SOCIO-ECONOMIC AND TECHNICAL ASSESSMENT OF ADAPTIVE CAPACITY TO CLIMATE CHANGE ADAPTATION AMONG THE TRANSITIONING PASTORALIST AND AGRO-PASTORALIST HOUSEHOLDS OF LAIKIPIA COUNTY, KENYA

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DECLARATION

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

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Socio-economic and technical assessment of adaptive capacity to climate change adaptation among the transitioning pastoralist and agro-pastoralist households of Laikipia County, Kenya.

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DEDICATION

I would like to dedicate this thesis to

my family, my beloved husband; Eng. Samuel Ng'ang'a Muiru, and our two sons, Noel Muiru and Newton Njuguna;

to the people of Il Ngwesi Group Ranch; and

all my friends without whom this work would not have been possible

And above all

To God Almighty

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LIST OF ABBREVIATIONS AND ACRONMYS

ASALs	Arid and Semi-Arid Lands
CSA	Climate-Smart Agricultural
DAAD	Germany Academic Exchange Service
EA	Eastern Africa
FGD	Focus Group Discussions
GHG	Greenhouse Gas
HH	Households
ICRAF	World Agroforestry Centre
IPCC	Intergovernmental Panel on Climate Change
KMC	Kenya Meat Commission
LAC	Local Adaptive Capacity framework
LARMAT	Land Resources Management and Agricultural Technologies
LGACC	Local Governance for Adaptation to Climate Change
ILRI	International Livestock Research Institute
MVP	Multivariate Probit
NGOs	Non-Governmental Organizations
ODK	Open Data Kit system
SES	Social-Ecological System's
SSA	Sub Saharan Africa

SLP	Sustainable Livelihoods Framework
USAID	United States Agency for International Development
WRUAs	Water Resources Users Associations

ABSTRACT

Climate change in Africa, the worst hit continent is real with observable changes due to its high levels of vulnerability. Sub Saharan Africa (SSA) home to nearly 300 million poor people is portrayed as a susceptible territory to the impact of climate change considering her low adaptive capacity to anticipated extreme events. The situation in the Kenyan arid and semi-arid lands (ASALs) is expounded by community over reliance on climate sensitive natural assets and ecosystems resources for their livelihood and food security. The dryland community, although have greatly benefited from the goods and services provided by the ecosystem, their future reliance on the same is very uncertain. The effect may be experienced in the future; however, some negative consequences are already felt now. Debates in adaptation science has attracted and developed interest especially in developing countries who call in support of building the adaptive capacity of these vulnerable communities to the consequences of climate change.

This PhD work builds on what is known and discussed about adaptation as a feature of human-environmental systems or as referred in literature as Social-Ecological Systems (SESs). Understanding adaptive capacity of such a system within the adaptation framework requires an empirical analysis of the complex social process framed by intangible processes of: innovations fostering; social institutional and entitlements; Asset's base; knowledge and information and decision making and governance. This thesis research undertakes an empirical assessment of adaptive capacity as a social technical process among the pastoralists and agro-pastoralists of Il Ngwesi group ranch, Northern Rift of Laikipia County, Kenya. Specifically analyzing household adaptation practices that facilitates the transition of the dryland community from pastoralism to agro-pastoralism. Secondly, characterizing assets and resources available in the commons that determine adaptive capacity of the pastoral and agro-pastoral community, and finally evaluating how access to these resources differentiate adaptive capacity among the community.

The study focused on members of Il Ngwesi Group Ranch, Laikipia County, Kenya living in the conservancy and those in the neighborhoods. Two regions were therefore considered, inside and outside the conservancy. Mixed methods of data collected was used, engaging both qualitative and quantitative approaches. Quantitative data was first analyzed using descriptive statistics and later econometric models such as Heckman Probit and Multivariate Probit Model. Qualitative data was manually coded for general trends and further interpretation.

The results show that irrigation is a growing adaptation practice that acts as a bridge in the transformation process of the pastoral community, transiting from pastoralism to agro-pastoralism. The social economic drivers that encourage its uptake are identified as: good quality land for food crops (**1.152****), government assistance (**0.906****), and large herds of livestock (small (**-0.473***) and medium (**-0.931****) livestock herds) as financial base and governance of community land tenure regime (**1.556****). Additionally agronomic information (**1.094*****) through extension services and targeting the young generation often left out of development interventions (older household heads (**-0.0219***)). Further results show three fundamental components that require more attention in adaptive capacity interventions, research and policy. These are: household asset, relevant information that shapes adaptation process and multi-level governance of land tenure regimes in pasture management in the drylands. Finally, social differentiation is viewed as an outcome of differentiated adaptation pathways that dictates institutional re-arrangement to create new knowledge and to accommodate the process of change. This calls to paying attention to this unfolding scenario, unpacking the broader term "adaptation" to "socially differentiated adaptation" to avoid effects of accelerating the growing inequality in the drylands where households are not coherent and homogenous units for either research, policy or development.

DEFINATION OF OPERATION TERMS

Adaptation: Adaptation to climate change is a demonstration of adaptive capacity (Smit and Wandel, 2006).

Adaptive capacity is a reflection of the potential of a system to adapt to the effects or impacts of climate change (Downing , 1991) and involves changes to better deal with problematic exposures and sensitivities (Smit and Wandel, 2006).

Social differentiation is a distinction made often in social science literature between social groups. The differentiation would be based on socio-economic and technical factors such as wealth, ethnicity, gender, and age

Socio-economic factors refer to how the society related to economic factors, these are factors that relate to and influence one another

Pastoralism is defined as systems where 50% of household revenue comes from livestock or livestock-related products (total value of livestock marketed products plus estimated value of livestock products consumed by the household) (Morton and Meadows, 2000).

Government land is defined as public land owned by the government and dedicated to a specified public use or made available for private use at the discretion of the government (Ministry of Lands, 2007).

Private land is defined as land held by an individual or other entity under freehold or leasehold tenure (Ministry of Lands, 2007).

Community land is defined as land lawfully held, managed and used by a specific community (Ministry of Lands, 2007).

Agro-pastoralists, people who derive more than half of their gross revenue from agriculture and at least 10% of their gross revenue from livestock" (Swift, 1988).

CHAPTER ONE: INTRODUCTION

1.1 Background Information

This chapter is the general introduction outlining the background information pertaining climate change and its effects on the dryland communities, and households, how adaptation is manifested in adaptive capacity as far as livestock and crop production in the ASAL is concerned. This brief introduction opens up the problem statement, justification and the objectives of the thesis.

1.1.1 Climate change and its effects on the dryland households

The impacts of climate change is real in the drylands of Eastern Africa and has increasingly attracted global debates (Ngum et al., 2018) as Africa remains the worst hit continent (Kempe Ronald Hope Sr, 2009). Climate change in Sub Saharan Africa (SSA) is manifested by recurrent, prolonged and severe drought and unpredictable rainfall trends (Nassef et al., 2009). SSA is home to nearly 300 million poor people, and stands out as the worst hit territory as portrayed by its susceptibility and high levels of vulnerability with low adaptive capacity to anticipated extreme events (Kempe Ronald Hope Sr, 2009; Reid and Vogel, 2006; Rosenzweig et al., 2008). These African households will be worst hit by effects of climate change which comes as an additional burden resulting to acute food and nutrition insecurity where women will continue to be more vulnerable (FAO et al., 2018).

The situation in Kenya is worsened by the fact that nearly 89% of the landmass is characterized by aridity also referred to as Arid and Semi-Arid Lands (ASALs) (Government of Kenya, 2012; Mosberg and Eriksen, 2015). This region is home to 38% of the Kenyan population who are predominantly pastoralists and agro-pastoralists. The severe and prolonged drought continues to devastate the already marginalized pastoral and agro-pastoral households due to their over-reliance on climate-sensitive natural assets and ecosystem resources for their livelihood and food security

(Government of Kenya, 2012). The negative impacts of climate change comes amidst other complex stressors such as rapid demographic growth, chronic poverty, land fragmentation and degradation, depletion of natural resources, insecurity and conflict (Government of Kenya, 2015; Headey and Kennedy, 2011).

The pastoralists and agro-pastoralists, although they have greatly benefited from the goods and services provided by the ecosystem, their future reliance on the same is very uncertain with altered significant resources (Hepburn and Stern, 2008). Their uptake of adaptation strategies is reported to be low when compared to other communities in other ecological zones such as the humid and temperate zones (Bryan et al., 2013). A situation associated with greater adaptation constraints such as: chronic poverty, insecure and ill-defined property rights, population pressure, the HIV/AIDS pandemic, insecurity and armed conflicts, land fragmentation and degradation (Bryan et al., 2013; Nassef et al., 2009; Silvestri et al., 2012). This notwithstanding, the dryland communities are learning, nurturing and adopting various strategies such as livestock migration, irrigation, destocking, changing livestock breeds and diversifying animal feed to mitigate climatic and non-climatic shocks that threaten their livelihoods (Bryan et al., 2013; Silvestri et al., 2012).

1.1.2 Adaptation as a manifestation of adaptive capacity

Debates in adaptation science and climate governance has attracted greatest interest in Africa where massive implication of the consequences of climate change is felt and the need to support and build the adaptive capacity of the vulnerable communities is highly needed. This goes beyond the institutional frameworks of adaptation to questions of adaptive capacity of households and the role of governance and institutions in addressing the impacts of climate change (Berkes, 2002).

Adaptation to climate change is a demonstration of adaptive capacity (Smit and Wandel, 2006). Adaptive capacity is a reflection of the potential of a system to adapt to the effects or impacts of

climate change (Downing , 1991) and involves changes to better deal with problematic exposures and sensitivities (Smit and Wandel, 2006). It is a socio-technical process that deals with Socio-ecological change and how it is mediated individually or as a collective action (Eriksen et al., 2015). The forces of adaptive capacity referred to as determinants or drivers describe the characteristics of a system or society to adapt to the changing external conditions (Fussel and Klein, 2006; Smit and Wandel, 2006), and have been categorized as context-specific (Smit and Wandel, 2006). Based on the "Local Adaptive Capacity framework (LAC)" (Jones et al., 2010), these characteristics are identified as: First: Household capital base that includes the five capitals namely, human, financial, social, physical and nature capitals. Second: Institutional dynamics and entitlements which should ensure impartial distribution of key resources. Third: Knowledge and information considered important for adaptation to take place. Fourthly: Innovation where the systems' ability to support innovation is examined. Fifth: Governance and informed decision-making where issues of participatory, transparency and community prioritization are considered.

This PhD thesis builds on what is known and discussed about adaptive capacity of a system within the adaptation framework as a complex social process framed by intangible processes of: innovations fostering; social institutional and entitlements; Assets base; knowledge and information and decision making and governance (Jones et al., 2010). It assesses adaptive capacity to climate change as a socio-economic and technical process among the transitioning pastoralist and agro-pastoralist households of Laikipia County, Kenya.

1.2 Statement of the problem

There is a declining trend in pastoralism, the main source of livelihood and a primary economic activity in the drylands of Kenya. This raises serious concerns as uptake of agro-pastoralism as an adaptation livelihood, poses a new challenge as it differentiates a community whose adaptive

capacity has not been assessed and characterized and therefore still unknown in a changing climatic environment. Exploring factors that determine adaptive capacity in this unfolding scenario is important knowledge for development, research and policy adaptation work.

The complexity of the unfolding system is real, from a community that was traditionally undifferentiated and collective actions dictated copying strategies to climate variability to household in transition with more individualized practices and adaptation strategies to climate change.

1.3 Justification

In the 1960s and early 1970s, the government promoted economic policies and measures to sedentarize pastoralists by promoting the formation of private and group ranches. This was done through registration of private rights to pastoral groups and in cooperating their production system into marketing economy (Fumagalli, 1978). Most ranches were then able to make a reasonable living until the late 1980s when the input costs became so expensive that ranchers started de-stocking. The collapse of the Kenya Meat Commission (KMC) and reduction of beef price resulted in making ranching unviable. The frequent drought experienced forced these households to migrate and settle in private and government land. This changes consequently limited the number of animals a household could own. Diversification and crop production started in potential areas. This set the transformation process from what was known as pastoralism to agro-pastoralism evidenced today.

The justification and rationale for the selection of this study area is based on the uniqueness of the pastoral community who converted their community livestock ranchland to wildlife conservancy and eco-tourism venture. Majority of the households were encouraged to migrate from the community land to private and government land tenure regimes. Over the years this resulted to

adoption of more individualized adaptation actions and consequently transiting from pastoralism to agro-pastoralism. This transformation from community collective copying strategy to more individualized adaptation practices at household level and increasing trend in uptake of agro pastoralism is what prompted the need for a research discourse on socio-economic and technical assessment of adaptive capacity among these transitioning dryland community of Laikipia County, Kenya.

The study specifically analyzes adaptive capacity to climate change as a socio-economic and technical process that determines adaptation and how this process has socially differentiated the community, and the implications thereof. It focuses on the complex adaptation processes and intangible elements of adaptive capacity of the pastoral and agro-pastoral communities. Elements like: innovations fostering; social institutional and entitlements; assets base; knowledge and information and decision-making governance. These elements define adaptation pathway as they examine individual and community's active involvement in adaptation practices which is demonstrated through case studies related to land and natural resources, value and power dimensions surrounding social institutions and assets entitlements. The key question addressed by this thesis is "How do the dryland community draw upon their social, economic and material resources to deal with climate shocks that accompany their social, political and environmental change? This process identifies the characteristics and features of a social ecological system that enables them to adapt to a changing climate among other multiple stressors. The research focuses on adaptive capacity as a socio-economic and technical process, where the key component examined are the individual household, the communities and the entire society as active innovators and creative actors in the process of change.

1.4 Objectives

The overall aim of this work is to undertake an empirical assessment of adaptive capacity to climate change as a socio-economic and technical process among a transitioning pastoralist and agro-pastoralist households of Laikipia County, Kenya.

1.4.1 Specific Research Objectives

The specific objectives of the study are to:

i. Analyze household adaptation practices that facilitate the transition of the dryland community from pastoralism to agro-pastoralism.
ii. Characterise the various assets and resources available in the commons that determine adaptive capacity of the pastoralists and agro-pastoralists households.
iii. Evaluate how access to key resources socially differentiates adaptive capacity among the pastoral Il Ngwesi community.

1.4.2 Research Questions:

i. What are the adaptation practices that facilitate the transition of the dryland community from pastoralism to agro-pastoralism?
ii. How does the various assets and resources available and accessible in the commons determine adaptive capacity of the pastoralists and agro-pastoralists?
iii. How does access to key resources (material, knowledge, social, etc.) differentiate adaptive capacity among the pastoralists and agro-pastoralists households?

1.5 Hypothesis

The adaptive capacity of households in this growing trend is hypothetically influenced by socio-economic and technical elements and socially differentiates the dryland community. These are

factors that dictate household uptake or lack of uptake of new adaptation practices. In literature, the characterization and differentiation of the adaptive capacity of the transitioning pastoral community has not been adequately addressed. This notwithstanding the fact that it is the main reason why new and individualized adaptation practices are unfolding. These are practices such as irrigated and rain-fed commercial farming, livestock-based enterprises and off farm activities like tourism-based activities and petty trade. This therefore calls for unpacking how adaptive capacity is characterized and socially differentiated in order to address and integrate social heterogeneity in climate change adaptation process. In particular the increasing needs and dynamics of women roles in development interventions and research (Mwanundu et al., 2009).

1.6 Structure of the thesis

This PhD research thesis is divided into six chapters. The first chapter is the general introduction outlining the background information problem statement, justification and objectives. Chapter two is on literature review discussing how the dynamics of adaptation to climate change have evolved, how this process has led to the transition of the pastoral community from pastoralism to agro-pastoralism. The debates on adaptation and adaptive capacity and concepts of adaptive capacity and vulnerability to climate change. This review enabled me to identify the research gap that are addressed in this thesis.

Chapter three analyzes the adaptation practices that facilitate the transition of the dryland community from pastoralism to agro-pastoralism where irrigation is identified as a key adaptation strategy in the drylands, representing a bridge and an avenue that introduces livestock keepers to a transition from nomadic pastoralism to sedentary agro-pastoralism. Chapter four characterizes how the various assets and resources available and accessible in the commons determine adaptive capacity of the pastoral community generating three fundament findings relevant to the growing

literature on adaptive capacity. Chapter five focuses on social differentiation in adaptation processes specifically determining how access to key resources differentiate adaptive capacity among the pastoralists and agro-pastoralists households. Chapter six outlines the general conclusion and recommendation drawn from the study

CHAPTER TWO: LITERATURE REVIEW

This chapter is on literature review discussing how the dynamics of adaptation to climate change have evolved, how this process has led to the transition of the pastoral community from pastoralism to agro-pastoralism. The debates on adaptation and adaptive capacity and concepts of adaptive capacity and vulnerability to climate change. This review enabled me to identify the research gap that are addressed in this thesis.

1.7 2.1 Evolving dynamics of adaptation to climate change

This section conceptualizes the socio-economic and technical process of adaptation as it has evolved in literature to generate interest in the dynamic and complexity of adaptation and adaptive capacity to climate change.

The utilization of the term "adaptation" within social science literature has its foundation from Julian Steward, an anthropologist and renown cultural ecologist who utilized the term "cultural adaptation" to illustrate "culture cores" and its adjustments to the natural environment (Butzer, 1989). In climate change literature, this term "adaptation" has attracted a lot of attention as a research, development and policy issue as well as a single action aimed at mitigating impacts and taking up prevailing opportunities. It has however, often been over-simplified indicating a response that is linear and politically neutral to changes expected or actual in the bio-physical systems. For example in agricultural impact studies, changes in planting dates and or crop variety are defined as adaptation (Dixon et al., 2014; Smith and Pilifosova, 2001). Recent literature clearly defines shift from approaches that suggest one-size-fits-all to an approach considering integration and inclusivity of both formal and informal institutions; special attention to the role of decision-making processes (Dixon et al., 2014). This makes it clear that adaptation should be an inclusive

process that can stimulate social and political change which may not have been necessarily driven by climatic changes (Eriksen et al., 2015).

Adaptive capacity is a socio-technical process (Eriksen et al., 2015) that deals with social ecological change, mediated individually or as a collective action (Eriksen et al., 2015). It is framed to include all the stakeholders and their interaction in framing the main climate change challenge. Eriksen et al. (2015) argues that adaptive capacity by itself is political and heavily contested. Adaptation to climate change is a complex process where adaptation options are considered (Eriksen et al., 2015) and debated by multiple actors. The stakeholders' interests determine the direction based on complex interaction between organizations/institutions and actors operating at different levels (Dixon et al., 2014).

This thesis is based on more recent debates addressing this social complexity. Examining adaptation to climate change as a social technical process. The work draws attention to questions of fostering the innovations; the structure and process of social institutional relations and assets and entitlements, knowledge and information and governance. While this focus includes the ecological system upon which the agro-pastoral communities depend on, it is limited to analyzing adaptive capacity of a human system within a natural or biological system. The focus therefore is on the adaptation as a social process and adaptive capacity of the agro-pastoral community at a household and at community level as shaped by social, political, economic and ecological processes.

1.8 2.2 Pastoralist transition to sedentary and agro-pastoralism

The sustainability of pastoralism as an important livelihood strategy and the basis of the region's economy is challenged by the increased frequency and the severity of drought (Bosh, 2014). In the Northern semi-arid counties of Kenya, there has been dramatic development in infrastructure

including agriculture. People are engaging in agricultural initiatives, in addition to keeping livestock, a trend that is slowing changing the previous pastoral lifestyle to sedentary agro-pastoralism (Bosh, 2014; Mukoya et al., 2007). Agro-pastoralist are engaging in crop production as an adaptation strategy. They are taking up irrigation along river banks to mitigate the climatic challenges and to reduce over dependency on food aid to become more self-reliant (Bosh, 2014). Agro-pastoralists, have been defined as "people who derive more than half of their gross revenue from agriculture and at least 10% of their gross revenue from livestock" (Swift, 1988). Borrowing this definition, this study defines agro-pastoralism as a livelihood strategy that entails crop and livestock production as a strategy of lessening the dependence on livestock and livestock products as a single source of livelihood for dryland communities. A community that grow grass and other leguminous plants as fodder for their livestock, but equally grow maize, beans and fruits and vegetables for domestic consumption and surplus for income.

1.9 2.3 Adaptation and adaptive capacity in climate change debates

Adaptation to climate change is more pronounced in the field of political ecology where the issues of adaptive capacity are viewed in reference to the relationship between ecosystems and political economy (Smit and Wandel, 2006). In this regard adaptation to climate change is a demonstration of adaptive capacity (Smit and Wandel, 2006) which is referred to as the potential of a system to adapt to the effects and impacts of climate change (Downing , 1991). Adaptation of a system involves its changes to better deal with problematic exposures and sensitivities, a reflection of adaptive capacity of the system (Smit and Wandel, 2006). Adaptation process manifests the potential of individual households or defined community at large based on how it is either embedded or challenged by socioeconomic, ecological and political processes at various scales. (Berkes, 2002). Generic concepts closely related or used together with adaptive capacity are

adaptability, management capacity, sensitivity, coping ability or range, robustness, flexibility, stability and resilience (Fussel and Klein, 2006; Neil Adger et al., 2005). These characteristics determine the system's capacity to adapt and are thereby defined as drivers or determinants of adaptive capacity of a system (Fussel and Klein, 2006).

The social ecological system in the drylands has changed over the last century, a situation attributed to shifts in climatic conditions, ecological landscapes and institutions frameworks (Agrawal, 2010). These changes have negatively affected the previous known relationships and consequently the effectiveness of certain adaptation and copying strategies (Wangui et al., 2012). Empirical evidence especially steming from developing countries characterises adaptation as highly context-specific. It identifies social economic elements that shape adaptation strategies as: social and institutional networks, local and indigenous knowledge and other non-climatic pressures (Eriksen et al., 2005). The pastoralists in the dryland for example have historical copying strategies that they deployed to respond to climate variability. This has however been increasingly compromised by the impacts and effects of climatic change such as drought. Goldman & Riosmena (2013) looking at the Maasai pastoralist in Northern Tanzania argued that as the relationship between livelihoods, landscape and institutions changes, the pastoralist are adapting and deploying adaptive capacity through the uptake of new technologies and innovations, abandoning certain cultural copying strategies. Berkes (2002) evaluating successful adaptation of common and communal property in reference to resilience thinking emphasizes that common researcher needs to look beyond institutional forms to questions regarding adaptive change and adaptive capacity of social groups and secondly institutional roles in addressing impacts associated with the environmental change.

1.10 2.4 The concepts of adaptive capacity and vulnerability in climate change debates

Accessing adaptation to climate change or in practice is ultimately connected with discussions and concepts relating to adaptive capacity, resilience and vulnerability (Smit and Wandel, 2006). For example adaptive capacity of a community or household determines its vulnerability to impacts of climate change (Downing , 1991). The consequences of adaptation is determined by how vulnerability from the first instant is conceptualized (Downing , 1991). The term vulnerability is therefore manifested and defined based on elements of adaptive capacity, sensitivity and exposure (Smith and Pilifosova, 2001). This does not often indicate how the impact of climate change affect different social groups in the society. Osbahr et al. (2010) cautions of oversimplifying adaptation framework and seeing all success stories as transferable due to the spatially and socially differentiated impacts of environmental change. Examining adaptation to climate change as a social technical and economic process, demands usage of the vulnerability concept as it defines the elements of a social ecological system that influences their adaptive capacity and ability to adapt.

The sections below examine the four features or dimension of adaptive capacity as a localized socio-economic and technical process in the common property institutions: innovations fostering; social institutional and entitlements; assets dynamics and climatic and agronomic information.

2.4.1 Innovation fostering as a component of adaptive capacity

Communities and households are creative and are using their imagination and experience to come up with innovations, practices and technologies in ecosystem management to exploit prevailing opportunities and environmental conditions or reduce and mitigate negative impacts (Abel and Langston, 2001). It is argued that indigenous knowledge, self-organization capacity of the pastoral

communities, institutional adaptability and the ecological resilience of the system plays an important role in sustainable natural resource management (Abel and Langston, 2001). Research indicates that contrary to the long old assumption that pastoralists' livestock actions are irrational and destructive (Niamir-Fuller, 1999), the pastoralists have over the years changed their coping practices to adaptation strategies that are resilience, rational and efficient and buildings their ability to deal with climate variation (Niamir-Fuller, 1999).

This research conducted among the dryland communities of Laikipia ranchlands focuses on this innovativeness. This is not only what they have developed but also how, the process in which the community is engaging own initiatives to develop innovative strategies to manage negative impacts of climate change. These innovations are not only technical but also socio-institutional at various levels. Emphasis is placed on innovations around land and natural resources as these forms the key building blocks that supports the systems' culture of innovation and creativity, consequently enhancing the adaptive capacity of the community.

2.4.2 Social institutional and entitlements as enabler of adaptive capacity

Traditional institutions in Kenyan drylands, are reorganizing themselves, forming hybrid institutions where interactions and networking among stakeholders within the common property and outside is visible (Kanyuuru et al., 2015). Institutions are the 'rules of the game' that govern belief systems or a society and they are either formally written, like the society constitutions and by-laws, or unwritten informal rules such as cultural norms (Ostrom, 2005).

Following the colonial era in the late 1950s, the government instituted Trust Lands and community group ranches as the land tenure systems in the drylands. Community conservancy operating in the community group ranches emerged with institutional rearrangement and operates in both the land tenure regimes. Kanyuuru et al. (2015) demonstrated evidence of co-management approach

where dynamic actors are actively involved in addressing the socioeconomic and ecological impacts of change. This notwithstanding, very little has been done on how institutional restructuring is affecting adaptive capacity pegged on equitable distribution and accessibility of key natural resources and household assets which are considered as fundamental characteristics of adaptive capacity.

2.4.3 Assets base as household capital

Communities that depend on ecosystem resource for their income and food security have been said to have limited adaptive capacity and consequently more vulnerable to the impacts of climate change (Smith and Pilifosova, 2001). The households vulnerability is aggravated due to limited asset base to engage in innovative adaptation process since their adaptive capacity depends strongly on their ability to access and control key resources (Speranza, 2011). Control over assets in the commons is highly influenced by factors such as gender which is a fundamental factor in building the adaptive capacity of households. It determines the utilization of assets essential in uptake of adaptation strategies (IFPRI, 2015). Actors are dynamic and have acquired different strategies of tackling climate change issues due to different preferences and abilities (IFPRI, 2015). Their decision-making process is influenced by what resources and assets they access and control. This PhD research considers tangible and intangible assets, looking at the relationship between assets and adaptation practices. Tangible assets include physical, financial and natural resources while intangible assets includes human and social resources necessary for a Social-Ecological System's (SES) to respond to a changing climate (Prowse and Scott, 2008).

