# THE IMPACTS OF CLIMATE CHANGE ON FOOD SECURITY AND COMMUNITY BASED ADAPTATION OPTIONS: THE CASE OF MAGU DISTRICT IN MWANZA, TANZANIA

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## CERTIFICATION

The undersigned certifies that he has read and hereby recommends for acceptance by the Open University of Tanzania a Thesis titled ***The Impacts of Climate Change on Food Security and Community Base Adaptation options: The Case of Magu District in Mwanza, Tanzania*** in fulfillment of the requirements for the degree of Master of Science in Environmental Management of The Open University of Tanzania.

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(Supervisor)

Date: ________________________________________

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## DECLARATION

I, Wilson R. Katunzi**,** declare that this thesis is my own original work and that it has not been presented and will not be presented to any other University for a similar or any other degree award.

Wilson R. Katunzi**,**

Date

# DEDICATION

Almighty God for being my shepherd, leading me to the path of righteousness, and for many blessings that He has made part of my life. This Master thesis is also devoted to my lovely father, Christian Rwegasira Katunzi (deceased). May God rest his soul in eternal serenity. Amen

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## ABSTRACT

This study assessed the impacts of climate change/variability on food security and documents community based adaptations. Three villages were selected representing three agro-ecological zones highlands, middle and lower lands. In each village, sample size of 5 percent of households was systematically selected. Both secondary and primary data were used. Rainfall anomalies were used to characterize wet and dry seasons, whilst mean annual maximum and mean minimum temperatures were used to establish the fluctuations in temperature. Findings indicated that both data from TMA and local people perceived changes in rainfall and temperature. The changes have affected crops and livestock in a number of ways resulting in reduced productivity. Empirical analysis of rainfall suggest decreasing rainfall trend between 1960 and 2009 whereas mean maximum and minimum temperature increased by 1.1 and 0.2°C respectively. Findings revealed that 82% of respondent's perceived rainfall pattern is decreasing in the past 30 years; 86% voted temperature pattern is increasing in the same period 90% appealed the occurrence of mosquitoes as human disease vector and armyworm to increase during extreme wet weather. There are different wealth groups namely the Better off, the middle as well as resource weak and these are vulnerable and adapted differently to climate change. Awareness on various adaptation options should be conducted to enhance community resilience and sustainable development. Further research should focus on water harvesting technologies, regulation of rivers flows and use of the underground water for irrigation works so as to achieve sustainable food production and livelihood security.

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## LIST OF ABBREVIATIONS

AIDS - Acquired Immune Deficiency Syndrome

ASL - Above Sea Level

EAMD - East African Meteorological Department

EIA - Environment Impact Assessment

EPMS - Environmental Protection and Management Services

ESRF - Economic and Social Research Foundation

FAO - Food and Agriculture Organization of the United Nations

FIVIMS - Food Insecurity and Vulnerability Information and Mapping System

FSIEWS - Food Security Information and Early Warning System

IFAD - International Fund for Agricultural Development

IPCC - Intergovernmental Panel on Climate Change (UN)

ITCZ - Inter-tropical Convergence Zone

HBS - Households Budgetary Survey

HIV - Human Immuno-defience Virus

JF - January-February

JJAS - June-July-August-September

MA - Millennium Assessments

MAM - March-April-May

MKUKUTA - Mkakati wa Kukuza Uchumi na Kupunguza Umasikini Tanzania

NBS - National Bureau of Statististcs

NEMC - National Environmental Management Council

OND - October-November-December

OCHA -

SARS - Severe Acute Respiratory Syndrome

SEI - Stockholm Environment Institute

SPSS - Statistical Package for Social Sciences

SRES - Special Report on Emissions Scenarios

START - Global Change System for Analysis, Research and Training

SEA - Strategic Environment Assessment

SUA - Supply and Utilization Account

TMA - Tanzania Metrological Agency

Tz PPA - Tanzania Participatory Poverty Assessment

UK DEFRA - United Kingdom Department for Environment, Food and Rural Affairs

UNCED - United Nations Conference on Environment and Development

UNDP - United Nations Development Programme

UNFF - United Nations Forum on Forests

UNEP - United Nations Environment Programme

UNESCO - United Nations Educational, Scientific and Cultural Organization

UNFCC - United Nations Framework Convention on Climate Change

UNICEF - United Nations Children’s Fund

URT - United Republic of Tanzania

USA - United States of America

(US $) - US dollar

WFP - World Food Programme

WHO - World Health Organization

WMO - World Metrological Organization

WRI - World Resource Institute

(°C) - Degree Celsius

# CHAPTER ONE

## 1.0 THE PROBLEM AND ITS CONTEXT

### 1.1 Introduction

This chapter presents the research problem and its context. The chapter comprise of sections on background of study, statement of the problem, study objectives, justification of the study, scope and limitations of the study and concepts and the structure of the thesis.

### 1.2 Background to the Study

Climate change is considered to be one of the most serious threats to sustainable development, with adverse impacts on the environment, human health, food security, economic activities, natural resources and physical infrastructure (FAO, 2007). Global climate varies naturally, but scientists agree that rising concentrations of anthropogenically produced greenhouse gases in the earth's atmosphere are leading to changes in the climate *(ibid)*. The World Economic Forum outlined the five core areas of global risk as economic, environmental, geopolitical, societal and technological. Within these, climate change is seen as one of the insignificant challenges for the twenty-first century, as it is a universal risk with impacts far away from the environment (World Economic Forum, 2007). According to the Intergovernmental Panel on Climate Change (IPCC, 2007), the effects of climate change have already been observed, and scientific findings indicate that precautionary and prompt actions are necessary. It is evident that climate change will impact Africa in various ways. For example, predictable impacts of climate change and variability by 2100 in Africa might include increases of 1.0 degree celsius (°C) to 4.7 °C in temperature bargain rainfall by 2-25 percent, augmented evapo-transpiration up to 132 percent, and cut-rate run-off by up to 50 percent (Magadza, 1996; Hulme, 1996).

Climate projections in apathetic emission scenarios (A1B and A2) denote that Tanzania will be warmer with an addition in minimum temperature of between 1.0 and 1.5°C by 2030 with regard to 2000 as baseline year. Maximum are predictable to increase in some area of the country by 3°C and decrease in other areas of the same scale. By 2050 minimum temperatures are anticipated to increase by 2°C Watkis *et al* (2011). Also at continental, regional and ocean basin scales, numerous long-term changes in climate have been pragmatic. They include changes in Arctic temperatures and ice melting, widespread changes in precipitation amounts, ocean salinity, wind patterns and aspects of intense weather including droughts, heavy precipitation, heat waves and strength of tropical cyclones (IPCC, 2007**).**

In most African countries, as well as Tanzania, farming depends almost entirely on quality of the rainy season (IPCC, 2007). This makes Africa mainly vulnerable to climate variability/change. Climate change, however, is considered to pose the greatest threat to agriculture and food security in the 21st Century, mostly in many unfortunate and agriculture-based countries of Sub-Saharan Africa (SSA) with their low ability to cope (Shah *et al*., 2008; Hellmann *et al*., 2009; IPCC, 2007; WHO, 2007; FAO, 2008). Analysis of present economic and environmental trends in Africa reveals increasing struggle over access and uses of freshwater resources (IPCC, 2007). Present climate change/variability i.e. extreme weather events such as drought and floods, previously guide to major economic cost in Tanzania. Individual annual events have economic costs in excess of 1% of GDP, and occur frequently reducing long-term growth and touching millions of people and livelihoods Watkis *et al.*, (2011*)*. At the identical time, population growth and climate inconsistency inflict a further pressure on these already inundated resources (UNEP /UNESCO /START, 2005).

Developing countries are particularly susceptible to climate change impacts, chiefly changes in rainfall (Vogel, 2000), because of their exposure to extreme weather events and reliance on natural resources (Vogel, 2002; Ikeme, 2003). Due to recurrently occurring drought, high temperatures, storms, hurricanes and flooding, food insecurity is of global alarm especially in developing countries. The circumstances are highly serious in Sub-Saharan Africa (FAO, 1996).

Agriculture-based livelihood systems that are previously susceptible to food insecurity face immediate risks of increased crop failure, new patterns of pests together with diseases, lack of suitable seeds as well as loss of livestock, fish stocks, increasing water scarcities and destruction of prolific assets (FAO, 2007). In developing countries, 11 percent of arable land could be exaggerated by climate change, including gross turn down of cereal production in up to 65 countries, concerning 16 percent of agricultural GDP (FAO, 2005). People living the length of the coast, floodplains, in mountains, and dry lands are nearly all at risk of tremendous of weather events. (Lemke, 2007). As meandering effect, low-income citizens all over, but particularly in urban areas, will be at jeopardy of food insecurity due to loss of assets and lack of adequate insurance treatment (FAO, 2008).

Climate change is seen to be a most important hazard to sustainability of livestock production systems in numerous parts of Africa (Moss *et al.*, 2000). Global demand for livestock products is expected to double during the first half of this century, as a result of the growing human population, and its growing prosperity. The crash of climate change on animal production one-time categorized by Rotter and Van de Geijn (1999) on (a) ease of use of feed grain, (b) pasture jointly with forage crop production as well as quality, (c) wellbeing growth together with reproduction and (d) diseases and their extend. Climate changes could thus consequence in decrease or amplify in population of livestock species in the region (Moss *et al.*, 2000; IPCC, 2007).

FAO, (2004) identifies regarding 852 million people universal to have been malnourished between the years 2000 and 2002. Out of these, 815 million people in developing countries, 28 million in countries in evolution and 9 million in industrialized countries (*ibid*). During the identical period, the numbers for Sub-Saharan Africa were 203.5 million away of a total population of 620 million, equal to `33 percent of the total population, whilst for the Eastern Africa region there were 86.2 million people out of a whole population of 217.7 million, equivalent to 40 percent (FAO, 1999). An additional 30 percent of hungry people are fisher-folks, herders, or landless countryside people and the rest is poor urban dwellers (UN Millennium Project, 2005). As well, impacts of climate change – sea level rise, droughts, heat waves, floods and rainfall deviation – could, by 2080, move forward another 600 million people into malnutrition and add to the number of people in front of water shortage by 1.8 billion (UNDP, 2008). According to the UN Office for the Coordination of Humanitarian Affairs (OCHA, 2007), the numeral of natural disasters has amplified, due to further frequent extreme weather events, such as hurricanes, cyclones, droughts and floods. In 2007, OCHA appealed for almost 400 million US $ in food and extra emergency aid for people exaggerated by 14 such calamities in developing countries (OCHA, 2007). In Tanzania, there are no all-inclusive statistics covering the starving population. However, taking undernourishment in the midst of children as a proxy, 44 percent of children under the age of five are emaciated, an indicative of unending food insecurity (HBS, 1992).

In nearly all developing countries, population growth is presently in a state of disparity with supply of food, energy and natural resource (Lee, 1975). Increased rainfall could escort to more repeated outbreaks of rift valley fever and armyworms.
In the Tanzanian framework, impacts of climate variability and change are not less depressing. More than 75 percent of the population is countryside and practices largely survival rain-fed agriculture (WHO/UNICEF, 2000). Hasty population growth and escalating demands for food shared with high variability in rainfall are putting massive pressure on use of resources (URT, 2003). According to (*Agrawala et al. 2003*), sectors potentially impacted by climate change within Tanzania are agriculture, forests, water resources, coastal resources, human health, energy, industry and transport. Agriculture is notorious to be the most pretentious sector as people in rural and urban areas experience from food insecurity. The situation is

linked with poor crop harvests due to insufficient rainfall, which also affects livestock and wildlife wherever animals die alongside weakening pasture and water (NAPA, 2006). On the foundation of these grounds, climate change can sluggish the pace of progress towards sustainable development, also directly through increased contact to unfavorable impact or indirectly through erosion of the capacity to acclimatize (Yohe *et al.,* 2007).

In an effort to contest environmental issues, Tanzania has signed a numeral of Multilateral Environmental Agreement (MEA), and has developed the National Adaptation Programme of Action (NAPA, 2006). The preparation of NAPA has been a appropriate opportunity to appear at the country's climate change linked vulnerabilities in a variety of sectors, which are significant for the economy. NAPA has recognized the agricultural sector as the majority vulnerable sector to climate change in the midst of others in the country.

Tanzania's economic platform depends much on the agricultural sector, which contributes regarding 44.7 percent to the national GDP (2007 - at constant prices of 1992). The sector is highly vulnerable to unpleasant impacts of climate change and variability. The impacts are already vivid through stern drought that affects most parts of the country, triggering food shortage. An economic survey conducted in 2005 showed that the agricultural sector grew by only 5.2 percent compared to 5.8 percent growth in 2004 and again it was accredited to the prolonged drought in 2005/2006. Moreover, climate variability/change will influence all four dimensions of food security: food availability, food accessibility, food utilization and food systems stability (FAO, 2003). It will have an impact on human health, livelihood assets, food production and allocation channels, as well as altering purchasing power and market flows.

### 1.3 Statement of the Problem

Agriculture is a major economic activity in Magu District. Crops grown in the district include maize, paddy, sorghum, cassava and mixed vegetables. Agriculture, livestock and fishing are used as sources of incomes and food (Mwita, 2004). Thus, there is a symbiotic relationship of paramount importance between agriculture and communities livelihoods. There are two agricultural practices in Magu District, rain fed agriculture during the rainy season and dry season agriculture. The latter is done through irrigation and or in areas with high moisture in the wetlands along the shore of Lake Victoria and in river Simiyu and Lamadi. Rainfall characteristics and variability affect the agricultural production and productivity. Factors which affect water availability for rain-fed agriculture include the characteristics of rainy seasons (onset, duration, end, amounts and number of events), distribution of rainfall amounts and number of events within the rainy seasons and rainfall intensity. For example, late rain seasons are usually short, with reduced amounts of rainfall which have been linked with agricultural failure particularly in rain-fed agricultural practices. The other consequence is the reduction of water availability to the community. The vulnerability and impact of the variability in rainfall and moisture and how the affected communities adapt have not been well studied and documented. Hence, this study aimed at assessing the impacts of climate change on food security and adaptive capacity of households. Recognizing that vulnerability needs to be understood at the local level and that households engaged in agriculture employ a variety of measures in response to changing stress, the study complemented rainfall seasonality with participatory approach to gain an understanding through mutual learning and exchange with affected communities.

## 1.4 Study Objectives

### 1.4.1 Main Objective

The main objective of the study was to assess the impacts of climate change/ variability on food security and document community based adaptations.

### 1.4.2 Specific Objectives

The study had the following specific objectives;

1. To determine the impact of climate change/variability on food security.
2. To assess community based adaptation strategies on food security; and
3. To identify adaptations options that could enhance community resilience to climate valiability/change impacts with particular reference to food security.

### 1.4.3 Research Questions

1. What are rainfall and temperature patterns in the study area?
2. What are impacts of climate change/variability on food security?
3. How does plants and animal pests' outbreaks and human diseases vectors affecting food security?
4. What is community based adaptation options to climate change on food security takes place in the study area? as well as what could be enhanced.

## 1.5 Justification

An assessment of the impact of climate change and vulnerability on food security and community adaptation options has been done in various parts of the country, but not well documented in Magu District. This study would establish the magnitude of climate change and variability and associated impacts to community, and how the community is responding to such impacts. Furthermore, results from this study would contribute to baseline information on impacts of climate change/variability on food security and implications for rural livelihoods.

The study findings will provide recommendations for policy makers on the sustainable strategies to address climate change and vulnerability impacts in areas prone to the effects of climate change. In addition, the study will contribute to efforts of the National Strategy for Growth and Reduction of Poverty (NSRGP) with particular reference to agricultural sector and sustainable food security in the country.

## 1.6 Scope and Limitations

Research covered the impacts of climate variability/change that affect production and productivity of grown crops (both food and cash crops), livestock, and fish. The research also included other socio-economic activities which contribute to food and livelihood security in the area. Proliferation of pests and human diseases vectors and their impacts to animals and plants during floods and drought periods were assessed. Furthermore, the study investigated community response to impacts of climate variability/change. On the other hand, adaptive capacity of the individual households and community were investigated.

Limitations encountered during the study were low level of daily income which inhibited some of resource weak head of households to participate in household's interviews and focus group discussions as most of them had been engaged in cash and food labor to struggle for their survival, they had no time to share experiences and opinions with research team. The research team encountered a problem of getting prices and sales data for cotton, paddy, and chickpeas from village cooperatives as most of farmers sold these commodities to private companies which are not submitted data to the village authorities.

## 1.7 Structure of the Thesis

This thesis is organized into five chapters. Chapter One presents the problem and its context, while Chapter Two provides literature review. Chapter Three described research methodology used in the study, whilst Chapter Four gives results and discussion. Chapter Five presents conclusion and recommendations of the study.

# CHAPTER TWO

# 2.0 LITERATURE REVIEW

## 2.1 Introduction

This Chapter presents review of the literature that highlights impacts of climate change/variability on agriculture and food security in the four pillars of food availability, accessibility, utilization and stability. It also explores community based adaptation options used by farmers. Finally, it provides a synthesis and research gap that study wishes to fill.

## 2.2 Climate Variability/Change

The term "climate variability" is often used to denote deviations of climate statistics over a given period of time (such as a specific month, season or year) from the long-term climate statistics relating to the corresponding calendar period. In this intelligence, climate variability is calculated by those deviations, which are regularly termed anomalies (WMO, 2005). The term “climate change” is used to refer to changes in the Earth's climate. In the broadest sense, it can be full to mean changes over all time scales and in all of the components of climate, including precipitation and clouds as well as temperature. Climate changes can be caused by both natural forces and human activities (IPCC, 2008). The following sections provide detailed description of these concepts.

### 2.2.1 Climate Variability

Climate variability refers to *deviation from the long-term meteorological average* over a confident era of time, for example, an explicit month, season or year (WMO, 1992). A stronger than normal Monsoon, a more extreme drought period, or wet spells in a barren region area are examples of climate variation (Obasi, 1997). Some recognized examples are foremost droughts of the Sahel region of Africa in the 1970s and 1980s, the documentation floods on the Mississippi River in the USA in 1993, the Rhine River in Western Europe in 1995, and East African rivers in 1997/1998 and in Mozambique in February 2002, which was caused by too much rains in river basins (Obasi, 1997).

Rainfall and water resources in Africa demonstrate high levels of variability across an array of spatial and temporal scales with imperative implications for the livelihoods of communities in this region. Studies by Sutcliffe and Knott (1987), Grove (1996) and Conway (2002) confirmed such high levels of inter-annual variability in numerous river basins in Africa. Also comprehensive studies in an assortment of river basins in Tanzania indicated changes in day after day flow individuality. For example, Valimba *et al.,* (2004) branded the effects of human activities on the land plane and their influence on flow regimes in Mara River washbasin. A study carried out in the Pangani River basin explained the difficulties of telling and illumination the causes of spatial as well as chronological variability on rainfall data as well as river flows, due to the sparsity and quality of rainfall information together with river flow proceedings (Valimba *et al.,* 2004).

Prose on the impact of climate change has developed significantly, especially in the area of vulnerabilities of environmental systems (Lal *et al.*, 1998*;* Jones *et al.*, 1994; Aspinall and Matthews, 1994) and human systems (Gall *et al.*, 1992; McMichael, 1995; Martens *et al.*, 1995). Arnell (1996) eminent that an escalating number of documents published in several key journals illustrates that center and interest are drained to study of effects of climate change on hydrological regimes and water resources. It has been explained that the climate of Africa is warmer than it was 100 years ago (Hulme *et al.*, 2001). Though there is no verification for extensive desiccation of the continent during the 21$^{st}$ century, in some regions, significant inter-annual and multi-20 decadal rainfall variations have been pragmatic also near continent-wide droughts in 1983 as well as 1984 had vivid impacts on both the environment and some economies (Benson and Clay, 1998). Nevertheless the degree to which rainfall variations is related to greenhouse gas-induced global warming, stay uncertain (Hulme *et al.*, 2001). However, a warming climate will lay extra strains on water resources, whether or not future rainfall is drastically altered. Model-based predictions of prospect greenhouse gas-induced climate change for the continent evidently suggest that warming will persist and, in most scenarios, go faster so that the continent on typical could be between 2$^{o}$ and 6$^{o}$C warmer in 100 years era (Hulme *et al*., 2001).

### 2.2.2 Climate Change

Climate change will lead to more deep and longer droughts than have been observed over wider areas in view of the fact that the 1970s, predominantly in the tropics and subtropics (Trenberth *et al.*, 2007). Climate change refers to (i) long-term changes in average weather conditions (WMO usage); (ii) all changes in the climate system, counting drivers of change, changes themselves and their sound effects (GCOS usage); or (iii) only human-induced changes in the climate system (UNFCCC usage).

Climate refers to the characteristic conditions of the earth's lower surface atmosphere at a specific location; while weather refers to day-to-day fluctuations in these environments at the same locality (IPCC, 2007). Variables that are generally used by meteorologists to calculate daily weather phenomena are air, temperature, precipitation (for example. rain, sleet, snow and hail), atmospheric pressure, humidity, wind; sunshine and cloud cover (WMO, 2005). Whilst such weather phenomena are measured methodically at a specific location over numerous years, an evidence of observations is accumulated from which averages, ranges, maximum and minimum statistics for each variable can be computed, along with frequency and duration of exceedingly extreme events (WMO, 2007). Climate can be described on divergent scales. Global climate is regular temperature of the earth's plane as well as atmosphere in contact with it, and is deliberate by analyzing thousands of temperature report composed from stations all over the world for 30 years, both on land and at sea (IPCC, 2007).

## 2.3 Agriculture, Climate Change and Food Security

Agriculture is important for food security in two ways: it produces food eaten by people; and perhaps even more important also it provides the primary source of livelihoods for 36 percent of the world's entire workforce (FAO, 2005). In heavily populated countries of Asia and the Pacific, such assign ranges from 40 to 50 percent, while in Sub-Saharan Africa, two-thirds of the working population still turn out their living from agriculture (ILO, 2007). If agricultural production in low-income developing countries of Asia and Africa is unfavorably exaggerated by climate change, livelihoods of large statistics of the rural poor will be at risk of augmented food insecurity (FAO, 2008). Agriculture, forestry and fisheries are all susceptible to climate. The production processes are likely to be affected by climate change. However, a food system is vulnerable when one or more of the four components of food security; food availability, food accessibility, food utilization and food system stability are doubtful and insecure. These are more in depth in the following paragraphs.

### 2.3.1 Potential Impacts of Climate Change on Food availability

As production in agriculture, forestry and fisheries is reliant on ecosystem services, food availability in broad-spectrum is sensitive to climate variability and climate change (FAO, 2007). Such compassion is owing to direct effects of climate change on agro-ecological conditions, for example, due to more repeated extreme weather events, rising sea levels, changing mean temperatures and precipitation patterns (*ibid).* In the case of fisheries, sensitivity is out of ocean acidification and changes in flow regimes (Nellemann *et al.,* 2008).

Production of food and other agricultural commodities may keep speed with cumulative demand, but there are probable to be noteworthy changes in local cropping patterns and farming practices (FAO, 2007). There have been various researches on impacts that climate change could have on agricultural production, predominantly cultivated crops. In seasonally dry and tropical regions, crop productivity is anticipated to decrease with even small local temperature increases (1-2°C), which would add together to the threat of hunger due to reduced food availability (Easterling *et al.*, 2007).

Some 50 percent of total crop production comes from forest and mountain ecosystems, as well as all tree crops, while crops cultivated on open, arable flat land report for only 13 percent of annual overall crop production (Schmidhuber and Tubiello, 2007). Production from both rain-fed and irrigated agriculture in dry land ecosystems, accounts for more or less 25 percent, and rice produced in coastal ecosystems accounts for 12 percent (MEA, 2005).

Estimate of impacts of climate change on agricultural production, food supply and agriculture-based livelihoods must take into account the characteristics of the agro-ecosystem where particular climate-induced changes in biochemical processes are occurring, in order to determine the extent to which such changes will be positive, negative or neutral in their effects (FAO, 2008).

The so-called "greenhouse fertilization effect" will produce local advantageous effects where higher levels of atmospheric carbon dioxide accelerate plant growth. This is anticipated to occur mostly in temperate zones, with yields projected to increase from 10 to 25 percent for crops with a lessen rate of photosynthetic efficiency (C3 crops), and by 0 to 10 percent for those with a higher degree of photosynthetic efficiency (C4 crops), assuming that $CO_2$ levels in the atmosphere reach 550 parts per million (IPCC, 2007). However, such effects are not likely to stimulus projections of world food supply (Tubiello *et al.*, 2007).

Mature forests are also not projected to be affected, although the growth of young tree stands will be improved (Norby *et al.*, 2005). Impacts of mean temperature increase will be practiced differently, depending on location (Leff, Ramamurthy and

Foley, 2004). For instance, moderate warming (increases of 1 to 3ºC in mean temperature) is anticipated to benefit crop and pasture yields in temperate regions, while in tropical and seasonally dry regions, it is expected to have negative impacts, intensely for cereal crops. Warming of more than 3ºC is expected to have pessimistic effects on production in all regions (IPCC, 2007). The supply of meat and other livestock products will be subjective by crop production trends, as feed crops account for almost 25 percent of the world's cropland.

Climate variables such as rainfall, soil moisture, temperature and solar radiation, influences crops thresholds away from which growth and yield are compromised (Porter and Semenov, 2005). In the European heat wave of 2003, when temperatures were 6ºC above long-term means, crop yields dropped drastically, such as by 36 percent for maize in Italy, and by 25 percent for fruit as well as 30 percent for forage in France (IPCC, 2007). Increased concentration and frequency of storms, altered hydrological cycles, and precipitation variance also have long-term implications on the viability of current world agro ecosystems *(ibid).*

Although projections suggest that normal carryover stocks, food aid and international trade should be capable to cope up with limited to small area food shortages that are likely to outcome from crop losses owing to rigorous droughts or floods, now they are being questioned in view of the price roar that the world has experienced since 2006. According to (FAO, 2008) the universal food price indicator rose by 9 percent in 2006 and by 37 percent in 2007. The price boom has been accompanied with much higher price instability than in the past, especially in the cereals and oilseeds sectors, it reflects reduced inventories, strong relationships between agricultural commodity and other markets, and occurrence of greater market ambiguity in general (Schmidhuber and Tubiello, 2007). It has triggered extensive fear about food price inflation, which is fuelling debates about future direction of agricultural commodity prices in importing and exporting countries, rich or poor, it gives rise to uncertainties that a world food crisis similar in significance to those of the early 1970s and 1980s may be imminent, with little panorama for a quick rebound as the effects of climate change take their toll (FAO, 2008).

### 2.3.2 Impacts of Climate Change on Food Accessibility

Food accessibility is a measure of ability to secure entitlements, which are defined as the set of resources (including legal, political, economic and social) that an individual requires in obtaining access to food (Sen, 1989, cited in FAO, 2003). Until the 1970s, food security was connected mainly to national food production and worldwide trade (Devereux and Maxwell, 2001).

Since then the perception has been expanded to include households' and an individuals' access to food. Food is allocated through markets and non-market distribution mechanisms. Factors that determine whether or not people will have access to sufficient food through markets are considered in the following section on affordability. Factors embrace income-generating capacity; amount of compensation received for products and goods sold or labour, as well as services rendered, and the relation of the cost of a lowest amount daily food basket to the average daily income (FAO, 2006).

Non-market mechanisms comprise production for own consumption, food preparation and allocation practices within the household, and public or charitable food allocation schemes. For rural people who produce a substantial part of their own food, climate change impacts on food production might reduce availability to the point that share choices have to be made within the household (IPCC, 2007).

A family may diminish the daily amount of food inspired equally among all household members, or assign food preferably to certain members, often able-bodied male adults, who are unspecified to need it the most to reside fit and continue working to maintain the family (FAO, 2008). Non-farming low-income rural and urban households whose incomes fall beneath the poverty line because of climate change impacts will confront similar choices (Schmidhuber and Tubiello, 2007).

Urbanization is increasing rapidly global, and a growing percentage of the increasing urban population is poor (Ruel *et al.*, 1998). Share issues resulting from climate change are likely to become more and more noteworthy in urban areas over time. Where urban gardens are available, they offer horticultural produce for home use and local sale, but urban land-use limitations together with getting higher cost for water and land hold down their potential for expansion (Schmidhuber and Tubiello, 2007).

Urban agriculture has an imperfect ability to donate to the welfare of poor people in developing countries because the bulk of their essential food requirements still require to be transported from rural areas (Ellis and Sumberg, 1998). Political and social power interactions are key factors influencing portion decisions in times of shortage. If agricultural production declines and households find substitute livelihood activities, social processes and reciprocal affairs in which locally produced food is given to other family members in exchange for their support may change or fade away altogether (Schmidhuber and Tubiello, 2007).

Public and charitable food distribution schemes transfer food to the neediest such that it is serving on more wealthy segments of society to give such food. If climate changes, with resulting increases in occurrence of food insecurity, hunger and famine related deaths occurs (FAO, 2006).

Affordability, in terms of ratio of costs for a bare minimum daily food basket to an average daily income, is used in many countries as a gauge of poverty (World Bank Poverty Net, 2008). When such ratio falls underneath a certain threshold, it signifies that food is reasonably priced and people are not impoverished. When it exceeds the recognized threshold, food would not be inexpensive and people would have difficulties in obtaining enough to eat (Schmidhuber and Tubiello, 2007). Such decisive factor is an indicator of chronic poverty, and can also be used to decide when people have fallen into momentary food insecurity, owing to reduced food supply and increased prices, and hasty fall in household income or to both. Income-generating ability and the payment received for products as well as goods sold or labour together with services rendered are primary determinants of common daily incomes.

Incomes of all farming households depend on what they obtain from selling some or all of their crops and animals each year. Commercial farmers are usually sheltered by insurance, but small-scale farmers in developing countries are not protected. Small scale-farmers' incomes can decline harshly if there is a market glut, or if their own crops fail and they would have nothing to sell when prices get high (FAO, 2008).

Food for several households is not produced by individual households but is acquired by way of buying, trading and borrowing (Du Toit and Ziervogel, 2004). Climate impacts on income-earning opportunities can affect the capability to buy food, and a change in climate or climate extremes may affect the availability of certain food products, which may encouragement their price (Schmidhuber and Tubiello, 2007).

High prices may make certain foods too expensive and can have an impact on an individual's nutrition and health. According to Block *et al*, (2004), when rice prices greater than before in Indonesia in the late 1990s, mothers in poor families responded by dropping their caloric intake in order to feed their children better, such that the pattern led to an increase in maternal wasting.

Changes in demand for seasonal agricultural labour, caused by changes in production practices in response to climate change, can positively or negatively have an effect on income-generating capacity (FAO, 2007). Mechanization may decrease the need for recurrent labour in many places, and labour demands are often reduced when crops fail, frequently owing to such factors as drought, flood, frost or pest outbreaks, which can be influenced by climate (IPCC, 2007). On the other hand, some adaptation options boost demand for seasonal agricultural labour. Local food prices in most parts of the world are strongly influenced by worldwide market conditions, but there may be short-term fluctuations connected to variations in national yields, which are influenced by climate, among other factors (Schmidhuber and Tubiello, 2007).

An increase in food prices has a real income consequence with low-income households often distress most, as they tend to dedicate larger shares of their incomes to food than higher-income households (Thomsen and Metz, 1998). When they cannot manage to pay for food, households adjust by eating less of their favored foods or diminish total quantities consumed as food prices raise. Given the growing number of people who depend on the market for their food supplies, food prices are vital to consumers' food security and must be watched. Food frequently is transported at very long distances, consequently has implications for costs (Pretty *et al.*, 2005). Increasing fuel costs could lead to more expensive food and increased food insecurity (FAO, 2008).

The increasing market for biofuels is predictable to have implications for food security because crops grown as feedstock for liquid biofuels can change food crops, which then have to be sourced elsewhere at higher cost (FAO, 2007). Any attempt to adapt food systems to climate change necessarily involves several components of food security. Measures exclusively focused on technical solutions for enhanced food production cannot meet the intricate adaptation wishes in other areas of food security (Ericksen *et al*., 2009).

