ASSESSMENT OF THE IMPLICATIONS OF CLIMATE VARIABILITY ON MAIZE PRODUCTION AND LIVELIHOODS IN MBOZI DISTRICT- TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

A study was carried out to assess the implications of climate variability (CV) on maize production and livelihoods in Mbozi District-Tanzania. Specifically, the study aimed at assessing the trends of rainfall and temperature for the last 30 years (1982-2012); establishing the relationship between CV and maize production; assessing the effects of CV on household livelihood; examining the relative importance of CV on maize production compared to other variables and assessing coping strategies devised by communities against CV. The study used a sample of 120 respondents selected randomly from four villages namely Senjele, Idunda, Isalalo and Utambalila. A structured questionnaire was administered for primary data collection. Maize production and CV secondary data for the period 1982-2012 were collected from District Agricultural Office and Mbimba meteological station respectively. Descriptive and inferential statistics were determined. Data was analysed by using SPSS. Results showed that: there was significant decrease in the mean annual rainfall and increase of temperature over the period. Climate Variability significantly influenced maize production and accounted for 88.6% of the variations in maize production. It also led to persistent food insecurity and low incomes among farmers'. Results also showed there was significant positive relationship between maize production and some socio-economic variable (household size, use of tractors and fertilizers and increase in farm size). Farmer in the study area devised various coping strategies which are non-agricultural and agricultural including stop selling foods; engage in small business, expansion of agricultural area, cultivation on wetland areas, timing and selling forest products. The study recommends that extension services be strengthened so that farmers will be more aware of the impacts of climate variability and can therefore design coping strategies that lead to reduction of the impacts for sustainable maize production.

DECLARATION

I, Hadija Mongomongo, do here by declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and that, it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

06/11/2014

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The above declaration is confirmed

6/11/2014

Prof. J.F. Kessy — Date
(Supervisor

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AMCEN	Addressing Climate Change Challenges in Africa
CV	Climate variability
DAICO	District Agricultural, Irrigation and Cooperative Officer
DED	District Executive Director
DNRO	District natural resource officer
FAO	Food and Agriculture Organisation of the United Nation
FGDs	Focus Group discussions
GM	Genetically Modified
Ha	Hectares
IPCC	Intergovernmental Panel Climate Change
KGS	Kilograms
MDC	Mbozi District Council
MT	Metric Tons
NAPA	National Adaptation Programmes of Action
SHZ	Southern highlands zone
SNAL	Sokoine National Agricultural Library
SPSS	Statistical Package for Social Sciences
SD	Standard Deviation
SUA	Sokoine University of Agriculture
TZS	Tanzania Shillings
TMA	Tanzania Metrological Agency
URT	United Republic of Tanzania
VEO	Village Executive Officer

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agriculture plays a very important role in providing food and income for the majority of the population in Sub-Sahara Africa (FAO, 2002). It accounts for an average of 45% of Gross Net Product and 60% of total export earnings (Majule, 2008). In Tanzania, agriculture is dominated by smallholder farmers, who depend mostly on rain fed agriculture (Mongi *et al.*, 2010).

Maize production is one of the most important agricultural activities considered as the main economic driver in Tanzania (Thurlow and Wobst, 2003) cited by (Rowhani *et al.*, 2011). The crop is largely grown in the Southern highlands zone for food and cash (SHZ) (Katinila *et al.*, 1998). Maize produced in this zone accounts for almost 50% of the total national maize production and up to 90% of the annual purchase of maize for the national strategic grain reserve (Lymo, 2006). Mbeya and Iringa regions are the largest maize producers, accounting for a quarter of the national maize production by producing on average more than 700 000 tonnes each year (Rowhani *et al.*, 2011; Barreiro-Hurle, 2012). In Mbeya Region, Mbozi District is the second largest maize producer producing 29.2% of regional maize production (URT, 2007). Maize has been cultivated in Mbozi for several hundred years, although currently it has attracted the attention of commercial farmers, it has never achieved the economic importance of coffee (MDC, 2012). Maize production accounts for 63.12% of all agricultural production in the District (MDC, 2013). Igamba is the leading Division in maize production, followed by Iyula and Itaka Divisions (MDC, 2010).

