10.3138/GH27-1847-QP71-7TP7

Shiferaw, B. A., Okello, J., & Reddy, R. V. (2009). Adoption and adaptation of natural resource management innovations in smallholder agriculture: reflections on key lessons and best practices. *Environment, Development and Sustainability*, *11*(3), 601-619.

Snyder, W. M., & Wenger, E. (2010). Our world as a learning system: A communities-of-practice approach. *Social learning systems and communities of practice*, 107-124.

Spielman, D., Davis, K., Negash, M., & Ayele, G. (2011). Rural innovation systems and networks: Findings from a study of Ethiopian smallholders. *Agriculture and Human Values*, *28*(2), 195–212.

Stein, D., & Valters, C. (2012). Understanding theory of Change, in International Development: A Review of Existing Knowledge. JSRP Paper 1, London: JSRP and the Asia Foundation.

Steinfeld, H., Wassenaar, T., & Jutzi, S. (2006). Livestock Production systems in developing countries: status, drivers, trends. *Revue scientifique et technique*, *25*(2), 505-216.

Stites, E., J. Burns, and D. Akabwai. (2014). "It's better to sweat than to die": Rural-to-urban migration, Northern Karamoja, Uganda. *Feinstein International Center*, Friedman School of Nutrition Science and Policy at Tufts University, Boston

Stringer, E. (2010). *Action Research in Education*. Elsevier. https://doi.org/10.1016/B978-0-08-044894-7.01531-1

Stringer, L. C., Dougill, A. J. Fraser, E. Hubacek, K. Prell, C. & Reed. M. S (2006). Unpacking "participation" in the adaptive management of social-ecological systems: a critical review. *Ecology and Society*, (11(2), 39. http://www.ecologyandsociety.org/vol11/iss2/art39/

Sui, D. (2014). Opportunities and impediments for open GIS. *Transactions in GIS*, *18*(1), 1–24. https://doi.org/10.1111/tgis.12075

Sulaiman, V. R., Hall A., & Raina R. (2006). From disseminating technologies to promoting innovation: implications for agricultural extension. *Paper prepared for the SAIC Regional Workshop on Research-Extension Linkages for Effective Delivery of Agricultural Technologies in SAARC Countries* (20-22 November, 2006).

Sullivan, S., & Homewood, K. (2003). *"On Non-Equilibrium and Nomadism: Knowledge, Diversity and Global Modernity in Drylands (and Beyond)*". Centre for the Study of Globalisation and Regionalisation (CSGR), University of Warwick, Coventry, CV4 7AL, United Kingdom. URL: http://www.csgr.org

Swartling, Å. G., Lundholm, C., Plummer, R., & Armitage, D. (2011). *Social Learning and Sustainability: Exploring Critical Issues in Relation to Environmental Change and Governance.*

Tabara, J. D., & Pahl-Wostl, C., (2007). Sustainability learning in natural resource use and management. *Ecology and Society, 12(20):3.* http://www.ecologyandsociety.org/vol12/iss2/art3

Tappan, G.G., Cushing, W.M., Cotillon, S.E., Mathis, M.L., Hutchinson, J.A., & Dalsted, K.J., (2016). *West Africa land use land cover time series: U.S. Geological Survey data release*, https:// doi.org/10.5066/F73N21JF.

Tarmizi, H., Vreede, G., & Zigurs, I. (2006). Identifying Challenges for Facilitation in Communities of Practice, In System Sciences, 2006. HICSS '06. *Proceedings of the 39th Annual Hawaii International Conference on: System Sciences*, pp. 26-36.

Teklewold, H., Kassie, M. & Shiferaw, B. (2013). Adoption of Multiple Sustainable Agricultural Practices in Rural Ethiopia. *Journal of Agricultural economics*, 64, (3), 597-623. https://doi.org/10.1111/1477-9552.12011

TerrAfrica. (2009). *Sustainable land management in Sub-Saharan Africa*. Draft TerrAfrica overview paper. TerrAfrica.org. Url: http://www.terrafrica.org/.

Thomson, J., (1887). *Through Masai land: a journey of exploration among the snow-clad volcanic mountains and strange tribes of Eastern equatorial Africa*. *Being the narrative of the Royal Geographical Society's expedition to Mount Kenia and Lake Victoria Nyanza, 1883-1884*. London: Sampson Low, Marston, Searle, & Rivington.

Thornton, P. K., & Herrero, M. (2010). Potential for reduced methane and carbon dioxide emissions from livestock and pasture management in the tropics. *Proceedings of the National Academy of Sciences, 107(46),* 19667-19672.

