AGRO-PASTORAL COPING STRATEGIES TO CLIMATE CHANGE AND VARIABILITY IN ILEMELA AND MAGU DISTRICTS

EMMA LASWAI

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE, MOROGORO, TANZANIA.

2014

ABSTRACT

Effects of climate change vary across regions, farming systems, households and individuals. Agro-pastoralists, through experimentation over time, have developed different strategies to cope with climate change and variability. In Ilemela and Magu Districts, little has been done in evaluating coping strategies developed to address the impacts of climate variability to agro-pastoralism and the socio-economic factors influencing their coping capacity. This study therefore highlighted on the coping strategies that agro-pastoralists in the two districts are employing to counteract the effects of climate change and variability. Data were collected through focus group discussions and in-depth interviews using questionnaire which was administered to 120 households in selected villages. Analysis was through descriptive statistics, multinomial logistic regression model, complemented with the time-series analysis of annual and seasonal climatic values. The results of analysis indicated that households were aware of climate variability and mentioned increase in unpredictability of rainfall patterns, decline in natural forest cover, disappearance of some species, increase in temperature and incidences of droughts leading to drying-up of some rivers and springs as indicators of climate change. The available coping strategies included migration (87%), diversification of activities (78%), splitting herds (55%), making boreholes (50%) and using tap water (65%). The socio-economic factors that significantly influenced the adaptive capacity ($p<0.05$) were herd size, number of years lived and age of the head of household as they had a significance level of 0.032, 0.047 and 0.011, respectively. The study recommends a need for appropriate interventions ensuring management of rangeland and water availability so as to improve livestock productivity. Socio-economic factors spotted can be a determining factor in upgrading and introduction of more advanced technologies and or strategies.

DECLARATION

I, Emma Laswai, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

Laswai — 17/11/2014.

Emma Laswai — Date

(MSc. Candidate)

The above declaration is confirmed:

Kashaigili — 17/11/2014

Prof. J.J. Kashaigili — Date

(First Supervisor)

Abdallah — 17.11.2014

Dr. J.M. Abdallah — Date

(Second Supervisor)

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ACKNOWLEDGEMENTS

I am greatfull to God almighty for his love, guidance and protection that brought me this far. My sincere heartfelt appreciations are expressed to my parents Prof. and Mrs. H. S. Laswai, for their love and financial support throughout the course of this study. In addition, I am sending my sincere gratitude to the Lake Victoria Research (VicRes) Program for funding my research work.

I also would like to express my heartfelt gratitude to my two supervisors Prof. J. J. Kashaigili and Dr. J. M Abdallah of the Faculty of Forestry and Nature Conservation whose valuable and untiring efforts, guidance, inputs, corrections and close follow-ups led to the success of this dissertation.

I am very thankful to all the instructors in the Faculty of Forest and Nature Conservation particularly in the Department of Forest Economics for their valuable comments during seminar presentations and support offered during the entire period from proposal writing to completion of this dissertation. I am indeed thankful to my friends and course mates for their support and assistance.

My sincere gratitude to staff (agriculture and livestock officers) from the Magu District offices, Mwanza city offices and Ukiriguru, Ukerewe, Mwanza Airport weather stations for their cooperation in providing all the necessary information for this study.

Lastly, to my siblings Constancia and Mathias, whom always I owe a lot for helping and encouraging me whenever I felt like despairing and to my beloved daughter Aristidia for her tolerance of staying away from my attention during the period of study.

DEDICATION

This research work is dedicated to my parents Professors Germana and Henry Laswai, my siblings and daughter Aristidia for their love and support in diverse ways and for always being there for me.

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LIST OF ABBREVIATIONS AND ACRONYMS

AfJARE	African Journal of Agriculture and Resource Economics
CCAFS	Climate Change, Agriculture and Food Security
CGIAR	Consultative Group on International Agricultural Research
DRSRS	Department of Resource Surveys and Remote Sensing
EAC	East African Community
FAO	Food and Agriculture Organization of the United Nationsz
FGD	Focus Group Discussion
GCAPP	Global Climate Adaptation Partnership and Partners
GCM	Global Circulation Model
GDP	Gross Domestic Product
GWI	Global Water Initiative
IDP	Internally Displaced Persons
IIED	International Institute for Environment and Development
ILCA	International Livestock Centre for Africa
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
Lat	Latitude
Long	Longitude
l	Litres
LVB	Lake Victoria Basin
MEA	Millennium Ecosystem Assessment
NAPA	National Adaptation Program of Action
NAWAPO	National Water Policy
NPV	Net Present Value

NRSP	National Rural Support Programme
NSCA	National Sample Census of Agriculture
OSSREA	Organization for Social Science Research in Eastern and Southern Africa
RWH	Rain Water Harvesting
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture
SWMRP	Soil-Water Management Research Programme
TAS	Tanzanian Shilling
TMA	Tanzania Meteorological Agency
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework for Climate Change Convention
URT	United Republic of Tanzania
VPO	Vice President's Office

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agro-pastoralism is a set of practices that combine pastoral livelihoods with crop production of crops such as millet, sorghum, maize, cotton, vegetables and pulses (annual legumes) (Mortimore, 2009). This system is extremely important and is the most prevalent land use in arid and semi-arid environments. Sixty-five percent of global dry land in Africa consists of grassland used for livestock production which supports livelihoods of 800 million people (Mortimore, 2009). In sub-Saharan Africa alone, 25 million pastoralists and 240 million agro-pastoralists depend on livestock as their primary source of income. Most of them live in arid and semi-arid zones impacted by climate variation, particularly low rainfall and drought (IIED, 2010).

The East African Community (EAC) climate change policy (2011) defined climate change as the change of climate attributed directly or indirectly to human activity that alters the composition of global atmosphere addition to natural climate variability observed over comparable period. Climate variability refers to seasonal shifts in mean climatic conditions such as temperature and precipitation.

Climate variability and change are noted as a complex and interdependent environmental challenge facing the world today (Clark *et al.,* 2002; Obasi, 1997). African countries including Tanzania are among the most vulnerable countries to the impacts of climate change due to lack of or inadequate adaptation capacities, economic development and institutional capacity (IPCC, 2007). Climate variability and change may lead to decreased precipitation in semi-arid to arid areas, hence leading to vulnerability and food insecurity to most of the communities (Huq *et al.,* 2003).

The negative impacts associated with climate variability and change are also compounded by many factors, including widespread poverty, human diseases and high population density, which is estimated to double the demand for food, water, and livestock forage within the next 30 years (IPCC, 2007). Climate variability and changes are expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain (Apata *et al.,* 2009).

Climate variability is an intrinsic feature in the arid and semi arid areas of Lake Victoria Basin (LVB) and Mwanza Region in particular (Niboye, 2010). The area frequently suffers from the devastating impacts of floods and droughts. Rains help to break a multiple year drought. Drought seriously damage crops, livestock and infrastructures, with serious financial costs which most part of the region are neither prepared for nor able to afford repairing the damage. Rainfall seasonality affects livestock ecosystem structure and function and has always influenced low livestock production (Stakhiv and Stewart, 2010). The reliance on the seasonal availability of pastures and water has led to overall low reproduction, light weight at slaughter and poor quality products that do not fetch good price in the market this may indirectly lead to low food security.

While the impacts of climate change have been more evident (IPCC, 2007), there is limited understanding on the perceptions, vulnerability and adaptive capacities of different communities such as in the agro-pastoral communities along LVB. Although some substantial research undertaken by Lema and Majule (2009), Thornton *et al.* (2010) and Below *et al.* (2012) improve our understanding of complexities with regard to addressing climate variability and change, there are significant knowledge gaps regarding the understanding of agro-pastoralist' perceptions, coping and adaptation patterns which

are likely to result from climate variability and change. In addition, it is not clear to what extent the climate variability has influenced water availability in the LVB. This study contributes to addressing these gaps based on experiences from agro-pastoral communities in the selected study areas within the LVB as a way of informing appropriate interventions.

1.2 Problem Statement and Justification of the study

1.2.1 Problem statement

In the year 2010 livestock contributed about 13% per cent of the Agricultural Gross Domestic Product (GDP) in Tanzania with forty percent (40%) of the agricultural households being involved in crops and livestock production (agro-pastoralism) as documented in the Livestock Sector Development Strategy of URT (2010). Livestock is concentrated in the water scarce areas, constituting dry open grasslands or wooded grasslands where rainfall is marginal for cultivation (NAWAPO, 2002). Livestock migration and overstocking constitute one of the key causes of water and land conflicts between pastoralists and other water users. Scarce grazing lands and scattered distribution of livestock watering points, especially during the dry season, forces heavy traffic patterns in livestock densely populated areas, which impact upon water resources and the environment. The issue in this sector is how to ensure availability of adequate and reliable water and pasture for livestock so as to reduce conflicts and increase contribution of the sector to the national GDP.

Livestock constitutes an important component in livelihood support systems in the agro-pastoral farming systems that are predominant in the Ilemela and Magu Districts (Niboye, 2010). Farming communities in these areas as in other districts in LVB are somehow sedentary, operating subsistence mixed economies combining livestock and crop

production. Livestock serve as the main source of investment capital, animal proteins, income, drought power, manure, provide household food security and other social functions (Niboye, 2010).

Despite these variations in temperature and rainfall, various pastoral communities such as the Maasai have over centuries lived and practiced their activities in their regions such as Arusha and Manyara; which indicates that they develop, put in use and enhance indigenous coping strategies to climate variability (Galvin *et al.,* 2001). From several studies conducted in the Maasai pastoral communities of East Africa, it has not been well documented whether similar coping strategies can be applied in other areas adjacent to LVB.

What then are the factors, determining the adaptive or coping capacity of pastoralist? This question will also be addressed in this research. The research, therefore, identified the socio-economic factors influencing pastoral adaptive capacity, since it has been established that people respond differently to climatic events in their communities based on their adaptive capacity.

Furthermore, economic implication of coping or adaptation has become a topic over the past few years, since the adverse impacts of climate variability are raising important concerns about the future livelihoods of many people around the world. In the very near term, vulnerable communities will need to accelerate adaptation in order to mitigate the additional burdens of climate variability (Smit and Wandel, 2006). This is especially important in the context of agriculture, given the critical role of that sector in the livelihoods of populations throughout the developing world (World Bank, 2010).

1.2.2 Justification of the Study

The increasing human as well as animal population in the LVB, changes in the mean temperature, rainfall patterns and rainfall variability (Niboye, 2010), deaths of large numbers of livestock due to lack of water and pasture and reliance on seasonal availability of pastures and water have occurred repeatedly in LVB in recent years, hence threatening livelihood of pastoralists in the basin. This has also led to low reproduction, suboptimal weights at slaughter and poor quality products that do not fetch good prices in the market, leaving farmers vulnerable to poverty and food insecurity (Thornton and Jones, 2008).

A trend analysis on the aspects of climate and temperature is as well of great significance in this study. This is due to the fact that rainfall has been predicted to increase by 25-50 percent in the Lake Victoria Basin. Changes in the mean temperature, rainfall patterns and rainfall variability are likely to prolong dry seasons and to increase the severity of periodic droughts (Paavola, 2004). As per Jijuuko and Othero (2010) this would result into severe effects on livestock sector as well as pastoralists livelihoods at large.

This study assessed the trends for rainfall and temperature, evaluated the coping strategies that are on ground, factors influencing adaptation of such strategies and coping strategies that are economically profitable, socially acceptable and environmentally friendly for the pastoral communities in the face of climate change and variability. This will also help decision makers when planning especially at the village council to ensure that strategies to be implemented are economically affordable and socially acceptable by their communities. Henceforth, this study intends to assess agro-pastoral perception towards variations in climate change and ascertain climate variability trend, identify and assess existing coping strategies in the two districts and see their implication towards coping with climate variability.

1.3 Objectives of the Study

1.3.1 Overall objective

The main objective of the study was to assess perceptions and socio-economic factors influencing agro pastoral coping strategies to the effects of climate change and variability in Ilemela and Magu Districts.

1.3.2 Specific objectives

The specific objectives of the study were to:-

i. Assess the agro-pastoral perceptions on climate change and variability and ascertain with recorded climatic data

ii. Evaluate agro-pastoral coping strategies and their economic implication and

iii. Determine socio-economic factors influencing adaptive and coping capacity of pastoral communities

1.4 Research Hypotheses

i. Trends of rainfall and temperature patterns in the study area have been constant over the past 30 years

ii. Existing agro-pastoral coping strategies have positive economic implication to the agro-pastoral communities

iii. Socio-economic factors are not significant in determining the adaptive or coping capacity of pastoral communities

1.5 Conceptual Framework

The concept behind this study is to show the link between the selected climate variables, and household economic implications Climate variables such as rainfall and temperature have been significantly varying in recent years hence a need for trend analysis of the

climate variables of interest. This is a result of several disturbances among them being anthropogenic that led to various effects such as seasons of floods, droughts and heat stresses in various societies. The communities of interest in this study were the agro-pastoralists in Ilemela and Magu Districts. Livestock resources, such as water tend to be significantly affected. What then are the coping strategies to be adapted? What factors determine the adaptive or coping capacity of agro-pastoralist? Thereafter the economic implication of the identified coping strategies can be deduced. The conceptual framework for the study is summarized in Fig. 1.