Climate variability (CV) is rapidly emerging as one of the most serious global problems affecting many sectors in the world and is considered to be one of the most serious threats to sustainable development with adverse impact on environment, human health, food security, economic activities, natural resources and physical infrastructure (IPCC, 2007; Huq *et al.*, 2006). According to Tanzania's NAPA (2007), agriculture has been identified to be the second most vulnerable sector to the impacts of climate change and variability.

Climate is statistical information, a synthesis of weather variation focusing on a specific area for a specified interval. Climate variability refers to change in one or more climatic variables such as rainfall and temperature over a specified time on temporal and spatial scale (CDIAC, 1990, Easterling *et al.*, 2000; Rowhani *et al.*, 2011). Examples of climate variability include extended droughts, floods and conditions that result from periodic El Niño and La Niña events. Climate variability is predicted to exacerbate current pressures on food security by affecting precipitation and increasing drought as well as pests and diseases (IPCC, 2007). Increase in temperature leads to higher rates of evapo-transpiration and heat stress to crops and further limits their yield potentials. The progressive decline in soil fertility is linked to a decline in soil organic matter content which results into limited soil water holding capacity, poor water infiltration rates and thus limits the availability of both water and nutrients to the crop plants (FAO, 2010). Siebert and Sieber (2010) asserted that, change in global climate variables may present risks to future livelihoods.

Maize production has complex interactions with climate variables. Thus, decreased rainfall and high temperature stress lead to a decrease in maize production (Madiyazhagan *et al.*, 2004). The quantity and quality of maize produced had been linked to climatic conditions, thus, predictability of these climatic elements is imperative for planning of farm operations (Sownmi and Akintola, 2009). The risk associated with climate variability of maize production in general depends mainly on the growth stage of the maize crop when the weather aberration occurs (Oseni and Masarirambi, 2011). Since maize production plays an important role in enhancing food security and household income (Morris *et al.,* 2003), increasing productivity is essential for livelihoods of smallholders who make the majority of the rural poor in Tanzania (Msuya, 2008).

1.2 Problem Statement and Justification of the Study

Climate variability is a global problem that will continue to influence agriculture production, and that farmers will continue becoming vulnerable to its impacts which can enhance or diminish agriculture (Molua, 2002). Poor rainfall in both amount and distribution coupled with prolonged drought spells has amplified the problem of moisture stress (Paavola, 2003). Such a situation has serious impact on food security and people's livelihood (Mongi *et al.,* 2010). The impact of climate variability on crops in Tanzania is expected to increase and have significant consequences on food production since both intra and inter-seasonal changes in temperature and precipitation will influence maize yields (Rowhani *et al.,* 2011). According to Paavola (2003), maize yields in Tanzania will be reduced by 80% by year 2075 due to impacts of climate variability. This will have substantial effects on economic performance and livelihood of rural communities that depend on rain fed agriculture (Lema and Majule, 2009).

Although major impacts of climate variability on agriculture have been documented, yet the extent of climate variability impact in Mbozi District has not been adequately studied. Further, very little is known on the extent to which maize production and livelihoods in the study area have been affected. Likewise, there is limited knowledge on the relative influence of climate variability on productivity when compared to other factors than those emanating from climate. On the other hand, coping strategies adopted by communities in Mbozi District as a result of climate variability have not been adequately studied. This study will facilitate understanding of the implications of climate variability on maize production and livelihoods in order to recommend on relevant intervention based on the existing knowledge and advice on what stakeholders should do in order to improve maize production and livelihoods.

1.3 Objectives of the Study

1.3.1 General Objective

To analyse the implications of climate variability on maize production and livelihoods of small scale farmers in Mbozi District.

1.3.2 Specific Objectives

The specific objectives were to:

(i) assess trends of rainfall and temperature in Mbozi District for the last 30 years

(ii) assess relationship between climate variability and maize production in Mbozi District

(iii) assess perceived effects of climate variability on household livelihood in Mbozi District

(iv) assess relative importance of climate variability as it affects maize productivity compared to socio economic variables in Mbozi District

(v) assess coping strategies devised by communities against climate variability in Mbozi District

1.4 Research Questions

(i) What are the trends of rainfall and temperature for the last 30 years in Mbozi District?

