IMPACT OF CLIMATE CHANGE ON INDIGENOUS PEOPLES' LIVELIHOODS: A CASE OF LOODOKILANI MAASAI, KAJIADO COUNTY.

BY

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Declaration

This research Project is my original work and has not been presented for the award of any degree at this or any other University or Institute.

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This research project has been submitted with our approval as University supervisors.

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Dedication

This research work is dedicated with lots of love, respect and appreciation to my wife, Grace Salau and children Linah Silantoi, Faith Rayon, Isaac Sabaya and the newly borne baby Joan Saidimua!

Acknowledgement

This project would not have been possible without the grace of God that has sufficiently enabled me to successfully complete it. I would also want to acknowledge the cooperation and invaluable assistance of many people who contributed to this final work. I owe them my gratitude.

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Abstract

The study on the impacts of climate change on the livelihoods of the Maasai comes at a time when the community has been facing acute food insecurity and threatened livelihoods. It would be timely and necessary to establish whether this trend of diminishing livelihoods and escalating poverty could be linked to climate change and its related effect. This research was guided by use of cross-sectional survey. Both simple random and purposive sampling technique was used to select 110 respondents out of which 105 participated in the cross-sectional survey. A validated structured questionnaire with variables on livelihoods related information was used to collect the primary data. Data summary and classification were done using descriptive statistics from Statistical Package for Social Sciences (SPSS) software.

The study concluded that majority of respondents in Magadi and Elang'ata Wuas were men while the predominant age was between 18 and 24 years. The level of education showed that majority of the respondents are illiterate followed by those with secondary education while the next largest group is the primary school level. Majority of the respondents are livestock farmers while another sizeable group are students. A number of respondents are employed as teachers and a similar number is unemployed. The respondents were distributed across the two divisions of Magadi and Elang'ata Wuas. There is huge concentration in Magadi and Kilonito because of the big livestock markets in the two towns.

The Maasai pastoralists of Magadi and Elang'ata Wuas confirms that their lifeline is cattle farming and pastoralism in that matter. They also confirm that they are aware of climatic changes that are taking place and have experienced social-economic stress due to frequent droughts that have killed their livestock. Majority of the responded have also acknowledged that besides their livestock, a lot more other natural resources are stressed including wildlife, forests, and water sources among others. The responded admits that they have been forced by circumstances to explore other ways of complementing their diminishing traditional livelihoods by venturing into new areas such crop farming, fishing, small businesses among others.

The responded unanimously allege that they have been victims of poor policies or lack of it especially in regard to land and natural resource administration. This they say, has exacerbated an

already challenging situation and make it hard for the community to adequately adjust and cope with the changes. This is confirmed by an extensive literature review that was carried out.

The community's understanding of climate change and access to information, capacity building and partnership with other stakeholders including the government, would help to lessen the impact of climate change and enhance their resilience to its impacts.

List of Acronyms:

ASAL	Arid and Semi-Arid Lands
CO2	Carbon Dioxide
CIWOCH	Center for Indigenous Women and Child
FAO	Food Agricultural Organization
GHG	Green House Gases
HFC	Hexa Flora Carbon
KMD	Kenya Meteorological Department
MoE	Ministry of Environment
NDMA	National Drought Management Authority
O2	Oxygen
NGO	Non-Governmental Organization
NIA	Neighbors Initiative Alliance
NEMA	National Environment Management Authority
PFC	Per FluoroCarbons
IIN	Indigenous Information Network
IPCC	Inter- governmental parties on climate change
IWGA	International Working Group for Indigenous Affairs
SF6	Sulphur Hexafluoride
SPSS	Statistics Package for social sciences
UNFCCC	United Nations Framework Convention on Climate Change
UN	United Nations

CHAPTER ONE

INTRODUCTION

1.0 Background

Changes in climate are expected to manifest in terms of shifting seasons, increased frequencies and intensities/severity of extreme weather/climate events such as droughts, heavy rainfall and associated flooding (Shah *et al*, 2012). This is especially expected to happen and severely impact low, coastal, arid and semi-arid regions. It is expected to affect various groups of people differently depending on their geographical location, mode of subsistence and/or livelihoods, and environmental attachment, among other socioeconomic factors.

Some indigenous communities, such as the Maasai in Kenya, predominantly occupy arid and semiarid lands and are already vulnerable to the adverse impacts of climate variability and change. The Maasai perfectly fits into the United Nation's (UN) definition of Indigenous Peoples (IPs); "indigenous communities, peoples and nations are those which, having a historical continuity with pre-invasion and pre-colonial societies that developed on their territories, consider themselves distinct from other segments of the societies now prevailing in those territories, or parts of them (Cobo, 1986). These people at present constitute minority segments of society and yet are determined to preserve, develop and transmit to future generations their ancestral territories and their ethnic identity as the basis of their continued existence as peoples in accordance with their own cultural patterns, social institutions and legal systems."

One major characteristic of Indigenous Peoples is their inextricable attachment to the natural environment, not only for economic wellbeing but also for their social and spiritual nourishment.

Further, the livelihoods of indigenous peoples are pegged largely on natural resources and on natural elements of weather and climate variability, (IIN, 2008).

In Kenya, these people are predominantly pastoralists who keep livestock under a nomadic free range system and depend on livestock for subsistence and cultural reverence. They have been marginalized for decades from mainstream development with limited access to water and basic social amenities such as healthcare and schools (Hughes, 2006). Such marginalization was deeply entrenched in Kenya since independence, and pastoralist areas were neglected in the policy development processes and allocation of resources. This has negatively impacted on the socioeconomic advancement of the community and subsequently reduced their adaptation abilities (Ellis, 1995, Moiko, 2004).

Pastoralism evolved in Africa specifically as an adaptive response to climate and environmental extreme conditions which limited the expansion of agriculture. Pastoralism has co-evolved as diverse cultural and economic systems within ecological niches around Africa. The result has been millennia of managing sheep, camels and cattle in different ecosystems and landscapes throughout long cycles of climatic change. Pastoralism has always been premised on the need to maintain biodiversity as the underpinning factor of human and livestock well-being (Vandana, 1997).

Climate change in combination with other drivers of declining biodiversity has reduced the effectiveness of pastoral societies to maintain both social harmony and resilience. At the same time, the reduction in pastoralist's capacity will likely lead to decreased reliance on pastoralism and agro-pastoralism for food security.

Pastoralism is a weather sensitive livelihood system that purely depends on availability and distribution of precipitation and appropriate temperature ranges among other climatic elements. While climate change may present some opportunities in some cases, it is also likely to impact negatively on the livelihoods of the Maasai community.

Over the years, the Maasai community has been known for their cultural resilience in adjusting to the challenges of globalization such as commercialization of land, capitalism, and homogenous cultures, among others. They have survived for more than a century with near intact cultural values and practices in the midst of global integration (Oxfam GB, 2002). However, the community has in the recent past been exposed to various push factors that are almost tipping the community beyond their coping capacity. Such factors include but are not limited to land demarcation and subsequent land selling that has tremendously reduced its carrying capacity, increased population mainly due to immigrants' encroachment, and environmental degradation, among others. Climate change, together with pollution and environmental degradation, poses a serious threat to indigenous peoples, who often live in marginal lands and fragile ecosystems which are particularly sensitive to alterations in the physical environment (Macchi 2008). Since Indigenous Peoples depend largely on the natural environment, adverse climate change-related impacts could affect their traditional livelihoods. This would also threaten their cultural identity that is closely linked to their traditional lands and livelihoods (A/HRC/4/32, 2009). The loss of the positive cultural values and traditional knowledge has affected their adaptation capability.

According to the Initial National Communication of Kenya (2002), the most vulnerable areas to climate change in Kenya are the arid and semi-arid lands (ASALs), where the frequency and severity of both droughts and floods are ever increasing. This presents a serious challenge,

especially in these low potential areas which make up to over 80 % of the country's land mass and inhabited by 20% of the population (Government of Kenya, 2009 population census). It is generally hot (14 – 31 degrees Celsius) and dry (rainfall varies from 300-800mm depending on the ecological zone) (Awuor, *et al*, 2007).

1.1 **Problem Statement**

The effect of climate change on the environment and socio-cultural values remains hard to be quantified in economic terms. Lack of disaggregated data in this area makes it hard for policy makers to address climate change related impacts that has a bearing on the indigenous and local communities, their values and livelihoods. The limited access to local environment resources adversely affects most economic and society livelihood activities, Homewood, K (2009)

The limited access to water resources both for human and livestock consumption is a major problem facing pastoralists in general and the Maasai of Elang'at Wuas/Magadi area of the southern Kenya. In addition, increasing population, sedentary lifestyles and some maladaptation practices such as introduction of some rain dependent crop farming in the traditional pastoral lands continue to impose restrictions to the migration patterns of the pastoralists, making the pastoral community more vulnerable to the adverse effects of climate variability and change. Traditional pastoral management strategies, which worked well under intact grasslands, no longer suffice under enhanced land fragmentation currently experienced in the southern rangelands of Kenya.

Improper land use practices have characterized the Southern rangelands due to lack of appropriate land master planning to facilitate distinct and different livelihood practices by separating pastoralism and crop farming in arid and semi-arid areas. Lumping together the two livelihoods has created conflict of land use and water resource utilization.

Traditionally, the ASALS and in particular the Elang'ata Wuas/Magadi area has been highly prone to droughts, (NDMA, 2013). The last decade has seen three major droughts and frequent erratic weather patterns that caused deaths for over half of the livestock for the community, (Daily Nation, 2014). Associated famine has led to malnutrition and starvation of mainly the elderly and the young leading to unprecedented poverty levels and deaths, Whether or not the community will survive another 'climate holocaust' in a situation where their food sovereignty is already at stake remains the greatest challenge of the 21st century. This study, therefore, seeks to establish the extent of community's resilience against the backdrop of climate change.

In Kenya, the inappropriate land management policy for the ASALs has exacerbated the impact of climate change by eroding the traditional adaptation mechanism of the community. Sub-division of arid lands into small uneconomical units in these regions continues to curtail nomadism that has been used over years for environmental management and consequently adaptation to unfavorable seasons. These policies, therefore, erode the climate change resilience capacities of the Maasai community.

It is in the light of the foregoing challenges that this study critically examined the interaction between climate change and natural resources and cultural factors that impact the socio-economic and livelihood situation of the Maasai community of South Rift Kenya. To achieve this, the study attempted to answer the following research questions;

i. Which livelihood practices are vulnerable to the prevailing climate change trends and how has it compromised the resource base of the Maasai community?
ii. What are the current coping mechanisms used by the Maasai community and how has it addressed the prevailing climate change trends?

iii. What are the opportunities that may be taken advantage of and challenges that can be addressed from the implementation of the identified coping strategies to climate change by the Maasai Community?

iv. Which sustainable adaptation strategies are available and to what extent are the current policies supporting efforts by the Maasai community to adapt to the adverse effects of climate change?

1.2 Objective of the Study

The overarching objective of this study was to explore the impact of climate change on the livelihoods of the Maasai community of South Rift Kenya with a view to establishing possible sustainable climate change adaptation mechanisms for the community.

a). Specific Objectives

The specific objectives of the study were:

i. To establish key livelihoods practices and resources that are vulnerable to changing climatic trends and how they are impacted by such changes.

ii. To establish existing capacities, opportunities and challenges available to the Maasai community in coping with climate related disasters.

iii. To establish a strategy for mainstreaming climate risk management approaches for the Maasai and other pastoral communities' livelihood systems into the County, National and regional policy frameworks for Kenya.

1.3 Justification of the study

There is now clear evidence that weather and climatic patterns and their variability have changed, (Thornton et al., 2006). According to Opole (2013), the inter-annual rainfall variation at Mashuru meteorological department in Kajiado for the period 1964-2011, indicates that the return period for poor performing years were more frequent to a tune of 4 to 6 years; a sign that droughts could be more frequent in the area compared to return rates of above normal rains.

The Maasai community attests, from their historical timelines that climate change has indeed occurred. This has had direct impacts on their social-economic wellbeing. The communities have naturally been trying to adjust their livelihoods systems through livestock breed selection and fodder management among others in order to cope with the adverse effects of climate change (Unganai, 2000). This study will help in pinpointing vulnerability areas that are prone to changing climatic trends and providing specific measures that have potential to help the community to cope and better adapt to the changing climate.

Kenya is currently formulating a climate change policy and legislation for mitigation and adaptation, having completed the National Climate Change Response Strategy, NCCRS 2010, (GoK 2010) with the aim of informing subsequent programmatic action plans and climate change policy.

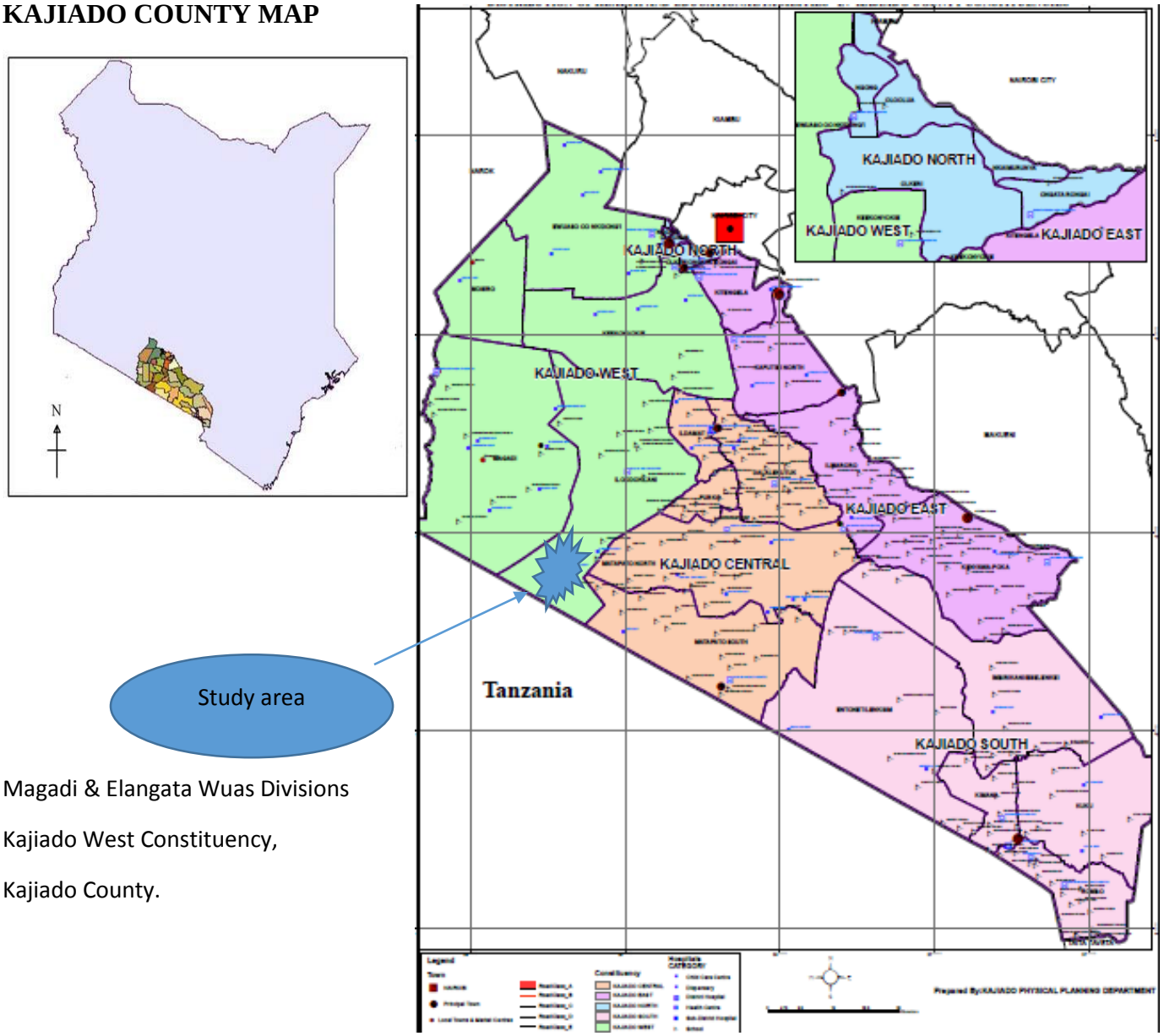
However, the National Climate Change Response Strategy process lacks sufficient disaggregated data and sound facts based on community experiences to inform the effectiveness of future policies and adaptation plans emanating from it, (Davies 2007). This study will bring to the fore salient issues that are experienced first-hand by the victims at the community level to help policy makers at all levels make informed decisions.