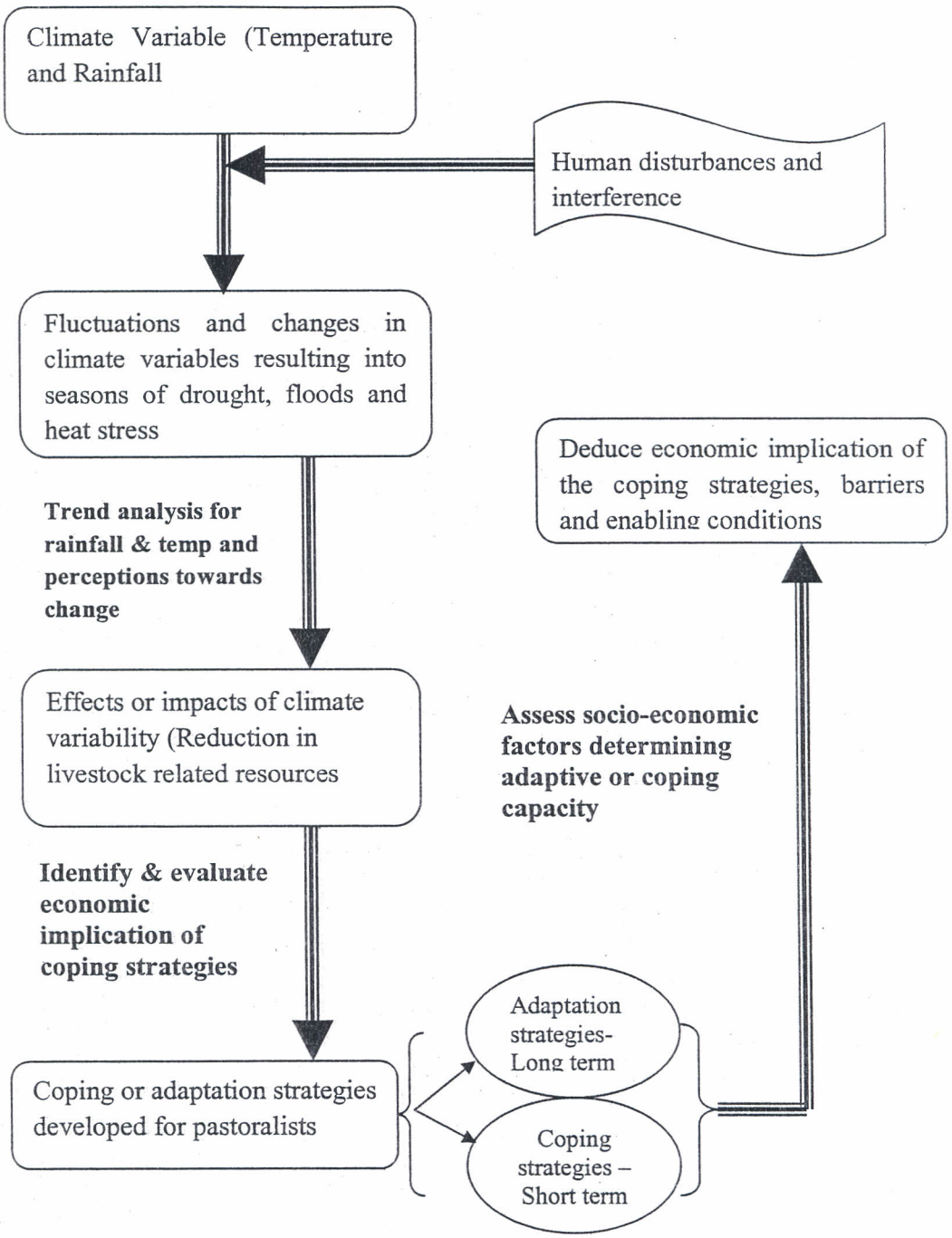

Figure 1: A conceptual framework

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Livestock Production in Tanzania

Livestock production is very important to the economy of Tanzania as out of 4.9 million agricultural households, about 36% keep livestock, 35% engage in both crop and livestock agriculture, while 1% is purely livestock keepers (Tumbo *et al.*, 2011). Livestock accounted for 5.9% of total GDP in 2006 and 4.7% in 2010 (Mashingo, 2010). The system also contributes to national food supply as most of the meat and 70% of the milk consumed in Tanzania comes from the agro-pastoral and pastoral livestock production systems. Cattle from these production systems contribute 53% of total meat consumed in Tanzania (Njombe and Msanga, 2010).

2.2 Challenges Facing Agro-pastoralists

Overstocking and overgrazing are very common, usually accompanied by the adverse effects of land degradation. Based on the livestock numbers, the population is 34 times the recommended carrying capacity for Mwanza Region (NAPA, 2007). Rising populations and the deterioration of land quality in the pastoral and agro-pastoral areas of northern and central Tanzania forced livestock farmers to migrate southward to the Iringa and Mbeya Regions in search of water and pasture (Kangalawe and Liwenga, 2005). The potential for expansion of the livestock industry into other regions is, however, constrained by the lack of clear land rights for livestock farmers nationally. The future or sustainability of the free-ranging livestock-keeping system is uncertain as grazing land becomes scarce due to population pressure – both from livestock and humans – and the lack of demarcated land for pastoralists nationally (Tumbo *et al.*, 2011).

2.2.1 Climate variability and pastoralists

Climate variability has implications to pastoralists (Simms, 2005). For the northern Tanzanian pastoralists, transhumance and the sale of cattle have been traditional responses to seasonal and other climatic variations. Transhumance involves regular population movements over relatively small or long distances which enable more extensive use of pastures and the maintenance of social links and organization (Ndagala, 1998).

2.2.2 Impacts of climate variability on grasslands and livestock

There are both direct and indirect effects on plant productivity as a result of an imbalance between rainfall, temperature and evaporation. These variables affect productivity and reproduction in plant species and therefore the composition and distribution of the latter over the landmass.

The Global Circulation Model (GCM) assessment on the vulnerability of grassland and livestock to climate change impacts in Tanzania reveals changes in foliage associations and a shift in foliage species composition with the most palatable species having been grazed out. These will continuously be replaced by more climate tolerant species and the overall carrying capacity of the rangeland would be low due to variations in rainfall, temperature and evaporation as CO_2 doubles in the atmosphere. Surplus foliage would prevail in areas of increased precipitation; however as plants lignify upon reaching maturity, crude protein content would be lowered. This would result into poor performance of the grazing animals and poor production in milk and meat. Such conditions coupled with incidences of pests and diseases would force farmers to adjust their grazing habits and management to ensure livestock have enough pasture all year round consistent with the grassland resources.

If proper adaptive measures are not taken into account early enough due to prevailing uncertainties on impacts and the rate of occurrence, the reactive adaptive measures taken by farmers would result into huge economic losses (URT, 2003).

2.2.3 Direct and indirect effects of climate variability and change

There are a range of direct and indirect effects of climate variability aspects in pastoral communities. In most instances a decrease in rainfall results in an even greater decrease in river runoff/stream-flow. The dry condition (drought) is a recurring phenomenon and its impact on water resources is usually devastating. Increases in temperature leads to increase in evaporation which can have a direct impact on the losses from major water storages and river systems (Little *et al.,* 2001). Increased rainfall intensity can also lead to increases in runoff as soil moisture stores are full and a greater percentage of the rainfall runs off, whereby increased runoffs lead to flooding of low-lying areas. In dry periods, the demand for water from most users increase with the urban sector seeking supplies for lawns and gardens and the agriculture sector seeking supplies for crops and pastures. Prolonged drought has affected animals and pastoralists in the arid and semi arid parts of Tanzania. During prolonged drought, pastoral grazing land and water for livestock diminish (Roger, 1999 cited by Tumbo *et al.*, 2011). This makes pastoralists spend more hours searching for water and pasture for their herds hence increasing distance to grazing and water sources therefore increases magnitude of drought conditions and impacts to the community at large.

Over the past four decades, the country has been hit by a string of severe droughts (Kandji *et al.,* 2006). This has resulted into an increase in livestock mobility by pastoralists and agro-pastoralists in search of pastures and water, creating conflicts with crop farmers. During drought periods the price of cattle may fall and sometimes animals may die as

they tend to be weaker and in most of the times they are sold at a cheaper price so as to get some money before they die rather than ending up with losses (Mashingo, 2010).

Conversely, in wetter times there is less demand on water supplies and supply systems can be refreshed for example, groundwater resources. Both climate variability and change has resulted into; catchments degradation, drying up of rivers, receding of lake levels, heavy siltation in dams and pans meant for both hydropower generation and water supplies, deterioration of water quality, increased water use conflicts due to competition on the available water resources, damaged roads, railway lines, bridges, buildings and water intakes (Shemsanga *et al.,* 2010).

2.3 Adaptation and Coping Strategies Against Climate Variability and Change

Adaptation measures for the livestock sub-sector involve changes in management as well as changes in land-uses. Management aspects are adjustment to grazing systems that avoid the destruction of the environment, the planning of animal breeding during the rainy season, better animal husbandry measures and the optimization of livestock production. Land use will involve providing title deeds to pastoral organizations and encouraging rangeland development initiatives. Government policies would need to support livestock keepers to adjust and cope with the effects of changes in climate (URT, 2003).

Both long and short term changes in climate disproportionately affect regions in both the semi-arid and arid parts of the globe and the more humid tropics (Rayner and Malone, 2001). The effects of climate change vary across regions, farming systems, households and individuals. As smallholder farmers climate variability has been affecting them, farmers through experimentation over time, have developed different traditional

technologies in order to cope with the climate change vulnerability (Shemdoe, 2011). Coping strategies in the broadest sense are thoughts and behaviors undertaken to reduce, minimize or master some environmental or psychological demand that represents a potential threat, existing harm or loss (Unsworth *et al.,* 2013).

Coping strategies are short term adjustments in social or economic systems made in response to actual or expected climate effects (Smit, 2001). Such adjustments are intended to reduce the vulnerability of society to changes in the climate system (Kates, 2000). These vary among regions and socio-economic groups, in that those with the least capacity to adapt are generally the most vulnerable to climate variability and change impacts (Finan and Nelson, 2001; Lamb, 1995; Little *et al.,* 2001).

Developing countries are dependent on climatic resources and because of growing populations and poor technological capabilities; they generally have low adaptive capacity (Downing, 1997; Magistro and Roncoli, 2001; Mendelsohn, Dinar and Williams, 2006). This is especially true for pastoral people, who inhabit the arid and semi-arid regions with high climate variability. Most pastoral coping and adaptation strategies to climate variability are socio-cultural (that is, changes in management), usually a series of reactive responses to event such as drought (Regassa, 2011; Galvin *et al.,* 2001; Little *et al.,* 2001). Pastoralists in various parts of Tanzania have a diversity of coping strategies to sustain production which is important for their own livelihoods as well as their national economies (Galvin, 1992).

Pastoral strategies for maintaining production include moving livestock according to vegetation needs and water availability, keeping species-specific herds (those that drought tolerant) to take advantage of the heterogeneous nature of the environment, and

diversifying economic strategies to include agriculture and wage labour, among others. In some cases temporary or permanent emigration out of the pastoral system can happen and even allocating seasonal and drought-induced nutritional stress among community members occurs (Galvin *et al.,* 1994).

The strategies of pastoralists have changed over the last few decades as a response to adverse climatic conditions, population pressure, cattle diseases, unfavorable price ratios between livestock and crops, restrictions of mobility imposed by the encroachment of sedentary agriculturalists and their relatively clearer property rights and deepening poverty in the pastoral communities. New strategies include long distance relocation with cattle and migration to cities to wage employment (McCabe, 2003). Vulnerable people generally have a variety of alternatives to increase their adaptability and decrease their risk in times of stress and shock. However, new and persistent environmental, political and social pressures can limit choices that have traditionally been available (Kasperson, 2001).

According to Unsworth *et al.* (2013), one of the biggest problems that a lot of farmers are facing is not necessarily a failure in desire to adapt and try a different way of farming, but rather the inability to put these desires into action. The financial risk involved in taking a chance that might not pay off, as well as not being financially secure enough to wait for the longer-term return. As mentioned earlier some farms would go under with only one worse year/season.