2.4.4 Climate and Agronomic Information

For adaptation to practically take place among the community and the households, information of future change and respond solutions to threats posed is needed. In the changing dynamics, no single

group, society or agency is a master of all the information , and therefore the call for co-production or co-generation of knowledge (Lance, 2009). The co-production of knowledge was defined by Armitage et al. (2011) as a process of collaboration where information is produced by a diverse source of stakeholders who identifies the challenges and together identifies solutions to address the challenges. This process identifies fundamental elements needed in building the adaptive capacity of a community. The Non-Governmental Organizations (NGOs) have been known to often play this significant role of bridging and bringing stakeholders into such processes (Armitage et al., 2011).

This thesis examined elements of social learning and deliberate production of information that facilitates households and the community to collectively anticipate future scenarios for climate change. Secondly identifies facilities available to develop and disseminate information and knowledge to inform and support adaptation practices and the capacity to assess and implement the suitable options.

1.11 2.5 Research gaps identified

The framework for assessing adaptive capacity although developed and inspired by Turner et al. (2003) who developed it as an integrated conceptual framework that accounts for interactions among the three aspects of examining vulnerability: sensitivity, exposure and adaptive capacity, it has not been empirically tested and verified in the dryland context where SES has evolved over time in this era of global climate change. The researcher therefore used the framework to organize and analyze primary empirical data paying attention to process details and not system's snapshot pictures which are a major benefit compared to other methodological frameworks. This includes multiple linkages between the human and bio-physical environment.

Adaptive capacity and adaptation to climate change are at the core of global debates. The major knowledge gap, an opportunity taken by this PhD research is to empirically analyze adaptive capacity of the pastoral and agro-pastoral community that has not been deeply dealt with in adaptation and climate change literature.

Various approaches and frameworks for indicators of adaptive capacity/resilience have been developed in recent years. There is however no single recognized framework that looks at different sets of indicators. This suggests that indirect measurements of aspects potentially related to a person's or community's ability to adapt can provide enough insight into their adaptive capacity. The most common approach of measuring adaptive capacity is an indicator approach, which calculates an index from a selection of pre-set indicators. These indicators are often based on quantitative data, more rarely on qualitative data and sometimes on both. While this approach has its merit, and is thus also part of this research, it most commonly assesses different assets of the target households and communities.

The LAC framework approach taken in this PhD thesis emphasizes the main determinants of adaptive capacity but does not focus on specific methods for operationalizing or analyzing it and therefore wider than a simple index asset assessment. It is based on the insight that systems are complex and fluctuating and that complexity demands a shift from exclusively looking at factors that enable a system to adapt to actions of a system that increases its potential to adapt (WRI, 2009).

CHAPTER THREE: IRRIGATION AS AN ADAPTATION PRACTICE THAT FACILITATES THE TRANSITION OF THE DRYLAND COMMUNITY

1.12 3.1 Abstract

Climate change amidst other stressors such as degraded ecosystems, has adversely affected pastoralists of Kenya. A community that historically depended on climate-sensitive ecosystems to sustain their livelihoods is learning and nurturing new adaptation strategies, adapting to the diminishing yet crucial natural resources. Irrigation is identified as one of the many adaptation strategies that accompany the transformation witnessed from pastoralism to agro-pastoralism. This chapter is timely and important because it identifies the socio-economic factors that influence uptake or hinder irrigation as an adaptation strategy among the pastoral dryland community. A Heckman probit model is used to assess the household perception of climate change and to identify the drivers that either encourage or hinder the uptake of irrigation. Results indicate that 80% of the households investigated perceive climate change. Of this, 32% adopted irrigation as an adaptation strategy. The drivers that encourage this adoption are: quality of land for food production (**1.152****), assistance received from government (**0.906****), large livestock herd size, governance of community land tenure (**1.556****) and agronomic information (**1.094*****). There is a low possibility of the older household heads (**-0.0219***) and those with small (**-0.473***) and medium (**-0.931****) livestock herds adopting Irrigation. This implies the need to have large herds of livestock as financial asset and the need to target the young generation often left out of development interventions. Recommendations are suggested to ensure irrigation is sustainable in a fragile and drought-stressed landscape.

Key words: Adaptation Strategy, Irrigation, Pastoralists, Agro-pastoralists, Climate Change,

1.13 3.2 Introduction

The Kenyan dry lands, also referred to as Arid and Semi-Arid Lands (ASALs), are estimated to occupy 89% of the total terrestrial surface area (Government of Kenya 2015). The arid areas receive between 150 mm and 550 mm of rainfall while semi-arid areas receive 550 mm to 850 mm annually (Government of Kenya 2015). The low and erratic amounts of rainfall limits agricultural production and rural settlement (Funk et al. 2010) and make the ASALs fragile, prone to degradation and sensitive to climate change (Ojwang et al. 2010). Yet, the dry land pastoral communities heavily depend on climate-sensitive rain-fed ecosystems of livestock production and dry land farming for food security (Mude et al. 2007; Ojwang et al. 2010). 36% of the total Kenyan population live in the ASAL regions, and 90% of them are dependent on pastoralism[1]. A climate-sensitive rain-fed livelihood system of livestock mobility for pasture and water for food security (Davies, 2007; Government of Kenya, 2015; Mude et al., 2007). Mobility and extensive grazing of livestock in community land tenures and open access spaces is the principle defining feature of pastoralism (Morton and Meadows, 2000). Pastoralists in the arid areas own 70% of the national herd, making pastoralism a significant source of food security not only for the dry land communities, but also for the nation (Magembe et al. 2013).

The semi-arid areas are characterized by agro-pastoralism, mixing livestock production with cropping (Government of Kenya 2015), where both livestock mobility as well as crop production, both rain-fed and irrigated are common (Government of Kenya, 2015). These drylands support other varied ecosystem services such as energy and forestry products and more than 80% of the country's tourism activities (Alemu et al., 2014; Davies, 2007). Although the opportunity for

[1]Pastoralism is defined as systems where 50% of household revenue comes from livestock or livestock-related products (total value of livestock marketed products plus estimated value of livestock products consumed by the household) (Morton and Meadows 2000).

irrigation exists, the conversion of pastoral rangeland to irrigated agriculture is considered undesirable due to challenges of environmental sustainability (McGahey et al. 2014). This makes the communities more vulnerable to climate change and variability. A broader water harvesting strategies in water-scarce environment has been recommended (Headey and Kennedy 2011) to support ASAL communities especially during the dry spells (Maddrell and Neal 2012). Strategies that recharge the aquifers as well as reduces downstream flood risks, providing water to the community all year round (Neal 2012). This is in line with the primary policy goal of the Kenyan Government on sustainable food and nutritional security in drought-prone environments (Government of Kenya 2015).

The Maasai community of Il Ngwesi Group Ranch, historically are pastoralists who lived in the arid lands of Laikipia County. Climate change trends in Laikipia County, shows rising temperatures, decreasing precipitation with increased unpredictability and more frequent and intense drought events (MoALF 2017), with negative effects on both pastoralists and agro-pastoralists. This comes amidst other stressors, such as degraded ecosystems, food and nutritional insecurity, drought, pests and diseases, poor infrastructure and an increasing population (Fratkin 2001; Government of Kenya 2015; Maitima and Gumbo 2007). In addition, the dry land communities face land tenure insecurity and land encroachment (Morton and Meadows 2000). These challenges have led to over 75% of the Il Ngwesi pastoralists over the years, to acquire land and re-settled in the semi-arid regions of Laikipia and neighboring Meru and Isiolo Counties where resources for irrigated agriculture are available. Like other pastoralists in Eastern African, they are responding to the ongoing lifestyle changes inclusive of climatic challenges by diversifying and adopting new livelihood strategies such as irrigated crop production (Olayide et al. 2016) and sedentary lifestyles (Fratkin 2001). With increased reliance on crop production, irrigation acts as

a buffer that reduces risks associated with rain-fed agriculture (Olayide et al. 2016; UNDP 2012). Their uptake of irrigation, although considered an adaptation strategy in this chapter, is not a new practice among these pastoralists. Historically, households that had lost their livestock used it as a means of recovering back into pastoralism (Sandford 2011). It was therefore a one-off process as the labor demand for mobile pastoralism could not allow for full-time engagement in irrigation activities (Sandford 2011). Ng'ang'a and Crane (2020) have explained how the community converted their communal land that they used to reside in and graze their livestock into a nature and wildlife conservancy.

The diversification and settlement of the dryland community, transforming from pastoralism into sedentary agro-pastoralism as a way of life and adapting irrigation as an adaptation strategy, involves a deliberate integration of crop production and livestock grazing (Magembe et al., 2013; Maitima and Gumbo, 2007; Watson and van Binsbergen, 2013). Irrigation is documented as a climate-smart agricultural adaptation strategy in because it reduces vulnerability to drought (Vermeulen et al. 2012). As a practice, it is increasingly been recognized as a viable adaptation option to address household nutrition and food security (Christian et al. 2018). In relation to the 300,000 hectares estimated agricultural potential in the ASALS of Kenya, irrigation is limited in scale (0.44%), where crop production (26%) and tree crops (0.03%) are mainly based on rain-fed production (Ojwang et al. 2010). Irrigation is taken up by agro-pastoralists as a means of adapting to the effects of climate change and improving food security (King et al. 2017). This is in small-scale, based on various technologies and techniques such as furrow irrigation along the riverine areas, and rainwater harvesting. More recently, sprinkler and drip irrigation are used to produce high value horticultural crops like onions. Some households produce either or both food and fodder crops (Mwenzwa 2011).

The emerging differentiated adaptive capacity to engage in diverse adaptation strategies like irrigation among the Il Ngwesi Maasai is based on resources available and accessible to individual households (King et al. 2018; Ng'ang'a & Crane, 2020). The ability to uptake irrigation goes hand in hand with other factors that propel sedentary lifestyles among the pastoralists, factors such as privatization of rangeland, insecurity and livestock raids (Mude et al. 2007). The capacity of households to engage in adaptation strategies like irrigation depends on assets, information and governance of land tenure (Jones et al. 2010). The drivers of irrigation in the Kenyan dry lands have been analyzed for public irrigation projects, where issues of management and community participation were identified as positive influencers (Miruri and Wanjohi 2017). King et al. (2017) analyzed socio-economic factors that support decision at landscape and community levels to engage in irrigation as a development intervention in crop production. However, the transformation process and the facts at play in adoption of irrigation as an adaptive individual initiative at household level have not been adequately addressed among transitioning pastoralists.

The objective of this article is to analyze the socio-economic drivers that either encourage or hinder uptake of irrigation as a climate change adaptation strategy among the Maasai agro-pastoralists in the dry land of Laikipia County, Kenya. The process starts by analyzing factors that influence household perception of climate change, followed by the drivers that encourage or hinder uptake of irrigation as an adaptation strategy. These results contribute to the growing literature on climate change adaptation and pastoral transformations.

1.14 3.3 Methodology

3.3.1 Description of the study area

The study focuses on Il Ngwesi Group Ranch of Mukogodo Division, Laikipia County (Figure 3.1). The county number 31 of the 47 counties in Kenya is ecologically endowed with abundant natural resources such as forests, rangelands, wildlife, undulating landscapes and rivers, among others, however, it has a large proportion (80%) of low potential and unsuitable land for crop production (County-Laikipia 2013). The county Based on historical analysis, the county has been experiencing moderate increase in temperature, resulting to increased heat stress days with an average rainfall of 400-750 mm annually (MoALF 2017). An increased precipitation associated with high intensity rainfall and flash floods has been recorded (MoALF 2017). The farmers perceive increased drought and unpredictable onset of rainfall as the indicators of climate change (MoALF 2017). The County, although is ecologically endowed with abundant natural resources such as forests, rangelands, wildlife, undulating landscapes and rivers, among others, it has a large proportion of the land (80%) with low potential, unsuitable land for crop production with compounding effects of frequent dry spells and poor rainfall distribution (County-Laikipia, 2013). This notwithstanding, the county land tenure regime has gone through historical pressure and continues to undergo increasing social, political, economic and environmental challenges resulting in progressive fragmentation and individualization of land (Mwangi, 2006, 2005). The main land tenure regimes available are Government lands[2], Private lands[3] and Community lands[4]. These are utilized as pasture land, conservancies and livestock ranches as well as agricultural land as the

[2]Government land is defined as public land owned by the Government and dedicated to a specified public use or made available for private use at the discretion of the Government (Ministry of Lands 2007).

[3]Private land is defined as land held by an individual or other entity under freehold or leasehold tenure (Ministry of Lands 2007).

[4]Community land is defined as land lawfully held, managed and used by a specific community (Ministry of Lands 2007).

main economic activities (Fred 2012). There are 48 ranches of which 13 are community land owned by the pastoral communities. In 1979-80 and 1984, the county experienced two severe and consecutive droughts that led to high livestock mortality. The experienced drought in 1987 resulted in the death of more than 1800 cattle and 3000 goats and sheep in Mukogodo division (MoALF 2017). The negative impacts of these prolonged droughts together with changing land tenure regime informed the community's decision to convert their community ranch land into a nature and wildlife conservancy as an alternative source of livelihood. In this respect, to create space for the operationalization of the new arrangement, over 75% of ranch members migrated and settled in neighboring villages in Laikipia County while others went to Meru and Isiolo Counties, and formed what is referred to by their group constitution as "seven neighborhoods". These are Chumvi, Ethi, Ngare-Ndare/Manyagalo, Lukusero/Nandugoro, Leparua, and Lower and Upper Il Ngwesi neighborhoods (Figure 3.1).

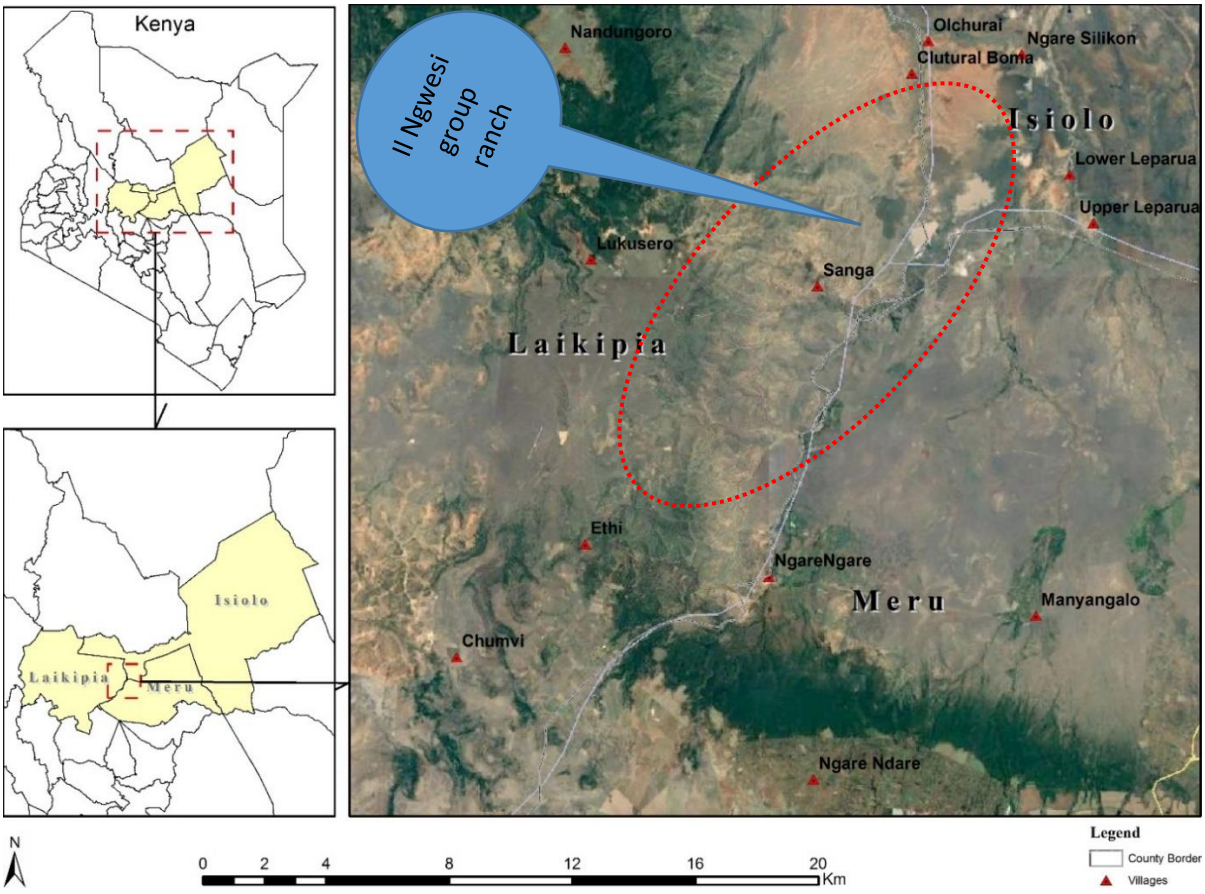

Figure 3. 1: Map showing the study site and the seven neighborhoods

3.3.2 Data collection

The seven neighborhoods (Figure 3.1) were purposely selected to represent areas where the Il Ngwesi Group Ranch members settled. Three neighborhoods are composed of two villages each: Ngare-Ndare/Manyagalo represents Ngare-Ndare and Manyagalo villages, Nandugoro/Lukusero represents Nandugoro and Lukusero villages, Upper Il Ngwesi represents Lower Sanga and Murua. A total of 12 villages were treated as separate units during data collection and only aggregated during data analysis to represent the seven neighborhoods of the group ranch. The percentage representation of members in the various neighborhoods is show in figure 3.2. Quantitative data to assess how various assets and resources available in the dry lands determine, predict and build adaptation practices of the agro-pastoral communities was collected using

household survey (HHS). Of the 494 households sample size interviewed, 49.39% were agro-pastoralists, 46.61% were pastoralists and 4% were farmers (Descriptive analysis). The flow chart below (Figure 3.3) expresses the survey and statistical process undertaken more clearly.

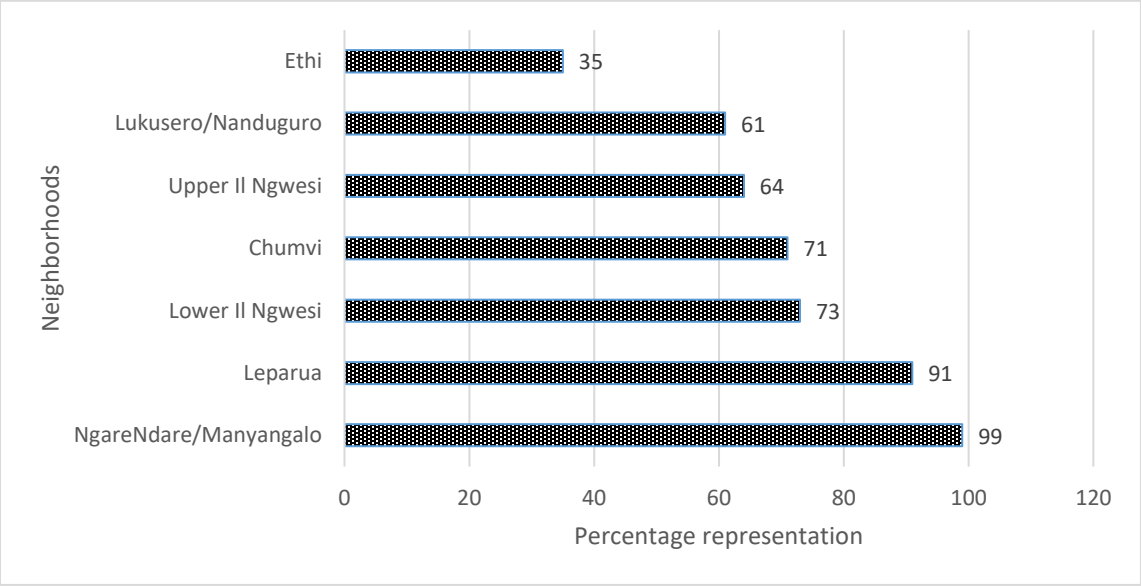

Figure 3. 2: Percentage representation of members in the various neighborhoods

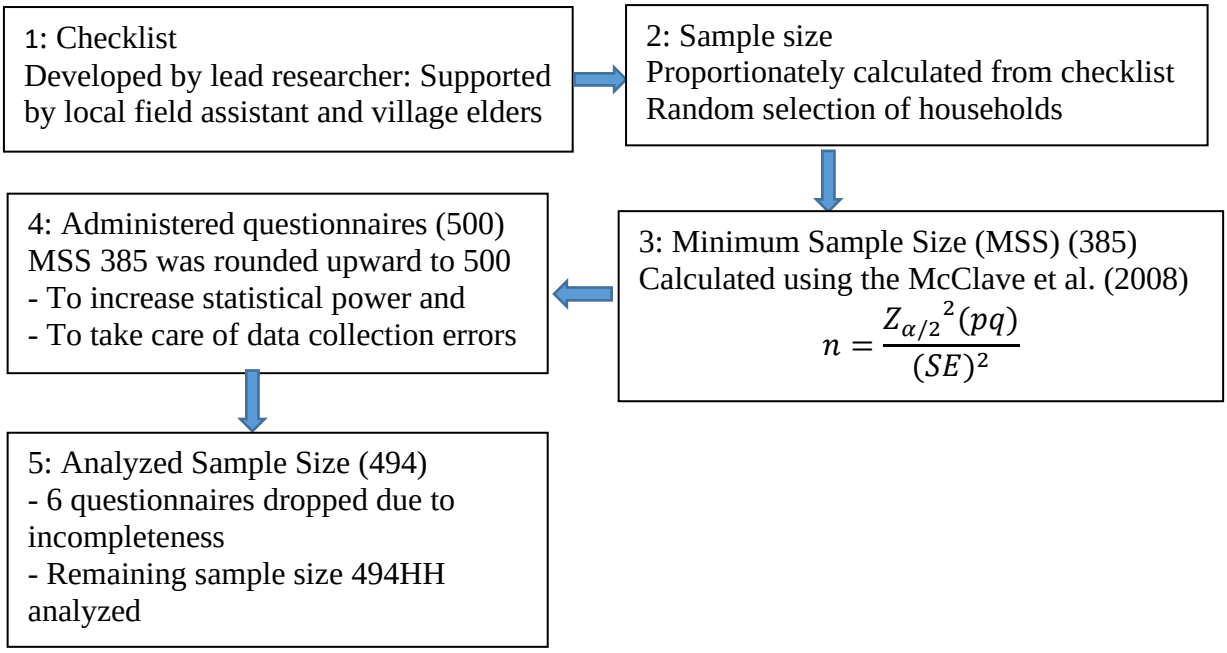

Figure 3. 3. Flow chart expressing the survey and statistical process

A team of 12 well-trained enumerators, all undergraduates, were used to administer the questionnaires over a period of 15 days. The data was collected on an Open Data Kit (ODK) system using electronic devices such as tablets. This electronic system of data collection has the advantage of minimizing errors in data entry and saves data cleaning time significantly. Information on household socioeconomic data, their perception of climate change, adaptation strategies employed, household assets, climate and agronomic information accessed as well as main land tenure regime owned or accessed was elicited.

The explanatory variables (household assets, governance and information) used in quantitative data were selected based on climate change adaptation literature (Jones et al. 2010). First, household assets were divided into five sections for examination based on the five capitals: human, natural, social, financial, and physical capitals (FAO 2002). The indicators selected for human assets included: age, education, household size and female literacy. Indicator for natural assets included: quality of land for food and fodder production. Social assets indicators were represented by: membership to any association, assistance from a friend, relative or government while financial assets was represented by livestock numbers and access to credit). Physical assets were based on the constructed household asset index and household distance from the main road. The governance variable entailed the land ownership and tenure regimes prevailing in the different neighborhoods. As a key focus of the study, this necessitated constructing the variable based on the respondents' residence and their reported land states to establish the land entitlement. Finally access and availability of climate and agronomic information. Table 3.1, describes the household assets indicators and the expectation of the scientist on the direction of any of the variable. Secondly is the governance of land tenure, this entails the land ownership and tenure regimes prevailing in the different neighborhoods. As a key focus of the study, this necessitated constructing the selected

variable based on the respondents' residence and their reported land states to establish the land entitlement (Figure 3.4). Thirdly and the last variable was information which was based on availability and households' access of climate and agronomic information.

Qualitative methods such as focus group discussions (FGDs), key informant interviews and participatory observations were used to better design the questionnaire, triangulate the data and support interpretation of the survey results. A total of 24 gender disaggregated FGDs with participants ranging from 9-16 persons per village were randomly selected as the issues discussed were based on collective knowledge. The disaggregation identified the strategic differences between women and men in adapting to climate change. Based on specific adaptation strategies, a total of 17 key informants' interviews were conducted. The structure of the qualitative data was based on a semi-structured interview guide. The structure of the qualitative data collected was based on a semi-structured interview guide. To collect this ethnographic information, the researcher stayed in the field for four months sharing the daily lives of the community in the various villages, conducting meetings and observing their daily livelihood patterns in the months of May through to August 2016.

3.3.3 Analytical methods

The analysis is based primarily on the quantitative data of the household survey and complemented by results of the qualitative data. Average values for adaptation strategies identification from literature and FGDs and incorporated into the household questionnaire are presented in Figure 3.5. Descriptive statistics generated shows the overall picture. Table 3.3 presents the average values for both dependent and explanatory variables on perception to climate change and adaptation strategies. The econometric Heckman probit model was used to address and correct the issue of sample selection bias. Indeed, adaptation with a focus on irrigation in this chapter involves two

steps. First, perception of climate change and second, the decision on whether to take up irrigation as an adaptation strategy or not. The researcher had a problem of sample selection due to non-randomness of the main outcome variable, given that households who use irrigation as an adaptation strategy are only those who perceive climate change. Heckman sample selection was used to correct this problem and to avoid bias estimators.

Heckman's sample selection is based on the following relationship: $y^*_{1j} = x_j\beta + \mu_{1j}$, where y^*_{1j} represents the latent or unobserved variable on the propensity to uptake irrigation, represents a vector of explanatory variables hypothesized to influence the uptake of irrigation, β and μ_{1j} are parameters to estimate the error term. The binary outcome of whether a household uptake of irrigation is given by the following probit model: $y_{1j} = 1 \text{ if } y^*_{1j} > 0; y_{1j} = 0 \text{ otherwise}$

The latent variable Y^*_{1j} is only observed if the selection equation on perception of climate change is observed. $Y_{2j} = 1 \text{ if } y^*_{2j} > 0; Y_{2j} = 0 \text{ otherwise}$ with $y^*_{2j} = z_j\gamma + \mu_{2j}$.

y^*_{2j} represents the latent and continuous variable on the household propensity to perceive climate change; z_j represents the vector of explanatory variables likely to influence perception and γ is the parameter to estimate and μ_{2j} is the error term.