In addition, at community level, this study will avail such facts, as the level of awareness by the communities on climate change, the real impacts as experienced by the community, their adaptation efforts and their limitations of which they would require external support. This would create a bottom-up strategic approach in tackling the climate change challenges facing the community through formulation of effective policies and strategic development plans by the national and county governments as well as other development agencies. This would enhance the adaptation capacity and resilience of the community to the adverse effects of climate change.

1.4 Study Area

The study was conducted in Kajiado West sub-county, in Kajiado County covering Magadi and Elang'ata Wuas divisions. This area boarders Kajiado town, the capital of Kajiado County and stretches south to Magadi along the Kenya-Tanzania border (Figure 1).

KAJIADO COUNTY MAP



Magadi & Elangata Wuas Divisions

Kajiado West Constituency,

Kajiado County.

Figure 1: Map of study area covering Magadi and Elang'ata Wuas divisions (courtesy of Geo-maps Kenya)

The main physical features of Kajiado County are plains, valleys and occasional volcanic hills ranging from an altitude of 500 meters at Lake Magadi to 2,500 meters in Ngong Hills.

Kajiado County in general has a bi-modal rainfall pattern. The short rains fall between October and December while the long rains fall between March and May. Heavy rains occur around Ngong Hills, Chyulu Hills, Loitokitok and Nguruman Escarpment which receive an estimated 1250mm

while Magadi receives less than 500mm per annum. Temperatures vary both with altitude and season. The highest temperatures of about 34 degrees Celsius are recorded around Lake Magadi while the lowest minimum temperatures of 10 degrees Celsius are experienced at Loitokitok on the Eastern slopes of Mt. Kilimanjaro. The coolest period is between July and August, while the hottest months are from November to April throughout the county, (NDMA, 2013).

This study area is mainly arid and semi-arid, with Magadi being the lowest point with soaring temperatures. The people of this area are predominantly nomadic pastoralists with small areas of irrigated agriculture practiced in Nguruman escarpment at the border of Narok County. The annual rainfall is enough for livestock farming only if well distributed across the year. Dry land agriculture with drought tolerant crops such as beans and maize also thrives where soil fertility is high.

The two divisions have two different land tenure systems. Magadi is still under group ranches (communally owned) and Elang'ata Wuas has been subdivided into private ranches (individually owned). The area under study, just like the wider Kajiado, receives low bi-modal rainfall spread between March-May (normally referred to as long-rainy season) and October-November (normally referred to as short rainy season). The average rainfall received in the area ranges between 300mm to 750mm per year.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of literature regarding the impact of climate change on indigenous peoples' livelihoods in general and its implication on the food security situation of the Maasai pastoralists in relation to changing climate. The chapter also presents the available options for pastoralist's adaptation and resilience to climate change including the information that is available in the public domain that would empower pastoral communities to make reliable and informed adaptation decisions as well as influence policy at different levels.

2.1. Global and Regional climate Change

Climate is subject to natural variability and is also influenced by both natural and anthropogenic (human-induced) factors. Natural factors that influences climate include but are not limited to volcanic activities as well as changes in the orbital distance of the earth from the sun. Climate change is linked to the presence of Green House Gases (GHGs) in the atmosphere (Malone, 1998). The natural greenhouse effect, however which is essential to life on earth is now being disrupted by human activity due to rising emissions of GHGs from the consumption of fossil fuels including coal, oil and gas along with intensive agriculture, forest clearance and other land use changes. This also contribute to increase in greenhouse gas concentration in the atmosphere due to reduction in the carbon sinks. The man-made chemicals such as hydrocarbons (HFCs), per fluorocarbons (PFCs), Sulphur hexafluoride (SF6) and other halocarbon gases are additional contributors of GHGs.

Climate change presents prospects for both benefits and drawbacks to food production. To address any of them more clearly, it is necessary to define the main interactions that link a chain of processes together: food is derived from crops and animals which are major livelihood systems for many communities both in developing and developed countries. Understanding the potential impacts of global environmental change on this sequence of interlocking elements is a first step in modeling what will happen when any one of them is changed as a result of possible global warming, and a prerequisite for defining appropriate societal responses (Christensen, 2007)

A climate trend analysis conducted in Kenya in 2010 indicates consistent patterns of observed climate change during the 1960–2009 period with respect to rainfall. Extending the observed 1960–2009 changes to 2025 indicates that large parts of Kenya will experience more than 100 mm decline in long rainy season rainfall (GOK 2009,). In addition, the relative magnitude of the identified long rainy season rainfall decreases will be accompanied by significant increases in average air temperatures, with the temperature increases generally being more than twice the interpolation standard errors (King'uyu et al 2000, GOK 2010).

An analysis of the trends in temperatures, rainfall, sea levels, and extreme climate events points to clear evidence of climate change in Kenya, Herero *et al*, (2010). Studies indicate that temperatures have generally risen throughout the country primarily near the large water bodies and the country's arid and semi-arid lands are experiencing extreme temperature occurrences, Kilavi (2008).

2.2. Impacts of Climate Change on Rangelands Ecosystems

Analysis of the social-economic impacts of current and future climate shows that climate variability has and will continue to have significant economic loss implications for Kenya.

Extreme events in the form of periodic floods and droughts have caused major social economic impacts and have reduced economic growth in Kenya in the recent past (MoE, 2012). The rangelands ecosystems are especially fragile and sensitive to the slightest climatic change. A relatively small change in climate can cause or exacerbate water resource problems and food insecurity in the rangelands, Smith, *et al,* (1995). Such impacts include change in forage quality and quantity, plant adaptability or shift in species and/or change in livestock adaptability.

According to the IPCC report 2014, future climate risks are expected to take a high toll on among other areas; rural livelihoods, food security and production. Major future rural impacts are expected in the near term and beyond through impacts on water availability and supply, food security, and agricultural incomes. These impacts are expected to disproportionately affect the welfare of the poor in rural areas, such as female-headed households and those with limited access to land, modern agricultural inputs, infrastructure, and education. Throughout the 21st century, climate change impacts are projected to slow down economic growth, make poverty reduction more difficult, further erode food security, and prolong existing and create new poverty traps. This s is expected to be more pronounce in the rangelands ecosystem. Impacts of climate change are expected to exacerbate poverty in most developing countries especially in those countries with high inequality and disproportionate allocation of resources, FAO (2004).

Knowledge of environmental hazards, climate impact assessments and climate history offer bases for integrated assessments of the social consequences of and responses to harmful variations in precipitation and temperature in addressing challenges of vulnerability and response. Among biophysical agents, weather and climate are by far the most lethal to mankind worldwide. Together, flood, hurricane and drought account for 75% of the world's natural disasters (Malone &Rayner, 1998).

Climate change poses one of the greatest challenges to humanity. Global warming and associated climatic changes are impacting on pastoralist peoples with increasing frequency and severity of droughts and floods. African indigenous peoples' delegates at the N'Djamena conference on adaptation noted first-hand experiences of droughts, flooding, changes or shifts of seasonal cycles, changes in the composition of grazing lands, and changes in accessibility and quality of water, (Barume, 2010).

Changes in water quantity and quality due to climate change are expected to affect food availability, stability, access and utilization. This is expected to lead to decreased food security and increased vulnerability of poor rural farmers especially in the arid and semi-arid tropics and African Mega-deltas (Bryson, et al., 2008).

The social economic impacts of droughts may arise from the interaction between natural conditions and human factors such as changes in land use, land cover and the demand for and use of water.

Droughts have become so common especially in the tropics and sub-tropics since 1970. The working group 1 of the 4^{th} Assessment Report (AR4) for policy makers concluded that the area affected by drought has increased since 1970 and it is more likely than not that there is human contribution to this trend. Changes in the frequency and intensity of droughts and flooding will affect the stability of and access to critical food supplies.

Temperature and moisture regimes are key variables influencing spread of species. Grassland and savanna productivity is highly sensitive to precipitation variability. Where precipitation variables are limited by climate change, such as in arid and semi-arid rangelands in the tropics and sub-tropics, agricultural production is very vulnerable to climate change (FAO, 2003).

2.3 Climate change, Indigenous peoples' Cultures and food security

Weather and climate are some of the risk factors impacting on the performance and management of all socio-economic activities in Kenya (Muthama *et al*. 2012). This is particularly relevant to Indigenous Peoples whose livelihoods solely depend on the natural environment that is quite sensitive to climate related risk factors.

Increased global warming will have devastating effects on the third world countries that lack the technical and financial resources to cope with such climate related impacts, Hulme et al (2001). Any reduction in rainfall would obviously be disastrous for poor farmers in the arid and semi-arid areas of sub-Saharan Africa. According to IPCC AR4 WG2 (2007), the group of experts appointed to assess the global warming issues indicated that the vulnerability of agriculture to climate change in the semi-arid tropical regions derives not only from high levels of dependence on a narrow range of rainfall levels and patterns but also on the characteristic conditions of poverty, high population growth, and environmental stress including erosion and desertification. These conditions make adjustments to different agricultural practices difficult.

The semi-arid regions are already characterized by widespread malnourishment and declining per capita food production and climate change could aggravate this condition due to the increasing severity and frequency of drought. Further, Africa economies are currently based on a narrow range of economic activities, most of which are highly vulnerable to climate variability and change. The most damaging climate related hazards in Africa is drought that increases its vulnerability to food insecurity. Vulnerability varies with region, group and communities, Western *et al.,* (2003).

Adapting to climate change by Indigenous peoples may mean diversification of livelihoods, hence a shift from indigenous foods to more conventional drought tolerant crops that can do well in arid

areas. Such a shift will however, affect the indigenous peoples' culture as food has further cultural and spiritual relevance. A pastoralist's livestock does not solemnly serve as a basis for livelihood, it also plays a central role in the cultural identity of a community (Galvin 2010).

Change of pastoralism to a more sedentary agrarian system, will erode a positive aspect of Indigenous Peoples' cultures, Portalewska, (2014). Any adaptation strategy therefore, need to take into account Indigenous Peoples' aspirations and wishes so as to bring about a holistic approach to climate change adaptation.

2.4. Climate Change Adaptation in the context of pastoralists

Pastoralists have always considered themselves capable of undertaking major adaptation strategies in response to changing environmental circumstances. For example, they are always prepared to change breeds, move from one place to another, undertake culling, postpone animal breeding or take whatever measures that are likely to increase their food security. Such adaptation strategies, however, take time and come with costs. Technical know-how and reliable information is needed for decision making. Whereas this may not be a problem to the mainstream society, it is a big challenge for indigenous peoples occupying marginal and /or remote areas, Ensor *et al* (2009).

A case study of pastoralists coping strategies in Northern Kenya and Southern Ethiopia shows that African Pastoralism has evolved adaptation strategies to harsh environments with very high spatial and temporal variability of rainfall (Ellis, 1995). The coping mechanisms range from the age old mobility technique where seasonal migration is the norm to the latest livelihood diversification practices. Mobility has, however, been curtailed over years by encroachment by agrarian societies courtesy of privatization of land. This has led to gradual sedenteralization lifestyle necessitated by the need to have schools, hospitals and other essential social amenities.

Indigenous pastoralists have also survived the harsh climatic conditions that threatened to wipe out their livestock through huge heard accumulation. This ensures that risks are spread across the board and while weaker livestock eventually die, lots of other animals do survive. This combined with seasonal cattle raiding, has become a rational form of insurance which the community used to cushion itself against drought (IWGIA Report, 2007).

The Maasai have also ventured to various forms of diversified livelihoods such as crop farming, small businesses and rearing of other animals (chicken, fish and camel) other than the traditional ones (cows, sheep and goats). The community has also indulged in, charcoal production and cash trading. The farmers therefore can now buy supplementary feeds and drugs hence combine the scientific and indigenous knowledge in livestock management.

2.5 Climate change and Land Tenure Systems

Land is a primary production resource upon which pastoralists, indigenous and local communities' livelihoods are based. Pastoralism is a land based livelihood that require open space to thrive. The land management regime therefore has far reaching implications on its accessibility and use, playing a critical role in climate change adaptation. This has, however, become one single problem facing minority groups and pastoralists in Kenya, Galvin & Cathleen (2008). Land use policies has been discriminative against pastoralists and this finds its roots in colonialism and European legal biases imported into Africa, Reid *et al,* (2009). This is most evident in the problems of land tenure and resource rights of mobile peoples in Africa today. Following the arrival of the settlers in Kenya, communities became either squatters or confined to native reserves severely affecting their right to land. A colonial agent quoted by Okoth-Ogendo (1991), stated: "Am afraid we have got to hurt their (communities) feelings, we have got to wound their susceptibilities and, in some cases,

am afraid we may even have to violate some of their most cherished and possibly even sacred traditions if we have to move communities from land on which, according to their own customary law, they have an inalienable right to live, and settle them on land from which the owner has, under that same customary law the right to eject them". This marked a gradual but systematic land dispossession especially from high potential areas that cushioned the community from harsh climatic conditions. Moving the community to low potential, drier areas became a priority for the powers of the day and those that followed suit, Moiko, (2004).

This intention was effected by the Swynerton plan of 1954 which promoted the agrarian policy and facilitated gradual but sure loss of land beyond independence, Barume (2010) quotes the policy, "In the future...former government policy will be reversed and able, energetic or rich Africans will be able to acquire more land and bad or poor farmers less, creating a landed or landless class. This is a normal step in the evolution of a country". This has since come to pass with the current policy of willing-seller willing –buyer, further alienating the remaining land totally curtailing the nomadic movement of pastoralists.

