Perception and management strategies for climate-induced risks among pastoralists and agro-pastoralists

A case study from dryland farming systems in northern Kenya

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Perception och förvaltningsstrategier för klimatinducerade risker bland pastoralister och agro-pastoralister. En fallstudie från torrlandbrukssystem i norra Kenya

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Abstract

Agriculture is the backbone of many economies around the world, and it is arguably the sector most affected by climate change with its variability and extremes. Farmers have suffered significant losses as a result of such occurrences in the past and have used a variety of risk management strategies to deal with the risks involved. This master's thesis aimed to investigate pastoralists' and agro pastoralists' perceptions of climate-induced risks, as well as their adaptation strategies for mitigating the negative on agricultural production. This study took a qualitative approach to understand and managing agricultural risks with a specific focus on climate-induced risks among pastoralists and agro-pastoral farmers. The findings are based on eighteen interviews conducted in each of the two study areas identified through the purposive sampling technique. The empirical data gathered through semi-structured interviews were analyzed using thematic analysis. The findings indicate that farmers have experienced extreme events that have significantly affected their agricultural production over the years and have devised risk management strategies identified in this study as preventive, coping and mitigation strategies. However, the majority of respondents feel that extreme events are driven by other natural forces rather than climate change, while only a few believe that climate change is real and have plans to manage the risks associated with it by adopting better mitigation strategies. As this thesis was based on the dryland transform project's fourth pillar, focused on understanding community resilience to seasonality and climate variability, the study recommends improving farmers' access to climate change-related information through partnerships with stakeholders involved in enhancing agricultural productivity. Furthermore, educating farmers and pastoralists on the importance of education and other long-term strategies is recommended. In addition to the academic contribution, this study outlines some policy initiatives that can be implemented to improve farmers' ability to adapt to climate change.

Keywords: Risk, climate change, risk management, climate change risk perception model, agriculture, risk preferences, adaptation and mitigation strategies

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Abbreviations

CCRPM	Climate Change Risk Perception Model
GDP	Gross Domestic Products
IPCC	Intergovernmental Panel on Climate Change
KWS	Kenya Wildlife Services
NGO	Non-Governmental Organization
OECD	Organization for Economic Cooperation and Development.
SDGs	Sustainable Development Goals
SEK	Swedish krona
SLU	Sveriges Lantbruksuniversitet (Swedish University of Agricultural Sciences)
TIMPS	Technology, Innovation and Management Practices

1. Introduction

This section presents the background to the study on climate change and agriculture, pastoralism and agro-pastoralism in drylands of developing countries, the problem statement and the aim and research questions. The delimitations of this study and the outline will be presented as well.

1.1 Climate change and agriculture

With the world population likely to increase from 6.7 billion to 9.3 billion by 2050 agriculture faces the challenge of producing at sufficient levels to generate enough food, feeds, and fibers to match the rising level of demand in the face of changing climate and exhausting natural resources (Anwar et al., 2013). As a result, efforts that help reduce the vulnerability of agricultural sectors to climate-related risks are likely to result in significant global benefits, both economically and socially (Meinke et al., 2007). Climate change is arguably the most serious issue confronting the world in the twenty-first century. It is widely regarded as one of the most significant global challenges, owing to the magnitude of its impact in terms of global and temporal spread, as well as the diversity of sectors affected by this phenomenon, which distinguishes it from other global challenges (Otto, 2015). Climate change cannot be considered in isolation from other global challenges. It is a multi-sectoral issue that has the potential to affect global water supplies, agricultural production, human health, and our energy infrastructure (ibid). Changes in climate influence the mean and variability of weather conditions, as well as the frequency of extreme weather events, which in turn influences the fluctuations in the productivity and yields in agriculture (Antón *et al.*, 2013). For at least two factors, agriculture is at the heart of the dynamic issues surrounding climate change. To begin with, one of the major concerns about future climate change is that agricultural systems will be unable to produce at the same level as they do today due to changing conditions, especially drought. Secondly, agriculture plays a significant role in addressing climate change. Farming practices can either significantly increase or reduce climate change, based on how they are built (Rosenzweig *et al.*, 2014).

Agriculture is arguably one of our global economy's most climate-sensitive sectors (Meinke *et al.*, 2007). It is the backbone of the majority of African economies, accounting for 55% of the continent's GDP. It is the foundation of food security and the primary source of income for 85 percent of the population, who rely on rain-fed farming systems (Kogo *et al.*, 2021). The agricultural sector is critical to increasing food availability and thus contributing to food security. Furthermore, the sector contributes significantly to poverty reduction in developing countries (Pawlak & Kołodziejczak, 2020). For the developed nations, agriculture occupies a special place in the national consciousness (Meinke *et al.*, 2007). Similarly, agriculture is an important sector in developing countries because the majority of the population relies on it for income and to improve

food security. Furthermore, agriculture accounts for a sizable portion of GDP in developing countries (Pawlak & Kołodziejczak, 2020).

Due to their greater vulnerability, developing countries have unique adaptation needs. Despite the fact that industrialized countries are responsible for greenhouse gas emissions, developing countries bear the majority of the global cost of climate change. This is because many developing countries rely on agriculture for national income and employment, which is directly affected by climate. Furthermore, developing countries' economic and technological adaptability to climate change is limited. Poverty levels in developing countries also contribute to these economies' vulnerability to the negative effects of climate change (Mertz *et al.*, 2009). These economies are particularly vulnerable to extreme weather events such as rising surface temperatures and fluctuating precipitation (Khan *et al.*, 2020).

African countries, including Kenya, are already facing significant challenges due to their limited capacity to adapt. With a poverty rate of 52 percent and a labor force dependency on agricultural production of 73 percent, and agricultural production being the primary source of livelihood, it is critical to strengthen the agricultural sector's resilience, protect the sources of livelihood of the poor, and ensure food security in Kenya (Bryan et al., 2013). Kenya, like many other countries around the world, is vulnerable to extreme events caused by climate change, and the climate scenarios used to predict future changes indicate that drier areas, such as the northern part of Kenya, will be more affected. The projections of Kenya's future climate under several simulations until the year 2050 show yield losses in certain crops such as maize, wheat, rice, and groundnuts across the country. Even though the magnitude of the drop in yields for most crops is uncertain, this decline is expected to be a 50% drop in maize yield production (Kogo *et al.*, 2021).

Dealing with potential climate uncertainties is one of the most daunting problems, and it is crucial for countries, economies, and communities due to a high level of uncertainty regarding what direction of climate change will be based on the representative concentration pathways (RCPs) (Yousefpour & Hanewinkel, 2016). As a result, while the rest of the world is concerned about reducing global emissions, Africa's main concern is an adaptation to climate change and deteriorating opportunities, as the consequences are already visible (Collier *et al.*, 2008). Farmers are encouraged to be proactive in order to improve their ability to assess, plan for, and respond to risks. Preventive, mitigation, and coping strategies are the applicable techniques of risk management (Iqbal *et al.*, 2020). Adapting agriculture to climate change is recognized as a critical policy option for reducing vulnerability and negative impacts. As a result, there is a growing focus on the critical need for adaptation in African agriculture. Adaptation is defined as "adjustment in natural or human systems in response to actual or anticipated climatic stimuli or their effects, which mitigates harm or capitalizes on beneficial opportunities" (Tambo & Abdoulaye, 2013).

Risk awareness and risk perception are two important factors that influence adaptive behavior in climate change risk management. The level of recognition of potential hazards that affect agricultural production as a result of changing climatic conditions is referred to as risk awareness.

Risk perception, on the other hand, can be defined as a subjective assessment of the risks involved. A high level of awareness and perception have been identified as critical factors in widespread attention for policy changes and precautionary disaster risk reduction decision making (Stefan *et al.*, 2021). Relevant risk perception can be viewed as a prerequisite for choosing an effective risk-coping strategy, because a farmer who is unaware of the risks that face him is clearly incapable of managing them effectively. Furthermore, other socioeconomic factors such as education, wealth, age, and gender are all believed to influence the preference of coping strategies (Berman *et al.*, 2015). Many studies claim that climate change, with its variability and extremes, is a major source of risk in agriculture (Smit *et al.*, 2000), and that the drier will be the hardest hit (Bryan *et al.*, 2013). This necessitates identifying and analyzing farmers' risk perceptions, current management practices, and future adaptation plans in production activities amidst climate change.

1.2 Pastoralism and agro pastoralism in drylands of developing countries

Drylands cover 40% of the world's landmass, are home to one-third of the world's human population and 50% of the world's livestock, and are primarily inhabited by pastoralist communities who manage the land through communal land ownership. In Sub-Saharan Africa, 25 million pastoralists and 240 million agro-pastoralists depend on livestock, occupying 40% of total available land (Nyberg *et al.*, 2015). Pastoralism and agro-pastoralism are the main sources of income and traction power in the drylands, where households rely on livestock production for food, income, and traction power to till the land for crop production. In addition to providing food security, livestock serves as a source of social pride and security. Pastoralists and agro-pastoralists have devised strategies for centuries that have allowed them to maintain culture and flexibility by using indigenous complex knowledge to manage the common resource base and adapt to a highly uncertain environment, particularly the climate (Worku *et al.*, 2014).

Pastoralism in the arid and semi-arid lands in Kenya is defined as both an economic activity and cultural identity. It serves important socio-cultural roles as a source of prestige, affluence, bride price, and a form of payment in the resolution of domestic disputes as a cultural identity. The pastoral production system contributes significantly to the Kenyan economy, where livestock production accounts for approximately 50% of agricultural GDP. It accounts for 20% to 30% of the total gross domestic product. This, however, could be an underestimation of the contribution of the livestock sector to the gross domestic product as only livestock and livestock products that are taken to the market are valued neglecting the value of the non-marketed livestock and products used for subsistence consumption and other social-cultural benefits (Nyariki & Amwata, 2019).

Pastoralism is estimated to contribute between 10% and 44% of the gross domestic product in African countries, with 1.3 billion people benefiting from the livestock value chain. (Nyariki & Amwata, 2019). Pastoral and agro-pastoral production systems face numerous challenges that

prevent them from reaching their full potential, despite their contributions to local, national, and global economies. Climate change, the effects of globalization, urbanization, and the undervaluation of such a production system all contribute to this setback (ibid). Drylands in East Africa contribute significantly to national economies and society as they support agriculture, livestock rearing, and wild resource harvesting, and thus play a critical role in ensuring national food security. Pastoral and agro pastoral production systems in the drylands provide the majority of animal products consumed in the Horn of Africa and exported to the Middle East (Notenbaert *et al.,* 2012).

1.3 Problem statement

Agricultural production is subject to a variety of risks, including production risk, financial risk, market risk, human risk, and institutional risk (Hardaker *et al.,* 2015). This necessitates that producers remain vigilant and develop various management techniques and strategies to ensure that their production processes continue year after year. Climate change, including variability and extreme events, is a significant risk factor in agricultural production (Smit *et al.,* 2000). Farmers are used to dealing with changes from year to year, but climate change is expected to increase hence the need for better management practices and adaptation strategies (Yousefpour & Hanewinkel, 2016). Researchers worldwide have been interested in studying farmers' perceptions and management strategies used to combat the negative effects of climate change on agriculture in various parts of the world. Aydogdu and Yenigün (2016), for example, conducted a quantitative study on farmers' perceptions of climate change and adaptation strategies in Sub-Saharan West-African countries such as Benin, Burkina Faso, Ghana, Niger, and Togo, and found that 98 percent of respondents from a sample of 234 farmers agreed that geographical location and current climate were determinants of future expected climate changes. Mengistu (2011) investigated farmers' perceptions and knowledge of climate change, as well as their coping strategies in the Central Tigray region of Ethiopia, where 144 farmers were interviewed via focused group discussion to assess drought early warning systems and weather forecasting. According to the study, the majority of respondents perceived drought as the primary climate-related hazard that frequently affects their livelihood, and vulnerability varies according to hazard coping capacity. Other similar study include that conducted by Arndal Woods *et al.* (2017) in Denmark, which revealed that farmers were not substantially concerned about climate change but were willing to undertake adaptation actions in the future.

The existing studies within the study areas concentrated on the environmental management perspectives, land tenure and management systems, and economic aspects concerning agricultural commercialization among others in connection with climate change (Wairore *et al*., 2015; Obwocha *et al*., 2022; Wernersson, 2014). However, research on climate change concerns applying behavioral approach in relation to pastoralist and agro pastoralist risk perception and

management strategies is limited, particularly in Kenya's Arid and Semi-Arid pastoral production setup. Based on these risks, which are likely to harm agricultural production and thus the agro pastoralists' and pastoralists' standard of living, it is interesting to investigate how they perceive climate change risks, its impact, and their adaptation strategies. It is critical to understand how pastoralists consider climate change in their risk management strategies, as this will serve as a foundation for policymakers, advisors, and development actors working with the agricultural sector in the region to contribute to the development and evaluation of risk management strategies.