μ_{1j} and μ_{2j} are assumed to be normally distributed where the mean is 0 and variance 1.

When the error terms for the selection and outcome equations are correlated with coefficient $\rho(\text{cov}(\mu_{1j}, \mu_{2j}) = \rho)$, this implies non-randomness in the sampling scheme. In such a case, standard probit technique to assess uptake of irrigation lead to bias estimates and the Heckman sample selection model becomes appropriate to provide consistent, asymptotic estimates for all the parameters in the model (Van de Ven, Wynand and Van Praag, Bernard 1981).

The variable perception of climate change has been proxied by using some indicators on the number of rainy days, drought occurrence and the number of hot days. A household was assumed to perceive climate change if they indicated a significant decrease in the number of days it rained while number of hot days and drought occurrence had significantly increased. To effectively discuss adaptation strategies, it is important to understand household perceptions of climate change based on the assumption that uptake of new livelihood practices emanates from how households perceive environmental changes than from actual information generated by scientists (Adger et al. 2009). An inductive approach is used to analyze qualitative data where the lead researcher took time to understand the individual observations and manually coded for general trends.

Descriptive statistics of the dependent and explanatory variables are presented in Table 3.1

Table 3.1: Definitions of explanatory variables

Overall Variable	Description of Variables	Value	Expected sign
Human Capital	Age of the household head	Years	+
	Education status of the household head	Years	+
	Family size	Number	±
	Literacy level of female household head or spouse	1=Yes, 0= No	+
Natural Capital	Quality of land used for food production	1=Yes, 0= No	+
	Quality of land used for fodder production	1=Yes, 0= No	±
Social Capital	Membership to any association, cooperative, community	1=Yes, 0= No	±
	Assistance received from a friend	1=Yes, 0= No	±
	Assistance received from a relative	1=Yes, 0= No	±
	Assistance received from government	1=Yes, 0= No	+
Financial Capital	Small numbers of livestock	Range of Numbers	±
	Medium numbers of livestock	Range of Numbers	±
	Access to credit	1=Yes, 0= No	+
Physical Capital	Physical asset index		+
Governance of Land Tenure	Government land tenure	Location	+
	Private land tenure	Location	+
	Community land tenure	Location	-
Agronomic and Climate Information	Access to climate information for grazing purposes	1=Yes, 0= No	+
	Access to information on pasture availability	1=Yes, 0= No	+
	Access to information on water point availability	1=Yes, 0= No	+
	Access to climate information to decide about agronomic technology	1=Yes, 0= No	+
	access to agronomic information on farm technology	1=Yes, 0= No	+

1.15 3.4 Results

This section discusses descriptive and econometric results of household perception of climate change as first step in determining household purposed decisions to adapt to climate change. Secondly, the factors that encourage or hinder adoption of irrigation as an adaptation strategy.

3.4.1 Descriptive results

Descriptive statistics of the dependent and explanatory variables (Table 3.2), shows that 80% of the households interviewed experience the indicators of climate change asked in the questionnaire (Figure 3.6). This is based on their perception that the number of rainy days had decreased and the number of hot days and frequency of drought had significantly increased. Triangulating these findings, all the 24 FGDs indicated experiencing prolonged, frequent and severe droughts, long periods of dry and hot days and reduced and unpredictable rainfall patterns.

Of these 80% households that indicated perceiving climate change, a small but growing population (32%) (Table 3.2) has taken up irrigation as an adaptation strategy. This explains why the larger sample size of 494 dropped to 149 (Table 3.3).

The average education level for the household head is three years with a family size of seven members with 33% of female heads or spouses classified as literate (Table 3.2). Good quality of land for fodder production is mentioned by 62% of the respondents, while 17% affirmed it as good quality land for crop production (Table 3.2). Households engaging in crop production cultivate an average of 4 acres (1.6 ha). 50% of respondents receive assistance from relatives or government during times of climatic shocks. A smaller percentage (33%) associate themselves with an association, cooperative or community group. Majority (78%) own livestock, particularly small herds (less than 50 heads). A substantial percentage (71%) of the population receive weather

information from sources such as radio and extension workers. In relation to land tenure system (Figure 3.4), 32% live on private land, 31% reside in land owned by the government, while 28% on community land and 9% are landless. Irrigation is identified and ranked third (46.36%) as the general adaptation strategies adopted by the Il Ngwesi Maasai, the dry land community (Figure 3.5). Disintegrating adaptation strategies identified by the pastoralists and agro-pastoralists (Figure 3.7) outlines irrigation as the fourth highest (56%) strategy among the agro-pastoralists after livestock manure (88%), seasonal livestock migration (pastoralists (86%) & agro-pastoralists (82%)), and crop residue as fodder (60% agro-pastoralists and 5% pastoralists). During triangulation, irrigation as an adaptation strategy, was mentioned by 11 out of 24 FGDs and was therefore selected for further analysis as an adaptation strategy facilitating the Maasai community to transition to agro pastoralists. Additionally, because it is a pro-active adaptation strategy that reduces over-dependence on rain-fed systems (Amole and Ayantunde, 2016). Its importance has been confirmed by Bryan et al (2013) who conducted a Participatory Research Appraisal (PRA) exercise in different agro-ecological zones of Kenya and found that irrigation and water harvesting technologies ranked top among other adaptation strategies.

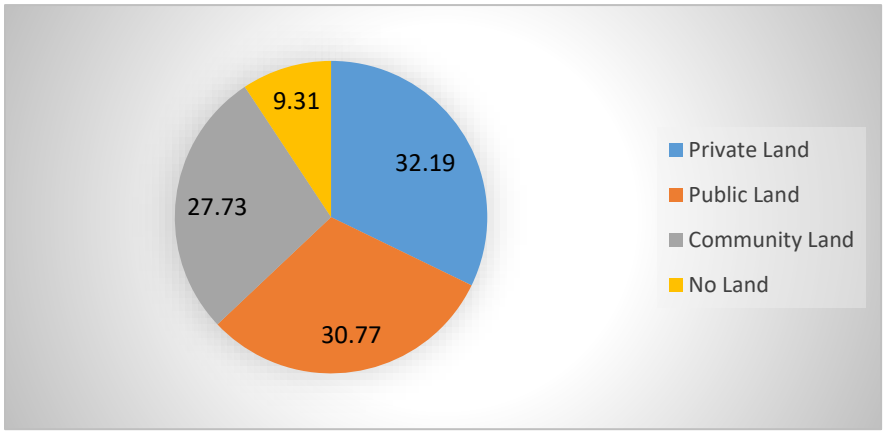

Figure 3.4 Pie chart showing the various land tenure regimes

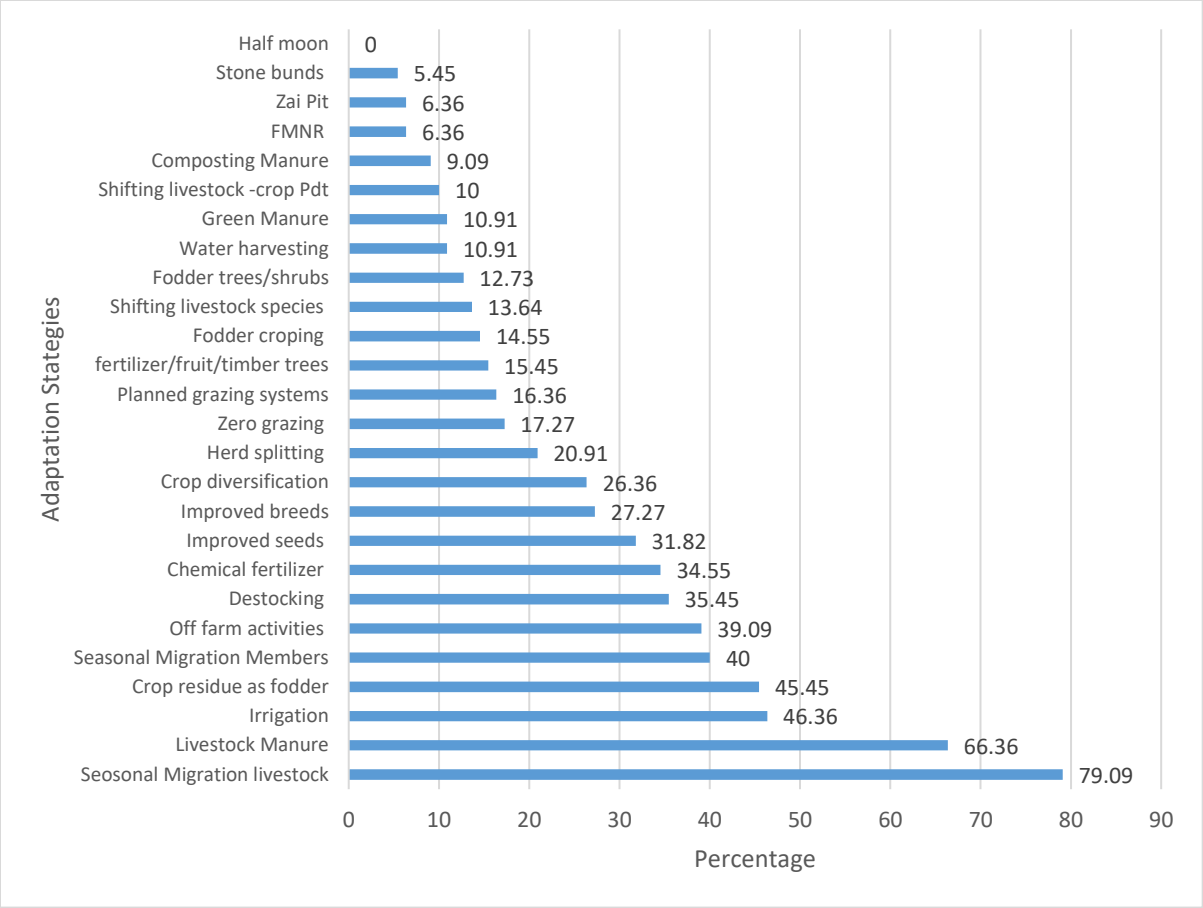

Figure 3.5. General adaptation strategies adopted by the households in general

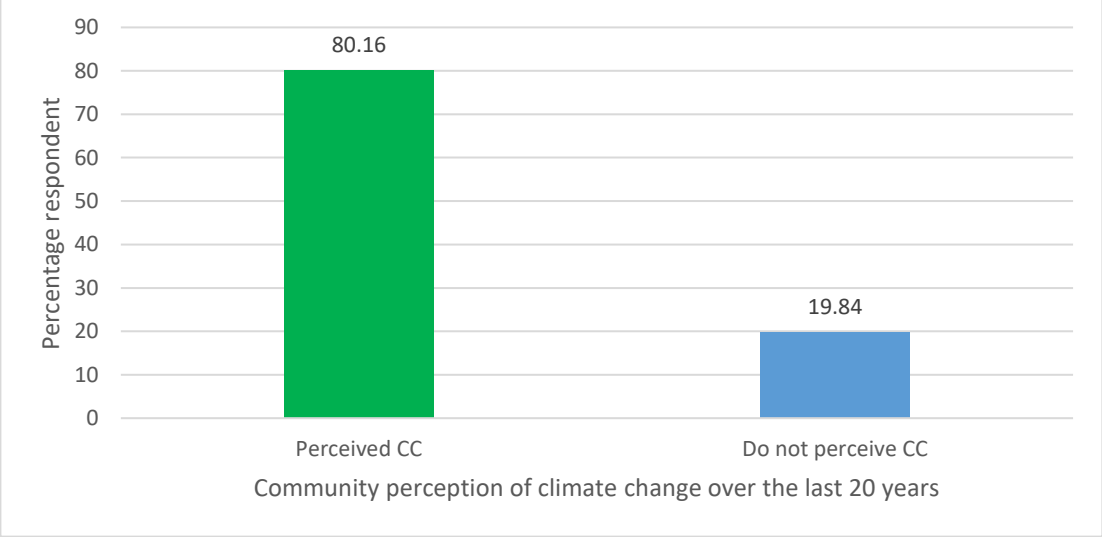

Figure 3.6: Community perception of climate change

Table 3.2: Perception of climate change, uptake of irrigation and explanatory variables

(a) Dependent variables		
Description	Households that perceive climate change (percentage)	Households that do not perceive climate change (percentage)
Perception of climate change (dummy takes the value of 1 if perceived and 0 otherwise)	80.16%	19.84%
Description	Households that perceive climate change and use irrigation as an adaptation strategy	Households that perceive climate change but do not use irrigation as an adaptation strategy
Uptake of irrigation as adaptation strategy if HH perceived climate change	31.80%	68.18%

b) Explanatory variables

Description	Mean	S.D.
Education level of the household head in years (Continuous)	3.48	4.73
Family size (Continuous)	7.44	3.16
Literacy level of female household head or spouse (dummy: 1 if can read otherwise 0)	0.33	0.48
Quality of land for food production (dummy: 1 if a good quality, otherwise 0)	0.17	0.38
Quality of land for fodder production (dummy: 1 if good quality, otherwise 0)	0.62	0.49
Membership to association, cooperative, community (dummy: 1 if a member otherwise 0)	0.33	0.47
Assistance received from a friend (dummy: 1 if a yes otherwise 0)	0.54	0.50
Assistance received from a relative (dummy: 1 if a yes otherwise 0)	0.57	0.50
Assistance received from government (dummy: 1 if a yes otherwise 0)	0.21	0.41
Small number of livestock (dummy: 1 if a yes otherwise 0)	0.78	0.42
Medium number of livestock (dummy: 1 if a yes otherwise 0)	0.15	0.36
Access to credit (dummy: 1 if a yes otherwise 0)	0.26	0.44
Physical asset index×	3.78E-09	2.44
Government land tenure (dummy: 1 if a yes otherwise 0)	0.31	0.46
Privately land tenure (dummy: 1 if a yes otherwise 0)	0.32	0.47
Community land tenure (dummy: 1 if a yes otherwise 0)	0.28	0.45
Household distance from main road (km)	2.47	3.61
Size of land used for crop production (acres)	3.75	4.18
Access to agronomic information (dummy: 1 if a yes otherwise 0)	0.11	0.31
Climate information (dummy: 1 if received climate information, otherwise 0)	0.71	0.45

×A comprehensive physical asset index was constructed following the methodology developed by Gbetibouo et al (2010) to aggregate the different indicators (household assets, household dwelling and access to physical infrastructure) of physical capital.

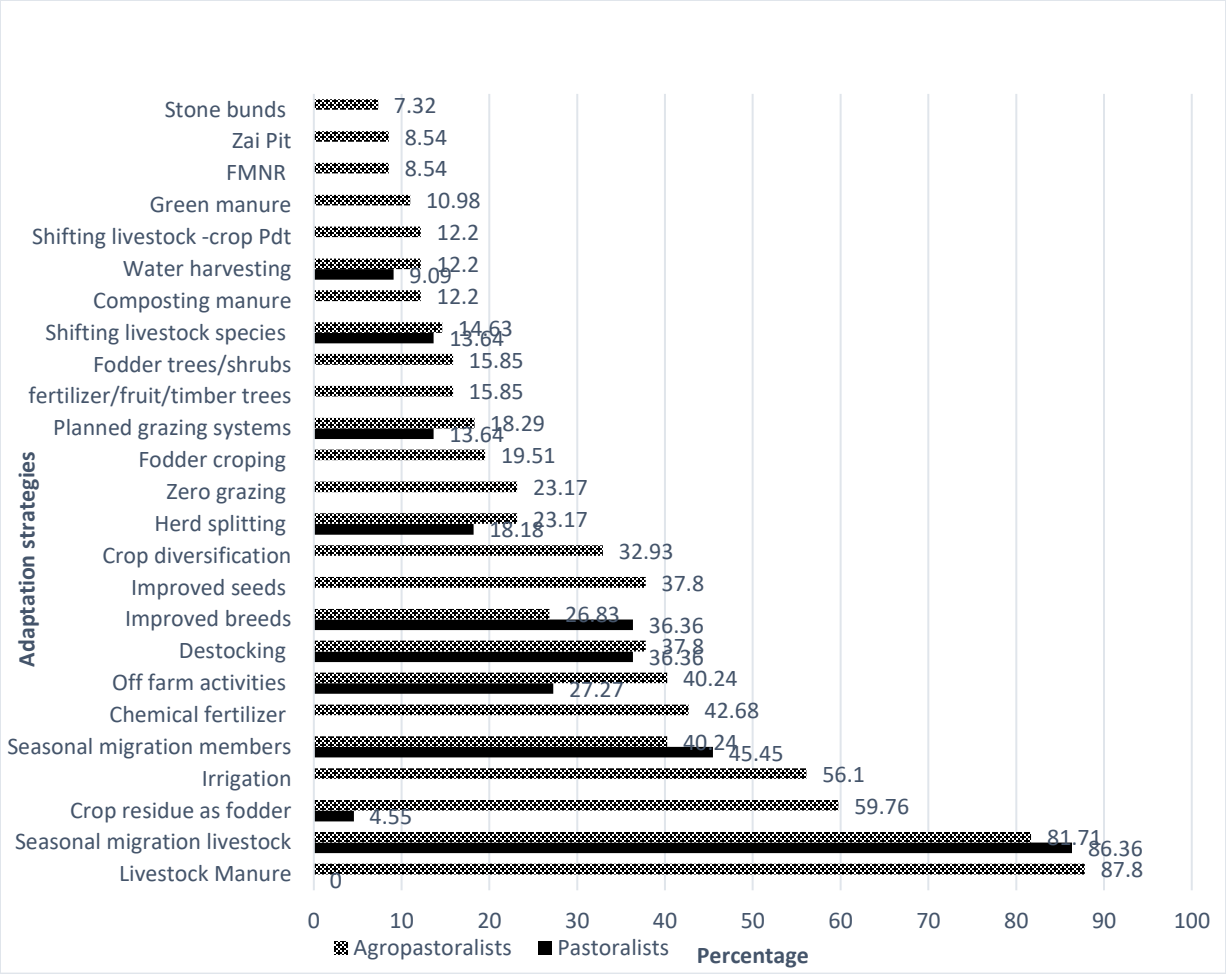

Figure 3.7: Adaptation strategies identified by pastoralists and agro-pastoralists

3.4.2 Econometric results

Table 3.4 presents results of the coefficients of the Heckman probit model determining the good fit or not in relation to perception of climate change and uptake of irrigation as an adaptation strategy. The Wald test for independent equations is significant, providing evidence of sample selection and justifying the use of Heckman probit model.

Table 3. 3: Econometric Results

Variable	Perception of climate change		Irrigation		
	ß-Coefficient	Standard Error	ß-Coefficient	Standard Error	
Age	**0.0315****	(0.0130)	**-0.0219***	(0.0128)	
Education of the household head	0.0229	(0.0292)	-0.00174	(0.0289)	
Family Size	**-0.118*****	(0.0419)	0.0468	(0.0459)	
Female Literacy	0.177	(0.300)	-0.412	(0.330)	
Land Quality for food	-0.752	(0.504)	**1.152****	(0.554)	
Land Quality for fodder	**0.530***	(0.318)	-0.00253	(0.282)	
Membership in Association	-0.355	(0.309)	0.373	(0.288)	
Assistance from Friends	-0.252	(0.290)	0.117	(0.312)	
Assistance from Relative	**0.589****	(0.282)	-0.272	(0.342)	
Assistance from Government	0.0992	(0.352)	**0.906****	(0.359)	
Small number Livestock	-0.210	(0.247)	**-0.473***	(0.249)	
Medium number Livestock	**6.730*****	(0.386)	**-0.931****	(0.453)	
Access to Credit			0.0529	(0.307)	
Physical asset Index			0.0608	(0.0743)	
Government land Tenure	-0.741	(0.590)	0.343	(0.487)	
Private land Tenure	-0.256	(0.518)	0.369	(0.475)	
Community land Tenure	-0.273	(0.666)	**1.556****	(0.618)	
Agronomic Information			**1.094*****	(0.393)	
Distance from the main road			0.0839	(0.0795)	
Size of land cultivated			-0.149	(0.0980)	
					1.340***
Constant	-0.0954	(0.909)	0.878	(0.809)	(0.0756)
Observations	149	149	149		
Wald test for independent equations	6.48** probit>chi(2)=0.0109				
Robust standard errors in parentheses					

*** p<0.01, ** p<0.05, * p<0.1

3.4.2.1 Drivers of household perception of climate change

Household perception of climate change is positively influenced by: age, quality of land for fodder production, assistance received from relatives, medium number of livestock herd owned by households and climate information available and accessed. Perception of climate change by households is however influenced negatively by the size of the family.

Age as a positive driver of household perception to climate change is as expected (Table 3.1). Triangulation this finding during FGDs, it was observed that the older generation were more knowledgeable on climate-related issues than the younger generation.

The positive correlation quality of land has on household perception of climate change is expected as the agro-pastoralists are farming on land with good soil characteristics and their investment is informed by their perception of the environmental changes. It was further observed during FGDs that villages involved in fodder production, discuss and are more aware of climatic changes as they preserved fodder for utilization during periods of prolonged drought.

The positive coefficient observed between assistance households receive from relatives and their perception of climate change is as expected (Table 3.1). It was observed that households residing in regions with good pasture (Lukusero/Nandugoro) often hosts their relatives' livestock who are agro-pastoralists in regions with limited grazing land (Ngare-Ndare/Chumvi). There is a positive relationship between medium size herds (51-149) of livestock with household perception of climate change. The positive relation climate information has on household perception of climate change is as expected (Table 3.1). The coefficient of family size was expected to take any direction. In this study it has a negative influence on household perception on indicators of climate change.

3.4.2.2 Drivers that encourage or hinder uptake of irrigation as an adaptation strategy

The socio-economic variables that significantly influence uptake of irrigation (Table 3.4) as an adaptation strategy among the pastoralists and agro-pastoralists are: quality of land for food crops, assistance received from government, community land tenure and agronomic information. Those that hinder its uptake are age of the household head and ownership of small and medium livestock herd. The positive relation land quality for food crops has on adoption of irrigation is as expected (Table 3.1). This is an indication that only households with access to fertile land and reliable source of water can engage in irrigation as a climate adaptation strategy.

The positive coefficient observed between assistance received by households from the government and irrigation is as expected (Table 3.1). This scenario is attributed to the government initiatives and devolved county government functions that support water resource users to access and utilize water sustainably among other initiatives like provision of seedlings. The positive correlation the community land tenure has with uptake of irrigation is an interesting observation and not in line with the expectations, since irrigation was not observed to take place among the pastoralists in the communal land. Agronomic information was observed to positively influence irrigation and this was expected (Table 3.1). Households who access agronomic information through various means demonstrated a greater propensity to adopt new agricultural strategies, including irrigation among others.

A negative coefficient was observed between age of the household head and irrigation. The older household heads (55-85 years) although were recorded to be more knowledgeable about climate change, had inbuilt limitation in their way of adapting to climate change. An inverse influence was observed between small (<50) and medium (50-150) herds of livestock size with uptake of irrigation, although this was expected to take any direction, in this case the negative coefficient

reveals that households with large (>150) herds of livestock are more likely to adopt irrigation than those with smaller and medium herds.

1.16 3.5 Discussion

The analysis of the socio-economic drivers, shows that a large proportion (80%) of the community perceive the indicators of climate change (Figure 3.8). This observation of the climatic condition by the community is in line with the predicted rise in temperature in Africa of 1.5 to 3°C by 2050 (AMCEN Secretariat 2007; Christensen and Hewitson 2007). In Kenya, temperature is expected to increase by 1°C by 2050 (Funk et al. 2010; Government of Kenya 2016). In the Sub-Saharan African, temperature is reported to have increased by 1°C between the years 1960 and 2003 (CIAT 2015). Since the 1970s, drought has become common (AMCEN Secretariat 2007) and is expected to increase with more dry years punctuated by good and poor rainy seasons (Funk et al. 2010). In Africa, drought is projected to increase by 5 to 8% in ASAL by the year 2080 (AMCEN Secretariat 2007). Rainfall seasons, annual trends and extreme events of floods are expected in East Africa although the amounts remain unclear (AMCEN Secretariat 2007).

Off the indicators that positively influenced household perception of indicators of climate change, among them is age. The older the household head the more sensitive and knowledgeable the household was in matters of climate change. The older generation is said to be more sensitive to climatic changes than the younger generation (Ndambiri et al. 2012). The positive correlation quality of land has on household perception of climate change can be explained by the fact that farming of both crops and fodder is practically taking place on land with good soil characteristics and water holding capacities. Households practicing this farming discuss changing climatic conditions with diverse stakeholders making them more aware of the global issues on climate change. Little et al. (2016) confirmed the practicality of agro-pastoralism in regions with good

quality of land with reliable rainfall. The positive coefficient assistance from relatives that households enjoy with their perception of climate change can be explained as a growing family support system viewed as a social safety net and an adaptation mechanism (Little et al. 2016). This comes in various forms among the pastoralists. Its continuity as a social safety net in times of duress is a growing concern (Mude et al. 2007). The positive relation medium herds (51-149) of livestock have with perception of climate change is associated with pasture availability and accessibility. In times of prolonged drought, households migrate their livestock in search of pasture and water. Those with small herds are challenged by the high cost involved in feeding them if they do not migrate, but also maintaining the herder upon migration. This makes them more aware of climate change and its impacts. The positive relation climate information has on household perception of climate change is as expected because households with access to this information are more aware of issues around climate change than households without access either because of limited network or the remoteness of their residing villages. The negative influence family size has on household perception of climate change can be explained by the fact that large family size was viewed to have labor capacity to diversity, taking up both pastoral and non-climate sensitive opportunities that bring more income to the household. These households are observed to engage many other livelihood sources to cope with increasing income demands like petty businesses. For example, in a large family setup, some household members migrate livestock in search of pasture and water, others engage in crop production while others in non-farm activities like employment and business.

Of those (80%) who perceived indicators of climatic changes, a limited (32%) but growing population has taken up irrigation as an adaptation strategy (Figure 3.8). Majority (93%) are agro-

pastoralists[5] in line with literature discussion that pastoralists are diversifying into agro-pastoralism while others are moving out (Nassef, Hesse, and Anderson 2009). Ideally, only households that perceive climate change have taken up irrigation as a proactive adaptation strategy. This decision is not influenced by climate change alone but other factors such as changes in land tenure, increased population, changing lifestyles and increased demand for agricultural products.