(ii) What is the relationship between climate variability and maize production in the study area?

(iii) What are the effects of climate variability on the livelihoods of households in Mbozi District?

(iv) What is the relative importance of climate variability as a variable affecting productivity when compared to other variables in Mbozi District?

(v) What are the strategies used by the communities in Mbozi District to cope with climate variability?

1.5 Conceptual Framework

There is evidence that climate variability is the major driver of changes in the crop calendar, yields and quality of crop products, because of the progressive rising in temperature and decreasing rainfall that had been taking place over decades, whose effects are more pronounced in the least developing countries (LDCs) especially African countries (AMCEN, 2011). Hence, the variability in rainfall patterns and the frequency of extreme weather events have placed considerable pressure on livelihoods and economies across the continent including Tanzania (*ibid*).

The conceptual framework presented in Fig. 1, describes diagrammatically the relationships and implications of climate variability on maize production and household livelihoods in Mbozi District from the concept that, temperature and rainfall affect maize production which in turn reduces household income and food security, and negatively affect household livelihoods. Variables presented include: climate variability (Temperature and Rainfall) which stands as independent variable that implicate the level of livelihood (dependent variable) by causing low maize and low household income and food insecurity. Also the presented conceptual framework explains socio-economic characteristics, institutional characteristics and coping strategies adopted by farmers in response to climate variability stimuli.