1.4 Study aim

This research aims to investigate pastoralists' and agro pastoralists' perception of climate change and their adaptation strategies put in place to mitigate the adverse effect of risks posed by the changing climate on agricultural production. To achieve this objective, the following research questions have been formulated focusing on dryland farming in northern Kenya.

- What strategies are the pastoralists putting in place to adapt to the adverse effect of climate change?
- How do farmers perceive the concept of climate change and related risks?

1.5 Delimitation

The research concentrated on two wards in northern Kenya namely Chepareria ward in West Pokot County and the Lokiriama ward in Turkana County. The two wards were among the selected sites for the dryland transform project. This is a research project being carried out in Eastern Africa by the Swedish University of Agricultural Sciences (SLU) between October 2020 and September 2024, with funding from the Swedish research council for sustainable development (FORMAS) aimed at achieving Sustainable Development Goals (SDGs) within the region. The project has five themes, which include; land health linked to human health, livestock cafes, the resilience of communities, innovative governance with a focus on land tenure, and the future scenarios. This research will be mainly delimitated to the resilience of communities on seasonality and climate variability on food, livelihood, and resilience. In addition, this research was delimited in the selection of the respondents as the focus was on lead farmers and pastoralists within all the sub-locations in the two wards to establish the climate risk perception and their risk management strategies as well as their future perception and mitigation plans.

2. Literature Review and Theoretical Framework

The literature review on risk management, risk in agriculture, risk preferences, risk perception, and knowledge transfer will be presented in this section. This will be followed by the study's conceptual framework.

2.1 Risks perception in agriculture

Different authors have tried to define risk and uncertainty in various ways. Hardarker *et al.* (2015), defined risk as uncertain consequences of an occurrence with a possibility of exposing an entity or individual to an unfavorable result. Hardwood *et al.* (1999) described risk as uncertainty that affects a person's welfare, which in turn can be characterized by a situation where the individual is unsure of what will happen eventually. Risk is an unpleasant and irrational occurrence that can make people question their beliefs, and how people perceive risk depends on a number of different factors. Risk, which generally refers to the uncertainty that occurs as a result of different events, has been described in some literature to have positive or negative effects on organizations (de Araújo Lima *et al.*, 2020; Abu Hatab *et al.*, 2021). In agricultural production, risk in most literature refers to risks as the variation in the income from the agricultural output and the prices as well as the cost variability (Gabriel & Baker, 1980). This study focused on the negative effects and risks related to climate change on agricultural production in the pastoral and agro-pastoral production systems.

Agricultural risks are classified into seven categories, the most well-known of which are output price and market risks, financial risks, production risks, institutional risks, and human risks (Hardaker *et al.*, 2015). Market risks are the consequences of fluctuating input and output prices, as well as any shocks to the market. Financial risks are those that arise as a result of unexpected and unfavorable changes in loan terms and interest rates related to agricultural production financing. Unfavorable and unpredictable weather events, pest and disease attacks, and technological changes all pose production risks. Changes in government policies, such as rules, taxes, and regulations, which negatively affect agricultural activities, create institutional risks. Human risk is associated with farm owners, which can be as a result of death or incapacity, which leads to loss of profit or inhibits the agricultural business's sustainability (Hardaker *et al.*, 2015).

Production risk is a significant source of agricultural production and food security, and it is significantly and increasingly influenced by climate change, pests, and diseases. This further distinguishes the sixth and seventh categories of risks that stem from the production risk. Weather and climate change risks, which are frequently included in weather-related risks, and biosecurity threats, which include pest and disease outbreaks as well as invasive species, are the two categories (Duong *et al.*, 2019).

Droughts are one of the most serious threats to pastoral economies. This is a common risk in the arid and semi-arid regions, where herders live in fragile ecosystems that are extremely vulnerable to climate change. These areas are not only affected by the successive years without rainfall but also are also characterized by overstocking and non-sustainable grazing methods and high population growth that results in irreversible degradation of pastures. This factors lead to soil degradation and also reduces the carrying capacity of the rangelands that turns out to be a severe problem to animal husbandry (Bollig & Göbel, 1997). The scenarios used to explain future climatic changes predict an increase in the variability of weather elements like rainfall and temperature. In this regard, global climate change will ultimately lead to more frequent extreme weather events across several continents, potentially intensifying pastoral production risks (Næss, 2013).

Risk perception is built around the information that the farmers gather. It is through such information gathered by individual farmers from various sources around them that they engage in risk management exercises using this information, hence dealing with agricultural risks and farm management entails risk assessment and management (Winsen *et al.*, 2013). In the context of agricultural economics risk perception research can be approached through methods that originate from the psychometric paradigm (Winsen *et al.*, 2013). The psychometric paradigm helps the researcher to understand the question of why various risks are perceived differently by individuals. To put it another way, the psychometric paradigm seeks to uncover the factors that influence risk perception (Siegrist *et al.*, 2005).

Individual risk perception influences farmers' ability to adapt to natural disasters efficiently and effectively. Most researchers concur that there are positive links between farmers' perceptions of climate change risks and their adaptive decisions in recent studies on adaptive behaviors by farmers to climate-related risk (Duinen *et al.*, 2015). Such studies that link adaptive decisions and risk perceptions, on the other hand, are quite compressive, treating risk perception as a static and exogenous element. In this regard, scholars and policymakers benefit from viewing farmers' risk perception as an endogenous formed phenomenon because it provides a foundation for understanding responses to risk management in natural disasters such as drought, among others (Duinen *et al.*, 2015).

Scholars in developing countries have been particularly interested in the factors that influence farmers' risk perceptions of the climate change crisis in general. These studies mostly take the form of approaching farmers' perceptions on a binary scale of whether or not they observed changes in climate over time (Maddison, 2007). When conducting such studies, some scholars focused on climate change risks and gave some weight to sociodemographic, economic, and biophysical factors. Observing changes in temperature and precipitation, on the other hand, is an interpretation of climate change awareness rather than risk perception. Climate change risk perception extends beyond risk awareness because it is associated with the likelihood of such an occurrence, negative outcomes, and feelings of dread associated with climate change events (Slovic *et al.*,2004).

Perception of risks according to relates to awareness concerning an object or evens of value that may likely have an undesirable impact and belief or understanding that an individual is vulnerable in the future. As a result, it is commonly regarded as an individual's assessment of the effects of climate change on health, economics, and the environment (Arbuckle *et al.*, 2013). Risk perception and willingness to adapt to the current impacts and reduce the impact of the anticipated changes in climate are determined by the knowledge about the causes as well as the knowledge of the consequences. Such knowledge can be based on personal or direct experience, or it can be secondhand information passed on to an individual by another, which shapes the individual's attitude toward the cause and its consequences (Linden, 2015).

2.2 Risk preference and management

The majority of empirical studies suggest that farmers' risk perceptions and preferences influence their risk management strategies (Asravor, 2019). Risk preference can be defined as an individual's general risk proclivity based on past experiences and beliefs (Debertin, 2012). Individuals develop various risk preferences and attitudes toward risks based on the sources of specific risk elements. Farmers' risk preferences can be influenced by a variety of factors, including their individual goals, context, and financial situation. Other demographic and social factors, such as age, experience, education, farm size, and geographic location, influence farmers' risk preferences, as well as information availability and an individual's mental model (Hardaker *et al.*, 2015). According to evidence from broader risk preferences and climate change adaptation studies, decision-makers' socio-cognitive processes appear to be critical for motivating adaptation decisions (Jianjun *et al.*, 2015).

Risk preferences can be classified into three categories, according to Hardaker *et al.* (2015): risk-averse, risk-neutral, and risk-seeking. Individuals with risk-averse nature preferences are the most common, and they are defined as those who prefer secure income over uncertain income of equal expected value. Such people avoid risky situations that are thought to have higher returns if things go well and thus miss out on the opportunity to achieve better results than they would have if they took the risk. According to several studies, farmers are generally risk-averse when making decisions that affect their income and welfare.

According to Anton *et al.* (2013), the literature commonly suggests that some risk management strategies include risk transfer, pooling, or management. The probability of risk occurrence, the impact or magnitude of anticipated losses, and the extent to which the risk is believed to be catastrophic all influence how the risk is handled. The efficiency of risk management instruments varies across layers, as explained in the OECD 2009 report. The risk retention layer describes the strategy for managing frequently occurring risks that result in small losses. Such risks have little impact on farmers' income, and they can manage them efficiently, allowing them to retain. Risks are greater but less frequent in the market insurance layer, and farmers can use insurance or other market options. Finally, the market failure layer generates very large and systemic losses at low

frequencies, making it more difficult to pool them through insurance. Following these disastrous events, the government may decide to intervene, generally with ex-post payments (ibid). In the absence of transaction costs, insurance is thought to be the best risk management strategy, but agricultural insurance appears to be problematic. It is costly to observe farmers' efforts, and because it is practically applied within small communities in Africa, insurance may be inapplicable for climatic shocks because they are covariant across the community. Some pilot insurance policy plans are being developed that have proven to be feasible in rural Africa, with payments triggered by a specified variation in a local rainfall index (Collier *et al.*, 2008).

Risk management research emphasizes that a risk assessment, and particular measures taken to minimize, hedge, transfer, or mitigate risk are important components of agricultural choices (Smit & Skinner, 2002). Risk management in agricultural production can take the form of adaptation strategies used by farmers and pastoralists to address climate-change risks. There are several categories of measures used as adaptation options, which can be grouped into the following non-exclusive categories (Smit & Skinner, 2002). Technological development, government programs and insurance, farm production practices, and farm financial management are examples of these categories. The first two categories are primarily implemented by government agencies. Crop and livestock development can be a form of technological development by introducing breeds that are tolerant and suitable for specific climatic conditions. The advancement of technology also allows the government to create early warning systems by providing daily weather forecasts and seasonal forecasts (Smit & Skinner, 2002). Furthermore, it contributes to the resolution of issues related to water management innovations such as irrigation to address the risk of moisture deficiency and drought, as well as changing temperatures.

Government programs, such as subsidies and other support programs, as well as insurance, have an impact on farm-level risk management strategies in terms of crop yields and income loss due to disasters and extreme events. Furthermore, the government may exert influence over private insurance companies to develop and implement policies to reduce climate-related risks to farm-level production, infrastructure, and income. Crop and livestock diversification, for example, aid in mitigating environmental and economic risks at the farm level. Other farm-level strategies include changing the location of crops and livestock, as well as other land use, fallow and tillage practices, irrigation, and changing the timing of operations such as ploughing and breeding. In terms of farm financial management, farmers can choose crop and livestock insurance, invest in crop and livestock shares, and diversify the source of household income to mitigate the risk of climate-related income loss (ibid).

In agricultural production, some of the risk management instruments applied include insurance, assistance by development actors and the government, especially designed to influence the incentives to adapt. Traditional agricultural insurance can help manage production risks but is deemed expensive, and will demoralize the incentives to adapt to changing climate. Some other approaches like weather index insurance that do not necessarily require on-farm verification that keeps the administrative costs low are believed to be more favorable and encourage the incentives

to adapt (Antón *et al.*, 2013). Farmers will factor in any insurance subsidization or ex-post yield failure payments into their production decisions, potentially favoring insurance over other diversifying and risk management and adaptation strategies. Insurance in the agricultural sector is at times used assistance in cases of disaster occurrence. Being a formal contract it is advantageous with the financial participation of farmers and the evaluation and payment is relatively faster (ibid).

Mobility is arguably an important factor for survival as a risk management strategy in cases of pasture unavailability in an area, and it has been used for centuries to manage environmental risks in areas with patchy and unpredictable pasture. When compared to their sedentary counterparts, pastoralists who migrate have fewer cases of livestock death during unfavorable climatic conditions (Næss, 2013). In terms of risk, aspect mobility is advantageous because it means moving from a region of scarce pasture to one of abundance, thereby aiding in the management of resource variability. Furthermore, mobility allows nomadic pastoralists to take advantage of resources such as water and various types of pasture or vegetation in areas where geographical mobility is possible. Mobility is one of the key factors explaining why some pastoralists fare well during severe weather events while others fare poorly (Næss, 2013).

Prevention, mitigation, and coping strategies are some of the risk management strategies used in agricultural production and business. The prevention strategy is a mechanism that is implemented prior to the occurrence of anticipated risk events in order to reduce the likelihood of negative risks and, as a result, the variation in expected income from agricultural production activities (Hardaker, 2015). These strategies can be based on factors that are beyond the farmers' control, such as government policies, unexpected extreme weather, and market-based mechanisms, as well as factors that the farmers can control, such as technology selection and investment. The second strategy is mitigation, which is used in the same way as prevention, but instead of reducing the likelihood of a risk occurrence, mitigation strategies aim to reduce the potential impact of a risk occurrence. Diversification of agricultural production activities, such as crop diversification, as well as mixed farming, where a farmer keeps livestock while planting crops, are some of the mitigation strategies. Other options include purchasing insurance, getting a job while farming, and selling assets at different times, as well as trading with counterparts. The third strategy is referred to as a coping strategy, which is used after a risk has occurred to reduce the risk's impact (ibid).