Some hope however exists as a number of pastoral societies have started to learn alternative livelihood support activities. Such strategies however are only useful for short-term and non-severe effects of climate change (Shemsanga *et al.,* 2010). Worth noting,

the number of livestock already overwhelms the carrying capacity of many grazing grounds in the central, north and west Tanzania, where droughts are common. As a result, pastoralists are forced to relocate to places where pasture and water are available (Shayo, 2006 cited by Shemsanga *et al.,* 2010).

Agro-pastoralists and pastoralists have different strategies to reduce their vulnerability and adapt to, or cope with, current climate variability. These strategies include temporary and permanent migration and keeping different types of livestock (cattle, goats and sheep) (Obando *et al.,* 2010). In the case of temporary migration, during drought periods livestock farmers partition their herds to different locations depending on the availability of water and pasture. Unwritten arrangements that are always respected among pastoralists in different areas of the country allow them to settle temporarily in a new area in times of drought and return the favor in kind when rain season starts by leaving few cattle behind or food crops (Mashingo, 2010).

Migration patterns in Sukuma-land; is an economically significant activity (URT, 1997, cited by Madulu, 1998). The major reasons behind continued migration are the search for new farming land, better pasture and water for livestock, and employment opportunities. On the other hand Unsworth *et al.* (2013) emphasize that coping strategies should not only be economically significant but also environmentally sustainable for the farmer to embrace it fully. By this, it is clear that the currently existing land conflicts among livestock keepers and the crop farmers are significantly increasing due to the un-authorized migration of herds that are associated destruction of crops and farms in search for water and pasture.

Other coping strategies against climate change and variability include partitioning of the herd into core and satellite herds and keeping them in different areas; maintenance of a

female-dominated herd structure which offsets long calving intervals and thus stabilizes milk production (Coppock, 1994); restocking of the herds of destitute families from those of fellow pastoralists; and diversification beyond agriculture into other activities such as mining (Haule, 2009).

According to Little (2009), livelihood diversification in pastoral areas is the pursuit of any non-pastoral income-earning activity, whether in rural or urban areas. This definition includes any form of trading occupation (selling milk, firewood, animals, or other products); wage employment, both local and outside the area, including working as a hired herder, farm worker, and migrant labourer; retail shop activities; rental property ownership and sales; gathering and selling wild products (firewood or medicinal plants); and farming (both for subsistence and cash incomes).

Pastoralists and smallholder farmers are being pushed to seek alternate means of income generation or household support. The general trend has been to migrate to urban or per-urban areas to engage in waged labor activities. Many older pastoralists (those that engaged in pastoralism in the previous) and smallholder farmers are left with no alternative but to take low-paying jobs because they lack vocational skills and/or education (Lai, 2007). Their employment options tend to be limited to work as security guards, construction workers or petty traders (business).

However, it also seems that, in some areas, herding for others is becoming a growing occupation, but one in which poorer herders become dependent on the benefactor (Aklilu and Catley, 2010). Poor pastoralists, in general, work as herders for rich pastoralists (particularly those with large herd sizes and or their own boreholes or water reservoirs), rain fed or irrigation farmers and other investors, in addition to raising income and small numbers of their own stock.

2.4 Factors Influencing Adaptive and/or Coping Capacity

Adaptive capacity definition as modified from IPCC (Reser and Swim, 2011) is the ability of a person to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences through psychological resources (that is coping strategies) and supporting relevant wider policies. Main concept within research on adaptation as well as coping to climate change is the concept of adaptive capacity: the potential or ability of a system, region, or community to adapt to the effects or impacts of climate change (Smit and Pilifosova, 2001). Considerable attention should be devoted to the so-called determinants of adaptive capacity, which are characteristics of communities, countries, and regions that influence their propensity or ability to adapt and hence their vulnerability to risks associated with climate change. Therefore, the so called "determinants" of adaptive capacity are also seen as determinants of adaptation (Smit and Pilifosova, 2001).

From literature, the IPCC (Reser and Swim, 2011) identify a list of socioeconomic features of communities or regions that seem to determine their adaptive capacity and adaptation. They argue that countries with limited economic resources, low levels of technology, poor information and skills, poor infrastructure, unstable or weak institutions, and inequitable empowerment and access to resources have little capacity to adapt and are highly vulnerable (Maddison, 2006). Similarly, Adger (2003) argues that, for individuals, their capacity to adapt to climate change "is a function of their access to resources". On the other hand, Nyangito and Nyariki (2012) as well as Mutsvwanga-Sammie *et al.* (2013) found out gender of the household head as one of the key drivers of households vulnerability. Together with gender, Regassa (2011) found educational status, age of the head of household and household size to be statistically significant factors ($p<0.05$) in influencing (positively) adaptive as well as coping capacity of an individual.

CHAPTER THREE

3.0 METHODOLOGY

3.1 The Study Area

3.1.1 Location

The study was conducted in selected villages of Magu and Ilemela Districts of Mwanza Region. This was due to the fact that these districts are convenient of access and the existence of a good number of agro-pastoral household back in the history compared to the other districts in the region. Ilemela and Magu Districts are located between latitude 2° 10' and 2° 50' South and longitude 33° and 34° East in Mwanza Region (Fig. 2).

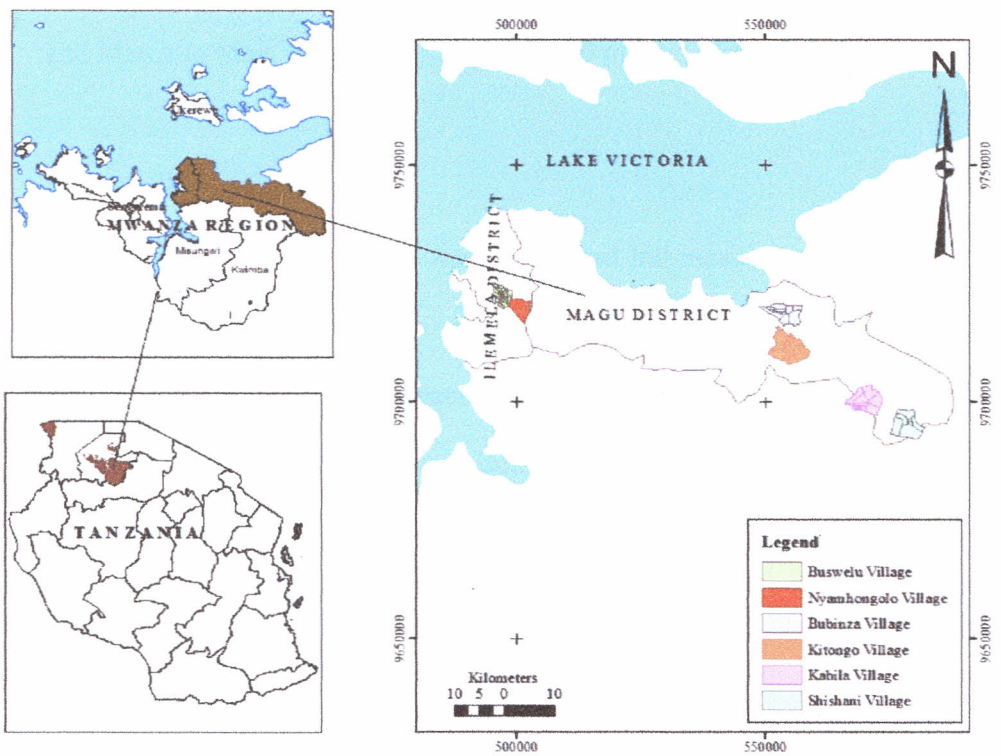

Figure 2: Map of the study area showing surveyed villages in Magu and Ilemela Districts

Mwanza Region is located in the northern part of Tanzania bordering Lake Victoria in the south. Ilemela District is bordered to the north by the Nyamagana District, to the east by Magu District, to the east and south by Misungwi District and to the west by the Mwanza Gulf of Lake Victoria. It is part of the Mwanza regional's capital, Magu District is bordered to the north by Lake Victoria and Ukerewe District, to the north east by Mara Region and the south east borders Shinyanga Region. Kwimba and Misungwi Districts are to the south, while the western border is shared with Ilemela.

3.1.2 Climate

The area has tropical type of climate with clearly distinguished rain and dry seasons with mean temperature ranging between 25^0 and 30^0C. The area receives an inadequate and unreliable rainfall distribution whose pattern is bimodal, starting in October to December and March to May, ranging from 700 to 1000 mm.

3.1.3 Topography and soil

The topography of the area is one of isolated hill-masses and ridges, with wide plains. The soils are of the typical Sukuma-land catena ranging from red to yellow sandy clay loams which are widely cultivated, to granite inselbergs with a progression yellow-red "hill sands" to the poorly drained dark grey loam sands and clays of the valley bottoms, and low lying plains.

3.1.4 Population

The main ethnic group of the study area is the Sukuma tribe whose major occupation is farming and livestock keeping. According to the 2012 population and housing census, Magu District had a total population of 299 759 people with 51 682 number of household

while Ilemela had a total population of 343 001people with 71 458 households. The two districts also have a cattle population of 320 163 and 73 621 respectively (NSCA, 2008).

3.1.5 Land use and socio-economic activities

The districts are under semi-arid geographical location zone, experiencing drought, hunger, fodder shortages, short and unreliable rainfall and with severe soil erosion. With these conditions, the main crops grown in the region include cotton, paddy, maize, sorghum, sweet potatoes, groundnuts, cassava and horticultural crops, such as tomatoes, onions and vegetables. Apart from crop cultivation, livestock keeping is another main occupation in the study area with cows, goats, and sheep. Out migration of people and livestock to areas such as western Geita is the traditional solution to the problem of land deficit in the area.

3.2 Sampling Procedure and Data Collection

3.2.1 Sampling design

Two districts, were purposefully selected from Mwanza Region; one was from a per-urban (Ilemela) and another one a typical rural area (Magu) since these had a higher number of livestock specifically cattle. From them 3 divisions and six villages were selected based on water shortage problem and one village chosen purposively from each of the six wards. A simple random sampling was used to draw a representative sample from the sampling frame which was the agro pastoral households.

3.2.2 Sample size

The sample size for household survey was 20 respondents (pastoral households) from each village both Ilemela and Magu District. A sample size of 120 agro-pastoral households was considered enough for meaningful analysis of the study. Sudman (1976)

confirmed that a minimum of 100 respondents is enough when comparative study (between Ilemela and Magu Districts) is conducted. In addition, the choice of this sample is reasonable due to limited time and funds but fulfills the requirements of the study for meaningful analysis (Bailey, 1994). The households were drawn within Magu and Ilemela Districts as shown in Table 1.

Table 1: Sample size

District	Village	Sample size	Pastoral HH per village
Ilemela	Nyamhongolo	20	301
	Busenga /Bulola	20	321
Magu	Shishani	20	375
	Kabila	20	537
	Kitongo	20	437
	Bubinza	20	453
	Total	**120**	2423

Source: Mwanza Regional Offices (2012)

3.2.4 Data collection

The study used both primary and secondary data as well as qualitative as well as the quantitative data. Research tools used were structured and semi- structured questionnaires and check list that was administered through interview schedule. The two tools were used to obtain information from household survey and Focus Group Discussion (FDG). Sections 3.3 to 3.5 provide details of data collection and analysis methods by specific objective.

3.3 Assessment of Agro-pastoral Perception and Ascertaining Climatic Trends

3.3.1 Analyzing climate data for the past 30 years

In order to analyze climate variability, rainfall and temperature data of at least 30 years were collected from neighboring Metrological stations (Ukiriguru, Ukerewe, Magu, Mwanza and Musoma airport stations). The data were analyzed to show long-term and seasonal trends. The non-parametric Mann-Kendall test for identifying trends in time series was applied. The test compared the relative magnitudes of the sample data rather than the data values themselves (Gilbert, 1987). Kendall (1975) describes a normal-

approximation test that was used for datasets with more than 10 values, provided there were not many tied values within the data set. The normalized test statistic Z was computed from the formula 1;

$$Z = \frac{S-1}{[VAR(S)]^{1/2}} \quad \text{if } S > 0$$
$$= 0 \quad \text{if } S = 0$$
$$= \frac{S+1}{[VAR(S)]^{1/2}} \quad \text{if } S < 0 \qquad \text{.......... (1)}$$

The probability density functions for a normal distribution with a mean of 0 and a standard deviation of 1was given by formula 2:

$$f(z) = \frac{1}{\sqrt{2\pi}} e^{-\frac{z^2}{2}} \qquad \text{.......... (2)}$$

The decision on a probability level of significance was at 95% ($p<0.05$). The trend was said to be decreasing if Z was negative and the computed probability greater than the level of significance. On the other hand, the trend was evaluated to be increasing if the computed Z was positive and the computed probability was greater than the level of significance.