Food preferences influence the kinds of food that households will attempt to obtain. Changing climatic conditions could affect both physical and economic availability of certain favorite food items, which might make it impossible to meet some preferences (Schmidhuber and Tubiello, 2007). Changes in availability and relative price changes for most important food items may result in people either altering their food basket, or spend a greater percentage of their income on food when prices of preferred food items increase. In southern Africa, for instance, many households eat maize as the staple crop, but when there is less rainfall, sorghum fair better, and people consume more of it (*ibid*). Many people prefer maize to sorghum, and therefore, they continue to plant maize besides its poor yields, and would buy maize rather than sorghum, when necessary. The extent to which food preferences change in response to changes in relative prices of grain-fed beef compared with other sources of animal protein will be an important determinant of food security in the medium-term. Increased prices for grain-fed beef are foreseeable, because of increasing competition for land for intensive feed grain production, increasing scarcity of water and rising fuel costs (FAO, 2007).

If preferences shift to other sources of animal protein, the livestock sector's demands on resources that are likely to be under stress as a consequence of climate change may be contained. If not, continued growth in demand for grain-fed beef, from wealthier segments of the world's population, could trigger across-the-board increases in food prices, which would have serious adverse impacts on food security for urban and rural poor.

### 2.3.3 Potential Impacts of Climate Change on Food Utilization

Utilization refers to accurate use of food and includes the existence of suitable food processing, proper storage practices, sufficient knowledge application of nutrition, child care and adequate health as well as hygiene services (FAO, 2000; FANTA, 2006).

Food insecurity is usually linked with malnutrition, because diets of people who are unable to gratify all of their food needs usually do not contain a high amount of staple foods and be deficient in the variety needed to satisfy nutritional requirements (FAO, 2008). Declines in availability of wild foods, and limits on small-scale horticultural production due to insufficiency of water or labour resultant from climate change could influence nutritional status critically (Schmidhuber and Tubiello, 2007). On the other hand, undernourishment increases the risk for both acquiring and dying from communicable diseases. For example, in Bangladesh, both impacts of drought and lack of food were linked with an amplified menace in mortality from diarrheal illness (Aziz *et al.*, 1990).

In broad-spectrum, the main impact of climate change on nutrition is expected to be felt indirectly, through its effects on incomes and capacities to procure foods. Moreover, inadequate calorie consumption often goes hand-in-hand with micronutrient malnutrition (FAO, 2004). Likewise, micronutrient malnutrition can be viewed as an encroachment on human right to adequate food, which implies availability and accessibility of food in quality ample to suit the dietary needs of everyone (UNCESCR, 1999). Mothers who endure from chronic caloric or micronutrient deficiencies are more probable to have low birth weight babies (FAO, 2006). In outcome, they pass their undernourishment on to the next generation (Black *et al*., 2008; World Bank, 2006; FAO, 2004). Physiological utilization of foods consumed also affects nutritional status, and in turn, it is exaggerated by illnesses (FAO, 2006).

Climate change will cause modern patterns of pests and diseases to emerge, affecting plants, animals and humans thereby would pose new risks for food security, food safety and human health. Increased incidence of water-borne diseases is experienced in flood-prone areas. Projected climate-change related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity, This can happen through; increased deaths, disease and injury due to heat-waves, floods, storms, fires and droughts; increases in malnutrition, increased occurrence of cardio-respiratory diseases, altered spatial distribution of some infectious-disease vectors; and enlarged load of diarrheal diseases (FAO, 2008).

Climate change also causes changes in vectors for climate-responsive pests together with diseases, and appearance of new diseases that could affect both the food chain and people's physiological ability to obtain essential nutrients from foods consumed (Schmidhuber and Tubiello, 2007). Adults affected by malnutrition might have a low body mass index or nutritional oedema (retention of fluid). If emaciated adults continue to have inadequate food, health and care into old age, would remain malnourished and less proficient to assist in caring for children (Victora *et al*., 2008; SCN, 2004).

Vector changes are a effective certainty for pests and diseases that flourish only at precise temperatures and under specific humidity as well as irrigation management regimes. That exposes crops, livestock, fish and humans to new risks to which they have not yet adapted. They will also place new pressures on care givers within the home, who are often women, will continue to give that service to sick people and not participating in food production processes. Malaria in particular is anticipated to change its scattering as a result of climate change (IPCC, 2007).

In coastal areas, more people may be exposed to vector- and water-borne diseases through flooding linked to sea-level rise. Health risks can also be linked to changes in diseases from either increased or decreased precipitation, thereby reducing people's capacity to utilize food effectively and often resulting in the need for improved nutritional intake (IPCC, 2007). Owing to very large number of people that may be affected, malnutrition associated to extreme climatic events, may be one of the majority important consequences of climate change (Confalonieri *et al.*, 2007).

Where vector changes for pests and diseases can be predicted, varieties and breeds that are resistant to the likely new arrivals can be introduced as an adaptive measure (Schmidhuber and Tubiello, 2007). A recent upsurge in the appearance of new viruses may also be climate-related, although this link is uncertain. Viruses such as avian flu, ebola, HIV/AIDS and SARS have a variety of implications for food security. Risk includes livelihoods of small-scale poultry operations in the case of avian flu, and additional nutritional requirements of affected citizens in the case of HIV-AIDS (WHO, 2005). Currently HIV/AIDS affects 33 million people, 70 percent in Sub-Saharan Africa and is scattering hastily in some other developing regions (UNAIDS, 2007).

Socio-cultural values of foods consumed will also be affected by the availability and affordability of food. Social values of foods are imperative determinants of food preferences, with foods that are accorded high value being favored, and those accorded low value being avoided.

In many cultures, feasts involving preparation of specific foods mark important seasonal occasions, rites of passage and celebratory events. The increased cost or absolute unavailability of such foods could force societies to abandon their traditional practices, with unforeseeable secondary impacts on cohesiveness and sustainability of the cultures themselves. In many cultures, reciprocal giving of gifts or sharing of food is common. It is often regarded to be social obligation to feed guests, even when they have dropped in food suppliers unexpectedly. In conditions of chronic food scarcity, households' ability to honor these obligations is breaking down; the trend is likely to be reinforced in locations where the impacts of climate change play a role to increasing incidence of food shortages (FAO, 2008).

Food safety may be compromised in various ways. Increasing temperatures can cause food quality to deteriorate, unless there is bigger investment in cooling and refrigeration equipment or more dependence on rapid processing of perishable foods to lengthen their shelf-life (Schmidhuber and Tubiello, 2007).

### 2.3.4 Potential Impacts of Climate Change on Food system Stability

Many crops have annual cycles, and yields vary with climate variability, especially rainfall and temperature (IPCC, 2007). Stability of food supply when production is seasonal is hence challenging. Results for impacts on production are generally simulated in two different ways either climate-induced yield changes are projected without agronomic (farm-level) and economic (sector-level) change or different static cases are compared, with an agreed level of climatic change and an inflexible adaptation factor (Harrison *et al*., 2000; Adams *et al*., 1999; Darwin *et al*., 1999; Parry *et al*., 2004).

Droughts and floods are a particular hazard to food stability and could bring about both chronic and transient food insecurity (FAO, 2008). In rural areas that depend on rain-fed agriculture for an important part of their local food supply, changes in the amount and timing of rainfall within the season and an increase in weather variability are likely to intensify the instability of local food systems (Nellemann *et al.*, 2008).

As previously noted, affordability of food is strong-minded by the relationship between household income and the cost of a typical food basket (FAO, 2008). Trade leftovers the main mechanism for exchange in today's global economy. Although most food trade takes place within national boundaries, global trade is the balancing device that keeps exchange flowing smoothly (Stevens, Devereux and Kennan, 2003). Global food markets may display greater price volatility, such that they may endanger stability of returns to farmers and access to purchased food of both farming and non-farming poor people (Schmidhuber and Tubiello, 2007). Food prices may well have an impact on food access of households, by limiting the acquirement of appropriate foods for a nutritious diet and the purchasing power of food aid programmes. A fair worldwide trading system can help go forward food security and nutrition (Von Braun, 2007). Climate variability and change will likely contribute significantly to rising food prices (Cline, 2007; von Braun, 2007). Temperature increases of more than 3°C may trigger prices to increase by up to 40 percent (Easterling *et al*., 2007).

Decreasing stability of supply, attributable to consequences of climate change, will most likely lead to increases in the incidence and magnitude of food emergencies with which the international food system is ill-equipped to cope up (WFP, 2007). An increase in human conflict, caused in part by migration and resource competition attributable to changing climatic conditions, would also destabilize food systems at all levels. Climate change may exacerbate conflict in numerous ways, although links between climate change and conflicts should be presented with care (*ibid)*.

The causes and consequences of migration are also extremely dependent on the social and ecological contexts from which people are in motion and to which they move (Locke *et al*. 2000). Increasing incidences of drought may force people to migrate from one area to another, giving escalate to conflicts over access to resources in the receiving area (WFP, 2007). Resource scarcity can also activate conflicts and could be driven by global environmental change (OCHA, 2007). Grain reserves are used in emergency-prone areas to counterbalance for crop losses and support food relief programmes for displaced people and refugees (WFP, 2007).

Higher temperatures and humidity associated with climate change may well require increased expenditure to conserve stored grain, which will bound countries' abilities to uphold reserves of sufficient size to respond effectively to large-scale natural or human-incurred disasters (FAO, 2008). There is a vital need to build up sustainable adaptive strategies and early warning systems that will deal with future climate change challenges (*ibid*). Collective efforts that improve adaptation to current climate variability and future climate change, that incorporate early warning systems, knowledge of disease, medical health infrastructure, provision of services, and improved socio-economic status would lower the existing vulnerable situation (FAO, 2008). Future adaptation programs should take into account the assortment of factors that persuade society's capacity to cope up with the changes. Such programs should take into respect demographic trends and socio-economic factors, because they have an effect on land use, which may, in turn, speed up or compound the effect of climate change (Schmidhuber and Tubiello, 2007). Trends in demographic and socio-economic development would without doubt have a dampening effect on change of land use which is a potential outcome of climate change (WRI, 2005).

## 2.4 Impacts of Climate Change on Plants and Animals

Climate change is shifting the distribution of animal pests and plant pests and diseases, such that special effects are difficult to predict. Changes in temperature, moisture and atmospheric gases can fuel growth and generation rates of plants, fungi and insects; there they may amend the interactions between pests, their natural enemies and their hosts (FAO, (2008). Changes in ground cover, such as deforestation or desertification, can make remaining plants and animals ever more vulnerable to pests as well as diseases. For example, foremost shocks faced by rural Households in Singida and Dodoma are death of livestock and crop harvest failure ensuing from drought, floods, crop and pests (Kessy *et al.*, 2011*)* At the same time as new pests and diseases have frequently emerged throughout history, climate change is now throwing several unknowns into the equation (IPCC, 2007).

Some of the most dramatic effects of climate change on animal pests and diseases are likely to be seen among arthropod insects, like mosquitoes, midges, ticks, fleas and sand flies, together with foot-and-mouth disease, bovine spongiform encephalopathy, classical swine fever and, mainly recently, bird flu, all predictable to cause economic losses and together with all pathologies they carry (IPCC, 2007). With changes in temperatures and humidity levels, populations of insects could get bigger their geographic range, and expose animals as well as humans to diseases to which they have no natural immunity (*ibid*).

Other climate changes can generate more opportunities for vector-borne diseases. In pastoral areas, such as, drier conditions may mean fewer watering places, which will increase interactions between domestic livestock and wildlife. Increased interactions between cattle and wildebeest in East Africa could lead to a serious outbreak of malignant catarrhal fever which is a highly fatal disease for cattle, since all wildebeests carry the virus (Cleaveland *et al*., 2001). Aquatic animals are also vulnerable to emerging climate-related diseases, particularly so because their ecosystems are so fragile and water is such an effective disease carrier. A fungal disease called the epizootic ulcerative syndrome recently expanded to transmit a disease to aquatic animals in Southern Africa due partly to increases in temperature and rainfall levels. It is mostly awkward in the long rains when wildebeests, for instance migrate from Maasai Mara to Serengeti ecosystem. Such a pattern is the chief cause for infecting cattle owned by Maasai in Ngorongoro Conservation Area (*Ibid*)

Climate change has undeviating effects on livestock productivity as well as indirect effects all the way through changes on the availability of fodder and pastures (Rotter, and Van de Geijn, 1999). Specific impacts of climate change on livestock production include turn down in livestock productivity, decline in forage resources, problem of access to water, restricted livestock mobility, conflicts over natural resource use, fluctuations in livestock market prices, (emerging and re-emerging) animal diseases species and breed of livestock that be able to be kept like shift in livestock species from cattle to small ruminants (Tol, 2002). Climate determines the type of livestock for the most part adapted to different agro-ecological zones and therefore, determines the animals that are capable to sustain rural communities.

There are measures that can help to trim down the overall impact of climate change in livestock production that comprise sustainable intensification which will be used to reduce effects on deforestation, pasture degradation, wildlife biodiversity and suitable use of resources. Intensification should be addressed through technologies and policies that can improve overall sustainability of livestock production (Delgado *et al*., 1999).

Climate change is expected to have an effect on all livestock fodders at species level (FAO, 2005). In some areas it will turn warmer, and the grass could be restricted to higher altitudes where grass and fodder is difficult to obtain. Therefore, communities would seek other for species for production of pastures by relying on their own knowledge. Since changes are relatively slow, due to insufficient resources there is need to improve the local fodder species which are more resistant to weather vagaries and use of farmer's experiences as well as their local knowledge. Climate changes will also affect nomadic and transhumant livestock keepers because routes and pastures will have to be found to ensure adequate pastures and water (FAO, 2008)

The negative impact of ruminants on greenhouse gases emissions can be addressed through changes in animal husbandry as well as ruminant diets and animal stocking ratios so as to avoid nitrous oxides emissions. Thus, larger changes in climate can raise costs exponentially IPCC, (200I).

## 2.5 Climate Change and Fisheries

Increase in temperature lead to changes in the spreading of marine fisheries and fish community interactions (Parry *et al.*, 2005). Brackish water species from delicate estuarine eco-systems are particularly sensitive to temperature and salinity changes. Water temperature increases lead to mortalities of crustacean and shrimp postlarvae (Tirado *et al.*, 1993). Regional changes in distribution and productivity of particular fish species are anticipated due to continued warming and local extinctions will take place at the edges of ranges, particularly in freshwater as well as diadromous species such as salmon or sturgeon (Easterling *et al.*, 2007). Increases in atmospheric $CO_2$ are raising ocean acidity. According to The Royal Society (2005), increase in $CO_2$ affects calcification processes leading to coral reefs bleaching and thus disturbing the balance of the food chain.

Variability on a range of time-scales has constantly been a feature of fisheries, especially capture fisheries. Recruitment and productivity in most fisheries vary from year to year and are superimposed on longer scale variability which naturally occurs on a scale of decades (IPCC, 2007). Inter-annual and decadal scale variability, often involving shifts in productivity patterns and dominant species, of populations of small pelagic fish in upwelling systems, are examples of multi-scale variability (FAO, 2008).

Where there is an established effective management, fishery systems have developed adaptive strategies, through monitoring and feedback, fishing effort as well as catches are often modified according to state of the stock. In due regards, fishers must have either the robustness or flexibility (or both) to absorb changes in resource abundance so as to avoid negative ecological, social or economic impacts (FAO, 2008).

Robustness is typically linked with factors such as total fishing capacity being appropriate with the productive capacity of the resource during its lower productivity phases, availability of alternative fishery resources, investments in flexible technologies like multipurpose boats (as opposed to specialized vessels) and flexible processing chains, or skill and opportunity (WRI, 2005).

Climate change and variability influence food contamination with non-infectious hazards such as biotoxins (for example mycotoxins or marine toxins) and chemicals, which may have an impact on food stability and animal feed stability, access and/or utilization. Chemical food contamination may lead to recommendations to control consumption of locally produced food in order to protect human health, thus reduce dietary options of rural communities and indigenous peoples compromising their traditional diets (FANTA, 2006). For example, high contamination with dioxins connected with severe droughts in Central Asia have led to recommendations that poor rural communities limit the consumption of locally produced foods (Mountean *et al.*, 2003). Higher ocean temperatures are leading to increased levels of methyl mercury in fish and marine mammals, prompting recommendations to limit the intake of fish and marine fats by pregnant women (Kuhnlein *et al.*, 2002; Booth and Zeller, 2005).

## 2.6 Climate Change and Water Availability

Rapid population growth and rising demand for food combined with high variability in rainfall are putting huge pressure on land resources (URT, 2003). Analysis of current economic and environmental trends in Africa reveals increased competition over access and uses of freshwater resources. At the same time, population growth and climate change impose a further strain on such already overwhelmed resources.

Tanzania is careful sensitive to climatic change since, in the past the country has been harmfully affected by episodes of climate variability/change. The country has experienced at least one major drought each decade over the past 30 years. There were severe droughts in 1973/1974, 1984/1985, 1987, 1992/1994 and 1999/2000. Other occurred in (2005), 2003/2004, and 2004/2005 and recently in 2008/2009. It is believed that they are translucent signs of increasing climatic shakiness due to the increased incidence and intensity in drought (FAO/STAT, 2000).

Low rainfall, for example, is linked to reduced moisture availability in soils, leading to poor growing conditions and consequently low crop production. On the other hand, recurrent high daily rainfall, which occurs during the peak of the rainy season, is accompanied with floods that destroy the previously grown crops (Valimba, 2004). They could be a noteworthy barrier preventing Tanzania from achieving its poverty reduction commitments under MKUKUTA, the Millennium Development Goals and the Tanzania Development Vision 2025. Such failure means that escalating poverty would have an allied effect on livelihoods, assets, infrastructure, environmental resources and economic growth. Vulnerability may be greater for water users in catchments and wetlands anywhere there is intense dependency on water for their livelihoods (URT, 2003). Insecure water rights and poor water use planning may add to community vulnerable to climate variability/change impacts.

## 2.7 Climate Change Adaptation

The two major types of adaptation are autonomous and planned adaptation (FAO, 2007). Autonomous adaptation has been defined as the "ongoing implementation of existing knowledge and technology in response to the changes in climate experienced (IPCC, 2007). It is often conceived by individuals or small groups' reactions to varying conditions (Reilly and Schimmelpfennig, (1999). Many autonomous adaptation options are extensions or intensifications of obtainable risk management or production-improvement activities for cropping systems, livestock, forestry and fisheries production (Easterling *et al.*, 2007).

Planned adaptation, on the other hand, is the term to include more harmonized action on higher aggregation levels, or "the increase in adaptive capacity by mobilising institutions and policies to set up or strengthen conditions positive for effective adaptation and investment in new technologies and infrastructure (*ibid).*

Policy based adaptations to climate change will interrelate with, depend on, or perhaps even be just a compartment of policies on natural resource management, human and animal health, governance and human rights, among a lot of others (Yohe *et al.*, 2007). (IPCC, 2001) defined climate change adaptation as ‘alteration in nature or human system in response to actual or predictable climatic incentive or either effect, which demonstrates harm or exploits valuable opportunities’. The (Inter Agency Report 2007) also defines climate change as the capacity to respond and adjust to actual or potential impacts of changing climate conditions in ways that modest harm or take improvement of any positive opportunity that the climate could afford. Mitigating climate change means reducing greenhouse gas emissions and sequestering or storing carbon in short term together with development choices that will lead to low emissions in the long-term. Acclimatization is essentially adaptation that occurs spontaneously through self-directed efforts. It is a influential and effective adaptation strategy. In simple terms, it means getting used to climate change and learning to live with it. Adaptation to climate change involves purposeful adjustments in natural or human systems and behaviors to lessen risks to people’s lives as well as livelihoods. All living organisms, including humans, adapt and develop in response to changes in climate and habitat (FAO, 2008). The need for adaptation may be augmented by growing populations in areas vulnerable to extreme events. However, adaptation only is not expected to cope with all the projected effects of climate change with no mitigation especially not over the long term because most impacts increase in scope as level of environmental deterioration is increasing due to higer level of growing population.

Adaptations may vary not merely with respect to their climatic stimuli but also with respect to other, non-climate conditions. They are sometimes called intervening conditions, which serve to manipulate the sensitivity of systems and nature of communities' adjustments. For instance, a series of droughts may have like impacts on crop yields in two areas, but differing economic and institutional arrangements in the two areas could well result in entirely dissimilar impacts on farmers and hence in completely different adaptive responses, both in the short and long terms Smit *et al*., (2000).

Although every individual will be affected by climate change in Tanzania, small-holder farmers in rural areas especially women are likely to be more affected by climate change because of their low adaptive capacity, extreme poverty and dependence on rain-fed agriculture, activity more sensitive to climate change. Moreover, inequalities existing between men and women partly due to statutory and/or customary laws that often restrict women's property and land rights; constrain women from accessing important resources for example, land and credit, undermining further their adaptive capacity (International Fund for Agricultural Development (IFAD), 2008; Osman-Elasha, 2008; Brody et al., 2008). The fact that women are likely to be more affected by climate change is also supported by climate change literature (Lambrou and Piana, 2006; UNFPA, 2009; United Nations Development Programme (UNDP), 2009)

Most ecological and social systems have determine of an in-built adaptation capacity (autonomous adaptation) but current rapid rate of climate change will impose new and potentially tremendous pressures on existing adaptation capacity. It is specifically true given the fact that resultant changes induced by climate change are expected to weaken the ability of people and ecosystems to manage up with changes and get well from extreme climate events as well as other natural hazards (FAO, 2008).

Potential events of adaptation to climate change in agriculture, forestry and fisheries include a entire range of changes in management (sowing and harvesting dates, irrigation, tillage methods, forest fire management, and promotion of agroforestry together with measures that in a straight line relate to and make employ of biological diversity (FAO, 2008). Crop selection and breeding strategies aiming at tolerance to abiotic as well as biotic stresses (temperature, drought, pest resistance and combined use of different varieties and genetically diverse populations as well as related hard work are seen to be key mechanism for adaptation (FAO, 2007).

Autonomous adaptation is reaction of, for example, a farmer to changing precipitation patterns, in that a changes crops or uses different harvest and planting/sowing dates (FAO, 2008). Deliberate crops assortment and distribution strategies crossways different agro-climatic zones, replacement of new crops for old ones and resource exchange induced by scarcity (Easterling, 1996). Farm level analyses have publicized that large reductions in adverse impacts from climate change are likely when adaptation is fully implemented (Mendelsohn and Dinar, 1999).

Short-term adjustments are seen to be autonomous in the feeling that no other sectors (like policy, research and the like) are essential in their development and implementation. Long-term adaptations are foremost structural changes to overcome hard times such as changes in land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency related techniques. According to Reilly and Schimmelpfennig (1999), chief classes of adaptation to seasonal changes and sowing dates, different variety or species, water supply and irrigation system, other inputs (fertilizer, tillage methods, grain drying, other field operations), new crop varieties, forest fire management, promotion of agro-forestry, adaptive management with suitable species and silvi-cultural practices. If managed carefully, climate adaptation strategies may well have environmental benefits for some countries (Adams *et al*., 1999).

Accordingly, types of responses include cutback of food security risk, identifying present vulnerabilities, adjusting agricultural research priorities, defending genetic resources, protecting intellectual property rights, other includes strengthening agricultural extension, intensification communication systems, adjustment in commodity as well as trade policy, increased training and education and identification and encouragement of climatic benefits and environmental services of trees and forests Adger and Kelly, (1999). With changes in precipitation and hydrology, temperature, length of growing season and frequency of extreme weather events, considerable efforts would be compulsory to prepare developing countries to contract with climate-related impacts in agriculture (Mendelsohn and Neumann, 1999).

Among key challenges will be to help out countries that are embarrassed by limited economic resources and infrastructure, low levels of technology, poor access to information and knowledge inefficient institutions, inadequate empowerment and access to resources. The agricultural sector should adapt suitable measures, to reduce the impact of climate change that consist of; use of artificial systems to improve water use/availability as well as safeguard against soil erosion, change farming systems, change timing of farm operations, use of different crop varieties, change governmental policies and institutional policies as well as programmes, and research into new technologies (FAO, 2008).

Several of these involve improved resource management – an option with payback that broadens beyond adaptation. These "additional" benefits should not be underestimated. Climate change and variability are among the most important challenges in front of least developed countries because of their strong economic reliance on natural resources and rain-fed agriculture (IPCC, 2007).

People living in marginal areas for example dry lands or mountains face additional challenges with limited management options to diminish impacts (Darwin, 1999). Climate change adaptation strategies should reflect such situation in terms of speed of the reply and choice of options. Also Wisner *et al.*, (2004) argue that situations differ between communities and among individuals as regards how and which coping as well as adaptation strategies finally take place. Moreover, aspect of change compels analysis to put together multiple scales socio-economic aspects as positions and situations over time (FAO, 2008).

Agricultural research can help to create new technologies that will facilitate agriculture-based adaptation strategies. For example, research is underway at CGIAR-supported international agricultural research centers to breed new, drought-tolerant varieties of sorghum that will make available food, feed and fuel all from a single plant, lacking current tradeoffs among uses (Metz *et al.*, 2007). In this regard, a structure for climate change adaptation needs to be directed all together along several interrelated lines, which involve legal and institutional elements – decisions making, institutional mechanisms, legislation, implementing human right norms, tenure as well as ownership, regulatory tools, legal principles, governance arrangements, coordination arrangements, resource allocation and networking civil society (Easterling, 1996).

# CHAPTER THREE

# 3.0 RESEARCH METHODOLOGY

## 3.1 Introduction

This chapter presents the research methodology used in this study. The chapter begins by describing the study area, followed by a description of the sample and sample size, selection of the target population and data collection methods used. Finally the chapter ends by showing a data analysis plan and data validity and reliability of the data collected.

## 3.2 Study Area

This study was conducted in the Magu District, Mwanza of Region. The district was chosen based on the past record of food insecurity incidences. The district was among districts, which experienced chronic food insecurity since the mid 1990s and has several times received food aid packages to rescue people’s lives and livelihood security.

Administratively, Magu is one of the 8 districts in Mwanza Region in northern Tanzania. Other districts are Misungwi, Kwimba, Sengerema, Geita, Ukerewe, Nyamagana and Ilemela. It borders with Bunda and Ukerewe districts to the North. It borders with Kwimba, Misungwi and Maswa to the South. To the West it borders with Ilemela. Also, to the east it borders with Bariadi district in Shinyanga region. The district occupies a total of 4,795 sq. km where 1,725 sq km are under water in Lake Victoria and 3,070 sq km is covered by land. Magu district occupies 13.6 percent of Mwanza region. It lays within $2^0$ - $3^0$ Latitudes (south of Equator) and $33^0$ - $34^0$ Longitudes (East of Greenwich) (Figure 3.1).

The study area is characterized by three agro-ecological zones namely, a highland, which covers the hilly, mountain zone and mid as well as lowland areas along Lake Victoria shore basin (Magu District Profile, 2006). Rainfall in the district is very unreliable and seldom comes on time (Magu District Profile, 2006). Even though it is the nature of the area not to have enough rainfall, in recent years the problem seems to have been highly severe due to an increased occurrence of extreme events (Magu District Profile, 2006).

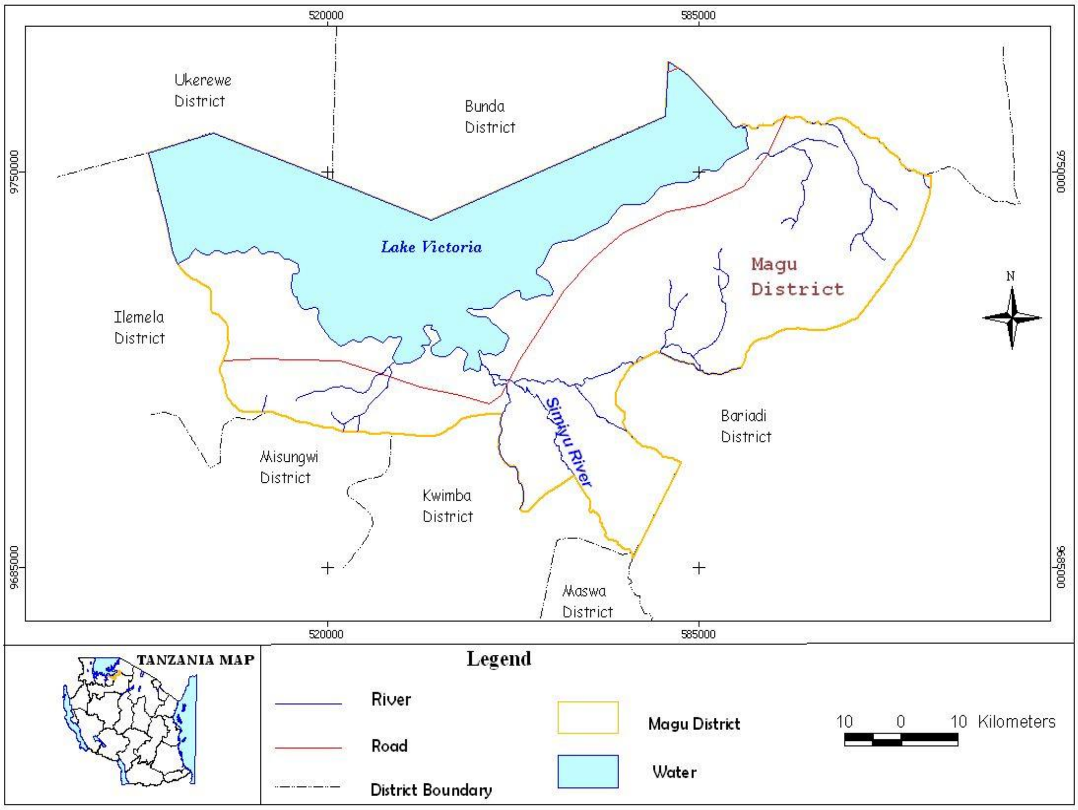


**Figure 3.1: Map showing location of Mwanza Region and Magu District**

### 3.2.1 Biophysical characteristics

The minimum and maximum temperature ranges from $18^0$ C to $20^0$ C during the rainy season and $26^0$ C to $30^0$ C during the dry season. A large portion of the district soil is granite with a progression of yellow – red hill sands to the poorly drained dark–grey loam sands and clays in valleys and low-lying plain. The district has an extensive wetland dominated by dark grey clay soils, which are very fertile, due to alluvial deposition brought by floods during the wet season (Magu District Profile, 2006).

The wetland provides households with several services, for example, fertile areas are used for cultivation of various crops and are main source of water for households use as well as livestock during the dry season. Farmers are engaged in a combination of rain-fed as well as irrigated farming, producing the first (sweet potatoes) crop and third crop (maize), respectively. The second crop is beans cultivated at the end of the rainy season by using residual moisture, and when the first is maturing and waiting to be harvested (DALDO, 2006).

Areas surrounding wetlands are associated with a progression of yellow-red hill sands to poorly drained dark soils (Magu District Profile, 2006). The district topography is 3,095 m above sea level. Rainfall patterns in the basin tend to be associated with an atmospheric belt of low pressure, the Inter-tropical Convergence Zone (ITCZ), which follows the sun twice a year across the equator. Long rains" *Masika*" fall in the episode from March to May and short rains "*vuli'* in October-November-December (EAMD, 1975). The district weather condition is characterized by low and unreliable rainfall ranges from 800 mm to 900 mm annually (DALDO, 2008). It has one obvious permanent river inflow that is Simiyu, which meanders along the flood-plain northwards, and discharges into Lake Victoria (Magu District Profile, 2006).

### 3.2.2 Demographic Characteristics

Magu District has a growing and dynamic population. In addition to population growth of over 2.1 percent, migration, in particular, labor migration is common. Demographic characteristics of an area, such as population density, population growth, household size and migration, may induce access to resources connected to household livelihood strategies (Eriksson, 2005).

The national census of 2002 showed that the district had a total population of 431, 771 where 223,119 were females and males were 208, 652 with an annual growth rate of 2 percent. In 2010, the total population was estimated to be 477,642 people (248, 233 females and 229,409 males). Population density ratio is 1:104. Adult Literacy Rate is 45 percent for males and 55 percent for females. Magu is one of the poorer districts in Tanzania where the greater part of the population live under poverty line (Wamara, 2000).

### 3.2.3 Socio-economic Activities

Most people depend on agriculture as the main source of their livelihood. Main food crops grown are maize, paddy, sorghum, cassava, sweet potatoes and pulses (beans, groundnuts, bambara nuts and chick peas) while cash crops includes cotton, cowpeas and sesame. Economically, agriculture and livestock contribute 85 percent, fishing 10 percent, industry (small and medium) 3 percent and service sector 2 percent (Magu District Profile, 2006). Livestock is kept for food and commercial as well as for subsistence uses. Fishing is done in Lake Victoria and, in the rivers. Small-scale fishing is done for consumption (Magu District Profile, 2006). During the wet season, the fish catch is high and therefore, some of the fish are sold in the local markets. Large-scale fishing is carried out in Lake Victoria, mainly for commercial purposes. Also the district has a few tourist hotels in Lamadi and Magu towns which give significant incomes for some of people in the district (*ibid*). Data from Ministry of Agriculture Food Security and Cooperatives categorized Magu District as chronic food insecure since the mid 1990s due to the clear evidence that food availability were less than annual food requirements.