2.3 Conceptual Framework

Farmers' views of climate threats are influenced by their understanding of the causes of climate change, their attitudes, social norms, and values, as well as their previous exposure to climate-related information and events. Farmers' decisions are influenced not only by climate threats but also by other agricultural production risks that are equally or other significant factors (Eitzinger *et al.*, 2018). According to Concu *et al.*, (2020) climate change science and policy must take into account the dynamics of knowledge transfer as well as the variety of attitudes and values that inform and influence it. Risk management research acknowledges that risk evaluation and concrete

steps are taken to minimize, hedge, pass, or mitigate risk are both essential components of agricultural decisions (Smit & Skinner, 2002). Knowledge, experience, and learning are among the fundamental concepts of sustainable environmental practices. Knowledge exchange is increasingly being recognized as critical to facilitating research's social, environmental, and economic impact. This can be seen in the requirements for funding applications to identify potential beneficiaries, as well as strategies and pathways to mitigating the effects of climate change. Knowledge generation, co-production of knowledge, knowledge transfer, and knowledge storage are some of the terms commonly used in the concept of knowledge exchange (Fazey *et al.*, 2013). According to Gliessman, (2014), knowledge transfers enable decision-makers to apply the most recent knowledge, which aids in the application of adoptive innovative concepts as well as improving efficiency through the incorporation of acquired knowledge. Because there is a public interest in the transmission of knowledge from one point to another, there are few or no constraints in the process of knowledge transfer. As a result, knowledge has some benefits to a farmer's well-being, so there should be no restriction on transmission while keeping the cost of knowledge transfer in mind (Adnan *et al.*, 2018).

Farmer-to-farmer knowledge transfer is regarded as an effective agricultural extension mechanism. However, it is not always clear whether knowledge transfer spreads to the larger community as a whole in terms of practice adaptation or whether some farmers are isolated in accessing the knowledge. Social ties within and beyond the community boundaries are required for individual farmers as well as groups to access information from external agencies, disseminate it, and then adopt innovation strategies (Cadger *et al.*, 2016). In practice, the process of assimilation of knowledge on climatic changes risks warning and response planning in policy and action to address the impact of change in the pastoral sector begins with the interaction between potential users via social and other networks where they share the information that they have. Multiple factors influence the collaboration and relationships among the various actors involved in the generation and transmission of weather and climate-related forecasts, as well as associated advisories and warnings concerning pastoral setup (Ofoegbu *et al.*, 2018).

In this study, the researcher examined how climate change is considered in the current climate change risk associated management practice and their future management plans based on the Climate Change Risk Perception Model (CCRPM). This model developed by Van der Linden (2015) integrates and explains risk perception predictors into four different variable sets. Socio-demographic, cognitive, experiential, and social-cultural factors are all included. Van der Linden justifies the inclusion of these factors by claiming that socio-demographic characteristics of interest and significance are gender, party affiliation, and level of education. Cognitive factors assess the level or extent to which individuals in society understand the causes and consequences, as well as the response mechanisms and their effectiveness. Indeed, previous research has found that accurate climate change knowledge is a significant predictor of climate change risk perception. In his study, van der Linden identified that correct identification of the causes of climate change is associated with greater risk perception.

The effect and personal experiences of individuals in relation to extreme weather occurrences are the focus of the experiential processes. The effect in van der Linden's (2015) model referred to the extent to which respondents perceived climate change to be unpleasant, unfavorable, and negative. The model distinguishes affect from emotion by viewing it as an evaluative heuristic that influences information processing. Personal experience explains the extent to which respondents have experienced extreme weather events in their communities over the last five years. Personal experience is thought to influence risk perception by eliciting vivid emotions that strongly influence risk perception judgments. Lastly, perception is a function of socio-cultural influences such as the social norms and broad value orientations that affects the socio-demographic characteristics. While putting into consideration these dimensions in describing the public perceptions of risks related to climate change, it is important to mention that the affective and cognitive processing operates in parallel and interacts with one another continuously. As a result, both cognitive and affective processing mechanisms may be influenced by a third element, the socio-cultural differences. For this research, inspired by Climate Change Risk Perception Model the conceptual framework as illustrated in Figure 2.1 was developed.

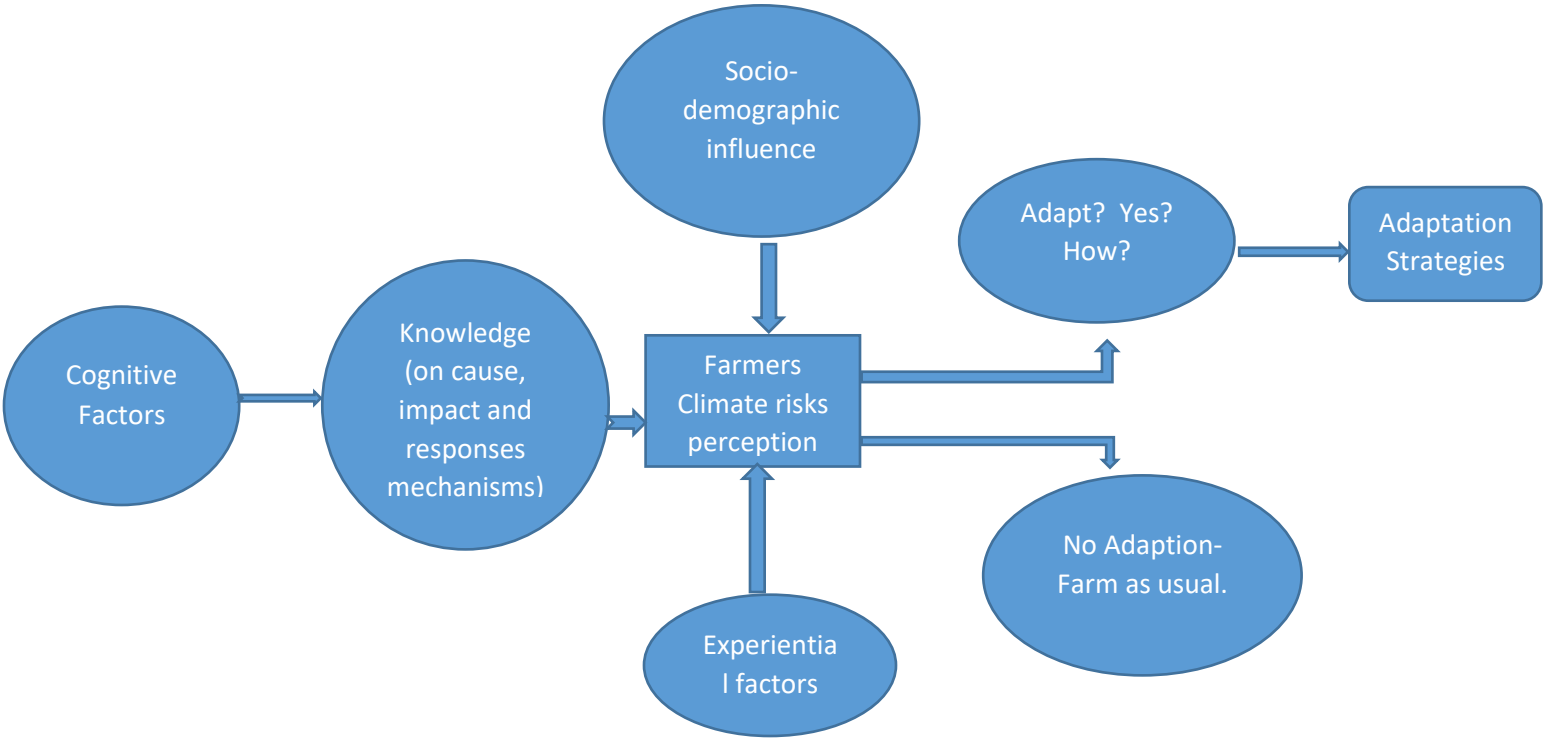


Figure 2.1 Conceptual framework-own illustration (Inspiration from van der Linden, 2015)

3. Method

The following section will present the research design, method choice sampling technique, and the sample size as well as the data collection method and analysis. This will be followed by the ethical consideration and the quality assurance part.

3.1 Research design and approach

For this study, an exploratory multiple case study was conducted to determine the perception of pastoral and agro-pastoral farmers towards climate change and their management strategies concerning agricultural risks. A case study does not aim to investigate an entire entity, but rather a specific problem or unit of analysis. Such research is essential when the researcher wants to understand a specific issue or situation in detail and can distinguish cases with many details. Researchers will perform interviews with different types of respondents using semi-structured questions while conducting case studies (Rowley, 2002).

Case studies can both be qualitative and quantitative in nature. The study intent, problems, propositions, and theoretical meaning will all influence case selection, but there will also be other factors to consider. These factors include data accessibility from a case person or organization, financial capital to facilitate data processing and interpretation while traveling, and time availability. In case the time available is limited, it could be better to research a small enterprise rather than a large company or to classify a unit of research within a large corporation rather than to evaluate the organization as a whole. Typically, a case study selection would include a wide range of information from various outlets. The study's data analysis is focused on processing, categorizing, and tabulating information to determine if the findings confirms or contradicts the study's initial assertions (Rowley, 2002).

However, case studies have been criticized, despite their benefits. To start with, such studies are often chastised for their lack of rigor. The case study investigator may be careless, allowing ambiguous facts or negative viewpoints to sway the observations and conclusions. Secondly, since case studies use a limited number of subjects, some of which are done with just one topic, they have no ground for scientific generalization. Thirdly, case studies are often criticized for being too lengthy, difficult to perform, and generating a large volume of data. Case studies that are experimental in nature or longitudinal, in particular, can elicit a large amount of data over a long period. The risk arises where data is not controlled and structured comprehensively (Zainal, 2007). The researcher’s approach to tackle this criticism is assured by the quality assurance explained.

The choice of which methodology the researcher adopts depends on the research problem. Case studies do not aim to investigate an entire entity or region, but rather a specific problem or unit of

analysis. Such research is essential when the researcher wants to understand a specific issue or situation in details and can distinguish cases with many details. Researchers perform interviews with different types of respondents using semi-structured questions while conducting case studies (Mohd Noor, 2008). According to Rowley (2002), case studies can be qualitative and quantitative. The study intent, problems, propositions, and theoretical meaning will all influence case selection, but there will also be other factors to consider. These factors include data accessibility from a case person or organization, financial capital to facilitate data processing and interpretation while traveling, and time availability.

While investigating human behavior and actions, a qualitative approach to research is thought to be particularly useful. This method allows the researcher to gain a better understanding of the respondents' social characteristics as well as their opinions (Bryman & Bell, 2015). The qualitative approach to this study allowed for the flexible use of semi-structured interviews that takes into account human language, allows the researcher to add more questions during the interview at any time, and is appropriate for qualitative research studies because such interviews follow the respondent's perspectives and interests. This approach enables the researcher to follow up on responses directly by conducting face-to-face interviews (Larsson & Lindahl, 2017). Qualitative research has the advantage of using a descriptive approach, which allows the researcher to gain a contextual understanding of the phenomenon being studied, which is difficult to achieve with quantitative research (Bryman & Bell, 2015). For this study, the researcher chose the qualitative method based on the number of targeted respondent.

3.2 Sampling technique and sample size

There are two types of sampling methods: probability sampling methods and non-probability sampling methods. Probability sampling includes cluster, multi-stage, and random sampling, which can be random, stratified, or systematic. Volunteer, convenient, quota, snowball, matched, genealogy-based, and purposive sampling are examples of non-probability sampling methods (Alvi, 2016). When the characteristics of the elements chosen are similar to those of the entire target population, a sample is said to be representative. Since it is impossible to assess every single element in the population while conducting investigative research, a small subset of the population that serves as representatives is chosen for evaluation. The more representative the sample is of the population, the more accurate the logical deductions and the better the result for generalization to the targeted population (Alvi, 2016).

This study adopted the purposive sampling technique. Purposive sampling is a nonprobability sampling technique used by researchers to select a sample from a given population in which the researcher doesn't really seek respondents in the study at random but rather in a strategic way to ensure that the sample chosen is a good fit for the research questions being asked (Bell *et al.*, 2022). Lead farmers from the two study sites were selected as the sample for this study. Lead farmers are those farmers who are considered experienced and motivate other farmers to adopt

new technologies. They also lead by example by practicing what they are taught and are often chosen by other farmers to represent them in agricultural development and train them to use new technologies (Fisher *et al.*, 2017). Identification of the respondents was done through the County Commissioner's office and the County Department of Agriculture within the selected study areas, Chepareria ward in West Pokot County and Lokiriama Ward in Turkana County. Both study sites have six administrative divisions called sub-locations headed by assistant chiefs, a representative of the office of the president. The researcher identified three lead farmers from each of the sub-locations after consulting with the two offices, and a sample of three lead farmers from each was chosen. There were eighteen lead farmers in total for each of the two study sites (wards).