Thornton, P., Schuetz, T., Förch, W., Cramer, L., Abreu, D., Vermeulen, S., & Campbell, M. (2017). Responding to global change: a theory of change approach to making agricultural research for development outcome-based. *Agricutural systems, 152, 145-153*

Tolno, E., Kobayashi H., Ichizen M., Esham M., & Balde B.S. (2016). Potato Production and Supply by Smallholder Farmers in Guinea: An Economic Analysis. *Asian Journal of Agricultural Extension, Economics & Sociology 8(3), 1-16.*

Triste, L., Debruyne. L., Vandenabeele, J., Marchand. F., & Lauwers, L (2018). Communities of practice for knowledge co-creation on sustainable dairy farming: features for value creation for farmers. *Sustainability Science.* doi.org/10.1007/s11625-018-0554-5

Trochim, W. M., (2006). *The Research Methods Knowledge Base, 2nd Edition*. Available in http://www.socialresearchmethods.net/kb/>

UNCCD & World Bank, (2016). *Land for Life: Create Wealth Transform Lives*. A Joint Publication of the World Bank/TerrAfrica and UNCCD Secretariat, with contributions from International Union for the Conservation of Nature, The Global Environment Facility, UNDP's Global Policy Centre on Resilient Ecosystems and Desertification and the UNCCD Land for Life Programme.

UNCCD (2012). *Zero net land degradation: A new sustainable development goal for Rio+ 20*. Secretariat of the United Nations Convention to Combat Desertification (UNCCD).

United Nations (2011). *Global Drylands: A UN system-wide response*. Prepared by the Environment Management Group. United Nations.

United Nations Development Programme. (2017). *Coherence of Sustainable Development Goals, Climate Change Adaptation and Sendai framework on Disaster Risk Reduction at the International Perspective.* Speech by Ms. Beate Trankmann, Mongolia Resident Coordinator, United Nations.

University of Reading Statistical Centre. (2000). *Guidelines for Planning Effective Surveys*. Statistical Services Centre, University of Reading.

Valters, C. (2015). *Theories of Change: Time for a radical approach to learning in development*. Overseas Development Institute (ODI). 203 Blackfriars Road.

Value chain partnership Group (2011). *Value Chain Partnerships in food and agriculture working groups*. www.valuechains.org.

Van Buuren, A., & J. Edelenbos. (2006). Innovations in the Dutch polder: Communities of practice and the challenge of coevolution. *Emergence: Complexity and Organization* 8(1) 42-49

Van Putten, I., F. Boschetti, E. A. Fulton, A. D. Smith, M., & Thebaud. O (2014). Individual transferable quota contribution to environmental stewardship: a theory in need of validation. *Ecology and Society,* 19(2): 35.

Van Slyke, D.M. (2005). Agents or Stewards: Using Theory to Understand the Government-Nonprofit Social Service Contracting Relationship. *Journal of Public Administration Research and Theory, 2*(17): 157-87.

Vankeerberghen, A., & Stassart, P. M. (2016). The transition to conservation agriculture: An insularization process towards sustainability. *International Journal of Agricultural Sustainability, 14*, 392–407. https://doi.org/10.1080/14735903.2016.1141561

Verdoodt, A., Mureithi, S.M, & Van Ranst, E. (2010). Impacts of management and enclosure age on recovery of the herbaceous rangeland vegetation in semi-arid Kenya. *Journal of Arid Environments, 74*, 1066–1073.

Victorian Catchment Management Council and Department of Sustainability and Environment. (2003). *Land Stewardship, Ecosystem Services through Land Stewardship Practices: Issues and Options,* http://www.landcarevic.net.au/resources/publications/

Von Braun, J., Gerber, N., Mirzabaev, A., & Nkonya, E. (2013). *The economics of land degradation.* ZEF Working Paper Series, 109.

Wairore, J., Mureithi, S., Wasonga, O., & Nyberg, G. (2015). *Benefits derived from rehabilitating a degraded semi-arid rangeland in private enclosures in west pokot county, Kenya.* Published online in Wiley Online Library (wiley onlinelibrary.com).

Warf, B., & Sui, D. (2010). From GIS to neogeography: Ontological implications and theories of truth. *Annals of GIS*, *16*(4), 197–209. https://doi.org/10.1080/19475683.2010.539985

Warner, K.D. (2007). *Agroecology in Action: Extending Alternative Agriculture through Social Networks*. Cambridge, MA: MIT Press.

Wasige, J. E., Groen, T. A., Smaling, E., & Jetten, V. (2013). Monitoring basin-scale land cover changes in Kagera Basin of Lake Victoria using ancillary data and remote sensing. *International Journal of Applied Earth Observation and Geoinformation, 21*, 32-42.

Webler, T., Kastenholz, H. & Renn, O. (1995). Public participation in impact assessment: a social learning perspective. *Environmental Impact Assessment Review, 15*, 443–463.

Weiss, C. (1995). *Nothing as Practical as Good Theory: Exploring Theory-Based Evaluation for Comprehensive Community Initiatives for Children and Families* in 'New Approaches to Evaluating Community Initiatives'. Aspen Institute.

Wenger, E. (2006). *Cultivating communities of practice: A quick start-up guide,* http://www.ewenger.com/theory/index.htm

Wenger, E. (2009). *Communities of practice and social learning systems: The career of a concept.* http://www.ewenger.com/pub/index.htm

Wenger, E., Fenton-O'Creevy, M., Hutchinson, M., Kubiak, C., & Trayner, B. (2015). *Learning in landscapes of practice*. Routledge Press.

Wenger, E., Trayner, B., & Maarten, L. (2011). *Promoting and assessing value creation in communities and networks: a conceptual framework*. Ruud de Moor Centrum.