### 3.3 Sample and Sample Size

As mentioned earlier, selection of the district was based on the past record of food insecurity incidences. Study was conducted in three agro-ecological zones in which one representative village was selected for each ecological zone. Using stratified sampling technique each agro-ecological zone was regarded as strata (highlands, middle and lower lands). Selection of the villages from each agro-ecological zone was done by using a district map in collaboration with district authorities that are familiar with location of the villages in the district. The population number and list of households for each village were obtained from the village register (Table 3.1).

**Table 3.1: Selected households**

| Village | Total population | Number of households per village | Number of household selected | Percentage (%) |
|---|---|---|---|---|
| Ihale | 3238 | 623 | 31 | 39.2 |
| Ng'haya | 2972 | 531 | 27 | 34.2 |
| Igombe | 2250 | 417 | 22 | 26.6 |
| Total | 8460 | 1571 | 80 | 100 |

**Source: Village Registers (2009)**

The village registers containing names of all the people and all households in each village were used to select the households for interview. With the assistance of village governments, 5 percent of households were systematically selected from each study village (Stern *et al.*, 2004).

## 3.4 Sampling Procedures

Systematic sampling technique was employed in selection of households for the study in these villages. A household was used as a sample unit and it was composed of a husband, wife, children, individuals and dependants living in the family. Household heads identified by village authorities (both women and men) were interviewed.

Field surveys were carried out in Ihale, Ng'haya and Igombe villages. Ihale village had 623 households, Ng'haya village had 531 households and Igombe village had 417 households. A total sample of 80 households was obtained. The study was conducted in Igombe (highland agro-ecological zone), Ng'haya (middle agro-ecological zone) and Ihale (lowland agro-ecological zone) villages.

## 3.5 Data Collection Methods

Several data collection methods were used in this study in order to complement each other and generate both qualitative and quantitative data from primary and secondary sources. An integrated approach using both quantitative and qualitative techniques was employed in assessing the impact of climate change and variability on food security, how people adapted as well as adaptive capacity of communities in Magu district also was adressed. The household survey of 80 semi-structured interviews (SSIs) was conducted in the three villages.

### 3.5.1 Primary Data Collection

The primary data sources were sampled villages. The main sources were informal and formal interviews conducted with individual households and key informants. Reconnaissance surveys and direct observations contributed to and supplemented the interview data. Both qualitative and quantitative research approaches were used in primary data collection to provide historical and current information on the impact of climate change and variability and community response to such impacts. Moreover, methods were used to gather information on other socio-economic characteristics, including participatory approaches such as Participatory Rural Appraisal (PRA) for qualitative data, questionnaire (for quantitative data) and direct observations. These methods have strengths and limitations, as discussed by Mettrick (1993), Chambers (1992), and Mikkelsen 1995). Therefore, a variety of methods were combined during the fieldwork to obtain more reliable field data.

#### 3.5.1.1 Household interviews

At the household level, structured interview questionnaire were used to probe household head and capture information on local perceptions on climate change and variability, including their influence on food security. Furthermore, they were used to assess the impact of climate change and variability on food security. They were also used to examine existing adaptive capacities of households. Data collection at households proceeded by self-introduction to households' members by informing about the objective of study. A household is the basic unit of production and consumption in the villages and hence was used as a unit of analysis preferably with household head as the key informant.

#### 3.5.1.2 Focus Group Discussions

Focus Group Discussions (FGD) were held in three villages. Village leaders helped to identify key informants in each village where a group of 10 – 12 people from each village were selected for focus group discussions. Efforts were made to ensure an adequate representation of women and men. Through discussion, data such as seasonal calendar, climate historical time line of the area was established and other socio-economic activities were listed and fixed in a seasonal calendar. On the other hand, variation in planting and harvesting time in the annual cycles established the seasonal changes occurred in district. Transect walk were carried out for one kilometer from the centre of each study village in four directions (North, East, South and West). This provided an understanding on main food and cash crops, livestock, vegetation/forest cover plus other socio-economic activities used to maintain food security in the village.

Some of PRA tools used included a pile of 100 beans/maize of the same size which helped to get data in percentage because most of the local people cannot establish data in percentages. Planting calendar and historical timelines approaches were used to establish impacts of climate change/variability on food security and how communities have been addressing the impacts for the past 30 years. Similar methods were also used to examine existing adaptive capacities of local communities to climate change and variability, and predict consequences of climate change/variability on agricultural production. Data sets collected included weather patterns, indicators of climate change, planting and harvesting calendar of the area, historical climatic events, and crop productivity. Other data sets collected were on community perceptions on climate change and its influence on food security. These included trends in livestock productivity, fish and fisheries, households' food security, and types and trend of crops grown over time, occurrence of crop pests and human disease vectors, rainfall seasonality, and farming practices, assessment of the impact of climate change on crop production, food availability, food accessibility and food utilization (preference, preparation, eating patterns, nutrition/health status) as well as water availability. A checklist guided the discussions during interviews and when probing (key informant) to get appropriate answers related to the field of study.

Group discussions were conducted in the three selected villages, with participants drawn from all the sub-villages (*vitongoji*) based on various demographic factors (example sex, age, wealth, and level of education). These discussions aimed at obtaining general overview of experiences with the impact of climate change and variability on food security and community based adaptation strategies used by the community, and the local perceptions on food insecurity vulnerabilities and adaptation mechanisms (autonomous and planned). Essentially, this exercise aimed to identify indigenous knowledge on impacts in local communities, socio-economic factors associated with vulnerability, and adaptation to such impacts. The research team facilitated the discussions, but participants had equal chance to express their opinions. Notes were taken on issues once consensus was reached among the participants. To generate the information needed, the discussion began with an introduction on the survey and criteria used to classify them.

**Figure 3.2: Focus group discussions at Igombe Village**

### 3.5.3 Secondary Data

Secondary data on socio-economic and physical aspects were obtained from reviews of both published and unpublished literature from Libraries such as Dar es Salaam National Library, Agricultural Research library and Livestock Research Library. Other includes National Bureau of Statistics library, Ubungo-Tanzania Metrological Agency library, Open University of Tanzania library, University of Dar es salaam library and Magu District Library.

### 3.6 Validity and Reliability

The research proposal was presented and approved by the Faculty of Science, Technology, and Environmental Studies, the Postgraduate Studies Committee and Senate of The Open University of Tanzania. The questionnaire was pre-tested (in Ihale Village) prior to the fieldwork and modifications were subsequently made on some questions that seemed to be difficult for households to answer. Some of the questions were rephrased in order to make them much easier to understand. Pre-testing of the questionnaire was done to enable members of the research team to check out their own understanding of the various concepts used in the questionnaires (Mettrick, 1993). A short training of field assistants was done to familiarise them with the exercise and techniques of asking questions. Similarly initial data cleaning was implemented in the field during the data collection process.

### 3.7 Data Analysis Plan

Quantitative data were organized, sorted, edited, coded and analyzed using a Statistical Package for Social Sciences (SPSS) version 12 computer software and Microsoft Excel 3.3.1. Results are presented in frequency charts, figures and tables. Qualitative data were sorted and organized into thematic areas and arranged in a master sheet. Then, data were analyzed using content analysis.

#### 3.7.1 Rainfall Data Processing and Analysis

Collected rainfall records were of variable quality and length. Thus, was necessary to select the most suitable stations for the study in order to obtain a spatially representative data set for determination of rainfall indices and the longest and most continuous time series of rainfall indices for characterization of drought as well as flood periods. Such selection criteria were mainly based on record length, continuity of the records, and spatial evenness of the distribution of rainfall stations. Based on these reasons, stations with the longest records between 40 and 20 years with the most continuous data sets were selected for this study.

### 3.7.2 Rainfall Seasonality

Long-term rainfall data are good representatives for telling rainfall behavior of a specific rainfall station (WMO, 2005). Statistics useful for this study included stations' monthly mean rainfall and standard deviation. Monthly rainfall amounts, the mean of monthly amounts and the standard deviations were calculated by using Microsoft Excel software. A year was defined from 1st October to 30th September of the following year and was divided into four seasons: from October to December (OND), from January to February (JF) and from March to May (MAM) as wet seasons and the June-September (JJAS) a dry season spell. Seasonal rainfall indices were determined only for years with non-missing values.

#### 3.7.2.1 Characterization of Hydrological Years

Hydrological years were characterized by using a series of rainfall anomalies for each season (OND, JF, and MAM). The anomalies were calculated as standardized differences between actual rainfall amounts and long-term average rainfall. Standardization was done through division by standard deviations:

$$X\,an\,i = \frac{Xi - \bar{X}}{\sigma X} \quad \text{= (equation.1)}$$

Where $X\,ani$, = rainfall anomaly in month, $Xi$ = monthly rainfall; $\bar{X}$ = long-term average rainfall; and $\sigma X$ = standard deviation of monthly rainfall.

Criteria were set to determine extreme hydrological years. Such criteria ensured a sufficient sample size in the period of data to be collected. Climate variability is measured by those deviations, which are usually termed anomalies (WMO, 1992, updated on 12 June 2005).

**Table 3.2: Criteria for Selection Characterization of Hydrological Years**

| Criteria | OND | JF | MAM |
|---|---|---|---|
| Extremely wet years | Anomaly >2.0 | Anomaly >2.0 | Anomaly >1.5 |
| Wet Years | 2.0≥ Anomaly >1.0 | 2.0≥ Anomaly >1.0 | ≥ 1.0 |
| Normal | 1.0≥ Anomaly ≥ -1.0 | 1.0≥ Anomaly ≥ -1.0 | 1.0≥ Anomaly ≥ -1.0 |
| Dry years | -2.0≤Anomaly >1.0 | 2.0≤Anormaly 1.0 | ≤ -2.0 |
| Extremely dry years | ≤ -2.0 | ≤ -2.0 | ≤ -2.5 |

**Source: Adapted From WMO (2005)**

Series of rainfall anomalies were plotted for the whole period of available records and visually analyzed record. The measure provides limits that appropriately define the wetness and dryness of the year, by taking into consideration what had actually happened as indicated by the literature, household surveys and focus group discussions. From visual plots of time series of seasonal rainfall anomalies, limiting anomaly values were appropriately used in defining the extremes for wet and dry years. The period when rainfall exceeded normal or was below the normal rainfall amount was categorized as wet or dry year, while normal years were classified based on occurrence of many events over a period of time.

### 3.7.2.2 Temperature Fluctuation

Long-term mean maximum and minimum temperature statistics were collected representing and describing temperature behavior of a particular weather station. The statistics useful for this study included stations monthly changes in mean maximum and minimum temperatures. Data were calculated by using Microsoft Excel software.

### 3.7.3 Socio-economic Data Processing and Analysis

Data from questionnaires were coded into specific categories after carefully editing the completed questionnaires. Descriptive analysis of events and simple statistics, such as frequency and percentages, were employed to summarize and analyze the data. The Statistical Package for Social Sciences (SPSS) computer software and Microsoft Excel were used for quantitative data analysis. Different seasons and years were correlated with different socio-economic attributes because each season has different amounts of rainfall with different crop and livestock production. Such facts necessitate separated analysis for each season and individual years.

### 3.7.4 Trend Analysis

Trend analysis, was used to analyze collected information of rainfall, temperatures and socio-economic activities obtained in the study area also used in spotting out patterns, or trends, in the information in order to extract meaningful statistics including other characteristics of the data. Microsoft excel software, were used for trend analysis.

### 3.7.5 Vulnerability Assessment

Vulnerability assessment was conducted using Tanzania Participatory Poverty Assessment (TzPPA) methodology. The assessment aimed at identification of vulnerable groups. The working definition adopted by the PPA (20022/3 cycle) understands vulnerability as – *‘the susceptibility of individuals, households and communities to becoming poor or poorer as a result of events or processes that occur around them* (ESRF, 2003).

# CHAPTER FOUR

# 4.0 RESULTS AND DISCUSSION

## 4.1 Introduction

This Chapter presents Results and Discussion. It is centered on the following aspects; likelihood of occurrence of extreme weather events (drought, floods and temperature); occurrence of pests, crop productivity and livestock productivity and adaptation options that sustain communities during incidences of climate change/variability as well as extreme events. Others are economic analyses mainly for agriculture, livestock keeping and fishing since these are the main economic activities that are carried out in study areas.

## 4.2 Characteristics

This section provides demographic and socio-economic profile of respondents by describing basic background characteristics such as men and women including age structure, marital status, education, and their occupation.

### 4.2.1 Demographic Characteristics

Out of the surveyed 80 households in three villages, 73.8 percent of respondents were males and 26.3 percent females. Among them 13.8 percent were single, 52.5 percent married monogamists, 18.8 percent married polygamists, and 15 percent were divorced or separated. There were variations in household sizes whereby in Ng’haya village, household size ranged from one to twelve people, while in Ihale as well as Igombe, household size ranged from one to fifteen people per household.

Demographic characteristics of an area, such as population density, population growth, household size and migration, may influence access to resources integral to household livelihood strategies (Erikssen, 2005).

Further analysis revealed that, some households had large size of household members between 13 -15 people it showed significant difference from data exposed by Household Budgetary Survey (HBS) in year 2007. This was associated with social behavior or customs of residents (*wasukuma*) where head of households stay with their relatives, married sons and their families (children and spouse) while other households are polygamists therefore have many children and normally work together in fields and eat in the same pot.

The study established that, most of the large size households were households which diversify family labor in different works such livestock herding, cooking, digging, weeding, planting and harvesting at the same time. In turn households got surplus food and cash crops as well as owned big number of livestock. Normally these families are households which, owned large fertile fields termed as “well-off” (*wasabi)* households used the family labor-force to get significant wealth in villages. Normally they were food secure households and some owned tractors, shops, milling machine as well as large traditional storage structures (*Vihenge*). Also they provided food and cash labor to resource weak households when they fell in food shortage in the area. This help to stabilize food and livelihood security in the area. Through the analysis respondent’s age structure is summarized in (Table 4.1).

**Table 4.1: Respondents; Age Structure**

| Average age of Respondents | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | 15 to 30 years | 7 | 8.6 | 8.8 | 8.8 |
| | 31 to 40 years | 16 | 19.8 | 20.0 | 28.8 |
| | 41 to 50 years | 26 | 32.1 | 32.5 | 61.3 |
| | 51 to 60 years | 20 | 24.7 | 25.0 | 86.3 |
| | Over 60 years | 11 | 13.6 | 13.8 | 100.0 |
| | **Total** | **80** | **100.0** | **100.0** | |

Household analysis revealed that most of interviewed households are in mature age category, a situation suggesting that they had enough experience on climatic related events in their localities. Study established that the age of household heads can influence the livelihood strategies pursued by households through the lesson leant from past extreme weather events. Ellis and Bahiigwa, (2003) states that family life cycle features such as age, education and number of family members can sway households and individual's objective such as risk management practices, consumer preferences, and/ or strategies available to cope up with shocks.

Through the analysis, majority of respondents reported to have been born in villages they were living, followed by those who went in search for farms, married in the village others went in search for work (Figure 4.1). This ensured that most of them understood and could compare climate variability of the area as they were settled in villages for a long time.

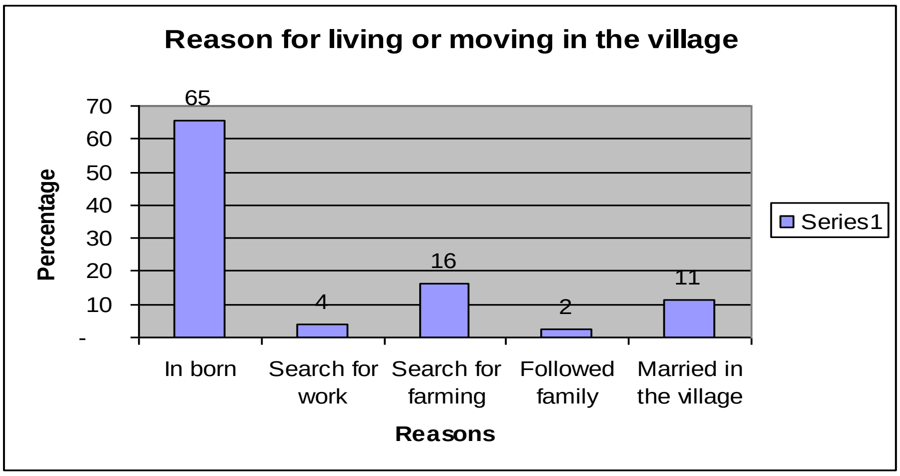


**Figure 4.1: Reason for Households heads to move or live in the village by percentage**

Education levels acquired by respondents varied significantly as summarized in (Figure 4.3). Most of households in which the head has primary education are more likely to engage in off farm work as were those who had training in agriculture and, accessing weather information through reading publications such as magazines, books and bulletins provide by government and development partners. Srivastava and Jaffe, (1992), noted that access to weather information is significant for the planning of farmers' agricultural activities and improvement of their adaptive capacity. Those engaged in secondary and college education employed in parastatals, community based organizations, public works and church works. Low education level contributes largely to poverty in Magu district (Table 4.2) due to lack of alternative ways of making their living and hence depended entirely on using natural resources. That has implications for resource use and management as shown in (Table 4.2). According to (Van de Poel *et al.*, 2008), in all regions of the developing world, lower income households experience drastically higher rates of preschooler stunting than better-off families.

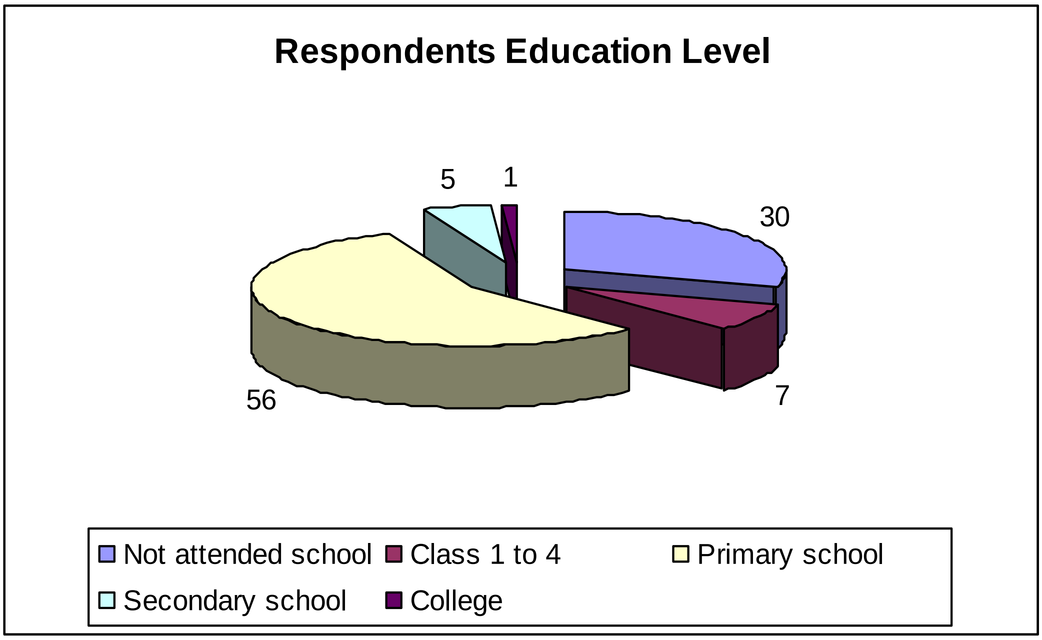


**Figure 4.2: Respondents Education levels by percentage**

**Table 4.2: Household wealth status as a functional of education level**

| Wealth group | None | Class 1– 4 | Primary school | O-level complete | High school | College |
|---|---|---|---|---|---|---|
| Resource weak | 17.2percent | 3.7percent | 21.2percent | 1.3percent | | |
| Middle | 8.3percent | 1.3percent | 37.4percent | 1.7percent | 1.3percent | |
| Better off | | | 4percent | 1.3percent | | 1.3percent |

Through focus group discussion with key informants, and use of proportional piling method, farmers managed to group households in piles to indicate the household wealth status as a function of education level in communities living in the study area (Table 4.2). Education enables local community members acquire new technology through access to information, training and be more involved in developmental activities. Through discussions it was evident that poorer people were unaware of ongoing environmental conservation initiatives in the area, such as food security and Green belt programmes under VI Agro-forestry Project and the Beach Management Units (BMU). The study established that resource weak groups were always marginalized in planning and other crucial stages when such programmes were being implemented. On the other hand, another reason for their lack of involvement in mitigation projects was their inability to read and write, which made them to be suitable only for manual or hauling workers in cotton stores and fishing factories.

#### 4.2.2 Socio-economic Activities

There were various types of socio-economic activities across the agro-ecological zones in the sampled villages. In Ihale village, which represented the lower agro-ecological zone, situated along the Lake Victoria shore, most people were engaged in fishing and related activities such as fish selling, smoking/drying fish and working in fish processing factories. Ng'haya village allocated in a middle zone and Igombe in the upper zone of the district were less engaged in fishing activities compared to Ihale village.

The extent of household's involvement in various farm activities varies with agro-ecological zone and from one household to another, mainly depending on the socio-economic status of households. Results from the study revealed majority of respondents' main occupation was agriculture, followed by livestock keeping and fishing (fishing and fish sales). Hence, one household engaged in one or more socio-economic activities as indicated in (Table 4.3).

**Table 4.3: Occupation of Households Head**

| Main socio-economic activities (percent) | | | | |
|---|---|---|---|---|
| **Main Economic Activity** | **Village** | | | **Total in Percentage** |
| | **Ihale** | **Ng'haya** | **Igombe** | |
| Farming | 96.8 | 96.3 | 100 | 98.8 |
| Livestock keeping | 61.3 | 14.8 | 68.2 | 75.0 |
| Fishing | 41.9 | 14.8 | 9.1 | 23.8 |
| Employment | 12.9 | 33.3 | 4.5 | 17.5 |
| Forest product | 12.9 | 37.0 | 4.5 | 20.0 |
| Businesses | 25.8 | 23.1 | 27.3 | 25.3 |
| Mason | 9.7 | 3.7 | 18.2 | 10.0 |
| Carpentry | 9.7 | 3.7 | 18,2 | 10.0 |
| Mining/quarrying | 9.7 | 14.8 | 0.0 | 11.3 |

Other socio-economic activities included business (milling machine, shop, kiosk, hotel and food vendor*)* and forest activities (charcoal, medicinal, firewood and honey). Few of them were employees in government, parastatals, non-governmental organization, community based organizations, and others were retired. According to Ellis (1997), livelihood encompasses income (both cash and in kind), as well as social institutions, gender relationships and property rights required to maintain or sustain a given living standard. Moreover, it was observed that some farmers in the three villages did not have enough incomes to support and sustain their livelihoods during extreme weather events. As such, during drought, farmers complained of food shortages due to inadequate production as well as lack of cash to purchase food from the markets.

#### 4.2.2.1 Agriculture

Agriculture is a cornerstone of the district economy where more than 80 percent of the district population depends on (Magu District Profile Data, 2006).

##### 4.2.2.1.1 Crop Production

Most farmers were engaged in crop production as the main source for their livelihoods. It was observed that majority of household incomes were obtained from selling food crops, some of them got incomes from selling cash crops and other respondents were engaged in cash labor as well as food labor (Table 4.4). It implies that most respondents depended more on food crops for both food and income than cash crops. Such a pattern reduced their abilities to diversify in case of weather vagaries because most food crops are not drought resistant. Also, it was observed that most farmers in the area were not engaged in cotton production which is less susceptible to drought when compared to cereals. Cereals have fibrous root system while cotton has tap root system which help the crop to get water moisture deeper in the soils. Farmers' sale cotton and buy food commodities in case of food shortage in the area.

**Table 4.4: Household Income Obtained from Farming**

| | Income source | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | Food crops | 46.0 | 56.8 | 57.5 | 57.5 |
| | Cash crops | 30.0 | 37.0 | 37.5 | 95.0 |
| | Food labour | 1.0 | 1.2 | 1.3 | 96.3 |
| | Cash labour | 2.0 | 2.5 | 2.5 | 100.0 |
| | **Total** | **80** | **100.0** | **100.0** | |

Main food crops grown in the area were maize, sorghum, cassava, paddy and sweet potatoes, while cash crops include cotton and chickpeas (*dengu*). Results revealed that Magu district normally has two distinct patterns of rainfall in the year (bimodal rainfall) where short rains (*vuli*) start in October to December and long-rains (*masika*) start in March to Mid-May. In previous years, farmers had been growing maize and beans twice a year, but nowadays, they grow them once a year due to change in rainfall patterns. In recent years, short rains started late in mid-November to December. (Valimba, 2004) argued that in rain-fed agriculture, factors which influence water and moisture availability comprise the characteristics of the rainy seasons (onset, duration, end and amounts), the distribution of rainfall amounts within the rainy seasons as well as rainfall intensity.

During bad years, farmers grow more horticultural crops in wetlands in order to recover food and cash gap occurred in the main season. Grown vegetables include tomatoes, cabbage, spinach, and onion to support food security as well as people’s livelihoods. For example, (Palela, 2000) stated that, horticultural activities in Msimbazi valley in Dar es Salaam region bear subsistence and give income-generation opportunities to users. Likewise, in the Lake Victoria wetlands, horticulture employs a number of people particularly during dry season (NEMC, 1998; Mwita, 2003).

#### 4.2.2.1.2 Livestock Keeping

Livestock keeping is an essential activity in the district. It contributes to basics of food and incomes as well as other social and cultural functions. Farmers keep animals in the district for direct consumption of food products such as milk, meat, eggs and non-food items like manure and draught power. Livestock types kept include cattle, goat, sheep, pig and poultry.

During group discussions, farmers argued that in normal year's numbers of livestock in the area got higher than during drought years. In a normal year pasture and water for livestock are readily available such that livestock keepers graze their livestock within village boundaries. Respondents stated that during normal years availability of food in the villages was usually good compared to a drought year. During drought year, cattle are sold to support household incomes so as to buy food commodities and other household items. Droughts are one of the most significant (and frequent) environmental stressors of agriculturalists and pastoralists in a similar way within East Africa (Paavola, 2003; IDRC/CCAA, 2009). Although drought is a slow onset hazard, it is impacting more people in Africa than other hazards. Significantly, climate change is anticipated to increase risks of drought over numerous part of Africa inside the 21st century IDRC/CCAA, (2009).

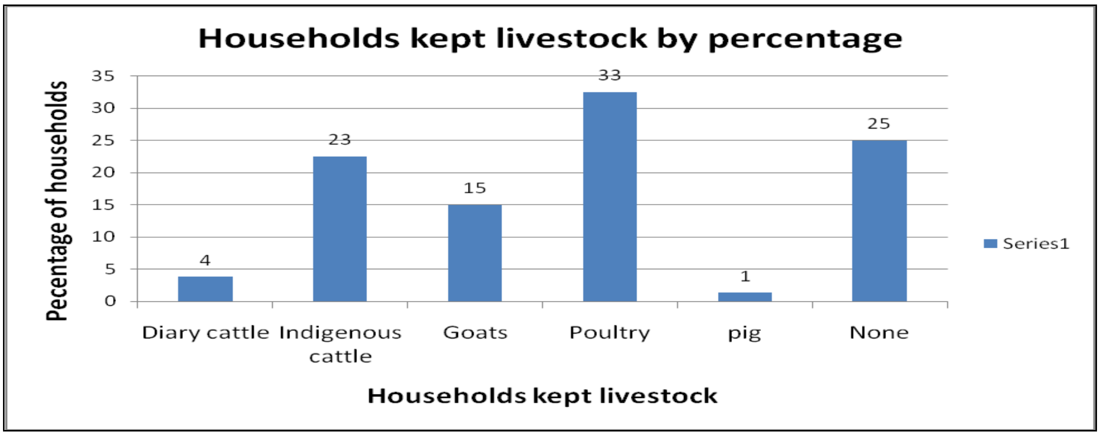


**Figure 4.3: Livestock Keeping in Magu District**

Furthermore, when *Wasukuma* harvest surplus, they normally sell and buy more cattle and shoats to rebuild the livestock stocks, sold during famine years. Sometimes that is done through exchange of food crops for livestock. Also they use other ways of making their livestock to survive in extreme dry weather condition such as supplementary feeds and migration to other areas where they could get enough pasture and water. For example, during the dry period of 2005/2006, pasture and water were scarce such that livestock keepers moved their animals search for water and pastures, they returned during the rainy season. It was reported that livestock keepers who own larger numbers of livestock move away from the district in search for water and pastures in Kilosa district in Morogoro region, Mufindi in Iringa region and Usangu wetlands in Mbeya region, where they were reported to trigger overgrazing and land degradation (Paavola, 2003).

At the same time, people in the study area reported high population growth which reduce land for settlement and recreation which reduced farming land and grazing area. This increased land degradation the conflict of land between crop farmers and livestock keepers.

According to (UNDP-Global Environmental Facility, 2004); and Scherr, 1999) overgrazing and deforestation also play a part to land degradation as well as climate change. Also such migrant’s pastoralists create land conflicts between crop farmers and livestock keepers. According to LEAD, (2006), an increasing scarcity of basic food and water resources and environmental degradation increase the probability of violent conflicts. The Southern African Millennium Ecosystem Assessment suggests that bi-directional causal connection between ecological stress and social conflict may well cause environmental degradation but the end may also trigger conflict (Biggs *et al.*, 2004). In addition, constraints on water availability are a growing concern, which climate change will exacerbate. Conflicts over water resources will have implications for both food production and people's access to food in tension zones (Gleick, 1993).

Direct and indirect effects on particular sectors of food production may systemically reduce or endanger existing livelihoods in their particular spatial and functional arrangements thus destabilise social settings as well as intimidate food security (Kasperson and Kasperson, 2001). Also (UNEP /UNESCO/START, 2005) argues that, analysis of current economic and environmental trends in Africa reveals increasing struggle over access and uses of land together with freshwater resources. (Barnett and Adger, 2007) assert that land use conflicts migration, *social disruption* and civil strife may result from systemic changes, with potentially the majority of all severe forms of secondary consequences for food security.

Furthermore, analysis revealed that most cattle keepers also kept sheep, goats and poultry to diversify their incomes. Small livestock help them to get quick money for scholars, and buy households items. Sometimes they are slaughtered for group of farmers who go to help during the peak of field works such as planting, weeding and harvesting. The value of cattle in the areas was higher than other livestock because cattle are kept for dowry and prestige rather than other economic values.

It was observed that during extreme wet years, climatic conditions favored incidence of ticks that accelerate tick-borne diseases such as east coast fever, heart water, black quarter and anaplasmosis where most livestock keepers lose livestock, especially calves. Moreover, during extremely dry years there is serious proliferate of zoonotic diseases from wildlife which kills livestock because they communicate the watering points with livestock due to water shortages in National Parks and Game Reserves. Magu district borders Serengeti National Park a long north-east area and Maswa Game Reserve in the east side of the district.

#### 4.2.2.1.3 Fishing

Worldwide, some 200 million people and their dependants, most of them in developing countries, live from fishing and aquaculture (FAO, 2008). Fish provide an important source of cash income for many poor households and are a widely traded food commodity. As well as stimulating local market economies, fish can also be an important source of foreign exchange.

Fishing is essentially a hunting activity. So its success or failure depends heavily on vagaries of nature (FAO, 2007). Climate change is creating more anomalies, both failures and bonanzas, among multiple species, as well as drastic shifts in the areas where small, migrating fish are found in various places like in lakes, rivers and wetlands (*Ibid*). The falls of water level in Lake Victoria in 2006 destroyed the natural habitat of fauna and flora around the lake shore. According to (Rockstrom, 2003) water insecurity constitutes a serious restriction to sustainable development, specifically in Savannah regions, which covers about 40 percent of the world's land area. Water scarcity may lead to multiple adverse health outcomes as well as water-borne diseases, exposure to chemicals, vector-borne diseases linked with water-storage systems and malnutrition (*ibid*). Also, water shortages influence fish availability and aqua-culture production.