3.3 Data collection

Majority of empirical existing studies have two broad approaches for assessing risk when assessing the relationship between agricultural decisions and risk preferences and perception. The first employs survey questions to evoke risk perceptions by inquiring about personal characteristics linked to risk aversion. The second method employs experimental methods to evaluate subject choices that represent each person's risk preferences (Jianjun *et al.*, 2015). For this study, semi-structured interview is utilized as the research takes survey approach.

The semi-structured interview method is flexible, takes human language into consideration, allows the researcher to add more questions during the interview whenever given opportunity and is suitable for studies following a qualitative research design since such interviews follow the perspectives and interests of the respondent (Larsson & Lindahl (2017). With a well-prepared interview guide beforehand semi-structured interviews are deemed to be a flexible and fluid form of an interview to collect qualitative data. Having a good interview technique helps smoothen the process (Bell *et al.*, 2018). To guide the entire process, the researcher prepared the interview guide in advance (see Appendix 1). However, to gain more insights, the researcher asked more questions and details whenever the respondents introduced some unknown issues to get further understanding.

Face-to-face interviews were used for the semi-structured interviews, which has some advantages, including no time delay between question and answer, and the interviewer and interviewee can directly react to what the other says or does. Furthermore, with the consent of the respondents, the interviews can be recorded, providing the researcher with more accurate data than simply taking notes. Face-to-face interviews also make it easier to create a pleasant interview environment. The researcher used both techniques in this study to ensure that all of the questions were answered and the data was accurately recorded (Bell *et al.*, 2022).

The researcher conducted a pilot test of the interview process with friends to gain a better understanding of the interview process and taste the application of interview techniques. As a

result, the initial interview guide was modified to better suit the study. In total, 36 semi-structured interviews were conducted in Kenya's Chepareria and Turkana wards, which were chosen as the study's locations. The interviews were conducted in a relaxed manner by the researcher, who used research assistants who spoke the local language and made the respondents feel at ease. The interviews were conducted at a location and time that was convenient for the respondents, which was accomplished by informing the respondents of the intended interview, the purpose, and requesting their availability. The interview guide was kept short in accordance with the study's themes, with an approximate time allocation of 50 minutes, in order to not take up too much of the respondents' time. The interviews took fifteen days to complete due to travel time within the selected sub-locations in the two selected wards.

From the initial data collection exercise the following themes were identified; background information, risks in agriculture, risk preferences, risk management, climate change, and planned adaptation strategies. The background information was aimed at knowing the respondents better in terms of their age, gender, level of education, experiences as farmers and the sources of livelihood in their families or households. This enabled the researcher to understand the different aspects and similarities among the selected respondents.

The themes on agricultural risks and risk management sought to better understand the risks that pastoralists and agro-pastoralists face in their agricultural production processes, as well as how they manage these risks. The theme of agricultural risks also assisted the researcher in comprehending the risks faced by pastoral and agro-pastoral production systems, as well as their categories proposed by Hardaker *et al* (2015). The risk preference question allowed the researcher to determine whether respondents were willing to engage in risky management strategies. The themes also assisted the researcher in determining whether respondents associate the risks they face and the management strategies they employ with the other major theme, climate change. The researcher framed the question based on whether and how they heard about climate change. The theme of future or planned adaptation and climate change strategies was adapted to learn whether farmers are concerned about current and future climate change risks and whether they plan to adapt or continue farming as usual.

Ethical consideration is crucial while conducting qualitative research when choosing interviews as a method of data collection. This ensures the protection of the integrity of the respondents and their confidentiality (Bryman & Bell, 2015). Some of the key ethical guidelines in research are informed consent, the confidentiality of personal data, the role of the researcher, and consequences (Kvale & Brinkman, 2014). The researcher followed the guidelines because he was aware of the ethical issues. The researcher wrote a formal letter to the authorities expressing his interest in conducting the study, and the first point of contact was the administration office, where the researcher obtained permission from the County Commissioner's office to conduct the data collection exercise within the region. The respondents were identified through the ward's Agriculture office, and the respondents were contacted to ask for their voluntary participation in

the study. The respondents gave their consent to the researcher recording the interviews and assured them that the information obtained would be used solely for academic purposes. The researcher ensured that the information gathered from the respondents was handled with extreme caution and confidentiality. The identities of key informants were never revealed in this report.

3.4 Data analysis

The unit of analysis for this study was the individual pastoralists and farmers from the pastoral and agro pastorals farming systems in Chepareria wards in West Pokot County and Lokiriama in Turkana County Kenya. The data collected through semi-structured interviews were recorded with the consent of the farmers, translated, transcribed and coded for final analysis. The data was analyzed through thematic analysis as the research questions included the background information of the respondents, their understanding of the risks in agriculture and climate change as well as the future planned adaptation strategies as means of risk management. Inductive thematic analysis, also known as reflexive thematic analysis, was used for this study. This method entailed gathering the data first and familiarizing oneself with it by reading and re-reading the transcribed data. The researcher coded the data using the methods recommended by Braun & Clarke (2013). The approach comprised familiarization with the data, coding, producing initial themes, developing and reviewing themes, refining and naming themes and final write-up (Braun & Clarke, 2013).

3.5 Quality assurance

Credibility in qualitative research refers to the accuracy of the evidence or respondent perspectives, as well as the researcher's understanding and description of them. The researcher's credibility is strengthened by explaining his or her study experience and confirming the study results with the respondents. The researcher can show commitment, techniques of observation, and data integrity to help authenticity when presenting a qualitative analysis (Cope, 2014). In this study, the researcher the credibility has been assured as the researcher explained the due process followed in data collection as well as analysis. The respondent’s identity has also been kept anonymous as none of their identities have been exposed.

Confirmability refers to the capacity of the researcher to show that the study accurately reflects the respondents' opinions rather than the researcher's prejudices or viewpoints. The researcher may show that the results were drawn directly from the evidence by explaining how conclusions and observations were reached (Cypress, 2017). This has been shown in this qualitative study reports by using rich quotes from respondents that represent each evolving trend. The term dependability refers to the data's consistency under identical circumstances. If another researcher agrees with the judgment trails at each point of the testing process, this may be accomplished (Cypress, 2017).

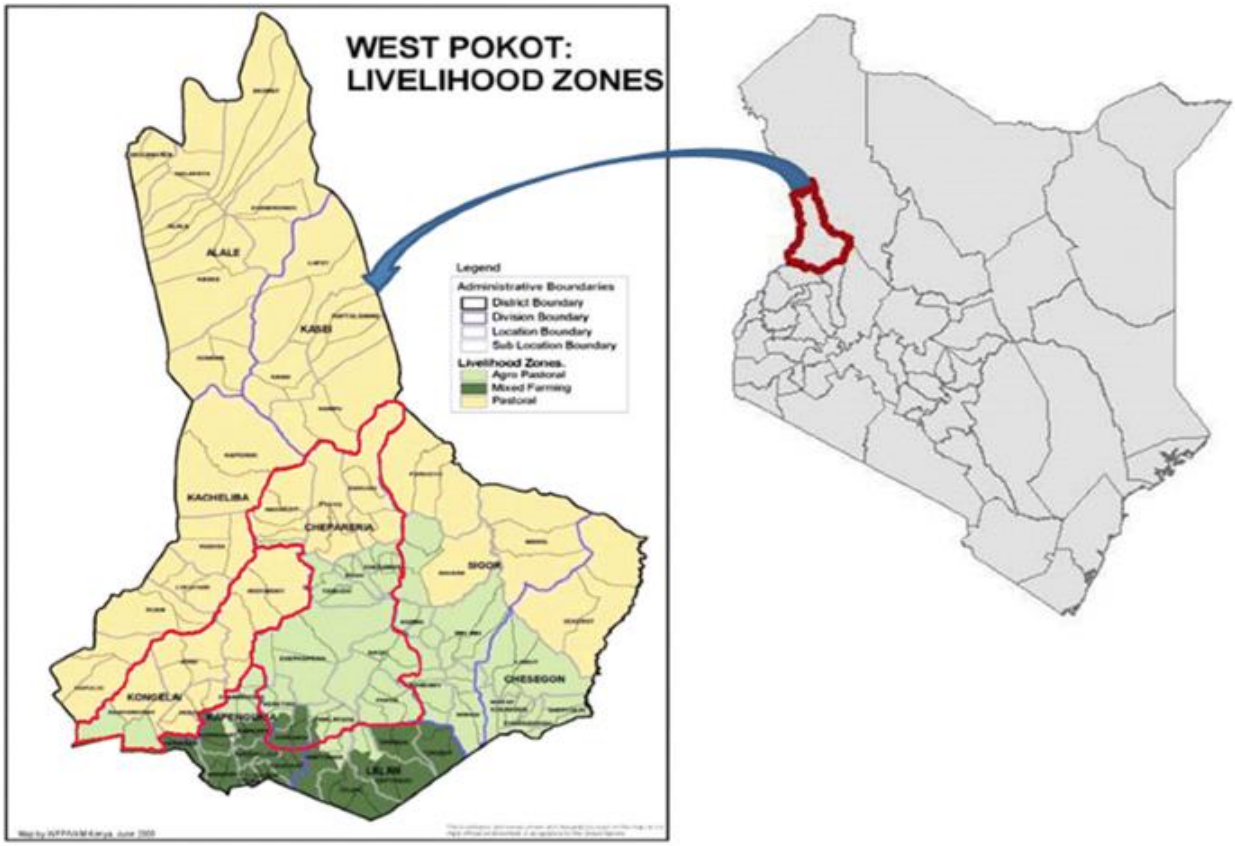
This was done in this study by following a clear outline from the introduction to the literature review to the methodology used.

The term "transferability" refers to research findings that can be applied to a variety of settings or classes. Sample to population, analytic, and case-to-case are the three simple transferability options. The study has met this criterion if the findings of a qualitative survey have meaning for people who are not interested in the study and readers can relate the findings to their own lives. In order for the reader to make an informed decision about the findings, researchers should provide enough information about the informants and the research context. (Cope, 2014). In this context of the study of climate change risk perception among agro-pastoralism and pastoralism, the researcher does not intend to generalize the data findings to similar farming systems as well as different forms of farming under different circumstances. However, for a population with a similar production system and social, economic and political characteristics such findings and conclusions may apply.

3.6 Study area

The study was conducted in Chepareria ward in West Pokot and Lokiriama ward in Turkana County. West Pokot County, located on Kenya's northwest border with Uganda, is one of the 47 counties established under the 2010 constitution. It covers an estimated 8,418 km2 of land and receives varying amounts of rainfall, ranging from 400mm in the lowlands to 1500mm in the highlands. Pastoralism is the most prevalent farming and livelihood system in the county. Agro-pastoralism and mixed farming are common in the southern central part, which is characterized by high altitude and ample rainfall (Nyberg *et al.*, 2015). Chepareria is one of the twenty wards within West Pokot County and it is one of the selected sites for this study. The respondents were selected from all the sub-locations within the ward, which includes Kipkomo, Senentu, Shalpough, Chepkobeh, Ywalateke and Pserum