The socio-economic variables that encourage uptake of irrigation as an adaptation strategy at household level are indicated in green (Figure 3.8). These are: first, quality of land for food crops. This too has a positive correlation with household perception of climate change, an indication that households with access to fertile soils with good water holding capacity are not only aware of the changing climatic conditions but are equally adapting irrigation to reduce the risks. In Leparua neighborhood for example, households with access to fertile land and water practice irrigated agriculture. In this village irrigation takes place only along the riverine of River Ngare Silicon as the rest of the landscape is rocky, dry and degraded. Some of the households that migrated to semi-arid regions such as Ngare-Ndare and Manyagalo villages, and purchased land with good soil water holding characteristics, practice irrigation for food security and income through horticulture farming. This is in line with a similar observation by Gbetibouo (2009), who observed that land with fertile soil enhances the probability of expansion for crop production in the dry land.

Secondly, the positive correlation irrigation has with assistance received from government can be viewed from a landscape intervention. The dry land community relate regional landscape initiatives such as the formation of Water Resources Users Associations (WRUAs), institutions that manage water projects and trans-boundary water sources with government support. Adaptation

[5]'Agro-pastoralists' defined as those who earn over 50% of their household revenue from farming activities and 10-50% from livestock (Morton and Meadows 2000)

to climate change in the dry land therefore calls for the need to link adaptation to government development policies in addressing regional public goods (Collier, Conway, and Venables 2008).

Thirdly, community land tenure has an interesting positive relation with irrigation and not in line with expectations. This does not necessarily imply that irrigation is taking place in the community land where nature and wildlife conservation initiatives are taking place. During FGDs it was however observed that some pastoralists living in the communal lands (Lower Sanga village) were venturing into irrigation agriculture in rented lands in neighboring villages (Ngare-Ndare and Manyagalo) where land is of good quality and water for irrigation is available. Indeed, however, they continue to live within the community land and practice pastoralism. The question posed by the survey was whether households practiced irrigation which did not necessarily mean that they practice in the location of their residence in this case, community land.

Finally, access to information by the dry land community was observed to not only create awareness on climate change but equally encourage uptake of adaptation strategies. Agronomic information for example has a positive social economic driver of irrigation is based on information obtained from informal set-ups, social linkages and extension services, especially in horticulture and contract farming. This was observed to highly influence farming decision taken up by the households. This is an indication that households with access to extension services have a higher probability of adapting various adaptation strategies in agriculture than those without. This is in line with Gbetibouo (2009), who observed that adaption of soil and water conservation strategies is enhanced by the availability of information and technical skill provided to the households. This was due to enhanced efficiency in making decisions, new information and technical skill. Additional, Temesgen et al. (2014) related extension services with uptake of adaptation strategies.

Two variables were observed to hinder uptake of irrigation. First, age of the household head whose negative coefficient with uptake of irrigation implies that older household heads (55-85 years) although are observed to perceive climate change (Table 3.3), they are risk averse with limited flexibility to take up new strategies. The younger generation (21-55 years) is more open to innovations and modern agricultural technologies and therefore have a higher propensity to adopt irrigation as an adaptation strategy. This is an age group in transition; in the dry land, some of these age group members have moved from the community land and settled in private farms or on public land where they "privatize" land for individualized farming strategies. The results of FGDs showed that the older generation were more oriented towards traditional nomadic pastoralism or semi-nomadic pastoralism and were not likely to engage in new and risky adaptation strategies like crop production. Although this results indicate a negative correlation, and in line with Ndambiri et al. (2013), who equally observes that farmers in the age brackets 25-60 years engage in various adaptation strategies, other studies identify age as context- and technologically-specific and could go any direction (Gbetibouo, 2009).

The second variable that negatively influence uptake of irrigation is ownership of small (<50) and medium (50-150) livestock herd. This reveals that households with large (>150) herds of livestock are more likely to adopt irrigation than those with smaller and medium herds. The possible explanation of this scenario is the fact that livestock is used as a financial asset by many pastoral households to either smoothen consumption or for investment. Small and medium herds of livestock are typically sold to cover immediate domestic needs rather than for bigger investments such as irrigation. This limits the capacity of the poor herders to take risk in the name of new ventures. This observation is in line with Temesgen et al. (2014) who recorded that livestock herd

size had a significantly negative relationship with uptake of agricultural inputs like drought-tolerant crops and adoption of agronomic strategies.

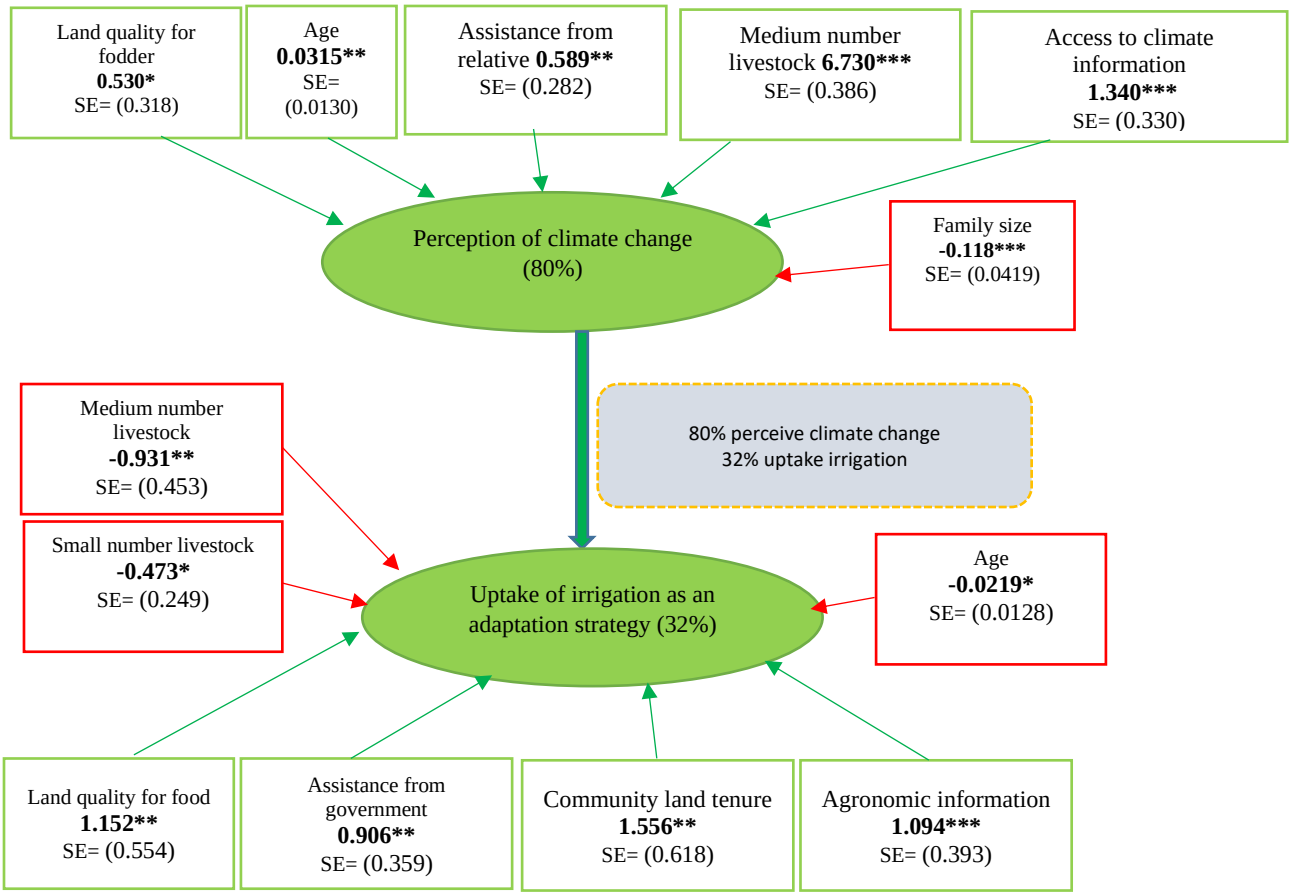

Figure 3.8. Social economic variables that influence (green) or hinder (red) perception of climate change and uptake of irrigation

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1.19 3.6 Conclusion

This chapter stipulates clearly that agriculture in Kenya's ASALs, although encouraged and promoted by the government, is limited due to prolonged drought and access to water for irrigation. Pastoralism has been well known as the most efficient way of using the natural resources in the ASAL, ideally decided by nature. Nevertheless, it is important to note that uptake of irrigation at household level is taking shape and is positively influenced first by good quality land for food crops. To sustainably utilize the dry land for crop production, irrigation plays a key strategy as it represents a bridge, an avenue that introduces livestock keepers to a transition from nomadic pastoralism to sedentary agro-pastoralism (King et al. 2018). Investing in strategies that build the soil fertility, water holding capacity and rain water harvesting is paramount (NEPAD 2002) in the fragile ASAL. Equally, an enabling environment for investment in irrigation, water management strategies and scaling out the uptake of this practice among other adaptation practices need policy consideration.

The governance of community land tenure has an interesting positive relation with uptake of irrigation. This implies that the set rules and regulations that govern land in the ASAL supports both collective rangeland management (Damonte and Rodríguez 2016), and individualized adaptation strategies practiced outside the ranch. It allows diversification outside pastoralism but ensures its continuity as the best suited adaptation strategy in the arid areas of Kenya. Appropriate access to extension services is however needed to harness the positive influence agronomic information has on uptake of irrigation. Extension services plays a major role in providing climate information for climate smart agricultural practices such as water harvesting and conservation needed for the sustainability of irrigation as a technology in the dry land.

The significant negative influence age has on uptake of adaptation strategy suggests the need to target the young generation often left out of agricultural related development interventions. It is often perceived that the younger generation has an open approach towards new technologies and innovative ideas compared to the older generation. On the other hand, the negative influence ownership of small and medium livestock herd has on irrigation indicates the need to have large herds of livestock as financial asset or financial diversification since a financial investment is needed in any adaptation. Pastoral large livestock herd is a significant financial asset, implying a need to develop a livestock breeding and marketing programs that can ideally liquidate livestock to cash or finances when urgently required to invest in adaptation strategies among the dry land community.

The dry lands are characterized by limited supply of water, amidst other stressors exacerbated by climate change, threatening the sustainability of pastoralism as a livelihood option for the dry land community. The increasing livelihood diversification and uptake of new adaptation strategies taking place in the region calls for policy attention to this environmental challenge to ensure that principles of climate-smart strategies are adhered to in this fragile and drought stressed ecosystem. For example, the sustainability of irrigation in the dry land is an empirical question which can be effective through: improved land tenure security, water management and sustainable landscape strategies including rainwater harvesting and agroforestry. These landscape conservation technologies will conserve and stabilize the water supply. An ecosystem-based adaptation approach that will contribute significantly to averting the negative consequences of climate change. Trees in particular play a crucial role in the ecosystem and ground water recharge (Ilstedt et al. 2016).

Proposed future research based on the limitations observed includes: to conduct research at the landscape level to assess trade-offs and complementarity between irrigation and other livelihood strategies such as agroforestry. This is ideally because water management is a landscape concern in the catchment area and needs to go beyond household and community level. Secondly, assess households' decisions to simultaneously adopt several strategies, beyond irrigation with the potential of reducing household vulnerability to climate change and increase food security. This paper focused solely on irrigation as one of the main adaptation strategies, however, descriptive analyses showed that the households adapt several strategies simultaneously.

CHAPTER FOUR: CHARACTERISING ASSETS AND RESOURCES THAT DETERMINE ADAPTIVE CAPACITY OF THE DRY LAND COMMUNITY.

1.20 4.1 Abstract

Climate change is a reality in Africa's drylands. Pastoralists are engaging and embracing a range of adaptive strategies to adapt to these changes. The socio-economic factors driving them to engage in multiple portfolios of adaptation strategies have not been adequately addressed in the existing literature. The researcher used a multivariate probit model to analyze the determinants of adaptive capacity that promotes or hinders adaptation to climate change. Adaptation is represented by uptake of multiple strategies (irrigation, livestock migration, fodder production and improved livestock breeds) by households, a demonstration of household's ability to diversify and adapt to the effects of climate change. Household asset base, particularly social capital represented by government assistance, stood out as it positively influenced uptake of four out of five adaptation strategies, that is; irrigation, livestock manure, fodder production and improved breeds. Information heavily supports the adaptation process as it influences all the five adaptation strategies analyzed but has a heterogeneous effect, supporting households to either adopt or reject a strategy. Crop-based information positively determines uptake of yield-enhancing strategies while relevant information for livestock activities contributes to the uptake of livestock-based strategies. These findings suggest that mainstreaming agricultural innovations, building household asset base and facilitating access to agronomic and climatic information will enable dryland community to better adapt to climate change.

Key words: *Climate change adaptation, Adaptive capacity, Pastoralists and agro-pastoralists, Household assets, Land tenure, Climate and agronomic information*

1.21 4.2 Introduction

Climate change is real in the drylands of Eastern Africa (EA) which stands out as the worst hit region in the world due to its susceptibility, high levels of vulnerability and low adaptive capacity (Kempe Ronald Hope Sr, 2009; Reid and Vogel, 2006; Rosenzweig et al., 2008). In Kenya, this is more critical because, nearly 89% of the landmass is under arid and semi-arid lands (ASAL) (Government of Kenya, 2012). These are homes to 38% of the Kenyan population who are predominantly pastoralists and agro-pastoralists, communities that heavily depends on climate-sensitive natural assets and ecosystem resources for their livelihood and food security thus exacerbating the already dire situation,(Government of Kenya, 2012). The negative impacts of climate change and variability such as prolonged drought, delayed onset of rains and extreme floods leads to economic losses, food insecurity and conflict over scarce resources (Government of Kenya, 2013). This comes amidst other complex stressors such as rapid demographic growth, chronic poverty, land fragmentation and degradation, depletion of natural resources, insecurity and conflict (Government of Kenya, 2015; Headey and Kennedy, 2011).

The uptake of adaptation strategies in the ASAL is reported to be low compared to other ecological zones such as the humid and temperate zones (Bryan et al., 2013). This low adaptation situation is associated with greater constraints in the drylands such as chronic poverty, insecure and ill-defined property rights, population pressure, the HIV/AIDS pandemic, insecurity and armed conflicts, land fragmentation and degradation (Bryan et al., 2013; Nassef et al., 2009; Silvestri et al., 2012). This notwithstanding, the dryland communities are learning, nurturing and adopting multiple strategies such as livestock migration, irrigation, destocking, changing livestock breeds and diversifying animal feed to mitigate climatic and non-climatic shocks that threaten their livelihoods (Bryan et al., 2013; Silvestri et al., 2012). Adaptation to climate change is a demonstration of adaptive

capacity (Smit and Wandel, 2006), defined as a reflection of the potential of a system to adapt to the effects or impacts of climate change (Downing , 1991). It involves changes to better deal with problematic exposures and sensitivities (Smit and Wandel, 2006) and the factors that drive this adaptive capacity or the determinants, have been categorized as context-specific (Smit and Wandel, 2006).

The objective of this chapter is to analyze the socio-economic factors at play in encouraging or hindering pastoralists and agro-pastoralists households to engage simultaneously in multiple adaptation strategies. It focuses specifically on household assets, governance of land tenure and climatic and agronomic information among the Maasai community of Laikipia County Kenya.

1.22 4.3 Background information

4.3.1 Pastoralism and agro-pastoralism in the drylands of Kenya

The Kenyan drylands, synonymous with arid and semi-arid lands (ASAL), occupies 89% of the country's total landmass (Government of Kenya, 2012). The ASALs are climatically unstable with aridity as the dominant characteristic where low and erratic rainfall ranges from 150-550mm per annum in arid areas and 550-850mm per annum in the semi-arid areas (Fratkin, 2001; Government of Kenya, 2012). These drylands, are sparsely populated and host a numerically small percentage (38%) of the Kenyan population (Government of Kenya, 2015). Pastoralism is the dominant social and economic activity in these climate risk-prone arid areas. It entails an extensive livestock production system in the rangelands where livestock mobility and communal natural resources as risk management strategies for water and pasture are the main defining features (Government of Kenya, 2012). Pastoral mobility, is however not just about a coping strategy in the face of a problem as commonly interpreted in literature, but also a strategy used by pastoralists to match the variable distribution of nutrients for livestock in the rangelands (Krätli, 2015). It is a highly

appropriate production strategy in environments characterized by high climate variability and unpredictability (Adriansen, 2005).

In the literature from the 1990s, a gradual shift from nomadic pastoralism, to agro-pastoralism was recommended, where fodder would be cultivated for livestock production (Steen, 1994). In Ethiopia, this shift is observed (Lemenih and Kassa, 2011) while in northern Tanzania pastoralists are modifying certain coping strategies such as mobility while taking up new adaptation practices such as purchasing rights to pasture, and abandoning certain cultural coping practices like reciprocity (Goldman and Riosmena, 2013). This notwithstanding, changes in land use in ASAL has resulted to land fragmentation, intensification of agriculture demanding more farm inputs, overgrazing, conflict over scarce and diminishing resources, water scarcity among other issues (Maitima and Gumbo, 2007). The Maasai community of Laikipia County, Kenya, are selected for this study for three reasons: First, as a pastoralist community whose main source of livelihood is domestic livestock (cattle, goats, sheep, camel and donkeys). Second, as a community that is responding to political, environmental, social and economic changes by diversifying into agro-pastoralism, sedentary lifestyle and more individualized adaptation actions (Government of Kenya, 2012). Finally, as a community whose footsteps other pastoralists in the drylands are following (Fratkin, 2001).

Agro-pastoralism, is defined as a livelihood system where households obtain more than 50% of their domestic revenue from crop production and 10-49% from livestock and related products (Morton and Meadows, 2000). Individualization of land use and ownership that promotes agro-pastoralism is a primary policy challenge as it undermines pastoral livestock mobility systems and collective customary institutions needed as adaptation strategies in ASAL regions (Mwangi, 2006). Individualized actions result in socially differentiated vulnerability of the community to impacts

of climate change (Adger Neil. W, 2003) where households endowed with sufficient assets attain better adaptive capacity (Mude et al., 2007). The transformation among the Maasai community dates back to the infamous 1904/1911 Maasai agreement, a historical colonial regime which saw massive appropriation of Maasai land to foreigners (Koissaba, 2016). Subsequently the post-independence laws that promoted economic policies and measures advocating for land privatization and subdivision of communal lands into private group ranches and trust lands (Koissaba, 2016). This was done through registration of private rights of pastoral groups and incorporating commercial livestock production systems into the market (Fumagalli, 1978). Most ranch owners were able to make a reasonable living until the late 1980s, when the input costs became so high that ranchers began de-stocking. The collapse of the Kenya Meat Commission (KMC) and unpredictable beef prices made ranching even more economically unviable. Introduction of group ranches in Maasai land, ushered a process of individualization of land use and ownership in the early 1980s (BurnSilver, 2016; Mwangi, 2006; Rutten, 1992). The subdivision of land hindered the pastoral mobility, a production system viable in the ASAL region as well as other economic activities that benefited from collective action (Mwangi, 2006).These land use changes followed by the drought of 2001 saw an increase in sheep and goat farming, cultivation and habitation in the transitioning ranches (Georgiadis et al., 2007). The need for alternative income in the late 1980s together with government policies suppressed pastoral communities in favor of eco-tourism and wildlife conservation while maintaining low livestock commercial ranching (Unks et al., 2019). These changes have had a bearing on the propensity of pastoral communities to adapt to climate change and this explains the underlying reasons as to why some are shifting to more sedentary lifestyles. Whether or not these changes are in response to

opportunity (positive) or constraints (negative) - the root of this in Laikipia County lies in the historical contingencies in the past, exacerbated by climate change.

4.3.2 Conceptualizing the propensity to adapt

The climatic conditions, ecological landscapes and institutional frameworks of the drylands have experienced drastic changes over the last century (Agrawal, 2010; Wangui et al., 2012). Changes such as onset of rains, its cessation, duration and intensity have adversely affected pastoral coping mechanisms to climate variability (Nassef et al., 2009; Wangui et al., 2012). Climate change adaptation rhetoric around pastoralists in the drylands of Kenya has featured more on institutional frameworks, this chapter explores question of household adaptive capacity based on the roles of assets, governance and climatic and agronomic information in addressing climate change impacts (ACCRA, 2010; Berkes, 2002).

Adaptive capacity reflects the propensity of households and community systems to prepare, adjust or adapt to the effects or impacts of climate change (Engle, 2011; Smit and Wandel, 2006; Downing , 1991). It is reflected through adaptation as a socio-economic and technical process performed individually or as a collective action by actors in response to socio-ecological change (Crane et al., 2011; Eriksen et al., 2015). The forces of adaptive capacity, referred to as determinants, describe the characteristics of a system or society to adapt to the changing external conditions (Fussel and Klein, 2006; Smit and Wandel, 2006). These characteristics are based on the "Local Adaptive Capacity framework (LAC)" (Jones et al., 2010) which has five components. First, household asset base that includes the five capitals in literature: human, financial, social, physical and natural capitals. Second, institutions and entitlements which ensure impartial distribution of key resources. Third, knowledge and information considered important for adaptation to take place. Fourth, innovation where the systems' ability to support innovation is

examined. And finally, governance and informed decision-making where issues of participatory, transparency and community prioritization are considered.

The uptake of adaptation strategies is a manifestation of adaptive capacity (Smit and Wandel, 2006). In this chapter I build on this argument to conceptualize that the adaptive capacity of the pastoral community is demonstrated by the adaptation strategies they are engaging in. I therefore critically identify those factors that either promote or hinder the uptake of the identified adaptation strategies. These factors are identified through the LAC framework; asset base, information and governance (Jones et al., 2010). Asset base is observed through the Sustainable Livelihoods Framework (SLF) which identifies the five capitals owned and/or accessible by households. Information looks at agronomic and climatic information available and accessed by households on pasture, water and farm technologies. Governance is observed through land tenure regimes that examines the state of land the households own or access which determines their adaptation decisions. I connect these determinants of uptake of adaptation strategies as indicators of propensity to adapt or adaptive capacity of the pastoralists and agro-pastoralists communities.

4.3.3 Propensity to adapt among pastoralists and agro-pastoralists

The pastoral households are diversifying, taking up multiple strategies such as livestock migration, irrigation and non-climate dependent livelihoods like petty trade (Bryan et al., 2013). There is no coherent information on how these households adopt multiple strategies and the factors that drive their decisions. Opiyo et al., (2016) identified household capital such as human, financial and physical as factors that determined the ability of pastoral communities to adapt using Heckman probit model. This step wise process, however, did not consider their ability to adopt multiple adaptation strategies like is practically happening on the ground. In the Eastern drylands of Kenya, the Heckman model was equally used to identify farmers' adaptation strategies and the assets that

influenced their likelihood of adaptation (Ndambiri et al., 2013). This study did not statistically relate the assets as determinants of any specific adaptation strategy. In Malawi, Multivariate Probit (MVP) was employed to model household selection of Climate-Smart Agricultural (CSA) practices (Asfaw et al., 2014). This study identified distinct nature of climate change adaptation decisions made by individual farmers in employing different climate-smart farm practices (Asfaw et al., 2014). This is fundamental information in adaptation process as it facilitates understanding of community interaction with specific practices, identifying the promoters and barriers of adaptation process. This information although relevant for policy, research and development among the pastoral community in the drylands of Kenya, is missing and therefore a key motivation for this chapter.

The aim of this chapter is to identify socio-economic and technical factors that hinder or encourage adoption of multiple adaptation strategies and to empirically characterize adaptive capacity of a transitioning pastoral community. This knowledge provides important insights for policy makers, researchers and development practitioners designing interventions to support the climate change adaptation process in the drylands.

1.23 4.4 Methodology

A complete methodology inclusive of the study area and data collection methods is discussed in chapter 3.

4.4.1 Description of the community under study

Laikipia County, located in the drylands of Kenya, is home to the Laikipiak Maasai, of Il Ngwesi Group Ranch. This dryland community practices a mix of pastoralism and agro-pastoralism livelihood systems. While I recognize that there is a fluid gradient between these two categories

of livelihood rather than a hard boundary (Krätli and Swift, 2016), I use these labels as a heuristic to discuss the transitional trajectories towards crop based livelihood systems observed in some sub-populations of this community. Although this distinction has been critiqued (Krätli et al., 2015), the two terms are here used as analytical categories rather than an indication of cultural self-identification. For the purposes of this chapter, pastoralists are therefore viewed as households with a high, over 50% (Morton and Meadows, 2000) level of dependency on livestock production system in the drylands with mobility as the main defining characteristic. Agro-pastoralists are viewed as households with some level of livestock mobility and have shifted to high level of dependency on crop-based systems such as taking up rain-fed and irrigated agriculture. This changing dynamic is related to the fragmentation of the "Laikipiak" Maasai who originally lived in the community-owned Il Ngwesi Group Ranch. Majority (>75%) of these ranch members have migrated from the semi-arid or arid savannah land to settle in neighboring semi-arid parts of Laikipia, Meru and Isiolo. These are regions with climatic opportunities for crop production and therefore the transition observed. The array of livelihood diversification strategies that accompany the Il Ngwesi diaspora forms the basis for analyzing factors that contribute to adaptive capacity.

The transition of the ranch members became more prominent due to increased rainfall variability and consequently high (>75%) livestock mortality (Little et al., 2016; Unks et al., 2019). Equally, of importance was the critical decisions made by the community leadership to convert the ranch into a conservancy and eco-tourism facility. According to the group ranch constitution, the villages where members have settled are aggregated and referred to as the seven neighborhoods (Figure 3.1). These are Chumvi, Ethi, Ngare-Ndare/Manyangalo, Lukusero/Nandugoro, Leparua, and Lower and Upper Il Ngwesi (Figure 3.1). The community's main source of livelihood is pastoralism and agro-pastoralism.

4.4.2 Selection of the dependent variables

An exhaustive list of adaptation strategies (Figure 3.5) generated from FGDs and literature was incorporated into the household questionnaire. The five adaptation strategies selected according to descriptive statistics are pro-active and not reactive to climate stress, they contribute to enhanced crop yields and improved livestock productivity and management and these includes livestock manure, seasonal livestock migration, and crop residue as fodder, irrigation and improved livestock breeds. These five strategies were used as dependent variables and subjected to econometric model analysis.