Change in occurrence of extreme events is likely to excessively impact smallholder farmers and artisanal fishers (Easterling *et al.*, 2007). According to (FAO, 2007) fishing is frequently integral to mixed livelihood strategies in which people take advantage of seasonal stock availability or resort to fishing when other forms of food production and income generation fall short. Fishing is often related to extreme poverty and may serve as a vital safety net for people with limited livelihood alternatives and extreme vulnerability to changes in environment. However, viability of fishing as a sustainable livelihood is threatened by climate change. Fishing communities that depend on inland fishery resources are likely to be particularly in danger to climate change access to water resources and arrangements with other sectors for sharing and reuse will become a key to imminent sustainability. Furthermore, (McCarthy *et al.*, 2001) revealed that inland and marine fisheries give a prominent contribution to protein intake in many African countries. As a consequence of water stress and land degradation, inland fisheries will be rendered significantly vulnerable to periodic droughts and habitat damage (*ibid*).

In Tanzania fresh water fishing is widely practiced in Lake Victoria on a full-time basis. Fishermen use boats with engines, which makes easier to travel across the lake, searching for fish in large scale fishing. Small holders use canoes to catch fish around lake shore and sell them to get food commodities including other household items. Fish caught include Cichlids, Catfish, Nile Perch, Lungfish, Cyprinids, Mormyrids, sardines (*Rastreneobola argentea*) and other small fish (*Haplochromis spps*). Seasonal fishing, practiced in seasonal rivers such as Lamadi and Simiyu, is common. During heavy rains fishing is done in flooded, areas of Simiyu wetland in Magu Bay. Fishing season is from 1st July to 31st December every year in short-rains and in long-rains, normally starting in March to May. Fish catches during the wet season are higher than during the dry season.

**Table 4.5a: Fishing Occupation in Magu District**

| **Fishing activities** | **Frequency** | **Percent** | **Valid Percent** | **Cumulative Percent** |
|---|---|---|---|---|
| Fishing | 12.0 | 14.8 | 15.0 | 15.0 |
| Fish sales | 7.0 | 8.6 | 8.8 | 23.8 |
| Not applicable | 61.0 | 75.3 | 76.3 | 100.0 |
| **Total** | **80.0** | **100.0** | **100.0** | |

Data obtained from the study revealed that contribution of the fishing sector in socio-economic activities is highly significant in Magu district development. However, the percentage of households engaged in the fishing activities is minimal. A few of the respondents were engaged in fishing and fish sales while majority were not engaged in fishing (Table 4.5a). According to district economies, people did not benefit directly from the sector. But they benefited indirectly through multiplier effects such as nutrition for both adults and children, Money injected in the district economy during collected revenues from fishing and fish sale licenses, employment of people in fishing factories and donations from large scale fishers to public services such as building of dispensaries and schools. In addition, large scale fishers get a significant income from the fishing sector. They use such income to build modern houses and invest in social service sector such as building modern restaurants and guest houses, which in turn, contribute to the national economy through different taxes.

**Table 4.5b: Magu Fishing data by type from 2000 to 2009 (Quantity in Tons)**

| Types of fish | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|---|---|---|---|---|---|---|---|---|---|---|
| Nile perch | 6,570 | 8,325 | 11,372 | 7,030 | 5392 | 3,602 | 13,565 | 2,913 | 3,663 | 1,122 |
| Tilapia | 6 | 10 | 4 | 12 | | 139 | 5,589 | 70 | 106 | 138 |
| Haplochromis | 360 | 520 | 519 | 651 | 680 | 5,587 | 6,025 | 7,955 | 2,770 | 13,391 |
| Sardines | 12,41 | 832 | 7589 | 460 | 410 | 8719 | 2,390 | 637 | 1,567 | 14,670 |

**Source: Magu District Council**

According to fishing data collected from the District Fisheries Office (Table 4.5b), the district officials argued that there was an increase in the fish catch in the district since 2005 due to an increased demand in fishing factories. Also, it was reported by fisheries officers that fish is free from cholesterol and makes more people prefer eating fish than red meat. Fish obtained from Lake Victoria is transported to Europe, Asia and the Far East, which injects foreign money into the national economy. Furthermore, sardines (*dagaa*) from Lake Victoria are cheap and are easily accessible to resource weak households all over in the country and other neighbouring countries. Also they provide significant nutritional values to animal feed and special foods to nourish sick people including children. According to (Bwathondi, 1991), in Tanzania, fishing employs a substantial number of people and is a basis of food and foreign exchange. (NEMC, 1998), states that more than 40 percent of the fish harvested from Lake Victoria is processed for export.

## 4.3 Perception of the Term "Climate"

The concept of "climate" was perceived differently by respondents in the surveyed villages. Such perception was limited to a few who are more educated or linked to issues related to climate. Analyzed data differentiated understanding of the term "climate". Greater part associated climate with a combination of rainfall, temperature and drought, while some voted for rainfall followed by drought and temperature (Figure 4.6).

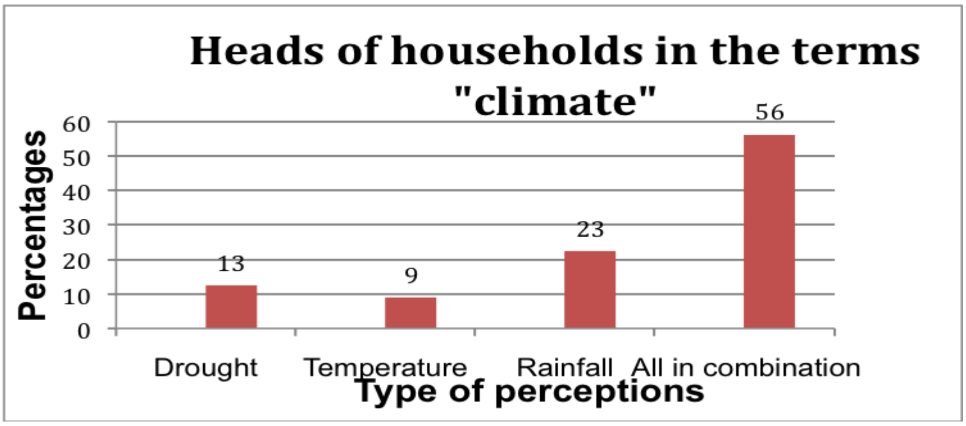


**Figure 4.4: Respondents Perception to the Term Climate**

Through perception and understanding of most respondents of the word 'climate' it is easy for the community to know change of climate in their area and find ways and means which will help them to overcome its problems. Furthermore, if they will be trained on environmental conservation they could mainstream environmental issues, strengthen resilience of vulnerable livelihood systems and participate in new technological solutions so as to reduce impacts of climate change in their area.

### 4.3.1 Likelihood of Occurrence of Hydrological Extreme Events

Occurrence of extreme weather events in the study area accelerated by changes in temperatures which caused changes of atmospheric pressure, wind speed and direction, increases of evaporation rate as well as change of rainfall regime.

### 4.3.2 Rainfall Seasonality

Results revealed that there is a well-defined bimodal rainfall regime with relatively equal peaks in November and April, which are peaks of the short rains (*vuli*), from October to December (OND) and long rains or (*masika),* from March to May, (MAM) (Figure 4.7a).

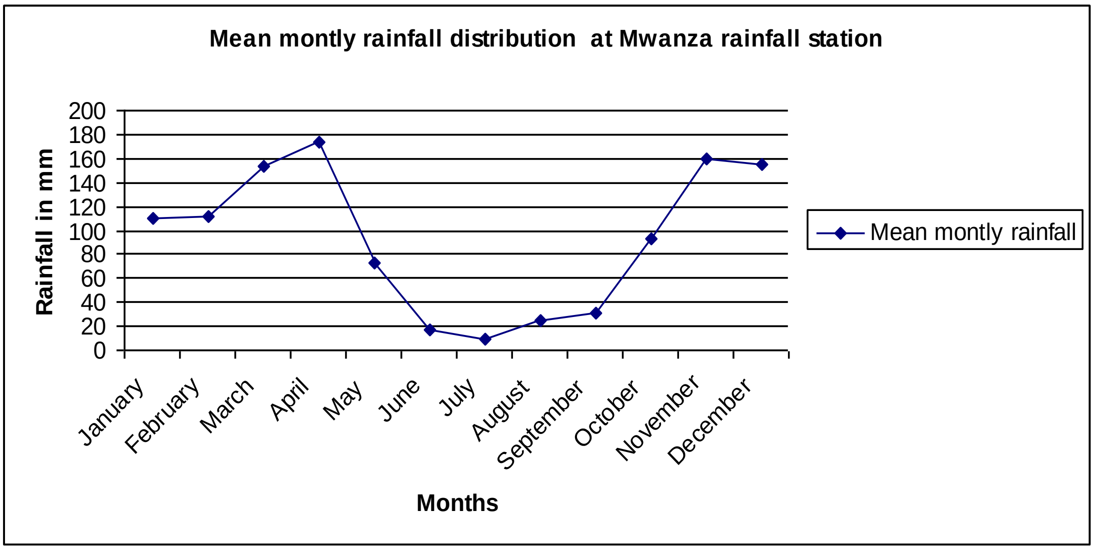


**Figure 4.5a: Mean monthly rainfall distribution from January 1960 to December 2010 at Mwanza Airport weather station (ID 923209)**

Furthermore, it was revealed that the beginning of the wet season is in October and continues until May with reduced rainfall amounts in January and February. The dry season normally starts from June to September (Figure 4.7a). Normally, OND and MAM seasons do not have the same strength and sign of anomalies as it was in 1961/62 and 1967/68 which showed the wettest and driest OND rains, respectively. Such seasonal fluctuations have led to fluctuations in agricultural and livestock production. Reduced rainfall is linked to reduced moisture availability in soils, leading to poor growing conditions and consequently, low crop production. Also, extended dry day spells and increased frequency of high rainfall may lead to frequent disastrous flooding, during the rainy season as and extended periods of severe low flows of water during the dry season. Following observations it was identified that famine was related to erratic OND rains from October 1971 to April 1972. Also, during the discussions, people expressed periods of experienced extreme events in their area from 1939 to 2009 (Table 4.6).

**Table 4.6: Famine reported cases and periods of events in Magu district**

| Periods of experienced Extreme Event | Event | Local name for a Particular Event |
|---|---|---|
| 1939 | Drought | |
| 1949 | Drought | Legu legu |
| 1959 | Drought | |
| 1961 | Floods | Uhuru |
| 1974/75 | Drought | Njaa ya Gata |
| 1984 | Drought | Makopo (kimbo) |
| 1994 | Drought | Njaa ya Nkalalo |
| 1996 | Drought | |
| 1997/98 | Floods due to El Nino rains | El Nino |
| 2004/05 | Drought | Bululu |
| 2006 | Floods | |
| 2008 | Drought | |

Rainfall anomalies during the early 1960s were related to extremely high rainfall conditions in 1961, followed by very high rainfall in 1965 and succession of wet OND seasons (Figure 4.7b). According to **(**Conway, 2002), the period between the late 1960s to the early 1980s transversely much of Equatorial East Africa, year 1961 was the highest extreme wet year. The same applied to the OND season for 2006, which experienced relatively high rainfall and increased river flows in almost all river basins in Tanzania (T M A, 2007). In spite of the large influence of rainfall fluctuations on river flow variability and implications for lowlands, such variations may also be influenced by other factors like changes in land cover or land use. A typical example can be observed in the (Sahel Mahe, *et al*., 2005; Valimba and *et al*.,

2004) recognized effects of human activities on land surface and their influence on flow regimes in the Mara river basin.

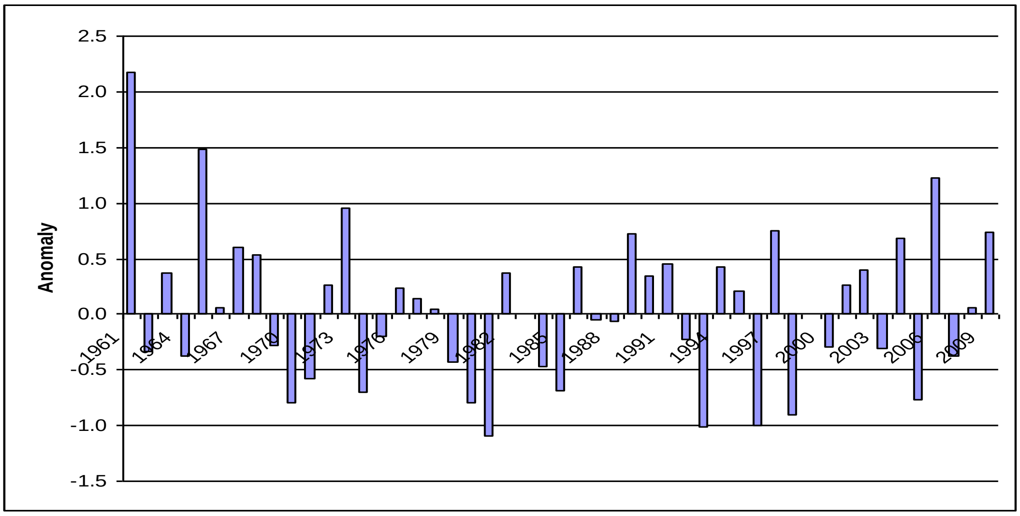


**Figure 4.5b: Time series of normalized anomalies of OND seasonal rainfall amount at Mwanza Air port Station** (ID 923209)

Time series of normalized anomalies of March, April and May (MAM) and January and February seasonal rainfall amount at Mwanza Air port Station, are attached in the (Appendices 2 and 3).

### 4.3.3 Characterization of Hydrological Extreme Events

Time series of OND rainfall indicates wet and dry years (Table 4.7). The year 1961 was identified to be extremely wet year. Rains during that year were known as hurt rains. It occurred during independence when the entire country experienced above average rainfall. Furthermore, 1997 was indicated as an extremely wet year due to occurrence of El Niño phenomena. From 1975 -1979 and 1983/84, conditions were dry throughout the country as time series of March, April and May (MAM) rainfall showed that 1962 was an extremely wet year and 2000 was an extremely dry year

(Appendix 2). However, information from literature and focus group discussion in the study area was reported to be the driest years as indicated in (Table 4.7). Dry years throughout the period 1973 -1976 impacted most of Tanzania. Also during the 1987 to 1993, 1996 and 2004-2005 periods, many parts of Tanzania received below normal rainfall. During wet years, high crop production was experienced, with an increased fish catch and larger numbers of livestock while, dry years experienced low production of crops, a low fish catch and reduced number of livestock. Factors, which contributed to reduction in number of livestock during the dry seasons in the study area included lack of pasture and water, selling of livestock at cheap prices to earn money for food and moving livestock to other places in search for good pastures. All factors caused conflicts between farmers and livestock keepers in areas where people migrated with their livestock.

**Table 4.7: Characterization of Years According to Rainfall Amount**

| | **Seasons** | |
|---|---|---|
| **Years characterization** | **Short rains OND** | **Long rains MAM** |
| Extreme wet | 1961, 1997 | 1962 |
| Wet | 1961, 1997 | 1981 |
| Dry | 1964 ,1966,1970,1993 | 1973 |
| Extreme dry | 1990 | 2000 |

Drought years identified by respondents were 2004/2005 and 2005/2006, followed by those experienced in 1994, 1996, 1984/1985 and1974/75 (Table 4.6). Majority of respondents agreed that the most devastating droughts were experienced in 1984/1985 and 2005/2006. On the other hand, 1961 and 1997/98 were identified to be extreme flood years. Respondents had general feeling that rainfall pattern in last

30 years had been decreasing (Figure 4.10). According to (Ehrhart and Twena, 2006) stated that drought that occurred in 2005/06 and the El Niño in 1997/98, emphasize the country's vulnerability to current climatic hazards.

In the view of the above, study established that local knowledge is as objective as scientific knowledge. Science would benefit from integration of both knowledges.

Data collected from lhale village, which represented the lower agro-ecological zone in the study area was noted that rainfall mostly changed followed by temperature. Change in rainfall was serious in such way that the area is classified/placed "in transitional state" from bimodal to unimodal rainfall. Respondents argued that short rains in recent years were erratic and were late in such that farmers did not utilize available soil moisture for planting new crops in the fields. They were used for making land preparation for long rains and helped to rejuvenate pasture for livestock. Also they raised alarm about rise in temperatures which accelerated the rate of evapo-transpiration which eventually caused field crops and pastures to suffer from moisture stress a few days after rainfall. About 90 percent of respondents confirmed having change in rainfall pattern (Figure 4.10). (Valimba, 2004) revealed that bimodal areas of Lake Victoria basin have experienced more unreliable rains in recent decades, leading to recurrent failures of rain-fed agriculture, especially in short rains seasons.

Key informants from Ng'haya village situated in middle agro-ecological zone noticed rainfall and temperature changes in their areas. Also they reported poor rainfall distribution experienced in recent years they concluded that rainfall was not unpredictable in their area when they compared with past seasons in1980s. In recent seasons, rainfall distribution changes for example rainfall started earlier on time, which encouraged farmers to prepare land for planting when they have to sow seeds but fortunately it stopped before crop reached maturity. They revealed that it was a common phenomenon so that they had to plant drought resistance and early maturity varieties. (Easterling, 1996) argued that deliberate crops selection and distribution strategies across different agro-climatic zones, substitution of new crops for old ones and resource substitution were induced by scarcity.

Igombe village represented the higher/upper agro-ecological zones of Magu district. The area has a well distinct rainfall regime compared with other places in the district where short rains normally start in October to December and long rains starts in early March to early June. Rainfall pattern enable farmers to plant maize, paddy, cassava and sorghum comfortably without worries from drought in long period except during past extreme dry years. During discussions with farmers about the weather conditions in their area, they noted slight below changes in rainfall pattern. Resulted to harvest less in maize in the same fields compared with previous years. However, production of other crops such as sorghum, paddy and cassava was still normal. Further analysis established that Igombe village in the highland zone did not report change in temperatures compared with Ihale village in the lower zone where almost every respondent complained of high change in temperatures.

#### 4.3.3.1 Rainfall Pattern in Magu District Council

There has been a significant decrease in rainfall in recent years as shown in (Figure 4.7c). Also, it was confirmed by key informants during the focus group discussion

(Figure 4.10)**.** It affects plant and animal metabolisms as well as reproduction processes. According to (McClean *et al*., 2005) stated that habitat change is already happening in some areas, leading to species range shifts and changes in plant diversity, which includes native foods and plant-based medicines. Changes in climatic conditions have led to significant declines in the provision of wild foods by a variety of ecosystems, and further impacts can be expected as the world climate continues to change. For the 5,000 plant species examined within a sub-Saharan African study (Levin and Pershing, 2005), it is predicted that 81 to 97 percent of the appropriate habitats will decrease in size or shift due to climate change.

By 2085, between 25 and 42 percent of the species' habitats are expected to be lost altogether. The implications of these changes are expected to be particularly great among communities that use the plants as food or medicine (IPCC, 2007). A significant inter-relationship arises from the reality that insufficient water for livestock and crop production constitutes the major constraint to food security for millions of smallholder farmers, above all in semi-arid and sub - humid Sub-Sahara Africa (Assan, 2008; Assan *et al*., 2009; Enfors & Gordon 2008; Falkenmark & Rockstrom, 2004; Hanh *et al*., 2008; IPCC, 2007). By 2000, about 300 million Africans risked living in water scarce environments.

By 2025, the number of countries experiencing water stress will rise to 18, disturbing 75 to 250 million and 350 to 600 million people inside the world (Arnell, 2004; Hahn *et al*., 2008; IPCC, 2007). Such a scenario will likely worsen existing patterns of poverty and challenge policy attempts towards poverty alleviation, in promoting sustainability and improvement in household's comfort (Arnell 2004; Assan *et al*., 2009; Hahn *et al*., 2008; IPCC, 2007; Falkenmarker and Rockstrom, 2004).

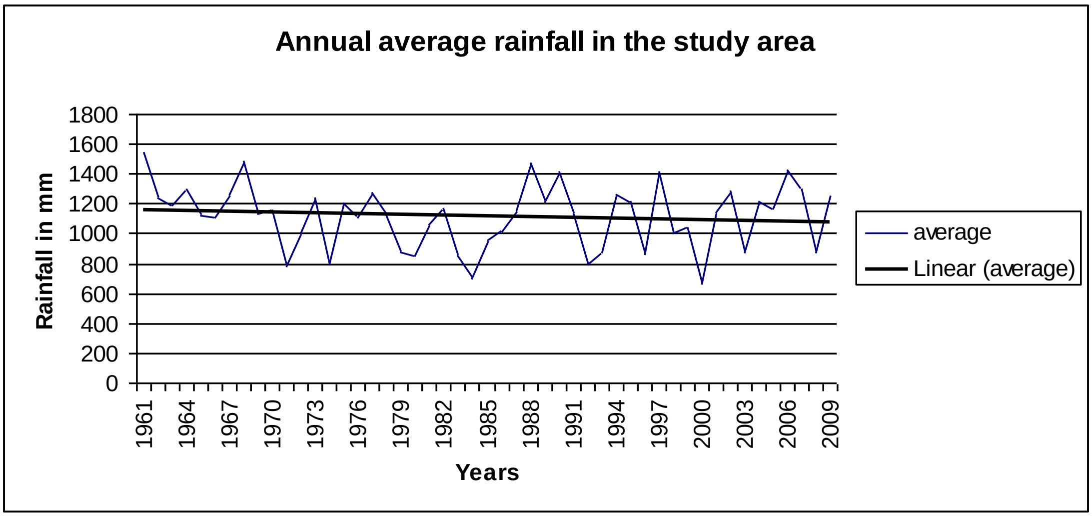


**Figure 4.5c: Trend of Annual Rainfall for Mwanza Air port Station, 1961 to 2010**

Moreover, there has been a difference between famine reported cases and periods of events advocated by communities (Table 4.6) and recorded trend of rainfall pattern in study area, (Figure 4.7c). Well distributed rainfall in the production year, favored production and productivity of crop including availability of pasture and water for livestock where farmers get good harvests even if the rainfall amount was very low in all investigated years. For example, during the year 2000 where rainfall amount was very low compared to other years identified to be the most extreme dry year (Figure 4.7c; Table 4.8) the communities in the study area did not mention the 2001/2002 consumption year as famine year (Table 4.6). Therefore, the study established that crop and livestock production as well as productivity did not depend on high rainfall amount in production year, mostly depending on good rainfall distribution in the specific production period.

#### 4.3.3.2 Temperature Pattern in the Study Area

Annual temperature data recorded at Mwanza airport station indicated an increased trend in mean maximum temperatures shown (Figure 4.8a). Also, seasonal mean maximum temperature of October November and December (OND) showed increased trend (Figure 4.8b). Other seasonal temperature analyses for January, February (JF) and March, April and May (MAM) are available in (Figure 4.8c); Figure 4.8d) respectively. Analysis of mean minimum temperature from 1960 to 2010 indicated a constant trend, as in (Appendix 6). In addition, during focus group discussions and interviews with household heads people argued that temperatures were increasing (Figure 4.11). That could be the main cause of rainfall fluctuation, increase wind speed and increase of evaporation as well as transpiration which eventually change the natural habitat for fauna and flora in the area.

Based on analysis of time series data on temperature in study area, change of mean maximum temperature is a real evidence of climate change in the area, which contributed to change of ecological nature for many organisms living in the area. (Hulme *et al*., 2001), explained that climate of Africa is warmer than it was 100 years ago. Model-based predictions of future greenhouse gas-induced climate change for the continent clearly suggest that warming would continue and, in most scenarios, would accelerate so that the continent on average could be between 2º and 6ºC warmer in 100 years time. The best estimate for the low scenario, among the Special Report on Emissions Scenarios (SRES)4 projected by the 4th IPCC assessment, is an increase of 1.8°C and the best estimate for the high SRES scenario is 4.0°C (Meehl *et al.*, 2007).

Additionally, the projected impacts of climate change and variability by 2100 in Africa may include increases of 1.0° to 4.7°C in temperature, reduced rainfall by 2 to 25 percent, increased evapour-transpiration up to 132 percent, and reduced runoff by up to 50 percent (Magadza, 1996; Hulme, 1996). Also (WMO, 2007) noticed that when weather phenomena are measured systematically at a specific location over several years, a record of observations is accumulated from which averages, ranges, maximum measurements and minimum measurements for each variable can be computed along with frequency and duration of more extreme events can be observed.

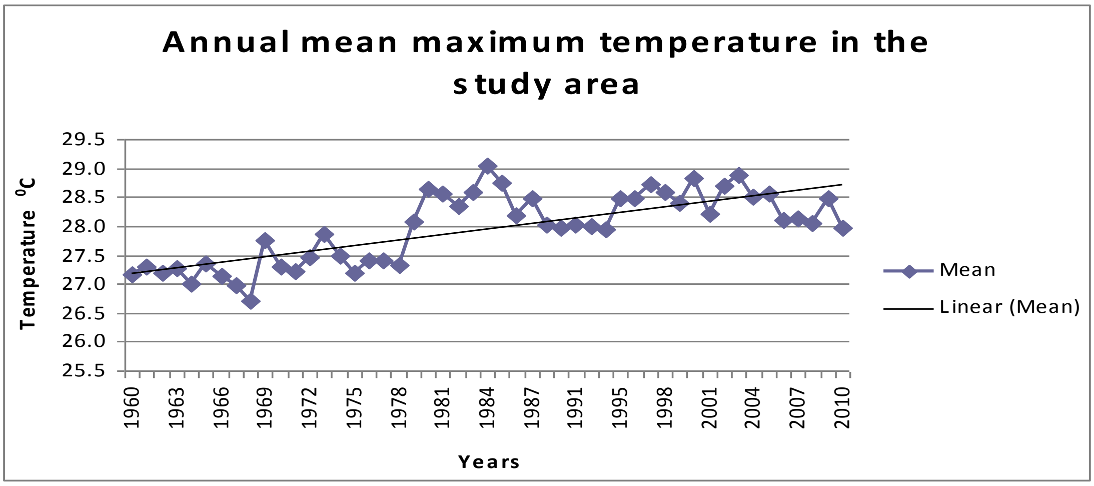


**Figure 4.6a: Time Series of Annual Mean Maximum Temperature at Mwanza Airport Station (ID 923209)**

Plants can be efficiently grown depending upon climate conditions of which temperature is one of the major factors (IPCC, 2007). Plants need adequate water to maintain their temperatures within an optimal range. Without water for cooling, plants will suffer from heat stress. For example, cereals and fruit tree yields can be damaged by a few days of temperatures higher than or under a certain threshold

(Wheeler *et al*., 2000). Changes in ambient temperature affect livestock because they create heat stress to livestock, affect feed intake as well as normal physiological process and cause induced behavioral and metabolic changes, thus affecting growth and reproductive processes, (Rotter and Van de Geijn, 1999). Freshwater species in both lotic as well as lentic systems will be showing to rising water temperatures, due to global temperature increase. Growth, reproduction and activity of freshwater fish are affected by rising temperatures. It means that individuals face changes regarding their metabolism, food consumption and reproductive successes. Fish populations exposed to rising water temperatures may experience range shifts, culminating in extinction.

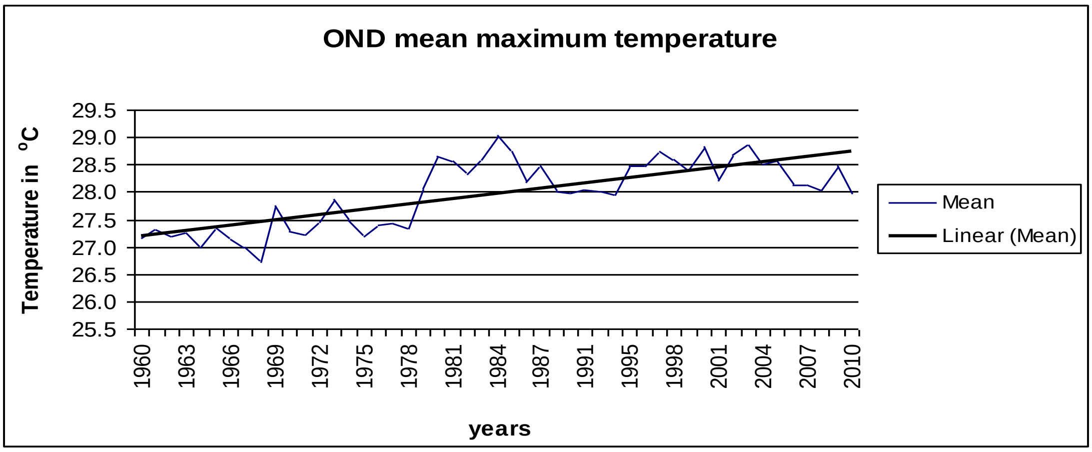


**Figure 4.6b: Time Series of OND Mean Maximum Temperature at Mwanza Air Port Station** (ID 923209)

Furthermore, (Fickler *et al.*, 2007) stated that going up water temperatures limit levels of dissolved oxygen. Depending on a high number of other local factors, rising water temperatures are likely to cause decreased dissolved oxygen in at least some systems, which can lead to an “oxygen squeeze” when decreased oxygen levels in the water cannot encounter increased oxyget demand of fishes.

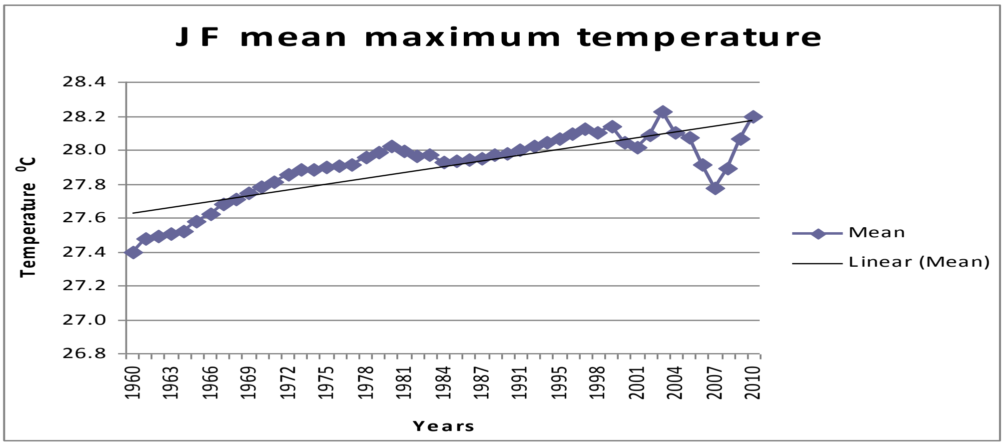


**Figure: 4.6c: Time series data from 1960 to 2010 for January and February seasonal rainfall amount at Mwanza Airport Station** (ID 923209)

Generally, changes in temperature patterns have contributed to changes in biological nature of fauna and flora living in the study area whereby natural habitats have been affected. The climate change may result in decrease or increase in population of a species in a region (Moss *et al.*, 2000; IPCC, 2007). As some species would not be able to adapt to habitat changes, shifting ecosystem boundaries would have clear impacts on biological diversity. Species with small populations or populations with small habitats will be particularly vulnerable to climate change (Reid and Swiderska, 2008). According to (IPCC, 2001) evaluation of climate change impacts on agricultural production, food supply and agriculture-based livelihoods must take into account characteristics of agro-ecosystem where particular climate-induced changes in biophysical processes are occurring. The measure facilitates to determine the extent to which such changes will be positive, negative or neutral in their effects *(ibid).* Change of mean temperature affected weather variations in precipitation, evaporation, transpiration, runoff and groundwater recharge as well as ground water flow. These variations have led to impacts on both surface and underground water systems which, in turn, impact on water requirements such as domestic water supply, irrigation, industrial use, navigation and water-based tourism (FAO, 2008). Furthermore, increased pest and vector outbreaks have led to reduction of crop and livestock productivity in the surveyed area. An amplified temperature favours diseases and vectors to intensify malaria along with cholera epidemics (McCarthy *et al*., 2001).

Vulnerability of small holder farmers is joined up with higher temperatures that have been straight changing crop yields (Challinor *et al.*, 2007; Gregory *et al*., 2009). Moreover, dropped water level in Lake Victoria in 2006 destroying fish spawning areas in the peripheral of the lake due to increased temperature associated with water shortfall and altering the natural habitants of fishes in turn affected the fish caught.