Wenger. E., McDermott. R. & Snyder. W., (2002). *A Guide to Managing Knowledge: Cultivating Communities of Practice.* Harvard Business School Publishing.

Wennink, B., Nederlof, E.S., & Heemskerk, W. (2007) *Access of the poor to Agricultural Services: the role of farmer organizations in social inclusion*. KIT bulletin.

Whitfield, S., & Reed, M.S., (2012). Participatory environmental assessment in drylands: introducing a new approach. *Journal of Arid Environment. 77*, 1-10.

Woodhill, A.J. (2004). Dialogue and transboundary water resources management: Towards a framework for facilitating social learning. In: Langaas S, Timmerman JG (eds). *The role and use of information in European transboundary river basin management*. IWA Publishing. pp 44–59.

Woodhill, J., & Rolling, N. (2000). The Second Wing of the Eagle: The Human Dimension in Learning our Way to more Sustainable Future", in Rolling N. (ed.), *Facilitating Sustainable Agriculture.* Participatory Learning and Adaptive Management in Times of Environmental Uncertainity, pp 46-71.

World Agroforestly Centre. (2017). *Restoration of degraded land for food security and poverty reduction in East Africa and the Sahel: taking successes in land restoration to scale. A project Brief.* http://www.worldagroforestry.org/project/restoration-degraded-land-food-security-and-poverty-reduction-east-africa-and-sahel-taking

World Bank. (2008). *Gender in Agriculture Source book. The international bank for reconstruction and development*, World Bank.

World Bank. (2006). *Enhancing Agricultural Innovation: How to Go Beyond the Strengthening of Research Systems.* Agriculture and Rural Development, The World Bank.

Yin, R.K. (2009). *Case study research: Design and methods* (4th Ed.). Thousand Oaks, CA: Sage Publishing.

Zeweld, W.; Van Huylenbroeck, G.; Tesfay, G.; Azadi, H., & Speelman, S. (2018). Impacts of Socio-Psychological Factors on Actual Adoption of Sustainable Land Management

Practices in Dryland and Water Stressed Areas. *Sustainability 10*, 2963. https://doi.org/10.3390/su10092963

APPENDICES

Appendix A: Household Questionnaire

Introduction

This survey is aimed at assessing the causes and impact of land degradation and the challenges of rehabilitation of degraded lands among agropastoralists in Baringo South sub-county. Your honest answers are important to this study and will be treated with utmost confidentiality.

SECTION I: SOCIO-ECONOMIC BACKGROUND OF THE HOUSEHOLD HEADS

Date of interview_____

Ward_____

1) Age _____
2) Gender of the household Head Male [ ] Female [ ]
3) Marital status [(1) Married [ ] (2) Widow/Widower [ ]
   (3) Unmarried [ ] (4) Separated) [ ]
4) Level of education
   (1) No formal Education [ ] (2) Lower Primary [ ]
   (3) KCPE [ ] (4) Secondary [ ]
   (5) Tertiary [ ]
5) Family size._____
6) Land size (acres). _____
7) Occupation ----------
8) Land tenure:
   (1) Owned with title deed [ ] (2) Owned without title deed [ ]
   (3) Rented [ ] (4) Community owned [ ]
   (5) Others Specify_____
9) Size of land grown crops in acres _____

10) Indicate the main enterprises you have on your farm

Crops	**Acres**	**Livestock enterprises**	**Numbers**
Maize		Goats	
Beans		Cattle	
Sorghum		Sheep	
Millet		Chicken	
Green grams		Bees (Hives)	

Others		Others	

11) Indicate sources of household income and approximate total earnings per year

Source of income	**Yearly earnings (Ksh)**
Livestock farming	
Crop Farming	
Salary from Employment	
Small business (Kiosk, shop, bar)	
Assistance from relatives	
Selling charcoal	
Others (specify)	
TOTAL	

12) Have you accessed a loan for improving agricultural production in the last 5 years?

1. Yes **[ ]** 2. No **[ ]**

14) If yes, indicate the institution you obtained the loan?

1. Bank **[ ]** 2.Farmers SACCO **[ ]**
3. Farmer group **[ ]** 4. Microfinance **[ ]**
5. Others …….

SECTION II: LAND USE AND COVER CHANGE

1) How long have you practiced farming/pastoralism/agropastoralism in the area?----------

-

2) During this time, have you noted any land use and cover change in the area?

1.Yes [ ] 2.No [ ]

3). If yes**,** how has land use and cover changed during time of your residence in the area

Indicate the level and reasons for the change

Land use Change	**Same=0 Decrease =1 Increase =2**	**% Change**	**Reasons for the change**
Number of cattle			
Number of goats			
Number of sheep			
Poultry			
Cropped land			
Nomadism			
Trees			
Shrubs			
Natural pasture			
Towns			

Reasons of land use/cover change

1=Increased family expenses 2=Increased droughts and Water scarcity

3=Larger and better market access 4=To Compensate for decreased livestock

5=Land privatization and enclosing 6=Increased population

7= Invasive Prosopis (Mathenge) 8=New livestock pests and diseases

9=Insecurity/Conflict over pasture 10=charcoal burning

11. migration 12=overgrazing

4) What are the effects of land use changes on community livelihoods? Tick Appropriately

Negative effects	**Tick**	**Positive effects**	**Tick**
Land degradation		Improved road infrastructure	
Increased land based/pasture conflicts		Better disease and pest control	
Increase in land sales/commodification		Increased household income	
Land fragmentation with no title deeds		Better access to education	
Low livestock productivity		New technologies	
Youth migration/loss of labour		Access to a larger market	
Increase in vulnerability		Better access to health facilities	
Landlessness/squatters		General development	

5) How do households deal with land use and landcover change?