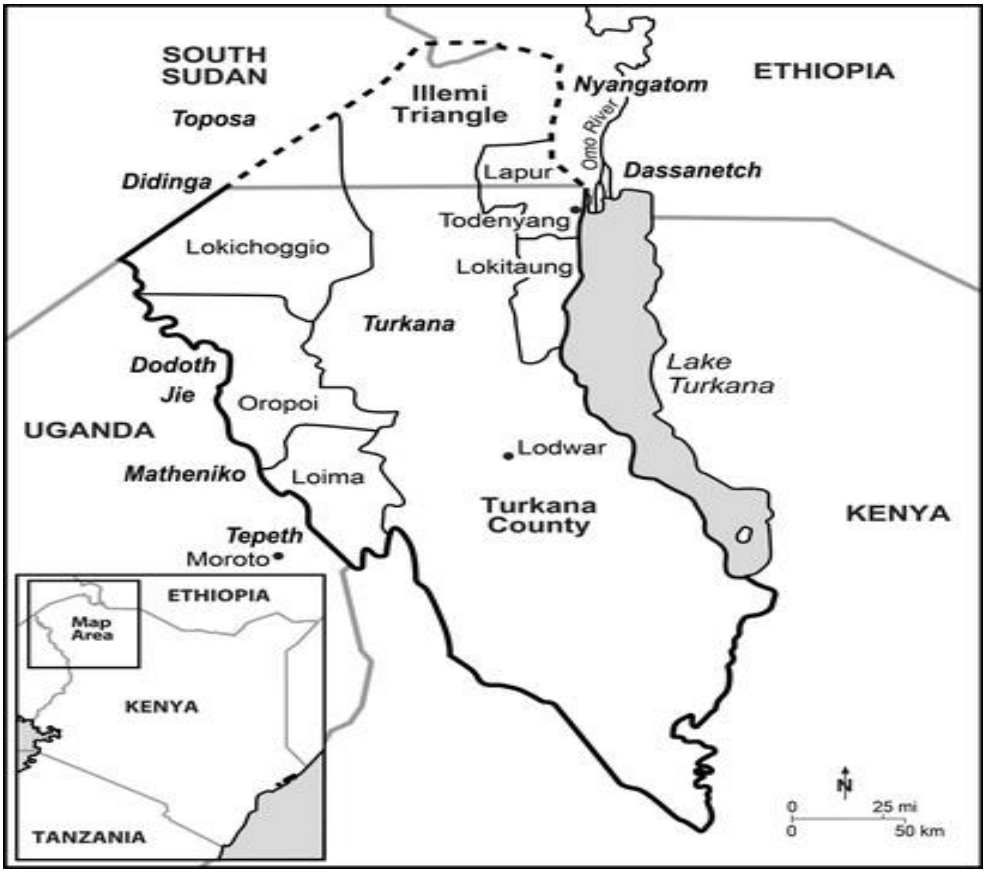
Figure 3.1 West Pokot county map



Source: Nyberg *et al.*, 2015 (Chepareria encircled in red)

Turkana County borders West Pokot County to the North and is also one of the 47 Counties established under the Constitution 2010 of Kenya. Lokirima ward, which is the selected site for this study is located in the Loima sub-county and is one of the 30 wards within the county. Pastoralism is the main economic activity within this region where the residents keep livestock for subsistence and sometimes commercial purposes. The area is mainly characterized by plains and a few hills with an estimated altitude of about 900m. It is located in northern Kenya (Said, 2020) Furthermore, livestock keeping is important in pastoral settings because it is used for dowry payment, as a symbol of prestige and prosperity, as compensation for injured warriors during raids, as a sign of wealth, and security against drought, diseases, and other natural catastrophes as well as commercial purposes (Behnke, 2008).

Figure 3.2 Turkana County Map



Source: Shanguhyia, (2021)

The selected study sites are located in the northern part of Kenya, which is covered by arid and semi-arid lands, which account for 80 percent of the country's landmass and support one-third of the population as well as 70 percent of the national livestock population. The majority of the residents practice nomadic pastoralism, which is characterized by risk spreading and flexible mechanisms such as mobility, community land ownership, large and diverse herd sizes, and herds splitting or separation. The herders practice mixed livestock keeping to manage and spread risks. They raise zebu cattle, camels, goats, sheep, and donkeys. The possession of livestock serves multiple social, economic, and religious functions in their livelihood by providing food in the form of milk, meat, and blood, as well as being sold for cash to pay for cereals, education, health care, and other services (Schilling *et al.*, 2012).

4. Results and Analysis

This chapter presents the empirical data gathered through semi-structured interviews conducted at the study's two sites and the analysis. This includes information about the respondents' backgrounds as well as the research areas. The themes used in this study include perceived risks in agriculture, risk management, understanding of climate change, and planned future adaptation strategies, which are based on the responses to the study guide questions.

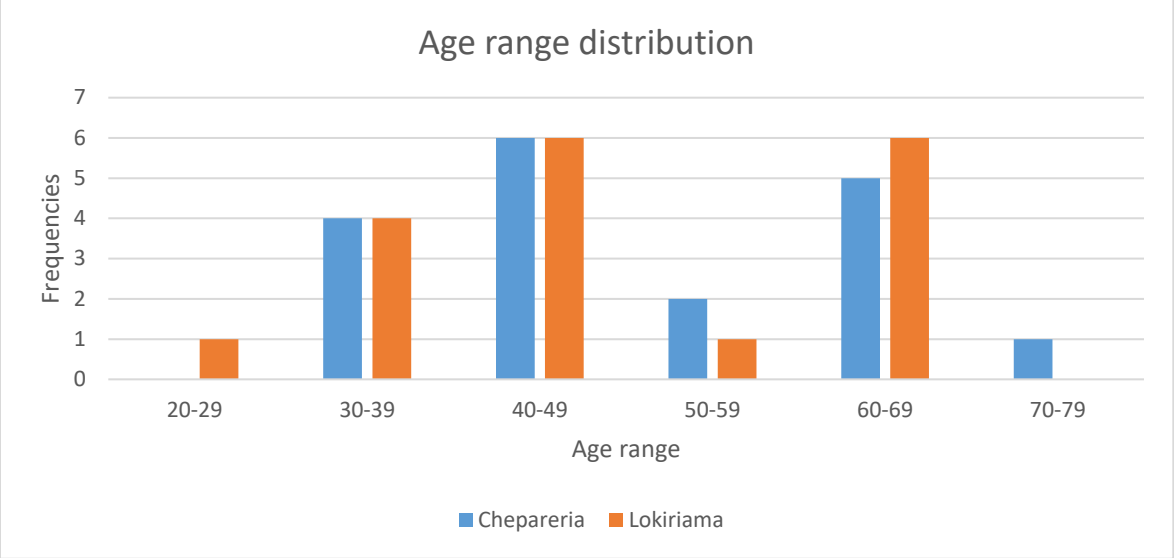
4.1 Background information

The background information on the selected respondents from the two study sites focused on the age, level of education, years of experience and the sources of livelihood of the farmers. To make it easier for the reader to understand the information obtained is presented using a graph (see Figure 4.1), pie charts (see Figures 4.2 and 4.3) and a table (see Table 4-1) to show the ranges of the age of the selected farmers and the years of farming experience as well as the gender proportion and the level of education.

4.1.1 Sample description

According to Van der Linden (2015), socio-demographic factors age included are important in analyzing risk perception, so they must be taken into account when looking at the background information of the respondents. The respondents in the Chepareria ward range in age from 34 to 72 years old, with a mean of 49.7 and a standard deviation of 11.93. The respondents in Lokiriama Ward range in age from 31 to 67 years old, with a mean of 48.28 and a standard deviation of 13.07. The majority of the respondents are under the age of 60. The age distribution of the respondents is shown in Figure 4.1.

Figure 4.1 Age distribution of the respondents in Chepareria and Lokiriama wards.



The research examined the respondents' years of experience in the agro-pastoral and pastoral systems to see how long they had been involved in agricultural production in the drylands. The respondents' farming experience ranges from 8 to 47 years in the Chepareria ward. The age range in the Lokiriama ward is 6 to 48 years old. The distribution results from the Chepareria and Lokiriama wards are shown in Table 4.1

Table 4-1 Years of experience distribution of the respondents in Chepareria and Lokiriama wards

Response Range	**Chepareria**		**Lokiriama**	
	Frequency	Percentage	Frequency	Percentage
5-20	5	27.8	8	44.5
21-36	10	55.6	4	22.2
37-52	3	16.6	6	33.3
Above 52	0	0	0	0
TOTAL	**18**	**100**	**18**	**100**

The study sought to determine the respondents' educational level, which is an important factor in comprehending Van der Linden's 2015 climate change risk perception model. The majority of respondents in the Chepareria ward have completed primary school, secondary school and college combined while a few have received no formal education based on the Kenyan educational system. In Lokiriama, the majority of the respondents have not undergone any form of formal education and only a few have been able to attain the primary level. Figures 4.2 and 4.3 show the results for Chepareria and Lokiriama wards respectively.

Figure 4.2 Respondents level of education in Chepareria ward.

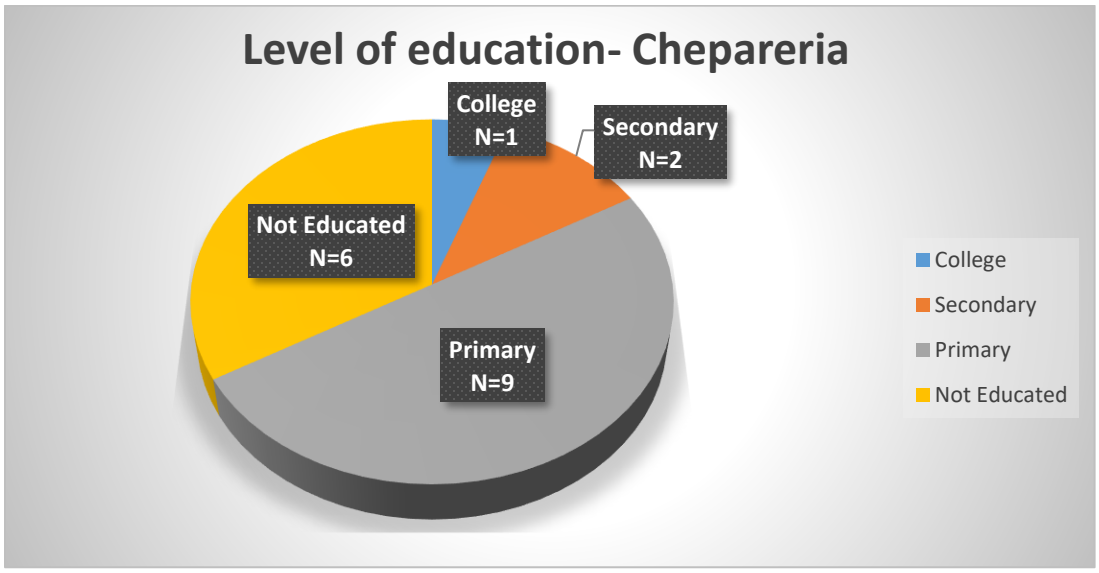
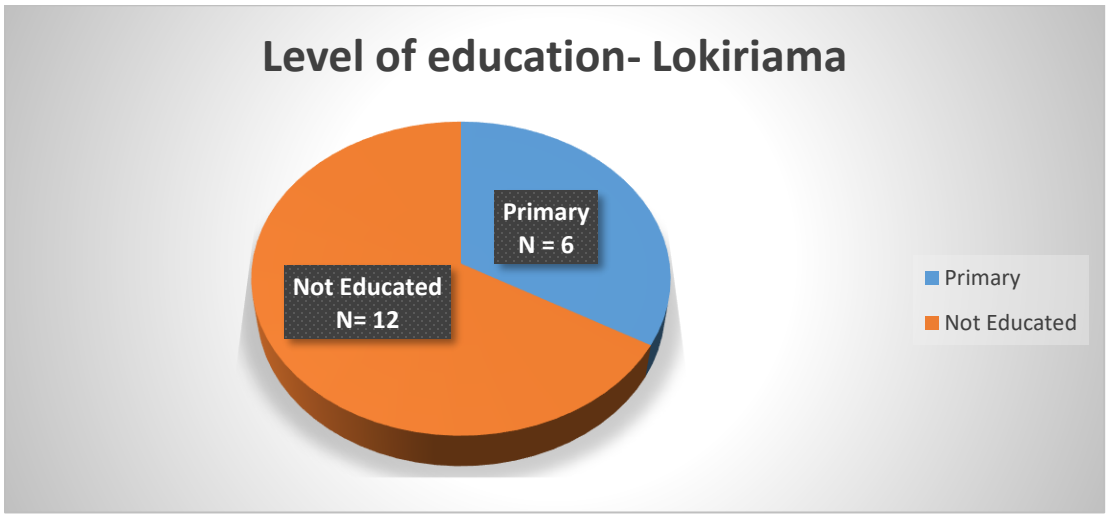


Figure 4.3 Respondents level of education in Lokiriama ward.



In addition to the data presented, the background information also included the gender of the respondents as well as the sources of livelihood for the respondents and their families. In terms of gender representation, there was great disparity in both wards, which suggests little involvement of women in agricultural production activities within the study areas. In both the study areas selected there were only three female respondents, which account for 16.7% of the respondents while 83.3% are male.