Traditionally, hunters, herders, farmers and fishing peoples had complementary land and natural resource use and tenure systems. There was coherence between rights to resources and the responsibility of communities for stewardship and conservation. This coherence of rights and responsibilities has been damaged and has not been adequately addressed in the post-colonial context. The current marginalisation of indigenous pastoralists, especially in light of climate change regime, can only be resolved by reforms to land rights, land tenure and access to natural resources legislation and practices, Ogolla et al, (1996)).

The total effect of climate change includes greater vulnerability of ecosystems as well as threatening human social and economic systems. Climate change is impacting negatively on health, livelihoods, peace and security. While the only answer is an urgent, robust and binding global agreement on the reduction of Green House Gas emissions, the reality is that Africa must take urgent steps to adapt to climate instability, reduce vulnerability and build resilience of both natural and human systems (IIN, 2007)

Despite the very serious risks from climate change, the N'Djamena conference delegates noted that climate change is only one element of the many challenges facing African indigenous pastoralists. Changes in land use and occupancy, different forms of pollution (e.g. radioactive pollution of aquifers), dry lands deforestation, the negative impacts of extractive industries and a general decline in biodiversity across Africa are all contributing to growing poverty and vulnerability of indigenous peoples.

However, through the Land Ordinance Act of 1967, the government saw the wisdom to subdivide pastoral lands into group ranches and subsequently into private ranches. This has had far reaching implications because the land carrying capacity has reduced making the livestock and consequently people, more vulnerable. The mobility of cattle has significantly reduced confining them to small geographical coverage leading to environmental degradation and increased susceptibility to the adverse effects of climate change. Future adaptation capability by the Maasai, in the advent of climate change will therefore largely depend on land use and land tenure system.

2.6. Climate Change Adaptation and Indigenous knowledge systems

Traditional knowledge and climate science are both critically important for adaptation policy formulation and support for resilience building of rural communities to cope with impacts of

climate change. Local indigenous communities are rich with traditional knowledge that they have used over years to survive and adapt to various disasters. This knowledge is intricately linked to biodiversity utilization and conservation (Vandana Shiva *et al,* 1997). If this knowledge is harnessed and mainstreamed into the contemporary climate change adaptation process, it will provide a unique approach to combat and adapt to the adverse effects of climate change.

The challenge for both knowledge systems (- traditional and scientific) is how they can be made usable for decision making and how they can be used in synergy with each other to ensure a robust, shared approach to adaptation. Attention and expertise is required to facilitate the intercultural mediation of Science and Traditional Knowledge, generating understandable and usable research products that help decision makers at local, national and regional scales. There is therefore need to protect the intellectual property rights of the traditional knowledge holders before it is harnessed and used in the public domain (Edwards *et al,* 1996).

The Maasai community has had reliable indigenous knowledge that can forecast weather related occurrences. They are well aware of how to mitigate disasters and adapt to the challenges of climate change. On indigenous knowledge, herd diversity practiced by pastoralists ensured sustainable livestock production. According to NEMA (2011), the forage such as *emurua (*Cyndondaxty) and *olpalakai* (panicium maximum) are reserved for drought season use.

Despite the rich and diverse knowledge, there is little recognition of this fact and the policies and long term integrated plans are deficient of indigenous knowledge on pastoralism, biodiversity conservation and disaster risk reduction. The Kenya development blue print, vision 2030, has not taken fully into account the role that ASALS and pastoralism plays in contributing to the economic

development of this country. Neither has it captured the importance and integration of traditional knowledge into the development agenda, UNDP 2014.

2.7 Seasonal Climate forecasts and Information dissemination

The growing understanding of ocean-atmosphere interactions, technological revolution and advances in global climate systems modelling, now provide a usable degree of advanced predictability of climate (Goddard *et al*. 2001). This combined with the ability to systematically quantify livelihood practices, timely information availability, and enhanced understanding of climate issues modelling, offers an opportunity to improve climate risk management (Meinke and Stone 2004). This, however, needs to be extended to ASAL rangelands where such scientific information are gravely lacking, Luseno *et al*, (2003). Integrating seasonal climate forecasting with agricultural system analysis, and dissemination of such information in a consumable version can increase its effectiveness in adaptation (Meinke *et al*, 2001). The recent improvement of seasonal climate forecasts has meant that forecasts on how much rain to expect over the season, and predictions of seasonal variability of rainfall are now widely available but need to be disseminated to the consumers of such information. The seasonal forecast is based on the fact that lower-boundary forcing, measured by sea surface temperatures, drives future atmospheric perturbations (Murphy *et al*. 2001). These boundary conditions evolve slowly and so enable predictions of rainfall to be made (Palmer and Anderson 1994). The forecasts, however, do not give much weight to the temporal distribution, such that if the amount of rainfall forecast were to fall over a few days, the seasonal forecast would still be correct but the impact could be catastrophic (Agrawala *et al*. 2001). It is this probabilistic nature that needs to be given attention in dissemination of forecast information so that farmers and especially pastoralists can base their adaptation strategies.

In the agricultural sector, forecasts have provided information for agricultural decisions relating to dry land farming, irrigated farming and livestock management (Marshall *et al*. 1996). The types of decisions that seasonal forecasts can support include both operational short-term decisions, and tactical and strategic longer-term decisions. A strategic decision for dry land farming and pastoralism in particular is to determine when and where to migrate, water and pasture reserves and when to undertake livestock breeding. This would not only avert catastrophic famine but possible conflict over dwindling resources such as water and pasture. A forecast for below-normal rainfall could encourage livestock culling, postponement of breeding, securing pasture reserves and migration to better-off places. If the forecast provides better than 'best-guess' information about the rainfall in the succeeding season, it allows better decision making and maximization of conditions (Walker *et al*. 2001). This however need to be made available to the farmers in the simplest form possible.

The ability to manage weather variation is one of the strength of seasonal forecasts is that it provides for planning. This is equally important in managing and negative impacts of climatic variability. The most useful forecast information, according to the farmers, are the early warning on anticipated poor season, the commencement of the season and adequacy of anticipated rains (Phillips *et al*, 2001). Above all, the forecast should be stated and presented in a language and in terms that the target end users understand (Unganai, 2000). Advances in the science of seasonal climate forecasting, communication and use of the products thereof are therefore essential in driving the climate change adaptation strategies for the vulnerable ASAL communities.

2.8 Climate change and Loss of Biodiversity and natural resources.

According to IPCC (2007), climate change will result in the extinction of many species and cause reductions in the biodiversity of ecosystems. Biodiversity underlies goods and services upon which

human societies depend. Possible impacts depend on different species adapting to climate change in different ways. Those dependent on ecosystems that are now more fragmented will be more at risk of being unable to adapt at an appropriate rate. There could be strong negative impacts on migratory species as a result of shifts in the timing of annual season events. It is estimated that 10-15% of the world's species could become extinct by 2030 (Peake, 2003). In some cases, there will be an acceleration of existing problems such as invasive plant species like prosopis Fujiflora in Baringo. It should be noted however, that besides climate change, there is a multiplicity of other factors which directly or indirectly affect ecosystem processes and functioning. This may not only change the natural environment, but may diminish the natural resources that the species depend on causing them either to die or migrate. The changes are not easy to project or determine, as some of the species may adapt to warmer temperatures, while others may move pole wards to cooler waters. But, what is most obvious is that extinction of some aquatic ecosystem life is imminent (Union of Concerned Scientists, 2009).

According to the 5th Assessment report (IPCC 2014), climate change is projected to affect ecosystems, cultures and all aspects of biodiversity. CO_2 emissions are projected to lead to a 4.4˚C increase in temperature by the end of the 21st century. Precipitation is projected to increase in high latitude areas and equatorial areas while the subtropics will see reduced precipitation with an increase in precipitation events. Land areas will experience higher temperatures than the oceans while high latitude areas will be hotter than the tropics. Sea levels will rise, causing coastal flooding, and the loss of habitats and of species in some coastal ecosystems and within the marine ecosystems, Clark & Mugabe (1998). This will by extension affect the hinterland rainfall pattern and such changes will affect individual organisms, populations, species distribution, and ecosystem composition and function both directly, and indirectly. Pastoralism is particularly

sensitive to ecosystem composition and distribution of species due to the symbiotic relationships that exist between livestock and flora and fauna, Nyariki *et al.,* (2009).

Further projections reveal that, by the year 2080 nearly 20% of all coastal wetlands will be extinct due to rise in sea levels (IPCC, 2002). In effect, countries will lose income generated from coastal tourism activities. Such impacts will have a series of connected outcomes resulting from these changes. Countries such as Kenya that heavily rely on tourism will lose their national income.

The current projections spell danger for species which are habitat specific and have restricted or specific habitat requirements. The adaptation ability of such species is low and their extinction is imminent. Such species will include mangroves, coastal wetlands, and species in dry land areas, among others. Mountain species will lose their habitats should the snow melt, and the rivers flowing down mainly to savannah grasslands will dry up impacting negatively on the biodiversity downstream. The water sources for example in Loitokitok and Amboseli grass lands that largely depend on water flowing from the melting glaciers of Mt. Kilimanjaro are continually getting strained as the ice sheet continue to recede, Davies (2007).

2.9 Weather Variability and Prevailing climatic trends in Kajiado

According to the IPCC temperatures in Kenya have risen by 1°C over the past 50 years (Christensen, *et al,* 2007). Looking particularly at highlands Pascual et al. (2006) find a significant warming trend of 0.5°C since the end of the 1970s. As for precipitation, the proportion of rain falling in heavy rainfall events has increased. These events are projected to occur more often, resulting in a higher total amount of rainfall and an increase of rainfall variability (Christensen et al. 2007; McSweeney *et al,* 2008).

The projected trend of increasing temperatures and less reliable rainfall increases the likelihood of floods and droughts in Kenya (Few, *et al*, 2006). In arid and semi- arid lands (ASALs), which make up 80% of Kenya's land area, droughts are a common phenomenon (GoK 2007b). The drought frequency has increased as 4 of the 28 droughts occurred in the last 10 years (Mude, *et al*, 2009). According to Ojwang *et al*, (2010), variability of rainfall is expected to increase and warmer temperatures are likely to increase the intensity and frequency of extreme weather events in the region, meaning that many areas in East Africa will be faced with an increased risk of longer dry spells and heavier storms. Kajiado district is prone to climatic shocks and in particular droughts (GOK, 2005) which affects the livelihood sustainability of the people through livestock deaths and crops failure. Further droughts have the effect of exacerbating range degradation (GOK, 2005). In Mashuru Division, for example, drought phenomenon occurred during 1952-1955, 1960-1961, 1975/6, 1984, 1994 and 2000 (UNEP and GoK, 2000). A study by Opolo (2013) depicts that both inter-annual and seasonal climate variability is high in Kajiado County and as such the rainfalls are unreliable and unpredictable. Rainfall over Kajiado had therefore overtime revealed high variability both spatially, seasonally and inter-annually, implying that climate variability is experienced in the area.

CHAPTER THREE

DATA AND METHODOLOGY

3.0 Data and Methodology

This chapter presents the data and methodology used in this study. It includes data types and sources, research design, and target population, selection of respondents, data collection, data quality control, ethical issues and data analysis methodologies.

3.1 Data types and sources.

Both primary and secondary data were used in this study. Secondary data provided invaluable qualitative information that further enriched this study. Secondary data is work already done in relation to the topic of research which is available in public domain. Information was obtained from published and unpublished books, journals, magazines as well as on-line resources within the World Wide Web to establish a theoretical framework for the study. A desktop research was extensively undertaken to establish and review available information and data in relation to the topic and area of study.

Primary data was mainly sourced from specific individuals within the target community. Primary data is the researcher's original work obtained and analyzed for public consumption. The raw data was obtained through questionnaires, focus group discussions and participant's observation. The questionnaires and guided interviews were administered to key informants such as chiefs, opinion leaders, government officials, and other identified respondents. The primary data entailed the assessment of the respondent's level of awareness of climate change and the extent to which the community understood its impacts and coping strategies. Archived climate data sets from Magadi Weather station was used to provide an independent view of climate change trends.

3.2 Methodology

A research methodology is the process used to collect information and data for the purpose of making decisions, (Orcher 2005). The methodology includes all the methods used to collect data such as undertaking publication research, interviews, surveys and other research techniques, including both present and historical information.

The methodological approach entailed a description of the research design that guided the study. It also include the sampling techniques used in selecting respondents and the sample size that was applied. It also explains the instrument that was used in data collection, its validity and how the reliability coefficient was assessed. Finally the methodology indicates how data was processed and analyzed.

3.3 Research Design

This study used a cross-sectional survey research design. This is a descriptive research design which involves a representative sub-set of a population. This design was ideal for this study because it provided for sampling from the study population is at a given point in time (Wiersma (1986) and also allowed for data collection under natural setting. The advantage of this design is that it is relatively quicker and cheaper to undertake and the results can easily be inferred to the larger population. Its application allows for collection of both qualitative and quantitative data from pastoralists whose productivity is dependent on the natural environment and rain. Sampling of interviewees was targeted at a cross section of the community across different ages, gender and social status.

The research was designed by first developing a hypothesis regarding the problem area to be studied. A set of research questions were established through which specific research objectives

where deduced. The types and sources of the relevant information was determined as well as how to access such information. A clear and effective method of data collection and analysis was determined and tested to ensure that it will deliver the desired proposed outcome. A timeframe and resources required, both financial and human were established.

This research was designed so as to obtain as accurate information as possible from the target community on the subject matter under study. The study embraced both qualitative and quantitative research approaches involving household surveys, focus group discussions and key informants. A basic semi-structured questionnaire, observation and participatory dialogue were used to acquire the requisite information.

3.4 Sampling Technique and size

Both simple random sampling and purposive sampling techniques were used to select the pastoralists from Magadi region of Kajiado County. A simple random sampling is the basic sampling technique where a group of subject (sample) is selected for study from a larger group (a population), Orcher 2005). This technique was used because in a diverse geographical area such as Magadi, simple random sampling presents an opportunity for each individual to be chosen entirely by chance and each member of the population has an equal chance of being included in the sample.

Purposive sampling entailed the selection of a group of respondents because of a specific characteristic that is unique to that group. This was applicable under the area of study because part of the respondents were under communal land and others were under private ranches. Climate change affect these groups differently because of different land tenure system.

The research design cutting across different ages, gender and social standing involved a sample of 110 pastoralists from Magadi and Elang'ata Wuas divisions of Kajiado County. According to the District Statistics officer, Kajiado (2000), the area has a population of 20,112 people and 0.5% of the population was taken as a representative sample. Singleton and Royce (1975) recommends a sample of at least 100 for social research. 50% of the respondents were identified from Magadi whose land use system is still largely communal and another 50% from Elang'ata Wuas whose land tenure is privately owned.