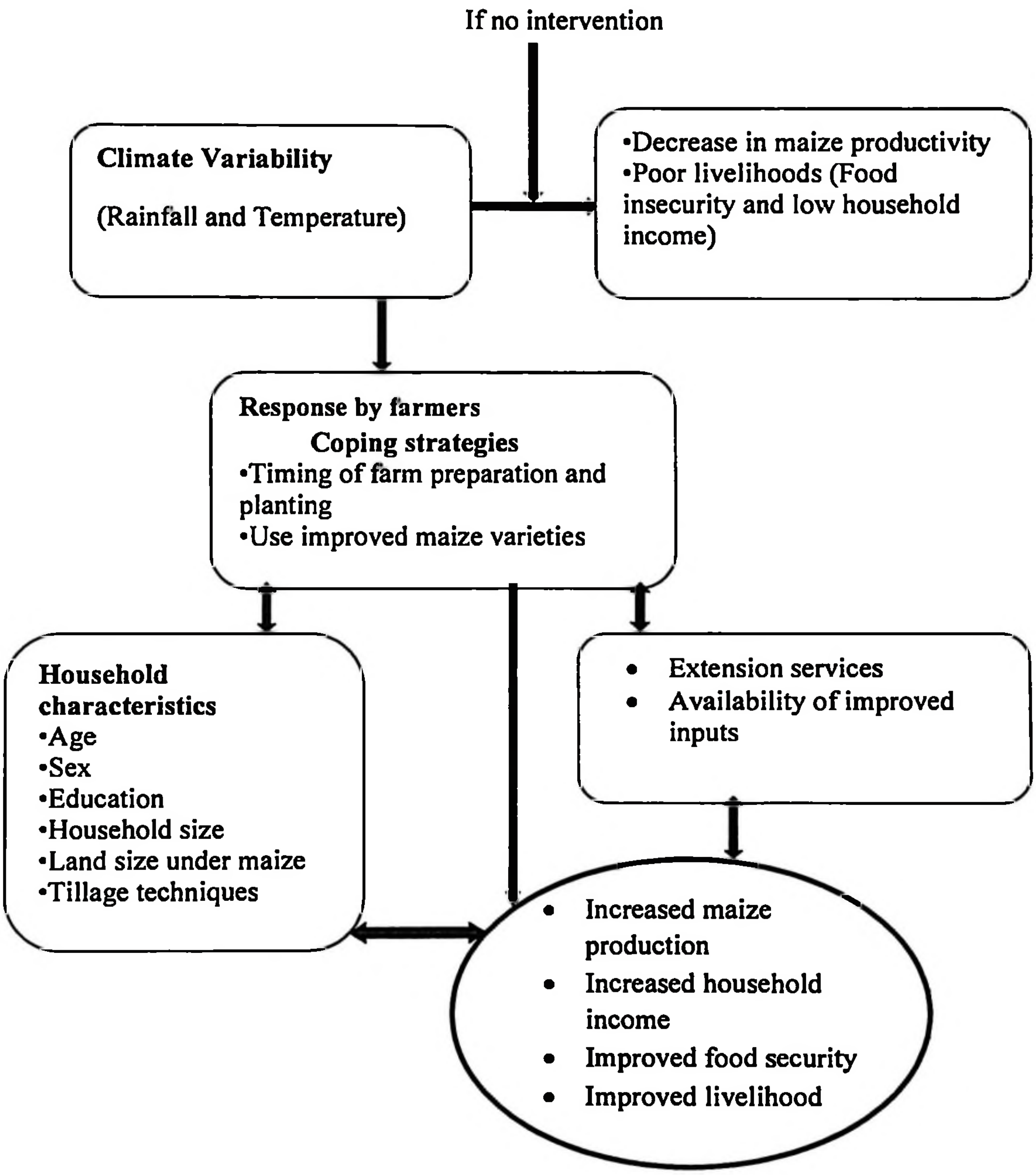

Figure 1: Conceptual framework

Source: Modified from FAO (2007)

The extreme events of climate variability which is explained in terms of trend decline rainfall and increase in temperature largely reduces crop yields especially maize yields if farmers will not be prepared for and if they are not correctly responding to the climate stimuli by developing coping strategies. However, copping strategies in response to climate variability will depend on farmers' socio-economic characteristics such as age, sex, education level, household size, and land size; and institutional factor such as availability of extension services, and availability and affordability of improved inputs.

Household characteristics influence the type of coping strategies by the farmer, for example, more educated farmers are expected to adopt coping strategies which lead to sustainable crop production than less educated farmers. Likewise households with large family size are thought of coping strategies which are labour intensive when compared to smaller sized households. Again extension services are thought of increasing farmer's awareness on various technologies which could be used by farmers to cope with climate variability effects which in turn increases maize production. Moreover, the availability of improved inputs determines accessibility of the input price and knowledge on how to use them. Thus, the level of maize production to sustain the livelihood of farmers depends on how they cope with variability risks through strategies (Adejaye, 2002). Capacities to cope with climate variability risks are built for sustainable maize production and increased household income, food security and improved household livelihoods.

Important copping strategies that are thought to be adopted by farmers in order to minimize the impact of climate variability include: improvement in the farm management practices, timely land preparation and planting, selling of forest products, cultivation on the wet lands, use of improved maize varieties, and use of the right fertilizer in terms of quality and quantity.

Since climate variability is a significant problem facing maize farmers in the study area, the knowledge of the climate variability trends will be imperative in order to exactly understand maize productivity in relation to climate variability trend so that correct and well-designed interventions could be made to make farmers adopt those copping strategies which will enhance sustainable maize production and environmental conservation within the study area. Moreover, the assessment of the perceived effects of climate variability on household livelihoods (household income and food security) in Mbozi District was important in this study since it was aimed at exploring what effects of climate variability had been brought to the households in order to inform various stakeholders like policy makers and non-Governmental organisations (NGOs) who plan for interventions, design the right developmental programmes and projects which will suit their client demand.

Furthermore, the assessment of the relative importance of climate variability as it affects maize productivity when compared to socio economic variables in the study was conceptualized to be important as it aimed at understanding the quantified effect of climate variability severity on maize production. This in turn could help to make various stakeholders be aware of the profound effects of climate variability which some people may have an oversight on them. Finally understanding of the coping strategies devised by the community in study area against climate variability, will be important in order to be well informed on various strategies used by farmers from which farmers will be advised to leave those strategies which contravene with reducing climate variability effects by advising the government and NGOs to help farmers use the best alternative strategies which could ensure sustainable crop production and reduce environmental degradation.