1. Extensification (more land opened) [ ]
2. Intensification (more technology/inputs) [ ]
3. Diversification (kiosk, charcoal burning, crop farming) [ ]
4. Migration [ ]
5. Form partnerships/Join groups/Building social capita [ ]

SECTION III: LAND DEGRADATION AND SUSTAINABLE LAND MANAGEMENT

1) How serious is the problem of land degradation in your area? Tick

(1). Not serious [ ] (2). Somewhat serious [ ]

(3) Moderately serious [ ] (4) Very serious [ ]

2) What are the common indicators of land degradation in the area? Tick

1. Gullies [ ] 2. Invasive species [ ]

3. Bare ground [ ] 4. Flooding of the lake

5.Disappearance of preferred natural pasture grasses [ ]

6. Others(specify)---------- ----

3) How has land degradation affected your area/community? Tick

1. Increased Droughts and Water scarcity [ ]
2. Increased Pasture conflicts [ ]
3. Loss of grazing and agriculture land [ ]
4. Loss of indigenous trees, shrubs and grasses [ ]
5. Human displacement [ ]
6. Destruction of infrastructure and social amenities [ ]
7. Increase in livestock and human diseases [ ]
8. Others ----------

4) In your opinion what are the causes of land degradation in the area?

1. Invasive species [ ]
2. Over grazing [ ]
3. Prolonged droughts [ ]
4. Erosion customary institutions governing land [ ]
5. Deforestation [ ]
6. Poor agricultural practices [ ]
7. Loose soils [ ]
8. Insecurity of Tenure [ ]
9. Others----------

5) What practices are you using in your farm to stop/rehabilitate degraded land? Tick

(1). Terraces [ ] (2). Organic manure [ ]
(3). Mulching [ ] (4). Check dams [ ]
(5). Agroforestry [ ] (6). Paddocking pasture land [ ]
(7). Trash lines [ ] (8). Water pans [ ]
(9). Cover Crops [ ] (10). Others----------

6) What challenges do you face in carrying out the above practices? Tick

(1). Labour shortage [ ] (2). High cost of SLM practices [ ]
(3). Lack of knowledge and skills [ ] (4).Land tenure security [ ]
(5). Climatic Variation [ ] (6).Others ----------

7) How do you rate your own level of knowledge about combating and rehabilitation of degraded land? Use likert scale below.

(1) Very low [ ] (2) Low [ ] (3) Moderate [ ]

(4) High [ ] (5) Very High [ ]

8) From where do you obtain information about rehabilitation of degraded lands practices?

(1) Neighbors [ ] (2) Government Extension [ ]

(3) Community/Farmers groups[ ] (4) Agro-dealers [ ]

(5) NGOs [ ] (6) Radio [ ]

IV. FARMER GROUPS AND THEIR SUPPORTING AGENCIES

1) Are you a member of a community group involved in any agricultural, natural resources management or environmental conservation activities?

1. Yes [ ] 2. No [ ]

2) How many such groups do you belong to? ----------

3) How many members of your household s belong to the above type of groups ----------

4) Which position do you hold in the group?

1. Official **[ ]**
2. Ex-official **[ ]**
3. Ordinary member **[ ]**

5) What was your reason for joining the group? Tick

Reason for joining group	**Tick**	**Have your reasons been met? (Yes=1; No=0)**	**To which extent? 1= Low 2=Moderate 3=High**
Access to credit and for funding			
Labor Sharing			
Access to inputs (free or subsidized)			
Access to Market			
Access to agricultural extension services			
Joint management of grazing land			
Access to common resources			
promote environmental conservation			
Others (Specify)			

6) Which conditions did you have to fulfill to become and remain a member of your group?

1.Pay Membership fee **[ ]** 2. Abide by groups by-laws **[ ]**

3. Pay group contributions on time **[ ]** 4. Attendance of meetings **[ ]**

5**.** Resident in the area **[ ]**

7) How was your group formed? _____

1. Own efforts **[ ]** 2. Through government project **[ ]** 3. Initiated by NGO **[ ]**

8) In your view, to what extent do you participate in this group's general activities compared to other members

1. Low [ ] 2. Moderate [ ] 3. High [ ]

9)Does your group work or interact with other groups or agencies with similar goals?

1. No [ ] 2. Yes, occasionally [ ] 3. Yes, frequently [ ]

10) Which agencies/groups does your group interact with and what support do you get from those agencies?