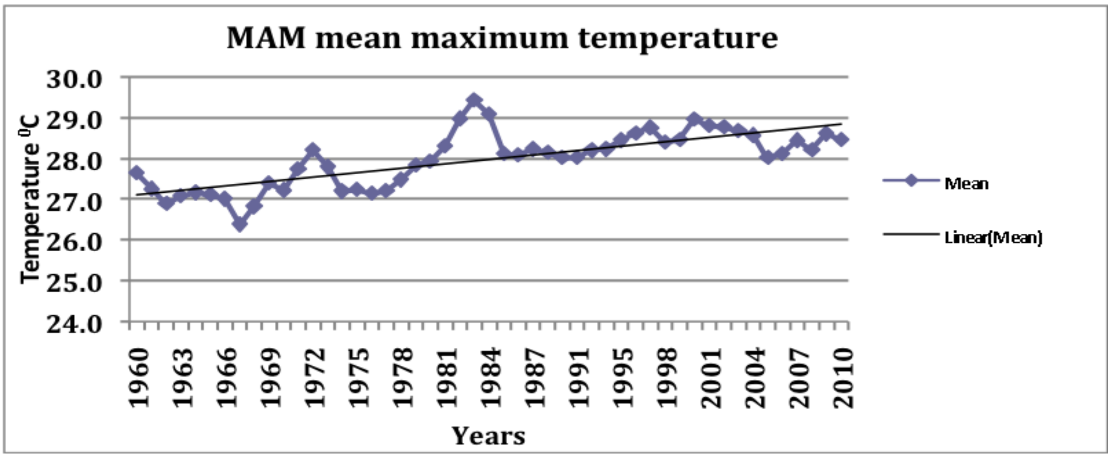


**Figure 4.6d: Time Series Data from 1960 to 2010 for March, April and May of Seasonal Rainfall Amount at Mwanza Airport Station** (ID 923209)

According to data obtained in for establishing climate historical timeline, farmers clearly reported noticed change in rainfall and temperature patterns since 2000 onwards where failure of short rains and unpredicted planting dates in long rains were vividly observed. Increased intensity and frequency of altered hydrological cycles including precipitation variation also have long-term implications on viability of current area agro-ecosystems. (FAO, 2008) argued that, for rural people who depend on natural resource base for their livelihoods, protecting food security in face of climate change will require improved management of the environment, especially during climate extremes, which brings the greatest risk of degradation of the environment and threats to sustainability of livelihood systems they depend on.

### 4.4 Impacts of Climate Change on Food Security

Impacts of climate change mainly caused by extreme weather events (drought and flooding) on fauna and flora in the study area are believed to encompass loss of biodiversity, land degradation as well as deforestation and eventually lead to food insecurity together with effects on food chain and natural habitats. During focus group discussions it was reported that climate change caused weak resource people to live without having enough food to meet their requirements especially in drought years. According to (Bhutta *et al*., 2008) exposed that households failed to meet their obligations such as contributing food to school feeding programme increasing undernourishment for pre-school children.

With regard to malnutrition among pre-school children, a strong consensus emerged that there is a crucial and narrow, “window of opportunity” for action: from conception through the first 18-24 months of a child’s life. Damage caused by malnutrition causes to a child’s physical and mental development during this time is likely to be considerable and irreversible as well as possibly fatal. Therefore, interventions should focus on this period (World Bank, 2006), while not neglecting other age groups, other family members, or low-income childless households who may well equally be in need of support. According to (Geissler and Powers, 2005), extended periods of inadequate nutrition reduce productivity of adults through reduction in the physical abilities to achieve work both by increasing number of days for sick leave and reducing the rate and the amount of work that be able to be accomplished.

### 4.4.1 Crop Productivity Trend Analysis in Past 10 Years

Due to fluctuations of temperature and rainfall for a long period of time, crops did not get appropriate soil moisture to enable crop to absorb nutrients from the soils. That affected crop growth, makes more susceptible to pests and diseases in turn affecting crop productivity. Reduced food availability in the area and caused food shortages. Safeguarding food security in features of climate change also implies avoiding disruptions or declines in global and local food supplies that could result from changes in temperature and precipitation regimes together with new patterns of pests and diseases. (FAO, 2008), reported that raised productivity from improved agricultural water management will be crucial in ensuring global food supply and global food security. More than in any other sector, improvements in agricultural performance have the capability to increase rural incomes and purchasing power for large numbers of people to elevate out of poverty (NEPAD, 2002; Wiggins, 2006).

In addition to strengthen the productivity and incomes of hungry as well as poor people, targeting the rural areas where the vast mass of them live and the agriculture sector on which their livelihoods depend are critical (IFAD, 2001; von Braun *et al*., 2005; Ahmed *et al*., 2007). (FAO, 2008) revealed that improving agricultural productivity through investing in agriculture and encouraging the growth of domestic agricultural production, improving infrastructure, distribution, preservation, processing and storage systems will improve the food security and wellbeing of the people.

#### 4.4.1.1 Maize Productivity

Increased agricultural productivity will be required in future to supply the needs of an increasing population. Agricultural productivity is dependent upon the climate and land resources (FAO, 2000). According to (FAO, 2005), stated that in developing countries, 11 percent of arable land may perhaps be affected by climate change, and cause a reduction of cereal production in 65 countries.

Based on findings from the study, majority of the respondents in all surveyed villages said maize productivity was decreasing. However, some of respondents alleged that maize productivity is increasing and few voted no change, are those new comers in the area or young ages who could not compare well the present and the past in the study area.

**Table 4.8: Maize Productivity Trend Analysis per Acre in Past 10 Years**

| Local perception on crop productivity | Percent of household responses by village | | | Average percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 9.7 | 7.4 | 27.3 | 13.8 |
| Decreases | 90.3 | 88.9 | 68.2 | 83.8 |
| Same | 0 | 3.7 | 4.5 | 2.5 |
| Not grown | 0 | 0 | 0 | 0 |

Results revealed that, all households surveyed grew maize in all agro-ecological zones (Table 4.8). Analysis indicated that declining trend of maize productivity is directly proportional to agro-ecological zone in the district. For example Ihale and Ng'haya villages representing lower and middle agro-ecological zones, majority of respondents said maize productivity is highly decreased; meanwhile Igombe village from the higher zone, greater part of respondents voted maize productivity is slightly decreasing.

The decline trend of maize productivity in different agro-ecological zone was a good indicator of the impact of climate change in the area as most of maize grown in the area depends on rain fed agriculture. The impacts of mean temperature increase will be experienced differently, depending on location (Leff, Ramamurthy and Foley, 2004). For example, moderate warming (increases of 1 to 3ºC in mean temperature) is anticipated to benefit crop and pasture yields in temperate regions, even as in tropical and seasonally dry regions, it is likely to have harmful impacts, mainly for cereals productivity in the tropics. Maize is staple food in Magu district, thus decreasing of maize productivity leads to great shock in district Supply and Utilization Account (SUA) in turn affected food balance sheet.

#### 4.3.1.2 Paddy Productivity

Paddy is a crop, which is used for food and cash in Magu district. When cotton production decreased significantly, paddy took the lead. Findings from the field were analysed and summarized in (Table 4.9).

**Table 4.9: Paddy Productivity Trend Analysis per Acre in Past 10 Years**

| Local perception on crop productivity | Percent of household responses by village | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 19.4 | 22.2 | 22.7 | 21.3 |
| Decreases | 19.4 | 49.1 | 59.1 | 40.0 |
| Same | 9.7 | 14.8 | 9.1 | 11.3 |
| Not grown | 51.1 | 14.8 | 9.1 | 27.5 |

Productivity trend analysis of paddy decreased from the lower agro-ecological zone to the upper zone while maize productivity trend is vice versa as in (Table 4.9) and (Table 4.10). Further analysis showed majority of respondents in Igombe village (upper agro-ecological zone) were engaged in paddy production while, half of respondents in lower zone are engaged in paddy production. This implies that areas receiving more rainfall are those farmers growing more paddies (water loving plant).

#### 4.4.1.3 Cassava Productivity

Analysis of cassava productivity indicated a slightly decreased as shown in (Table 4.10). However, cassava regarded as a crop that save people during famine in the study area can stay in the field for more than one year. But in other areas it can stay longer before being harvested and be used when the households are in food shortage. Also, cassava can be chopped into small chips dried and kept for future use. Moreover, can provide a significant yield in poor fertility soils and is more tolerant to drought than cereals. Cassava is a very essential crop to the rural households as it provides fuel wood, food and vegetable (*kisanvu*) which has crucial nutrients used mostly by resource weak households (Hillocks *et al.*, 2001).

**Table 4.10: Cassava Productivity Trend Analysis per Acre in Past 10 Years**

| Local perception on crop productivity | Percent of household responses by village | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 9.7 | 7.4 | 4.5 | 7.5 |
| Decreases | 54.8 | 51.8 | 27.3 | 42.3 |
| Same | 19.4 | 7.4 | 4.5 | 11.3 |
| Not grown | 16.1 | 33.3 | 63.6 | 35.0 |

**Source: Field data (2010)**

Besides, widely held of respondents from Ihale village representing the lower agro-ecological zone were engaged in cassava production and some of respondents from Igombe upper agro-ecological zone were engaged in cassava production. Moreover analysis indicates that majority of respondents from Ng'haya village in the middle agro-ecological zone were engaged in cassava production. It implies that an area experiencing unreliable rainfall is more engaged in cassava production than those having reliable rainfall. Slightly decrease in cassava productivity has negative impacts in household food security and people's livelihoods in the study area.

#### 4.4.1.4 Sorghum Productivity

Sorghum is a coarse grain, which can grow in areas with low rainfall and low soil fertility and it provides a significant yield in that areas compared to other cereals. Results revealed that most of the respondents from Ihale village in lower zone reported declined was experienced less of sorghum productivity in (Table 4.11). The productivity decline trend is less in villages or zones, which received average to above average rainfall such as Ng'haya and Igombe villages respectively.

**Table 4.11**: **Sorghum productivity trend analysis per acre in past 10 years**

| Local perception on crop productivity | Percent of household responses by village | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 35.5 | 7.4 | 4.5 | 3.8 |
| Decreases | 64.5 | 7.4 | 27.3 | 23.8 |
| Same | 0 | 7.4 | 9.1 | 5.0 |
| Not grown | 0 | 77.8 | 59.1 | 67.5 |

The study recognized that, sorghum is the cornerstone of those areas receiving erratic rainfall this was witnessed in Ihale village where all respondents engaged in sorghum production and some of respondents in Igombe village were engaged in sorghum production (Table 4.11). On other hand, results revealed that, in lower agro-ecological zone people had already changed the consumption pattern (depending more on sorghum rather than maize) due to prevailed conditions. According to (FAO, 2005) climate change requires risk management and adaptive management that focus on modifying behaviours over the medium to long-term to cope up with gradual changes in precipitation and temperature regimes. Such modifications are likely to concern consumption patterns, health care, food as well as agricultural production practices, sources including use of energy, and livelihood strategies (FAO, 2006).

Further analysis of the people perceptions in the study area revealed that there was a great need for improving quality and taste of existing sorghum varieties. For example, sorghum blending with other foodstuff is crucial to increase palatability of the commodity. Also sorghum recipes from food nutritionists should be in place to contribute further to use of the crop and strengthen resilience during extreme weather events DALDO, (2010).

#### 4.4.1.5 Cotton Productivity

Findings from the study disclosed that cotton is the major cash crop in the area, which majority of households depend on for their incomes. Most of surveyed households reported a significant decline in cotton productivity affecting household incomes normally used to settle their bills. The pattern affected people's livelihood in the area because cotton is the main source of incomes in the district. The findings vividly revealed in Ihale village representing lower agro-ecological zone that all interviewed households were engaged in cotton production but the area experienced poor rainfall (Table 4.12).

Cotton plant has a tap root system which helps it to withstand drought conditions thus it gives significant yields during moisture stress. Nevertheless, analysis revealed that cotton productivity indicated a declined trend due to climate change and other socio-economic factors including marketing problems such undefined marketing area, improper weighing scales used during farmers sale cotton to buyers, fluctuating price in marketing season and cooperatives bought cotton by credit to farmers.

**Table 4.12: Cotton Productivity trend analysis per acre in past 10 years**

| Local perception of crop productivity | Percent of household responses by village | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 6.5 | 3.7 | 4.5 | 5.0 |
| Decreases | 38.7 | 66.7 | 81.8 | 57.5 |
| Same | 41.9 | 11.1 | 0.0 | 5.5 |
| Not grown | 0.0 | 18.5 | 13.6 | 32.0 |

Additionally, a few of respondents were not engaged in cotton production. Analysis showed that during normal years, people sold a lot of food crops to get cash for various household needs and remain with little food stocks which could not sustain them in case of crop failure in next season. The pattern reduces livelihood diversity and lessens resilience capacity of the households to cope up with climate change in the area. It was disclosed that people in food secure areas have no tendency of growing cotton and other cash crops such as sesame and chickpeas to strengthening the livelihood diversity during the extreme weather events. Such behaviour would likely reduce efforts made by government and developmental partners to combat hunger and food security.

### 4.4.2 Livestock Productivity Trend Analysis in Past 10 Years

Effects of climate change on livestock productivity are divided into two scenarios direct and indirect. In a direct scenario, livestock are affected through changes in ambient temperature, which creates heat stress to livestock and affects feed intake as well as normal physiological process to livestock. Also it brings about induced behavioural and metabolic changes, affects growth and affects reproductive processes of animals. On the other hand, it influences quantity and quality of feed available, reduces water resources, which in turn reduces pasture availability, increases severity and distribution of livestock diseases and parasite, thus, reducing value of livestock products and livestock productivity.

Generally," livestock productivity means more than meat and milk. Farmers keep animals for direct consumption of food which involves milk, meat and eggs. Non-food products including skin, hides, wool, and hair but manure for fuel and urine for medicine (output function) are used.

**Figure 4.7: Livestock Transporting Maize from Field to Storage**
***Source:* FAO/Giulio Napolitano**

Some of these products provide inputs for other activities: manure, urine and grazing fallow are beneficial for crop production and productivity; stubble fields help pastoralists to feed their animals; animals give draught power for transport, and hoofs as well as manure help to disperse seeds and improve seed germination. In addition their grazing prevents bush fires and controls shrubs growth; stimulates grass tillering, and breaks up the hard soil crust (physical weathering). Livestock also helps farmers to raise money in time of need (Van der Ploeg, 2009).

Livestock productivity in the study area benefits the same to those kept livestock. Therefore, anything that affects or hinders livestock productivity especially those events associated with extreme weather makes households involved in livestock keeping to lose the said benefits.

#### 4.4.2.1 Cattle Productivity

Climate change was seen to be major threat to survival of many species, ecosystems and sustainability of livestock production systems in the study area. Findings indicated that cattle productivity is crucial for those owning livestock. Cattle are used as savings bank in the area when household harvest surplus, sell and then buy cattle or other livestock (World Bank, 2008).

**Table 4.13: Cattle Productivity trend analysis for in past 10 years**

| Local perception of crop productivity | Percent of household responses by village | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 19.4 | 37.0 | 13.6 | 17.5 |
| Decreases | 25.8 | 0 | 0 | 26.3 |
| Same | 0 | 3.7 | 0 | 1.3 |
| Not livestock | 54.8 | 59.3 | 86.4 | 65 |

Through field analysis, trend of cattle productivity in the study area revealed that more than half of the respondents in Ihale village (lower agro-ecological zone) were not engaged in cattle keeping and for those engaged in cattle keeping some of them reported a decline in cattle productivity (Table 4.13). The study established that a few people were engaged in cattle keeping and those not engaged were affected by decrease in cattle productivity. Most people living in the area use livestock products on a daily basis there was reduction in cattle products such as meat and milk. Normally, milk provides essential nutrients for adults and younger children as supplementary food after weaning. Factors that accelerated by decrease of availability of water and pastures are negative change in rainfall and temperature patterns as (Figure 4.7c and 4.8a), high population pressure in surveyed area, which forced alter of land use for cultivation, recreation and settlements. According to (Gregory, Ingram and Braklacich, 2005) "Dynamic interactions between and within the biogeophysical and human environments lead to the production, processing, preparation and consumption of food, resulting in food systems that underpin food security.

#### 4.4.2.2 Goats and Sheep Productivity

Goats and sheep are the most adaptable geographically and spread out livestock species (Van der ploeg, 2009). According to data collected, about half of respondents were engaged in goat and sheep farming in small holdings (Table 4.14). Many people keep goat for meat, skin and other benefits such as manure but ignore milk due to inadequate knowledge of its high nutritional and medicinal values. Through analysis, people argued that goats and sheep are essential small ruminants, which provide meat, skin, manure and milk for those keeping dairy goats. Furthermore, analysis made known that goats and sheep were used for rituals and dowry as additional social values.

**Table 4.14: Goats and Sheep Productivity Trend Analysis for in Past 10 Years**

| Local perception on crop productivity | Percent of household responses by village | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 25.8 | 3.7 | 27.3 | 11.2 |
| Decreases | 19.4 | 25.9 | 0 | 23.8 |
| Same | 6.5 | 14.8 | 18.2 | 12.5 |
| Not livestock | 48.4 | 55.6 | 54.5 | 52.5 |

Analysis revealed that, respondents argued that some farmers kept goats alone while others mixed cattle and sheep. Those who kept goats alone practised intensive farming where goats were fed indoors. This type of feeding increases goat productivity as shoats did not use much energy to search for water and pasture but is more difficult to manage when the pasture are scarce (Rangnekhar, 2006; Van der ploeg, 2009). Those engaged in mixed farming of goats, sheep and cattle normally, practiced extensive farming where goats, sheep and cattle were grazed together within the villages' boundaries.

The productivity trend of goats and sheep was reported to decline slightly in middle and lower zone but no decline trend was reported in the upper agro-ecological zones. That was associated to the area having enough pastures and shrubs because goats are browsers. Generally, productivity trend of such small ruminants was reported to be slightly below normal but in the near future, the situation may change to more worse due to high population pressure and the impacts of climate change, which force people to change landuse. Hence, it would result in reducing the grazing area.

#### 4.4.2.3 Poultry Productivity

Poultry production and productivity are essential for household food security in the area where majority of respondents, especially resource weak households reported to keep poultry. Analysis of responses of poultry productivity indicated that poultry were mostly kept by using an extensive rearing system where they roamed around households and got back in the evening into the poultry barn. Others households kept poultry indoors.

During focus group discussion, farmers complained about high temperature occurred during the day and night caused heat stress that affected poultry growth and egg production. Also, complained about high infestation of poultry diseases such as Newcastle, typhoid and coccidiossis during wet weather. The varying temperature, high humidity, and excessive heat due to climate change have negative effects on poultry production in terms of eggs, body weight, health, diseases, and income of farmers, people's diet and quality as well as the quantity of poultry products (Charles *et. al.*, 1980).

Climate change cause heat stress, which reduces ability of poultry to feed properly it leads to loss of body weight, high body temperature in this way reducing the rate of growth of poultry (Arjona *et al.*, 1988).

Management costs are expected to increase as a consequence of the need to cool buildings during high temperatures and diminish house humidity (Awoniyi, 2003). Building infrastructure and maintenance will have to cope with more intense weather events and increased rainfall. This means that construction plans need to consider more sustainable options, with better investment in drainage systems to accommodate more extreme and recurrent floods and frequent rainfall (Demeke, 2004; Gueye, 1988).

Through adaptation, poultry farmers should reconsider to have new building designs, which fit to changed climate including the installation of more/new equipment to cope with new climate extremes. Data collected from village's poultry productivity showed a low trend as summarised in (Table 4.15).

**Table 4.15: Poultry productivity trend analysis for in past 10 years**

| Local perception of Poultry productivity | Percent of household responses by village | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Increases | 35.5 | 37.0 | 9.1 | 27.7 |
| Decreases | 22.6 | 22.2 | 43.5 | 29.8 |
| Same | 22.6 | 22.2 | 21.7 | 22.5 |
| Not Poultry | 19.4 | 18.5 | 21.7 | 20.0 |

Further analysis, revealed that poultry are more affected by climate change because most of poultry diseases such as coccidiosis and typhoid are associated or favoured with extreme wet weather conditions. Moreover, an extensive free range system of production has poor bio-security and there is mingling with wild birds, domestic birds as well as human beings that could increase spread of poultry disease as well as reduce the poultry productivity.

### 4.5 Indicators of Climate Change

Through field findings it noted that there were some factors that vividly indicated climate change in their area they included change in temperate and rainfall patterns, occurrences of new crop and livestock pests as well as human disease vectors, changing of natural vegetation, and changing of permanent rivers to seasonal rivers. According to (Fischlin *et al*., 2007), resilience of many ecosystems is expected to be exceeded this century by an extraordinary combination of climate change, associated disturbances (e.g, flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (such as landuse change, pollution, and overexploitation of resources).

### 4.5.1 Change in Rainfall Patterns

Analysis of discussions at the village level revealed that there was a growing feeling and perception that climate change and variability were already occurring. At the village level concept “climate change” was associated with variability in weather conditions, associated with rainfall inconsistency and unpredictability for many over years rather than actual change. Variability was related to variations in agricultural seasons in a year. Major concerns were related to indicators like reduced amounts of rainfall, rainfall receiving late, increased temperatures, and increased incidences of drought and decreases crop as well as livestock productivity. Also was observed that the El-Nino Southern Oscillation (ENSO) episodes in East Africa have become irregular and were of shorter durations. Magu district is not shielded from global environmental change. Both climatic and global environmental changes have resulted in declining agricultural productivity, deterioration of water quality and quantity including loss of biodiversity. These have serious implications on livelihoods and the environment (Hulme, 1996).

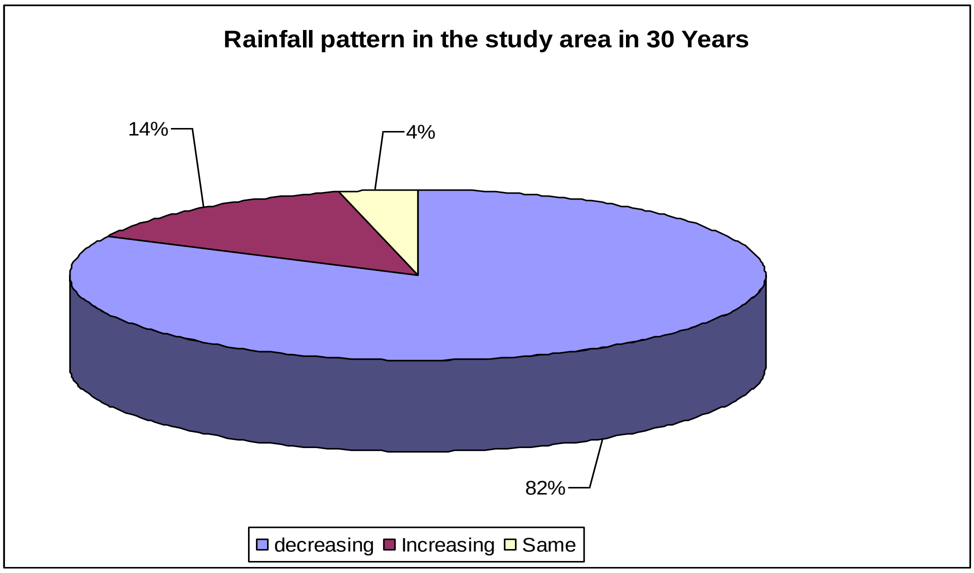


**Figure 4.8: Rainfall Pattern in Magu District in the Past 30 Years**

Findings revealed that about majority of respondents perceived that rainfall pattern in the last 30 years was decreasing, some exposed that rainfall was increasing, while few did not notice any difference from normal pattern or were the same (Figure 4.10). Those who stated that rainfall was increasing or is the same are from highlands zone and those who had a little experiences in the area were new comers and young age with short duration of stay in the villages.

Generally, decrease in rainfall pattern and increased temperature in the study area resulted in a decrease in crop production and productivity. According to (Carpenter *et al.*, 1992) availability of water influences mainly biome types and potential agricultural productivity. Similarly, humans depend directly on freshwater for drinking, irrigation, industry, transportation, recreation and fisheries.

Furthermore, it was reported that there was change in rainfall onset compared with the past 30 years. Rainfall onset in the mid1980s and1990s normally were started in late September to early October where farmers planted maize and beans in October they harvested first beans in December and then maize in January and planted again for long-rains in February and harvested in May. Currently, rainfall starts mid-November and they plant in late-November for beans and maize. They harvest beans in February and maize in March. Such changed completely the possibility of planting and harvesting crops twice in a year. On the other hand, farmers complained about the crop failure at different levels caused by drought when visited Ihale, Ng'haya and Igombe villages. Ihale village which is representing the lower agro-ecological zone reported more crop failure than other villages in other zones.

Late onset and early stop of rainfall are a common phenomenon expressed by respondents. In addition, distribution of rainfall was another issue it was reported to reduce production and productivity of crops for more than 50 percent of expected production. Late rainy seasons usually bring reduced amounts of rainfall and have been linked with agricultural failure specifically in rain-fed farming systems leading in Tanzania (UTR, 2003). Furthermore, long period of time observations indicate that some rainy seasons were becoming more erratic while others are declining (Mwandosya *et al.*, 1998).

The pattern so as forced them to cultivate in wetlands to rescue their families from expected famine, which also caused loss of biodiversity, deforestation and soil degradation on river banks. According to (Scherr, 1999) degraded soils reduce agricultural productivity and ultimately become unable to produce crops. All human societies and activities are sensitive to climate change, in one way or another (IPCC, 2001). This is because, in large areas, where people live and the manner they generate their livelihoods are influenced by the climate system. For example, during the past two decades, most flood-plains in semi-arid northern Nigeria have come under severe pressure of their livelihoods. Rainfall has been declining inside the area (Anyadike 1993; Hess *et al.,* 1995) it has led to an increase in vulnerability of rain-fed agriculture, in addition has made numerous farmers change farm activities toward flood-plain (*fadama*) agriculture (Adams, 1986; Dabi and Anderson, 1998).

As well, effects of rainfall patterns in the area normally affect differently field crops such, maize and vegetable, which suffer from water stress in one or two weeks after stopping of rainfall, whereas sorghum and cassava can tolerate the moisture stress for more than two months or more months. The degree of tolerance differs from one crop to another as farmers who previously grew maize and vegetables they opted for sorghum and cassava, which are drought tolerant crops.

Evidence of climate change showing contrasting features of maize versus sorghum were witnessed by respondents in all surveyed areas. At the same time, pasture improvement was observed alongside general recovery of livestock from drought experienced in the earlier part of the 2005/06 crop season as a positive effect of climate change.

Further, key informants argued that an increase in rainfall was evidence of climate variability/change. Both noticed changes were noted since 1978. The El Nino event in 1997/98, outbreaks of new crop pests like army worms (*mbilizi)* in 1988, and recurrent droughts like those of 1971/72 as well as 2005/06 were further evidences of climate change observed by farmers in the villages. Grasshoppers' (*shenene)* have been normal insects to the area but during El Nino, they changed to become a serious pest in paddy, maize and sorghum.

### 4.5.2 Change in Temperature Patterns

Temperature patterns in the past 30 years were reported to have increased compared with past periods as reported by most of the respondents. This is supported by time series data in (Figures 4.8a – d). Other people's perceptions and opinions are summarized in (Figure 4.11).

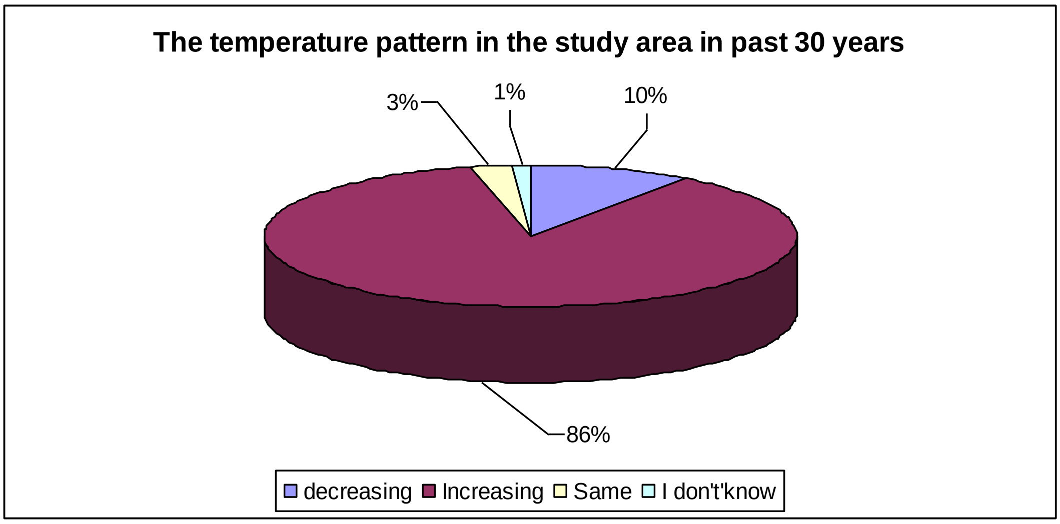


**Figure 4.9: Temperature Pattern in Magu District in the Past 30 Years**

Findings regarding temperature change patterns revealed by households' heads key informants and analysis of mean maximum temperature are indicated in (Figures 4.8a – d). Such changes affected crop production and productivity including livestock in the area. Larger changes in climate are capable of increase recovery costs exponentially (Hahn and Morgan, 1999; cited in IPCC, 2001). Also it was observed that the high temperature increases and wind speeds that accelerated the rate of evaporation which dried out field crops quickly. However, increased temperature with high humidity stimulates growth of plants and causes diseases such as head smut in maize and insects altering interactions between pests plus their natural enemies plus their hosts (IPCC, 2007).

Historical success in coping up with climate variability suggests that some livestock systems could adapt to climate change successfully. Benefits that may be realized during cooler seasons might be less than (negative) hot weather impacts (Hahn *et al.*, 1992). However, adaptation may well involve dislocation costs for certain producers for instance migrate to other areas or building new structure which could endure prevailing conditions.

### 4.5.3 Occurrences of Crop and Livestock Pests

According to results from the visited villages' changes in rainfall and temperature patterns together with high humidity caused new patterns of pests and diseases to emerge, affecting crops and livestock's. For example, farmers in the surveyed areas indicated an increased occurrence of armyworms (*mbilizi*), especially during the wet weather that invaded field crop such as maize, millet, paddy and sorghum. The up to date speed of change also threatens social and economic systems, together with agriculture, food and water supply, coastal infrastructure, climate dependent livelihood systems, and vulnerability to pests and diseases (UNFCCC, 2006).

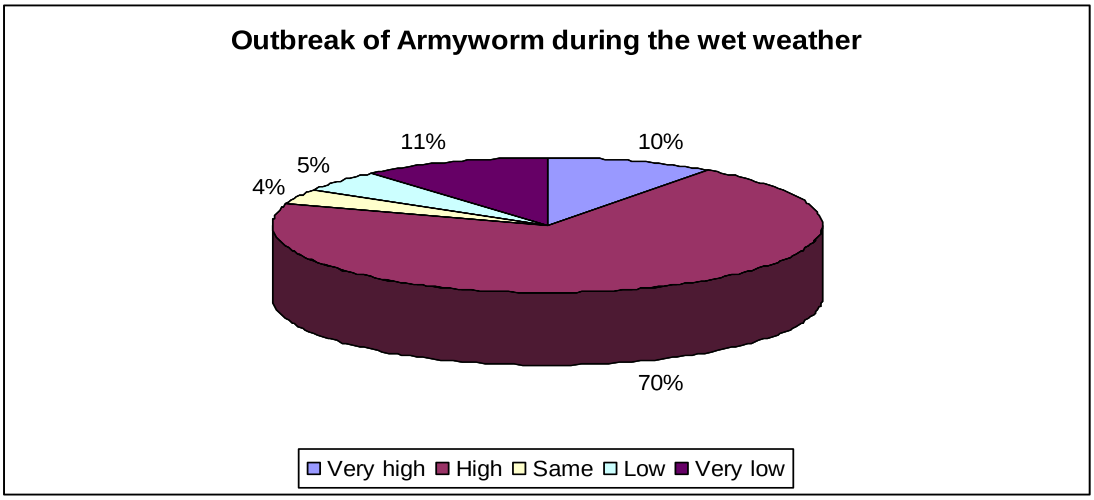


**Figure 4.10: Occurrences of Armyworm in Magu District in the Past 30 Years**

On the other hand, high temperatures in wet seasons caused eruption of diseases in livestock's (like rift valley fever) crops such as mildews), and crop pests such as grasshoppers in (Appendix 5) Crop pests like armyworms indicated in (Figure 4.12) and other examples are grain borers, Stalk borer and *quelea quelea* birds affect crop production and hence, impacted on food availability in the surveyed area. Other emerging crop pests and diseases mentioned by respondents included a range of vermin's, birds, insects including fungal, bacterial and viral diseases such as rodents, quela quelea, grasshoppers (*shenene*), American bollworm, Aphids (*zezemya*), grain borer (*chibungi*), maize streak (*nyakwela),* maize stalk borer (magino) cassava mosaic, grain moth (*balababu*), and rust particularly in green grams

Results from the study indicated virtual certainty for pests and diseases that flourish only at specific temperatures and under specific humidity. Most identified livestock disease by local farmers engaged in livestock keeping included East coast fever (*madundo),* anaplasmosis (*ngundi kukembe*), foot and mouth disease (*bukekele)* and black quarter (*lyoho*). They expose livestock to new risks to which they have not yet adapted (FAO, 2008). Majority of respondents voted increases of pests in recent years when they compared with the past years. The study established that the occurrences of pests and diseases were favored by extreme wet weather conditions which supported the reproduction and growth cycle of pests.