Livestock manure is a dominant strategy among the agro-pastoralists (88%) (Figure 3.7). Manure is used in crop production as well as a source of income in the livestock manure trade (Kigiria et al., 2013). Although livestock manure is documented as a contributor to global climate change through greenhouse gas (GHG) emission (Bank. and CIAT, 2015), with proper management, it is taken as an adaptation strategy among smallholder farmers in a mixed farming system (Roncoli et al., 2010). This is due to its low cost of fertility restoration in comparison to inorganic fertilizer and for improving soil water-holding capacity (Amole and Ayantunde, 2016; EIP-AGRI Focus Group, 2016; Roncoli et al., 2010).

Historically, pastoralists used seasonal migration of livestock as a way of life to overcome climate variability (Gautier et al., 2016) as well as to take advantage of variable distribution of resources in the rangelands (Krätli, 2015). With the fundamental transitional changes taking place, the dryland community is adapting a modified pastoral mobility livestock strategy (86% pastoralist, 82% agro-pastoralist) (Figure 3.7) to respond to heightened variability and unpredictability as a result of climate change. Livestock mobility is now more strategic with less involvement of family members like the case of “Laikipiak” Maasai who let their livestock to migrate with herders and

or with a family member and the rest of the household members are left in the established homesteads.

Irrigation is an investment among the agro-pastoralists (56%) (Figure 3.7), a documented adaptation strategy at the farm level (Bryan et al., 2013). It facilitates the household to embrace production and marketing of high value crops like french beans, tomatoes and onions and reduces on their dependence on the unpredictable rainy seasons, improving household food security and income (UNDP, 2009). The capacity of households to engage in irrigation depends on multiple household capital (social, financial and physical) (King et al., 2018).

The utilization of crop residues as livestock feed is a dominant practice among the agro-pastoralists (60%) (Figure 3.7). A community that practice crop production and therefore an expected assumption. Additionally, a strategy documented as a fundamental practice of feeding livestock among pastoralists (Little et al., 2016). Crop residues as fodder was equally prioritized at the FGD as participants discussed cultivation of fodder as hay, a practice that is on the rise in the drylands of Kenya.

Improving livestock breeds was identified as an adaptation strategy during FGDs. Its uptake in the region is on the rise. A strategy documented among the well-off Maasai of Tanzania who target livestock markets (Goldman and Riosmena, 2013). It involves introducing a superior male breed to a herd of indigenous female livestock to produce improved offsprings.

4.4.3 Selection of the independent variables

Table 4.1 presents the independent variables (household assets, information and governance) selected based on climate change adaptation literature.

Household assets entails analyzing the five sustainable livelihood assets: human, natural, social, financial, and physical capitals (FOA, 2002). Human capital as a determinant of adaptation is

grounded on household structures and composition (Dulal et al., 2010; White, 2009). The variables selected to represent it include: age and education of household head, family size and female literacy. Female literacy was of particular interest as was observed to be low (33%) as indicated by descriptive statistics (Table 4.2) and in pastoral community as confirmed by (Mude et al., 2007). This is a hindrance to some decision making processes inclusive of adaptation (FOA, 2002). Natural capital defined as "world's stock of natural resources" (Morton and Meadows, 2000) was represented by quality of land for crop and fodder production. Social capital that defines the way social relations develop between individuals and households in the society (Kgathi et al., 2007) was represented by assistance from a friend, relative, or the government and membership to any association. The type of assistance elicited in this chapter was in the form of money or food the household got in the previous 12 months to the survey. Financial capital entails resources and assets, available to the household to provide goods and services (Morton and Meadows, 2000). To model financial assets, livestock herd size and access to credit were selected as representative variables. Although household livestock units has often been used as a proxy for analyzing household wealth, it failed to account for other household financial sources (King et al., 2018) such as access to credit and saving (Pettengell, 2010). Taking note of this, access to micro-credit institutions was therefore included as a representative of financial asset variable. Physical capital was viewed as household infrastructure inclusive of household dwelling and physical infrastructures (roads and market) (Headey and Kennedy, 2011). To aggregate these different indicators of physical capital, a comprehensive asset index was constructed following the methodology developed by Gbetibouo et al. (2010).

Information as a public good provided by the government enhance adaptation (Collier et al., 2008) and its accessibility improves the likelihood of households to adapt (Belay et al., 2017) while of it

hinders adaptation (Gbetibouo, 2009). To analyze climatic and agronomic-related knowhow of the households, the following variables were considered: climate information for grazing purposes, information on pasture availability, information on water point availability, climate information to decide about agronomic technology and agronomic information on farm technology.

Governance of land tenure regime was defined as institutional arrangements that set up rules and govern the relationship people have with land (Damonte and Rodríguez, 2016). Three such land regimes available in the dryland were identified and considered as variables in the model: 1. Public land, defined as land owned by the government and dedicated to a specified public use or made available for private use at the discretion of the government (Ministry of Lands, 2007). 2. Private land which is land held by an individual or other entity under freehold or leasehold tenure (Ministry of Lands, 2007). 3. Community land, defined as lawfully held, managed and used by a specific community and aimed at ensuring preservation of the asset base for current and future generations (Ministry of Lands, 2007).

Table 4. 1: Independent/indicators variables identified for MVP model

Independent variables	Indicators identified for the analyses

Households' assets/capital	
Human	- Age of the household head - Education level of the household head - Female literacy - Family size
Natural	- Land quality for crop production - Land quality for fodder production
Social	- Membership in farmers' group or association - Assistance from friends, relatives and government
Financial	- Access to micro-credit institutions (formal, informal, community or NGO lending institutions) - Ownership of livestock (cattle, goats and sheep)
Physical	- Aggregate index encompasses household equipment such as radio, TV, cell phone, bicycle, motorbike, as well as farm equipment such as cart, water pump, ox plough, and access to road infrastructure
Governance	- Public Land Tenure - Community Land Tenure - Private Land Tenure
Information	- Climate information for grazing purposes - Information on pasture availability - Information on water point availability - Climate information for agronomic technology - Agronomic information for farm technology

4.4.4 Analytical methods

Descriptive statistics such as means, and frequencies are used to first give an overall picture of the socio-economic characteristics of the households (Table 4.2) and, secondly, to determine the land tenure regimes which was constructed based on the respondent's locations and their reported conditions of land ownership. Third, the average values of the dependent and explanatory variables guided formulation of the econometric model which was found suitable due to its ability to model the influence of a set of predictor variables on each of the adaptation options, while allowing error terms between the unobserved and unmeasured disturbance to freely correlate jointly (Lin et al., 2005). This would occur due to possible complementarity (positive correlation) or substitutability (negative correlation) between the different adaptation strategies (Asfaw et al., 2014; Ashraf et al., 2014). The Multivariate Probit (MVP) model used, draws from statistical literature of Asfaw et al., (2014); Ashraf et al., (2014); and Lin et al., (2005). It models the relationship between explanatory variables (household assets, governance and information) and the five adaptation strategies identified.

The MVP model used in this study is characterized by a set of five (*n*) binary-dependent variables (Seasonal livestock migration, livestock manure, irrigation, crop residue as fodder, and improved livestock breeds), such that:

$Y_{in} = 1 \quad if\ X'_{in}\beta n + u_{in} > 0$

(Eq 1)

$Y_{in} = 0 \quad if\ X'_{in}\beta n + u_{in} \leq 0\ Where\ i = 1,2,\ldots,N. \qquad n = 1,\ldots..5$

In equation 1, the assumption is that a rational i^{th} household has a latent variable Y^{*}_{in} which captures the unobserved preferences or demand associated with the n^{th} option of adaptation strategy. X'_{in} is a vector of explanatory variables, $\beta 1, \beta 2\ldots, \beta n$ denotes conformable vector of parameters to be

estimated, u_{in} are the random error terms distributed as multivariate normal distribution with zero mean and unitary variance.

Table 4. 2: Definition of explanatory variables and their mean

Dependant variables	Irrigation	Livestock migration	Fodder production	Livestock manure	Improved livestock breeds
Irrigation	1				
Livestock migration	-0.0383	1			
Fodder production	0.3401***	0.042	1		
Livestock manure	0.6158***	0.0567	0.2894***	1	
Improved livestock breeds	0.0879*	0.1591***	0.0844*	0.1638***	1

*Significance levels: *, **, *** Significance at 10, 5 and 1%, respectively*

1.24 4.5 Results and discussions

4.5.1 Social-economic and technical determinants of adaptation

The correlation matrix (Table 4.2) indicate interdependence between multiple adaptation strategies engaged by pastoralists and agro-pastoralists as either complementing or substituting each other. The MVP model (Table 4.3) show statistically significant coefficients, indicating the notion of possible complementarity (positive correlation) or substitutability (negative correlation) across the different adaptation strategies (Asfaw et al., 2014; Ashraf et al., 2014). This supported the use of MVP model which allowed potential correlation between the unobserved disturbances and interrelationship between adaptation options (Kassie et al, 2013). This indicates critical points that require consideration during research, policy and development interventions.

Table 4.3: Estimated correlation matrix of MVP analysis

Variable code	Variables	Description	Mean	Standard Deviation
Human capital				
hhage	Age	Continuous (years)	45	13.2
hheduc	Education level of the household head	Continuous (years)	3.50	4.73
hhtot	Family size	Continuous (number)	7.00	3.16
fhlit	Female literacy	dummy: 1 if can read otherwise 0	0.33	0.48
Natural capital				
landqfood1	Quality of land used for food production	Dummy: 1 if a yes high overall quality otherwise 0	0.32	0.47
landqfood2	Quality of land used for fodder production	Dummy: 1 if a yes high overall quality otherwise 0	0.21	0.41
Social capital				
membass	Membership to any association, cooperative, community	dummy: 1 if a member otherwise 0	0.33	0.47
assfriend	Assistance received from a friend	dummy: 1 if a yes otherwise 0	0.54	0.50
assrel	Assistance received from a relative	dummy: 1 if a yes otherwise 0	0.57	0.50
assgov	Assistance received from government	dummy: 1 if a yes otherwise 0	0.21	0.41
Financial capital				
smallivest	Small numbers of livestock	dummy: 1 if a yes otherwise 0	0.78	0.42
medlivest	Medium numbers of livestock	dummy: 1 if a yes otherwise 0	0.15	0.36
credacc	Access to credit	dummy: 1 if a yes otherwise 0	0.26	0.44
Physical capital				
assetindx	Physical asset index*	Continuous	3.78E-09	2.44
Governance				
gov_own	Government land tenure	dummy: 1 if a yes otherwise 0	0.31	0.46
priv_own	Private land tenure	dummy: 1 if a yes otherwise 0	0.32	0.47
comm_own	Community land tenure	dummy: 1 if a yes otherwise 0	0.28	0.45
Information				
infclimwg	Seasonal climate forecast to decide where to graze	dummy: 1 if a yes otherwise 0	0.44	0.5
infpast	Information on pasture availability to decide where to graze	dummy: 1 if a yes otherwise 0	0.71	0.45
infwatpt	Information on water point availability to decide where to graze	dummy: 1 if a yes otherwise 1	0.64	0.48
infclimft	Climate information to decide which farm technology to use in the face of CC	dummy: 1 if a yes otherwise 2	0.11	0.31
infagroft	Agronomic information to decide which farm technology/adaptation option to use in the face of CC	dummy: 1 if a yes otherwise 0	0.50	0.22
	Constant	Number of Observations (N)		

ˣA comprehensive household asset index was constructed following the methodology developed by Gbetibouo et al. (2010) to aggregate the different indicators (household assets, household dwelling and physical infrastructure) of physical capital.

The second objective of this PhD study was to give insights on socio-economic and institutional factors that drive the adaptation process in the drylands. Table 4.3 outlines the household determinants that facilitate the pastoral community to adapt to climate change by engaging or disengaging in multiple portfolios of adaptation strategies.

Female literacy level as an indicator of human capital has a negative influence in the uptake of three adaptation strategies; these are: irrigation, fodder production and livestock manure. This is an unexpected scenario implying that an increase in the literacy level of women in the pastoral system reduces household propensity to adopt proactive adaptation strategies in line with pastoralism and agropastoralism. This is due to other available opportunities in the drylands that are easily embraced by the few women with higher literacy levels than the others. This was equally observed and discussed in FGD where the ladies who would communicate in the national language were sought for and engaged in activities that drew them away from on-farm activities.

I observed that the quality of land accessed or available to the households for either fodder or food production has a very high positive coefficient of correlation with production of fodder for livestock and utilization of livestock manure and an equally high but negative correlation with improved livestock breed, an indication that good quality of land reduces the likelihood to adopt improved livestock breeds. The pastoral community explained this scenario based on labor relation where crop production in good quality land was preferred to producing fodder for improved livestock which was said to be sensitive and more labor demanding.

Government assistance to the pastoral community was observed to significantly promote four technically demanding adaptation strategies (irrigation, fodder production, use of livestock manure and adoption of improved livestock breeds). However, it is interesting to note how livestock migration as an adaptation strategy has been left out of government assistance, implying that the

government does not facilitate pastoral livestock mobility as an adaptation strategy despite its effectiveness and strong historical track record. This could be explained by the stated government responses to climate change on livestock and pastoralism that includes livestock breed improvement, livestock insurance and fodder production (Government of Kenya, 2013) and omits the creation of an enabling environment for pastoral mobility. Membership to associations, cooperatives or community groups had a negative influence on fodder production, a scenario attributed to Hardin's argument on the "Tragedy of the Commons", the common pool resources (Ostrom et al., 2002). This is explained by how fodder production as an increasing trend in the ASAL region is emerging as a private collective practice (Ng'ang'a and Crane, 2020) where households are either individually or together as a group "privatizing" public good for fodder production, limiting its accessibility by others. This causes conflict and insecurity especially during periods of drought, watering down efforts done in fodder production as "others" try to get access to graze their livestock. Additionally, a negative correlation coefficient between assistance received from relatives and livestock manure is observed. This is explained by the fact that during periods of drought, relatives in areas with pasture and water, host family members' livestock and the manure generated belongs to the host.

Two scenarios were observed in relation to the size of livestock herd, first a positive correlation between medium size of livestock herd (51-149) and livestock migration and secondly, a negative correlation with small herd (<50) of livestock. This ideally implies that households with large herds of livestock above 51 have a higher probability of migrating their livestock for pasture and water. A larger herd of livestock is considered not only as a livelihood strategy but also as an enterprise that can either engage the owner fully as a herder or can pay for the services of a contracted herder.

The overall household index (3.78E-09) constructed to represent the physical asset positively influences uptake of two adaptation strategies: livestock manure and improved livestock breeds. This indicates the usefulness of livestock manure in households with higher household index, ideally because they have the capacity to transport the manure to their farms, for example, by use of a cart or have mobile phones that they use to contact potential buyers. Additionally, in regard to improved livestock breeds, these households can engage in livestock breed improvement programs because they can financially afford the higher quality male bulls or buck often purchased from neighboring private ranches. They can equally engage and participate in markets because they have access to the communication assets needed for such activities.

Climatic and agronomic information as a component of adaptive capacity has direct influence on all the five adaptation strategies in either or both directions. Climate information for grazing purposes positively influences uptake of irrigation and fodder production strategies but hinders improved livestock breeds. This scenario is related to governance of land tenure as households in private lands practicing irrigation can send their livestock to regions with pasture or fence off their land to produce fodder as a reserve during prolonged drought. Tradeoff between utilization of land for irrigation or for improved livestock breeds such as dairy goats and cows was observed to be in favor of the former, high value crop production.

Information on pasture availability promotes utilization of livestock manure and livestock breed improvement. Households use this information to plan the trade of manure with potential buyers as they communicate their migration and grazing plans. They communicate new locations of the livestock which implies new location where manure can be accessed. They are equally able to invest in a livestock breed improvement program based on the information available on pasture availability. Information on water point availability promotes uptake of livestock migration

strategy, this is expected because water points are often center of influence in relation to livestock migration and grazing decisions in the pastoral systems. It however hinders improved livestock breeds whose labour demands are often localized. Climate information on agronomic technology promotes irrigation and fodder production but reduces the likelihood of livestock migration as families moves towards sedentarisation lifestyle and crop production. Agronomic information on farm technology reduced the uptake of fodder production and utilization of livestock manure as a lot of information accessed is on horticulture production with recommended fertilizers and pesticides.

Fodder production is a near universal practice in the three land tenure regimes (government, private and community land tenure systems) as shown by the very high and statistically significant positive correlation. It is however, implemented differently in each of these land tenure categories. Households with access to government land tenure in Nandugoro neighborhood, collectively engage in fodder production as a community project. In the private land tenure regime, individualized fodder production is practiced by the households to feed the weak animals or lactation animals that are left behind after others have migrated. At the community land tenure regime, rotational (holistic) grass management and conservation efforts is embraced to ensure grass regeneration for utilization during periods of prolonged drought. Interesting to observe is the positive influence private land tenure has on migration of livestock, a scenario that implies that the more the household settle in private land tenure the more the need for livestock migration and mobility in search of pasture and water. This is explained by the fact that households living in private land tenure embrace agro-pastoralism, growing crops and keeping livestock. However, due to limited land spaces in the private schemes, they graze their livestock in the community and government land tenure regimes.

Table 4. 4: Household determinants of propensity to adapt to climate change

	Irrigation	Livestock migration	Fodder production	Livestock manure	Improved livestock breeds
Variables	**Coef (SE)**	**Coef(SE)**	**Coef(SE)**	**Coef(SE)**	**Coef(SE)**
Human capital					
Age	-0.010 (E0.012)	-0.007 (0.01)	-0.014 (0.02)	-0.006 (0.01)	0.009 (0.01)
Education level of the household head	0.023 (0.03)	0.030 (0.04)	**0.082*(0.04)**	9 (0.04)	0.049 (0.03)
Family size	-0.023 (0.04)	0.043 (0.04)	-0.130 (0.09)	0.007 (0.05)	0.031 (0.06)
Female literacy	**-0.537*(0.29)**	0.041 (0.32)	**-0.614*(0.36)**	**-0.839**(0.39)**	-0.365 (0.38)
Natural capital					
Quality of land used for food production	0.656 (0.57)	-0.838 (0.53)	**4.228***(0.87)**	0.940 (0.59)	-0.453 (0.48)
Quality of land used for fodder production	0.033 (0.312)	-0.485 (0.39)	**3.131***(0.75)**	**1.507***(0.50)**	**-1.099***(0.40)**
Social capital					
Membership to any association, cooperative, community	-0.079 (0.29)	0.235 (0.27)	**-0.808**(0.35)**	0.525 (0.40)	-0.039 (0.41)
Assistance received from a friend	0.042 (0.34)	0.509 (0.37)	**0.877**(0.38)**	0.594 (0.43)	0.002 (0.47)
Assistance received from a relative	-0.226 (0.33)	0.013 (0.37)	-0.567 (0.41)	**-0.922**(0.43)**	-0.341 (0.35)
Assistance received from government	**0.918***(0.35)**	0.720 (0.44)	**1.487***(0.45)**	**0.976*(0.57)**	**1.044**(0.48)**
Financial capital					
Small numbers of livestock	-0.388 (0.29)	**-0.649**(0.29)**	0.322 (0.40)	0.197 (0.34)	-0.060 (0.47)
Medium numbers of livestock	-0.308 (0.47)	**4.925***(0.49)**	0.413 (0.59)	_	_
Access to credit	0.356 (0.34)	0.489 (0.39)	0.234 (0.52)	-0.519 (0.35)	-0.661 (0.45)
Physical capital					
Physical asset index	0.017 (0.08)	-0.047 (0.11)	0.180 (0.13)	**0.219**(0.11)**	**0.191*(0.11)**
Information					
Climate information for grazing purposes	**1.077***(0.34)**	-0.358 (0.35)	**0.783**(0.39)**	0.224 (0.50)	**-0.759*(0.40)**
Information on pasture availability	-0.644 (0.60)	0.761 (0.54)	1.084 (0.79)	**2.134***(0.77)**	**2.530***(0.83)**
Information on water point availability	0.154 (0.53)	**0.813*(0.47)**	-0.539 (0.77)	0.101 (0.56)	**-2.586***(0.76)**
Climate information to decide about agronomic technology	**0.749*(0.42)**	**-1.081**(0.47)**	**1.047*(0.55)**	0.394 (0.78)	-1.020 (1.0)
Agronomic information on farm technology	0.436 (0.73)	-0.586 (0.55)	**-2.854***(1.03)**	**-2.150**(0.88)**	0.238 (1.16)
Governance					
Government land tenure	-0.697 (0.50)	0.992 (0.66)	**6.135***(0.84)**	**-1.531**(0.68)**	-0.708 (0.88)
Private land tenure	-0.289 (0.48)	**0.655**(0.50)**	**5.944***(0.80)**	0.004 (0.57)	1.161 (0.79)
Community land tenure	0.410 (0.65)	0.978 (0.74)	**5.367***(1.09)**	0.438 (0.76)	-0.859 (1.23)
Constant	1.337 (0.82)	-0.790 (0.96)	-9.763 (1.50)	-0.247 (0.943	-1.258 (1.18)
Number of Observations (N)	149				

*, **, *** Significance at 10, 5 and 1%, respectively.

4.5.2. Characterization of adaptive capacity

The second part of this chapter aims at empirically characterizing adaptive capacity of a transitioning pastoral community, ideally their propensity to adapt to climate change. This was assessed based on three components of the LAC framework: asset base, climatic and agronomic information and governance of land tenure (Jones et al., 2010) as stipulated in Figure 4.1.

Social capital as a component of household asset base was represented by assistance received from the government, which promoted four out of the five adaptation (80%) of adaptation strategies (irrigation, fodder production, livestock manure and improved livestock breeds). This heavy government support can be explained by the role of the government in building the social safety net of vulnerable pastoral communities (Kgathi et al., 2007). In Kenya, the government, at the national and county level, has been on the frontline supporting innovative and new practices among the dryland communities through water provision for irrigation, allocation of land and provision of seeds for fodder production, livestock manure through extension services, and livestock improved breeds through livestock breed improvement programs. An interesting insight though is how government is absent in livestock migration and mobility as an adaptation strategy. This is likely because it is the government policies that have continuously promoted the sedentary lifestyle of pastoralists, and therefore has not invested in landscape level strategies to facilitate livestock mobility.

Natural capital, as represented by quality of land for both crop and fodder production, was observed to highly promote fodder and livestock manure production. These high coefficients indicate the importance of good quality of land as a determinant of strategies targeting crop yields enhancement and livestock improvement. Fodder production, although a new concept within the pastoral community, contributes towards the success of agro-pastoralism, which demands availability of fertile lands for households to engage in both crop and livestock production (Little et al., 2016). Additionally, crop production and livestock keeping have mutual connection since livestock manure is a cheaper and easily available means of improving soil fertility, while crop residue are consumed by the livestock (Maitima and Gumbo, 2007). Quality of land, however, hinders uptake of improved livestock breeds that are associated with technically high and

demanding labor due to their sensitivity to risks and diseases in comparison to their traditional breeds. It is argued that although improved breeds would pay households more, they have their own challenges such as diseases if not well take care-off (Abiodun, 2014).

Human capital as represented by female literacy is surprisingly weak and hinders the uptake of three adaptation strategies (irrigation, fodder production and livestock manure). The low female literacy level (33%) indicated by descriptive statistics (Table 3.3) implies that the few educated women make decisions contrary to the two main systems of livelihood, pastoralism and agro-pastoralism. They are in favor of the limited emerging livelihood alternative that are non-climate sensitive such as petty trade, development work and leadership positions. This is an indication that education as a determinant of adaptive capacity is context specific. In western Kenya, although education promotes uptake of climate-smart agriculture, post-secondary education reduced its adoption because those who are more educated opt for urban "white collar" jobs over agriculture (Mungai et al., 2017)

Financial capital, represented by size of the livestock herd, portrays two scenarios. First, small livestock herd size (<50) correlates with lower mobility, while medium (51-149) and large (>151) herd sizes correlated with higher livestock mobility. This is expected because large herd sizes enables flexibility of pastoral households (Nassef et al. 2009) with less diversification portfolio (Fratkin, 2001; Mburu et al., 2017), furthermore, effectively maintaining larger herd size is not tenable without mobility. A small herd of livestock indicates a financial constraint in meeting cost of migration. What is surprising, however, is the low influence financial capital has on other adaptation strategies. This could be due to the lower likelihood of pastoralist selling their livestock to engage in agricultural practices, implying a weakness on how financial resources are positioned through livestock sizes. Challenging the idea that financial assets are a pillar of adaptive capacity

in the drylands. A similar scenario is reported with physical assets, where household index only influence uptake of two out of the five adaptation practices examined. These are livestock manure and improved breeds. Households with no infrastructure do not engage in the vibrant livestock manure trade in the drylands (Kigiria et al., 2013).

Availability and accessibility of climatic and agronomic information influence uptake of three adaptation strategies that accommodate agro-pastoralism: irrigation, fodder production and livestock manure, and two that promote pastoralism: improved livestock breeds and livestock migration. Surprisingly, however climate information for grazing purposes has a significant negative influence on improved livestock breeds and is silent on livestock migration, implying that migratory households are not interested in this kind of information. This is explained by the inbuilt and historical mechanism of communicating pasture availability. These results show that climate change and agronomic information as component of adaptive capacity influence uptake of all the five adaptation strategies analyzed in either or both directions. A heterogeneous relationship is implied, supporting household choices in taking up or rejecting adaptation strategies (Kgosikoma et al., 2018; Nassef et al., 2009; Ndambiri et al., 2013). In autonomous adaptation, households and communities at large need appropriate information about potential threats and impacts of future climate change (Jones et al., 2010).

As a component of adaptive capacity, governance is viewed as a facilitator of flexible decision-making, where issues of participation, transparency and community prioritization are considered (Jones et al., 2010). All the three types of land governance and property rights regime (government, private and community) are observed to promote fodder production as an adaptation strategy. This introduces the idea of addressing fodder as a near universal practice through a multilevel system: individual household level, community and the larger landscape level. On private land tenure

regime, decision-making is within the limited land boundaries. Community land tenure facilitates community participation and commitment to reserve pasture for the tough periods of drought. Government land supports implementation of collective actions as community members can collectively benefit from the natural landscape. However, fodder production in government land is challenged by insecurity from other neighboring communities in need of pasture for their livestock. There is therefore need for community participation and consultation to be all inclusive to avoid discrimination that would result in internal and external conflict because of the "public good" perception. The positive influence private land tenure has on fodder production and livestock migration implies that the land can be left free for engagement in other agricultural technologies that would support alternative adaptation strategies. Secure land tenure equally promotes investment and rapid uptake of adaptation strategies due to their individualized nature and localized decision-making (Nelson, 2011). Fodder production in community land tenure introduces the boundary and property right that can be enforced.