According to the respondents' responses, the agro-pastoral production system has a variety of sources of income. The eighteen farmers chosen are all intercropping maize and beans farmers, with an average of 2.5 acres per farmer and a standard deviation of 1.1. Some crop farmers said they grew millet and sorghum on a small scale, averaging 0.45 acres each, primarily for subsistence but also for commercial purposes. However, apart from crop farming, all of the respondents kept livestock, both small and large ruminants, for both subsistence and commercial purposes, selling the animals and their products to pay for their needs and bills. From the data collected from the respondents, they keep goats (local breed), sheep (local and Dorper breeds) and cattle (local and Sahiwal breeds) on an average of 15, 10 and 6 respectively. Among the respondents from the Kipkomo sub-location, which is located in the highlands and has sufficient rainfall as well as a permanent river, two of them reported planting trees for commercial purposes. These trees include grevillea, blue gum and cypress. They also practice coffee farming on a medium scale for commercial purposes. One of the respondents could explain in terms of acre coverage but the other explained using the number of coffee trees he has on his farm." *...and I also have 300 trees of coffee on the farm..."*- Respondent from Kipkomo sub location

" .... have planted three acres of coffee and also have twenty acres of trees for commercial purposes. Whenever the other sources of income are not sufficient I would cut like twenty trees and sell them for extra income…." – a respondent from Kipkomo sub location

Kipkomo and Senentu respondents also grow fruits and vegetables on a small scale for commercial purposes. All of the Kipkomo respondents grow bananas, mangoes, and avocados, while one Senentu respondent grows pawpaw, mangoes, and pumpkins. Kales, cabbages, and cowpeas are among the vegetables grown. One respondent is a beekeeper and a livestock trader in one of the sub-locations, Shalpough, who buys shoats and cattle from the local community and sells them at the main market in Kapenguria and across the border to Ugandan buyers.

According to the responses of the respondents, the source of livelihood in the pastoral production system in Lokiriama ward is primarily limited to livestock. Cattle, camels, goats, sheep, and chickens are among the animals they keep. The number of herds kept varies from herder to herder, with the respondents for this study keeping an average of 205 cattle, 23 camels, 254 shoats, 9 donkeys and 14 chickens. Two of the respondents engage in small-scale gold mining in the riverbeds. One of the respondents say, *"...it's something to get some few coins and on a good day*

I may get three carats...." Two of the respondents work in the livestock industry, where they buy and sell shoats and cattle and occasionally acts as a middleman for other traders. One of the respondents works as both a businessman and a pastoralist. He also operates a livestock and food transportation business.

4.2 Perceived risks in agriculture

The question about the risks associated with agricultural production in the pastoral and agro-pastoral production systems elicited a variety of responses. Weather elements were cited by all of the respondents as the most significant risk to their agricultural production. A major risk is changing rainfall patterns that turn out to be unreliable when making planting decisions, insufficient rainfall, and even failure to rain. Cases of high rainfall were also stated by some of the respondents in both study areas with flash floods sweeping away households and causing destruction an example of landslides in the Sebit area and flashflood in Lokiriama. Respondents in some interviews described their experiences with hailstone rains that destroyed crops. Drought is said to be a major risk for agro-pastoralists and pastoralists due to the lack of rain, which has a negative impact on yields and causes livestock death. Some of the respondents in Chepareria's drier and hotter areas reported high temperatures during one of the seasons, resulting in crop withering. One respondent from Chepkobeh location in Chepareria recalls a drought that began in 1984 and lasted for seven years. He adds *"…some years back it used to be consistent and it rains twice a year, March to May and October to December. The pattern changed and it rains once a year starting in March through to May. Now we are approaching May and it hasn't started yet..."*

Another major risk that has an impact on agricultural production in the study area is livestock pests and diseases. This causes animal health to deteriorate, and it can also have an impact on human health in cases where diseases are transmissible or pests cause human diseases. East Coast fever and foot and mouth are two diseases that farmers in agro-pastoral and pastoral setting can identify, while ticks are the most commonly reported pests. Furthermore, respondents identified crop pests and diseases as a risk in their production activities. This reduces yields as well as increases the costs of production.

The fluctuation in the market price of inputs and outputs in the production process is another risk expressed by respondents. Most of the time, market prices for inputs are high, unless the government offers subsidies during periods when prices are low.

"The market price is a big challenge especially when I need cash to pay school fees during school opening days. The buyers take advantage of the situation and a bull that normally sells at 40,000 shillings (approx. 4000 SEK) is valued at 20,000 (approx. 2000 SEK) shillings and we have to agree since I need money urgently"- respondent from Kipkomo sub location

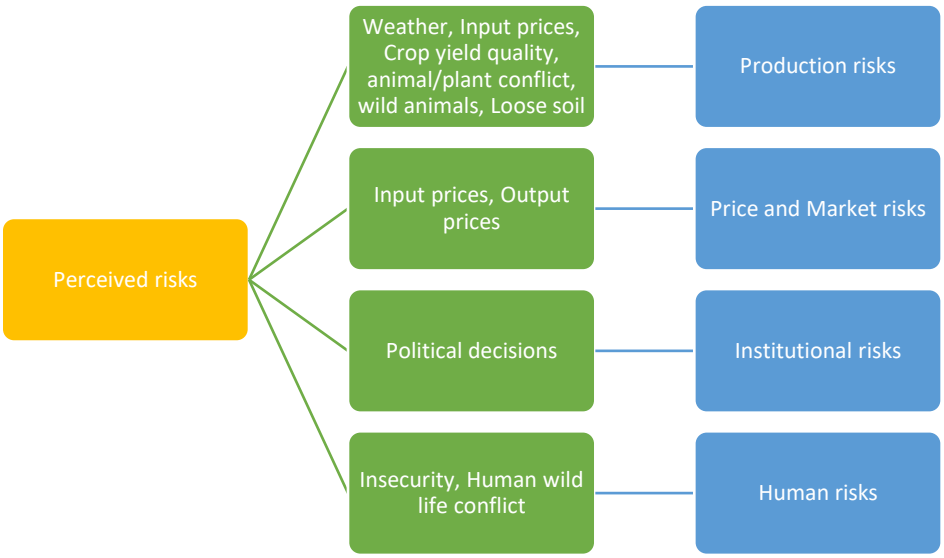
Communities in both study areas are frequently forced to migrate to Uganda due to a lack of pasture. This increases the risk of insecurity as communities compete for pasture and water for

their livestock among themselves and the communities living across the border. Respondents from Lokiriama also raised the issue of livestock diseases that occur as a result of migration, as livestock do not easily adapt to new weather conditions in a new area, negatively impacting animal health. This migration occurs over a long distance in the scorching sun, resulting in heat stress, low productivity, and animal death.

The majority of the respondents identified livestock and animal conflict as another risk in the agro-pastoral system, as the community relies heavily on the live fence as an enclosure through which the livestock can easily gain access to and destroy the plants. Wild animals such as hyenas and wild dogs pose a significant threat to livestock in the pastoral setting when they become disoriented in the bushes.

Two respondents in the agro-pastoral production setup and one respondent in the pastoral setup identified some political decision such as allocation of resources and construction of commonly shared resources such as water pans that causes conflicts between neighboring communities as a risk to their agricultural production. In one of the interviews, the respondent stated loosing 1875 heads of cattle to the neighboring across the border and lack of political support to follow up and recover the lost livestock, which was the main source of livelihood for his family. Changes in the government structure following the enactment of the constitution of Kenya 2010 where the agriculture department was devolved is seen by one of the respondents as a contributing factor to poor performance and hence acts as a risk to agricultural production. He said, *" ...during the previous set up before the county government came in place, there were enough vehicles and staff to advice farmers..."* The identified risks and the categories are illustrated in figure 4.4. Respondents from the Senentu sub-location reported that loose soil was a major threat to their agricultural production. Heavy rainfall creates huge gullies through which flash floods cut across farms, destroying crops and rendering the land untillable.

Figure 4.4 Identified perceived risks and their categorization



4.3 Risk Preference and Management

To get a better understanding of whether the respondents are willing to take some management practices that are deemed risky, the researcher sought to ask about their preferences towards risks. In a situation where the respondents do not understand due to their level of education, the researcher presented a scenario to explain and get their opinion. In the agro-pastoral production system in the Chepareria study site, only three respondents confessed to being risk-takers and have also explained their effort by engaging in production activities that they have little hope of making financial benefits such as planting trees for financial purposes and engaging in coffee production, which is not common in the area. One of the respondents says, *"…if you don't risk you don't prosper…"*

From the analysis, most of the risk-takers are farmers who have gone beyond the secondary level of education. Most of the respondents expressed their fear of engaging in a risky situation as they are afraid of losing the little that they have currently by investing or engaging in agricultural activities that have no certainty in terms of the outcome expected. However, some are neutral and based on the situation will weigh options and act. One of the respondents from Kipkomo said, *"…it depends with the situation at the given and the circumstances expected..."*

In the agro-pastoral production systems, all the respondents explained a common management practice in the area practiced over time. On drought risk management, the respondents from the Chepareria wards have an interesting approach to how they plan for the entire drought season to ensure that minimal or no animal death due to starvation happens. During the rainy season, the livestock depends on naturally growing grasses within the area and provides sufficient milk as well as gain good weight. The farmers also plant crops such as maize, sorghum, and millet as well as vegetable and fruits, which they sell in the market when they mature as a form of income. The maize stalks and other remaining dry plants that remain after harvest are stored on the trees beyond the reach of animals until the natural grass becomes depleted. For those who can afford it, stores are built for this purpose. These hays will be crushed with machines or fed to the livestock, as they are when the grass is depleted. After these stored hays get depleted the livestock, especially cattle are fed with the leaves of two species of trees locally known as "koloswo" and "sokoria" which are believed to be nutritious and do not dry up easily and are found abundantly in the area. It is after all these strategies are applied and the drought persists that the farmers buy feeds for the livestock or migrate to other places like the neighboring country, Uganda.

Diversification is a strategy used in the agro-pastoral set up to mitigate the risk posed by adverse weather conditions such as heavy rainfall, drought, or high temperatures. Farmers in the Chepareria ward practice crop farming as well as livestock keeping, which means that when one source of income fails, they turn to the other to feed their families and sell them in the market for some cash. Furthermore, they practice mixed farming, which means that on one farm, one farmer can grow a variety of crops such as maize, millet, sorghum, fruits and vegetables, as well as keep

a variety of livestock such as cattle, goats, sheep, and chicken. This aids in risk diversification, giving the farmer some assurance of a consistent income and food for the family.

Most respondents stated that they prepare ahead of time by budgeting for the expense and selling some animals to buy drugs for veterinary drug stores to reduce the incidences of animal pests and diseases affecting their production and yield. They spray on their own for pests, but for drugs that must be injected, they rely on community disease monitors and reporters who are typically trained by stakeholders in the livestock sectors. The government and other stakeholders, such as non-governmental organizations (NGOs) working in the area, assist in facilitating the vaccination process in both the pastoral and agro-pastoral production systems, where they vaccinate some of the animals for free and the owners pay for the rest. This effort from the government happens during some period, maybe before the onset of rain after which the government suspects outbreak of certain diseases. Traditional healing mechanisms, such as hot metals and stones held against the ribs of the affected animals, were mentioned by respondents in Lokiriama in the pastoral setting, and this sometimes helps for specific types of infections.

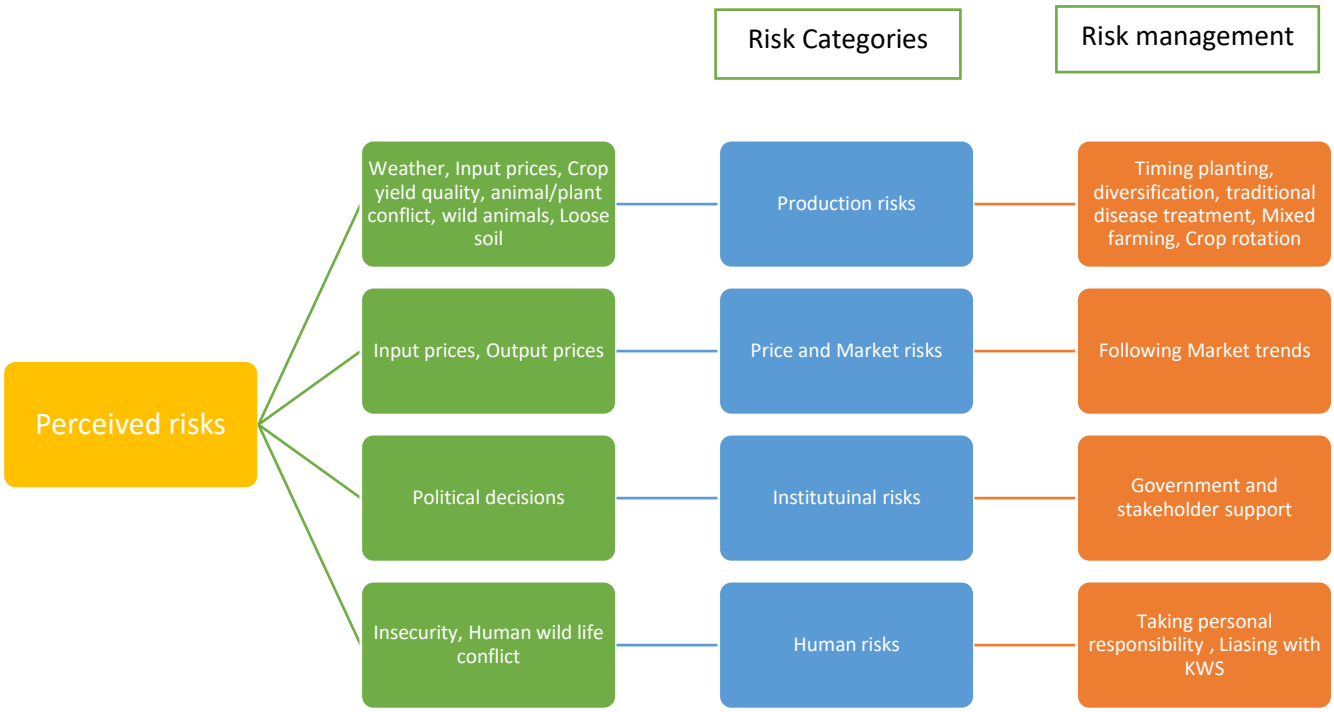
"I normally buy the drugs and vaccines from the agro-vet stores whenever my livestock gets sick and being a trained person inject them. But sometimes the government helps me by vaccinating like thirty goats for free and I pay for twenty."- a respondent from Lokiriama

Farmers in both the pastoral and agro-pastoral systems stated that they reduce the number of livestock by selling them whenever there are signs of drought. Some respondents said they sell the old and weak ones, but the majority said they also sell the healthy ones to reduce the risk of being swept away by the drought and that they fetch good market prices. The proceeds from the stock sale are used to purchase feed for the remaining animals as well as food for the family in the event of a drought or crop failure.