3.5 Research Instruments for the study

The key instruments used in this research are questionnaires, key informants interviews, and focus group discussions. A questionnaire is a set of written or printed questions organized in a systematic way for the purpose of eliciting information from respondents. A structured questionnaire was used as an instrument for collecting primary data from respondents to determine the socio economic characteristics, sources of climate information and the relevance of this information to the pastoralists of Magadi and Elang'ata wuas in Kajiado County. The structure of the questionnaire that was used is given in Annex 1.

The other instrument used in this study is the Focus Group Discussion. This is a special type of group interview in terms of its purpose, size and composition selected on the basis of certain characteristics relevant to the subject matter under study. Two focus group members of about 12 people each were therefore selected to discuss the subject matter in a more informal way. The groups consisted of both men, women, youth and opinion leaders. Focus groups participants were drawn across the target community to get proper geographical representation.

Key informants interviews was another instrument used in this study. These are specific individuals selected on the basis of their positions and influence in the community. These included

local chiefs, opinion leaders, government department representatives, NGO and political leaders. A total of seven key informants were interviewed, and they provided invaluable information that constituted the findings of this study.

3.6 Validity and reliability of the questionnaire

Validity is the accuracy and meaningfulness of inference and the degree to which the results obtained from the analysis of the data actually represents the phenomenon and investigation. The study established the reliability of structured questionnaire by pretesting it. Pre-testing entails subjecting the questionnaire to a few representatives of the population and analyzing the information to determine the degree to which it measures to the anticipated results. Outcomes of the pretest phase were used to improve the initially drafted questionnaire to enable it to capture appropriate, useful and dependable data whose finding and inferences can be a true reflection of the study population.

In this study, pretesting was done in Magadi division. Magadi is predominantly occupied by pastoralists. Pretesting was done with 15 pastoralists and responses and analysis used to review the data capture tool.

3.7 Data Analysis

Data analysis is the process of systematically arranging and organizing interview questionnaire forms, field notes, data and other materials obtained from the field with the aim of increasing understanding and presentation ability, Orcher (2005). The data under this study was organized, recorded and prepared for analysis in a way that allows manipulation through a computer software. This is done by summarizing and coding so as to convert the data to a form that permits efficient and accurate statistical analysis. Coding is the assigning of values (unique numerical codes) to the data of similar characteristic for purposes of classifying and grouping them together. This makes

it easy for the subsequent steps of data processing and analysis.

Analysis is done by the application of a computer software Statistical Package for Social Sciences (SPSS) Version 21.0. This is a comprehensive, integrated collection of computer programs for managing, analyzing and displaying data. This package helped in assigning chunks of data to domains/themes and develop abstracts within domains for analysis, processing and display in summarized form. Data summary and classification were done using descriptive statistics (mean and variance). The data is then displayed and presented using graphs, charts and tables.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

This chapter presents and discusses the results of the study in accordance with the stated specific objectives and respective methodologies.

4.0 Characteristics and Dynamics of the sample population

The social economic characteristics of the Magadi and Elang'ata Wuas communities as well as main livelihoods activities are outlined in this section. These details comprising of gender, age, education, occupation and geographical location are presented in Figures 2 to 6.

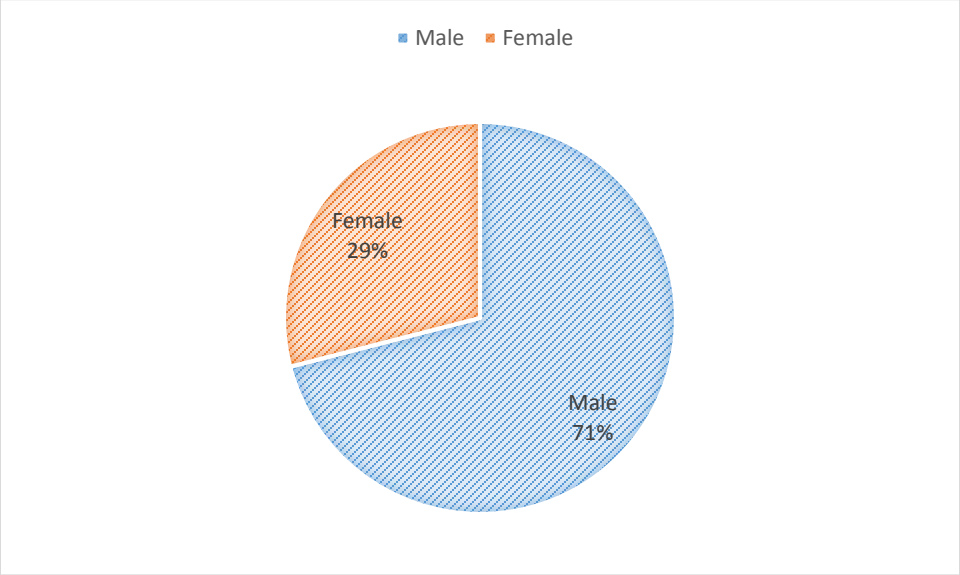


Figure 2: Gender distribution among the respondents

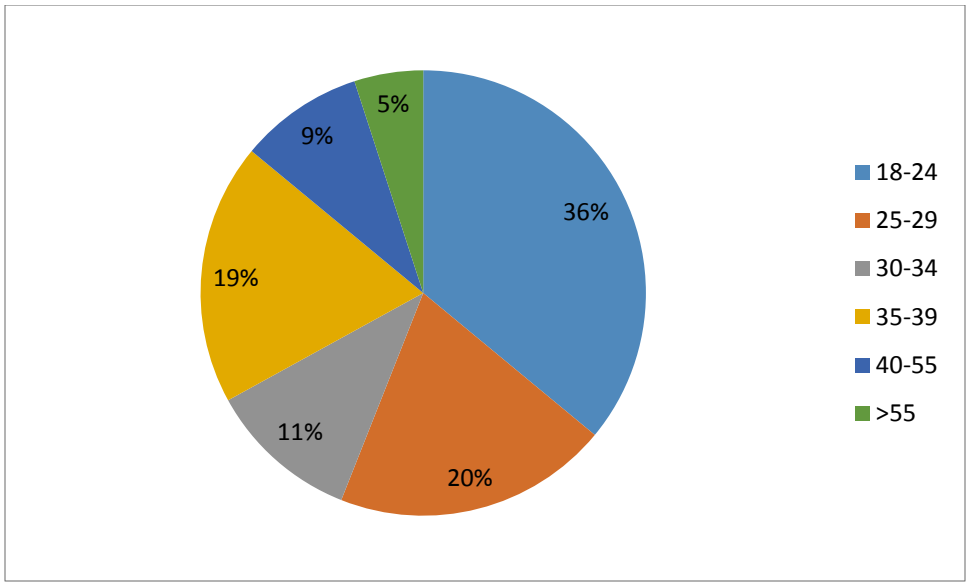


Figure 3: Age distribution among the respondents

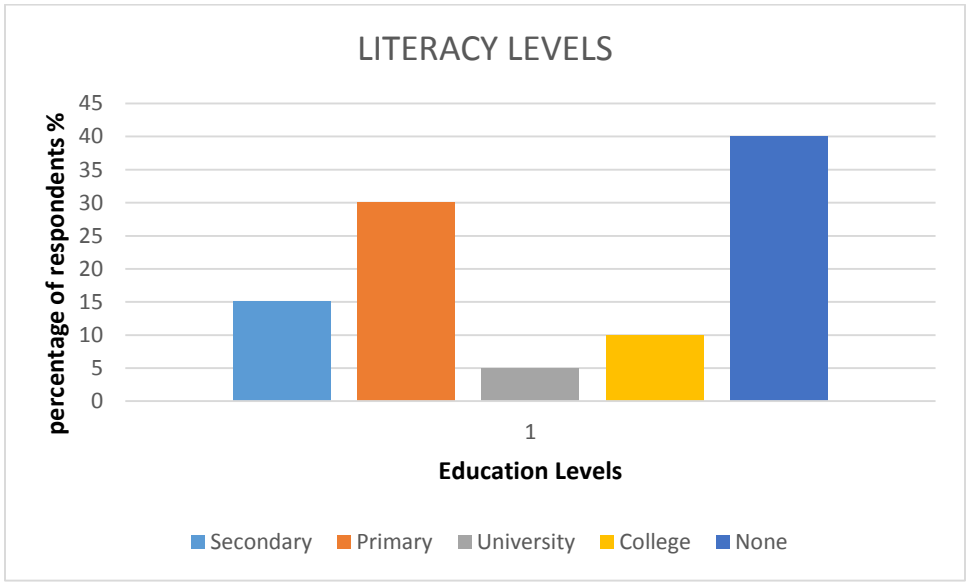


Figure 4: Education distribution among the respondents

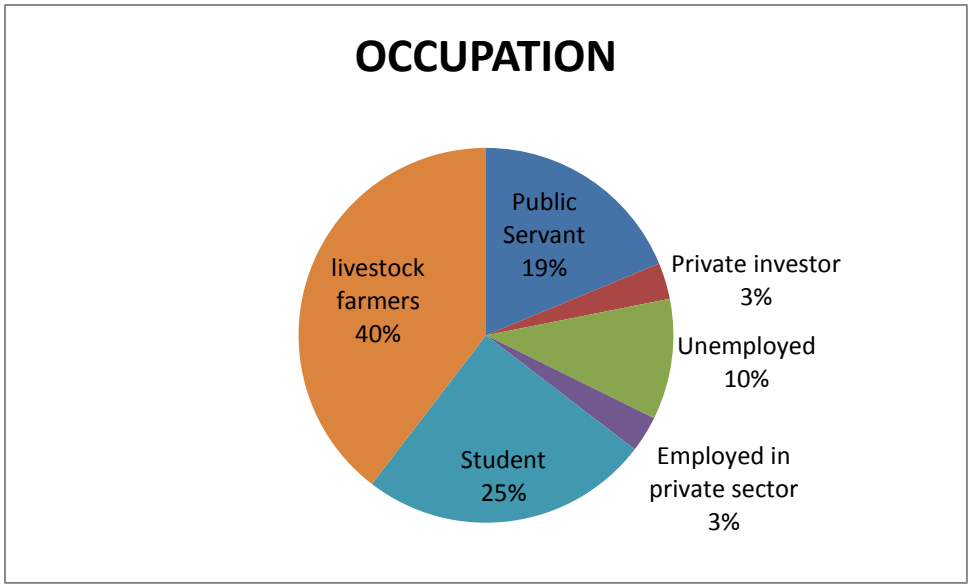


Figure 5: Distribution of the respondents by occupation

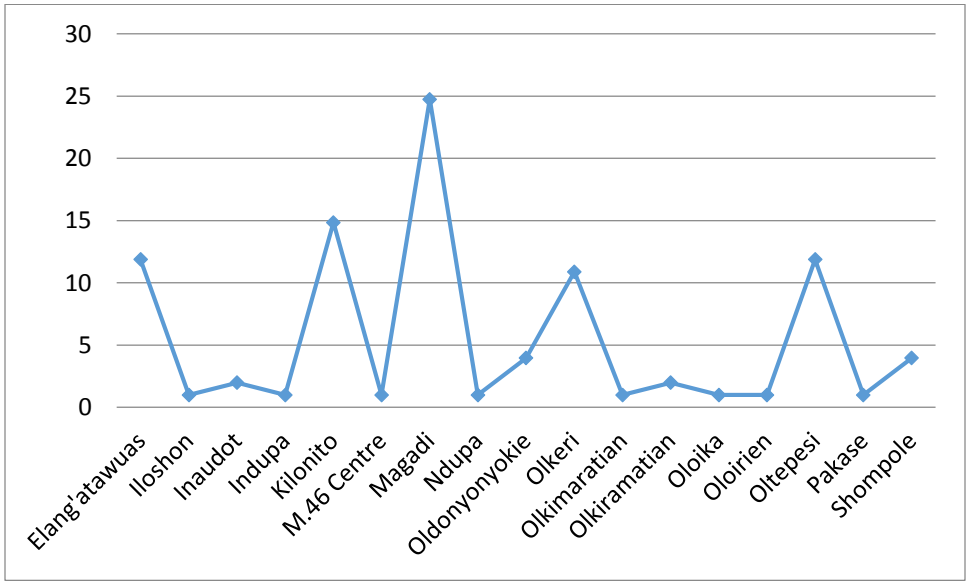


Figure 6: The geographical distribution of the respondents

.

The majority (71%) of the respondents were males while females comprised 29% of the total respondents. The respondents cut across all age groups although the majority (36%) were in the age bracket, 18-24 years, with the least (5%) being over the age of 55 years. Similarly, education level stands highest for those with primary education (30%) while the next largest group was the one for secondary level (15%) followed by college and university school level (10% and 5% respectively). Those without formal education stood highest at 40%. With regard to occupation, the majority of the respondents (40%) are purely engaged in livestock farming while another sizeable group (19%) are public servants whereas 25% are students. The remainder of the respondents are self-employed.

The respondents were drawn from the two divisions of Magadi and Elang'ata Wuas, with a bigger concentration in Magadi (25%) and Elang'ata Wuas (15%) because of the big livestock markets in the two towns.

4.1 Key livelihoods practices vulnerable to changing climatic trends

The prolonged droughts of the past decade have threatened food security and societal stability, especially in vulnerable pastoral areas (Economist 2009; UNDP 2007). Most of the pastoralist's livelihoods activities are natural environmentally based hence vulnerable to climate variability, FAO (2011). Opole (2013) confirms the above findings that there are prevailing climatic trends in Kajiado. An analysis of the rain data obtained from Magadi Soda weather station indicates that rainfall patterns are erratic and unpredictable. The summary of the data analysis is presented in the graph below.

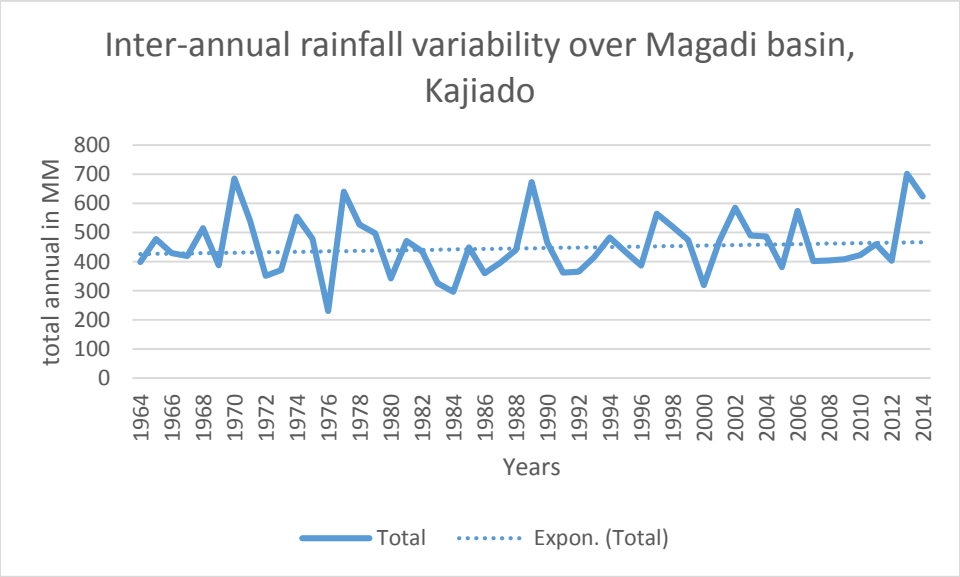


Figure 7: Rainfall variability in Magadi/Elang'ata Wuas area over the last 40 years

The sharp inter-annual rain variations depicted by figure 7 indicate fluctuating weather patterns over the last 40 years. The graph shows a gradual raising trend from 1964 to 2014. This is similar to the Ngong weather station report, Opole (2013), which recorded 27 years of below average rainfall and 27 years of above average rainfalls, indicating that the area could be prone to more drought years.