### 4.5.4 Occurrence of Vectors

Changes in vectors for climate-responsive pests and diseases, as in an emergence of new diseases, affected both the food chain and people's physiological capacity to obtain necessary nutrients from the foods they consumed (IPCC, 2007). According to (WHO, 2005) occurrences of pests and vectors will rendering crops, livestock, fish and humans to new risks of morbidity and intensify the rate of mortality. Where such vectors changes can be predicted, varieties and breeds that are resistant to the likely new arrivals can be introduced as an adaptive measure.

Further analysis in (Figure: 4.13) indicates that majority of respondents reported the incidence of mosquitoes were high and very high, especially in wet weather. According to (McMichael, 2004), climate change during 1970-2000 is estimated to have caused at least 160,000 deaths and 5 million disability-adjusted life years from only four factors: malaria, diarrhea, malnutrition and flooding. (Van Lieshout *et al*., 2004; Yanda *et al.*, 2005) reported that malaria has by now increased in highlands of Rwanda and Tanzania linked with recent changes in temperature.

Where such vectors changes can be predicted, varieties and breeds that are resistant to the likely new arrivals can be introduced as an adaptive measure. Also, greater part of respondents noted outbreak of house flies in their area as indicated in (Appendix 6). Those who reported very low, low and not applicable were not familiar with the real situation happening in the area. Additionally, the poor are more disadvantaged by their inability to access medical treatment and lack of health care facilities during such epidemics which affected the food utilizations.

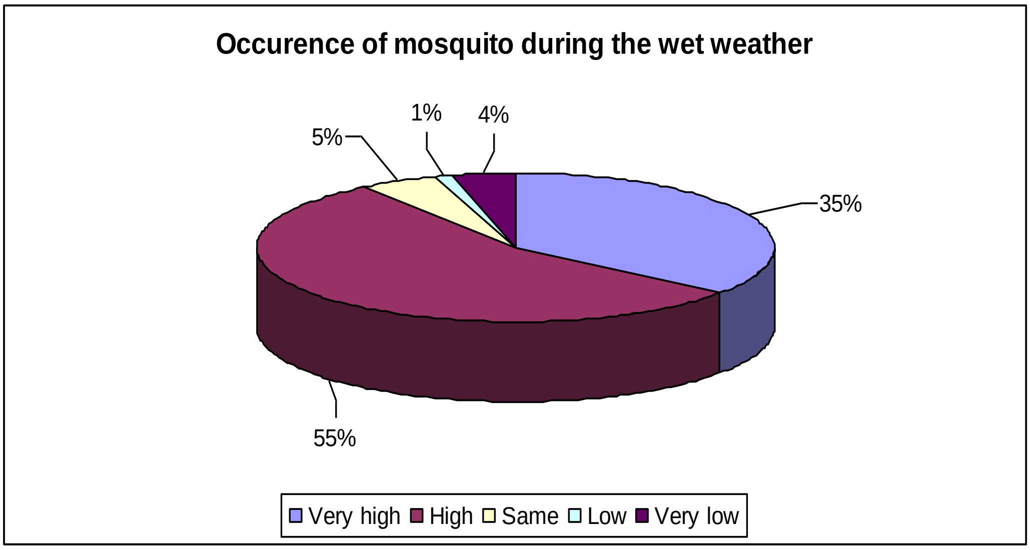


**Figure 4.11: Occurrences of Mosquitoes in Magu District for the Past 30 Years**

Proliferations of that vectors, caused high infestation of malaria mainly for those could not use mosquito nets due to high level of poverty. Poverty therefore seems to play a very big role in the vulnerability of communities to climate change and variations in the social system. Due to poverty and insufficient or lack of, early warning mechanisms, the communities not have effective strategies for coping up with climate-induced shocks such as diseases and weather extremes (WHO, 2005).

Food shortage of resulting from frequent droughts and floods contributed to malnutrition; particularly in poor households. It led to in poor health that makes individuals to succumb easily to diseases such as malaria and diarrhea. Associations between monthly temperature and diarrhea episodes as well as between extreme rainfall events and monthly reports of outbreaks of water-borne disease have been reported worldwide.

For example, higher temperatures have been connected with increased episodes of diarrhea disease in adults and children in Peru, where diarrhea reports increased 8 percent for every degree of temperature increase (Checkley, *et al.*, 2000). Diarrhea owing to food-borne diseases such as *Salmonellosis* have been establish to increase by 12 percent for each degree increase in weekly or monthly temperature above 6ºC ambient temperature (Kovats, *et al.*, 2004). Increased ocean temperatures are leading to augmented densities of *Vibrio spp.* (diarrheal agent) in shellfish (Zimmerman, *et al.*, 2007). However drier weather may decrease the transmission of malaria in some places in Sub-Saharan Africa, while in others, the geographical range will increase and the transmission season might be changed (Metz *et al.*, 2007).

Further, people argued that there was an increase in use of bed nets; but many households were unable to afford sufficient mosquito nets for all household members due to large household sizes and low incomes. At the same time, lack of access to potable water and good sanitation facilities made such communities to be highly vulnerable to cholera epidemics that in turn affected household's food security. Such poor families cannot afford preventive and curative measures have high malaria and diarrhea morbidity as well as mortality rates.

#### 4.5.5.1 Outbreak of Plant and Livestock Pests Including Human Disease

Interferences of pests in dry weather, indicating that most pests' occurred as normal insects/fungal/**vectors associated with climate change during the dry season.** Findings revealed that occurrences of pests and vectors in their areas were not associated with climate change in extreme dry weather conditions. Most respondents showed low response rate in outbreak or occurrence of virus which are important in the food chain, but their effects were not above the economic threshold as indicated in (Table 4.16).

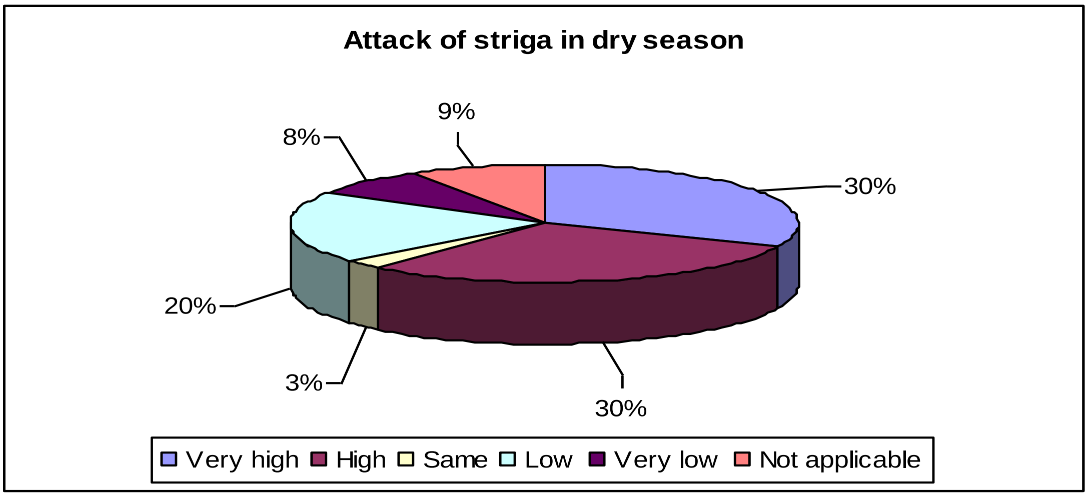


**Figure 4.12a: Attacks of Striga in Dry Season**

Over half of respondents reported striga plant as a pest, which is more serious during dry weather as in (Figure 4.14a) and also greater part of respondents mentioned that aphids were more serious during drought time (Figure 4.14b).

Literature on pests recognizes people's perception that striga and aphids are parasitic organisms which depend on other plants for their survival. Normally, striga plants feeds mucus on roots and stems of coarse cereals such as sorghum and maize for their survival.

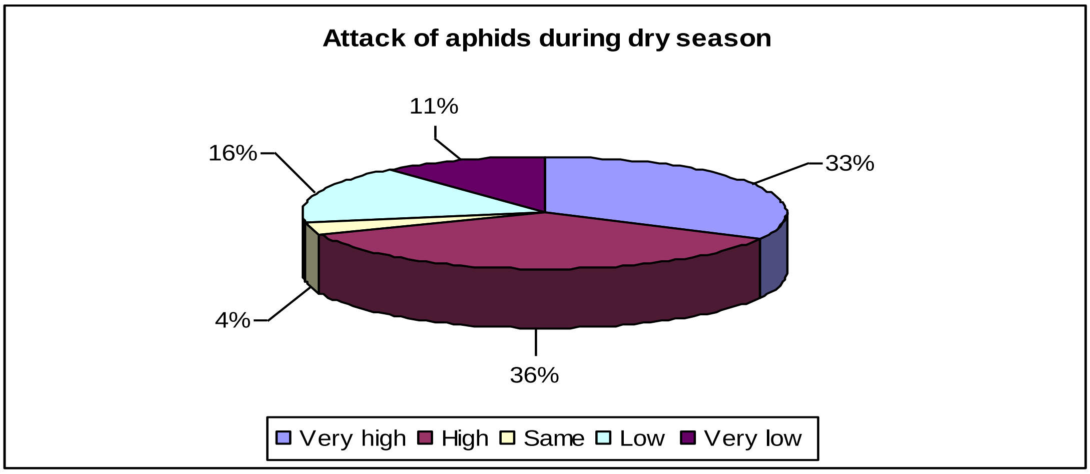


**Figure 4.12b: Attacks of Aphids in Dry Season**

It was more serious during dry periods when sorghum/maize plants are suffered from moisture stress. Such type of feeding behavior affects the host plant as the parasite takes nutrients from host plant causing failure to perform metabolic and reproduction processes.

Therefore, caused host plant to deteriorate while the parasitic plant flourishes. When farmers compared severity of the attack and flourishing of striga on cereal crops in the fields and other areas with no striga, they concluded that striga is more serious in extreme dry weather than in normal or during wet weather.

**Table 4.16: Responses on Outbreak of Plant and Livestock Pests and Human Disease Vectors Associated with Climate Change During the Dry Season**

| Pests during extremely drought seasons | Village | | | Total in Percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Armyworm | 13.2 | 19.7 | 4.5 | 15.0 |
| Quela quelea | 9.7 | 11.1 | 9.5 | 12.0 |
| Rodents | 3.2 | 22.2 | 36.4 | 23.8 |
| American bollworms | 29.0 | 22.2 | 31.8 | 42.5 |
| Cassava mosaic | 42.9 | 21.3 | 59.1 | 35.6 |
| Striga | 67.0 | 51.9 | 61.4 | 65.0 |
| Grasshoppers | 6.5 | 11.1 | 13.6 | 11.3 |
| Aphids | 64.5 | 33.3 | 54.5 | 53.8 |
| East coast fever | 25.8 | 22.2 | 13.6 | 30.0 |
| Foot and mouth disease | 12.9 | 14.8 | 4.5 | 15.0 |
| Anaplasmosis | 12.9 | 14.8 | 13.6 | 17.5 |
| Black quarter | 19.4 | 25.9 | 13.6 | 22.5 |
| Heart water | 13.2 | 20.6 | 12.1 | 18.8 |
| Mosquitoes | 3.2 | 14.8 | 4.5 | 11.5 |
| Houseflies | 6.5 | 11.1 | 0.0 | 10.0 |

On the other hand, aphids also survive on parasitic feeding behavior as striga where the pests normally suck in tender growing parts of cotton, okra, and tomatoes. It breaks the cell sap of plants and feed on fluids in plants eventually and it kills growing parts of the plant. Furthermore, when plants are in moisture stress aphids become more serious than in rainy periods. When people observe the attack of aphids on cotton, okra and tomatoes farmers concluded that aphids attacked favorably during extreme dry weather.

Thus, drought or extreme dry weather condition does not favor any type of pests or vectors but its effects are greatly seen during the drought weather. Study established that no any plant pest or vector is favored with extreme dry weather condition but its effects or attacks are more observed during droughts.

#### 4.5.5.2 Outbreak of Plant and Livestock Pests and Human Disease Vectors During Extreme Wet Weather

Results from the study revealed that, occurrences of pests and vectors are associated with occurrences of extreme wet weather with high temperatures. Wet weather conditions favors metabolic and reproduction processes of pests which enable pests to reproduce or proliferate at higher rate than normal.

For example during extreme wet conditions, female mosquitoes hatch eggs in stagnant water or in grasses where water moisture favors growth cycle of pest and eventually mosquitoes reproduced at high rate in the area. According to (IPCC, 2007) reported that some of the most dramatic effects of climate change on animal pests and diseases are likely to be seen among arthropod insects like mosquitoes, midges, ticks and fleas sand flies mostly during wet weather. Diseases include foot-and-mouth, bovine spongiform encephalopathy, classical swine fever and, most recently, birds flu, estimated to have caused economic losses.

**Table 4. 17: Responses on Outbreak of Plant And Livestock Pests and Human Disease Vectors During the Wet Weather**

| Pests during extremely wet seasons | Village | | | Total in Percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Armyworm | 90.3 | 85.2 | 86.4 | 87.9 |
| Quela quelea | 58.1 | 81.5 | 95.5 | 76.3 |
| Rodents | 87.1 | 81.5 | 72.7 | 78.8 |
| American bollworms | 74.2 | 74.1 | 68.2 | 65.0 |
| Cassava mosaic | 62.1 | 60.8 | 67.2 | 64.5 |
| Striga | 25.8 | 51.9 | 27.3 | 40.0 |
| Grasshoppers | 91.1 | 77.8 | 63.6 | 89.5 |
| Aphids | 35.5 | 85.2 | 63.6 | 60.0 |
| East coast fever | 61.3 | 96.7 | 77.3 | 80.4 |
| Foot and mouth disease | 71.0 | 70.4 | 77.3 | 70.0 |
| Anaplasmosis | 61.3 | 59.3 | 81.3 | 78.8 |
| Black quarter | 45.2 | 48.1 | 59.1 | 68.0 |
| Heart water | 61.3 | 59.3 | 90.9 | 78.8 |
| Mosquitoes | 83.9 | 92.6 | 90.9 | 88.8 |
| Houseflies | 90.3 | 88.9.7 | 90.9 | 90.0 |

Other emerging pests in the study area during wet weather included rodents, worms, armyworms, quela quelea, aphids, cassava mosaic virus, larger grain borers, leaf hoppers and stalk borers.

Greater part of respondents voted occurrence of houseflies and mosquitoes in wet weather. Also most respondents mentioned that East coast fever affected cattle especially calves mostly in extreme wet weather. Other reported pests include black quarter, anaplasmosis, heart water, and foot and mouth disease (Table 4.17).

## 4.6 Impact of Climate Change/Variation on Food Security in Magu District

Findings obtained from all respondents in three surveyed communities reported rainfall variations since 1980s where short-rains normally started from late September to early October but currently, the season starts from late October to mid November. Thus, they can no longer rely on timely onset of bimodal rainy season and hence, leading to unimodal season. Also there was an increase in sporadic high rainfall intensity, which destroyed crops in some areas, especially in lowland thereby affecting food security in that area.

### 4.6.1 Household Food Security

As mentioned earlier before, household is a basic unit of production and consumption of food. Hence, it was regarded as basic unit of food security in this study. The analysis food shortage in the area compared this with the past 10 years revealed that majority of respondents did not experience food shortage during the normal years. Also when they compared duration of food stock lasts before the next harvests in normal, drought, and wet or flooding years differences (Table 4.18 to 4.20).

**Table 4.18: Responses on Duration of Food Stocks Lasts in Normal Years in Magu Villages**

| Duration of food stocks lasts in normal years | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | Between 1 and 2 month | 15 | 18.5 | 18.8 | 18.8 |
| | Not applicable | 65 | 80.2 | 81.2 | 100.0 |
| | **Total** | **80** | **98.8** | **100.0** | |

However, some of respondents reported to have experienced food shortages in normal years it was an indication that rural communities were not homogenous. In household food economy analysis, it was revealed that village regarded as food secure; there are households which were food insecure throughout the year. Further analyses revealed that some of households experienced food shortages in normal, drought and flood years as indicated (Table: 4.18 to 4.20).

**Table 4.19: Responses on Duration Food Stocks Lasts During Drought Years in Magu Villages**

| Duration of food stocks lasts in drought year before next harvests | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | Between 1 and 2 month | 11.0 | 13.6 | 13.8 | 13.8 |
| | Between 3 and 4 month | 44.0 | 54.3 | 55.0 | 68.8 |
| | Between 5 and 6 month | 9.0 | 11.1 | 11.3 | 80.0 |
| | Not applicable | 16.0 | 19.8 | 20.0 | 100.0 |
| | **Total** | **80.0** | **100** | **100.0** | |

Furthermore, analysis revealed that during drought years greater part of households is experienced food shortfall for 3 to 4 months. That is a time where most households suffer from food insecurity especially for resource weak households and is a time when food aid or social safety net took the lead to rescue life and livelihood security (Table 4.19).

**Table 4.20: Responses on Duration Food Stocks last During Floods Years in Magu Villages**

| Length of time food stocks last during wet weather year before next harvests | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| | Between 1 and 2 month | 13.0 | 16.0 | 16.3 | 16.3 |
| | Between 3 and 4 month | 1.0 | 1.2 | 1.3 | 17.5 |
| | Not applicable | 66.0 | 81.5 | 82.5 | 100.0 |
| | **Total** | **80.0** | **98.8** | **100.0** | |

Findings from field showed that during the extreme wet weather conditions, normally affected people living in lowlands where the settlements and farms are affected by flooding waters. Emerged crop and livestock pests including human disease vectors such as rodents, armyworms, aphids, larger-grain borer, grass hoppers, cassava mosaic and quela quelea which attacks crops. Livestock pests involved East-coat fever, anaplasmosis, and back quarters as well as human diseases vectors were mosquitoes, houseflies, and tsetse flies. These pests affected growth and reproduction as well as affected production and productivity of crops and livestock. Also human diseases vectors caused killer diseases such malaria and cholera.

### 4.6.2 Analysis of Food Security in each Agro-Ecological Zone

Analysis of three agro-ecological zones in Magu district provided details of households and communities living in micro-climate with different elevations, soil types, and rainfall and temperatures patterns in a year. The measures permitted to know how people were impacted by climate variability/change and how they adapted in different agro-ecological zones.

#### 4.6.2a Lower Agro-ecological Zone

Ihale village situated at lower agro-ecological zone along the Lake Victoria. The village is highly populated due to influx of people from other areas in and out the district mainly engaged in agriculture, livestock keeping and fishing. Men were carrying out fishing and fisheries, while women were busy in fish processing and fish sale. Also they were making local brew and operated bars. The area is highly vulnerable to flooding and high temperatures compared to other villages in the middle and upper agro-ecological zones of the district. Also it was vulnerable to fall of water level of Lake Victoria during dry seasons. The soil is poor in the highland areas within villages but in lower land or valleys, land is very fertile due alluvial soils deposited during flooding. Hence, such land is suitable for paddy, sweet potatoes and vegetable production. In lower agro-ecological zone the soil is poor for maize due poor water holding capacity because most of soils are sandy. But in actual situation most farmers grow maize as their staple food.

Through the analysis, it was revealed that some farmers grew sorghum instead of maize due to prevailing conditions. In a normal year main staples in the area are maize, rice, sweet potatoes, cassava and sorghum (for a few). During the normal year, most of population were food secure and a few be food insecure as in (Figure 4.15a). However, most households experienced food deficit for 1 to 2 months. In drought years, which have become common phenomenon, majority of population were food insecure. Out of that population greater part experienced the shortfall of 3 to 4 months, while a few faced food shortage for 5 to 6 months. Some were normally food secure (Figure 4.15b). During flooding, most people are food secure and a small number were foods insecure for 1 to 2 months as in (Figure 4.15c).

The study established that people in lower agro-ecological zone were vulnerable to food shortage during the drought season, but they engaged in appropriate copping strategies such fishing and planting vegetables around Simiyu and Lamadi rivers. However, the practice is very dangerous to accelerate the loss of biodiversity because they use agro-chemicals in vegetable production that harm the spawning areas for fish. Also, they allow livestock to drink water around rivers, which endanger water sources and eventually they contaminate available water for domestic uses and for irrigation. Some livestock keepers in the upper lands shifted their cattle during dry season and invade lowlands as well as wetlands search for water and pastures for their livestock. According to (Dabi and Anderson, 1998), declining rainfall has led to water scarcity in semi-arid areas nomadic herdsmen graze their herds in lowlands and add pressure as well as competition for flood-plain resources. Also prolonged inundation is a major problem in study area due to nature of the terrain (flood-plain). Food insecurity and loss of livelihoods would be further exacerbated by loss of cultivated land as well as spawning areas for fisheries through inundation and coastal erosion in low lying areas (FAO, 2003). Low-lying plains around Simiyu and Lamadi rivers are frequently inundated with floodwaters and consequently, they are affected by outbreaks of water-borne diseases. During floods of 1961, the 1997 El Niño rains and the OND rains of 2006, the area was inundated for several weeks which significantly affected crops, pastures, infrastructure, and residences. They forced people to migrate to other area. Furthermore, people were unable to cultivate in water logging soils. Thus, production dropped for some crops like maize, cassava, green vegetables, water melons and tomatoes. They are experienced social safety net interventions at least after one to two cropping seasons especially during drought years.

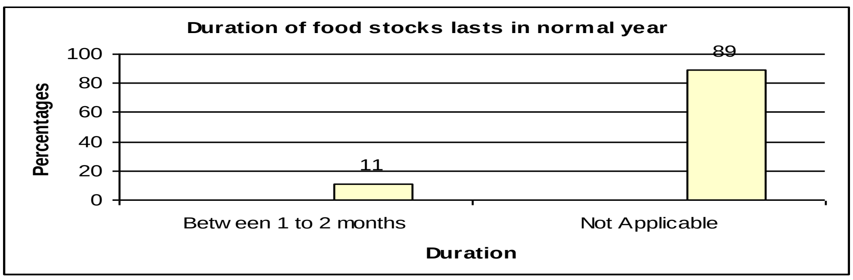


**Figure 4.13a: Duration of Food Stock lasts in Normal Years in Ihale Village**

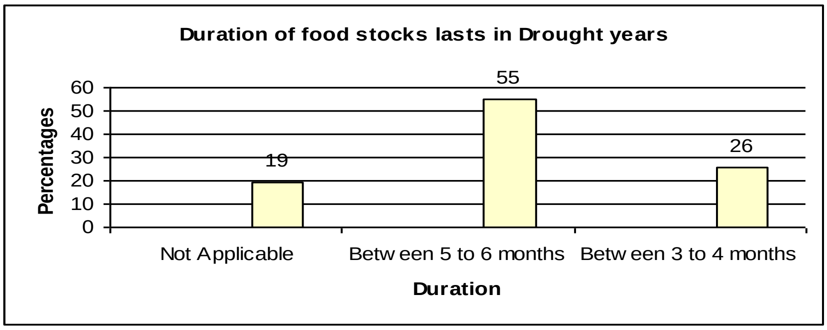


**Figure 4.13b: Duration of Food Stock Lasts in Drought Year in Ihale Village**

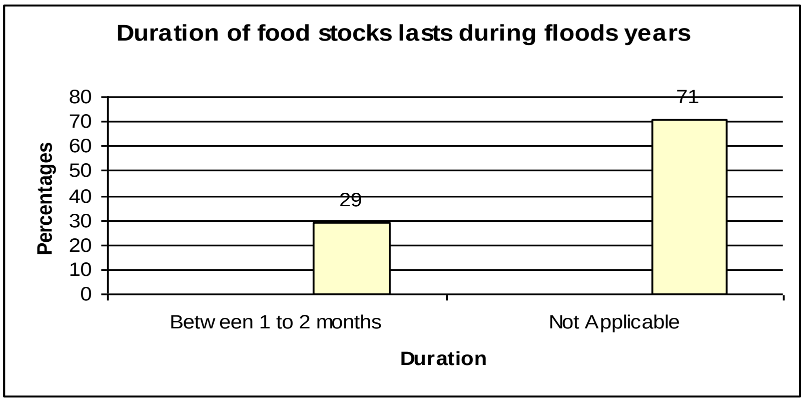


**Figure 4.13c: Duration of Food Stock Lasts During Floods Year in Ihale Village**

### 4.6.2.b Middle Agro-ecological Zone

Ng'haya village, situated at the middle part of the district, was selected to represent the middle agro-ecological zone in Magu district. Main staple foods in the area are same as in lower part of district. But the zone has a few areas to grow paddy and vegetables except in areas along Simiyu and Lamadi rivers, which cross the middle zone. Most farmers grow maize, cassava, sweet potatoes, cotton and little farmer plant sorghum as the climate starts to change compared to early 1980s. Maize production is still fair compared to lower zone where production of the crop is significantly below normal. Soil fertility is medium where crops such as cassava and sweet potatoes do well. They reported that occasionally people got food aid interventions from Government and developmental partners. The period of food shortfall are summarized in (Figure 4.16a to c).

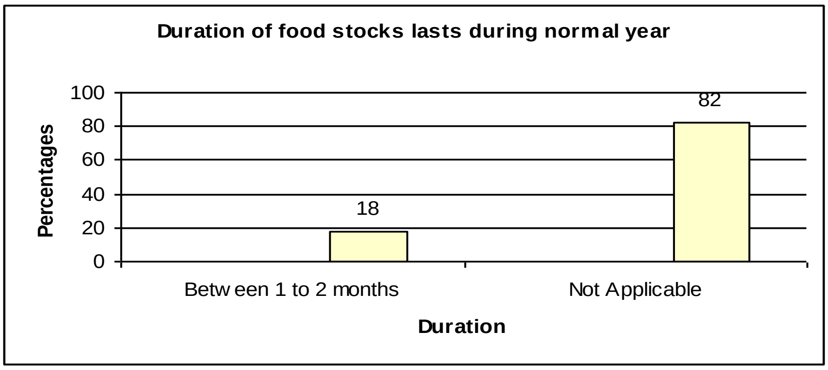


**Figure 4.14a: Duration of Food Stock Lasts in Normal Years in Ng'haya Village**

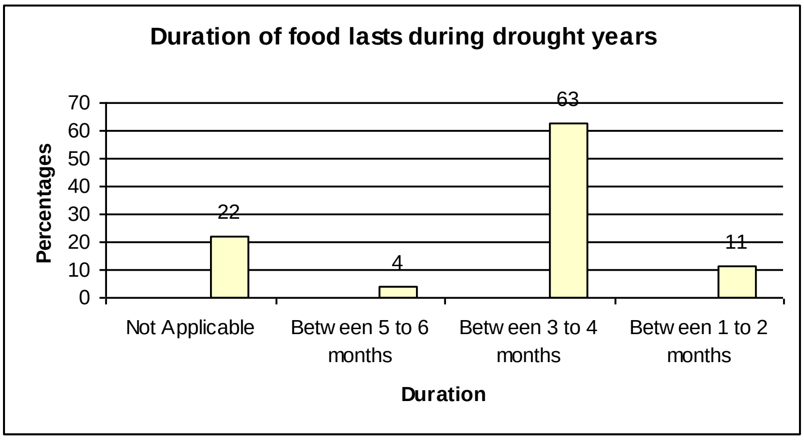


**Figure 4.14b Duration of Food Stock Lasts in Drought Years in Ng'haya Village**

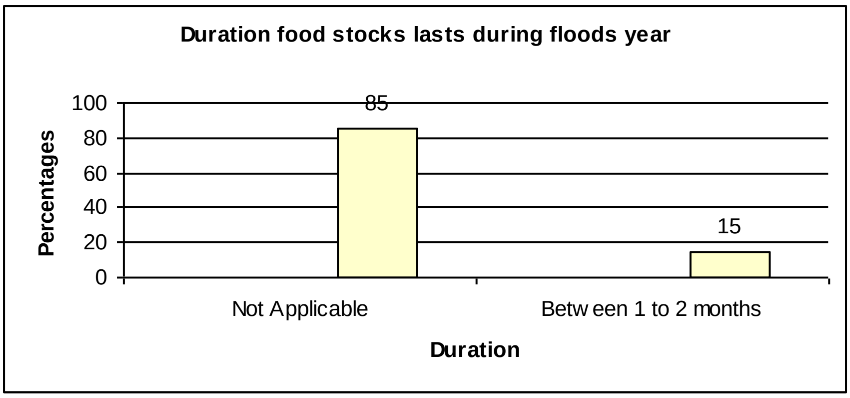


**Figure 4.14c: Duration of Food Stock in Floods Years in Ng'haya Village**

#### 4.6.2.c Upper Agro-ecological Zone

Igombe village represent higher agro-ecological zone where a few respondents noted the change of rainfall but was less significant. However, change of crop yield was noticed in maize crop only.

More analysis revealed that, respondents in Igombe village did not report change of temperature compared with Ihale village where almost every respondent complained about higher temperatures. Food insecurity periods in the area are summarized (Figure 4.17a to 4.17-c)

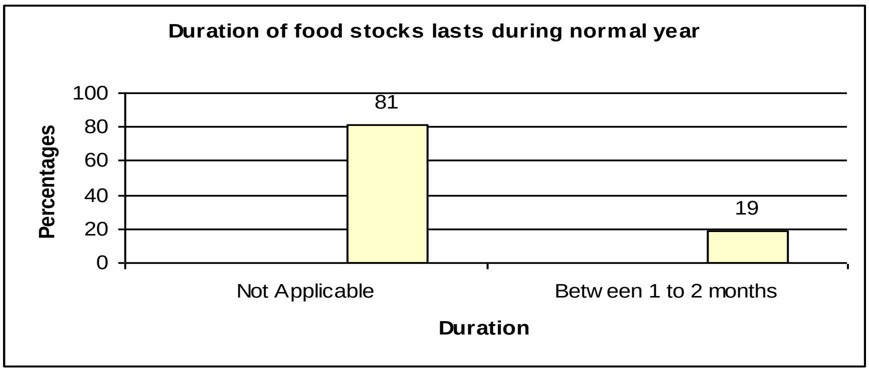


**Figure 4.15a: Duration of Food Stock Lasts in Normal Years in Ng'haya Village**

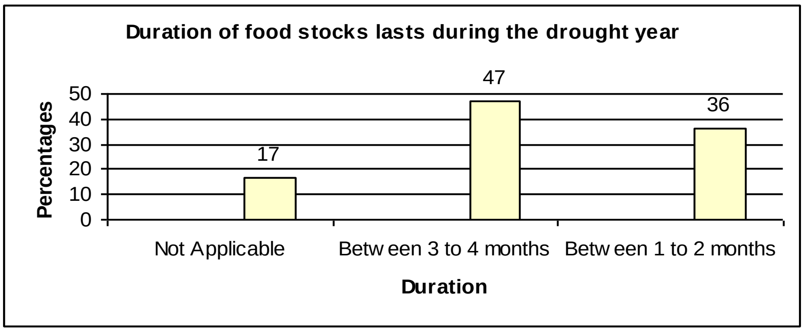


**Figure 4.15b: Duration of Food Stock Lasts in Drought Years in Igombe Village**

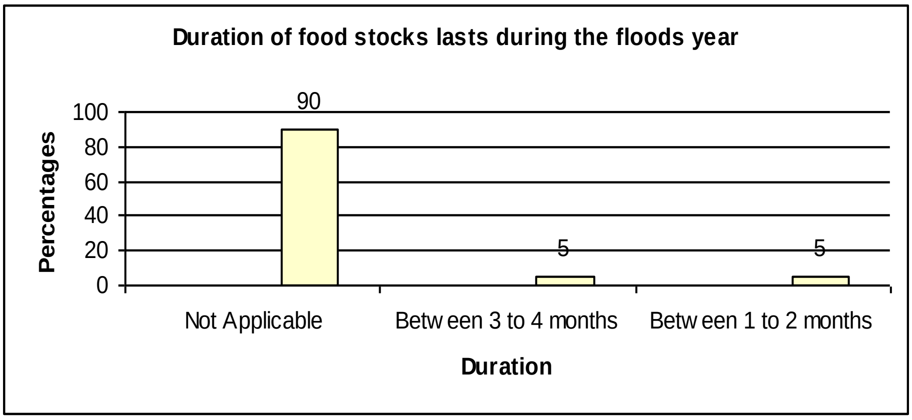


**Figure 4.15c: Duration of Food Stock During Floods Years in Igombe Village**

The upper agro-ecological was founded more food secure than other zones. Some villages in that zone got food aid only in famine years in the past 10 to 15 years (Table 4.6).