3.3.2 Assessing agro-pastoral perceptions towards climate change

Focus group discussions of 10-15 people that involved mainly environmental and natural resource committee and pastoralists that have lived in the area for more than 30 years and at least two old people (aged 60 and above) were used to trace changes in climate over the past 20-30 years and write down the activity versus season calendar as guided by the checklist in appendix ii. Also structured and unstructured questionnaires (Appendix 1) were administered to the pastoral households to give their view on climate parameters such as rainfall and temperature. Statistical Package for Social Science (SPSS) was used

to analyze the data where descriptive statistics (percentages) were obtained to summarize results. Content analysis was also used to compare results obtained from the questionnaire as well as the FGD.

3.4 Assessment of Economic Implications of Identified Agro Pastoral Coping Strategies to the Effects of Rainfall and Temperature Variability

3.4.1 Identification and assessment of pastoral coping strategies

Focus group discussions of 10-15 people that involved mainly livestock officers, environmental and natural resource committee and pastoralists were used to identify the adaptive and coping strategies used in the sampled village. Also structured and unstructured questionnaires were administered to the pastoral households to identify the coping strategies. Advantages, disadvantages and barriers enabling conditions of each were obtained. Results were analyzed by Statistical Package for Social Sciences (SPSS).

3.4.2 Economic implications of the existing strategies to cope with the effects of climate variability

Perceived costs (establishment and implementation costs) involved in each coping strategy were obtained through Focus Group Discussion and supplemented by household survey as well as literature review. They were analyzed using Microsoft. Excel Spread sheet and summarized to enable comprehensive discussion.

3.5 Assessing Socio-economic Factors Determining Adaptive or Coping Capacity of Pastoral Houuseholds

Structured as well as semi-structured questionnaires were administered to the pastoral households in order to identify and assess the socio-economic factors determining adaptive or coping capacity of pastoral communities.

3.6 Multinomial logistic (logit) regression model for analyzing socio-economic factors

Responses from the questionnaire on the number of coping strategies opted by a household versus socio-economic factors were analyzed using a multinomial logistic regression model, whereby there was only one dependent variable which is adaptive or coping capacity of agro-pastoralists households (measured by the number of strategies a household engages in as a way to cope with the effects of climate change). Those that opted to use as many strategies were regarded in this study as the ones who best cope with the effects and vice versa. The model had three dependent variables which are: those that employed three strategies, two strategies and one strategy. Independent variables included age of the head of the household, sex, education level of the head of household, herd size, number of years one has lived in the area, household size and cost of coping.

Multinomial logistic regression allows each category of an unordered response variable to be compared to a reference category, providing a number of logistic regression models. For example, to model which of three categories of coping strategies is likely to be chosen by an agro-pastoralist, two logit models are computed; one comparing three coping strategies with the reference category (one coping strategy) and one comparing two coping strategies with the reference category (one coping strategy). The model of choice behavior between three coping strategies can therefore be represented using two (i.e., j -1) logit models as seen in equations 3 and 4 below.

$$\log\left\{\frac{[y=3strategies]}{[Y=1\ strategy]}\right\} = \propto + \beta 1X1 + \beta 2X2 + \cdots + \beta kXk \quad \ldots\ldots (3)$$

$$\log\left\{\frac{[Y=2\ strategies]}{[Y=1\ strategy]}\right\} = \propto + \beta 1X1 + \beta 2X2 + \cdots \beta kXk \quad \ldots\ldots (4)$$

The models in equation 3 and 4 provide two estimates for the effect that each explanatory variable has on the response. This is useful information as the effect of the explanatory variables (X_k) can be assessed for each logit model (that is the effect of X_1 on the choice between three (3) strategies and one (1) and the effect of X_1 on the choice between 2 strategies and 1) and also for the model as a whole (that is the effect of X_1 across all coping strategies in the sample). It is also useful to interpret a single parameter for each explanatory variable in order to derive a single economical model of the response variable. The multinomial logistic regression model allows the effects of the explanatory variables to be assessed across all the logit models and provides estimates of the overall significance (i.e., for all comparisons rather than each individual comparison). The general multinomial logistic regression model is shown in equation 5:

$$\log\left\{\frac{[y=j]}{[y=j']}\right\} = \alpha + \beta 1X1.\beta 2X2 + \cdots + \beta kXk \quad \text{..... (5)}$$

Where j is the identified coping strategy and j' is the reference coping strategy

3.7 Limitations of the Study

3.7.1 Language barrier

Remembering climate issues especially indicators of climate change was not easily translated into Kiswahili then into English. Henceforth some of the words appear in their native language of respondents, which is "*Sukuma*".

3.7.2 Reluctance in sharing information

Most farmers were not willing to give the actual number of livestock (cattle herd size) due to some beliefs (theft and superstition) and the strictness in campaigns on reducing number of livestock per household. So this study had to go with a village leader in the household surveys so that the households may feel comfortable sharing the necessary information.

3.7.3 Inconsistent climate data

Most of the secondary data especially on climate that were collected from some weather stations were inconsistent. Efforts were made to gather them from various other weather stations available in the region so as to supplement the gaps that missed and harmonize the data accordingly.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Climate Variability and Change

This section intends to present and discuss information on the climate fluctuations in the study area. Through focus group discussions and household surveys, agro-pastoralists were able to produce their calendar showing agricultural activity versus the seasons for the past 20-30 years as well as the recent one that enabled this research to clearly see the change in climate that lead to changes in their production activities. Table 2 summarizes the calendar for various activities carried out in the past and present linking them to the major seasons of the year. Perceptions of the agro-pastoralists and meteorological data obtained from the weather stations showed the variability and change in the climate trends.

Table 2: Climate Variability and Activity Calendar in the Study Area: The Past and Present Situation

Months in English/ Sukuma	Season (Past)	Agric. Activities &Crops	Present Season	Agric. Activities &Crops
October (*Igabanhwa*)	Sprouting of trees and small plant Nndiga, white ant, small birds such as 'Lwelwe'.	Farm preparations Drilling and cleaning of well. Planting barley (from 15th Oct.)	Dry	Farm preparations Drilling and cleaning of well.
November (Lubingo)	Short rains starts, Fish breeding, Wild fruits, grasshopper and flying ants '*Kumbi kumbi'*	Planting millet, cotton, maize, wheat and ground nuts and short term crops(from 15th Nov)	Short rains	With enough rains same activities as in previous years
December (*Miili*)	Short rains, cold and moving light clouds, decrease in fish and appearance of green algae	Harrowing millet, cotton,Planting g. nuts, maize, sweet potato, cassava, wheat and green pees	Short rains with light clouds	With enough rains same activities as in previous years
January (*Saato*)	Heavy rains starts, heavy clouds, trees bearing fruits, armyworms, wild trees known as '*mipori'* fade out.	Harvest cotton, maize, green peas and leguminous plants Weeding cotton, wheat, cassava and sweet potato	No rain	Seasons tend to resemble a previous month's activity
February (*Nne*)	Sunny and rainy 'Ndimila yitambiyu' meaning end of planting long-term crops, 'armyworms'	Weeding of all crops and planting sweet potatoes for '*Nchembe*' meaning cut into slices.	Average rains	Seasons tend to resemble a previous month's activity
March (*Sanno*)	Long rain, floods, a lot of fish, rotting of birds' eggs, October birds start disappearing	Fishing in both rivers and lakes, planting potatoes for the next season	Long rains	Planting maize (modern breeds)
April (*Kaboja*)	Like in March, Fish rot easily, Lots of milk hence lots of flies, cockroach and mosquito	Planting potato for the next season, traditional dances '*Bucheye*'	Average rains	Weeding
May (*Mpungati*)	Little rains, strong wind, sunny and cold starts	Harvest cotton, rice and barley For women drying vegetable	Ending rain season	Harvesting cotton
June (*Nane*)	Wilting, a lot of grasshopper, sunny and reduction in fish.	Traditional dance (*Wigashe* and *Bugidu*) building houses and paying a visit to friends, cleaning wells, Selling cotton and millet extraction	Dry	Like past years
July *(Nkenda)*	Cold, strong winds *(Kashuruda)*,drought, *Soke* (during rainy season in the lake and is stronger than Kashuruda	Harvesting & selling cotton, Saba Saba, Masonry activities	Dry	Like past years
August (*Nkumi*)	Long and heavy rains, (*mashaambushi ya makumbang'halange*), reduction in milk,	Tradition celebrations, weddings and dances, building houses. Cutting down and burning cotton straw	Dry	Like past years
September *(Lyana Lyankumi)*	Sunny, dusty short rains at the end of the month, early graces	Preparation of farms. Marriage especially taking the brides to the groom's side	Light rains	Harvesting of irrigated crops, petty business and marriage and traditional dances

4.1.1 Perceptions of agro-pastoralists on climate change

Agro-pastoralists in the study area perceived climate change and its impacts in many different ways as summarized in Table 3. According to agro-pastoralists, the indicators of climate change included drying up of natural springs that never occurred up in the past, decrease in fish that existed in the springs as well as in the rivers such as Simiyu and Duma following decline in water levels. Other indicators included change in rainfall patterns and amount and increase in temperature in recent years relative to the past. According to farmers, in the past it used to rain from morning to evening during rainy season that started from November but nowadays, it rains once in a week and again after two weeks.

Table 3: Perceptions and effects of climate change as per communities in the study area

Local Indicators	Effects
Drying up of large number of natural spring Decline natural forests cover	Loss of biodiversity, vegetation and natural cover
Decrease in species existed in the past e.g. fish (in rivers), Birds (*Lwelwe, Giling'oma, Mbilibili)*	Increased water and pasture scarcity for livestock
Unreliable rainfall (Change in start and duration of rain season)	Pre-mature and poor agricultural yield Lack of enough pasture and grazing land in Ilemela Districts Water scarcity in the district for livestock watering Food insecurity to both cattle and human being
Drying up of Duma river, ponds and wells from 1990's	Water scarcity to both human and livestock in Magu district.
Increase in temperature	Water scarcity

For instance, back in 1975 rains used to start from July and August, and people started planting various crops and get good yields, but these days it has shifted to September or October and the length of season reduced. This leads to very poor agricultural yields and sometimes the crops do not reach maturity. Also livestock activities have been affected following extensive farming even in areas that were used for grazing and pasture, closing the stock routes towards the grazing sites.

The respondents mentioned some of the causes include increased population (of both livestock and human), industrialization and urbanization. These have generally increased invasion into catchment areas and hence increasing clearing of forests. This trend has a direct influence in climate as forests tend to regulate micro-climate by influencing how it rains and regulating temperatures. This has also been echoed by Bryan *et al.* (2010) that temperature increases have a significant impact on water availability in most areas especially semi-arid, thus exacerbating drought conditions. The increase in temperatures has greatly affected variations in seasons of the Sukuma calendar which starts in October where it is termed as the time when life starts since it was the start of the rain season in the past years. However, in the present time the climate has been varying considerably and this has resulted into numerous effects as summarized in Table 3.

Some areas drew their names from the type of climate that existed in that particular area: for example, *Buswelu* implied "green land cover", denoting an area with plenty of natural vegetation covers. However, due to increased drought and other anthropogenic effects, the area has turned bare. The perceptions of farmers on climate change are observed decline in water availability due to temperature increases as well as other environmental and social drivers such as an increase in population density.

4.1.2 Trends in climatic parameters, linkages to perceptions and implications

Trends in annual and seasonal climatic parameters are presented in Table 4. Results show that both short and long rainfall trends have generally decreased while temperature (maximum and minimum) have significantly increased across in both dry and transitional seasons of the year. The weather stations from which these data were collected are at latitude -1.93 and longitude 32.92 (Ukerewe Meteorological station) and 33.92 (Mwanza airport).