Agency	**Support**	**Level of support** **1= Low 2=Moderate 3=High**
Ministry of Agriculture		
KALRO		
Kerio development Authority		
World Vision		
County Government of Baringo		
RAE		
Kenya Red cross Society		

Support

1=Credit 2=Extension Information 3= Material support in form of inputs

4=Markets 5**=** Grants 6= Agricultural Technology

7=Training and capacity building 8= Food aid / famine relief

11) (***For group non-members***) Why have you not joined a group?

1. Lack of interest **[ ]** 2. Lack of time **[ ]**

3. Lack of trust **[ ]** 4. High participation expenses **[ ]**

12) Have you ever been a member of a group and left?

1. Yes **[ ]** 2.No **[ ]**

If yes why did you leave the group?

1. Left because group was not useful/profitable **[ ]**
2. Left because of poor management **[ ]**
3. Unable to pay annual subscription fee **[ ]**
4. Group ceased to exist **[ ]**

V. USE OF ENCLOSURES IN REHABILITATION OF DEGRADED LANDS

1) Is your land fenced? Yes [ ] NO [ ]
2) If yes, what are your reasons/benefits of fencing land? Tick
    1. Pasture conservation [ ]
    2. Facilitate crop farming [ ]
    3. Soil erosion control [ ]
    4. Marking boundary [ ]
    5. Others (specify) ----------
3) If No, why? Tick
    1. Labour [ ] 3. Capita [ ]
    2. Fence attracts snakes [ ] 4. Land is communal [ ]
    5.Others ----------
4) Has fencing land been beneficial in rehabilitating degraded lands?
    Yes [ ]. No **[ ]**
5) How has it beneficial? Tick
    1. Increased pasture **[ ]** 2) Facilitate crop farming **[ ]**
    3) Enabled livestock improvement **[ ]** 4) Facilitates pasture conservation **[ ]**
    5) Prevents over grazing **[ ]** 6) Reduced soil erosion **[ ]**
    7) Improved soil fertility **[ ]** 8) Soil water conservation **[ ]**
    8) Stemmed Trampling **[ ]** (9) Others, specify----------
6) In your opinion, should land be governed communally or privately?
    1.Communally **[ ]** 2. Privately **[ ]** **3.** Both integrated
7) Give reasons for your answer above (6). ***Only one not both***
8) What are the other effects of enclosing communal land in the area?
    1. Loss of communal grazing land for non members [ ]
    2. Land fragmentation [ ]
    3. Vulnerability to droughts to non-members [ ]
    4. Land conflicts [ ]
    5. Decrease in nomadism [ ]
    6. Others ----------

Appendix B: Focus Group Discussion Topic Guide

A. LAND USE CHANGE

i. How has land use and cover changed in the area in the last 30 years?
ii. What are the causes of these changes?
iii. What are the positive effects of the land use changes on the area?
iv. What are the negative effects of the land use changes on the area?

B. LAND DEGRADATION

i. What are the indicators of land degradation in the area?
ii. What are the causes of land degradation in the area?
iii. What are the effects of land degradation on the area environment?
iv. How does land degradation affect farmers' livelihoods in the area?

C. COMBATING LAND DEGRADATION PRACTICES

i. What land degradation practices do farmers in the area use?
ii. What are the challenges faced by farmers in implementing the land degradation mitigative practices?

D. SUPPORTING AGENCIES IN COMBATING LAND DEGRADATION

i. Which agencies support the farmers in the area in the mitigation of land degradation?
ii. What support do those agencies provide?
iii. How are the agencies involved?

Appendix C: Community of Practice Performance Evaluation

Introduction

The purpose of this survey is to evaluate the Community of Practice for the rehabilitation of degraded lands inNjemps Flats. Your honest answers are important to this study and will be treated with utmost confidentiality.

SECTION I: SOCIO-ECONOMIC BACKGROUND OF THE RESPONDENTS

1. Age _____
2. Marital status

   [(1) Married [ ] (2) Widowed [ ]

   (3) Unmarried [ ] (4) Separated) [ ]
3. Level of formal education

   (1) None [ ] (2) Lower Primary [ ]

   (3) KCPE [ ] (4) Secondary [ ]

   (5) Tertiary [ ]
4. Family size. _____
5. Land size (acres)_____
6. Cropped land _____
7. Indicate the livestock enterprises you have on your farm

Livestock enterprises	**Numbers**
Goats	
Cattle	
Sheep	
Chicken	
Bees (Hives)	
Others	

8. Please indicate why you joined the Cop

   (1) Connect with other farmers in the area [ ]

   (2) Access extension services [ ]

   (3) Start income generating activities in groups [ ]

   (4) Have people to depend on at time of crises [ ]

   (5) Others [ ]

9. How many other agricultural related groups do you belong to? _____
10. Do you hold any leadership position in this group or any other agricultural related group? 1. Yes [ ] 2. No [ ]
11. On a scale of 0 to 5 rate the following statements by recording the score that best reflects your level of participation in the following group activities.

Activity	**Rating**					
	0	**1**	**2**	**3**	**4**	**5**
Attendance to meetings internal to the group						
Attendance to meetings external to the group						
Participation in planning and decision making						
Participation in field days						
Timely financial contributions to the group						
Volunteer labour						
Sharing of skills and information with members						
Seeking information on group issues						
Contribute inputs						
Facilitating trials and demonstration						

SECTION II: EVALUATION OF THE COMMUNITY OF PRACTICE

1. Knowledge acquired in CoP

Rate the level of knowledge acquired in the following areas trained in the group in the last 8 months?