This study is expected to increase the knowledge on climate variability trend in the study area, the effects of climate variability relative to other factors on maize production, increase the knowledge on various sustainable coping strategies that do not increase climate variability, and therefore build farmers' capacity to cope with variability in climate for increased maize production, household income, food security and improved household livelihoods, and consequently contribute to the national strategy for growth and reduction of poverty among the people through maize production.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Climate Variability

Extreme climate variability conditions due to the global warming phenomenon have greatly affected the spatial and temporal distribution of rainfall in most parts of the world (Oseni and Masarirambi, 2011). The climate of Tanzania varies from place to place in accordance with geographical location, altitude, relief and vegetation cover (URT, 2003; NAPA, 2007).

2.1.1 Trends in rainfall

Although most parts of Africa have experienced decrease of rainfall in the last few decades, yet, there are some regions which have experienced an increase in rainfall (AMCEN, 2011). Rainfall had been decreasing in Botswana, Zimbabwe, the Transvaal, and in the Sahel during the period of 1961 to 1990 (Hulme *et al.,* 1996), but significant increase in rainfall was reported for South Africa (Mason *et al.*, 1999). In central Africa (Congo Basin), precipitation decreased slightly (2-3%) but heavy rainfall events increased in Angola, Namibia, Mozambique, Malawi and Zambia between year 1931 and 1990 (Boko *et al.,* 2007). The various changes in climate variables within a location and between locations increases the challenges already posed by climate variability in Africa (AMCEN, 2011). In Tanzania, predictions show that, areas with bimodal rainfall pattern will experience increased rainfall of about 5% – 45% while those with unimodal rainfall pattern will experience decrease in rainfall of 5%– 15%. All these changes increase impacts to the communities especially in the agriculture sector (NAPA, 2007).

2.1.2 Trends in temperature

Today, most parts of Africa experience increase in temperature (AMCEN, 2011). On regional scales, observation shows increases in temperature over the Sahel, tropical forests, Southern Africa, Eastern Africa and North Africa. The temperature of African tropical forests has increased by 0.29^0C since 1960, and that of Sahel increased by 0.2^0C-0.3^0C during the 1990s (Hulme *et al.,* 1996; Boko *et al.,* 2007). Collins (2011) reported significant increasing temperature trends in all African regions during the past two decades (1995-2010). Africa has experienced a 0.5^0C rise in temperature over the course of the 20th century, with some areas warming faster than others. Predictions show that annual mean surface air temperatures were expected to increase between 3^0C and 4^0C by 2099, roughly 1.5 times the average global temperatures (*Boko et al.,* 2007). Climatic projections show that annual temperatures in Tanzania may rise by 2.2^0C by 2100, with somewhat higher increases (2.6^0C) over June to August, and lower values (1.9^0C) for December to February. Temperature changes in Tanzania vary according to the geographical location, relief and altitude (NAPA, 2007).

2.2 Effect of Climate Variability on Agriculture

The African rain-fed agriculture is viewed by many observers to be the most vulnerable sector to climate variability and the potential impacts on agriculture are highly uncertain (Oseni and Masarirambi, 2011). In sub-Saharan Africa in particular, economic growth rates are closely tied to rainfall (AMCEN, 2011). There is substantial evidence that the frequency and intensity of extreme events of climate variability may continue to increase in the coming decades (IPCC, 2007), with this variability being particularly important for agriculture whereby changes in rainfall patterns and amounts have led to loss in crops production (Rosenzweig *et al.,* 2002). Also ground water resources decline/dried up due to prolonged drought results in to wide spread livestock mortality due to the lack of water and pasture in Mbeya Region (Bushesha *et al.*, 2009 cited by Lyimo and Kangalawe, 2010). The adverse impacts of climate variability in agriculture sector include reduced crop yield, reduced water availability, shifting of the seasonal rainfall and increased evapo-transpiration in the soil, which may keep crops from maturing due to lack of soil moisture and thus result in a shortage of food (IPCC, 2007). Increasing temperatures and declining precipitation in Africa resulting from climate variability are likely to reduce yields for primary crops in the next two decades, which will have a substantial impact on food security in Africa, although the extent and nature is uncertain (Boko *et al.*, 2007).