Table 4: Annual and seasonal trends in climatic parameters in the study area

		Record Length		Trends for Respective Record Periods				
Station Name	Parameter	From	To	SON (Short rains)	DJF (Transition)	MAM (Long rains)	JJA (Dry season)	Annual
Ukerewe MET	Rainfall	1970	2000	-0.17	0.136	-0.204	-1.75	-0.71
Mwanza airport	Maximum temperature	1970	1992	-1.2	1.244	0.053	0.292	1.93
	Minimum temperature	1970	1994	0.82	1.426	-0.584	1.193	1.45
	Evaporation	1970	2000	0.68	-.870	-0.153	0.919	0.24
	Sunshine	1970	1995	-1.1	-1.39	0.926	0.596	0.11
	Radiation	1970	2000	-0.4	-0.14	-0.867	-0.17	0.27
	Relative Humidity	1970	2000	-0.7	0.90	-0.749	-2.04	-0.34
	Wind run	1970	2000	-1.0	-2.04	-1.190	1.037	-0.71

SON for September, October November **DJF** for December, January February

MAM for March, April May **JJA** for June, July, August

4.1.2.1 Rainfall

Rainfall varies within seasons; September, October and November (SON) is the season with short rains and from the Z-test results indicate that the trend is decreasing. The same applied to the Long rain season (June, July and August (JJA)) as well as the dry season (March, April and May (MAM)) since the Z-test values are negative and an increase in trends of the intermediate season (December, January and February (DJF)). Also, from both household surveys and focus group discussions, 96.7% of agro-pastoralists responded that rainfall was generally decreasing as the year progresses (Table 5). This pattern is similar to the Annual average rainfall (ANN) that shows a decreasing trend. Fig. 3 and 4 represents rainfall pattern of at least 30 years in the study area.

Table 5: Perception of farmers on rainfall over 10-30years ago (n=120)

Rainfall	Percentage
Decreasing	96.7
Fluctuating	3.3
Total	**100**

Rainfall pattern in the study area is one of the most important determining factors shaping agro-pastoral production systems and livelihoods. The interviewed agro-pastoralists believed that rainfall had highly varied over the years, both temporally and spatially. The study area has experienced a highly variable climate and with shifts in rainfall patterns in terms of quantity and frequency over the past three decades with direct consequences on livelihoods.

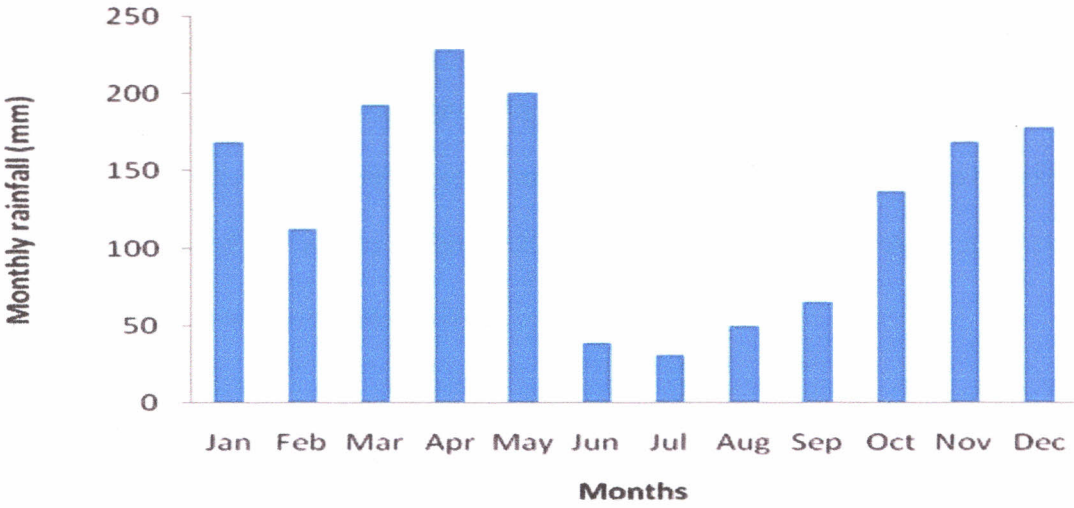

Figure 3: Mean monthly rainfall (mm) (1970-2000) from Ukerewe Meteorogical station

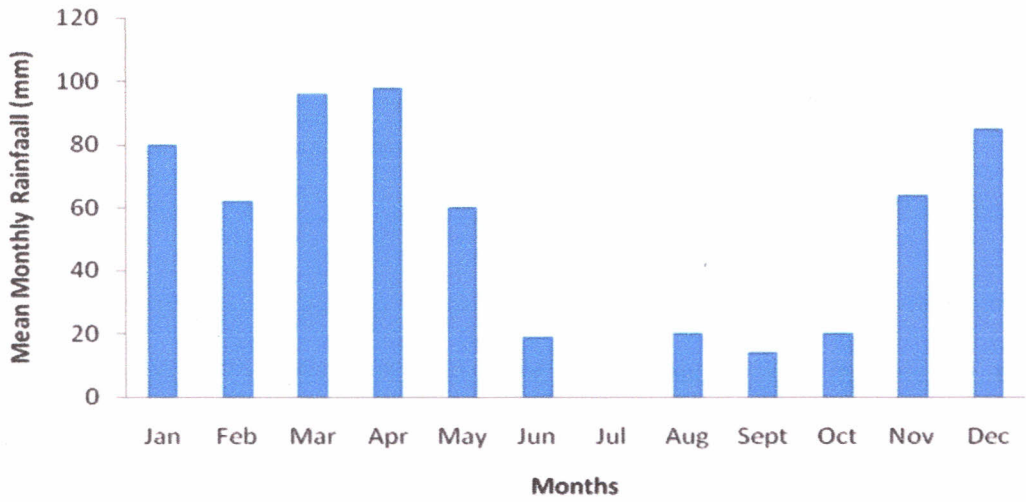

Figure 4: Magu weather station data (2001-2011)

Respondents in all villages reported change in rainfall patterns characterized by decrease in its quantity and frequency as determined by the hours in which it lasted and number of days in a week during the rain seasons. Of particular mention are four drought (*Nzala* meaning hunger) events given by the respondents as summarized in Table 6. Drought caused hunger, starvation and even death of livestock and pastoralists themselves in many areas of the region (Niboye, 2010). The names given to the hunger events reflected steps taken to ensure survival.

Recurrence of periodic droughts after every ten years (Table 6) in the study area may be attributed to the climate change. It is important to note that the occurrences of droughts were becoming more frequent and more hard-hitting than in the past. As connoted by Belay and Sugulle (2011) recurrent drought is reducing livestock numbers, causing the depletion of water sources; decreasing agricultural yields, and causing an overall decline in both livestock and agricultural production. Drought conditions have always been a recurring feature in the long history of pastoral production in the region.

Table 6: Major drought periods experienced in sample villages

Year	Given Local Name	Meaning/Implication
1974	*Nzala ya Gada/ Katani*	They sold/exchanged sisal for a maize
1984	*Nzala ya Makimbu/ Sungusungu*	Food aids were given in tins
1994	*Nzala ya Magobo*	Food aids were given in tins
2006	*Nzala ya Bululu*	Clouds were always Blue but no sign of rain

In all the villages in the two districts, agro-pastoralists practice rain-fed agriculture. Unpredictability of rainfall both in terms of its onset and quantity is, therefore, the most consequential change. During rainy season there is either average or insufficient to make good crop harvest. Moreover, from the household surveys, over 80% of respondents disagreed with the perception that drought conditions has significantly decreased in recent years while less than 5% argued that drought conditions have been fluctuating with some years having little rain and other years completely dry (Table 7). This implies that the

area has been experiencing an increase in drought condition. On the other hand the area has not experienced periods of floods in the recent10-15 years, as happened in year 1997 and only those villages near the Simiyu river were affected with the remaining villages no massive damage to them. Henceforth this implies that floods have not been a serious problem to these villages and Ilemela District at large.

Table 7: Incidences of droughts in the study area (n=120)

Drought decreased	Percentage
Strongly Disagree	82.5
Disagree	14.2
Fluctuation	3.3
Total	**100**

4.1.2.2 Temperature

Both maximum and minimum temperature showed increasing trends for the short rain season (SON), while in the minimum temperatures there is increasing temperatures throughout except for the long rain season (MAM). The results from Makesens' analysis (Table 4) and the agro-pastoralists views in Table 8 conform as majority (77.5%) indicated that generally the temperature was increasing tremendously. Fluctuations were also possible since in a year there are always months of cold and hot weather.

Table 8: Trends of temperature over 10-30 years ago (n=120)

Temperature trends	Percentage
Increasing	77.5
Fluctuating	10.8
Decreasing	9.2
No change	2.5
Total	**100**

While the rainfall was decreasing and becoming unpredictable, temperature levels have also been rising to an average maximum temperature of 27.5 ^{0}C (Fig. 5 and 6). There was a general consensus among the respondents that the temperature has increased during the past ten to twenty years. Changes in temperature and rainfall had a negative impact on livelihoods and contributed to shifts in planting calendar.

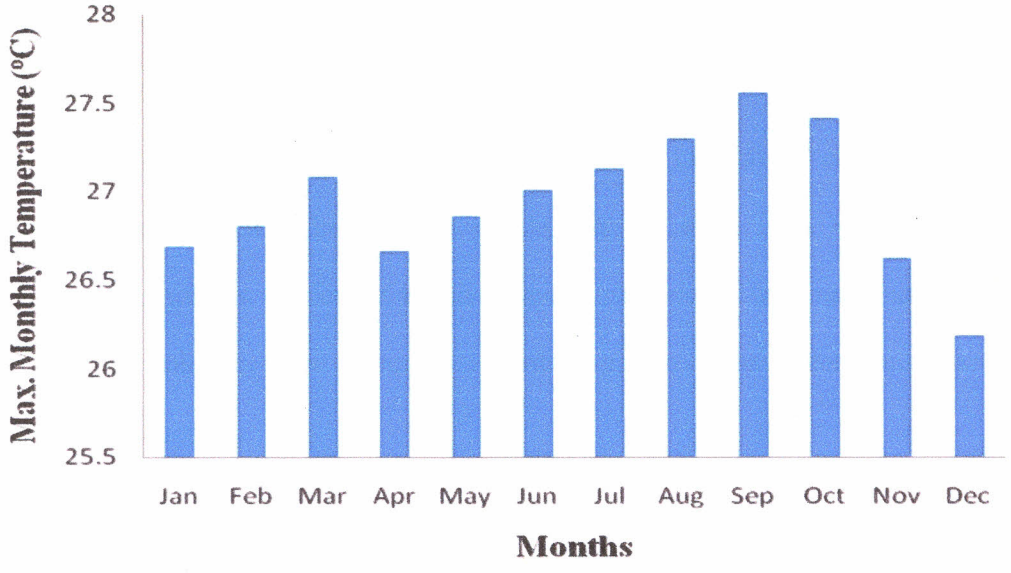

Figure 5: Maximum mean monthly temperature, 1970-1992 (^{0}C)

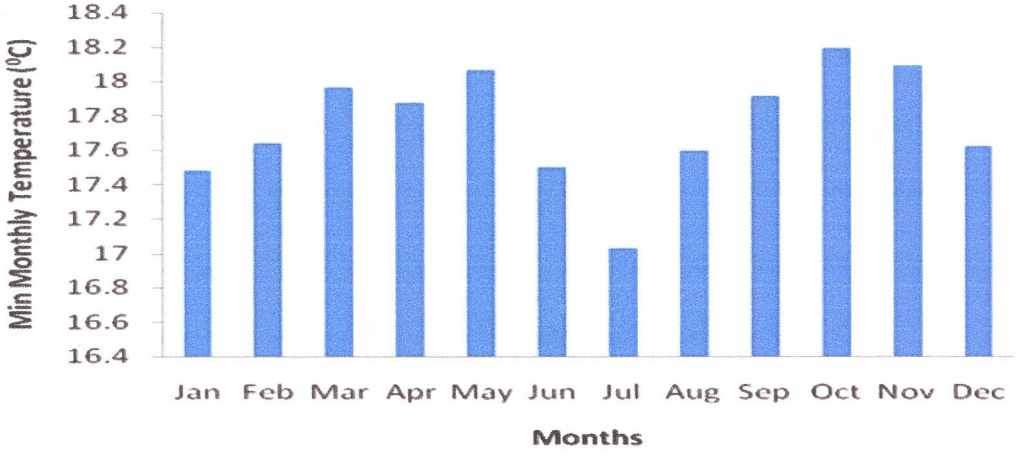

Figure 6: Minimum (1970-1994) temperature (^{0}C)

On the other hand, rise in temperature also causes high soil moisture loss, consequently affecting plant performance, resulting in stunted growth of crops and pasture. Many agro-pastoral household mentioned that use of traditional cultivation calendar they were accustomed in the past is becoming a problem. In the study area, where cereal crops comprise a significant portion of the food stock, an increase in temperature, especially when accompanied by low amounts of rainfall, proves to have detrimental effect on food/crop production.