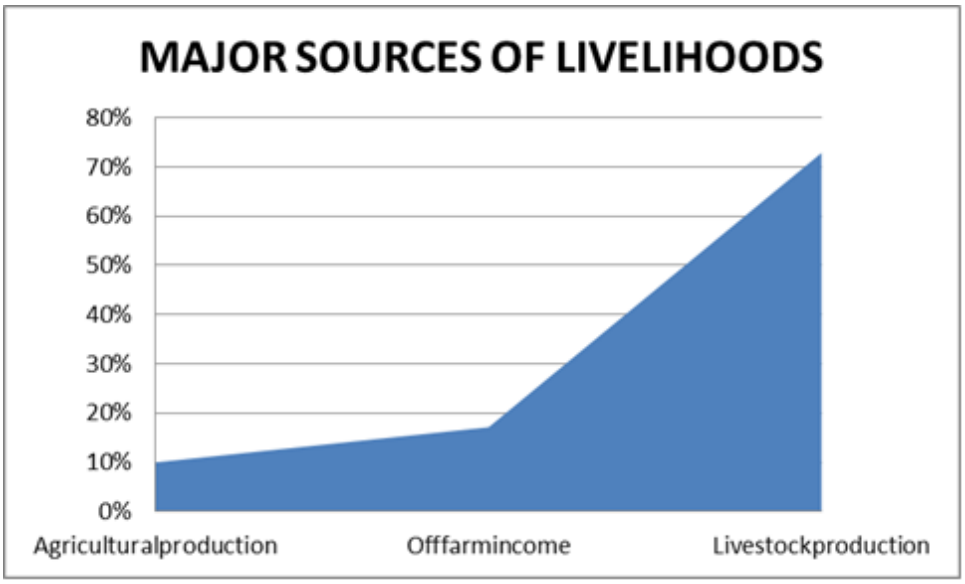
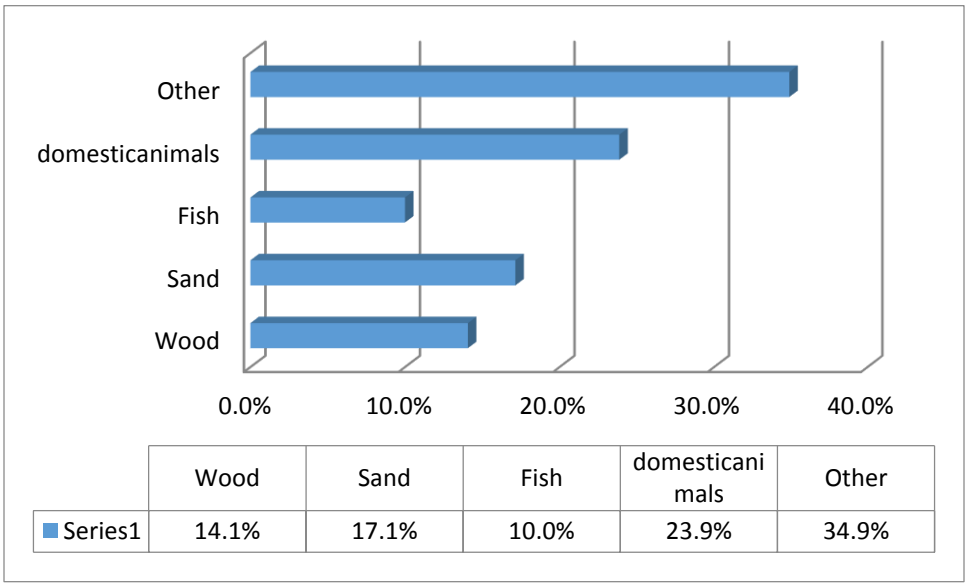


Figure 8: Major sources of livelihoods for the people of Magadi and Elang'ata Wuas



	Wood	Sand	Fish	domesticanimals	Other
Series1	14.1%	17.1%	10.0%	23.9%	34.9%

Figure 9: The resources upon which community livelihoods depend

According to Figure 8, the major sources of livelihoods for the respondents are livestock production (73%), off-farm activities (17%) and crop production (10%). This is an affirmation that the residents are mainly livestock farmers and depend on keeping cattle (cows), goats and sheep

for subsistence. Off-farm activities include small scale entrepreneurship and employment, among others. 10% of the respondents are engaged in crop agriculture in places where weather and soil conditions permit crop production as well as in some other areas where irrigation is practiced. Other livelihood activities that are practiced by the community, albeit on small scale, include sand harvesting, fishing (in rivers) and charcoal burning. All these are dependent on rain, and their levels of production may drastically reduce during seasons when the rains are low. Figure 8 shows key resources from which the community draws its livelihood. The community draws its living from domestic animals, wood, sand and in some instances fish. This is an indicator that the community is ready to diversify its livelihood base as an adaptation strategy.

The result under this objective is reaffirmed by the focus group discussion held in Magadi and Elang'ata Wuas which upheld the opinion that the livelihoods of indigenous nomadic pastoralists are largely dependent on their natural environment which is susceptible to any slight climatic changes. The Maasai community of Elng'ata Wuas and Magadi are therefore quite vulnerable and can be negatively impacted by climate change if proper adaptation and coping strategies are not put in place.

4.2 Vulnerability factors affecting Livelihoods and natural resources and the impact of changing climatic trends

According to Schilling (2014), the major vulnerability factors experienced by the community include inadequate land management systems, lack of reliable information regarding seasonal weather forecasts and limited livelihoods options. The most crucial resources that the community's livelihoods depends upon are seemingly under threat from climate change, further increasing their vulnerability as depicted in figure 10 below.

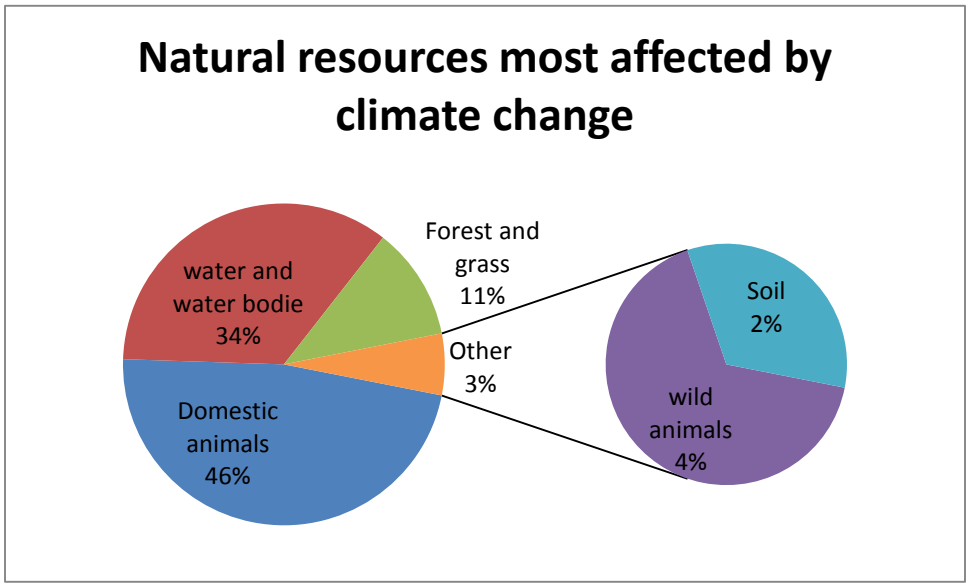


Figure 10: natural resources available in the community and how they are affected by Climate Change

The community's livelihood, like that of any typical indigenous group is so much dependent on natural resources as depicted in Figure 10. These resources are highly vulnerable to climate change and any slight change can cause disproportionate effects. The respondents ranked domestic animals the highest (46%) most affected resource that is particularly vulnerable to drought spells. Water bodies such as rivers, wells and pans gets quickly depleted and is ranked the second most vulnerable at 34%. This is followed by vegetation/forests and wildlife at 11% and 4% respectively. Whereas people resort to charcoal burning (for sale) to complement their traditional livelihoods, wild animals, a tourist attraction resource, either move to better places or die as a result of starvation. When these resources are threatened by climate change, then the livelihoods of the community becomes equally insecure.

All the above resources are all based on land, hence land becomes a very important factor in adaptation to climate change. Figure 11 to 13 present land as one of the primary resource whose management has over time accelerated community's vulnerability to climate change.

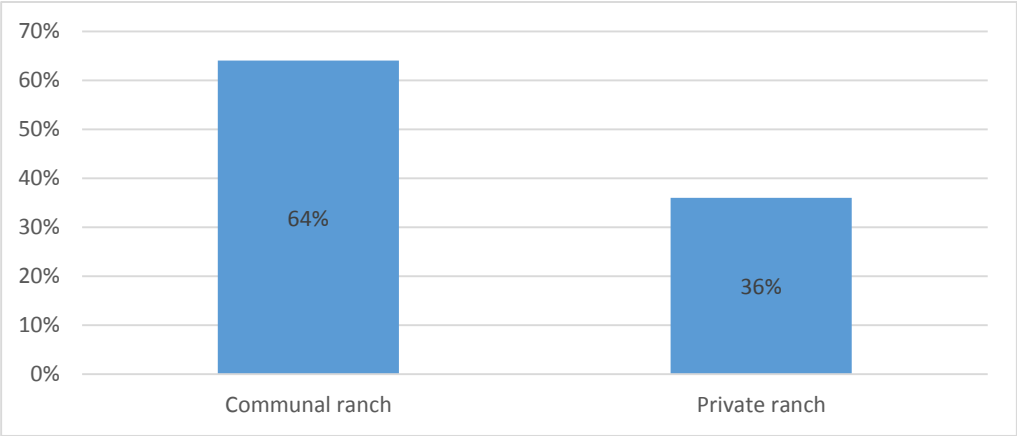


Figure 11: Settlement distribution as per the two main land tenure systems in the community

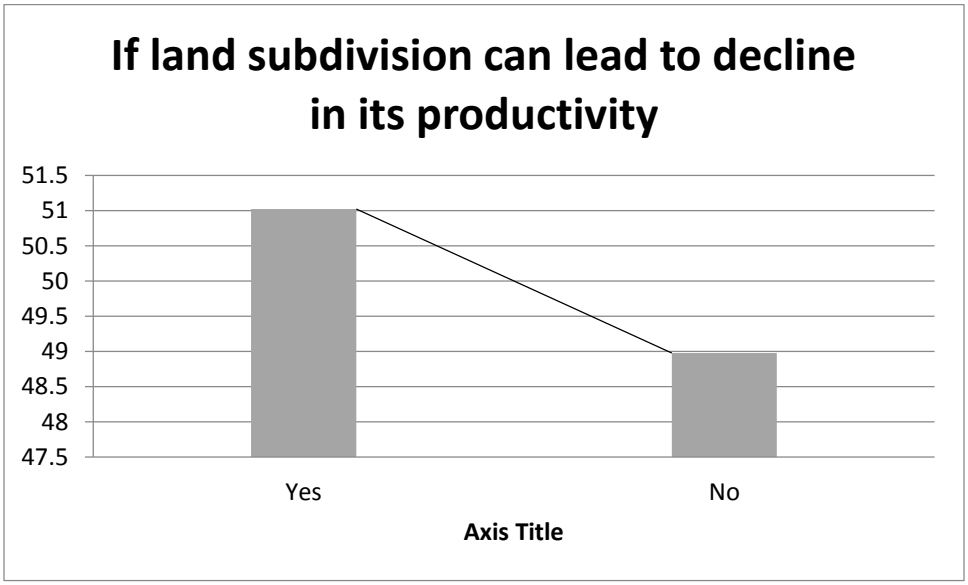


Figure 12: Perceived role of land sub-division in making the community more vulnerable to climate change

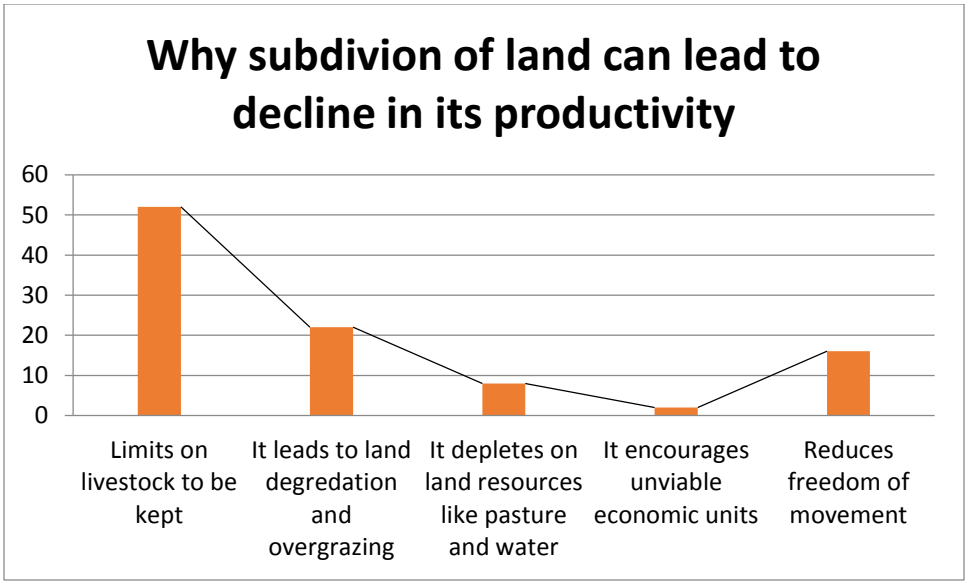


Figure 13: Reasons why sub-division of land makes the community more vulnerable to cc

Land is a factor that either cushions the community against the adverse effects of climate change or makes them more vulnerable depending on how it is being managed. In figure 11 above, 64% of the respondents are still under communal land ownership whereas 36% are in private ranches. Figure 12 shows that 51% of the respondents believe that land demarcation into individual ranches makes them vulnerable to climate change whereas 49% believe that it is not so. The reasons advanced by respondents opposed to sub-division of land are shown in Figure 13. This include the fact that private land regime limits the number of livestock to be kept hence reduces their chances of survival. The system, also reduces the scope of mobility and is prone to land loss through selling and grabbing. As opposed to communal land tenure, private ranches cannot be effectively managed through the traditional 'Olokeri' system of grass management. On the other hand, subdivision of land according to 49% of the respondents offers an opportunity for better pasture management and the quality and quantity of livestock to be kept. These are opposed views that divide the community opinion almost in the middle and may require further research to determine what land tenure system is ideal for the community especially in the view of climate change adaptation.