### 4.7 Main Causes of Food Shortages in the Households

Findings from household interviews indicated that there were several causes of food shortages. The causes ranged from natural calamities to socio-economic factors as summarized in (Table 4.21). However, the main causes of food shortages appeared to be those related to natural and social factors such as drought, floods, strong winds, hailstorms and excessive rainfall. Other significant causes included crop pests and livestock pests, low soil fertility, lack of labour, weeds, overselling of food commodities, and loss of livestock and poor health of family members.

Findings from the study indicated that climate related factors were significantly contributed to food shortages in the study areas. Drought was a major cause of food shortages and water for domestic use where traditional wells dried. Thus they remained with a few watering points that created conflicts between water users.

According to (Parikh and Denton, 2002) climate change may add to water and food insecurity such that it increases women's work levels, predominantly in Africa and Asia. In addition low soil fertility, crop pest and poor health of family members were reported to be main factors affecting all visited villages (Table 4.21). Other reasons included occurrence of weeds, lack of agricultural loan and presence of livestock pests. Birds were reported to be highly destructive in Ihale and Igombe villages where quelea quelea was reported as threat to grain production.

**Table 4.21: Responses on Causes of Food Shortages in Households**

| Main cause of food shortage | Villages | | | Total in Percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Drought | 100.0 | 100.0 | 100.0 | 100.0 |
| Floods | 22.6 | 40.7 | 27.3 | 30.0 |
| Strong winds | 71.0 | 33.3 | 40.9 | 50.0 |
| Too much rain | 3.2 | 29.6 | 18.2 | 16.3 |
| Overselling of food commodities | 9.7 | 18.5 | 9.1 | 12.5 |
| Low soil fertility | 90.3 | 81.5 | 95.5 | 88.8 |
| Weeds | 87.1 | 51.9 | 50.0 | 65.0 |
| Crop pests | 80.6 | 70.4 | 81.8 | 77.5 |
| Livestock pests | 25.8 | 48.1 | 50.0 | 45.0 |
| Loss of livestock | 41.9 | 33.3 | 40.9 | 38.8 |
| Shortage of agricultural labour | 29.0 | 11.1 | 27.3 | 32.5 |
| Low household income | 29.0 | 25.9 | 54.5 | 35.0 |
| Lack of production assets | 25.8 | 18.5 | 40.9 | 27.5 |
| Lack of social networks | 32.3 | 40.7 | 27.3 | 33.8 |
| Shortage of fishing facilities | 38.7 | 22.2 | 18.2 | 27.5 |
| Lack of agricultural loan | 74.2 | 25.9 | 45.5 | 50.0 |
| Poor availability of inputs | 48.4 | 33.3 | 63.6 | 47.5 |
| Poor health of family members | 96.8 | 59.3 | 72.7 | 77.5 |
| Shortage of non agricultural labour | 25.8 | 44.4 | 27.3 | 40.0 |

Besides, human disease vectors such as mosquitoes and houseflies were mentioned by respondents especially in wet weather to cause poor health of family members. (Yanda *et al*., 2005), revealed that East African highland communities living at altitudes above 1,100 meters above sea level and along the Lake shore are more susceptible to malaria and cholera epidemics owing to climate variability and change, be short of immunity, as well as poverty. The ability of these communities to cope up with problems is strongly challenged by these factors. It is estimated that in Africa climate change will increase the number of person-months of exposure to malaria by 16 to 28 percent by 2100 (McMichael, 2004). Malaria and diarrheal diseases affects food availability, access and utilization for both humans as well as livestock.

## 4.8 Community Vulnerability to Impacts of Climate Change

The vulnerability of individuals and societies is determined by the probable responses of the resources on which individuals depend, by the availability of resources and, crucially, by the entitlement of individuals and groups depending on these resources (Sen, 1981; 1999, Hewitt, 1983; 1997, Watts and Bohle, 1993, Ribot *et al.*, 1996; Adger, 1999).

The study established that, poverty levels in the study area were diverse, leading to formation of three major social classes of people characterized by different poverty indicators. Households considered ‘well-off’ {*Wasabi*) are typically defined by owning more than 12 to 20 acres of land, 50 goats, more than 200 cattle and they have better houses with a big household size. Furthermore, they are food secure all year round because they own very fertile land assurance of water availability for long periods. Sometimes they had capacity to irrigate their fields, hire labor (agricultural and non-agricultural) seasonally, they are educated up to primary or higher level and engage in diverse non-farm activities (trading, milling, and large-scale fishing) in addition to farming.

By using the proportional technique piling, with beans or maize of the same size, respective groups were established as shown in (Table 4.22)

**Table 4.22: Household wealth ranking in villages**

| Wealth status | Villages in percentage | | | Total in percentage |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Better- off | 6.5 | 10.2 | 14 | 10.2 |
| Middle | 26.2 | 32.6 | 37.1 | 32 |
| Weak resources | 67.3 | 57.2 | 48.9 | 57.8 |
| **Total** | **100** | **100** | **100** | **100** |

Furthermore, middle category that owns average wealth households indicated owning less most or all assets as a better-off group, towards the lower end of this category, households tended to be net sellers rather than buyers of labor. They were seasonally food insecure in most years, and they engaged in few or no non-farm activities.

Households regarded to be poor tended to have less than 0.5 to 2 hectares of land or did not own land at all, they did not own cattle otherwise had few goats and poultry, had houses constructed of mud and thatch. On the other hand, they were food insecure for 1 to 2 months in a normal year, and depended on selling labor or on social safety-net support for survival. The sustainable livelihood structure describes the assets portfolio of livelihood consisting of five types of capital, which comprise human, financial, physical as well as natural capital. These five livelihood types of capital offer the matrix from which individuals contain the means to make a living (Allison and Horemans, 2006). In addition (Black *et al.,* 2008) poor families cannot possess sufficient money to purchase animal source foods that be rich in protein plus bio-available micronutrients.

Social groups that are typically assigned to the poor category in wealth-ranking exercises were those who lacked assets or capability to use them they had limited access to livelihood platform or capital (physical, natural, human financial and social, they highly dependent on were disadvantaged by market relations; unable to cope up (that is, temporarily to make adjustments in face of change or adapt (make longer shift in livelihood strategies); who relied on small and ineffective social networks; malnourished and all households that fall in the bottom income quintile for different family types. (Bohle *et al.*, 1994) revealed that within the background of climate studies, the most at risk are considered to be those who are most exposed to perturbations, have a limited capacity for adaptation, and are the least resilient to recovery.

Based on wealth-ranking results, the poor categories as in (Table 4.22) are vulnerable to climate variability impacts due to the fact that they own very small plots of land from which production is poor they spend much of their time selling labor to overcome food shortages. It was observed that both men and women were poor.

Therefore they were equally vulnerable to climate variability impacts. It was also observed that there was gender disparity in property ownership and property rights. Social organization of the community in the study area is largely patriarchal whereby only men owned production resources (such as land and capital). Also male bias was illustrated in farmer training centers, established to provide residential training on technical subjects. When attendance of women was very high as a part of the total, they are trained mainly in home economics in addition to craft subjects, not technical agriculture (Staudt, 1973; Perraton, Jamison and Orival, 1983).

On the other hand, women in some households had an access to resources and had the right to use them to meet their livelihood requirements. However, women had no rights to organize the resources such as selling family land. Literature showed that had to do with unequal access to resources by females in most Africa countries. Females have been found to have less access to resources such as land, property and public services (Agarwal 1991; Nemarundwe 1993; Njuki *et al.*, 2008; Thomas and Slayter *et al.*, 1995).

According to Fothergill, (1998) men and women are affected differently in all phases of climate-related extreme weather events, from exposure to risk and hazard perception to attentiveness behaviors, warning interaction and response; physical, psychological, social and economic impacts; emergency respond; and ultimately, to revival and reconstruction. Also it was identified that female-headed households are the most vulnerable households in the study areas as most of them were involved in petty trading such because selling of sardines (*dagaa*), brewing and selling local beer.

## 4.9 Community Adaptation Strategies on Extreme Weather Events

Findings from the study exposed that adaptation to climate is not a new phenomenon in the areas. They used different ways to overcome natural disasters when people, property, economic activities and environmental resources always were at risk from climate change. They have continually sought after ways for adapting, sometimes successfully and sometimes not. The long history of adapting to variations and extremes of climate change includes crop diversification, irrigation, construction of water reservoirs and distribution systems, disaster management and insurance as well as even include, on a limited basis, current measures such as to acclimatize to climate change (Badger *et al.*, 2007).

According to (IPCC, 2001), adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in process, practices and structures to moderate potential damages or benefits from opportunities associated with climate change. It involves the action that people obtain in response to, or in anticipation of, expected or actual changes in climate, to reduce unfavorable impacts or acquire advantage of the opportunities posed by climate change (Parry *et al.*, 2005). Thus, it reduces communities' vulnerability or increases their resilience to climate shocks. Also it enables ecosystems to coexist with the changing climate, there enhancing their capacities to provide ecosystem services most critical for human wellbeing (Reisinger, 2004: Parry *et al.,* 2005; Millenium Assessment, 2005).

In many cases, adaptation activities are more localized (i.e. district, regional or national) issues rather than international issues (Paavola *et al.*, 2005; Parry *et al.*, 2005). This is because different communities in different geographical locations and scales possess different vulnerabilities and adaptive capabilities, and so they tend to be impacted differently, thereby exhibiting different adaptation needs. As a result, adaptation largely consists of uncoordinated action at household, firm and organization levels (Paavola *et al.*, 2005). Moreover, it may also involve collective action at the local, national, regional, and international levels and cross-scale interaction where these levels meet (ibid).

### 4.9.1 Adaptive Capacity

The study established that Individuals, communities, and nations have varying degrees of coping up with and adapt to climate variability and change. *Adaptive capacity* is used to refer to ability of countries, communities, households and individuals to adjust in order to reduce vulnerability to climate variation, moderate potential damage, cope up and recover from consequences, including ecosystem responses to climate change. According to Kessy et al (2011) Individual and household characteristics take part in an important role both in the choice of coping strategies and household expenditure. Household capital assets also play a critical role in choice of coping mechanisms and household expenditure patterns.

Adaptability, on the other hand, refers to degree to which adjustments are possible in practice, processes or structures of systems to projected or actual changes of climate and are dependent on availability and accessibility of resources by an individual or nation.

Likewise, Agricultural Extension Services (AES) have and continue to play a key role in agricultural development. They enhance adaptive capacity through diffusion of innovations as medium for exchange of experiences with farmers and act as a direct link or bridge between farmers and research. Therefore, extension services are playing a key role in adaptation to climate change in the field of agriculture (crop, livestock, fisheries and forest).

After recognizing climate change in the area, the District Council collaborated with agricultural extension workers within the district to provide services and promoted appropriate adaptation strategies to farmers. They covered the smallholder farmers engaged in subsistence and commercial crops as well as livestock production in high and low potential areas, and fishing households in Lake Victoria. According to (Staudt, 1973) in Africa agricultural extension strategies comprise customarily focused on increasing production and productivity of food crops, cash crops and livestock by provided that men with training, information, and access to inputs as well as services.

### 4.9.2 Community Adaptation Strategies on Extreme Dry Weather

Communities in the studied villages had a diverse set of approaches they undertake to adapt to changing environmental conditions. For instance, adaptation to drought conditions was achieved through various methods. Growing of early maturing crop varieties was a major approach in adapting to drought conditions followed by growing drought tolerant crops as reported by 70 percent and 60 percent, respectively. On the other hand, dry weather reported to reduce infestation of diseases that normally occurred in the area by prohibiting presence of disease vectors. According to (Metz *et al.*, 2007), drier weather cut-rate transmission of malaria in addition to cholera in some places in Sub-Saharan Africa, while in others, the geographical range will expand and the transmission season may be changed. According to (Reilly and Schimmelpfennig, 1999), long-term adaptations are major structural changes to overwhelm adversity such as changes into land-use to maximize yield under new conditions; application of new technologies; new land management techniques; and water-use efficiency.

Intercropping was also reported to be an important coping up strategy, especially during years of food shortage as expressed by half of respondents. It gives chance for intercropped materials in the field, be more than two types with more favored by weather or crop husbandry practices to that could give a significant yield rather than others, which are not. Intercropping is more practiced in subsistence farming than in large scale farming. Mixed farming is used as a strategy to ensure that in case one crop fails due to drought, another crop can survive due to differences in crop cycles, rooting depths and water requirements among others. The most common and widespread combination is maize together with cassava, groundnuts (*Arachis hypogea*) and cowpeas (*Vigna unguiculata*). In some areas farmers include beans (*Phaseolus vulgaris* or *Phaseolus aureus*) in this combination. In other areas, sweet potatoes are grown as a monocrop. Other crops grown in Lake Victoria basin include paddy (in a wet year) and cotton as a cash crop in dry years. The (IPCC, 2007; Bates *et al*., 2008) conclude that widely adopted adaptation strategies in agricultural production systems have a substantial potential to offset negative climate change impacts and can even take advantage of positive ones. At the same time, they can contribute to an increase in agricultural production sustainably.

It was more observed that the poorest households depended more heavily upon a combination of crops and/or natural resources (usually common resources) for their food security and income generating activities than the better-off groups. Growing of drought tolerant crops was a particular adaptation for the more drought prone agro-ecological zone in Ihale village where greater part of respondents said to use such copping mechanism. It pointed to long-term experience of drought conditions to the extent that nearly all members of the community understood the importance of using drought tolerant crops varieties.

Furthermore, the findings revealed that households had a variety of strategies for dealing with food shortages as shown in (Table 4.23). Measures included growing drought tolerant crops, buying supplementary food, getting assistance from relatives, selling livestock to buy food, working for food, reducing the amount of food eaten, eating less preferred foods, borrowing food, getting relief food, reducing number of meals and migrating to other areas. From (Table 4.23) it appears that buying food was the prominent way of dealing with food shortages, it implies a need for income generating activities to provide the required cash.

Income-generating ability and remuneration received for products and goods sold or labor as well as services rendered were primary determinants of average daily incomes for poor households. The incomes of all farming households depend on what they obtained from selling some or all of their crops and animals for each year. Commercial farmers were usually protected by insurance, but small-scale farmers in developing countries are not. Their incomes can decline sharply if there is a market glut, or if their own crops fail and they have nothing to sell when prices get high. For example (Du Toit and Ziervogel, 2004) revealed that most food is not produced by individual households but acquired through buying, trading and borrowing.

**Table 4.23: Community Adaptation Strategies on Extreme Dry Weather**

| Adaptation strategies during extreme dry weather | Villages | | | Total in percentages |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Growing drought tolerant crops | 80.6 | 68.2 | 40.7 | 63.8 |
| Growing early maturing crops | 80.6 | 68.2 | 44.4 | 70.0 |
| Buying supplementary foods | 29.0 | 29.6 | 22.7 | 32.5 |
| Inter cropping | 51.6 | 59.3 | 45.5 | 52.5 |
| Irrigation | 58.1 | 11.1 | 0 | 27.5 |
| Wetland cultivation) | 45.2 | 44.4 | 27.3 | 40.0 |
| Emphasis on rearing small ruminants and poultry | 67.7 | 33.3 | 13.6 | 42.5 |
| Emphasis on livestock keeping instead of crops | 64.5 | 14.8 | 4.5 | 31.3 |
| Increasing areas cultivated | 64.5 | 11.11 | 18.2 | 33.8 |
| Migrating (permanently/temporarily) | 12.5 | 9.1 | 3.7 | 0 |
| Seasonal migration of livestock keepers | 41.9 | 18.5 | 18.2 | 30.0 |
| Distributing livestock herds in different places | 48.4 | 33.3 | 13.6 | 33.8 |
| Casual labour | 35.5 | 44.4 | 22.7 | 35.5 |
| Selling of livestock and buying food commodities | 61.3 | 33.3 | 18.2 | 40.0 |
| Early planting | 38.7 | 25.9 | 18.2 | 28.8 |
| Growing non-traditional crops | 35.5 | 33.3 | 27.3 | 32.5 |
| Reducing meals | 40.7 | 27.3 | 19.4 | 22.5 |
| Brick making | 45.2 | 25.9 | 13.6 | 30.0 |
| Relief food | 48.4 | 13.6 | 0 | 33.8 |

Still, some of respondents relieved on food relief through food for work programme managed by World Food Programme (WFP) it enabled some people during the off-season to build social structures such as roads, schools, water reserve ponds, irrigation trenches and bridges while getting food for their families. According to (Paavola *et al.,* 2005; Parrry *et al.,* 2005) adaptation to climate change can therefore be reactive or proactive (anticipatory). Reactive adaptation responds by reacting to the present impacts of climate change with for example, the provision of food aid after a disaster, relocation or reconstruction of infrastructure after flood damage and migration to a new locality.

Other important adaptation mechanisms from study results includes irrigation, mainly involving wetland cultivation, increasing emphasis on rearing small ruminants stocks as well as emphasis on livestock keeping instead of crops. The general observation was that diversity of the reported adaptation measures could be a reflection that one single adaptation approach/strategy may not be sufficient for communities to be able to adapt to conditions of climate change/variability. For example (FAO, 2007) reported that promoting agro-biodiversity is particularly important for local adaptation and resilience.

On the other hand, many community members adapted through measures inbuilt within the communities. For example, some migrate to other places with better opportunities either permanently or temporarily. Other reported adaptation mechanisms included seasonal migration of livestock keepers; distributing livestock herds in different places; rainwater harvesting and doing casual labor to be able to get food and other household needs. Others included selling of livestock; timely planting; simplifying and/or reducing meals, brick making and selling and small businesses (including selling crops and livestock). In particular, during droughts some households in the communities had invariably relied on relief food from government. The efficacy of these measures was, however, variable.

This study also established that most communities in Magu district depended on assistance from family members, neighbors, the communities, government, and non-governmental organizations. Basic assistance they required from such bodies including food, clothes and shelter during severe floods, but in some cases, farm inputs, and money were provided. Apart from the government and family members' assistance, the communities also required advice on what to do after an extreme event (drought/flood).

It was observed that respondents in all three sampled villages were unaware of the need to plan for future occurrences of extreme events, except by key players. Such an attitude may be attributed education level or lack of access to information (for example, early warning systems/weather forecast). A few farmers received advice on how to cope up with drought or how to be prepared for other extreme events. Therefore, information on adaptation strategies for future climate variability was still unavailable.

### 4.9.3 Community Vulnerability and Adaptation Strategies on Extreme Wet Weather

All respondents in three communities reported to have observed effects of extreme wet weather events in their areas. Analysis of collected information of people in area were vulnerable but mostly vulnerable were those who planted and constructed in lowlands where individual houses, school, cattle dips, bridges, crops, food commodities and storage structures were destroyed by floods. According to (Valimba, 2004) recurrent high daily rainfall, which occurs during the peak of the rainy season, was accompanied by floods which destroy the already grown crops.

On the other hand, public and household toilets were broken and traditional water wells were flooded making the area susceptible to malaria and diarrhea diseases. After the disaster, the government, in collaboration with development partners donated food, health package and construction materials while community participated in construction works in the uplands. Where infrastructure is affected by climate, all the way through either heat stress on roads or increased frequency of flood events that destroy infrastructure, there are impacts on food distribution, influencing people's access in the direction of markets to sell or purchase food (Abdulai and CroleRees, 2001).

**Figure 4.16: Effect of Floods on Infrastructure (Bridge at Msambweni Village - Tanga to Mombasa Road)**

Vulnerability of individuals and societies is strong-minded by likely responses of the resources on which individuals depend, by the availability of resources along with, crucially, by privilege of individuals and groups depending on those resources (Sen, 1981; 1999, Hewitt, 1983; 1997, Watts and Bohle, 1993, Ribot *et al*., 1996, Adger, 1999). Further field analysis exposed that sometimes rainfall received in the area was above normal, where communities responded by adapting ways, which used to reduce incidences as recorded in (Table 4.24).

**Table 4.24: Community Adaptation Options on Extreme Wet Weather**

| Adaptation strategies during extreme wet weather | Villages | | | Total in percentages |
|---|---|---|---|---|
| | Ihale | Ng'haya | Igombe | |
| Growing early maturing crops at the end of rainfall in the uplands | 64.5 | 22.2 | 31.8 | 56.3 |
| Planting more water love plants | 51.6 | 33.3 | 27.3 | 38.8 |
| Buying supplementary foods | 41.9 | 29.6 | 27.3 | 35.0 |
| Engaged in fishing | 51.6 | 3.7 | 31.8 | 30.0 |
| Involves in fishing sale | 74.2 | 33.3 | 9.1 | 42.5 |
| Temporally migration | 22.6 | 7.4 | 4.5 | 12.5 |
| Engaged in hunting | 41.6 | 7.4 | 18.2 | 27.5 |
| Emphasis on livestock keeping instead of crops | 64.5 | 21.4 | 4.5 | 31.3 |
| Pet trading | 83.9 | 22.2 | 0.0 | 40.0 |
| Brick making | 48.4 | 3.7 | 31.6 | 23.8 |
| Reduce meals | 48.4 | 0.0 | 0.0 | 18.8 |
| Skip meals | 35.5 | 14.8 | 13.6 | 22.5 |
| More use of fertilizer | 51.6 | 25.0 | 4.5 | 30.0 |
| Get remittances | 19.4 | 14.8 | 0.0 | 12.5 |
| Casual labour | 9.7 | 48.1 | 31.8 | 28.8 |
| Selling livestock | 90.3 | 18.5 | 9.1 | 43.8 |
| Rainwater harvesting | 80.6 | 11.1 | 31.8 | 43.8 |

Under such situations, reported main adaptation options included growing early maturity crops at the end of the rainfall in the uplands, selling livestock to buy food, engaging in casual labour, involving in water harvesting, fishing and pet trade. In addition some of them engaged in growing water loving plants such as paddy. Others included buying supplementary foods, engaged in temporally migration outside their villages and received remittances from their relatives.

However, majority of household head reported to have no food shortfall during extreme wet years as indicated in (Table 4.20). It reflected the fact that in many instances, excessive rainfall was not always regarded by the local communities as a major problem compared to drought conditions.

The study established that people were not affected the same in all three agro-ecological zones. (Table 4.24) reveals that Ihale village from lower agro-ecological zone showed the greatest responses to flooding compared to other villages from other zones. Also, respondents from lower zone reported that people adapted to build their settlements in upland areas within their area. They planted crops such as cassava, maize, sweet potatoes and vegetables in up-lands and harvesting is done in lowlands earlier before the rain season set in.

### 4.9.4 Community Adaptations Strategies on Excessive Temperature

Results from study revealed that, lower zone reported to be more affected by excessive temperatures than other areas. People adapted by using more crop varieties that are drought tolerant and withstand excessive temperatures. Some farmers used mulches to reduce the impact of excessive temperatures in their fields. For example, (FAO, 2008) reported that conservation agriculture is an option for adaptation as well as for mitigation because an increase in soil organic matter reduces vulnerability to both excessive rainfall and drought. Crops under conservation agriculture suffer much less from drought conditions and are often the only crops to yield in such situations. Yield fluctuations under conservation agriculture are generally much fewer severe than under equivalent conventional agriculture (Tebrügge and Bohmsen, 1998; Derpsch, 2005).

In addition, mulching was reported to be limited to small fields, especially for horticultural crops. The explanation was that in many places, availability of materials for mulching had become difficult to get within the area that requires high labour to collect and carry. Besides those staying closer to wetlands reported to practice irrigation or wetland cultivation as means for supplying water to crop fields thereby reducing temperatures in the soil, since wetlands are relatively cooler and moister than upland fields. However, poorly developed irrigation facilities limited such practice to only small plots. Also other areas had high temperature and were very dry such that wetland cultivation lasted for few days after the rainfall has stopped, thus, it was so reliable in ensuring sustainable livelihoods because land dries up early before the crop reaches maturity. That was experienced in areas around Lamadi River in Magu district. Other respondents reported that they use irrigation to maintain field moisture and made use of the wetlands where soil moisture was constant.

Life forms have flourished on earth at even higher temperatures than those currently projected to be reached as a result of human actions in the current epoch. Nevertheless, according to (Hansen *et al*., 2006), "the earth is currently within +/- $1^0$C of its maximum temperature in the past million years" and it is clear that the current rapid increase in global temperatures has already begun to modify the complex web of systems that permit life to thrive on earth. Such global changes threaten balance of climatic conditions under which life evolved and is sustained. The present speed of change also threatens social plus economic systems together with agriculture, food supply, water supply, coastal infrastructure, climate dependent livelihood systems, and vulnerability towards pests as well as diseases (UNFCCC, 2006)

### 4.10 Useful Community Based Adaptation Options to be Enhanced

Analysis of useful community adaptations identified some experienced in the area that could be enhanced to improve resilience to climate change in other areas. According to (FAO, 2008) impacts of climate variability depend on how severely stressed people are or their level of vulnerability and on their resilience or decisions and/or action communities may take to minimize the impacts. Strengthening resilience involves adopting practices that enable vulnerable people to protect existing livelihood systems, diversify their sources of income, change their livelihood strategies or migrate, if this is the best option. In addition (FAO, 2006) reported that changing consumption patterns and food preparation practices may be sufficient to protect food security in many circumstances. Both market forces and voluntary choices influence individual decisions about the kind of food to eat and the manner on the way to maintain good health under a changing climate (FAO, 2008).

Findings revealed that, community members employed various copping up strategies immediately after encountering extreme weather events to save life of household members and essential household asserts (Table 4.25) shown that most strategies mainly used by community included improved technologies in food storages, crop rotation, conservation agriculture, improve traditional irrigation and introduced new irrigation schemes, improved mechanization and reduced livestock number by introducing the improved better breeds. (Reilly and Schimmelpfennig, 1999), defined major classes of adaptation to comprise seasonal changes and sowing dates, plant different variety or species, water supply and irrigation system, other inputs (fertilizer, tillage methods, grain drying, other field operations), new crop varieties, forest fire management, promotion of agro-forestry, adaptive management with appropriate species and silvi-cultural practices. Overall, sustainable development is able to be attained through sustainable human interaction with nature (Yanda and Mubaya, 2011).

**Table 4.25: Useful Community Based Adaptation Options Could be Enhanced**

| **Adaptation** | **Villages** | | | **Total in percentages** |
|---|---|---|---|---|
| | **Ihale** | **Ng'haya** | **Igombe** | |
| Improve mechanization(tractor and power tillers) | 83.9 | 29.6 | 61.9 | 59.5 |
| Reduce livestock numbers by introducing new better breeds | 67.7 | 37 | 40.9 | 50.0 |
| Use of improved technologies in food storage | 67.7 | 51.9 | 68.2 | 62.5 |
| Improve traditional irrigation and introduce new one | 77.4 | 48.1 | 54.5 | 61.3 |
| Improve awareness of weather information's/ forecasts | 87.1 | 55.6 | 45.5 | 65.0 |
| Use weather insurance | 80.6 | 44.4 | 68.2 | 65.0 |
| Agro-forest | 77.4 | 72.5 | 79.1 | 77.5 |
| Agricultural loan with a low interests | 87.1 | 55.6 | 54.5 | 67.5 |

Further, analysis indicated that lower agro-ecological zone had greater responses in all adaptations as in (Table 4.25), it implies that most people experienced the impact of climate change stayed more in this than other zones. Field data revealed further that most people in three villages identified agro-forest as the most useful community adaptation option in the study area. Also the District Council is supported the people's initiatives by operating  a food security project, which is functioned under the Natural Resources Department in Magu District Council. Through the project people were encouraged and supported to establish tree nurseries, plant trees, combat bush fire and reduce deforestation.

**Figure 4.17: Burning bricks by using rice husks at Nyanguge village in Magu district**

According to (Reid *et al*., 2004), government institutions required to implement such schemes often have insufficient strength and ability but have to involve community in implementation. People in this area adapted to reduce deforestation by reducing the use of building pole, nowadays used burnt or unburnt bricks to build their houses and other farm structures. Also during burning bricks they used tree logs as source of fuel wood but they were adapted to use rice husks to burn bricks as shown in (Figure 4.19)

Moreover, the study identified some useful community based adaptation options used to enhance availability and accessibility of food in the community.

### 4.10.1 Forest and Agro-forest Management

Forests provide over 90 percent of the Tanzanian energy supply through wood fuel and charcoal and 75 percent of construction materials (Milledge *et al*., 2007; Miles *et al*., 2009). Reforestation involves planting new trees in existing forested areas where old trees have been cut or burned. Afforestation involves planting stands of trees on land that is not currently classified as forest. Sustainable forest management requires that a new tree be planted for every tree cut down by logging, fuel-wood gathering or land clearing activities (FAO, 2007). Forests give hope of mitigating climate change and reduce emissions by developing a carbon sink. The world's forests are home to about 350 million people. Whilst around 1.6 billion depend on the forest (World Bank, 2004). Given that increased water demand, damage to crops, soil erosion, and more frequent droughts are all considered to be "likely consequences" of a changing climate in the near future, deforestation is projected to aggravate these impacts (IPCC, 2007).

Agro-forestry not only captures carbon also helps maintain soil health through nitrogen fixation and use of cuttings as fertilizer and mulch, but it as well provides fodder, fruit, timber, fuel, medicines as well as resins (UNFF, 2007). It can help improve nutrition in cultivator households through higher incomes and by directly adding diversity to diets (CGIAR, 2008). In addition, options for reducing emissions from grazing systems are also important. Adding nitrification inhibitors to urea or ammonium fertilizer compounds before application can substantially reduce emissions of nitrous oxide (Monteny, Bannink and Chadwick, 2006). According to (Smil, 1999), the best way to manage human interference in nitrogen cycle is to maximize the efficiency of nitrogen uses.

On the other hand, agro-forestry is management of trees for forest products. It can be an integral component of productive agriculture. It has an application to multiple uses of agricultural land, or as a single land use pattern. It may include existing native forests and forests established by landholders. It is a flexible concept, involving both small and large sized land holdings. Forests are multi functional, serving several purposes simultaneously.

Through forest management, people in study area learned/adapted to use tree branches for fuel wood rather than cutting the whole tree. The impact of this method was highly significant in the study area. When passed through the villages one can see many households covered with trees, a phenomenon which they reported that was new in their areas. In addition, interrelations between adaptations with mitigation require being carefully measured (Bates *et al*., 2008). At best, adaptation and mitigation strategies exhibit synergies. Positive examples include many carbon-sequestration practices involving reduced tillage, increased crop cover, including agro-forestry, and use of improved rotation systems. All lead to production systems highly resilient to climate variability, thus they providing good adaptation in view of increased pressure on water and soil resources.

The study exposed that, each individual or groups were encouraged to have "*ngitili"*. *Ngitili* is a reserved traditional forest which could be open or closed. Open *ngitili* is off or closed during the rainy season and open for grazing during the dry season, while closed *ngitili* is reserved traditional forest at all time of the year no livestock allowed to graze in. Bee keeping has also been introduced in these *ngitili* systems, which provides honey and bee wax that improve nutrition including cash for households involved in that activity. Also they harvest mature trees for making charcoal and normally they collect dried fuel wood, which has dropped from the larger trees. The practice helps to recover cost of keeping a forest which makes a sustainable forest use in the district. According to (FAO, 2008), improved pasture management and integrated agro-forestry systems that combine crops, grazing lands and trees in ecologically sustainable ways are also effective in conserving the environment and mitigating climate change, while providing more diversified and secure livelihoods for inhabitants.

The study suggested that ngitili system can be adapted in the nearby districts such as Misungwi, Maswa, Kwimba, and Bariadi to improve vegetation cover of the area and reduce the impacts of climate change. According to (Paavola *et al.*, 2005; Parry *et al*., 2005) in several cases, adaptation actions are more local (like district, regional or national) issues fairly than international issues. This is because dissimilar communities in different geographical locations and scales possess different vulnerabilities and adaptive capabilities, and so they tend to be impacted differently, thereby exhibiting different adaptation needs.