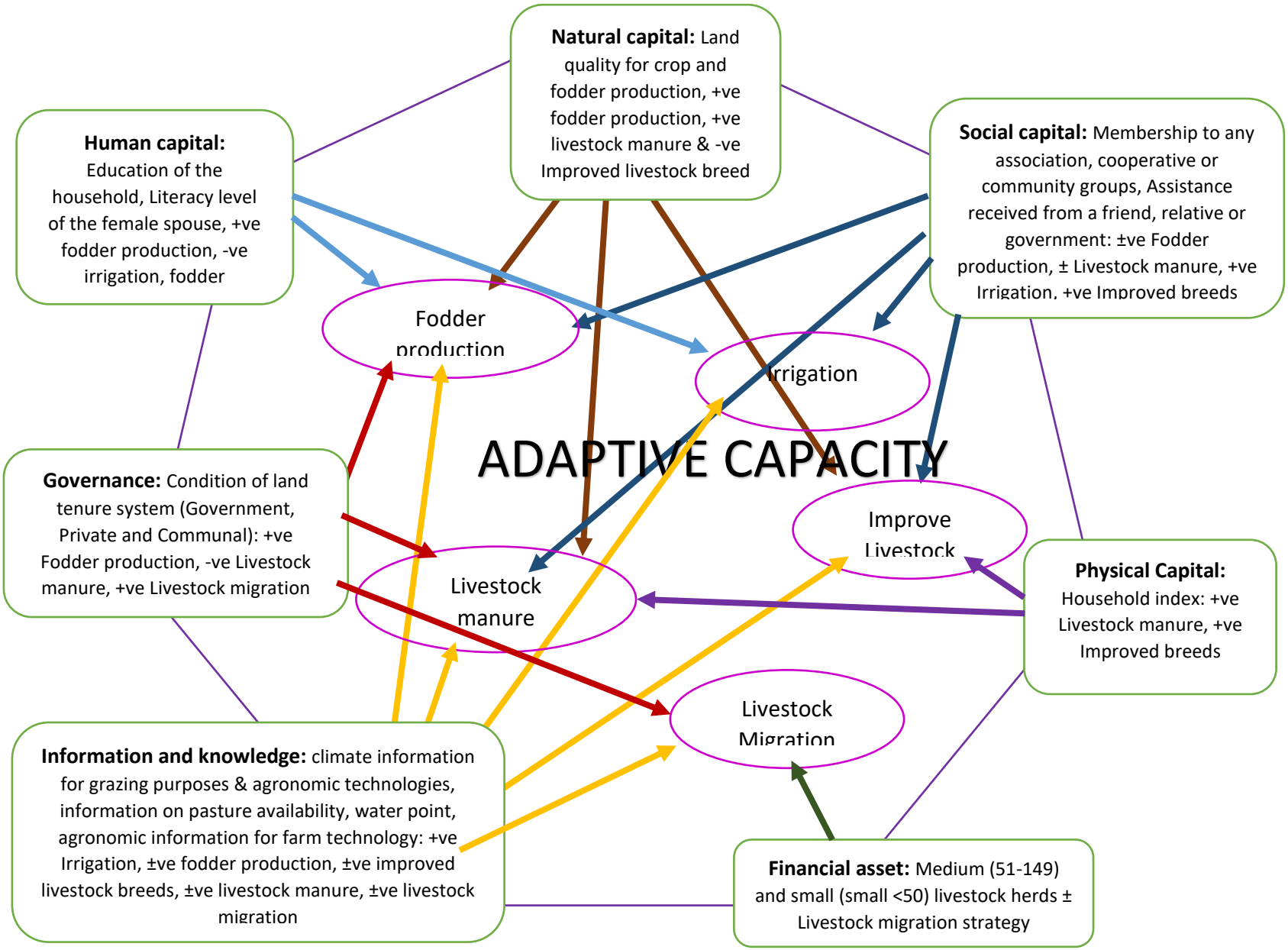

Figure 4. 1: Components of adaptive capacity

1.25 4.6 Conclusion and policy implication

The identification and analysis of socio-economic factors that hinder or encourage the uptake of specific adaptation strategies and characterization of the adaptive capacity generates three fundament findings relevant to the growing literature on adaptive capacity. 1) The household asset base is an important component in influencing adaptation process; however, it has a heterogenous effect across the adaptation strategies because of the various capitals and the differentiated variables that compose it. This makes it necessary to identify the variables that specifically influence an adaptation strategy. For example, social capital is represented by a suite of variables that affect adaptation strategy differently. Assistance received from the government positively influence four (irrigation, livestock manure, fodder production and improved breeds) out of the five adaptation strategies, while membership in any association, cooperative or community negatively influences one (fodder production) of the adaptation strategies. 2) Relevant climatic and agronomic information heavily shapes adaptation processes. The influence however, can take either direction in relation to building adaptive capacity of the target community. Information can support households in taking up or rejecting adaptation strategies implying a heterogeneous nature and therefore needs to be context-specific. 3) The multi-level governance of land tenure in the drylands opens fodder production as a universal practice in the ASAL; Ideally because it can be practiced at different levels to meet differentiated household objectives. This demands a deliberate national and county policy attention and focus on community-driven adaptation and localized development. A cognizance that adaptation is multi-leveled, taking place at individual, household, community and even at the larger landscape level as witnessed by the increasing privatization of fodder production. The security and clarity of the different tenure regimes however is significant for the success of this process.

Natural capital, although an important determinant of adaptive capacity, is very sensitive and vulnerable to natural shocks, political good will, climate change and insecurity. As a key determinant of sustainably achieving the country's long-term development plan, Kenya Vision 2030, the overall governance of land tenure in the drylands need a detailed policy clarification and development strategies that propels the community towards vibrant dryland economy. This entails embracing the stipulated National Climate Change Action plan, supporting the low carbon climate resilient pathway, and embracing the principles of a resilient landscape inclusive of water harvesting strategies, agroforestry and capacity building.

Although discussed in literature as important household assets that facilitate adaptation, human, physical and financial capital are in this chapter deemed to have little influence in facilitating adaptation. The intention is not to undermine their significance but to identify them as sectors that require development, research and policy focus. Equally, both financial and physical capital influence very few adaptation strategies. A general observation is inducted: that the three; human, financial and physical capital are the weak points in relation to categories of assets that contribute to adaptive capacity of households. The seemingly minor role they play in the uptake of proactive adaptation strategies ideally implies that households are deficient in them, contributing to their low utilization. They stand as assets that need to be improved to build the adaptive capacity of households in dryland areas.

CHAPTER 5: HOW WEALTH, AGE AND GENDER SHAPE DIFFERINTIAL ACCESS TO KEY RESOURCES AND BENEFITS IN THE RESPECTIVE ADAPATION PRACTICES

1.26 5.1 Abstract

Climate change adaptation literature on pastoralists often embraces a systems approach that uses aggregate analysis, giving a false assumption of community homogeneity. It assumes that a pastoral community is a coherent unit, an assumption that does not adequately capture the increasingly differentiated adaptation pathways. Analyzing key adaptation practices among Maasai (agro-) pastoralists' of Laikipia County, I outline how wealth, age and gender differentiate actors' adaptation pathways. The researcher argues that adaptation pathways are political processes highly negotiated by these elements of social differentiation and that individual actions on adaptation opportunities are substantially shaped by their social positions. Additionally, I make the case for using adaptation practices as focal points for adaptation pathways research because this methodological choice allows unpacking who, why and how questions in the uptake of emerging technical adaptation practices, especially how they are influenced by individual social positions of wealth, age and gender.

Key words: transitioning pastoralists, adaptation practices, differentiation, wealth, age and gender

1.27 5.2 Introduction

5.2.1 Background information

Severe and prolonged drought continue to devastate the already marginalized pastoral and agro-pastoral households in the Arid and Semi-Arid Lands (ASAL) of Africa. These households will be worst hit by effects of climate change, an additional burden to a community already experiencing chronic poverty, migration and land degradation, changing land tenure systems and increased human and livestock populations (Goldman and Riosmena, 2013; Mwanundu et al., 2009). Combined with increasing challenges of mobility, their heavy reliance on climate-sensitive systems for their livelihood results in acute food and nutrition insecurity, exacerbating the persistent regional inequality that defines the pastoralists in Eastern Africa (Borgerhoff Mulder et al., 2010; Government of Kenya, 2015) where women continues to be more vulnerable (FAO et al., 2018).

Recent sustainable development studies have shifted focus from emphasizing the impacts of climate change on pastoral livelihoods to insights on pastoral transitions, a forward-looking perspective with profound implications for development interventions (Galaty, 2016; King et al., 2018). Adaptation processes are shaped by uneven distribution of key resources (King et al., 2018) resulting in differentiated adaptive capacity – within households, between households and across different communities (Goldman and Riosmena, 2013) and emergence of diverse trajectories in the pastoral drylands (Lind et al., 2016). This necessitates analysis of ongoing dryland adaptation processes that shape the adaptation pathways of households and communities to either reduce the impacts of climate change or tap into the promising opportunities (Government of Kenya, 2015; Nassef et al., 2009). Such analysis sheds light on decision making and policy interventions as a prerequisite for a successful adaptation to climate change (Bryan et al., 2013). This necessitates

analysis of ongoing dryland adaptation processes that shapes the adaptation pathways of households and communities to either reduce the impacts of climate change or tap into the promising opportunities (Government of Kenya, 2015; Nassef et al., 2009). Such analysis sheds light on decision making and policy interventions as a prerequisite for a successful adaptation to climate change (Bryan et al., 2013).

Climate change, however, is occurring at the same time as other technological, political, socio-economic and environmental changes. The constant interactions between these factors highlight that any analyses, or prescriptions, of climate change adaptation as a social process need to account for how non-climate drivers influence actions that are designed to respond to climatic stress. For example, historically, pastoral communities dealt with climate variability through a well-developed spatial and institutional land-use system adapted to the drylands conditions (Antonio and Sperandini, 2009). Changing land tenure regimes, however, compounded by land fragmentation, resource degradation, severe and prolonged drought and population increase – have reduced pastoral management practices (Frankenberger et al., 2013; Goldman and Riosmena, 2013), affecting the adaptation options available to livestock keepers. In Kenya, pastoralists are on a gradual transition process, not only because of the changing climate, but also due to a host of other factors such as changing policies, information technologies, economic opportunities, etc. Their transitions are partial and uneven, as different individuals, households and communities have pursued different options with varied outcomes (Government of Kenya, 2015).

5.2.2 Socially differentiated adaption in practice

The uneven distribution of climate change impacts results from differing adaptive capacities across individuals, communities and countries (IPCC, 2007), underscoring the importance of approaching adaptation as a socio-political process (Eriksen et al., 2015; O'Brien, 2011). I use "adaptation

practices" to refer to peoples' material behaviors that are intended to reduce exposure or sensitivity to climate risks. While much attention is often given to the technical effectiveness of specific adaptation practices, less attention is paid to how new practices situate in, fail to situate in, or sometimes transform, specific social contexts. New practices are introduced to, or emerge from within, specific contexts through social decision making processes to achieve a range objectives (Crane et al., 2011). The outcomes of these processes create a new context which shapes subsequent adaptation possibilities and processes, creating an adaptation pathway with some degree of path dependency.

The adaptation pathways literature has several different threads, but they all build on approaches that understand socio-technical change as a process that involves societal choices and power, with some emphasizing moving toward greater sustainability (Haasnoot et al., 2013; Leach et al., 2010) others emphasizing socio-technical transitions more broadly (Geels and Schot, 2007). As such, the unifying element of the adaptation pathways concept is that adaptation needs to be seen as a negotiated process of change that integrates environmental, technical, social and political elements while anticipating and addressing issues of social equity and path dependency (Butler et al., 2016; Fazey et al., 2015; Wise et al., 2014). Some work uses an adaptation pathways approach as a tool for facilitating engagement with policy processes and planned adaptation initiatives, with the goal of opening up the scope of possibilities to address process inclusivity, underlying causes of vulnerability, and transformative options (Butler et al., 2016; Wise et al., 2014). Other work applies an adaptation pathways lens to analyze past or ongoing adaptation processes with the goal of understanding "…how and why change and responses may have occurred, the different ways different groups have perceived, responded to or navigated change, contextual issues (e.g. politics, social norms, values) that affect change dynamics and the role of power in shaping change and

human agency" (Fazey et al., 2015). In this chapter, I follow Fazey et al., (2015) in applying an adaptation pathways lens to analyze intertwined dynamics of change across time and social scales in order to identify how mechanisms of social differentiation affect adaptation processes.

Scholars have recently begun to highlight the importance of social differentiation in climate change adaptation pathways (King et al., 2018; Little et al., 2016; Mosberg and Eriksen, 2015). Much research focuses on elements of individual wealth, household characteristics and poverty dynamics to create an index measure of adaptive capacity to climate change (King et al., 2018; Kristjanson et al., 2010a). However, while this can be useful in establishing patterns of difference, it is less effective at identifying the mechanism that create differences. The objective of this chapter is to analyze the ways that wealth, age and gender interact with climate change adaptation practices to create socially-differentiated adaptation pathways. The researcher analyzed three emerging adaptation practices, relating how wealth, age and gender affects community capacities to benefit from adaptation practices, influencing the socially contingent adaptation pathways.

Material wealth among the Maasai pastoralists has often been based on the number of livestock owned (Borgerhoff Mulder et al., 2010), a scenario considered "inequitable" because wealthy individuals own larger herds while the poor have little or no livestock, or worse still have shifted from large ruminants to small ruminants (goats and sheep) (Crane, 2013; Little et al., 2016). The degree of this kind of wealth affects herders' rationales of diversification, as wealthy herders seek economic growth and poorer herders seek food survival strategies (Little, 2001). Wealthy households have purchased land and gotten title deeds for tenure security, while the poor have remained as landless herders (Fratkin, 2001). In addition to livestock wealth, social capital significantly affects pastoralists degree of adaptive capacity (King et al., 2018). This influences their ability and choice of engagement in climate adaptation strategies (Frankenberger et al.,

2013). In the drylands, choice of livelihood options are closely associated with household livestock wealth and social capital as resource endowment (Little et al., 2016; Smucker and Wangui, 2016). Age, as a component of social differentiation, is closely linked with intergenerational transmission of information, wealth and networks (Borgerhoff Mulder et al., 2010). Gender, as a social construction, highlights three domains that influence adaptation pathways: labor roles, access to and control over resources and decision making powers (CARE International, 2010; Vinyeta et al., 2015).

1.28 5.3 Methodology

The Il Ngwesi Group Ranch is in Laikipia County, an ASAL region in Northern Kenya. The ranch occupies 8,645 hectares and is communally-owned and managed by "Laikipiak" Maasai, a pastoral community that converted their ranch land into a wildlife conservancy in 1995 (UNDP, 2012b). This initiative necessitated resettlement of many community members, who relocated to 12 different villages surrounding the group ranch: six in Laikipia County, two in Meru County and four in Isiolo County (See Figure 3.1). A complete methodology of the description of the study area is discussed in chapter 3. Section 3.3.1.

5.3.1 Study site (additional details)

This section gives further details that facilitates understanding of the case study discussed. Despite the villages being in relatively close proximity, they are geographically distinct and vary by land tenure system, climatic condition, topography and social economic patterns

Table 5.1: Various factors that differentiate the villages/neighborhoods

Village	Physical and Topographic Features	Land Tenure	Ecological conditions	Tourism and wildlife	Social economic	Others
Sang'a	Northern part of the ranch	Community	Wildlife	Conservation settlement area wildlife,	Mainly pastoralists	Limited social economic activities
Olchurai & Cultural Boma	Low part of ranch Lowlands	Community	Wildlife	Conservation settlement area landscapes, unique local cultural practices	primarily pastoralists,	Proximity to the Il Ngwesi eco-lodge & tourism activities preferential tourism benefits, bead making cultural activities cultural artifacts, dancing and entertainment
Leparua & Ngare-Sirikon	Southern part of the ranch, in Isiolo County	Government	Wildlife	Isiolo County The unclear land ownership, conflict among different pastoral communities resulting to insecurity in the area.	mixed farming & pastoralism	Few households access Riverine land along the riverbanks of River Ngare Sirikon Practice furrow irrigation. Local market
Nandugoro & Lukusero	Meadows of Mukogodo forest forestry	Government	Indigenous forests wildlife	Forested landscapes, Community managed forest	predominantly pastoralists	Honey harvesting Hay production Rain-fed agriculture challenged by Human-wildlife conflict
Ngare-Ndare & Manyangalo	border of Meru and Laikipia Counties,	Private	Crop farming	Private Settlement	mixed farming	High-value horticulture activities onions, french beans, garlic are produced Contract farming
Ethi	Higher elevation Highlands forestry	Private	Forests wildlife Crop farming	Private Settlement	mixed farming	High Altitude and proximity to Ngare-Ndare forest, gives them a higher rainfall than the rest suitable for rain-fed agriculture, wheat farming, and livestock grazing in the forest. Deforestation in private lands

Chumvi	relatively dry in comparison to Ethi	Private	Sheep farming	Private Settlement	Livestock and business	Proximity to Urban town, opportunity for business. Water challenges, limiting crop production, Deforestation

5.3.2 Research design

People pursue and implement adaptation practices from diverse and socially-embedded positions, knowledge sets, values and goals in response to emergent environmental conditions associated with climate stress (Crane et al., 2011). I start from this conceptual premise to examine how wealth, age and gender shape people's access to resources, opportunities and benefits relating to adaptation practices. By analyzing the development and implementation of adaptation practices, I am able to identify the ways that social differentiation occurs along adaptation pathways.

This chapter focuses on three emerging practices that research participants identified as helping to buffer against climatic risks. These practices are implemented across diverse degrees of collective action, from community wide, to small groups, to households. The first practice is a change in land management from a group cattle ranch to a nature conservancy. As will be elaborated below, this shift was a direct response to the devastating droughts in the 1980s, which stimulated Il Ngwesi to consider how they could improve the economic productivity of their land in the face of climatic risk. It effectively set the stage for subsequent adaptation pathways. The second practice is rotational grazing, which is also a means of maintaining, or even improving, ecological and economic productivity of grazing land under conditions of environmental stress, including increasing climatic variability. The third practice is fodder cultivation and conservation, which buffers against increasingly climate variability by intensifying ecological and economic productivity of grazing land with the goal of feeding animals better during seasons of scarcity. I recognized that these practices may not be purely adaptations to climate change. They are also, in varying degrees, responses to new economic opportunities, changing tenure laws and land fragmentation, among other things. However, any climate change adaptations will inevitably occur

in the context of these other dynamics and thus cannot be disentangled from them. The important thing is that the practices analyze by the researcher helps buffer livelihoods from climatic risks.

Broadly speaking, this is designed as explanatory research, investigating mechanisms of causality in complex real life circumstances (Robert K. Yin, 1994; Tellis, 1997). Using a qualitative and inductive case study design, this chapter analyzes how adaptation pathways are socially differentiated in emerging practices among the Il Ngwesi community. This approach therefore treats adaptation practices (implementation of a techniques that buffer against climate impact) and processes (dynamics of change over time, often relating to new practices) as the primary units of analysis framing them as the main entity been analyzed in the study rather than examining household characteristics for such an analysis (Ng'ang'a et al., 2020). I choose this approach because of its ability 1. to focus on the multi-faceted realities of the actors in a system 2. to deal with the complex nature of mixed agro-pastoral systems, and 3. to address both the "what" and the "how" questions of adaptation process.

5.3.3 Data collection methods

To collect this ethnographic information, the researcher stayed in the field for four months, (May-August 2016) sharing the daily lives of the community in the various villages, conducting meetings and observing their daily livelihood patterns. Qualitative data collection based on an interactive historical timeline process and a semi-structured interview guide explored the community main sources of livelihood and its importance in terms of income in the household, average number of people practicing it, gender importance as well as geographical positioning. Equally, changes in livelihood sources, challenges experienced inclusive of climate change and uptake of new practices and strategies to overcome the challenges were covered. A total of 17 semi-structured interviews were conducted with key informants to elaborate the emerging adaptation practices. Furthermore,

22 gender-disaggregated focused group discussions (FGDs) were conducted in the 12 villages. The disaggregation identified the strategic differences between women and men in adapting to climate change. A range of 10-20 participants were selected per village to discuss issues relating to observed climate change impacts, emerging adaptation practices and how social variables affect adaptation. The data collection was supplemented by participant observation, where I participated in various activities such as grazing livestock, tethering dairy cows, harvesting of onions and bead making by women. This facilitated informal interviews enabling documentation of livelihood practices in details, gender roles, challenges and opportunities of the selected practices.

5.3.3 Data analysis methods

I used an inductive approach in data analysis where I manually coded the data first for social dimensions of how specific practices emerged and evolved over time in response to general as well as climate change related challenges. The second level of analysis identified adaptation practices at either collective or individual household levels. Finally, coding focused on the three axes of social differentiation – wealth, gender and age.

Results are presented in three subsections, each focusing on one of the adaptation practices observed: (1) conversion of community ranch to wildlife conservancy; (2) community rotational grazing units; (3) fodder production at individual and community level. These subsections highlight how wealth, age or gender shape differential access to key resources and benefits in the respective practices. In some cases, the interplay of the three factors is highlighted. The results are then discussed in terms of how social differentiation affects and is affected by adaptation practices, as well as the implications for climate change adaptation interventions and pathways.

1.29 5.4 Qualitative Case Study Results

5.4.1 Case study 1: Conversion of community ranch to a conservancy

The focus of this case study is on how wealth disparities is shaping adaptation pathways, setting households on markedly different livelihood trajectories. Wealth, in this case represented by livestock ownership at household level, influences access to opportunities and benefits, creating particular adaptation pathways. The transition process among the Kenyan dryland pastoral community can be dated back to the 1960s and early 1970s (Western and Nightingale, 2004). This became more prominent among the Il Ngwesi Maasai after the severe droughts of 1979-80, when they lost over 75% of their livestock (Little et al., 2016), and were then struck by the severe 1984-85 drought. This transition has accelerated in the last 30 years as need for alternative livelihoods on and off the farm has increasingly become a priority (Western and Nightingale, 2004).

Il Ngwesi Group Ranch was established as the first community-based conservancy in the Northern Rift Valley in 1995, as wildlife was viewed as an alternative livelihood opportunity, "second cow", that was less vulnerable to drought (Western and Nightingale, 2004). 80% of the group ranch was allocated as a conservation area, significantly limiting access for the residents and their livestock, while the remaining 20% was left for human settlement (Lind et al., 2016). Following these changes, many households relocated from the community land to new settlements with different land tenure systems, but remain members of the group ranch. There has been no clear, planned or documented rationale for how this relocation took place, but it is an ongoing process even today. Initially, the driving factor to relocate was a collective decision among adult male members of the community. The actual relocation has been based on individual agency and capacities, with over 75% of Il Ngwesi members now residing in villages outside the ranch.

The change in land use system from a livestock ranch to a wildlife conservation – and the subsequent relocations – has resulted in differentiated adaptation pathways by the individual households. This is illustrated by the history of Manyangalo which had been a 350-acre fertile agricultural land in the middle of a private conservancy. The land previously belonged to a white settler who practiced irrigated agriculture with laborers of Somali ethnic origin. The agrarian reforms following Kenya's independence in 1963, saw the land sold off to three politically powerful Kenyan in 1978, whose initials formed the name "Manyangalo". In 1982, they leased the land to the government for seven years (until 1989) after which they decided to sell it. This long process of handovers and transfers left the original white settler's laborers as victims of circumstances. They had no income, had accrued arrears and worse still had an eviction notice and nowhere to go after many years of service. They thus initiated a court proceeding demanding fair compensation, but this became too intense and expensive due to their financial incapacity. With this challenging situation, the laborers' leaders approached a few wealthy Maasai men and enticed them to sell off parts of their livestock herd so they could contribute 20,000Ksh (200£) on speculation for an equivalent of one share or one acre if the case was won.

In the year 2002, upon adjudication of the case in favor of the laborers, the land was redistributed based on individual benefits and accruals, including the Maasai investors. When Il Ngwesi leadership decided to become a conservancy, this decision found wealthy Maasai investors already at the peak of land negotiations and when it was settled, they had ready parcels of land on which to resettle their families. These are some of the current residents of Manyangalo village. They are mainly agro-pastoralists with over 50% of their income coming from irrigated high value horticultural crops. A similar story occurred in Ngare-Ndare village, whose land is under private

land tenure. Il Ngwesi members who bought this land are now agro-pastoralists equally embracing irrigated crop production and livestock.

Over the years, land acquisitions have depended on the wealth of the households, where herders with large numbers of livestock have greater wealth stability and can consider alternative investments, including purchasing high-quality land for crop production. Ngare-Ndare has the highest market value, followed by Manyangalo, Ethi and finally Chumvi. This gradient is primarily explained by the arability of the land, the microclimate of the villages and proximity to significant natural resources (Table 5.1). In the drylands, wealth through livestock herds, builds the household financial strength, social positions and consequently differentiates their adaptation pathways. Through these differentiated pathways, the Il Ngwesi Maasai now categorize themselves into those who identify themselves as agro-pastoralists and those that have remained as pastoralists. The agro-pastoralists have invested in agricultural land and have built more social connections beyond their own cultural community. They have gradually embraced new livelihood trajectories, including livelihood diversification as a strategy to reduce exposure to climate risk. They are therefore not only keeping livestock and practicing either irrigated or rain-fed farming, but are also embracing new opportunities in the growing economy, such as educating their children for urban employment and investing in enterprises that are less climate-sensitive. The agro-pastoralists' livelihoods spread risk to climate-driven impacts both through the diversified technical activities, as well as increased investment in less climate-sensitive economic opportunities. However, it is important to note that some pastoralists deliberately chose not to diversify into agriculture, even though they had the financial resources to relocate, although others lacked meaningful opportunities to pursue other alternative livelihoods. Whatever the case, the larger population still living in the community group ranch largely depends on climate-sensitive livestock enterprises,

but are increasingly transitioning to small ruminants and even camels, which are more drought tolerant than cattle. They are also engaging in enterprises that suit their situations, such as eco-tourism enterprises of cultural villages, bead making and traditional dancing (Table 5.1). These are, however, dependent on the security of the area, respect of the conservancy regulations and a vibrant tourism sector. This happens amidst insecurity and conflict over diminishing natural resources, as well as limited access to public goods and livelihood opportunities like shopping centers, health facilities, schools and communication facilities. These limit their immediate opportunities, but also their ability to influence policies in their favor, reducing their chances to adopt diversified livelihoods and non-climate sensitive enterprises. Their low incomes and limited livelihood alternatives coupled with poor housing and lack of land tenure security limit their prospective adaptation pathways.