According to Pastoralists Development Network of Kenya (PDNK, 2012), the inappropriate land management policy for the ASALs has exacerbated the impact of climate change by eroding the traditional adaptation mechanism of the community. Sub-division of arid lands into small uneconomical units in these regions continues to curtail nomadism that has been used over years for environmental management and consequently adaptation to unfavorable seasons. These policies, therefore, erode the climate change resilience capacities of the pastoralists.

Figure 14 and 15 shows the indicators of climate change and how it has affected the people's livelihoods.

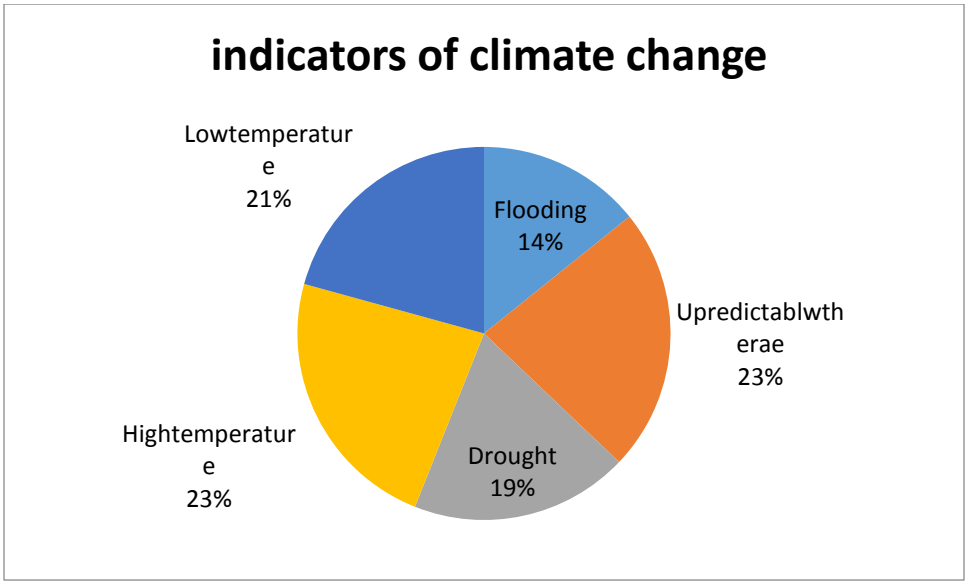


Figure 14: Major indicators of climate change

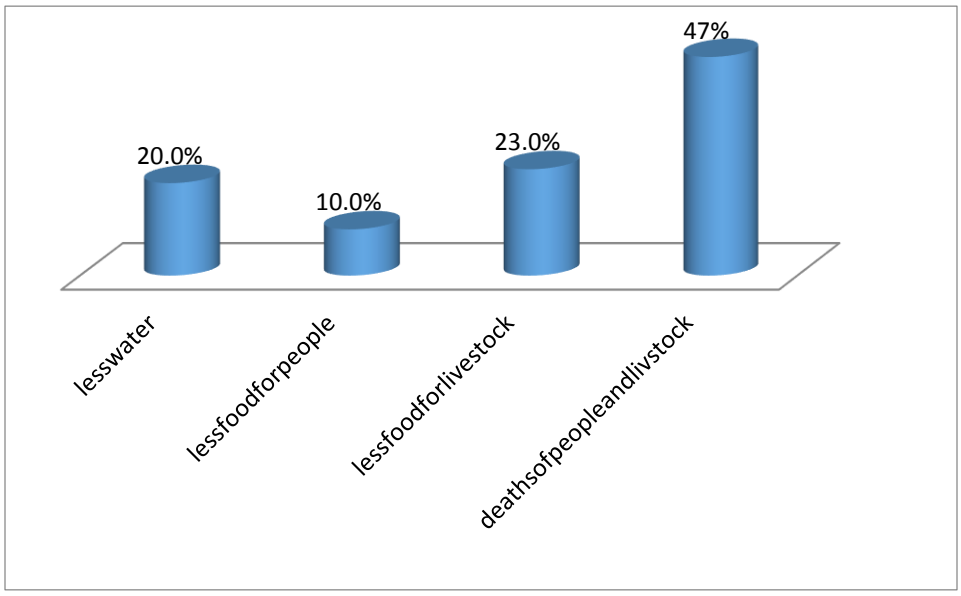


Figure 15: Ways in which Climate Change affect people

The respondents note in figure 14 that the key indicators of climate change is high temperatures and unpredictable and erratic weather patterns (both at 23%). Low temperatures was also noted by 21% of the respondents, meaning that there has been extremity in both high and low temperatures. The result of these manifestations is the prevalent drought noted by 19% of the respondents and floods by 14% of the respondents. This can be attributed to the flash floods that normally occur after a dry spell. This has directly impacted on people and livestock where 47% of the respondents said that it had caused deaths. The rest (23%) of the respondents indicated that there had been diminished food for people and forage for livestock, as well as water (20%).

The focus group discussion in Magadi revealed that the Maasai community has decided to engage in other livelihood activities that are not traditional to the community. The nearby permanent Ewuaso Nyiro river, provided delicious mud fish which the community has learnt to adopt as source of food protein after losing their livestock in droves due to the frequently recurring droughts. This was corroborated by Neighbors Initiatives Alliance (NIA), a local NGO that supports the community in the areas of governance, food security, livelihoods development, water

and sanitation. According to Kenny Matampash, (Director, NIA), the organization has been encouraging the community to diversify its livelihoods to widen its coping capacity to droughts and other climate change impacts.

4.3 Capacities, opportunities and challenges available in coping with climate related disasters

This objective sought to establish the community's existing capacities, gaps and challenges in the current coping strategies based on knowledge and access to information, indigenous early warning systems, and traditional coping mechanisms. Figure 16 depicts the respondent general knowledge of whether or not they have noted any change in climatic trends.

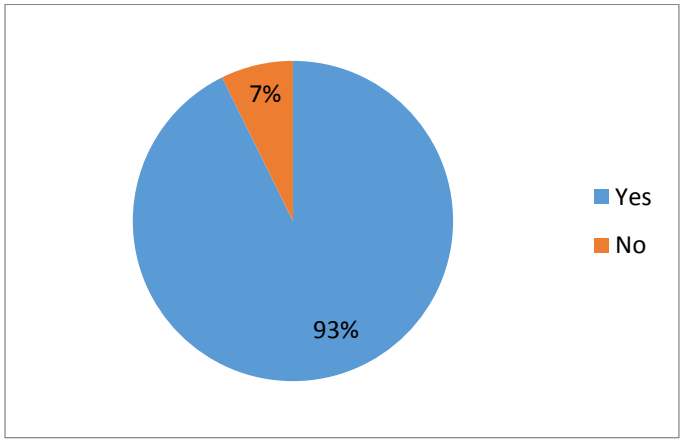


Figure 16: Whether or not they are aware about climate change

The community affirms to the fact that climate change is not only real, but that it is here to stay with them. As shown in figure 15, 93% of the respondents acknowledged that they are aware of climate change while the rest (7%) are not aware. This awareness is based on what they have heard through media and various forums as well as what they have observed and experienced themselves.

Figures 17 and 18 further elaborate how the respondents related their understanding of climate change with precipitation variability showing whether or not the weather has been getting drier or wet over the years. The stated percentages represent population. It shows their opinion on how the weather has been getting drier or wet.

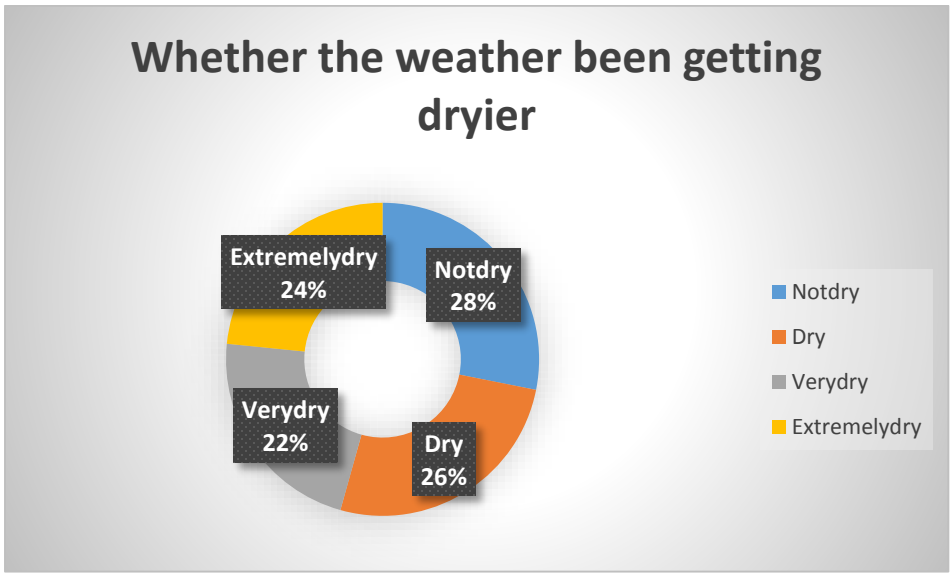


Figure 17: Whether or not the weather has been getting drier over time

Figure 17 depicts that 24% believed that the weather has actually been getting extremely dry, 28% very dry, 26% dry and 22% fairly dry over the last few decades. As confirmed by Opole (2013), there has been increased rainfall variability in Kajiado County leading to increased drier seasons.

Figures 18 and 19 show the available early warning systems used in the study area.

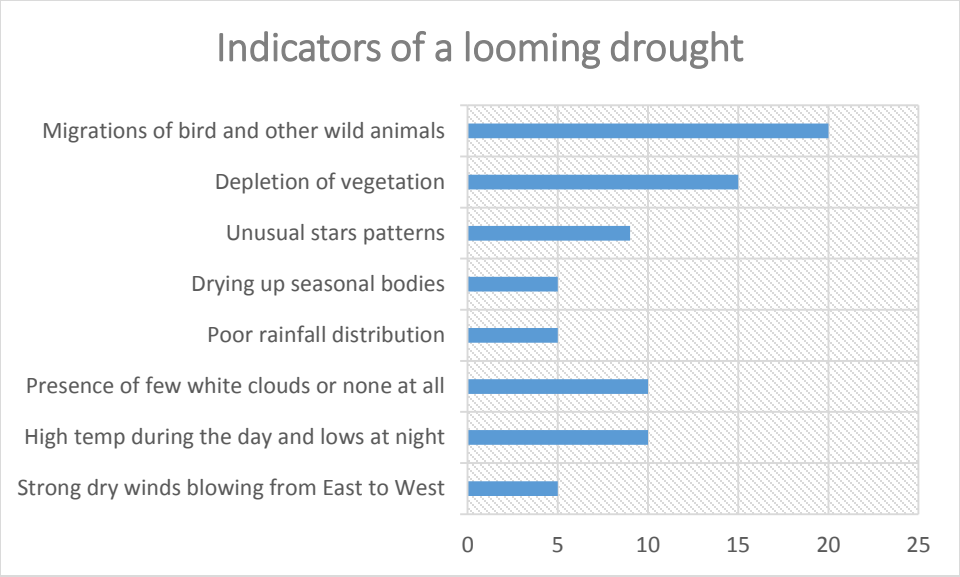


Figure 18: Indicators of a looming drought according to the respondents

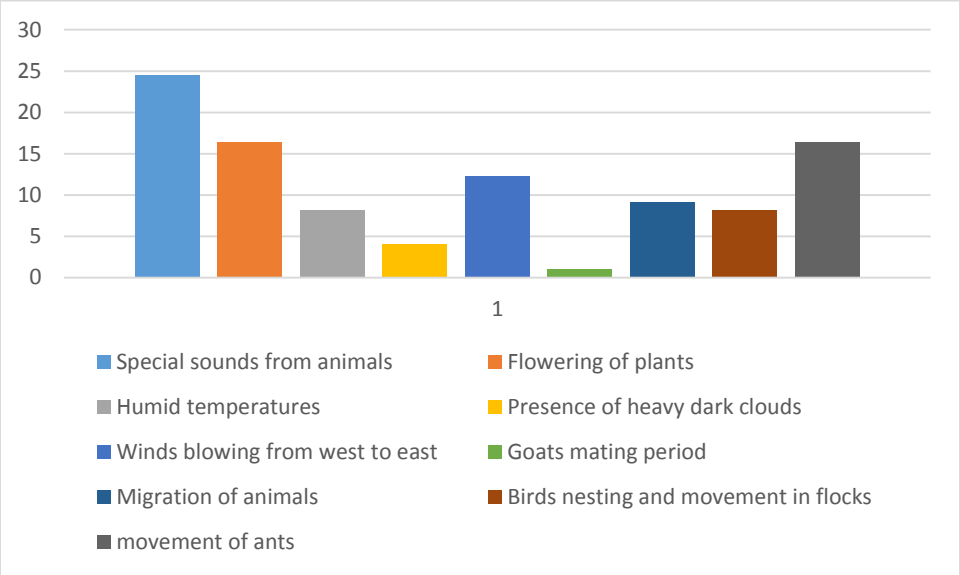


Figure 19: Indicators of a looming rainfall season

The most commonly used indicator by the community to depict possibility of no rains (Figure 18) is the migration of birds and animals (20%). In addition, appearance of unusual star patterns (9%) in the galaxy can be interpreted by experts of indigenous knowledge to tell whether it will rain or not. Other indicators include early depletion of vegetation (15%), drying up of streams/water

sources (5%), unusually high temperatures (10%) and dry winds blowing from east to west (5%). The significance of the wind direction is the moisture content it carries depending on the direction it is blowing from.

On the other hand, indicators of a looming rainy season as shown in figure 19 include special sounds made by animals (24%), movement of birds, ants and animals, flowering of plants (16%) and change of wind direction (12%).

The traditional community coping mechanism are presented in Figure 20.

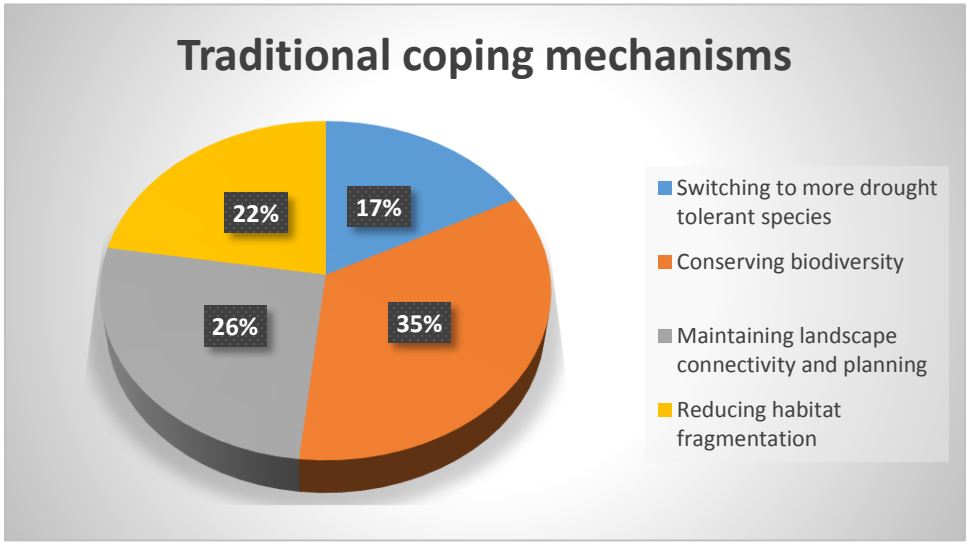


Figure 20: Strategies traditionally used to cope with climate change.