Training areas	**Level of Knowledge**				
	Very Low	**Low**	**Moderate**	**High**	**Very High**
Group formation					
Pasture production					
Pasture conservation					
Land degradation					
Tree nursery management					
Book Keeping					
Bee keeping					
Honey processing					

Proposal writing					

2. The level of CoP Generating of social Capital

i. The following statements indicate the effectiveness of the group in generating **bonding social capital.** Record the score that best reflects the level of bonding in the group on a scale of 0-5.

Statement	**Rating**					
	0	**1**	**2**	**3**	**4**	**5**
Members willingness to help in times of crises						
I express my opinions without fear of being judged						
I am comfortable asking for clarification						
Members are trusted to reciprocate good deeds						
Conflicts are dealt with amicably						
Members interact with each other outside group meetings						
There is a strong sense of belonging to the group						

ii. The following statements indicate the effectiveness of the group in generating **Bridging and linking social capital**. Record the score that best reflects the level of Bridging and linking social capital in the group on a scale of 0-5.

Statement	**Rating**					
Membership to more than one group	**0**	**1**	**2**	**3**	**4**	**5**
Access of information from NGOs						
Access to extension services						
Linkage to research						
Interaction with other groups with same interests						
Interaction with policy makers (government officials)						

3. Please indicate the level of knowledge you have acquired on the listed **SLM practices** through CoP training.

SLM Practice	**Level of Knowledge**				
	Very Low	**Low**	**Moderate**	**High**	**Very High**
Sand bags					
Cover cropping					
Terraces					
Tied ridges					
Minimum tillage					
Use of organic manure					
Check dams					
Water pans					
Zai pit					
Mulching					
Stone terrace					
Trashlines					
Others					

4. On a scale of 0-5, rate the following statements regarding the influence of interaction and learning in the group on **building stewardship**

Statement	**0**	**1**	**2**	**3**	**4**	**5**
I have a responsibility to take care of the environment for the future generations						
The learning raised my concerns about environmental degradation						
Natural resources are abundant and limitless so there is no need for conservation						
We will experience a major environmental disaster if land degradation continues						
Humans are severely abusing the environment						
I would be willing to contribute finances and labour for environmental conservation work						
Humans can co-exist with the nature						

5. Impact of social learning on Adoption behavior

The following statements indicate members uptake or future likelihood to adopt Sustainable Land Management (SLM) practices due to participation in CoP

Statement	**0**	**1**	**2**	**3**	**4**	**5**
I find the technology developed and tried through the group to be relevant to my situation						
Interaction with extension and research in the group motivates me to give the innovations a try						
Interactions in the group have improved self-confidence towards participating and sharing knowledge in groups						
The knowledge gained has led me to follow better farming practices						
Exposure to information from the group has improved my perception towards innovations						
Involvement of local leaders in training motivates me to give it a try						
Participation in group trainings has improved my confidence towards adoption						
Participating in planning and implementation gives me confidence to act						

6. Are there challenges you encounter in being a member of the group? (tick)
    1. Conflict [ ]
    2. Lack of transparency and unaccountability [ ]
    3. Climatic change [ ]
    4. Late contributions [ ]
    5. Poverty [ ]
    6. Political interference [ ]
    7. Personal interests [ ]
    8. Poor leadership [ ]
    9. Others----------

7. Suggest how the above challenges be addressed?

Appendix D: Letter of Research Authorization

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY AND INNOVATION

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

NACOSTI, Upper Kabete
Off Waiyaki Way
P.O. Box 30623-00100
NAIROBI-KENYA

Ref. No. **NACOSTI/P/19/62471/27713** Date: **1st February, 2019**

Rebecca Njoki Karaya
Egerton University
P.O. Box 536-20115
NJORO

RE: RESEARCH AUTHORIZATION

Following your application for authority to carry out research on ***"Role of social learning in linking knowledge and practice for the rehabilitation of degraded drylands in Njemps Flats, Baringo County, Kenya"*** I am pleased to inform you that you have been authorized to undertake research in **Baringo County** for the period ending **1st February, 2020.**

You are advised to report to **the County Commissioner and the County Director of Education, Baringo County** before embarking on the research project.

Kindly note that, as an applicant who has been licensed under the Science, Technology and Innovation Act, 2013 to conduct research in Kenya, you shall deposit **a copy** of the final research report to the Commission within **one year** of completion. The soft copy of the same should be submitted through the Online Research Information System.

DR. MOSES RUGUTT, PHD, OGW
DIRECTOR GENERAL/CEO

Copy to:

The County Commissioner
Baringo County.