The consequence of these differentiated responses to conservancy management and relocation, is that a community that was once on a collective development path is now experiencing high variability in their adaptation pathways. Wealth variability from decades ago has thus created differentiated livelihood and adaptation trajectories which continue to play out to this day.

5.4.2 Case study 2: Rotational grazing management

The second adaptation case study focuses on how intergenerational gaps among the pastoral community create friction between rotational grazing management as an adaptation practice and important cultural values and institutions. It illustrates the interacting factors of agency in the process of change, where the community members respond to multiple emerging issues from the perspective of their particular life stages and creatively draw upon competing priorities.

Rotational grazing – a practice based on the principles of "Holistic Management® (HM) " and anchored on ecological principles of soil, water and plant succession (Savory and Butterfield, 2016) – is at the heart of the conservation initiative discussed in case study one. Two staff of Il Ngwesi Group Ranch were trained on these principles and have led the implementation of HM on the ranch. The aim of this initiative is to improve the productivity of the ranch by reversing degradation and making the ranch economically viable for both wildlife and livestock (Savory and Butterfield, 2016). Livestock grazing is not allowed on the demarcated conservation area, except when it is officially opened as a pasture reserve for periods of drought. To implement the technical and institutional management practices of rotational grazing, Il Ngwesi had to adopt new governance practices and by-laws which requires strict group cohesion for collective decisions and actions to attain the expected results. Bunch grazing is an important technique for restoring and reclaiming degraded areas under HM (Obala et al., 2012). Livestock corrals (*bomas*) are strategically constructed on degraded spots, where animals spend 7-10 nights before they are transferred to another spot and are kept in close groups while grazing during the day. This enables breaking of hard pan and seed dispersal through livestock manure, which then leads to improvement of soil fertility, water holding capacity and grass regeneration. At the community level, the grazing committee leadership is in charge of enforcing these practices, while the leadership of the village grazing committees are charged with enforcing these practices in the settlement zones.

Bunch grazing, however, comes into conflict with a range of cultural social norms relating to age and youth masculine identity, affecting the effective implementation of rotational grazing and thus adaptation pathways. Cultural ceremonies such as circumcision among the Maasai defines the masculine youth identity (*moran*) from puberty up to 35 years of age. There are several ceremonies

conducted to a young man in this process before he is finally declared an elder (Kelele, 2017). The common factor in these cultural rites and rituals is social isolation of some kind. For example, before a young man is circumcised, he is expected to graze for seven days consecutively before the actual eighth day, when the ritual takes place. During this period, young men prefer to graze their herds in isolated places as peers and not mix with their elder men. After circumcision, the cultural norms restrict this age group from eating meat seen by a woman. In practice, this means they are separated from the rest of the community and they prefer remote grazing spots. Young men use this time to support each other in becoming strong warriors and nurturing brotherhood. During this 3–4-month period, young men go far into the hills away from the homestead where they share tasks and responsibilities, taking turns to watch over each other's herd. The complexity of cultural norms – particularly those promoting social isolation, but also demanding continuity of livelihood practices like grazing – thus has consequences for Holistic Management as an adaptation practice.

Despite the youth's resistance, middle-aged men are embracing more intensive pastoralism and commercial orientation, including livestock breed improvement and fattening. However, these also comes into tension with the application of Holistic Management. Livestock improvement requires herders to invest in a specific bull for breeding purposes. However, bunching of herds often leads to livestock mating according to their own impulses rather than a herder's plan. Livestock fattening programs, on the other hand, demand establishment of feedlots with specific grass species on identified spots of the ranch. Because these two practices are based on close management of breeding and eating behaviors of specific individual animals, they often come into conflict with rotational grazing in practice, which emphasizes herd level management. Incompatibilities between the technical implementation of HM and cultural institutions of masculine youth identity,

as well as commercial orientation, highlight the importance of understanding adaptation pathways as processes of socio-technical transformation that implicate many factors other than climate risk.

5.4.3 Case Study 3: Fodder production as a collective and as individual private good

The cultivation and conservation of fodder as an adaptation strategy is gaining popularity in the ASALs, where availability of pasture is on the decline due to prolonged drought and over grazing (Lugusa et al., 2016). Among the Il Ngwesi Maasai, fodder production is implemented both at a community and household level. At a community level, it started in Nandugoro village, where a private group of residents living on government land tenure as custodians of the land, initiated fodder and hay production as a self-help initiative. This is an innovative adaptation practice and not historically part of their mobility-based adaptation strategy. Their main motivation is to create a feed reserve where group members can access hay to buffer against fodder shortages in droughts and dry seasons, especially for lactating animals who are left behind for household nutritional security when the family herds migrate.

The initial participants in fodder cultivation and conservation were predominately middle-aged men with influential positions and decision-making powers. The older men were initially not interested and therefore not engaged in this initiative, because they didn't recognize the practicality of grass cultivation. The younger men were more interested in mobile pastoral activities, as outlined in the previous section. Fodder production was thus initiated by middle aged men and continues to be dominated by these men, while women were left out. However, women have several important roles in its implementation and have emerged as the key beneficiaries. First, Maasai women are primarily responsible for constructing and maintaining the fences that keep wild and domestic animals away from the fodder fields. While this could be construed as imposing an extra labor burden on women, the Il Ngwesi women do not see it this way. Rather than being

an imposition, their labor is negotiated and compensated, so fodder cultivation creates new and rare economic opportunity for women to earn an extra cash income. Additionally, this role is an extension of Maasai women's cultural responsibility to construct and control domestic household spaces (Smith, 2014).

Second, access to stored fodder reduces women's labor burden in caring for the vulnerable livestock. It is a cultural norm that women nurture vulnerable livestock (especially lambs and kids, calves and the sick animals) around the homestead. In the dry seasons, lack of pasture creates a significant labor burden on women, who spend most of their time searching for feed for the animals left at home. Fodder cultivation and conservation means that women have ready access to high quality fodder rather than having to search for pasture far from the homestead during dry seasons and droughts. They are therefore the direct beneficiaries and they perceive it as serving their interests.

Third, the availability of fodder reduces the time that livestock are away from the homestead improving women's access to milk, and thus the food and nutritional security for her family, which is also her cultural responsibility. In some instances, livestock migration in search of pasture leaves the now sedentary homesteads nutritionally insecure due to the absence of milk cows. Complaining of lack of milk when the livestock are away, women are often forced into diets of maize and beans, which is considered a poor person's meal.

Thus, while fodder production and conservation could be viewed as an adaptation strategy dominated by men in the pastoral community, its benefits are channeled through performance of culturally defined gender roles. It is, however, important to point out that fodder production does not benefit all women equally, because the intersection of wealth and gender differentiates the expected outcomes. At the onset of the fodder production initiative, members needed to pay a

registration fee 15,000Ksh (approximately $150). Additionally, the hay is sold to the members at subsidized rates ($1.50), whereas non-members are charged normal market price ($2.50). This means that fodder production, although grown on government lands, is not a public good, but a collective private good. Only those women whose husbands or household heads registered and can purchase hay when need arises enjoy these benefits.

1.30 5.5 Discussion

Applying an adaptation pathway lens (Fazey et al 2015), my case studies show intertwined and contingent processes that are influenced by key dimensions of social differentiation: wealth, age and gender. First, the conversion of community ranch into a conservancy focuses on how wealth, combined with willingness to assume financial risks, has set a significant number of households on markedly different adaptation and livelihood trajectories. This has opened new, diverging and unique adaptation pathways within the pastoral community. Importantly, the second and third practices are largely contingent upon the new context created by conversion of the ranch to conservancy management. The second case study focuses on how technical practices relating to rotational grazing create friction with culturally important practices of young masculinity and commercial orientation, reducing the effectiveness of rotational grazing as an adaptation practice. The third case study analyzes fodder production as a private collective adaptation practice, showing how implementation of and benefits from the innovation are channeled through customary cultural gender roles. This case highlights how adaptation pathways can be positively influenced by pre-existing gender norms, which is not always the case. Taken together, these cases illustrate how social and technical aspects of climate change adaptation pathways are fundamentally intertwined, whether antagonistically or synergistically. Furthermore, by pulling

out fine-grained social mechanisms of differentiation, we show interactions between micro-social dynamics and broad-scale adaptation pathways.

In the first case, the wealthy Maasai's risky support of the Manyangalo laborers' court case facilitated their acquisition of prime horticultural land, which over the years has enabled them to embrace new agro-pastoral adaptation opportunities. By contrast, those who remained pastoralists in the community land, whether by choice or due to limited wealth to invest in alternative opportunities, have very little opportunity to diversify into commercial horticultural production. This differentiation, which emerged from wealth disparities, continues to reinforce and accentuate socio-economic differentiation among the Il Ngwesi Maasai, where the wealthier individuals are motivated by economic growth, ownership and tenure security, and poorer households focus on short-term coping and survival strategies (Fratkin, 2001; Little, 2001), though they are also pursuing pastoral intensification strategies of managed grazing and fodder cultivation.

In the second case study, culturally contingent age-set practices, commercialization of pastoral systems and individualized social orientation are identified as interacting factors that shape adaptation pathways among the pastoral community. While the rules and regulations for the implementation of rotational grazing were set by elder men, the management of herds is culturally the responsibility of young men. The culturally mandated social isolation of Maasai *morans* dictates that they graze their herds of livestock in areas far from settlements, a norm that conflicts with the implementation of planned rotational grazing. These important cultural practices are proving incompatible with the implementation and efficacy of rotational grazing as a planned adaptation pathway. Changing socio-cultural dynamics influence prevailing indicators of Maasai social status, whereas age-set institutions dictate how daily practices of adaptation are conducted (Mosberg and Eriksen, 2015).

Finally, in addition to age-set institutions, this study shows that age also emerges as an important factor in how men evaluate new economic opportunities. Across East Africa, pastoralists have been slowly transforming their production systems from subsistence to commercially-oriented production systems (Goldman and Riosmena, 2013). Members of Il Ngwesi group ranch are not an exception. The middle-aged men are increasingly approaching livestock ranching as a commercial enterprise. Their evaluation of rotational grazing as an adaptation strategy is therefore increasingly informed more by commercial priorities of livestock breeds and establishing feedlots for livestock fattening during dry periods (Lugusa et al., 2016), and less by the traditional mobility system and open pasture reserves. This analysis of age as a factor for consideration in adaptation pathways highlights the necessity of paying attention to how technical adaptation practices interact with key social cultural institutions (Mosberg and Eriksen, 2015).

Adaptation literature focusing on gender tends to emphasize how institutionalized gender inequality leads to differentiated opportunities and constraints (Anbacha and Kjosavik, 2019; Crane, 2013; Rao, 2019; Wangui and Smucker, 2017). In Il Ngwesi, women appear to be pivotal players within their cultural spaces and positions in the implementation of fodder cultivation, notably an innovative practice initiated by men as an adaptation strategy to climate risk. The fodder production case study underscores the importance of livestock in women's livelihood portfolio (Kristjanson et al., 2010). If a Maasai woman has access to fodder – either through cultivation on quasi-privatized land or access to collectively grown hay – she has the capacity to manage a lactating animal while the rest of the animals migrates in search of pasture and water. This enables her to meet her family food security needs, which is her cultural responsibility (Kristjanson et al., 2010). Intensive fodder cultivation thus supports and reinforces women's customary role in ensuring family food security, even though it was not specifically designed with that objective in

mind, again emphasizing the contingency of social differentiation in adaptation pathways. Analyzing the social mechanisms that create differentiated responses to emerging adaptation practices can enable adaptation pathway planning to more explicitly address how proposed interventions will play out over time. In particular, because adaptation pathways approaches explicitly emphasize social equity and transformative interventions (Butler et al., 2016; Wise et al., 2014), they implicitly need to understand how technical or institutional interventions are likely to reconfigure socially-mediated access to opportunities and benefits. While our case has focused on a transitioning agro-pastoral region in Kenya, the general approach of socially-differentiated analysis of adaptation practices should apply to adaptation pathway interventions across geographies and domains.

Beyond topical findings, this chapter also advances conceptual and methodological innovations in the field of adaptation research. Using a conceptual framework that focuses on social differentiation and a research design that focuses on adaptation practices as units of analysis opens up space for a more nuanced analysis of adaptation as a socio-technical process, something quantitative indices of adaptive capacity fail to capture. This approach allows me to unpack the "who", "why" and "how" questions in the uptake of emerging adaptation practices as influenced by social qualities of wealth, age or gender. Close analysis of how various actors engage in technical change exposes the mechanisms that lead to socially differentiated adaptation pathways. In so doing, this chapter advances an approach to adaptation research that more tightly integrates social and technical change (Crane et al., 2011).

Finally, this chapter has treated wealth, age and gender distinctly for the purposes of illustrating the mechanisms of social differentiation in shaping adaptation pathways. However, these three axes of variability often intersect with each other in complex ways. While the researcher have

acknowledged these intersections where possible, in looking forward, the researcher encourages future research in this domain to adopt a more fully intersectional analytical approach (Djoudi et al., 2016; Iniesta-arandia et al., 2016; Tavenner and Crane, 2019) in order to further refine our understanding of the social dynamics and implications of adaptation, which can then inform more nuanced approaches to adaptation planning and interventions.

1.31 5.6 Conclusion

Social differentiation is both a driver and outcome of adaptation pathways because changing opportunities, cultural dynamics, values and social norms interact with environmental and technical change to result in different trajectories. I have argued that adaptation to climate change is a contingent process highly influenced by wealth, age and gender because these factors shape the positions from which actors negotiate, engage and evaluate different technical adaptation practices. This demonstrates the importance of embracing the analysis of social differentiation in the study of adaptation pathways because it facilitates understanding the diverse trajectories undertaken as well as the rationales for socially embedded decision-making. A more detailed consideration of how socio-technical adaptation interventions interact with, and create, socially differentiation should help policy makers, technical researchers and development practitioners in adaptation pathways planning forge more equitable outcomes.

It is recommended to pay attention to this unfolding scenario, unpacking the broader term “adaptation” to “socially differentiated adaptation” to avoid effects of accelerating the growing inequality in the drylands where households are not coherent and homogenous units for either research, policy or development. Social differentiation is a driver and outcome of differentiated adaptation pathways.

CHAPTER 6: GENERAL DISCUSSIONS, CONLUSIONS AND RECOMMENDATIONS

1.32 6.1 General Discussions

This PhD thesis empirically assesses adaptive capacity as a socio-economic and technical process among a transitioning pastoralist and agro-pastoralist households of Laikipia County, Kenya. It is anchored in the discourse of adaptive capacity within the adaptation framework where adaptation is reflected as a complex socio-economic and technical process framed by intangible processes of: innovations fostering; social institutional and entitlements; Assets base; knowledge and information and decision making and governance (Jones et al., 2010). Adaptive capacity in this thesis is therefore demonstrated by the uptake of adaptation strategies (Smit and Wandel, 2006), a reflection of the potential of a system to adapt (Downing , 1991). This thesis answers three questions addressed in chapter three, four and five.

Chapter three analyzes the adaptation practices that facilitate the transition of the dryland community from pastoralism to agro-pastoralism. Irrigation is identified as a key adaptation strategy in the drylands that represents a bridge and an avenue that introduces livestock keepers to a transition from nomadic pastoralism to sedentary agro-pastoralism (King et al., 2018). Analyzing the socio-economic drivers, the results shows that a large proportion (80%) of the community perceive climate change, among whom a limited (32%), but growing, population has taken up irrigation as an adaptation strategy. Ideally only households that perceive climate change have taken up irrigation as a proactive adaptation strategy. This decision is not only attributed to changes in climate but equally other factors such as changes in land tenure, increased population, changing lifestyles and increased demand for agricultural products are at play.

The socio-economic and technical drivers that encourage uptake of irrigation as an adaptation strategy at a household level are: i. quality of land for food crops and I recommend the need to improve the fragile ecosystem to sustainably utilize the drylands for agricultural productivity, by investing in strategies that build the soil fertility, water holding capacity and rain water harvesting (NEPAD, 2002). ii. Assistance received from government; ideally in creating an enabling environment for investment in irrigation, water management strategies and scaling out the uptake of this practice among other adaptation practices. This would enhance the scale out of irrigation as an adaption strategy. iii. Community land tenure; the governance of community land tenure facilitates collective rangeland management ensuring the sustainability of pastoralism (Damonte and Rodríguez, 2016), and supporting individualized and privatized adaptation strategies outside the common land and finally, iv. Agronomic information; access to appropriate extension services on agronomic information is needed to harness the positive influence of agronomic information on the uptake of irrigation in crop production.

Two factors were identified as hindering uptake of irrigation as an adaptation strategy. i. Age of the household head. There is a need to target the young generation often left out of development interventions. The youth are often perceived to have an open approach towards new technologies and innovative ideas compared to the elder generation. ii. Ownership of small and medium livestock herd. It was interesting to observe that large herds of livestock are an important financial capital base among the pastoral communities as it funds the uptake of irrigation as an adaptation strategy to climate change. This means that households with small and medium livestock herd have no capacity to take the risk of investing in irrigation.

Chapter four identifies and analyses the socio economic and technical factors that hinder or promote the uptake of specific adaptation strategies and characterizes the adaptive capacity

generating three fundamental findings relevant to the growing literature on adaptive capacity to climate change. First, household asset base is a fundamental component in building the adaptive capacity and influencing adaptation process to climate change. However, it is important to note its heterogeneous effect due to the various capitals and differentiated variables that compose it. For example, social capital is composed of various variables that influence decisions concerning adaptation strategies where some variables encourage uptake while other hinder adoption. It therefore calls for a specific identification of variables that positively influence an adaptation strategy. For example, government assistance can be used to promote strategies like irrigation, utilization of livestock manure, fodder production and improved livestock breeds, but not livestock migration.

Secondly, relevant climatic and agronomic information heavily shapes adaptation process in either direction and needs to be context specific due to its heterogeneous nature. This can support household choices in taking up or rejecting adaptation strategies and giving them options. This calls for context specific information in climate change adaptation interventions or development. Finally, the multi-level governance of land tenure opens fodder production as a universal practice in the dryland since it can be utilized differently to meet different targets. However, the security and clarity of the different tenure regimes is significant in building this process.

Chapter five focuses on social differentiation and applies an adaptation pathway lens (Fazey et al 2015), to show how social and technical aspects of climate change adaptation are intertwined and how different social positions as dictated by wealth, age and gender continues to reinforce and accentuate socio-economic differentiation among the pastoral community. Social differentiation is both a driver and outcome influenced by key dimensions of social differentiation: wealth, age and gender. I have argued that adaptation to climate change is a contingent process highly influenced

by wealth, age and gender because these factors shape the positions from which actors negotiate, engage and evaluate different technical adaptation practices. I have demonstrated the importance of embracing the analysis of social differentiation in the study of adaptation pathways because it facilitates understanding the diverse trajectories undertaken as well as the rationales for socially embedded decision-making. A more detailed consideration of how socio-technical adaptation interventions interact with, and create, socially differentiation should help policy makers, technical researchers and development practitioners in adaptation pathways planning forge more equitable outcomes.

1.33 6.2 Conclusions

Pastoralism is indicated as the main source of livelihood in the ASALs of Kenya where its downward trend raises concerns. This notwithstanding my observation is that the uptake of climate change adaptation strategies is low and this confirms Bryan et al., (2013) comparison of pastoral households with other households and communities in humid and temperate ecological zones. This low uptake of adaptation strategies by the pastoral community is associated or attributed to three main reasons. First the process of pastoral adaptation in the ASAL is highly privatized and individualized, a community that has historically depended on collective actions as coping strategies against climate variability is not only learning to adapt but to do this at household level and not at community level as was previously. Secondly the adaptive capacity is socially differentiated among the community making adaptation to climate change a contingent process which is highly influenced by elements of wealth, age and gender. These are discussed as factors that shape the positions from which actors negotiate, engage and evaluate different technical adaptation practices. Thirdly the socio-economic and technical elements of adaptation that

determines what individual households can or cannot engage in are not uniformly available and accessible to all members.

1.34 6.3 Recommendation

Use of irrigation as an adaptation strategy in the dryland raises concern due to the fragile nature of the landscape and there is need to invest in strategies that build the soil fertility and water holding capacity of the soils, paramount in increasing the area under irrigation (NEPAD, 2002). This requires government assistance in creating an enabling environment and enhancing the scaling out. There is need to support livestock as financial asset among the pastoral community as this would be used to invest in adaptation strategies inclusive of irrigation. Governance of community land tenure is an interesting positive relation, indicating that the rules and regulations set supports collective rangeland management ensuring the sustainability of pastoralism (Damonte and Rodríguez, 2016), and giving way to individualized adaptation strategies outside the ranch. Extension services with appropriate access to agronomic information are needed to harness the positive influence of agronomic information on the uptake of irrigation. There is also the need to target the young generation often left out of development interventions. It is often perceived that the younger generation have an open approach towards new technologies and innovative ideas compared to the elder generation.

Natural capital, although an important determinant of adaptive capacity, is very sensitive and vulnerable to natural shocks, political good will, climate change and insecurity. As a key determinant of sustainably achieving the country's long-term development plan, Kenya Vision 2030 the overall governance of land tenure in the drylands need a detailed policy clarification and development strategies that propels the community towards a vibrant dryland economy. This entails embracing the stipulated National Climate Change Action plan, supporting the low carbon

climate resilient pathways and embracing the principles of a resilient landscape inclusive of water harvesting strategies, agroforestry and capacity building.

Although discussed in literature as important household assets that facilitate adaptation, human, physical and financial capital are in this thesis deemed to have little influence in facilitating adaptation. The intention is not to undermine their significance but to identify them as sectors that require development, research and policy focus. Equally, financial and physical capital influence very few adaptation strategies and I inducted a general observation: that the three; human, financial and physical capital are the weak points in relation to categories of assets that contribute to adaptive capacity of households. The seemingly minor role they play in the uptake of proactive adaptation strategies implies that households are deficient in them, contributing to their low utilization. They stand as assets that need to be improved to build the adaptive capacity of households in dryland.

Although this thesis treated wealth, age and gender distinctly for the purposes of illustrating the mechanisms of social differentiation in shaping adaptation pathways. It is clear that these three axes of variability often intersect with each other in complex ways. While I have acknowledged these intersections where possible, in looking forward, I encourage future research in this domain to adopt a more fully intersectional analytical approach (Crenshaw, 1989) to further refine my understanding of the social dynamics and implications of adaptation, which can then inform more nuanced approaches to adaptation planning and interventions.

Recommendation further points out to areas of future research to conduct adaptive capacity and adaptation processes at the landscape level. This thesis focused on adaptation process of a human system, conducted at the household and community level, however I recognized the need to address the challenges at a landscape level to assess trade-offs and complementarity between

adaptation practices adopted and other livelihood strategies such as agroforestry. (Roncoli et al., 2010)

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Appendices

1.35 Conceptual framework and innovation and practices SSI protocol

TOOL # 1: IDENTIFICATION OF INNOVATION AND NEW PRACTICES (FGD)

Activities:

- Participants discuss their own understanding of the innovations and new practices among themselves.
- Participants write the different "innovations" on index cards, and facilitator pastes them randomly on the flipchart.
- The group participants discuss openly how the innovation is embedded in the people's practices and
- What people are doing with it?

Elements to look for as determinants of Adaptation as a social process:

- A willingness to adapt, learn and fail
- Ability to create new ideas, skills and technology
- Ability to take advantage of new opportunities
- Availability of assets and institutions to help foster or hinder innovation
- Embedment of innovations in people's practices
- What people are doing with it?
- What information do the community have on future climate change:

Key questions

a. Innovation: What new practices is the community engaging in due to noticeable climate-related changes? I.e. change in livestock herd composition. *(livelihood strategies above)*

i. **Prompt:** Has any climate-related change led to the adoption or invention of new practices? Yes/No
ii. If Yes! What new practices or processes has the community engaged in that was not there and not practiced 10 years ago?
iii. Brainstorming and developing a list for further probing!

b. **Land and natural resources management practices and changes.**

i. **Prompt:** What are the main natural resources uses especially those of land, water, soils, forest, vegetation, plants and animals.
ii. What are the main management practices around the natural resources?
iii. How have these changed within the past 5 years? 10years? 20 years?

Activities: Resource mapping tool

Mgmt. Practices	Observed Today	Changes from 10 – 20 years ago
Land		
Water		

TOOL # 2: SPECIFIC FOLLOW UP OF INNOVATION AND PRACTICES LISTED ABOVE (Most important once) (Semi structured interviews)

Innovation	Triggers	Type	Scale	Maturity	Process activities	Information source	Stakeholders	Decision making	Opportunities Barriers	Women Participation

Activities: "Innovations" are listed vertically on the flipchart and the participants discuss each "innovation" moving horizontally from one column to the next

c. Elevator Pitch: A brief description of the innovation.

d. Triggers: What specifically are the reasons behind the community or the household to start this practice or process?

i. **Prompt:** What caused the community to start the practice stated? *(focus on those associated with nature resource management)*

ii. Determine two level of causes, the proximate cause (*causing observed results*) and the ultimate cause *(real*)

Activities: Causal Tree Diagram

Use causal tree diagram to discuss interacting factors

Changed practices/Innovation	Holistic drivers	Interacting factors

iii. What are the major drivers of changes in natural resource management practices?

e. Type: What type of innovation is it?

i. Is it a planned, high-tech orientated, large scale, autonomous, or local?

ii. Is it an innovative practice taking advantage of opportunities or confronting challenges presented by climate change?

f. Scale: How many households/communities are facing the same issues and addressing it using this practice?

i. Who practices this innovation?

ii. Who is involved in this innovation?

iii. How is the response to the innovation both individual and group/institutional level)?

g. Maturity: How long has the community been engaging in this practice?

i. When was it started or initiated?

ii. When did it end or is it ongoing?

iii. What is the difference between people who have adopted the innovation and those who have not?

iv. What factors have affected the uptake of the innovation?

h. **Process/Activity:**

i. What major activities has taken place in support of the practice? Activities like training, meetings, experiments and etc.
ii. How was the innovation process organized in terms of network building, social learning and negotiations?

i. Source of Information:

i. Where did the innovator get information from that shaped the practice?
ii. What type and source of information was important in each stage of the innovation?
iii. Pastoralist and external actors' knowledge that has been used to enrich the innovation practice?
iv. Which is the most important process used by the community to share knowledge and information. OR
v. Is there a mechanism in place to promote and share risk and innovation within the community?

j. Stakeholders:

i. Who started this innovation? Who is the innovator?
ii. Who were the key stakeholders involved?
iii. What knowledge and information did they bring to enhance the practice?
iv. How was the information and knowledge presented to the different social disintegration?

k. Decision Making and governance

i. What are peoples' practical experience with the innovation?
ii. Who is involved in implementation and management of the innovation?
iii. At what level are decisions about livestock innovations among other innovation in NRM made: family, extended family unit, and community?
iv. At what level are decision about access to local natural resources (pasture and water) and innovations around them made?

l. Opportunities/Barriers

i. *If No to Question a.* If no new practices is observed or highlighted, why?
ii. Are there new successful opportunities/practices that were not viable in the past?
iii. What factors assist/hinder local populations in adopting new practices?
iv. Are there external actors or projects that have supported new practices to enable communities adapt to climate-related changes? Or
v. Supported the adoption of new practices?

m. Women Participation

i. Does the conservancy management and external actors provide support to the women to adapt to any changes observed in climate?
ii. To what extent do formal and informal organization communicate, and share information on new practices to the women?
iii. How do the innovations affect women positively and negatively?

n. Embedment of innovations in peoples practices

i. How able and willing is the community adopting the new practices and adjusting their own traditional practices? (reluctant to change traditional practices)

o. What people are doing with the innovation

i. Do the community have access to the new and improved innovation and practice needed to cope with climate change?

ii. Is the community taking risks and exploiting new opportunities presented by climate related changes?

iii. What effects does this new practices have on the community, both positive and negative? (5 assets)

iv.

p. What if question. Future climate change

i. Do the community collectively have the flexibility and capacity to deal with future climate change?

ii. What if the issues stated above worsens? What happens to the practice?