The communities had in the past used various strategies to build their resilience against effects of climate variability. The communities have been keen in selecting the drought tolerant breed both for livestock and crops (17%) that can withstand harsher conditions. Other strategies used have been to conserve biodiversity (35%) and landscapes/resource planning (26%) and reduce land fragmentation (22%). Conserving biodiversity entails the conservation of wildlife (for tourism purposes) and certain species of trees that becomes an essential source of fodder during the dry

season. Maintaining landscape connectivity and planning is the strict management of geographical areas that are rich with natural resources and can be useful in coping with climate vulnerability. Such areas include but not limited to wetlands, mountains, forests and riverine.

During the focus group discussions, it was noted that the community is rich with indigenous knowledge, particularly with regard to weather forecasting. Indeed the community perceived that in some cases the Indigenous Knowledge forecasts were more accurate than the departments' forecast. This is the knowledge that the community has depended upon for adaptation and coping with harsh climatic conditions and environments. It is based on the environment and biodiversity and therefore changes of the environment and biodiversity will deal a big blow to this invaluable knowledge. Furthermore, from the focus group discussions held in both Magadi and Elang'ata Wuas divisions, it emerged that the participants knew that all was not the same as far as the weather predictability and reliability was concerned. They were, however, not aware of what the causes were, whether a natural phenomenon or due to human activity.

However, the local NGO's are making attempts to bridge this gap by sensitizing the community about climate change, its causes and how to cope with it. Most of the organizations' objectives are informed by the challenges related to climate change impacts. For example, Dupoto E Maa organization is working on renewable energy such as solar, energy saving jikos and other appropriate technologies that would relieve the environment of the stress. Other strategies being promoted include use of greenhouses (established 14 greenhouses) where green vegetables are grown with minimal irrigation to compliment livestock food products. This has improved community nutritional status and ensured food security even in time of drought.

4.4 Proposed adaptation and coping strategies for mainstreaming climate risk management into the policy framework

This subsection, proposes coping and adaptation strategies for mainstreaming climate risk reduction into the policy framework so as to minimize the adverse effects of climate variability on community's livelihoods. Figure 21 presents the type of land tenure system in which livestock have better chances of survival.

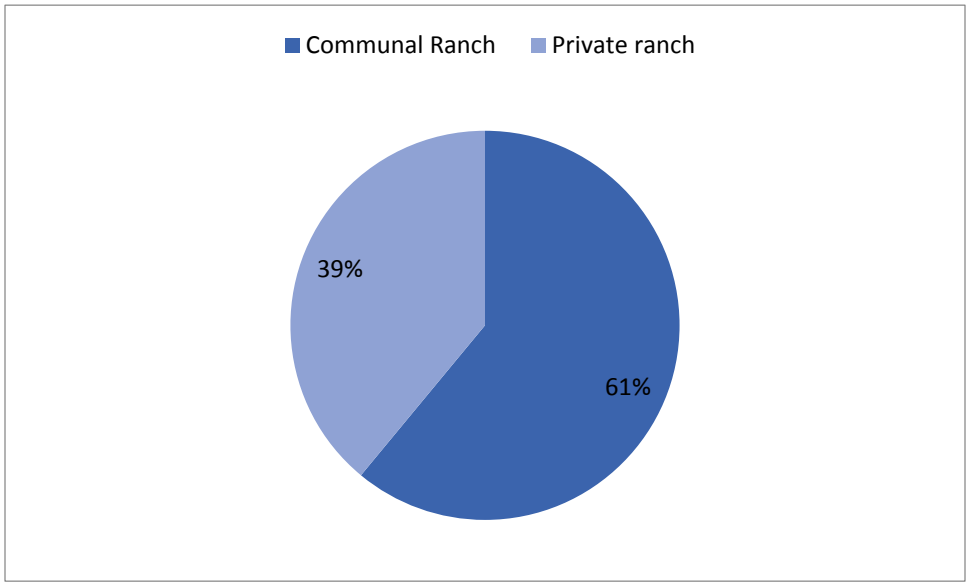


Figure 21: The type of land tenure where livestock have better chances of survival

Figure 11 in section 4.2 shows that the two main prevailing land tenure systems are communal land (64%) and private land (36%). The communal land ownership is mainly concentrated in Magadi area and which has got four group ranches, namely Shompole, Olkiramatian, Oldonyokie and Olkeri. The private land ownership is mainly concentrated in Elang'ata Wuas where the land was demarcated in 2005 and individuals possess title deeds as proof of ownership. According to the respondents, 61% believed that animals have a better chance of survival in communal lands while 39% believed that they are better off in private ranches.

In Fig 21, respondents from the areas where land has been sub-divided (that is Elang'ata Wuas area) feel that they are more vulnerable and can easily lose their livestock in case of a drought. The respondents therefore are of the view that undivided ranches should remain as a way to cushion them against drought. According to (Klein and Roehrig, 2006), reduction of the size of the land without adjusting the quantity of livestock depended on it will affect forage quality and quantity making the livestock susceptible to hunger and drought. The size of land is key to the survival of livestock and be extension the community. The expansion of grazing range together with the adjustment of wandering of herds is a traditional way of adaptation. It is an inherent feature of pastoralism to drive the livestock according to pasture and water ability and hence follow the seasonal pattern of rains (Butt et al. 2009)

Figure 22 presents strategies for enhancing coping capacities among the Maasai community that the government and other relevant authorities need to integrate in their plans and policies. Diversification of livelihoods to include irrigation, fishing among others is one of the ways that the community can use to adapt to climate change.

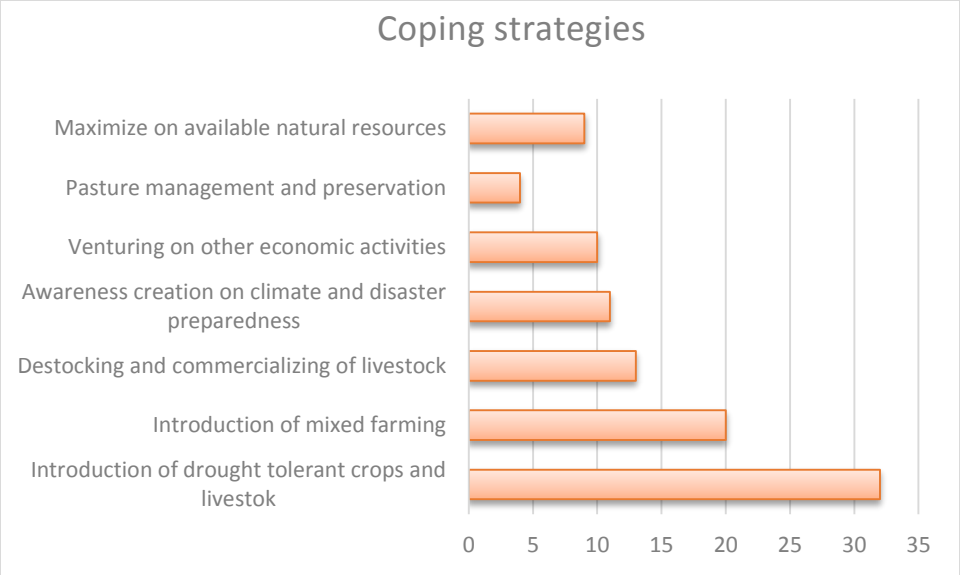


Figure 22: Strategies for enhancing coping mechanism

33% of the respondents believe that introduction of drought tolerant species of both livestock and crops (where feasible) would help to cope with the effects of climate change. Proposed species that need to be preserved are the red Maasai sheep and the indigenous zebu cows. This has in the past been slowly eroded by the introduction of doper sheep and sahiwal cows which are of higher value but vulnerable to drought. In addition 20% of the respondents suggest the need to diversify livelihoods and practice mixed farming to compliment the traditional livestock keeping. Commercialization of livestock farming was proposed by the 13% arguing that keeping cattle in the traditional context will lead to overstocking, land degradation and increase vulnerability to drought. Awareness creation on climate change and proper disaster preparedness was vouched by 11% of the respondents. The rest of the respondents advocated for proper pasture and natural resource management, 4% and 9% respectively.

These interventions has to a greater extent worked in arid and semi-arid areas such as the Southern region of Ethiopia. According to (Esikuri, 1999) the Borana pastoralists in Ethiopia has integrated

livelihoods where they undertake crop irrigation as well commercialize livestock production. This can be replicated in kajiado as it has similar conditions.

Figure 23 presents specific areas that the respondents felt that the government should address so as to enhance the community's resilience to climate change.

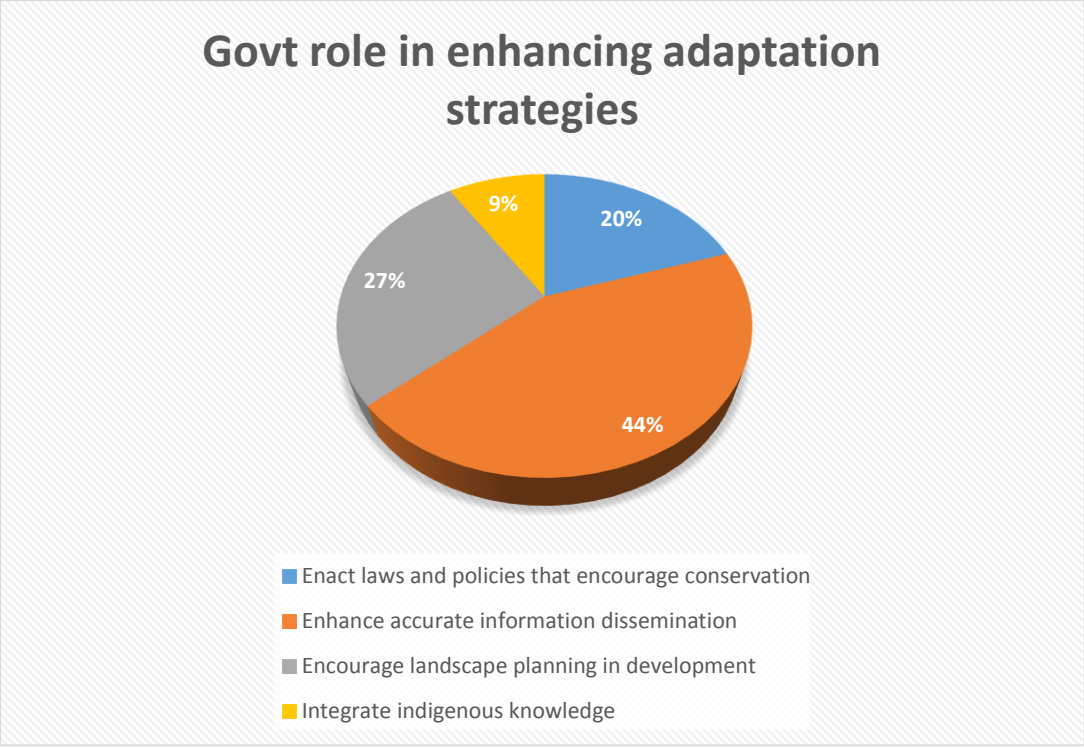


Figure 23: Ways in which the government can address the challenges and enhance coping mechanism

Information dissemination is key and 44% would want the government to provide accurate and timely weather/climate related information in a simplified and understandable version, possibly use of local language. Such information would enable farmers to make informed decisions on the next course of action such as whether or not to migrate, destock, breeding among others. Integrating landscape planning in development is important as proved by the 27% of the respondents who feel that proper land management should be mainstreamed in a way that it

enhances the resilience of the community. The respondents also strongly believe conservation of nature is important in the adaptation process and 20% of them suggest that the government should put in place the right laws and policies to that effect. Although there is existence of such laws as National Policy for the Sustainable Development of Arid and Semi- Arid Lands is highly relevant for climate change adaptation (GoK 2007b), it is not well known to the community. In spite of this policy, the county integrated development plans of Kajiado county government especially those based in arid and semi-arid areas are still devoid of systematic climate change intervention.

According to the National Climate Change Action Plan (GoK, 2012), there is need to develop a legal framework to operationalize the action plan. Among other things, the Climate Change 2014 Bill was envisaged to establish a climate change authority as well as provide a legal and institutional framework for climate change mitigation and adaption efforts. This however, is yet to be realized.

Indigenous knowledge on climate change was proposed by the 9% of the respondents to be integrated into the conventional adaptation plans. The government's role, however, is not sufficient both in terms of sensitization and/or adaptation programs. Both the County and National government need to be proactive in promoting adaptation options such as irrigation programs, intensive livestock marketing, eco-tourism initiatives among others.

These views were also echoed by the Center for Indigenous Women and Child (CIWOCH) based in Magadi and working with the community on using traditional land management system which are more resilient to climatic changes. The organization is of the view that the community is better off being placed under the communal land tenure system than private ranches, noting that arid and semi-arid lands are not economically viable if fragmented. It anchors its hope and that of the

community on the National Land Commission to develop progressive community land management policy that would safeguard the interest of vulnerable indigenous communities.

According to the respondents, the strategies of coping with climate change going forward would be for the government (both county and national) to formulate and enact policies that would integrate among others introduction of better livestock breeds and mixed farming to diversify livelihoods options. Mixed farming, where feasible, will help to compliment livestock production and provide safety nets to cushion the community from famine. All stakeholders should create awareness on climate change and available adaptation options. The community members should embrace proper livestock husbandry and practices such as destocking to reduce quantity and increase quality. There is also need to maximize on available natural resources, better pasture management and diversification of livelihoods.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents a summary of the study, highlighting the major findings, conclusions drawn from these results and recommendations for both future research and application at community and policy levels to address climate change related challenges among the vulnerable groups of the arid and semi-arid lands.

5.1 Conclusions

In conclusion, the study has established that there is indeed climate change trends taking place in Kajiado County. This coupled with other factors such as population growth, environmental degradation and land demarcation is set accelerate the community's vulnerability to climate change.

The study has also brought out salient issues regarding climate change and indigenous people's livelihoods. It affirms that the livelihoods of the Maasai are still largely based on animals such as goats, cows, and sheep and nomadic pastoralists for that matter. The livelihoods of indigenous nomadic pastoralists are largely depended on their natural environment which is susceptible to climatic changes. This study has established that the Maasai of Magadi and Elangata Wuas in Kajiado County strongly rely on the natural resources such as forage and water for livestock. They are also strongly depended on other biodiversity such as wildlife, forests, wet lands either for direct or indirect livelihood benefits. All these are therefore susceptible and sensitive to climate variability. The community under study therefore is vulnerable and will continue to be negatively impacted by climate change if proper adaptation and coping strategies are not put in place.