The County Director of Education
Baringo County

Appendix E: Research Permit

THIS IS TO CERTIFY THAT:
MS. REBECCA NJOKI KARAYA
of EGERTON UNIVERSITY, 1957-10101
Karatina,has been permitted to conduct
research in *Baringo County*

on the topic: *ROLE OF SOCIAL LEARNING IN LINKING KNOWLEDGE AND PRACTICE FOR THE REHABILITATION OF DEGRADED DRYLANDS IN NJEMPS FLATS, BARINGO COUNTY, KENYA*

for the period ending:
1st February,2020

.....
Applicant's Signature

Permit No : NACOSTI/P/19/62471/27713
Date Of Issue : 1st February,2019
Fee Recieved :Ksh 2000

.....
Director General
National Commission for Science, Technology & Innovation

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013

The Grant of Research Licenses is guided by the Science, Technology and Innovation (Research Licensing) Regulations, 2014.

CONDITIONS

1. The License is valid for the proposed research, location and specified period.
2. The License and any rights thereunder are non-transferable.
3. The Licensee shall inform the County Governor before commencement of the research.
4. Excavation, filming and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
5. The License does not give authority to transfer research materials.
6. NACOSTI may monitor and evaluate the licensed research project.
7. The Licensee shall submit one hard copy and upload a soft copy of their final report within one year of completion of the research.
8. NACOSTI reserves the right to modify the conditions of the License including cancellation without prior notice.

National Commission for Science, Technology and innovation
P.O. Box 30623 - 00100, Nairobi, Kenya
TEL: 020 400 7000, 0713 788787, 0735 404245
Email: dg@nacosti.go.ke, registry@nacosti.go.ke
Website: www.nacosti.go.ke

REPUBLIC OF KENYA

National Commission for Science, Technology and Innovation

RESEARCH LICENSE

Serial No.A 22992

CONDITIONS: see back page

Appendix F: Journal Publications

Asian Journal of Agricultural Extension, Economics & Sociology

38(11): 66-80, 2020; Article no.AJAEES.63392
ISSN: 2320-7027

The Effect of Participation in Farmer Groups on Household Adoption of Sustainable Land Management Practices in Kenyan Drylands

Rebecca N. Karaya[1,2*], Christopher A. Onyango[1] and George M. Ogendi[3,4]

[1]Department of Agricultural Education and Extension, Egerton University, Kenya.
[2]Department of Agricultural Sciences, Karatina University, Kenya.
[3]Department of Environmental Sciences, Egerton University, Kenya.
[4]Dryland Research Training and Ecotourism Centre, Chemeron, Kenya.

Authors' contributions

This work was carried out in collaboration among all authors. Author RNK designed the study, performed the statistical analysis and wrote the first draft of the manuscript. Authors CAO and GMO reviewed the study design and the first manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJAEES/2020/v38i1130454
Editor(s):
(1) Dr. Zhao Chen, University of Maryland, USA.
(2) Dr. Ian McFarlane(Rtd.), University of Reading, UK.
Reviewers:
(1) Svitlana Grygoruk, Khmelnytsky National University, Ukraine.
(2) Ronald Kakeeto, National Agricultural Research Organisation (NARO), Uganda.
Complete Peer review History: http://www.sdiarticle4.com/review-history/63392

Original Research Article

Received 24 September 2020
Accepted 28 November 2020
Published 05 December 2020

ABSTRACT

Land degradation is a major cause of declining yields and loss of dryland ecosystems resilience in the Lake Baringo Basin in Kenya. One of the solutions to land degradation in drylands is the application of Sustainable Land Management (SLM) technologies. Improving farmers' capacity to adopt SLM technologies has been an important strategy of the Kenyan government and her development partners to addressing land degradation. State agricultural extension services are charged with the role of building this capacity. Unfortunately, such extension services have had little impact in the Kenyan drylands. To counter this inadequacy in extension services, farmers have formed grass-root organisations to foster networks of support and information sharing. In this paper, we analysed the effect of participation in farmers organisation in promoting adoption of SLM practices by agropastoralists in the Lake Baringo Basin. Data were collected through in-depth

**Corresponding author: E-mail: rebeccakaraya@gmail.com;*

Karaya et al., *Cogent Food & Agriculture* (2021), *7*: 1872852
https://doi.org/10.1080/23311932.2021.1872852

cogent food & agriculture

SOIL & CROP SCIENCES | RESEARCH ARTICLE

A community-GIS supported dryland use and cover change assessment: The case of the Njemps flats in Kenya

Rebecca N. Karaya[1,2]*, Christopher A. Onyango[2] and George M. Ogendi[3,4]

Received: 29 October 2020
Accepted: 04 January 2021

*Corresponding author: Rebecca N. Karaya, Department of Agricultural Education and Extension, Egerton University, Nakuru, Kenya
E-mail: rebeccakaraya@gmail.com

Reviewing editor:
Manuel Tejada Moral, University of Seville, Seville, Spain

Additional information is available at the end of the article

Abstract: Land use and Land Cover Changes (LULCC) are a major cause of environmental degradation in Sub-Saharan Africa (SSA) drylands and hence a serious problem to sustainable utilization and development of those lands. Involving communities in their detection and identification can empower and convince them of the importance of adopting practices that minimize their undesirable impacts. In this study, we applied a GIS assisted community participatory approach to detect LULCC, their drivers and effects in the drylands of mid rift valley Kenya. Focus group discussions, key informant and household head interviews were corroborated with three Landsat images for three periods of 1980, 1995 and 2019. Results from community interviews and focus group discussion reported increasing trends in cropland and shrubland, Declining trend were reported in livestock mobility, livestock herd size, forest land and natural grasses. The GIS analysis reported increase of cropland from 370 Ha to 2889 Ha, increase in shrubland by 4.2%, expansion of Lake Baringo by 1.4%, decrease in forest cover by 1.2% and decrease in natural grass pastures by 1.1%. Major driving forces for LULCC were identified as population growth, insecurity caused by cattle rustling, government policies and interventions,