4.1.2.3 Sunshine and evaporation

Sunshine (hours) is another parameter that was captured in the study with an increase in sunshine during the dry seasons of the years and a decrease during the intermediate (transition period) and short rains period. Also sunshine is associated with evaporation and from Table 4 it can be seen that evaporation decreases in the long rain and intermediate season while increased during the short rain season and the dry season. This can be viewed clearly in Fig 7 and 8 showing the patterns described in this paragraph. It can be seen in Fig 6 from May towards November sunshine show a decreasing trend that is from end of dry season up to the end of short rains. From Fig. 7 August and September can be seen to have maximum evaporation and a decreasing trend follows thereafter up to January where an increasing trend picks off again.

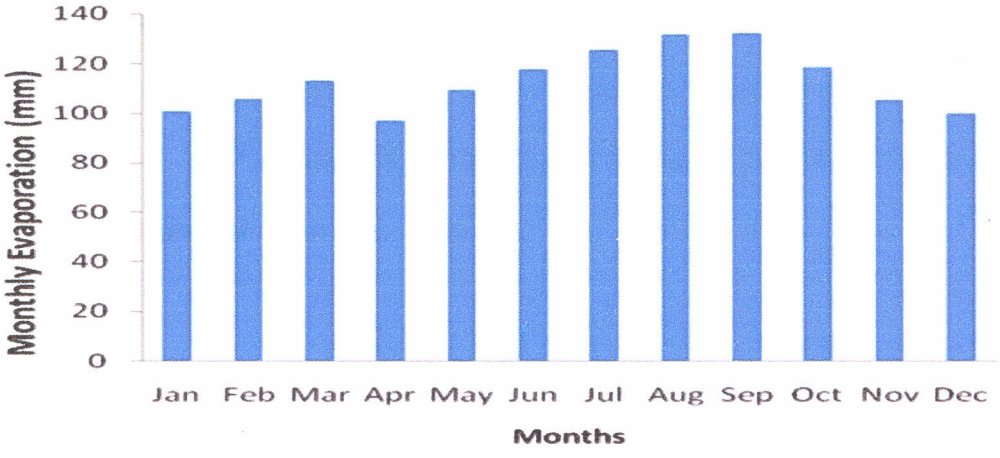

Figure 7: Mean monthly sunshine for the period (1970-1995) (hrs)

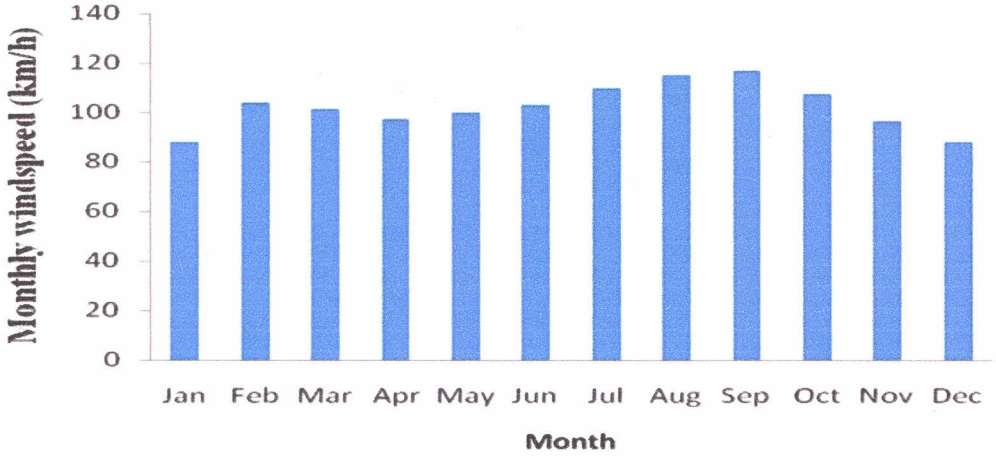

Figure 8: Mean monthly evaporation 1970-2000 (mm/hrs)

4.1.2.4 Wind speed and relative humidity

Generally, wind speed increased during the dry season and decreases throughout the year (Table 4). Also, relative humidity increased only during the intermediate season and decreased throughout the year (Fig. 9 and 10).

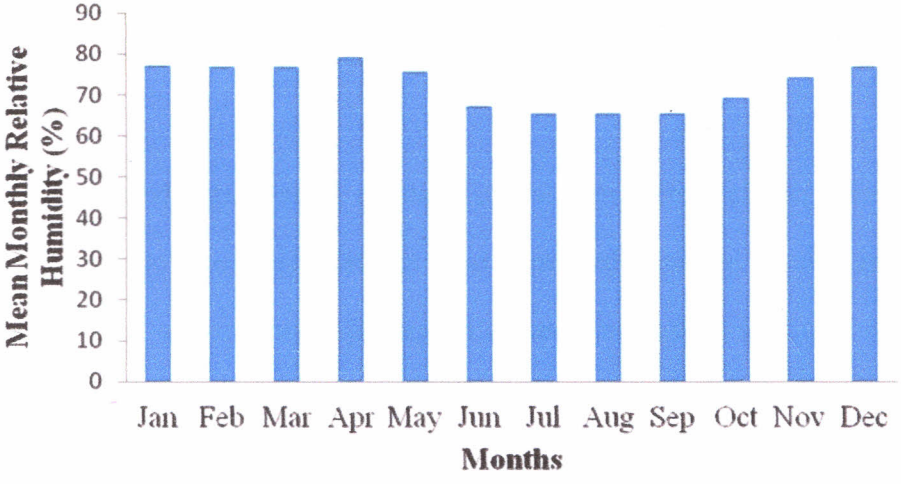

Figure 9: Mean monthly wind speed 1970-2000 (km/h)

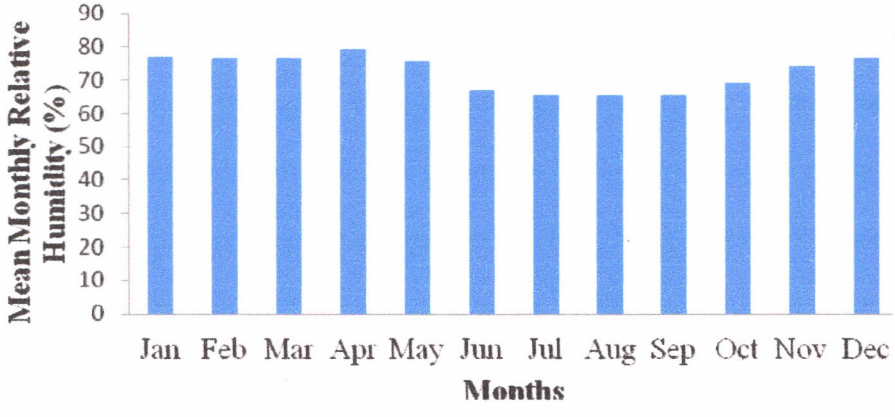

Figure 10: Mean Monthly Relative Humidity 1970-2000 (%)

The implication of the changes in various climatic parameters, such as rainfall and temperature have overall led to low agricultural yield, decrease in pasture and water sources for livestock (Niboye, 2010). These effects have led to low productivity, poor meat quality and generally low slaughter weights that fail to fetch better prices in markets (Orindi *et al.,* 2005). Agro-pastoralists opted to diversify livelihood (income generating) activities. Some exit pastoralism completely or left livestock keeping for other activities, such as crop cultivation or business (Ojwang' *et al.,* 2010).

The revealed variations in all these climate parameters affect various farm activities. According to agro-pastoralists the short rains used to start in October and were mainly for preparation of farms and rejuvenation of trees and pasture for livestock while long rains used for agricultural activities such as paddy and maize crops cultivation. Currently, the onset of rains has changed from mid to late October or early November which led to change in the staring time of various activities as well as their crop calendar.

On average, 42.2% of the respondents revealed that they were spending 9-10 hours per day searching for good grazing (Table 9), which included mainly searching for places for their animals. In the worst case, 5.6% indicated that they were spending 11-12 hours going to watering places. Climate variability has led to drying up of the water sources for both human and livestock. Agro-pastoralists have to travel long distances and use a lot of time (hours) searching for pasture and water. Presently, the majority of the sampled agro-pastoralists rely on few available water sources such as rivers, dams and some drilled boreholes which are likely to be degraded and dry up later and by which are not environmentally restricted.

Table 9: Average grazing time (hours per day) spent by pastoralists in Magu and Ilemela Districts

Grazing time	Percentage (%) Ilemela district n=40	Percentage (%) Magu District n=80	Average
1-4	10	0.6	5.3
5-6	33	2.8	17.9
7-8	51	6.6	28.8
9-10	4.4	80	42.2
11-12	1.6	10	5.6
Total	**100**	**100**	**100**

The revealed water sources in the study area are presented in Table 10. In Shishani and Kabila villages, 85% of the respondents depended on rivers (Duma and Simiyu) as their main water source. In Bubinza and Kitongo villages 78% depend on Lake Victoria whereas in Buswelu and Nyamhongolo villages, 65% depend on Boreholes and tap water. The most common water source in all the two districts was ponds in the rice fields. It should however be noted that during the dry seasons, most of the rivers dry-up hence leading to drilling of boreholes on the river beds.

Table 10: Sources of water for animals during the dry season n=120

Water source	Village (s)	Percentage
Rivers	Shishani and Kabila	85
Lake Victoria	Bubinza and Kitongo	78
Boreholes and tap water	Buswelu and Nyamhongolo	65
Dams, ponds in rice fields	All	75

4.1.3 Impacts of climate change

4.1.3.1 Impacts of climate change on livestock production

Livestock, together with crop production, were the main source of income for the agro-pastoralists in the study area. Delay in the onset of rains accompanied by short and insufficient and unpredictable rains caused pasture deficit. This led to livestock mortality, increasing their vulnerability to diseases and poor livestock health condition due to long distance travel in search of water and pasture as it was revealed in the focus group

discussions in the study area. This resulted in high migration or movement with cattle, reduced household incomes from livestock and livestock products.

4.1.3.2 Impacts on crop production

As it was observed in many parts of the study area, most of the agro-pastoralists (about 85%) practiced rain fed farming. Droughts and delays in the onset of rains have made the farm lands become drier and difficult to plough, caused stunted crop growth and slow germination of seeds, resulting in early wilting of the crops. In these districts rain-fed agriculture is dominant, harvests have diminished as was explained during the Focus Group Discussion that harvests of some short term crops like maize used to be twice a year. On average, farmers could harvest 8-15 sacks of (100kg) per acre but of recent, it is hard to get sacks; in some cases, because of water shortages induced by higher temperatures that caused high evapotranspiration in others because of disturbed crop cycles.

4.1.3.3 Impacts on water availability

The decrease in rainfall amount across the rainy season has impacted the water points and rain fed agricultural production systems. According to the respondents, water levels of shallow wells in the dry river beds are getting deeper while small scale irrigated farm plots are decreasing. On the other hand, despite of the apparent reduction of rainfall, it is also true that water extraction from seasonal water courses for irrigation purposes has increased with surge costs.

The low amount of rainfall has had an impact on water availability as well as agricultural production. Overall, it has led to increased vulnerability in food and water security, with direct effects on health (mainly mal-nutrition and water-borne diseases). It has become

apparent from the interviews and the focus group discussions that continued rainfall deficits in the past ten to twenty years or has created a dire situation in water quantity and access as well as production of rain fed crops. Moreover, the unpredictability of rainfall has made overall agro-pastoral production, the main source of income together with livestock, difficult and undependable.

4.2 Agro- pastoral Coping Strategies to Climate Change

The main adaptation and coping strategies (mechanisms) that were observed in the sample villages are summarized in Table 11. The climate change impacts discussed above paint a fairly negative outlook on the livelihoods of agro-pastoral communities. This is due to the fact that current and projected impacts of climate change are, and can continue to be, lessened through strengthened agro-pastoral resilience through adoption of viable adaptation strategies and risk management measures. These measures could eventually enable them to overcome the current and projected impacts of the climate change.

Table 11: Coping strategies employed by households in the study area (n=120)

Coping/ adaptation strategy	Village (s) practiced	Percentage
Migration to better places (temporarily or permanently)	All	87
Diversification of activities Crop cultivation Manson Petty business Charcoal production	All	78
Construction of Boreholes	Buswelu and Nyamhongolo	50
Splitting /diversification of herds	Shishani, Kabila, Kitongo and Bubinza	55
Drilling of temporary wells in rivers	Shishani, Kabila and Kitongo	80
Tap water	Buswelu and Nyamhongolo	65

4.2.1 Migration

Migration has been revealed to be one of the coping strategies adopted by agro-pastoralists in periods of dry seasons and water shortages (Table 11). During the dry season, agro-pastoralists in the study areas tend to migrate with their livestock,

particularly cattle, towards downstream areas and as far as to coastal areas. This had also been noted by Belay and Sugulle (2011) in Somaliland and Niboye, 2010 at Lake Victoria Basin of Tanzania. They usually move with their cattle while shoats and some few cattle for milk remain at the homestead areas. This is mainly because cattle travel long distances and need more feed than goats.