As a result, adaptation mostly consists of uncoordinated action at domestic, firm and organization levels (Paavola *et al.*, 2005). But it may also involve collective action at the local, national, regional, and international levels and cross-scale interaction where these levels meet. Sustainable forest management is a dynamic and evolving concept. The goal is to maintain and enhance the economic, social and environmental ethics of all types of forests for the benefit of current and future generations (UNFF, 2007).

### 4.10.2 Use of Weather Insurance

Additionally, the analysis found out that greater part of respondents mentioned weather insurance as the way in which communities could adapt to reduce impacts of weather vagaries. (The World Economic Forum, 2007) stated that climate-related risks have an effect on everybody, so insurance against the effect of catastrophic weather events needs to be globalized, and expenses should be minimized through actions to mitigate climate change. For example, in Ethiopia, emergency funding was secured through a private sector reinsurance company, AXA Re it was used to experiment with a new method to weather insurance whereby vulnerable households signed financial contracts obligating them to pay for an insurance premium prior to each growing season. The contracts allowed them to be given insurance payouts when abnormally shortage of rainfall causes value of crops in the ground to fall under a specified trigger. The scheme's success depended on the ability of local weather stations to monitor development of the growing season accurately. Capacity building for the meteorological service was element of the initial experiment. Payout funds from the insurance scheme had to help vulnerable households after crops failed because of drought and lessen their reliance on emergency relief *(*Hess, 2006).

Creating collaboration among relevant governments and companies around different global risks – "coalitions of the willing" – to make risk mitigation a process of slowly expanding alliances rather than a proposition requiring permanent agreement is important. Modern insurance schemes, such as a global reinsurance fund for damaged owing to climate change or expanded local coverage of weather-based insurance, are expected to be needed (Osgood, 2008). Adapting to climate change involves managing risk by improving the quality of information and its use thus provide insurance against climate change risk, adopting known good practices to reinforce the resilience of vulnerable livelihood systems, and finding new institutional as well as technological solutions. According to (Kunreuther and Michel- Kiernan, 2006), people in the insurance firm should make a transparent distinction between certain and uncertain risks. A risk is certain if the probabilities of precise states occurring in the future are exactly known, and uncertain if such probabilities are not precisely known.

### 4.10.3 Traditional Weather Forecasting

Climate variability, in particular, rainfall has a great impact on lives of people and communities in the traditional system of Tanzania who depend on rain fed subsistence agriculture for their livelihood (EPMS, 2009). Before the advent of modern scientific methods of forecasting, a traditional community in Magu was able to observe the stars and behavior of some animals, birds, and insects and plants such they used to forecast the weather for the next season. They predicted drought as well as weather related diseases by watching the movements of celestial bodies in combination with observing date of emergence of a certain plant species. Traditional forecasters are still a source of weather and climate information for farm management in rural areas.

All through field findings, were advocated various adaptation options employed during extreme dry and wet weather. Systematic traditional ways of weather forecasting in their area such as a group of birds (*twelve, mabwagwa)* at the beginning of rains indicated that the area would receive good rains. When Green pangolin (*Kaukauna)* was seen in any part of district or the nearby areas during the production periods it was predicted that they would get bumper harvests. Also, people normally accessed traditional information from weather predictors indicating that rainfall would be late or much rainfall is expected it make the people to be prepared to cultivate in wetland or lowlands where they could irrigate or cultivate to uplands in case of expected excessive rainfall. In case of forecasted drought year, they preserved their food stocks at households and bought additional food commodities. Livestock keepers' sold livestock and buy food commodity to enrich household's food stocks. Large scale fisher folks secured funds from financial institutions or sold livestock to buy fishing gears such as boats and fish nets in case of an excessive rainfall. Such early warning signals of an approaching environmental disaster were used to determine any preventive measures to prepare for mitigation and decided on course of community in using natural resources. According to (FAO, 2008), information is a crucial tool in decision-making, particularly in the context of climate change where there is high uncertainty. The type of information, its source(s), to whom it was targeted, and how it is to be used are important elements in determining the impact including response that information may generate (*ibid*).

#### 4.10.4 Water Harvesting Methodologies

Water resources are under increasing pressure due to intensive farming, increasing population and political tensions (FAO, 2008). The situation is exacerbated by climate change and environmental degradation. Practical Action continues to show how water resources can be managed even in the face of drought and other extreme weather conditions (IPCC, 2007). Competing demands for water means that there an integrated approach is required if needs of poor communities are to be met. Regarding water harvesting methodologies in place in Magu district, water harvesting was practiced in open dry lands by constructing a dam, which collected water during rainfall.

However, water level was declining as time went on after rainfall stopped. That was discussed in detail and the issue was, “how can water passing/meandering in rivers around the villages be used to irrigate vegetables around the rivers rather than use current methodology of harvesting water on open dry lands?”

First, lack of access to adequate water supply, both in quality and quantity, for domestic uses can be a major cause of declining nutritional status and of disease as well as morbidity. Second, domestic water is often a production input. Such production is essential for direct household consumption and/or income generation. Moreover, the amount of time used to collect water, and associated security together with health hazards, can be immeasurable, especially for women and girls (Magrath and Tesfu, 2006).

As well, amount of water allocated to agriculture and water management choices will determine, to a large extent, whether or societies attain economic and social development including ecological sustainability (Molden *et al.*, 2007). Also, with a more variable climate and less reliable weather patterns it will be essential to increase the water storage capacity for agriculture, to maintain global food supplies while satisfying other competing uses for agricultural water (Parry *et al.*, 2007).

Maintaining water flows in rivers will help to use water even far away from the river to other areas where irrigation is possible and then water to be controlled around the irrigated area in such way that water gets back to the main stream to maintain the river flow. Such methodology could maintain the life circle of aquatic organisms, especially fishes as water stays there permanently or for long time after rainfall has stopped. In some area where water is at high level, aquarium agriculture should be adapted. Besides that can allow farmers to cultivate more than twice a year and get additional food including incomes to maintain food security of the area.

Such as, Murray River in Australia was an unreliable supplier of water. During droughts, it could be cut-rate to a chain of saline ponds. A chain of drought years from 1895 to 1902 emphasized the need for drought protections in form of locks and weirs to facilitate further development in the Murray Valley. An excellent plan was devised and in 1917 NSW, Victoria and SA made available funding for the construction of weirs together with navigational locks to regulate water flow and facilitate navigation as well as irrigation. Currently such regulated river provides a consistent source of water for towns and industries. River regulation has permitted development of the Murray-Darling Basin and the successive economic benefits for Australia. As a result of regulation, summer flows are higher and winter flows are reduced, while weirs upstream of SA have reduced the incidence of floods. Weirs have also created permanent wetlands and a slower flowing river, compared to temporary wetlands and occasionally fast-flowing water before river regulation.

As well, the grand plan should in place to institute water management system which will lay out the scheme to systematize water resource in the country. This scheme will deal with water flow regulation in rivers as water normally is in access during the rainy season in most parts of the study area. In order for water controlling structures (weirs) to be constructed in rivers (Simiyu and Lamadi) in the study area and other rivers (Ruvu, Rufiji, Wami, Kagera, Mara, Malagalasi and Manonga) in Tanzania, a comprehensive study is required together with core environmental studies such as Strategic Environmental Assessments (SEA) at policy and planning levels and Environmental Impact Assessments (EIA) at project level should take place before construction begins. Simiyu River passes many places, starting in Arusha region through Ngorongoro Conservation Area, through Maswa Game Reserve and another branch of Simiyu come from Serengeti National Park making the area having highly significant hydrological potential. As well, the river might be perfectly studied where catchment areas identified, in the direction of understand dissimilar water flows in different places, it may well facilitate launching different development projects which will rescue the life of wildlife, livestock as well as human beings during the extremely drought seasons.

### 4.11 Adaptation Strategies Likely to have Negative Environmental Impacts

The study recorded some local adaptation strategies, which were used in the study area to strengthen resilience that may have negative environmental consequences. Many respondents advocated major coping up strategies, which included change land use for mining, urbanization, recreation, overgrazing and expansion of farmland that lead to environmental degradation through loss of biodiversity and soil erosion. Also, wetlands cultivation and irrigation did around Simiyu River and Lake Victoria shore change natural habitats where fauna and flora situate life in suspense. Cutting trees without replacement and bush fire destroys sources and sink of bio-energetic. Improper use of industrial fertilizers and pesticides kills intended as well as untended pests' as normal eliminating environmental friendly organisms. They may have caused mutation in some species, migration and changing the appropriate natural habitats for organisms to other places where life is trial and error (IPCC, 2007). Finally, people mentioned charcoal making as the most dangerous poverty coping up strategy because it destroys the environment. (Yanda, 2005) stated that emissions from deforestation add to agricultural emissions trends. Charcoal production and firewood collection are chief sources of energy in both rural and urban areas, as well as important sources of income generation for most rural areas.

# CHAPTER FIVE

# 5.0 CONCLUSIONS AND RECOMMANDATIONS

## 5.1 Introduction

This chapter presents conclusion and recommendations. This would assist policy makers to understand existing gaps regarding climate change and food security. Also would show what has to be done in order to reduce effects of climate change in Magu district and other areas like Magu in terms socio-economic and geographical aspects.

## 5.2 Conclusions

The study revealed that there were rainfall and temperature fluctuations between seasons and from one year to another. Normally, the OND and MAM seasons were dissimilar within the same hydrological year. Time series data from 1960 to 2010 collected at Mwanza Airport station from TMA, showed a significant level of decrease in rainfall and rise in temperature. Climate change significantly affected socio-economic activities (mainly rain-fed agriculture) and community livelihoods which are mainly dependent on natural resources (District Profile Data, 2006). It was established that agriculture was the cornerstone of the livelihoods of people in the district. Major socio-economic activities include crop production, livestock keeping and fishing.

The study revealed that communities had a clear perception that climate had changed and change involved variability in rainfall, temperature, wind velocity, and ground water regimes. Also, there was general perception that rainfall and temperature patterns over the last 30 years had changed. The main indicators for change include reduced rainfall, rainfall setting in late, increased day as well as night temperatures and increased frequencies of drought. Climate change was also associated with occurrence diseases in human disease vectors (malaria, cholera), livestock and crops pests (like East coast fever, anaplasmosis, and head-smut). It was reported that crop diseases and pests like the American bollworm, rodents and large grain borer attacked crops in the fields and in granaries hence affecting food availability, accessibility and utilization in most households.

Also the study established that most of crop, livestock and human pests and vectors are survive in wet weather but no pest was favoured by extreme dry weather those flourishing during drought are natural parasites.

Given that the livestock production system is sensitive to climate change and at the same time a contributor to the phenomenon, climate change has the potential to be an increasingly formidable challenge to the development of the livestock sector.

Generally, it was observed that there was a broad decline in crop and livestock productivity in all three assessed agro-ecological zones at varying degree. Decline in productivity was associated with climate change and other factors such as shortage of land; they made continuous cultivation without fallow which made land to be over-exploited. Also there was lack of agricultural inputs such as fertilizers plus use of improved seed.

The main causes of food shortages were noted to be those related to natural factors such as drought, floods, strong winds, excessive rainfall, crop pest, livestock pests and high infestation of weeds during extreme wet weather. Other reasons included: destructive birds and more use of local varieties. Birds such as quelea quelea were very destructive and led to serious food shortages. Furthermore, extreme weather events damaged or destroyed transport and infrastructures. Thus, they affected adversely other non-agricultural parts of the food system. Destroying bridges, eroding and sinking of lake shore gates, sweeping of crops and livestock in the fields as well as destroying homesteads were common phenomenon reported in study area especially during flooding.

The process of adaptation includes learning about risks, evaluating response options, creating the conditions that enable adaptation, mobilizing resources, implementing adaptations, and revising choices with new learning. But the conception of adaptation as a process is often the most important measure for formulating public interventions that will have lasting benefits. Multiple adaptation strategies done during extreme weather events included growing of fast maturing crop varieties, improved traditional irrigation and introduce new one. Other involved water harvesting methodologies, crop rotation, a forestation, reforestation, agro-forest management (*Ngitili* system), use of weather insurances and reduction of livestock numbers by introducing new better breeds. Also maintain biodiversity and genetic engineering growing of drought tolerant crops, irrigation, mainly involving wetland cultivation as well as improved livestock keeping, buying supplementary foods and storage, as well as subsidies on foods agricultural inputs.

Proposed adaptation strategies included growing short maturing crops; using drought tolerant crops; promoting irrigation; buying and preserving food stocks in good years to be used in bad years. Strengthening resilience involves adopting practices that enable vulnerable people to protect existing livelihood systems, diversify their sources of income, change their livelihood strategies or migrate, if this is the best option. Changing consumption patterns and food preparation practices may be sufficient to protect food security in many circumstances. Both market forces and voluntary choices have on influence individual decisions about the kind of food to eat and how to maintain good health despite a changing climate. This study established that communities were heterogeneous in terms of their adaptive capacities to impacts of climate change and variability. The ability and capacity to adapt to such impacts were found to be highly influenced by socio-economic well-being that prevailed in the households.

Furthermore, the study revealed that people in different agro-ecological zones were affected and adapted differently. Also, impacts of climate change on people or households and their adaptation in the same agro-ecological zone differed due to having different resources they accessed or they owned. Involving beneficiaries at risk in the process can increase effectiveness of adaptation to climate change.

Community based adaptation options included improving agricultural extension services; agro-forest management at village as well as households levels; conservation agriculture; crop rotation and substitution of new crops for old ones; improving traditional livestock breeds to increase productivity and pests resistance other included institution of appropriate methodologies of fish catches improved aquariums; promoting traditional as well as modern weather forecasting and improving water harvesting methodologies. Climate change has a direct link with development concerns and, therefore, it requires formulation of appropriate adaptation options for the sector. In the food and agriculture sector, adaptation and mitigation often go; hand-in-hand, and thus, adopting an integrated strategic approach represents the best way forward.

## 5.3 Recommendations

### 5.3.1 General Recommendations

1. Improving methods and tools such as installation of rainfall and temperature measuring instruments for assessing extreme weather events. They will guide adaptations and facilitate to carryout mitigation to increase awareness of climate change drivers that brought such change/variations. Predictions should be in place to help develop appropriate interventions.

2. Mainstreaming community-based adaptation and mitigation to climate change into national policies and firm commitment for implementation by relevant institutions that would require mainly, President's Office Local Government and Regional Administration and Vice President's Office in Environment Department in collaboration with other stakeholders such as Ministry of Agriculture Food Security and Cooperatives; Ministry of Livestock and Fisheries; Ministry of natural resources and tourism; Ministry of health and community welfare; Ministry of Water; Ministry of trade and Marketing; Ministry of Infrastructure development; and other bodies such as National Environmental Management Council (NEMC), (WWF) and (UICN).

3. The government and development partners should support to institute firm commitment for implementation of integrated multiple adaptation strategies such as improve traditional irrigation as well as introduce new forms, afforestation and reforestation, agro-forest management (*Ngitiri* system) and use weather insurances other include reduce livestock numbers by introducing new better breeds, biodiversity and genetic engineering which will produce drought tolerant crops, pests and diseases resistant to animals that will match with pace of climate change to promote crop and livestock productivity. The measure would help to ensure sustainable food and livelihood security.

4. There is great need to strengthening cassava and cotton production in Magu district to help them during the drought as cassava and cotton are drought tolerant crops; whilst cotton has tap-root system which enables cotton to get soil moisture in dipper soils that help to give a better yield during drought seasons. This will promote crop diversity in the area and improve food and livelihood security.

5. The community indigenous knowledge should be taped and be improved, in addition current barriers to rural livelihoods diversification need to be identified as well as removed in order to build community resilience to climate change.

### 5.3.2 Recommendation for Further Research

Research and policies should focus on water harvesting methodologies, regulates river flows by constructing weirs and use the underground water, which are appropriate integrated strategies in water management where SEA at policy and programme levels and EIA at project level will help to reduce environmental degradation at grass root level and identify water catchments where water can be retained.

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# APPENDECIES

## Appendix 1:THE IMPACTS OF CLIMATE CHANGES ON FOOD SECURITY AND COMMUNITY BASED ADAPTATION OPTIONS A CASE STUDY IN MAGU DISTRICT, MWANZA TANZANIA

### 1.0 IDENTICATION OF THE AREA

1.1 Name of village: …………… Ward:…………….Division: …...……………..
District:………….. Region ………………………..…

1.2 Proximity distance to the Lake Victoria (tick appropriate)

≤ 1Km. ( ) walking time ………………………………….

5Km. and < 10Km ( ) walking time …………………………………..

≥15 Km ( ) walking time ………………….……………….

### 2 .0 HOUSEHOLD CHARACTERISTICS

**Table 2.1: Please provide relevant information related to households in the table below**

| S N | Details related to household head (fill appropriately) | | Fill number | | |
|---|---|---|---|---|---|
| 1 | Sex and age of household head ( Male = 1 Female =2) | | | | |
| 2 | Name of respondent and marital status ________________ | | | | |
| 3 | Relations of respondent and household head | | | | |
| 4 | Households size | | | | |

Relationship to household head of (1-4)

(i) Household head

**Code:** 1. Son/daughter……… 2. Grandson/granddaughter….…. 3. Spouse.……...
4. Father/Mother …………………... 5. Other relatives

(i) Marital status (4)

Code: 1= Single, 2=married monogamy, 3=married polygamy, 4=divorced/separated

**Table: 2.2 Education level and reason for living/moving to the village**.

| **Education level** | **Tick appropriate** | **Reasons for living/moving in the village** | **Tick appropriate** |
|---|---|---|---|
| Not attended school | | In born | |
| Class 1- 4 | | Search for work | |
| Primary Education | | Search for farmland | |
| Secondary education | | Search for grazing | |
| High school | | Followed family | |
| College | | Married in the village | |
| University | | Others | |
| Others | | | |

## 3.0 SOCIO-ECONOMIC ACTIVITIES

**Table 3.1: What are household is main economic activities? Tick and rank (according to priority)**

| Activity | Tick | Rank | Activity | Tick | Rank |
|---|---|---|---|---|---|
| 1 Farm income | | | 4.5 Retired | | |
| 1.1 Food crops | | | 5.0Forest products | | |
| 1.2 Cash crops | | | 5.1 Wild foods | | |
| 1.3 Food labor | | | 5.2Building poles | | |
| 1.3 Cash labor | | | 5.3 Medicinal | | |
| 2 livestock keeping | | | 5.4 Firewood | | |
| 2.1 Dairy cattle | | | 5.5 Hunting | | |
| 2.3 Indigenous Cattle | | | 5.6 Charcoal | | |
| 2.4 Goats | | | 5.7 logging | | |
| 2.5 Sheep | | | 5.8 Timber | | |
| 2.6 Poultry | | | 5.9 Honey | | |
| 2.7 pig | | | 6. Businesses | | |
| 3 Fishing | | | 6.1 Shop/Kiosk | | |
| 3. 1 Fishing | | | 6.2 Milling machine | | |
| 3.2 Sale fish | | | 6.3 Hotel/ Mama nitilie | | |
| 4 Employee | | | 7.Mason | | |
| 4.1 Government | | | 8.Carpentary | | |
| 4.2 Parastatals | | | 9. Molding | | |
| 4.3 Community based organization | | | Mining/quarry | | |
| 4.4 Non-governmental organization | | | 10, Others | | |

## 4.0 INFORMATION ON IMPACTS OF CLIMATIC CHANGES /VARIATIONS ON FOOD SECURITY

**Table 4.1: How does households head understand the term "Climate" and does how she/he describe rainfall and temperature patterns of the area in the past 30 years**

| Understanding word "climate" | Tick appropriate | Rainfall pattern of the area in the past 30 years | Tick appropriate | Temperature pattern in the past 30 years | Tick appropriate |
|---|---|---|---|---|---|
| Climate as drought | | Decreasing | | Decreasing | |
| Climate as floods | | Increasing | | Increasing | |
| Climate as Temperature | | Same | | Same | |
| Climate as rainfall | | I do not know | | I do not know | |
| Climate as wind | | | | | |
| Climate as humidity | | | | | |
| All of the above | | | | | |

**Table 4.2: How has the trend been for crop productivity per acre in past 10 years (tick in the appropriate box for each crop below)**

| Crop productivity trend | Food and Cash crops | | | | | | |
|---|---|---|---|---|---|---|---|
| | Maize | Sorghum | Cassava | Paddy | Pulses | Cotton | Sweet potatoes |
| Increasing | | | | | | | |
| Decreasing | | | | | | | |
| Same | | | | | | | |
| Not grow | | | | | | | |

**Table 4.3: How the trend has been for productivity of livestock products in past 10 years**

| Crop productivity trend | Types of livestock | | | | |
|---|---|---|---|---|---|
| | Cattle | Goat | Sheep | Poultry | Pig |
| Increasing | | | | | |
| Decreasing | | | | | |
| Same | | | | | |
| No livestock | | | | | |

**Table 5.0: Do you remember emergence attacks of plant and livestock pests and human disease vectors in your area in different weather conditions? Please fill in the table below (accordingly**

| Pests during dry season (drought) | Put the appropriate code ( below) | Pests during wetter season (flooding) | Put the appropriate code ( below) | Do you consider these effects caused by climate change/variation in your area? Yes/No | |
|---|---|---|---|---|---|
| | | | | dry season | wetter season |
| Plant | | Plant | | | |
| Armyworm | | Armyworm | | | |
| L Cassava Uganda Virulent | | Cassava Uganda Virulent | | | |
| Quelaquelea | | Quelaquelea | | | |
| Rodents | | Rodents | | | |
| Maize stalk bore | | Maize stalk bore | | | |
| Cut worms | | Cut worms | | | |
| Cassava meal bug | | Cassava meal bug | | | |
| Cassava brown virus | | Cassava brown virus | | | |
| Cassava mosaic | | Cassava mosaic | | | |
| Maize streak | | Maize streak | | | |
| Rust –red four beetle | | Rust –red four beetle | | | |
| Maize and rice weevils | | Maize and rice weevils | | | |
| Grain borer | | Grain borer | | | |
| Striga | | Striga | | | |
| Bean bruchids | | Bean bruchids | | | |
| Grasshoppers | | Grasshoppers | | | |
| Aphids | | Aphids | | | |

| | | | | | |
|---|---|---|---|---|---|
| Grain moth | | Grain moth | | | |
| Mango flies | | Mango flies | | | |
| White flies | | White flies | | | |
| Livestock pests | | Livestock pests | | | |
| East coast fever | | East coast fever | | | |
| Foot and mouth | | Foot and mouth | | | |
| Anaplasmosis | | Anaplasmosis | | | |
| Black quarter | | Black quarter | | | |
| CBPP | | CBPP | | | |
| Heart water | | Heart water | | | |
| Human deceases vectors | | Human deceases vectors | | | |
| Mosquitoes | | Mosquitoes | | | |
| Houseflies | | Houseflies | | | |
| Snails | | Snails | | | |
| Tsetse flies | | Tsetse flies | | | |

**Code:** 1 very high, 2 High, 3 same, 4 low 5 very low 6 Not applicable

**Table 5.1: Is your household experiencing food shortages? Yes/No (tick appropriate). Compare an average of past 10 years. If yes and answer the following questions below (tick appropriate)**

| **Length in months** | **Length of time food stocks last in normal years** | **Length of time food stocks last in drought years** | **Length of time food stocks last in wet years** |
|---|---|---|---|
| Between 1 and 2 months | | | |
| Between 3 and 4 months | | | |
| Between 5 and 6 months | | | |
| Between 7 and 8 months | | | |
| Between 9 and 10 months | | | |
| Between less 12 month | | | |

**Table 5.2: What are main causes of food shortages in your household? Give the answer in the table below**

| Main cause of food shortage | Tick the appropriate | Rank according to the its importance | Please consider answer given associated with climate change? Yes/no |
|---|---|---|---|
| Drought | | | |
| Floods | | | |
| Strong winds | | | |
| Much rains | | | |
| Overselling of food commodities | | | |
| Low soil fertility | | | |
| Weeds | | | |
| Crop pests | | | |
| Loss of livestock | | | |
| Livestock pests | | | |
| Shortage agricultural of labour | | | |
| Low household income | | | |
| Lack of production assets | | | |
| Lack of social networks | | | |
| Shortage of non agricultural labour | | | |
| Shortage of fishing facilities | | | |
| Lack of agricultural loan | | | |
| Poor available of inputs | | | |
| Poor heath of family members | | | |
| Others | | | |

## 6.0 HOUSEHOLD ADAPTATION OPTIONS TO CLIMATE CHANGE ON FOOD SECURITY

**Table 6.1: How do you address food shortages? Please fill in table below**

| Strategies to deal with food shortages | Tick the appropriate | Rank according to the its importance or priority |
|---|---|---|
| Buying food at harvesting time and keep for future | | |
| Getting assistance from relatives | | |
| Selling livestock for food | | |
| Work for food | | |
| Reducing amount of food eaten | | |
| Skip meals | | |
| Getting relief food | | |
| Eating less preferred food | | |
| Borrowing food | | |
| Reducing number of meals | | |
| Selling household assets to buy foods | | |
| Migrating to other places | | |
| Eating wild foods | | |

**Table: 6.2 What are households based adaptation options to climate change**

| Response options during the dry years | Fill an appropriate option | Response options during wet years | Fill an appropriate option |
|---|---|---|---|
| Growing early maturing crops | | Growing early maturity crops at the end of rainfall in up lands | |
| Growing drought tolerant crops | | Planting more water love plants | |
| Buying supplementary foods | | Buying supplementary foods | |
| Intercropping | | Engaged in fishing | |
| Irrigation | | Involves in fish sale | |
| wetland cultivation | | Temporary migration | |
| Emphasis on rearing small ruminants and poultry | | Engaged in hunting | |
| Emphasis on livestock keeping instead of crops | | Petty trading | |
| Increasing areas cultivated | | Bricks making | |
| Migrating (permanently/temporarily) | | Reduce meals | |
| Seasonal migration of | | Skip meals | |

| | | | |
|---|---|---|---|
| livestock keepers | | | |
| livestock herds in different places | | More use of fertilizer | |
| Casual labour | | Get remittances | |
| Selling of livestock | | Casual labour | |
| Early planting | | Selling of livestock | |
| Growing non-traditional crops | | Rainwater harvesting | |
| Reducing meals | | Plant early maturity crops at the end of rainfall | |
| Brick making | | | |
| Relief food | | | |

**Table 6.3: What is your perception on the following response options towards improving climatic change conditions?**

| Adaptations | Tick appropriate option |
|---|---|
| Improve mechanization (tractors and power tillers) | |
| Reduce livestock number by improving/ introducing new better breeds | |
| Use of improved technologies in food storage | |
| Improve traditional irrigation and introduce new ones | |
| Increase awareness of weather information's/ forecasts | |
| Use weather insurance | |
| Agricultural loan with low interest rate | |
| Agro-forest | |
| Improve community based adaptations | |
| Not applicable | |

**THANKS FOR YOUR COOPERATION**

Date filled…………………….    Date Edited …………………..

Date Entered…………………….

**Appendix 2**

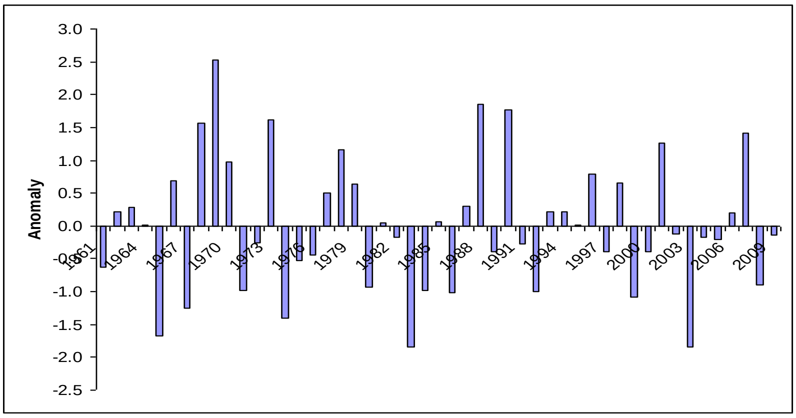


**Figure: Time series of normalized anomalies of January and February (JF) seasonal rainfall amount at Mwanza Airport Station** (ID 923209)

**Appendix 3**

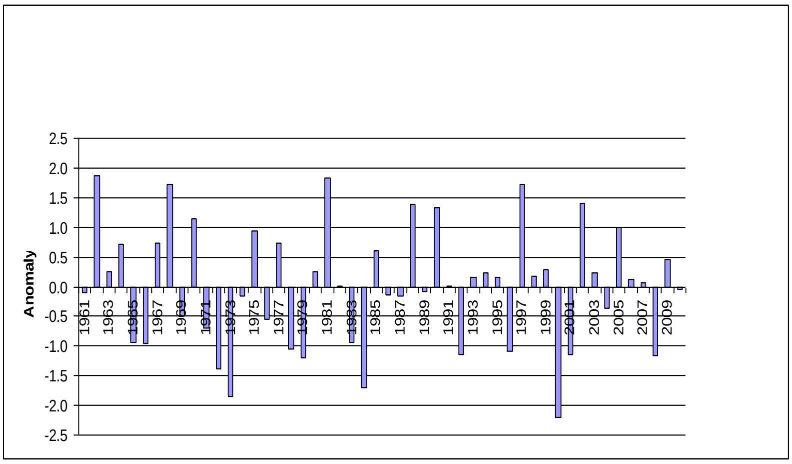


**Figure: Time series of normalized anomalies of MAM Seasonal rainfall amount at Mwanza Airport Station** (ID 923209)

**Appendix** 4

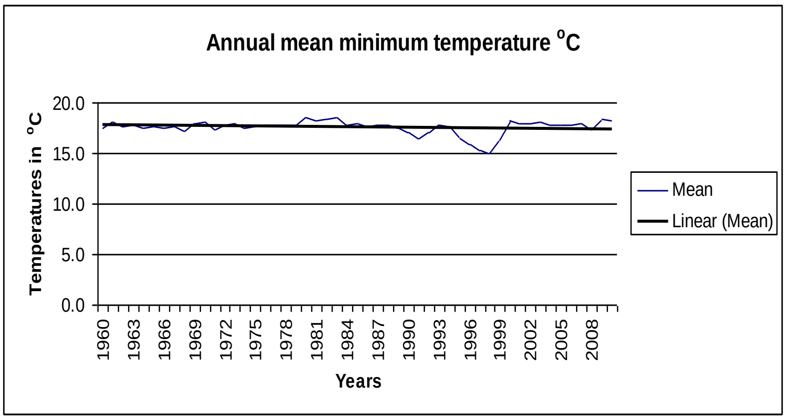


**Figure: Time series of annual mean minimum temperature at Mwanza Airport Station** (ID 923209)

**Appendix 5;**

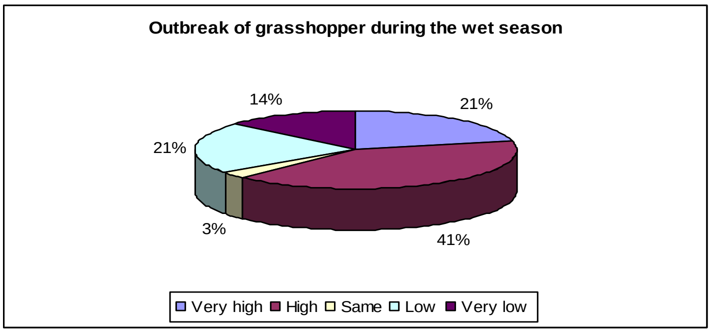


**Figure: Outbreak of grasshopper in wet season**

**Appendix 6**

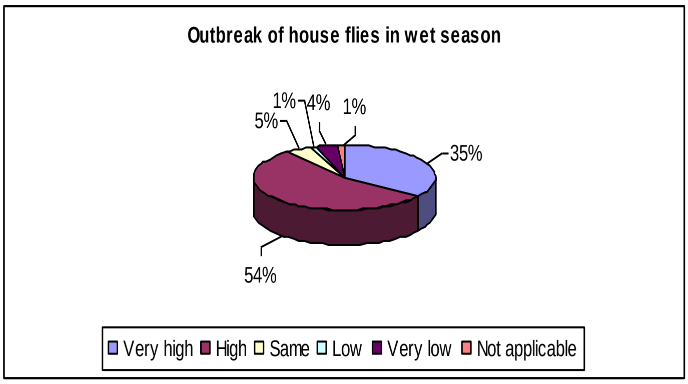


**Figure: Outbreak of house flies in wet season**