Other management strategies used by the majority of respondents include timing the sowing period to coincide with the arrival of rain to ensure a good harvest. Farmers in the Senentu sub-location, where gullies caused by heavy rainfall harmed their crops, said they dug ditches and built gabions with the assistance of the University of Eldoret to reduce the risk of their farms being swept away by floods. Furthermore, the community was educated on the importance of planting trees now and in the future, with demonstrations on how to do so during the farmers' field school. Three respondents, two of whom were the women I interviewed, stated that they participate in other activities such as table banking in their groups, in which farmer groups contribute monthly to a common pool that is shared at the end of the year as a mechanism to protect themselves against agricultural productivity failure. Another farmer stated that he works part-time to supplement his income and feed his family in the event that agricultural production fails. Respondents to questions

about wildlife and livestock conflicts mentioned taking personal responsibility for their animals and working with Kenya Wildlife Services (KWS) to reduce the number of livestock losses to wild animals. To understand the uptake of livestock and crop insurance within the study areas, the researcher inquired about whether the farmers have heard of such products' availability and whether they had ever taken insurance cover. Only one respondent from the Kipkomo location in Chepareria ward reported having taken insurance cover in the past but did not ever renew again due to the high cost of premiums.

Figure 4.5 Risk management responses



The themes introduced in sections 4.2 and 4.3, as illustrated by figures 4.4 and 4.5, provide answers to the first research question about the pastoralist and agro-pastoralist strategies for managing climate-induced risks. The findings are represented by the discussed themes, which include perceived risks in agriculture (in green colors) and risk management (in orange colors). Another theme of risk categories, represented in blue colors, was added during the data analysis process. The risk management strategies used by farmers in the pastoral and agro-pastoral farming systems in the study area can be classified as preventive, coping and mitigation strategies. Preventive strategies applied in the study areas include timing the planting to plant at the right time, crop rotation, and following market trends. Farmers have implemented mitigation strategies such as diversification of agricultural production and rearing/planting of improved breeds to better adapt

to harsh climatic conditions. Support from the government and stakeholders can be classified as a coping strategy.

4.4 Climate change and Climate change risk perception

The question about climate change was the last in the interview guide, and it was meant to gauge the respondents' understanding of the topic. The researcher framed the question on the respondents' past experience with natural phenomena that occurred within the area, what they believed caused such happenings, and how they responded, to investigate their knowledge of climate change, the cause, the consequences, and their beliefs on whether the situation will get better or worse.

When asked if they had heard about climate change and what it meant based on the information, 66.7 percent of the respondents in the agro-pastoral set up in the Chepareria study area said they had. They could attribute such events as the heavy rainfall in the Sebit area that resulted in a landslide that killed over fifty people and displaced many others. According to the information they heard, some other respondents from drier areas attribute high and rising temperatures to signs of climate change. The majority of respondents claim to have learned about this information from a local radio station program hosted by Lonyangole, a local reporter. Respondents from the Pserum sub-location also acknowledge that they were recently educated through workshops by an international NGO, World Vision, and the County Department of Agriculture. Among the pastoralist communities in the Lokiriama study area, 22.2% of the respondents admit to having heard about the issues of climate change. One of the respondents said to have attended a workshop on climate change in Turkana County headquarter, Lodwar, where they were informed about climate change causes, impact, and adaptation strategies. Three respondents admit to having heard through the radio and television programs. This could be attributed to the disparity in educational levels between the two study areas, as well as the nature of pastoralism, which is more engaging because farmers move from one location to another more frequently than agro-pastoral farmers.

The researcher asked about the causes and their opinion on the community's contribution to climate change in order to investigate the respondents' understanding of the causes of climate change. The majority of respondents claim to have heard that some of the causes include deforestation caused by people cutting down trees for charcoal and land expansion for agricultural purposes. Population growth is also thought to be a factor, as more people require more space, resulting in encroachment on preserved land and catchment areas. Some respondents stated that there were previously government sensitization and enticement programs to plant trees, which are no longer available, and that with the current economic pressures, people are encroaching on previously preserved lands. Furthermore, some of the respondents stated that some of the causes they heard were industries overstocking livestock and the community's failure to plant trees.

Different responses were received from respondents when asked about their understanding of the expected consequences of climate change based on the information they had. Droughts are becoming more frequent and severe, according to one respondent from each agro-pastoral and pastoral setting. Temperatures will continue to rise, according to some respondents, and rainfall frequency and intensity will be affected. A few respondents stated that he heard that nothing will be spared by the impact of climate change.

"…even the wildlife will not be spared. Arid areas will be the most affected. The same situation will move towards the highland like Transzoia where maize production is high. It has already started happening and will continue to worsen…" – one respondent from Kipkomo sub location.

Agro-pastoralists reported being sensitized to planting maize varieties that mature faster even with little rain and in a short period of three months as climate change adaptation measures. According to one of the respondents, all of the maize farmers who were respondents said they had adapted the species introduced to them by the Department of Agriculture, which included PH04, 520h. Planting fast-growing crops like sorghum were also recommended, but the respondents were discouraged due to the volume of output and market. In terms of livestock breeds, respondents mentioned being introduced to the Sahiwal cattle breed, Dorper sheep breed, and Galla goats, all of which are drought resistant. Few people took up the idea because they were willing to spend more money and were put off by the fact that some breeds, such as the Sahiwal cattle breeds, require a lot of feeding. One of the respondents in the pastoral setting mentioned hearing about the introduction of Galla goats, but the community was hesitant to adopt the idea. As a way to buffer against severe drought, cases of NGOs sensitizing and assisting communities in enclosing certain areas and assisting them in pasture production were mentioned.

In terms of experiential factors relating to personal and communal experiences of extreme weather events within the community, all respondents in both study areas stated that the most extreme events are frequent and severe droughts, which they have experienced in the past ten months, including the time when this data was collected. Other incidents include a landslide in the Sebit area of West Pokot County in 2019, which killed fifty people and displaced over a hundred. Residents in the Lokirima area reported heavy rains that caused the river Lochoralomala to overflow, displacing many households and necessitating the attention and eventual assistance of the Kenya Red Cross and the government. Locust invasion was also stated as an unusual occurrence that has not been experienced for ages, and led to the destruction of crops as well as infection to the livestock that fed on the grass where they bred.

4.5 Planned adaptation strategies

To learn more about farmers' intentions to adopt new technological management practices in the future as a means of managing climate change-related risks, the researcher asked them how they plan to handle such risks in the future or how they plan to change their production methods to produce more in the event that the weather situation worsens. In order to investigate this, the researcher asked respondents how they expect the situation to change in the future. In the pastoral setting of Lokiriama, all of the respondents believe that no one knows what the future holds, and that their only concern right now is their current output. They believe that lack of rain is God's punishment for people's wrongdoings, or an act of a witch doctor punishing people to get attention, and that when they come together and perform some ritual after a severe drought, it rains. "...only God knows about the future..." is repeated by the majority of them.

In the agro-pastoral setting, there were some mixed reactions to the question of future management plans in light of climate change. The majority of respondents (83.3%) have a similar attitude toward the climate change, believing that the future is unknown and that they will continue farming as usual. They did suggest, however, that they might consider adapting some improved maize breeds because maize is the area's main cash crop and has a ready market most of the time. Two respondents from the Kipkomo sub-location told the researcher about their existing plans to improve their adaptation in order to be in a better position to cushion themselves as the climate continues to worsen. One of the farmers has already dug an underground shallow well and is in the process of purchasing an overhead tank and installing a solar pump, allowing him to irrigate his land all year long, ensuring continuous production even during droughts. He also has piped water from a nearby river, which he uses to irrigate his land during the dry season. The second respondent is digging a similar well and will spend about 200,000 Kenyan shillings (approximately 20,000 SEK) to dig the well and install a solar pump upon inquiry. One of the respondents who is a resident of Shalpough, which is one of the drier regions mentioned starting a five-acre pasture production project whereby he plans to build a store for the hay both for commercial purposes and to feed his stock during the drought period.

The results presented in section 4.4 and 4.5 answers the second research question on the perception of pastoralists and agro pastoralists on climate change and the risks associated with it. The findings showed that respondents have experienced the risk related to climate change and have had some risk management mechanisms to continue with agricultural production but based on the opinions of the majority of the respondents the risks of extreme and unpredictable weather events that have been affecting their agricultural production has no links to the climate change but other natural forces that are beyond their controls and their understanding.

5. Discussion

The discussion of the study's findings is included in this chapter. Discussion includes both the results from Chapter four and earlier literature from Chapter two.

Climate variability has received considerable attention in past few decades, not only due to the world - wide unprecedented persistence of unusually low rainfall, but also due to society's and economic systems' inability to deal with climate change-related risks (Mengistu, 2011). Climate change is thought to exacerbate existing risks while also creating new ones for natural ecosystems and humans. These risks will be distributed unevenly, with the most vulnerable people and communities suffering the most in countries at all stages of development (IPCC, 2014; Menter & Hulme, 2012). Extreme climate variability, such as drought, is frequently accompanied by ecological decline, decimation of livestock herds, widespread food scarcity, mass migration, and significant loss of human life as a result of this low capacity (Mengistu, 2011). The northern part of Kenya, which is arid and semi-arid, is one of the most vulnerable areas, with relatively low rainfall and dominated by pastoralists and agro-pastoralists who face a variety of risks, including severe and frequent drought, which leads to poor production and livestock death. This motivates the investigation of farmers' perceptions of climate change awareness and the associated risks from a risk management standpoint, as well as whether their current and future risk management are linked to their climate change awareness. The study's goal was to look into the risks that pastoralists and agro-pastoralists face in northern Kenya, as well as their perceptions and understanding of climate change-related risks and risk management practices using a qualitative study approach.

The perception of climate risk and management strategies in pastoral and agro-pastoral production in dryland farming systems in northern Kenya were investigated in this study. The climate risk perception model was used to assess their perception based on their understanding of the cause, impact, and responses, as well as experiential factors and social demographic influences on their perception and risk management practices. The primary data for this study was collected through eighteen semi structured interviews with respondents chosen using a purposive sampling technique. Based on Namey *et al.* (2016)'s argument that theoretical saturation in such a study is normally achieved after the first twelve interviews, the number of respondents selected per study area is deemed sufficient. This was evident during the interviews, but the researcher interviewed eighteen farmers in each of the two study areas to cover a larger area and stick to the original study plan.

Since the aim of the study was to assess how farmers perceive climate change-related risks and their management strategies in the face of the changing climate the researcher deemed it relevant to examine the farmers' general understanding of the risks they face in their production activities. The different perceived risks were recorded and this enabled the researcher to identify which sources are linked to the climate change and whether the farmers are incorporating or willing to incorporate better management strategies with regard to the climate change-induced risks. According to Hardaker *et al.*, (2015), agricultural risk can be classified into five risk categories: production risk, financial risk, price and market risk, human or personal risk, and institutional risk. The risk domains described by Hardarker *et al.*, (2015) were used to analyze the perceived risks mentioned by the respondents. Extreme weather events, such as frequent and severe drought and heavy rainfall leading to flash floods, are cited by both pastoral and agro-pastoral respondents as major sources of risk in their agricultural production. A landslide was also reported in Sebit, West Pokot County, destroying crops, homes, and lives. Input price volatility, low output prices, crop yield quality, plant/animal conflicts, wild animals, loose soil, political decisions, insecurity, and human/wildlife conflict are among the other risks identified. Except for financial risks, which the researcher discovered had no responses that matched the description of financial risks, the perceived risks could all be linked to the risk categories. Despite the fact that Selvaraju (2010) claims that some production risks affect farmers' financial position and thus may be financial risks, Hardaker *et al.* (2015) emphasize financial risks as being related to borrowed funds used to fund farm operations. Such risks arise as a result of interest rate fluctuations and changes in the global economy.