The study has since established that there are some vulnerability factors that would accelerate the negative impacts of climate change. These include inaccessibility to accurate and timely information, land tenure system and coping capacity gaps. It has also emerged that the Maasai community is so rich with indigenous knowledge regarding weather forecasting and traditional adaptation skills that are not promoted. Destruction of the environment and biodiversity therefore will deal a big blow not only to this invaluable knowledge but to the natural resources that constitute a lifeline for the Maasai community.

Whereas this study has established that the community has some capacity to cope with climatic changes, it is far much limited to match with the accelerating rate of climate change. The government and other non-state actors has got a big role to play in building the capacity of the communities to enhance its adaptation ability. As for now, there is a big gap between the government and the communities in as far as climate change adaptation is concerned. This has resulted in the lack of clear information dissemination, adaptation strategies, community participation as well as lack of a clear policy for mainstreaming issues of climate change into the development agenda, Reid *et al* (2009). The County Government need to take advantage of the devolution spirit of the constitution to initiate adaptation related projects and policy framework at the county level. The enactment of the climate change Act is long overdue and need to be fast tracked.

5.2 Recommendations

The finding of this study are critical in providing a benchmark upon which various sectors can base their decisions and actions. The government departments will get to understand better the perceptions of the community on climate change related issues and how it is affecting their livelihoods. This emphasizes the importance of community participation in all decision making processes and development initiatives. The non-sectors will find these findings useful and can base the established facts to justify resource mobilization for their short-term intervention initiatives. It will also be for the interest of the academia and research institutions to build on these findings and research further on the recommended areas, especially integrating science with indigenous knowledge.

All stakeholders involved in climate change adaptation interventions will find it necessary to fully engage the communities, respect their values and traditional knowledge as well as disseminate timely and accurate information to the communities.

Based on the findings of the study, it is evident that a lot need to be done to cushion the community from further exposure to the risks associated with climate change. This calls for a collective concerted effort by all stakeholders at all levels including the communities themselves to undertake the following:

1. Increased sensitization and awareness creation on climate change, causes and its impacts on the livelihoods of communities, by the government, research institutions, NGOs and individuals. Accessing such information is critical for the community's preparedness to deal with risks and disasters associated with climate change.

2. The government and all development agencies need to engage and involve the community more when developing policies regarding environment, land, climate change adaptation and general development to take up their views and integrate them into mainstream development.
3. Research institutions need to undertake more research and establish in-depth understanding of the indigenous knowledge associated with weather forecasting, adaptation techniques and other traditional knowledge for purposes of creating synergies of this knowledge with science to develop a robust knowledge system that can be up scaled to the entire country.
4. The government and development agencies build the capacity of community, institutions, groups and individuals and empower them to take control of the challenges occasioned by climate change and provide homegrown solutions on the best ways to adapt to such circumstances. The communities should embrace the concept of fodder farming, diversification of livelihoods and commercialization of livestock farming.
5. While the government and development agencies are already providing short term interventions such as drilling of well and livestock off-take programs, this is still insufficient as it is hindered by limited resources. There is need to allocate more resources for such interventions that promote resilience and adaptation.
6. Areas recommended for further study is the in-depth understanding of the role of indigenous knowledge and culture in climate change adaptation, the effect of land demarcation to pastoralists in the face of climate change and the effect of maladaptation practices propagated by both state and non-state actors.

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7. Annexes

Annex1: Research Questionnaire

Impacts of Climate Change on Indigenous Peoples' livelihoods: a case of Loodokilani Maasai, Kajiado County, Kenya

This survey is being conducted by **Daniel Salau Rogei** in partial fulfilment of the requirements for the **Master's degree in Climate Change of the University of Nairobi.** The information given herein will be

PLACE OF INTERVIEW	
SEX	MALE ☐ FEMALE ☐
AGE	18-24 ☐ 25-29 ☐ 30-34 ☐ 35-39 ☐ 40-55 ☐ > 55 ☐
HIGHEST LEVEL OF EDUCATION REACHED	None ☐ Secondary education ☐ Primary ☐ College education ☐ University education ☐ Other. Specify……
CURRENT OCCUPATION	Public servant ☐ Employed in private sector ☐ Private investor ☐ Student ☐ Farmer ☐ civil society ☐ Retired ☐ Self employed ☐ Other, Specify_____
LOCATION*(current location of residence)*	
GROUP RANCH	

treated with strict confidentiality. The identity of the respondent and all matters connected with the responses are confidential and shall not be disclosed to any other parties safe for research purposes only.

LIVELIHOODS & AWARENESS ON CLIMATE CHANGE

1. What are your major sources of livelihood?
a.) Livestock production☐
b.) Agricultural production ☐
c.) Off-farm income (most people are employed) ☐
d.) Income from business (including regular trading of livestock or hides☐
e.) Other.....

2. What are the most crucial natural resources upon which your key livelihoods depend?

a.) Water ☐
b.) Wood/forests☐
c.) Wildlife ☐
d.) Wind/solar energy ☐
e.) Hydro-electric energy☐
f.) Iron ☐
g.) Sand ☐
h.) Fish ☐

i.) Domestic Animals☐
Other (specify)……

3. In your opinion, which of the natural resources in (2 above) are the most affected by climate change related changes and in which way?

.....
.....
.....

4. Have you noted any changes in the weather/ climate of this locality? a) Yes----- b) No -----

5. Has the weather/seasons been getting drier leading to severe droughts in the last 10 years? If your answer is (a), then go to question 6 (otherwise skip it)

a) Not dry

b) Dry

c). Very dry

d) Extremely dry

6. Has weather/seasons been getting wetter leading to floods in the last 10 years?

a). Not wet

b). Wet

c). Very wet

d)/ extremely wet

7. In which way has the changes above affected you? (Tick all that apply)

a) Less water. ☐
b) Less food for people ☐
c) Less food for livestock ☐
d) Deaths of people and livestock ☐
e) Other.....

8. In which way (s) can the governments assist you in addressing these challenges? (Tick *as many as applicable)*

a) Enact laws and tax policies that ☐ encourage energy conservation
b) Increase investments in public ☐ transportation
a) Encourage development patterns ☐ that minimize sprawl.
b) All of the above ☐
c) Other.....

Climate Change coping capacity and Vulnerability factors

9. What are the major consequences of climate change that you encounter in this area?
a). Flooding☐
b). Unpredictable Weather☐
c). Droughts☐
d). High temperatures ☐
e). Low temperature

10. Which of the following strategies do you use to cope with climate change related impacts?

a.) switching to more drought tolerant agricultural crops☐

b.) increasing use of irrigation in crop production in areas expected to become more arid☐

c.) conserving biodiversity☐

d.) maintaining landscape connectivity to aid vegetation and wildlife migration☐

e.) reducing habitat fragmentation☐

f.) actively managing species that can adapt to climate change☐

11. Name three signs/indicators that are traditionally used to determine that there is bound to be a bad drought?
a) ……
b) . …….
c)……

12. Name three signs/indicators that are traditionally used to determine that there is bound to be rain after a long period of drought?

a). ……..

b)…….

c)……..

13. Where do you live?
a.) Communal Ranch ☐ b.) Private ranch ☐

14. In which landholding do you think livestock have a better chance of survival in the face of climate change?

a.) Communal Ranch ☐ b. Private ranch ☐ none.

Explain

……
……
……

15. Do you think subdivision of land can lead to decline in its productive capacity and ability to support pastoral livelihoods?

a.) Yes ☐ b.) No ☐

Explain

……
……
……

16. What do you think need to be done in order to enhance the coping capacity of the Maasai community with the adverse effects of climate and climate change?

.....
.....
.....

Thank you for your time & interest in responding to this questionnaire.

Annex 2: Monthly Rainfall Data at M.S.W. Meteorological Station, 1964 – 2014

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total

1964	24.5	48.3	55.7	149.6	27.4	1.7	24.9	21.4	2.3	9.1	23.7	9.8	398.4
1965	19.5	57.1	72.7	157.0	20.7	0.5	0.0	0.0	14.3	69.1	10.8	55.6	477.3
1966	6.7	69.0	140.7	139.9	23.7	1.7	0.0	3.2	4.9	5.8	17.9	15.9	429.4
1967	0.0	18.4	5.9	159.1	90.1	0.2	1.5	6.3	7.7	18.0	30.5	81.5	419.2
1968	0.0	69.5	145.6	175.0	9.3	11.0	0.2	0.0	5.7	11.7	71.2	16.0	515.2
1969	99.9	59.9	32.2	13.0	96.3	1.0	0.0	1.7	1.1	19.4	56.1	6.4	387.0
1970	134.8	48.8	190.7	197.8	69.2	0.0	0.4	0.0	3.2	5.0	19.0	16.3	685.2
1971	63.0	13.0	35.0	130.7	76.3	0.0	15.0	18.3	0.0	15.2	26.9	146.6	540.0
1972	84.3	57.2	20.3	25.2	41.2	44.2	0.0	0.0	10.4	20.2	38.5	9.8	351.3
1973	111.6	50.5	0.0	100.9	12.5	9.8	0.0	1.3	20.5	7.5	31.1	25.7	371.4
1974	1.2	16.1	74.1	351.5	29.6	13.5	23.3	5.8	4.2	1.2	24.6	9.4	554.5
1975	21.8	15.3	58.4	111.9	86.5	0.0	27.7	0.0	17.0	23.9	11.6	104.6	478.7
1976	15.7	30.8	14.2	46.5	39.6	2.1	0.3	2.3	13.6	0.0	44.3	20.9	230.3
1977	60.8	52.7	16.5	236.7	101.8	1.9	17.6	2.4	0.2	18.6	78.6	52.5	640.3
1978	52.1	180.4	121.4	13.8	0.0	0.0	0.0	11.7	10.1	25.5	44.0	68.2	527.2
1979	88.2	64.4	81.6	126.5	13.1	4.5	8.7	0.0	8.4	33.2	18.6	50.6	497.8
1980	5.4	47.7	58.3	172.4	1.4	0.0	1.8	10.2	2.7	14.9	23.1	5.0	342.9

1981	42.8	146.9	154.8	62.0	0.0	0.0	0.0	4.9	19.2	19.8	15.8	4.6	470.8
1982	37.4	35.7	97.8	37.9	1.5	0.8	0.0	3.6	15.1	111.6	87.3	6.6	435.3
1983	92.0	7.3	12.9	20.4	5.2	1.4	0.5	3.1	41.4	25.1	41.8	74.8	325.9
1984	2.5	0.0	166.0	13.2	0.0	1.3	0.0	0.0	11.2	45.5	55.5	0.8	296.0
1985	88.9	72.5	131.3	21.7	2.3	0.0	0.0	0.0	24.9	24.9	21.8	60.3	448.6
1986	61.0	21.6	30.5	91.3	72.0	1.2	0.0	0.0	8.1	12.0	32.9	29.4	360.0
1987	77.9	27.7	47.3	66.7	55.5	25.4	6.2	0.0	6.2	0.9	75.4	7.6	396.8
1988	59.2	22.9	108.8	102.4	11.2	16.0	0.0	14.6	3.0	12.5	22.3	67.0	439.9
1989	48.0	31.4	73.1	199.0	95.9	2.4	2.7	2.7	37.0	16.6	2.9	161.7	673.4
1990	34.2	107.5	81.7	111.3	23.3	0.2	3.4	2.8	9.3	18.0	31.0	41.5	464.3
1991	21.9	25.7	67.1	97.9	21.2	8.9	3.4	3.3	9.3	17.2	46.9	39.3	361.9
1992	27.0	49.1	53.4	95.6	16.6	2.5	9.3	3.5	9.3	18.3	25.4	55.6	365.3
1993	66.0	52.2	47.9	29.0	80.5	20.2	0.0	3.6	9.2	19.9	40.2	46.1	414.8
1994	38.9	59.6	81.1	103.8	53.9	2.1	3.9	4.3	9.3	22.5	72.0	31.4	482.8
1995	43.9	40.3	96.9	59.4	75.9	6.1	4.5	3.7	9.6	29.0	38.4	25.9	433.5
1996	37.9	61.5	95.8	71.2	6.8	26.0	4.1	3.9	9.3	14.1	50.5	5.0	386.2
1997	36.7	24.7	55.7	178.2	76.2	0.0	3.7	4.0	9.2	26.8	91.9	57.6	564.7
1998	115.8	72.6	36.7	98.3	111.4	12.9	7.6	3.6	9.4	13.4	18.1	21.0	520.8
1999	37.2	24.3	164.4	58.5	8.1	0.0	3.5	4.0	9.5	17.8	75.5	71.1	474.1
2000	38.5	28.3	58.0	62.4	6.5	0.0	3.3	3.3	9.6	19.2	44.0	46.3	319.4
2001	121.1	49.3	51.0	103.1	10.6	3.5	5.6	3.7	9.5	22.3	42.6	49.8	472.3

2002	62.1	45.9	73.9	104.0	78.3	0.0	4.1	3.7	9.5	27.2	80.8	95.6	585.2
2003	52.1	47.3	55.5	107.7	141.9	0.1	4.0	4.4	8.1	18.8	25.7	24.4	490.0
2004	41.3	49.1	86.3	161.2	39.9	0.0	3.2	3.2	9.8	15.6	27.7	49.5	486.7
2005	30.8	39.3	96.7	68.7	66.5	0.0	4.4	3.6	4.2	17.4	25.8	23.6	381.1
2006	39.1	43.8	91.6	146.4	28.9	0.0	4.4	3.9	24.7	13.4	98.9	79.9	575.0
2007	52.5	67.8	57.6	73.6	50.1	4.2	4.1	3.7	10.1	15.5	28.4	34.3	402.1
2008	37.7	50.4	122.9	72.5	0.4	0.0	4.1	3.9	15.9	29.9	47.1	19.3	404.1
2009	44.0	33.1	40.6	82.0	55.9	6.9	3.9	3.5	11.7	23.0	36.2	67.7	408.6
2010	58.5	53.2	73.2	61.3	59.4	1.1	3.6	3.9	10.2	27.7	39.4	31.1	422.6
2011	46.4	36.2	89.8	34.8	26.5	7.1	4.6	4.0	10.5	56.6	66.1	77.1	459.7
2012	16.5	15.3	15.8	150.2	72.4	10.3	0	13.7	0	22.5	49.7	36.7	403.1
2013	9.3	0	186.9	144.8	106.5	15	0.5	0	0	36.5	42.2	160	701.7
2014	5.2	18.5	120.5	21	8.6	0	0	30	2.9	333	84	0	623.7
MEAN	**59.9**	**59.7**	**183.2**	**207.4**	**104.6**	**8.4**	**5.3**	**8.9**	**11.7**	**152.5**	**99.8**	**43.8**	**449.3**

Source: Magadi Soda Weather Meteorological Department, 2015