Rebecca N. Karaya

ABOUT THE AUTHOR

Rebecca Karaya was born in Kenya. She studied a BSc in agriculture education and extension, MSc in Agriculture Extension from Egerton University. She has done research projects in women group and food security, reduction of post-harvest losses in maize in Arid and Semi-Arid areas in Kenya and rehabilitation of degraded lands in Kenyan drylands. Rebecca is currently a PhD fellow in agriculture and rural innovations in Egerton University and works as a tutorial fellow in Karatina University Kenya. Her research interests include rural innovation systems, sustainable land management and gender in agriculture and rural development.

PUBLIC INTEREST STATEMENT

Kenyan drylands are faced with rapid Land Use and Land Cover Change (LULCC) that affect their ability to provide ecosystem services. Driven by factors like population growth, government policies and climate change, LULCC is associated with biodiversity loss and environmental degradation. Identifying LULCC, drivers and impacts provide critical information for developing effective policy strategies to slow and reverse their adverse effects. One of the most used methods for detecting LULCC is remote sensing and Geographic Information System (GIS) which has been criticised for being too top-bottom and needing specialized expertise to do and interpret. Integrating GIS with community participatory methods allow for an in between where researchers can introduce information in a discursive manner while co-opting local knowledge with scientific and practitioner knowledge in detecting and identification of LULCC. Our study suggests government policy strategies and interventions that halts and mitigate the adverse effects of LULCC in Kenyan drylands.

Karaya et al., *Cogent Food & Agriculture* (2021), *7*: 1872852
https://doi.org/10.1080/23311932.2021.1872852

cogent food & agriculture

SOIL & CROP SCIENCES | RESEARCH ARTICLE

A community-GIS supported dryland use and cover change assessment: The case of the Njemps flats in Kenya

Rebecca N. Karaya[1,2]*, Christopher A. Onyango[2] and George M. Ogendi[3,4]

Received: 29 October 2020
Accepted: 04 January 2021

*Corresponding author: Rebecca N. Karaya, Department of Agricultural Education and Extension, Egerton University, Nakuru, Kenya
E-mail: rebeccakaraya@gmail.com

Reviewing editor:
Manuel Tejada Moral, University of Seville, Seville, Spain

Additional information is available at the end of the article

Abstract: Land use and Land Cover Changes (LULCC) are a major cause of environmental degradation in Sub-Saharan Africa (SSA) drylands and hence a serious problem to sustainable utilization and development of those lands. Involving communities in their detection and identification can empower and convince them of the importance of adopting practices that minimize their undesirable impacts. In this study, we applied a GIS assisted community participatory approach to detect LULCC, their drivers and effects in the drylands of mid rift valley Kenya. Focus group discussions, key informant and household head interviews were corroborated with three Landsat images for three periods of 1980, 1995 and 2019. Results from community interviews and focus group discussion reported increasing trends in cropland and shrubland, Declining trend were reported in livestock mobility, livestock herd size, forest land and natural grasses. The GIS analysis reported increase of cropland from 370 Ha to 2889 Ha, increase in shrubland by 4.2%, expansion of Lake Baringo by 1.4%, decrease in forest cover by 1.2% and decrease in natural grass pastures by 1.1%. Major driving forces for LULCC were identified as population growth, insecurity caused by cattle rustling, government policies and interventions,

Rebecca N. Karaya

ABOUT THE AUTHOR

Rebecca Karaya was born in Kenya. She studied a BSc in agriculture education and extension, MSc in Agriculture Extension from Egerton University. She has done research projects in women group and food security, reduction of post-harvest losses in maize in Arid and Semi-Arid areas in Kenya and rehabilitation of degraded lands in Kenyan drylands. Rebecca is currently a PhD fellow in agriculture and rural innovations in Egerton University and works as a tutorial fellow in Karatina University Kenya. Her research interests include rural innovation systems, sustainable land management and gender in agriculture and rural development.

PUBLIC INTEREST STATEMENT

Kenyan drylands are faced with rapid Land Use and Land Cover Change (LULCC) that affect their ability to provide ecosystem services. Driven by factors like population growth, government policies and climate change, LULCC is associated with biodiversity loss and environmental degradation. Identifying LULCC, drivers and impacts provide critical information for developing effective policy strategies to slow and reverse their adverse effects. One of the most used methods for detecting LULCC is remote sensing and Geographic Information System (GIS) which has been criticised for being too top-bottom and needing specialized expertise to do and interpret. Integrating GIS with community participatory methods allow for an in between where researchers can introduce information in a discursive manner while co-opting local knowledge with scientific and practitioner knowledge in detecting and identification of LULCC. Our study suggests government policy strategies and interventions that halts and mitigate the adverse effects of LULCC in Kenyan drylands.