Cognitive aspects of risk judgments include understanding the causes and negative consequences of climate change. Individual's behavioral choices in risky and uncertain situations are determined by cognitive evaluations (Sundblad *et al.*, 2007). This study looked at the availability and sharing of climate change information to see how and whether farmers have received information that helps them understand and improve their knowledge of climate change causes, consequences, and responses to use to manage the expected risks associated with climate change. The two study areas received mixed responses, with the majority of the eighteen respondents in the Chepareria ward mentioning information they received from an international NGO about climate change and associated risks through workshops they attended. The majority also mentioned local radio stations informing farmers about the risks associated with expected extreme weather and what they should do to mitigate the effects. The government was mentioned as advising farmers on what species to plant based on the expected amount of rainfall through the Department of Agriculture in Chepareria study area. According to the pastoral setup from the Lokiriama ward, such information was scarce, as only three respondents mentioned attending workshops on climate change and its risks. According to the data gathered, the government's role in educating the public about the causes, effects, and management strategies was also limited.

Socio-demographic factors such as age, gender, religious beliefs, level of education and location affect beliefs related to climate change, and access to communication and shape the behaviors and opinions on climate change risks-related issues (Lee *et al.*, 2015). The two study areas presented some distinct results in this study, with respondents from the Chepareria area having a good mix in terms of education levels. The results of the study show that the more educated the farmers are, the better their understanding of climate change risks and hence better management strategies as evidenced by the Chepareria area where the farmers with college levels of education are taking extra steps to cushion themselves from future risks that come with the changing climate. The respondents' ages ranged from 25 to 72 years, which aided the researcher in understanding the effect of age on knowledge of the causes and consequences of climate change, experience over time, management strategies, and general perception of climate change. According to the findings, older farmers have more experience with extreme weather conditions and how they managed the risks associated with them. As evidenced in the Kipkomo location in the Chepareria study area, age combined with education level is an important factor that affects perception and climate change-induced risk management.

This study based on the theories of risk management and risk perception adds to the existing pool of knowledge on the existing research on farmers' risk perception and adaptation strategies to climate change by using different theories and targeting different respondents and different geographical locations. In addition, the research adds more value to the existing research by focusing on farmers in pastoral and agro-pastoral production systems, which differs from the existing research done in crop agriculture farming systems. This research can help confirm or add to current knowledge on this topic, which can be useful to public and private policymakers, as well as agricultural advisors. The results of this research also elaborate on a better understanding of how pastoralists and agro-pastoralists in the study region respond to climate change, which may vary from the previous studies and their findings.

6. Summary, Conclusions and Recommendations

The sixth and the last chapter of this thesis presents the summary of the findings, conclusion and recommendations as well as the opportunities for further research.

6.1 Summary

People learn about climate change through a combination of indirect means, such as communication from the media, neighbors, and community members, as well as direct experiences of changes in the environment and climatic conditions, according to Munoz-Carrier *et al* (2020). The perception of risk and beliefs about the certainty and origins of climate change are linked to the direct experience of climate change impacts (ibid). This study looked at the experiential factors as well as the knowledge on climate change from various sources that influence farmers' risk perceptions and how these risks are perceived in relation to climate change based on the responses from the respondents. Several extreme events were reported, including a landslide in West Pokot's Sebit area, a flood in Lochoralomala that displaced herders and destroyed property, and long and severe droughts that occurred on several occasions. The majority of the respondents acknowledge the existence of risks that come as a result of the extreme weather condition as well as other risks that impede their production activities. From the responses on their perception on whether the risks are as a result of climate change, and their future management plans in the face of changing climate, majority of the respondents attribute the phenomenon to the nature and believe that they are a result of the act of a higher force, God and witchcraft, but not related to climate change. Hence majority the respondents have no plans to align their future management strategies, and rather continue agricultural production as usual, while a few of the total sample in the two study areas believe that climate change is real and have already incorporated better management strategies in their future plans.

6.2 Conclusion

This study sought to investigate the communities' resilience to the changing climate from the risk management perspective in the drylands farming system in northern Kenya. This could give insight to the policymakers and other stakeholders working within the agricultural sectors to understand the need to educate the communities more on the negative impact of the changing climate on agricultural production and the future challenges expected and help communities learn new measures to cushion themselves against future extreme events. Reflecting on the model applied in this research sociodemographic factors, cognitive factors and experiential processing have been found to affect the perception of farmers towards climate change and its related risks as well as

affect their future management strategies. In conclusion, the study revealed that knowledge of the cause, impact and response to climate change risk has great significance on the farmers' risk perception and their management strategies. Socio-demographic factors such as age, gender, education, religious beliefs and location also influence the perception of the farmers and their risk management practices. Farmers' experience of previous extreme events influences their risk management strategies to cope with extreme events related to the changing climate over time.

6.3 Policy implications and recommendations

The results of this study point to the need for comprehensive policy responses to improve knowledge of climate-induced risks and develop long-term responses to climate change impacts with the participation of all societal stakeholders, including the government, interest groups within the agricultural sectors, and the general public. The study found that community participation and climate change awareness-raising measures could help with policy changes to mitigate their harmful effects. The study suggests that farmers' engagement could be more effective because it will result in a response to climate change that is coherent and consistent. After all, they will own the process and the decided-upon actions. The report makes the following policy suggestions in light of its findings. To combat the lack of understanding about climate change and the related hazards it poses to agricultural productivity, fundamental information needs to be made available. This will motivate people who want to mitigate climate change to focus their energy on the appropriate measures. The information should be communicated through media that are perceived to be credible and should be sustained regularly. Due to the scarcity of climate information, particularly in the pastoral production system, it is critical to make such information available in order to help communities mitigate the negative effects of climate variability and future losses of livelihood that are highly dependent on natural climate.

Partnership among public and private stakeholders in the implementation of adaptation policies and strategies is crucial. As the majority of the community, particularly the elderly, hold pessimistic views, all agricultural stakeholders and the government must work together to help them understand the value of modern climate prediction and forecasting, which will have a significant impact on future production and management practices. The study also recommends that farmers should be informed to modern risk management products such as crop and livestock insurance and initiatives by different stakeholders to provide incentives to farmers that adopt such practices be put in place.

Improving farmers' knowledge of various risk management practices in the face of changing climate is critical in helping the community build resilience by learning and adapting a wider range of adaptation options suitable for improving agricultural production in hot and dry climates. Policymakers and agricultural experts should collaborate with farmers to develop policies that will significantly increase production and sustain such levels of productivity in the face of climate

change. Drought-resistant crop varieties should be developed and introduced, and farmers should be encouraged and motivated to adopt them. Furthermore, forecasting should be improved by investing in modern technologies, climate information dissemination should be efficient, and farmers should be encouraged and supported to use farm-level adaptation measures such as irrigation technologies and efficient planting date adjustments.

Education plays an important role in the long run adaptability and building resilience in both pastoral and agro-pastoral production systems. This serves as a long-term adaptation strategy to get access to information and stable employment. The study revealed that the level of education within both the study area majorly are secondary and primary levels. This also reflects how the farmers take their children to school where the number of school-going children within the homesteads is low. Advocacy programs that target the sensitizing on the importance of education as a way of cushioning farmers in both the production set up in the face of changing climate, in the long run, is recommended. Insensitive to farmers to take more children to school can improve education uptake and hence build resilience.

Insecurity along Kenya-Uganda border has been reported by the pastoralists in the Lokiriama study area as one of the most impediment to the mobility across the border in search of pasture and livestock, which is a management strategy whenever there is drought on the Kenyan side. This is despite the existence of the Lokiriama Peace Accord, a peace treaty between the Turkana people and the Matheniko of Uganda. To enhance security and enable free mobility, the flaws within this accord should be investigated with other stakeholders and measures to improve this treaty be planned and implemented.

Government through the provision of extension services plays an important role in helping the farmers in the agro-pastoral and pastoral manage some production risks through livestock immunization programs, offering advisory services on planting time and expected weather conditions. However, with the devolution, agricultural extension services within the two study areas seemed to be below par according to the respondents. This study recommends that the government, in collaboration with other stakeholders should strengthen the advisory services through supportive partnership in the sourcing of funds and effective utilization by forming farmers' groups and funding collective initiatives in managing climate change-related risks. Provision of subsidized credit facilities or grants to individual farmers is also recommended for viable farm-level risk management initiatives.

6.4 Future Research

This research focused on dryland farming systems' pastoral and agro-pastoral production. Furthermore, the research was limited to two wards in northern Kenya. It will be interesting to see if the findings apply to other farming systems, such as pure crop farmers in Kenya's high-producing regions. Comparative studies of risk management practice from the perspective of gender could be conducted by conducting studies with an equal number of men and women in a similar study.

The qualitative approach was used in this study, with semi-structured interviews conducted in each of the two study areas with a total of eighteen respondents. This aided in the collection of enough data for this study. A quantitative study, on the other hand, would have targeted a larger number of respondents, making it easier to extrapolate the findings to a larger population. As a result, a quantitative study of climate risk perception and management strategies with a larger sample size and comparison of the results with the qualitative approach would be interesting.

This study used an approach inspired by Van der Linden's (2015) Climate Change Risk Perception Model, in which cognitive, experiential, and socio-demographic factors were used to assess climate change risk perception and, as a result, management strategies used by pastoral and agro-pastoral farmers in agricultural production activities. It might be interesting to apply each of the individual elements in future studies to see how they affect risk perception and management strategies in agricultural production. Studies using other risk perception models could be interesting as well.

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Popular science summary

The research investigated the perception of pastoralists and agro-pastoralists concerning climate change-induced risks and the management strategies put in place in the dry land farming systems in Kenya to reduce the impact of climate change-related risks. The management strategies form part of the phenomenon commonly used in agricultural practices, TIMPs (Technology, Innovation and Management Practices). The results of the study were obtained through semi-structured interviews within two study areas in northern Kenya where 36 participants were interviewed. The study revealed that the strategies used included preventive strategies which include timing the planting period to plant at the right time, crop rotation, and following the market trends; mitigation strategies such as diversification of agricultural production and rearing/planting of improved breeds to better adapt to the harsh climatic conditions and coping strategies such as taking personal initiative to protect against wildlife attack and support from the government and stakeholders. On the perception with regards to climate change majority of the respondents associate extreme weather change with other natural factors rather than climate change.

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_____

Elema Mamo

Uppsala, 2022

Appendix 1: Cover letter

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences
Department of Economics

Hi,

I am Elema Mamo a student from the Swedish University of Agricultural Sciences, Uppsala, Sweden, in the field of Agricultural Economics and Management. I am in the final semester of my studies currently writing my master's thesis. I will be collecting data within the dry lands transform project implementation areas of Chepareria and Lokiriama wards where I will be interviewing selected farmers. The aim of my research is to understand the farmers' perception of the risks they face in agricultural production and the causes related to these risks. Looking forward to your assistance. If you have any questions or concerns, please feel free to contact me via email or phone.

Email: eamo0003@stud.slu.se

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Appendix 2: Interview guide

Background information

1. Can you please introduce yourself?

   Name (optional), Age, Gender, Level of education, Year of farming experience

2. What are the sources of livelihood in your family?

Questions on the agricultural risks faced by the farmers.

1. As a farmer, what are some of the risks that you face in the agro pastoral/pastoral production system?
2. Within the last decades what could you say has been the incidences that posed the greatest risk in your agricultural production?
3. What source of risk affected your agricultural production the most?

Questions on risk preferences and management.

1. What strategies do you apply to prevent the extent/intensity of the impact of these risks?
2. In terms of risk preference, are you a risk seeker, risk averse or risk neutral? (Provide scenario in cases where the respondent doesn't understand about preferences)
3. Have you ever had insurance cover for the crops and livestock?

Questions on climate change and adaptation.

1. Over the last 2 decades what are some of the natural phenomena within the area that has affected agricultural production? In your opinion what do you think causes this phenomenon?

2. In anticipation of this occurrences, what action do you take to prevent or reduce the impact on your production? What action/actions have you taken to keep on with your agricultural activities to adopt to the effects of climate change?
3. Have you heard about climate change? What is it? Where did you hear about climate change and what sources do you perceive to be reliable? Do you get interested to learn more about it?

4. Can you attribute the natural phenomenon that affects your agricultural production to be as a result of climate change?

5. Do you have any plans to cushion yourself against the risk posed by such occurrences in the future?
6. In your opinion what role has the government undertaken to cushion your production activities against future occurrences?
7. Do you perceive climate change as a risk?
8. What are your future plans do you have to better manage the risks associated with the extreme weather conditions?

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