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1.36 Conceptual framework and Institutions & Entitlements SSI protocol

FIELD INSTITUTIONS AND ENTITLEMENTS SSI PROTOCOL

Main Objective: ***To identify the system's ability to ensure equitable access and entitlement to key resources as a fundamental characteristic of adaptation as a social process, linking it to the innovations.***

Activities:

- Differentiate the community based on residence, age, ethnicity, class, religion and gender
- Identify key informants
- Conduct Semi- Structured Interviews (SSI)

Elements to look for as institutional environment supporting adaptation as a social process:

- Institutions that support innovations
- Policies, established norms and rules which serve to guide or mandate action and conduct.
- An institutional environment that allows equitable opportunities to all groups
- Representation and participation in key institutions
- Access to key resources
- Participation in decision making process.
- Community Empowerment

Examples: Legislation, County or community by-laws, customary rules, Government policies and regulations, land tenure systems, management pans

Key questions A: An institutional environment that allows equitable opportunities to all groups

i. Identify formal and informal institutions who have a stake in IL Ngwesi group ranch?
    a. **Activity:** secondary data from NGOs, donors, county government to purposefully select key formal institutions.
    b. Organization's policies, regulations, reports and documents relating to Il Ngwesi Group Ranch.
    c. Identify informal institutions through literature searches and key informant interviews.
        i. What formal institutions (contracts, authority, incentives) and informal institutions (norms, routines, political process) that govern the management of the group ranch?
        ii. How is access and sharing of key resources in the group ranch embedded within this institutions?
        iii. What are some of the shared expectations and mutual understanding of informal and formal rules defining the socio-economic impact of Il Nqwesi group ranch?
        iv. How the rules are both informal and formal enforced and managed?

v. How does formal institutions actors influence household and community entitlements?
vi. Rankinstitutions based on those that ensure equitable distribution of resources.
vii. Is there any organized mechanism of information sharing about various stakeholders?
viii. Are there networks or forums where formal and informal organization meet?
ix. What happens at these forums?

Key questions B: Representation and participation in key decision-making institutions

ii. How the group ranch leadership elected and what is are their roles?

a. Activity: Semi-structured interviews

i. Who participates in decision making forums?
ii. How are new ideas and practices introduced or presented to the community?
iii. How are the various social disintegrated groups included in decision making? Which communities? How are they different? Kinds of households with different livelihoods and adaptation challenges.

iii. How are the various social institutions linked?

a. Activity: Identifying linkages among organizations and institutions. Institution mapping

i. Which ways do community share knowledge and information?
ii. What facilitates generation and flow of information and appropriate sharing of resources?
iii. How is coordination achieved among the various institutions?
iv. How is decision made at the various institution within the conservancy?
v. Is there anything happening in a coordinated way? Or any coordinated action to deal with impacts of climate change?

b. Household interviews (TO BE INCLUDED IN HHS)

i. How land has reforms affected household assets and entitlements?
ii. How has it affected the community's ability to influence and participate in decision relating to the management of the group ranch?
iii. How does private land ownership affect adaptation at household level?
iv. How easy or hard is it for the homestead to make decisions especially where they have private land tenure?

1.37 Household questionnaire

name	English
start	Start date and time of the survey.
today	Day of the survey.
deviceid	Device ID
basic_info	Enter basic info before starting the interview.
province	Province
commune	County
village	Village
farmer_code	Farmer Code
INTVRNAME	Interviewed by
INTDATE	Date of interview
intro_1	Introduce yourself. Explain the following: “Good morning/afternoon. We are coming from INERA/ICRAF in collaboration with PASMEP. We are developing a survey to understand how the different resources you own or have access to, influence your ability to adapt to climate change. We would like to ask you some questions that should take no more than 1.5 hours of your time.
consent	Explain to the respondent that his name will not appear in any data that is made publicly available. The information you provide will be strictly used for research purposes; your answers will not affect any government benefits or subsidies you may receive now or in the future. Ask: Do you consent to be part of this study? . If there are questions that you would prefer not to answer then we respect your right not to answer them.
hhloc	Location of Respondent's House
transition_1	In this first section, I would like you to tell me about yourself.
respondent_n	What is your full name?
contact_n	Mobile number (if available):
respsex	Select **Gender** of respondent
hheduc	How many years of formal Education have the household head had?
hhsex	Select **Gender** of the household head
hhage	What is the **Age** of the household head (in years)?

resprel	What is the **relationship** of main respondent **to household head?**
hhethnic	What **Ethnic Group** does the household head primarily belong to?
hhrelig	What is the household head's **Religion**?
hhlive	What is the **primary livelihood activity** of the household head
hhtype	What is the **Marital status** of the household head?
otherhhtype	Other household type
hhtot	What is the **total number of people** in the household?
hhbel15	How many household members are **below 15** (from 0 - 14)?
hhab64	How many household members are **above 64** (from 65 to a higher number)?
hhffw	How many household members are **fully engaged** in farm work for at least part of the year?
hhpfw	How many household members are **partially engaged** in farm work for at least part the year?
fhlit	Can the **female head/spouse** read a one page letter in any language?
hhnat	Is the household head a **native or migrant** in this locality?
hhtim	How long the household head has been residing in this locality?
transition_2	In this next section, I would like you to tell me about the assets owned and accessed to by the household.
assetname	Name of Asset
sofuelcook	What is the main **source of fuel for cooking** used by your household?
osofuelcook	Other source of fuel for cooking used by your household?
typtoil	What is the main **type of toilet facility** used by your household
otyptoil	Other type of toilet facility used by your household
roofhom	What is the main material used for the roof of your home?
oroofhom	Other main material used for the roof of your home?

transition_3	In this next section, I would like you to tell me about the physical infrastrutures accessed to by the household.
electav	Does your home have **electricity**?
solpan	Does your home use **solar panel/car battery** as a source of electricity?
sodrinkw	What is the main source where your household accesses its drinking water?
distdrinkw	How far (**distance in km**) is this main source of your household's drinking water from your household location?
distmroad	How far (**distance in km**) is it from your house to reach the main road?
typroaddist	What type of road is it to the **District/County center** ?
qroadsit	How would you rate the **quality of the road** to the District/County center?
passroad	How many months out of the year the main road leading to the District/County center is passable by vehicle?
barrcrop	During the last 12 months, did you and your household experience any barriers taking your crops to market?
barrliv	During the last 12 months, did you and your household experience any barriers taking livestock and livestock products to market
transition_4	In this next section, I would like you to tell me about your ownership and access to **natural assets**.
ownland	Does your household **own land** ?
sownland	What is the **size (ha) of land owned** by the household?
whownland	Please specify **who in the household owns land**
condownland	Conditions of land ownership
otherownland	Other condition of land ownership
ownrentland	Has your household farmed its **own land or any rented land** in the last 12 months, that is, from April 2015 to April 2016?
sownfland	What is the size (ha) of **land farmed last year** by the household that is used **for food crops**
sownfcland	What is the size (ha) of **land farmed last year** by the household that is used for **fodder crops**

qualfland	How would you assess the overall quality (fertility) of your farm land for food crops?
qualfcland	How will you assess the quality of the land used for fodder crops?
accsgland	During the last rainy season, did your household experience problems accessing communal suitable grasslands for grazing ?
acccrpres	During the last dry season, did your household experience problems accessing crop residues to feed your livestock (after crop are harvested)?
acclivfeed	During the last dry season, did your household experience problems accessing processed livestock feed (SPAI)?
transition_5	In this next section, I would like you to tell me about the **financial assets** you have accessed to.
fabank	Is there any **microfinance-institution/bank** available in the nearest commune or district?
formcred	Has anyone in your household taken any loans or borrowed cash/in-kind items from a FORMAL lending institution such as a bank or microfinance organization in the past 12 months, that is, from April 2015 to April 2016?
infcred	Has anyone in your household taken any loans or borrowed cash/in-kind items from an INFORMAL LENDER the past 12 months, that is, from April 2015 to April 2016?
frierelcred	Has anyone in your household taken any loans or borrowed cash/in-kind items from a FRIEND or RELATIVE in the past 12 months, that is, from April 2015 to April 2016?
ngocred	Has anyone in your household taken any loans or borrowed cash/in-kind items from an NGO or GOVERNMENT program in the past 12 months, that is, from April 2015 to April 2016?
comcred	Has anyone in your household taken any loans or borrowed cash from a community SAVING and LOANING group in the past 12 months, that is, from April 2015 to April 2016?
ownliv	Do you own livestock?

nbownlliv	Can you give an **estimate** of the number of large livestock you own?
nbownsliv	Can you give an **estimate** of the number of small livestock you own?
transition_6	In this next section, I would like you to tell me about the **social assets** you have accessed to.
membass	Are you a member of an association, cooperative, community group in the village?
typass	Please specify the type of association
othtypass	Specify other type of association you are a member
safriend	Does the household head or his/her spouse have a close friend in the village?
assfriend	Did the household get any money, food or any type of assistance from this friend in the last 12 month?
typassfriend	What type of assistance do you get from the close friend?
sarelvil	Does the household head or his/her spouse have any relatives in this village?
assrelvil	Did the household get any money, food or any type of assistance from these relatives in the last 12 month?
typassrelvil	What type of assistance do you get from the relatives in this village?
sarelovil	Does the household head or his/her spouse have any relatives in another village?
assrelovil	Did the household get any money, food or any type of assistance from these relatives in the last 12 month?
typassrelovil	What type of assistance do you get from the relatives in another village?
saneigb	Did the household get any money, food or any type of assistance from neighbors that are NOT close friends or relatives of the household head or his/her spouse in the last 12 month?
typassneigb	What type of assistance do you get from the neighbours?
assgov	Did the household get any money, food or any type of assistance from the government in the last 12 month?
typassgov	What type of assistance do you get from the government?

givohh	Did you or anybody in the household GIVE any money, food or any type of assistance to ANOTHER household in the last 12 month?
typassgivohh	What type of assistance did you give?
relhh	What is their relationship to your household?
transition_7	This section aims at gaining an understanding of the social network you have in the area
repeat_socialnetw	Social network
peophnam	What is the first name of the other person/organisation you know?
peoplnam	What is the last name of the other person/organisation you know?
peopgend	Gender
peophom	Where does this person/organisation lives/is located?
peoprel	What is the relationship of this person/organisation with you?
othpeoprel	Other relationship of this person/organisation with you?
peopvisw	Did you see him/her /it **last week**?
peopvism	Did you see him/her /it **last month**?
peopad	Does he/ she/it comes to you for advice or help?
repeat_socialnetw	
transition_8	This section aims at gaining an understanding of the **adaptation options** used on your farm or for your livelihood and your access to information
adirr	Do you practise **Irrigation** on your farm?
yadirr	How long (years) have you been practising irrigation on your farm?
efadirr	What is your perception of the effectiveness of irrigation for coping with climate shocks?
adothagrof	Do you use **fertilizer trees/fruit trees/timber trees** on your farm?

yadothagrof	How long have you been using fertilizer trees/fruit trees/timber trees on your farm?
efadothagrof	What is your perception of the effectiveness of fertilizer trees/fruit trees/timber trees for coping with climate shocks?
adfodtree	Do you use **fodder trees or shrubs** on your farm?
yadfodtree	How long have you been using fodder trees or shrubs on your farm?
efadfodtree	What is your perception of the effectiveness of fodder trees or shrubs for coping with climate shocks?
adfmnr	Do you practise **FMNR** (Farmer Managed Natural Regeneration Trees) on your farm?
yadfmnr	How long have you been practising FMNR (Farmer Managed Natural Regeneration Trees) on your farm?
efadfmnr	What is your perception of the effectiveness of FMNR for coping with climate shocks?
adgrman	Do you use **Green manures** on your farm?
yadgrman	How long have you been using Green manures on your farm?
efadgrman	What is your perception of the effectiveness of Green manures for coping with climate shocks?
adlivman	Do you use **Livestock manure** on your farm?
yadlivman	How long have you been using Livestock manure on your farm?
efadlivman	What is your perception of the effectiveness of Livestock manure for coping with climate shocks?
adcomp	Do you use **Composting** on your farm?
yadcomp	How long have you been using Composting on your farm?
efadcomp	What is your perception of the effectiveness of Composting for coping with climate shocks?
adzai	Do you practise **Zai** pits on your farm?
yadzai	How long have you been practising Zai pits on your farm?
efadzai	What is your perception of the effectiveness of Zai pits for coping with climate shocks?
adhmoon	Do you practise **Half moons** on your farm?

yadhmoon	How long have you been practising Half moons on your farm?
efadhmoon	What is your perception of the effectiveness of Half moons for coping with climate shocks?
adstbund	Do you use **Stone bunds** on your farm?
yadstbund	How long have you been using Stone bunds on your farm?
efadstbund	What is your perception of the effectiveness of Stone bunds for coping with climate shocks?
adchfert	Do you use **Chemical Fertilizers** on your farm?
yadchfert	How long have you been using Chemical Fertilizers on your farm?
efadchfert	What is your perception of the effectiveness of Chemical Fertilizers for coping with climate shocks?
adimpseed	Do you use **Improved seeds** on your farm?
yadimpseed	How long have you been ussing Improved seeds on your farm?
efadimpseed	What is your perception of the effectiveness of Improved seeds for coping with climate shocks?
adimpliv	Do you use **Improved breeds** of livestock ?
yadimpliv	How long have you been using Improved breeds of livestock ?
efadimpliv	What is your perception of the effectiveness of Improved breeds for coping with climate shocks?
adcdiv	Do you practise Crop diversification on your farm ?
yadcdiv	How long have you been practising **Crop diversification** on your farm ?
efadcdiv	What is your perception of the effectiveness of Crop diversification for coping with climate shocks?
adzgliv	Do you practise **Zero-grazing** livestock ?
yadzgliv	How long have you been practising Zero-grazing livestock ?
efadzgliv	What is your perception of the effectiveness of Zero-grazing livestock for coping with climate shocks?
adcres	Do you use of **Crop residues** as livestock feed ?
yadcres	How long have you been using of Crop residues as livestock feed?
efadcres	What is your perception of the effectiveness of Crop residues as livestock feed for coping with climate shocks?

adfodcrp	Do you practise **Fodder cropping** on your farm?
yadfodcrp	How long have you been practising Fodder cropping on your farm?
efadfodcrp	What is your perception of the effectiveness of Fodder cropping for coping with climate shocks?
adwelfa	Do you have some **Wells on farm/rain water harvesting** technologies on your farm?
yadwelfa	How long have you been having some Wells on farm/rain water harvesting technologies on your farm?
efadwelfa	What is your perception of the effectiveness of Wells on farm/rain water harvesting technologie for coping with climate shocks?
admigliv	Do you undertake **Seasonal migration of livestock herds** to greener pasture (transhumance)?
yadmigliv	How long have you been undertaking Seasonal migration of livestock herds to greener pasture (transhumance)?
efadmigliv	What is your perception of the effectiveness of Seasonal migration of livestock herds for coping with climate shocks?
adclivcrp	Have you **Changed in livestock species from cattle to goat or sheep**?
yadclivcrp	How long have you been Changing livestock species from cattle to goat or sheep?
efadclivcrp	What is your perception of the effectiveness of Changing livestock species from cattle to goat or sheep for coping with climate shocks?
adslivcrp	Have you **Shifted from livestock husbandry to crop production**?
yadslivcrp	How long have you been Shifting from livestock husbandry to crop production?
efadslivcrp	What is your perception of the effectiveness of Changing livestock species from shifting from livestock husbandry to crop production for coping with climate shocks?
adhdest	Have you practised **Herd destocking**?
yadhdest	How long have you been practising Herd destocking?
efadhdest	What is your perception of the effectiveness of Herd destocking for coping with climate shocks?
adhsplit	Have you practised **Herd splitting**?

yadhsplit	How long have you been practising Herd splitting?
efadhsplit	What is your perception of the effectiveness of Herd splitting for coping with climate shocks?
admighh	Did you experience **Seasonal migration of household members**?
yadmighh	How long have you been experiencing Seasonal migration of household members?
efadmighh	What is your perception of the effectiveness of Seasonal migration of household members for coping with climate shocks?
adpgrsys	Did you practise **Planned grazing systems**?
yadpgrsys	How long have you been practising Planned grazing systems?
efadpgrsys	What is your perception of the effectiveness of Seasonal migration of household members for coping with climate shocks?
adoffarm	Have you been involved in **Off farm activities** (casual workers, petty trade, mechanic, potery,…)?
typadoffarm	Please specify the type (s) of off-farm activities you are involved in
yadoffarm	How long have you been involved in Off farm activities (casual workers, petty trade, mechanic, potery,…)?
efadoffarm	What is your perception of the effectiveness of Off farm activities for coping with climate shocks?
othadapt	Do you use **other adaptation strategies**?
othadaptop	Other adaptation options
adname	Name of the other adaptation option used
yadname	Number of years you have been using this other adaptation option
efadname	Effectiveness of this other adaptation strategy for coping with climate shocks
othadaptop	
infclimwg	Do you have access to seasonal climate forecast to decide where to graze your cattle?
soucliminfowg	What is the source of climate information you have accessed to decide where to graze your cattle?
osoucliminfowg	Other source of climate information you have accessed to decide where to graze your cattle?

infpast	Do you have access to information on pasture availability to decide where to graze your cattle?
souinfpast	What is the source of information on pasture availability to decide where to graze your cattle?
oinfpast	Other source of information on pasture availability to decide where to graze your cattle?
infwatpt	Do you have access to information on water point availability to decide where to graze your cattle?
souinfwatpt	What is the source of information on water point availability to decide where to graze your cattle?
osouinfwatpt	Other source of information on water point availability to decide where to graze your cattle?
infclimft	Do you have access to climate information to decide which farm technology to use in the face of climate shocks?
souinfclimft	What is the source of climate information you have accessed to decide which farm technology to use in the face of climate shocks?
osouinfclimft	Other climate information you have accessed to decide which farm technology to use in the face of climate shocks?
infagroft	Do you have access to agronomic information to decide which farm technology or adaptation option to use in the face of climate shocks?
souinfoagroft	What is the source of agronomic information you have accessed to decide which farm technology or adaptation option to use in the face of climate shocks?
osouinfoagroft	Other source of agronomic information you have accessed to decide which farm technology or adaptation option to use in the face of climate shocks?
transition_9	This section aims at gaining an understanding of **Households' Perceptions of Natural Resource Availability, Seasonality and Change**
raindays	Has the **total number of rainfall days** increased or decreased or not changed over the last 20 years in your area?
floodocc	Has the **occurrence of flood** increased or decreased or not changed over the last 20 years in your area?
drouocc	Has the **occurrence of drought** increased or decreased or not changed over the last 20 years in your area?

dryspelnbr	Has the **number of dry spells** increased or decreased or not changed over the last 20 years in your area?
hotdays	Has the total **number of hot days** increased or decreased or not changed over the last 20 years in your area?
sevdroug	Has the **severity of drought** increased or decreased or not changed over the last 20 years in your area?
sevflood	Has the **severity of flood** increased or decreased or not changed over the last 20 years in your area?
afflandmg	Was your traditional land management systems and livelihood affected by the observed change in climate (rainfall and temperature)
wafflandmag	In what ways was your traditional land management systems and livelihood affected ?
othwafflandmag	other ways your traditional land management system was affected
migpopi	How do you perceive the migration of people from Outside your area to your area over the 20 past years?
migpopo	How do you perceive the migration of people from your area to other areas over 20 the past years?
peravpast	How do you perceive the availability of pasture over the 20 past years?
perprodpast	How do you perceive the productivity of pasture over the 20 past years?
pernutrpast	How do you perceive the nutritive value of pasture over the 20 past years?
peravwatpt	How do you perceive the availability of water points over the 20 past years?
peravfodtree	How do you perceive the availability of fodder trees/shrubs over the 20 past years?
transition_10	This section aims at gaining an understanding of Households' Perceptions of Governance
natresgrp	Have you participated in a natural resource management group during the past year that is since April of last year until April 2016?
wnatresgrp	Which specific natural resource management group?
ownatresgrp	Other natural resource management group

timwatgrp	How many times have you attended a meeting of the water management group during the past year, that is, since since April of last year up until April 2016?
invwatgrp	To what extent are you involved in deciding what activities this water management group undertakes?
timranglgrp	How many times have you attended a meeting of the rangeland management group during the past year, that is, since since April of last year up until April 2016?
invranglgrp	To what extent are you involved in deciding what activities this rangeland management group undertakes?
timsecgrp	How many times have you attended a meeting of the security management group during the past year, that is, since since April of last year up until April 2016?
invsecgrp	To what extent are you involved in deciding what activities this livestock health care group undertakes?
timlivcargrp	How many times have you attended a meeting of the livestock health care group during the past year, that is, since since April of last year up until April 2016?
invlivcargrp	To what extent are you involved in deciding what activities the livestock health care group undertakes?
timlivkepgrp	How many times have you attended a meeting of the cooperative for livestock keeper during the past year, that is, since since April of last year up until April 2016?
invlivkepgrp	To what extent are you involved in deciding what activities this cooperative for livestock keeper undertakes?
timonatresgrp	How many times have you attended a meeting of this other natural resource management group during the past year, that is, since since April of last year up until April 2016?
invonatresgrp	To what extent are you involved in deciding what activities this this other natural resource management group undertakes?
rulacrangld	Are there any rules that regulate the access and use of the rangeland?
rulrangld	What are the rules that regulate the access and use of the rangeland?
inobeyrulesrl	In your view, do individuals in the user group follow the rules for accessing and using the rangeland?

outobeyrulesrl	In your view, do individuals outside the user group follow the rules for accessing and using the rangeland?
sancrulerl	Are there any sanctions applied to individuals who do not follow the rules for the rangeland management?
typsancrulerl	Please, specify one or two sanctions that apply to individuals who do not follow the rules for the rangeland management
rulacwatpt	Are there any rules that regulate the access and use of the water points?
rulwatpt	What are the rules that regulate the access and use of the water points?
inobeyruleswp	In your view, do individuals in the user group follow the rules for accessing and using the water points?
outobeyruleswp	In your view, do individuals outside the user group follow the rules for accessing and using the water points?
sancrulewp	Are there any sanctions applied to individuals who do not follow the rules for the water points management?
typsancrulewp	Please, specify one or two sanctions that apply to individuals who do not follow the rules for the water points management
rulaclivcare	Are there any rules that regulate the access and use of the livestock care infrastructures?
rullivcare	What are the rules that regulate the access and use of the livestock care infrastructures?
inobeyrulivcare	In your view, do individuals in the user group follow the rules for accessing and using the livestock care infrastructures?
outobeyrulivcare	In your view, do individuals outside the user group follow the rules for accessing and using the livestock care infrastructures?
sancrulelc	Are there any sanctions applied to individuals who do not follow the rules for the livestock care management?
typsancrulelc	Please, specify one or two sanctions that apply to individuals who do not follow the rules for the livestock care management
impgrcontlh	During the past year, has the user group implemented rules for grazing contract with local herders?
passgrcontlh	During the past year, has the user group modified rules for grazing contract with local herders?
mpassgrcontlh	Please, specify what was mofified in the rules for grazing contract with local herders

impgrcontoh	During the past year, has the user group implemented rules for grazing contract with herders outside the area?
passgrcontoh	During the past year, has the user group modified rules for grazing contract with herders outside the area?
mpassgrcontoh	Please, specify what was mofified in the rules for grazing contract with herders outside the area
impmaintact	During the past year, has the user group implemented rules for Planting seeds, seedlings, or other maintenance activities to improve rangeland?
passmaintact	During the past year, has the user group modified rules for Planting seeds, seedlings, or other maintenance activities to improve rangeland?
mpassmaintact	Please, specify what was mofified in the rules for Planting seeds, seedlings, or other maintenance activities to improve rangeland
impwatpt	During the past year, has the user group implemented rules for creation and control of water points?
passwatpt	During the past year, has the user group modified rules for creation and control of water points?
mpasswatpt	Please, specify what was mofified in the rules for creation and control of water points
impconflres	During the past year, has the user group implemented rules for conflict resolution?
passonflres	During the past year, has the user group modified rules for conflict resolution?
mpassonflres	Please, specify what was mofified in the rules for conflict resolution
impvaccpk	During the past year, has the user group implemented rules for creation and use of vaccination park?
passvaccpk	During the past year, has the user group modified rules for creation and use of vaccination park?
mpassvaccpk	Please, specify what was mofified in the rules for creation and use of vaccination park
impbufire	During the past year, has the user group implemented rules for bush fire surveillance and control?
passbufire	During the past year, has the user group modified rules for bush fire surveillance and control?
mpassbufire	Please, specify what was mofified in the rules for bush fire surveillance and control

imptreecut	During the past year, has the user group implemented rules for Trees cutting surveillance and control?
passtreecut	During the past year, has the user group modified rules for Trees cutting surveillance and control?
mimptreecut	Please, specify what was mofified in the rules for Trees cutting surveillance and control
endnote	Thank the respondent for their participation and end the interview.
end	End date and time of the survey.