Migration has two major categories; Firstly, permanent shifting to other better places where there is water and pasture (grazing land) (e.g. near the lakes, rivers and the wetlands) is available. In such circumstances, the pastoralists move together with their livestock and family to other places.

The majority of pastoralists in the study area migrate to Shinyanga (Maswa), Simiyu and Musoma (Bariadi). Secondly, temporary shifting to other places during dry season and return when rain season starts as the water sources begins to refill. Studies by Tumbo *et al.* (2011) and Madulu (1998) also revealed migration as the most common agro-pastoral strategy in most of the semi-arid areas of Tanzania. Permanent migration was common in villages of Ilemela District, since the area is now under urban setting. Therefore, agro-pastoralists migrated following limited water and pasture availability. Temporary migration is the common practice in Magu District. Traditionally, most agro-pastoralists move seasonally with herds to places with pasture and water and come back to their homesteads in other seasons when pasture improves (Kaimba *et al.,* 2011). Nevertheless, the most dependable grazing land along Simiyu River in the dry season (temporary migration) was forest reserve for gazette. It is most likely that there will be more problems and conflicts mostly during the dry season due to limited grazing land. Furthermore, Nyamongo and Buswelu villages livestock theft was also another setback to resulting to permanent migration as also reported by Doss *et al.* (2008).

4.2.2 Diversification and splitting of herds

The increase of population and decrease in pasture combined with decreased livestock (deaths and migration and shifting) during drought have led to favorable environment for income diversification of pastoralists. During dry season, agro-pastoralists also tend to diversify their activities from livestock keeping to engagement into activities like crop cultivation, construction, petty business and charcoal production. This helps in times when they cannot earn much cash from livestock keeping.

Among the Sukuma, it is common for one to have large numbers of cattle and in the study area some tend to have up to thousands of herds. As it has also been reported in the research by Tumbo *et al.* (2011) in times of dry seasons the ones with large herd size tend to split them among neighbors and relatives so as to help cope with the effects of drought. This has also been observed in Kenya (Bryan *et al.,* 2010) as some delegate to herdsmen the management of part of the herd for security purposes and lack of land for grazing and water availability.

Also, due to recurrent droughts and shortage of livestock feed, especially grasses, agro-pastoral communities in the study area have shifted the composition of their livestock species from cattle dominated to shoats (sheep and goats). As discussed earlier, in the past, the number of cattle kept per household was larger due to the abundance of grazing land. Goats as browsers are resistant to droughts compared to cattle therefore, cattle numbers per household has been falling. Belay and Sugulle (2011) explained the reason that goats are more drought tolerant than cattle.

Despite the shortage of livestock feed, pastoralists in the study area indicated that they had no enclosures for fodder/pasture production in communal grazing lands except for

one (Bubinza village) of the six villages where at least an area had been reserved for pasture during dry period. The harvest is piled and stored as a reserve to serve as supplementary feed for lactating cows during the dry season when there is feed shortage.

4.2.3 Digging wells in the river sand beds and drilling of boreholes

With increasing climate variability and declining rains in the study area, agro-pastoralists have observed a change in the water table level of hand dug shallow wells in the rivers banks. The fall of water levels makes the farmers deepen the depth of the wells in pursuit of the water table. Mbilinyi *et al.* (2010) also found out that adaptation to climate change is associated with various impacts especially in agricultural systems. Also, a research by Obando *et al.* (2010) in Kenya sought on how vulnerabililties of pastoralists. The interviewed community members responded that they deepen their shallow wells to the depths of as deep as 4 metres. It is also important to mention here that there are risks inherent to the deepening of shallow wells and many lives of people and livestock are lost when well cavities cave in.

Large community depended on river as their main water sources (e.g. Kitongo, Shishani and Kabila villages) digs holes in the sand river to access water for their livestock. The whole process is normally carried out locally during dry season. Every year new, wells were dug leading to instability and degradation of the river banks. It can be argued that such activities are not sustainable and mainly result in secondary effect on the environment. In some villages in Ilemela District, drilling of boreholes using available expertise is considered as one of feasible adaptive measure.

4.2.4 Tap water and boreholes

Use of tap water and boreholes was another strategy that was employed by villages (the now changed to streets) near the town, such as Buswelu and Nyamhongolo. About 65% of respondents from Ilemela obtained water from the tap: this was not mentioned in any other villages in Magu Districts. These two have been combines since the water from the utility are stored in the boreholes to be used once there is no water. From the FGD tap water was the most common coping strategy in Ilemela District since it has been developed into a town where it is now a settled area and land tenure system is starting to emerge. Therefore agro-pastoralists in the area can no longer move their herds the way they want. Moreover most of the stock routes that were previously used for trekking livestock to water ponds and pasture have been closed by the established houses and roads. Enforcement of laws and regulations hinder agro-pastoralists from trekking herds to water ponds since there are fines that they have to incur when such laws are violated.

Due to the fine charges pastoralists decided to look for alternative ways to obtain water without violating the laws hence the only option was to use tap water and for the remaining 35% either decided to move their livestock to areas near the water sources even if it meant relocating or sending away the livestock.

This explains the reason for tremendous decrease in number of pastoralists as well as livestock in Nyamhongolo and Buswelu villages, as from the time reconnaissance survey was done (in May, 2012) to the time of data collection (in a six month time) the number of pastoralists had decreased to almost a half and by this it is likely that pastoralists are shifting to other areas where the conditions are more favorable.

4.2.5 Economic implication of coping strategies

From the focus group discussions and household questionnaire surveys the study was able to work out the economic implications of some of the identified coping and adaptation strategies. Priority was given to coping strategies that were mostly used at the same time the ones that are in line with the environment (EMA, 2004). Costs were identified and summed up for each strategy per the season. Some of the summarized costs identified are presented in Table 12 for the two districts studied.

The kind of migration observed with the agro-pastoralists in the area was both permanent (moving to another area with the whole family) though this was the minority (19.2%) while the remaining (80.8%) was temporary involving the herder and cattle as observed in the study by Obando *et al.*(2010). Average cost differed slightly between the two districts. This is the most practiced strategy in the Sukuma land. This land use practice is being discouraged/banned in the country by NEMC due to increased conflicts between the pastoralists and crop farmers. In addition, the practice has been reported to cause land degradation as well as soil erosion (Unsworth *et al.*, 2013). It is of great importance that alternative strategies other than migration be encouraged without looking at its cost. This is necessary due to the fact that migration also exacerbate the effects associating with climate change as these too are associated with clearing of natural forests in search of settlements as well as pasture.

Diversification of several activities as a coping strategy was identified and their average earning per season were obtained (Table 12). 44% of respondents opted for more than two alternative activities so as to get income as it was similarly noted by Haule (2009). Crop cultivation (26.7%) and Masson (24%) were the other activities that the respondents engaged, while petty businesses were done by fewer (5.3%) household. Small to medium

business is one of the strategies that need to be encouraged so that pastoralists can have alternative income generating activities that would help them advance their way of livestock keeping and improve their livelihood.

Drilling of temporary wells in rivers and streams was another strategy that the study estimated the cost implication despite knowing that the whole activity was not legal as per the Environmental Management Act (2004).The costs that were incurred as per the household was family labor or group of family members that engaged in the activity as well as the average number of days they spent until they get water. The approximate cost for drilling wells on average was TZS 40 000 per household (50% of the sampled population that engaged in drilling wells). This amount does not include the cost of migration to the temporary wells. However, the respondents found this strategy to be the cheapest since they ignored the migration cost, taking up to the temporary well and the number of days the well would contain water in the season. Henceforth, the strategy is also yet to be forbidden since it disturbs the nature of the water bodies and leads to increased siltation.

Boreholes that were constructed in the area were just small holes just for a household use and for those few households that could afford drilling big ones to cater for their herds. The results showed that the cost of drilling boreholes ranged between TZS 350 000 (52.9%) and TZS 1 000 000 (6.7%). The findings imply that agro-pastoralists could afford constructing boreholes if they could form small groups and construct different types of borehole for water source. From the results, it was observed that paddy (rice) *majaruba* fields which are temporary used as watering points since they are sources of conflicts between farmers and herds. From FGD it was mentioned as a source of water for animals on their way to the lakes and rivers but results into fine payment hence extra

cost. One has to obtain permission for such activity from the owner. The fines ranged from TZS 350 000 to 1 000 000.

Table 12: Costs of coping strategies (TZS/yr/hh) (n=120)

Cost (In 1000's)	Frequency	Percent
Cost of migration (1000's)		
1 811.25	80	66.7
1 592.5	40	33.3
Cost of diversification of activities		
All three 402	33	
Crop cultivation 240	20	44.0
Manson 100	18	26.7
Petty Business 62.5	4	24.0
		5.3
Cost of drilling temporary wells		
80	2	11.1
60	4	22.2
40	9	50.0
20	3	16.7
Cost of drilling boreholes		
350	9	52.9
500	7	41.2
1 000	1	6.7
Tap water		
350	12	46.2
500	10	38.5
More than 500	4	15.4

4.3 Socio-economic Factors Determining Adaptive /Coping Capacity

4.3.1 Adaptation and coping capacity

Coping capacity from this study has been defined by the ability to employ as many strategies as possible. In this study there were five main strategies identified. Table 13 summarizes the results from the sampled households in the two districts under study. It can be deduced that the two districts differ very much in the number of coping strategies employed and henceforth differ in their coping capacity.

Table 13: Agro-pastoral adaptation/ coping capacity in the study area

No. of coping strategies	Magu District (n=80) Percentage	Ilemela District (n=40) Percentage
3	11.3	75
2	37.5	22.5
1	51.3	2.5
Total	100	100

Responses from Ilemela showed that 75% of the interviewed respondents used up to three coping strategies while in Magu District only 11.3% used up to three strategies to cope with the effects of climate change. From this it can be said that agro-pastoralists in Magu Districts have low coping capacity compared to those from Ilemela districts as very few could employ up to three strategies. Again, from the results (Table 13) about 51.3% (more than half) of respondents in Magu Districts employ only one strategy to cope with the effects of climate change in contrary to those in Ilemela who only 2.5% use one strategy. As for those that apply up to two strategies in the two districts, 37.5% and 22.5% use up to two strategies to cope in Magu and Ilemela Districts, respectively.

This implies that most agro-pastoralists in towns such as those in Ilemela have ability to cope with the effects of climate change because they are closer to town hence they have access to information regarding climate change and how to cope than those in Magu. a rural setting. In addition, during the FGD, agro pastoralists in Ilemela said that currently grazing is restricted thus the option they have is either keeping livestock indoor and practice cut and carry in feeding or permanently move to other areas where they could continue grazing their animals.

Another plausible explanation which made most of agro-pastoralists in Magu District not adapting up to three coping strategies is because they still believe that livestock keeping is their culture and they have to maintain it. They still have the various rivers which are

crossing their area and the presence of the Lake Victoria where watering of their animals can be done. These two sources of water according to the respondents will always be there, so in case of drought they can always take their herds to those places for watering. Agro-pastoralist lack knowledge on environment and conservation, as most of them are unaware that areas around lakes and rivers are restricted from human activities (NAWAPO, 2002).

4.3.2 Socio-economic factors determining adaptation or coping capacity

4.3.2.1 Significance test of the model log likelihood

Table 14 presents results of the initial log likelihood value (263.518) a measure of a model with no independent variables, i.e. only a constant or intercept. The final log likelihood value (171.804) is a measure after all of the independent variables have been entered into the logistic regression. The difference between these two measures is the model chi-square value (X^2= 91.714 = 263.518 – 171.804) that is tested for statistical significance. This test for R^2 or change in R^2 value in multiple regressions, test whether or not the improvement in the model associated with the additional variables is statistically significant.

In this study the model Chi-Square value of 91.714 has $p< 0.05$, implying that there is a statistically significant relationship between the dependent variable and the set of independent variables. Hence the null hypothesis that socio-economic factors are not significant in determining adaptive and coping capacity of agro-pastoralists is rejected. Hence this support the alternative hypothesis socio-economic factors (number of years of residence in the village, herd size and age of the head of household, sex, household size, education and cost of coping) are significant in determining the adaptive and coping capacity of agro-pastoralists.

Table 14: Multinomial regression model fitting information

Model	Model Fitting Criteria	Likelihood		
	-2Log likelihood	Chi- square	d.f	Signf
Intercept	263.518			
Final	171.804	91.714	36	.000

4.3.2.2 Identifying the statistically significant predictor variables

Two outputs related to the statistical significance of individual predictor variables: the likelihood ratio tests and parameter estimates have been summarized in Tables 15 and 16 respectively. The likelihood ratio test indicates the contribution of the variables to the overall relationship between the dependent variable and the individual independent variables. The parameter estimates focus on the role of each independent variable in differentiating between the groups specified by the dependent variable.

Since the final model fitting information in Table 14 has shown that socio-economic factors were significant determinants of agro-pastoral coping capacity then Table 15 explains specifically which factors are statistically significant. In this model, the variables number of years of residence in the village, herd size and age of the head of household were found to be significant contributors to explaining differences in adapting or coping capacity ($p<0.05$).

Table 15: Likelihood ratio test

Model	Likelihood Chi- square	Significance Level
Constant	.000	.
Sex	9.032	.118
Herd Size	10.583	.032*
Size	15.689	.192
No.yrs	8.693	.047*
Age	7.370	.011*
Education	14.369	.157
Coping Cost	20.506	.286

*Significant at $p<0.05$

On the contrary sex, education, herd size as well as cost of coping have $p > 0.05$ and this implies that they are not statistically significant in influencing coping capacity among agro-pastoralists.

The variables with statistically significant relationship to distinguishing three strategies from two strategies in the first logistic regression equation were herd size, age and number of years lived in the area. This implies that the more the number of years one resides in the area positively influences the adaptive or coping capacity by 98%, for herd size the more the number of cattle one has is likely to influence the coping capacity by 99%. Herd size and number of years of residence have a positive influence on the agro-pastoral coping capacity in opting three strategies compared to two.

Hereafter, the more the number of years one has lived and the more the number of herds implies more coping capacity of agro-pastoral household. But on the contrary the age has got a negative influence on the coping capacity as shown in Table 16. The older the head of household tend to decrease the coping capacity of the household by 97% since most of these people tend to be rigid to fast adapt to new strategies quickly compared to the younger ones. Also this could be associated with the ability and strength of these older people to integrate issues happening now with the newer technologies being introduced now to counteract the resulting effects.

For the second model containing three to one strategy and the last model containing two to one strategy, it can be seen from Table 16 herd size and number of years of residence in the area was the main determining factors having a positive effect to coping capacity like for the model with three to two strategies. The larger the herds size in a household the more the number of strategies. Hence there is high coping capacity by 99% and 98% for

3/1strategy and 2/1 strategy respectively. For the number of years of residence, a similar trend can be seen in these last two models whereby the more the number of years the more the coping capacity by 98%. For the last model that compares two versus one strategy, it can be seen that age is again a determining factor and has a negative influence by 96.8% towards coping and adapting capacity. This implies that the older the individual the less the coping capacity towards the effect of climate change and variability.

Table 16: Influence of socio-economic factors toward agro-pastoral coping capacity

Socio-economic factors	Multinomial Logit estimates a B (ε)		
	3strat/2strat	3strat/1strat	2strat/1strat
Intercept	0.13 (2.08)	-6.73 (2.93)	0.55 (1.89)
No. of Years	0.02** (0.02)	0.01** (0.02)	0.04* (0.02)
Sex	0.31 (0.84)	-2.48 (0.94)	1.26 (0.9)
Age	-0.01** (0.03)	0.06(0.04)	-0.014** (0.032)
HH size	-0.09 (0.08)	0.07 (0.99)	-0.12 (0.081)
Education	-0.15 (0.27)	0.14(0.308)	-0.67 (0.36)
Herd size	0.01** (0.01)	0.01** (0.01)	0.00** (0.008)
Cost of cop	2.056 (0.593)	5.058 (0. 0)	5.05 (1.139)
N=120			
X2(d.f=14)=91.714			
Pseudo R2			
Cox & Snell= 0.513			
Nagelkerke= 0.577			
McFadden= 0.32			

** Significant at p <0.05 and
* Significant at p < 0.01

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Agro-pastoralist Perceptions and trends in climate change and variability: Climate change has resulted in environmental shocks such as drought, unpredictable rains and high temperatures – causing an inadequate supply of water and pasture, an increase in disease incidences, death of animals, and other effects. In this study it was clear that there has been significant change in rainfall, temperature and wind patterns for the last twenty to thirty years. These findings match well with the perceptions of the agro-pastoral communities. This implies that climate change is really happening and the farmers have started to understand what it means by climate variability and change from their day to day experience. Unpredictability of rainfall, temperature and wind is what affects agro-pastoralists' activities the most as agro-pastoral calendars are no longer clear as to when to start cultivating and all other weather dependent activities.

Agro-pastoralists adaptation and coping strategies: The effects of climate variability among agro-pastoralists are now apparent and the agro-pastoralists have developed strategies of reducing the risks associated with climate variations. Some of the short term seasonal coping strategies such as migration and drilling wells in the sand river bed to access water are not sustainable and can be considered to contribute to the secondary effect on the environment.

Since current climate change actions are not quite properly coordinated at local scales, most of the agro-pastoralists still use indigenous (local) strategies that have for a long time been used to cope with the climate change. Investments to address shocks in agro-

pastoralist are uncoordinated and inadequate. Agriculture and livestock extension officers have to be trained on climate change adaptation and deployed in all areas especially in rural areas where there are always few experts.

Socio-economic factors determining agro-pastoral adaptive capacity: As it has been observed that three out of seven factors (age, number of years lived and herd size) of residence are statistically significant in influencing adaptation and or coping capacity. Herd size and number of years lived have positive influence on coping capacity while others (age) have negative influence on the coping capacity.

5.2 Recommendations

From the findings of this study, the following recommendations are made to help agro-pastoralists best cope with climate change and variability;

i. Climate change and variability is now a reality and this has also been revealed from trend analysis of 30 years climatic data. It is likely that the revealed trends will continue and that there will be no reverse order to the present trends.

ii. In the trend analysis it was seen that rainfall trends are expected to increase while temperatures are at a decreasing trend. This should be a focus point to educate pastoralists on how best they can cope with such changes. Also Tanzania Meteorological Agency (TMA) should strengthen their zonal offices and close follow ups of Regional and District meteorological stations for proper record keeping and where possible set a database where the data are automatically fed and stored to the electronic database system and not on manual hard copies. This will help the communities be updated with ongoing trends within their areas.

iii. With increasing effects of climate change, the herd size per household should be reduced to match with the available resources so as to reduce the land conflicts that are currently becoming a country's threat due to the frequent migration and grazing into farmers' crops. This is to say not only should the agro-pastoralists split herds in time of drought but should resize them to match with the available natural resources.

iv. Appropriate interventions that aim at increasing water access and reducing travel distances and time to water sources such as rainwater harvesting and improvement in pasture availability are imperative.

v. Further research should be done to investigate appropriate interventions aiming at improving water availability and pasture for agro-pastoralist.

vi. Need for understanding performance of fodder grasses under various coping strategies such as rain water harvesting is imperative. This will help pastoralists harvest water for both watering and growing grasses using simple and local structures.

vii. More research on some other factors that could possibly influence the increasing adapting as well as coping capacity among agro-pastoral households as well as communities at large that have not been addressed.

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APPENDICES

Appendix 1: Questionnaire for Pastoralists

Questionnaire for pastoralists

Notes To Enumerators: Start the interview by introducing yourself and the aim of the interview as well as how the results of interviews will be used. Where the respondent wishes to be ensured about the confidentiality of the interview process, please do so.

Section 1: Identification Particulars, Staff & Survey Time Details

1. DISTRICT: 1) Ilemela 2) Magu	
2. DIVISION: 1)Ilemela; 2)Ndagaro; 3 Itumbili	
3. WARD:1)Buswelu; 2)Bugogwa; 3)Shishani; 4)Nkungulu; 5) Sukuma; 6)Lubugu	
4. VILLAGE:1) Nyamhongolo; 2) Busenga; 3)Shishani; 4)Kabila; 5)Kitongo; 6)	
5. HOUSEHOLD CATEGORY : Pastoralist	
6. HOUSEHOLD CODE/NAME:	
7. NUMBER OF YEARS LIVED IN THE VILLAGE:	
8. SEX OF HEAD OF	1) ___

NAME OF INTERVIEWER: _____

	DD		MM		YYYY			
DATE OF INTERVIEW								

STARTING TIME | | | : | | | Hours : minutes

ENDING TIME | | | : | | | Hours: minutes

Section 2: Household Demographics

Notes to Enumerators: The aim of this Section is to gather information related to demographic characteristics that will constitute a useful package of information for the Study.

2-1: ASK the respondents to make a complete list of his/her household members. For the purpose of this survey, a household is defined as persons eating under the same roof three or more days per week for at least six months out of the past year.

Person ID	Name	Sex 1= M 2= F	How old is [NAME] in completed years?	What is the relationship of [NAME] to head of the household? 1= Head 2= Spouse 3= Son/daughter 4= Grandchild 5= Step child 6= Parent of head or spouse 7= Sister/Brother of head or spouse 8= Nephew/Niece 9= Other relative 10= Servant 11= Non-relative 12= Other (specify)	During the **past 12 months**, how many months did [NAME] live in this household?	What is the highest grade of school that [NAME] completed? **0**= none **N** = nursery **1**= P1 **2**= P2 **3**= P3 **4**= P4 **5**= P5 **6**= P6 **7**= P7 **8**= S1 or P8 **9**= S2 or P9 **10**= S3 **11**= S4 **12**= S5 **13**= S6 **14**= Post primary specialized training or certificate **15**= Post secondary specialized training or diploma **16**= Completed degree **17**= Don't know

1	2	3	4	5	6	7
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						
11						

Total household size .....

Section 3: Facilitating & Limiting Factors In Environmental & Climate Change

		1 Strongly agree 2 Agree 3 Strongly Disagree 4 Disagree 5 Don't know	**Reasons** (Probe on frequency, time)
Awareness on Environmental Education			
3.1	There is adequate environmental education		
Perceptions on Climate Change			
	In recent years drought condition has decreased (how was it ,which years, effects resulted).		
	Flood has decreased (how was it ,which years, effects resulted)		
	Overstocking leads to environmental degradation		
	Water for livestock has decreased due to climate change		
	Rain Water harvesting improves livestock production		
Perception on Adequacy of Pasture			
	Pasture has decreased due to climate change		
	Grazing area is not a problem		
	Land tenure systems affect pasture availability		

Section 4: List All the Indicators, Causes and the Effects of Climate Changes

Indicators/ Events	Causes	Effects/Impacts (also probe on human, livestock, cultivation, settlement, vegetation, water resources, fauna, soil)

How many cattle do you have? 1=Less than 10 2=11-20 3=21-30 4=31-50 5=Over 51 Cattles	Do you have any other livestock ? 1=Yes 2=No If Yes>>	Where do you normally water your livestock? 1=River 2=Pond 3=Valley 4 Dam 5=Protected spring 6= Borehole 7 =Lake 8=Others (specify)	View on how it rains these days compared to 10-30 years ago 1=Increased 2=Decreased 3= Fluctuating 4=No change	View on temperature these days compared to 10-30 years ago 1=Increased 2=Decreased 3= Fluctuating 4=No change	Which coping strategies do you practice?		
					Migration searching for water	Diversification into other activities	Water harvest
					1=Yes 2=No	1=Yes 2=No	1=Yes 2=No
1	**2**	**3**	**4**	**5**	6	7	**8**

4.2.1Mention the factors influencing the choice of coping strategy

.....

.....

4.2.2 Costs involved in the coping strategies

Strategy	Who were involved? 1=The family 2=Some members of the family	Cost of moving		Days spent in a season	Other
		Establish a new home	Renting rooms		
1					
2					
3					
4					
5					
6					

Thank you for your time and cooperation!

Appendix 2: Checklist guide for focus group discussion guide for pastoralists in the village

Region.....District.....Division.....Ward.....

Name of the community/village.....

Date of discussion.....

FGD No.....

1. Are there any changes in climate in this area? Yes.....No.....
2. What is your view on how it rains these days, 10years back, 20years back, and 30years back?
3. What is your view on temperature these days, 10years back, 20years back, and 30years back?
4. Which years can you recall the occurrence of such events (drought and floods) and related impacts to pastoral?
5. How have the above changes affected livestock activities in this community?
6. How have the above changes affected livestock based resources such as water and pasture?
7. What measures/ strategies have you taken to deal with the above effects on your activities?
8. Where can those measures/strategies be found so that any other person can follow and use them in future?
9. For how long have you used those strategies as a community?
10. Ranking the identified strategies in terms of most preferred the most efficient in the community concerned.
11. What are your feelings and experiences with those measures that you are using to deal with the above situation?
12. What other strategies would you recommend to deal with the changes?

13. What factors determine the adaptive capacity of pastoral household?
14. What are the barriers and enabling conditions towards implementation of these strategies?
15. Is there any more contribution you would like to make?

Thank you for your cooperation