2.2.1 Effect of climate variability on maize production

Maize is grown in all regions of Tanzania (Katinila *et al.*, 1998). Most (85%) of the maize produced is consumed at the household level. Surpluses are bought by other farmers, by urban dwellers and by maize-deficient regions (Lyimo *et al.*, 2014). Climate variability affects maize yield and the various crop processes and activities in maize production. Year-to-year weather variability is regarded as the primary cause of year-to-year fluctuations in yields (Kumar e*t al.*, 2004). Maize as a crop is affected by climate variability (Kangalawe, 2010) due to higher temperatures that shorten the growing season and decrease rainfall in some regions (Mongi *et al.*, 2010). In areas where rainfall increases, there will be problems with leaching of nutrients and water logging (Häckner, 2009). Therefore, maize needs special attention in the adaption process and crop switching from maize is likely. Simulations conducted by Agrawala *et al.* (2003) show that the average yield of maize in Tanzania could decrease by 33% over the entire country over 2075. The simulations showed highest decrease in maize yield of 84 % would occur in Dodoma and Tabora regions. Mbeya and Songea were estimated to have yield decrease of 10 to 15 % (NAPA, 2007; URT, 2007). These declines have significant impact on food security given that maize is the most important staple food in Tanzania (World Bank, 2009).

Over 80% of maize production in Tanzania is produced by small-scale farmers under a wide range of management practices, climatic conditions and socioeconomic circumstances (Bisanda and Mwangi, 1996). Maize is grown almost exclusively under rain fed conditions. Dependence on rainfall has resulted in marked annual output fluctuations. According to this study, it is hypothesised that, increase in temperature is likely to cause significant reduction in maize production, while, the corresponding increase in the amount of rainfall is likely to cause significant increase in the maize production. This implies respective negative and positive relationships between maize production and climate variables (temperature and rainfall).

Although temperature and precipitation are the most critical to the sustainability of food security and household income, yet, they are not the only determinants, since there are other factors also affecting food security and income either positively or negatively. Other factors which affect maize production include production systems, farm size, seed varieties, and soil fertility management, production inputs, pests and diseases (URT, 2003). However, it is important to study their effects because they result into diversion of resources to buying food staffs instead of being directed towards achieving livelihood development issues like education and health services.

2.3 Effects of Climate Variability on Livelihoods

Households are involved in rain-fed agriculture as their main source for livelihood (Lyimo and Kangalawe, 2010). Climate variability induces various types of stresses on livelihoods, such as reduced production of food crop in affected areas, reducing food access and incomes from agricultural production. Increases in food prices compromise affordability and access to food, resulting from less food being produced or less money available to buy more expensive food and farm inputs (Malberg, 2011). The agricultural system which is dominated by a single crop (maize) which is largely dependent on rain-fed agriculture has declined over the years due to rainfall variability and drought, subsequently increasing households' vulnerability to erratic weather and food insecurity. Minimal shocks to maize production due to weather vagaries therefore have, a profound impact on the ability of rural households, especially the chronically and resource poor, to maintain their food security (Oseni and Masarirambi, 2011).

2.3.1 Livelihood Concepts and Livelihood Strategies

A livelihood is a means of making a living. It encompasses people's capabilities, assets, income and activities required to secure the necessities of life (Chambers, 1989; Chambers and, Conway, 1992; FAO, 2005). According to Anand *et al.* (2005) and, Martha and Sen (2003), capability refers to ability human being to make a good life, and that, living a good life is the opportunity rather than the accumulation of resources; thus, accumulations of resources doesn't matter for an individual to have good life except that, he or she get opportunity for transforming resources into well-being.

Livelihood is also defined as adequate stocks and flows of food and cash to meet basic needs. Three fundamental attributes of livelihoods are the possession of human capabilities such as education, skills, health; access to tangible and intangible assets; and the existence of economic activities (Chambers and Conway, 1991). Interaction between these attributes defines the livelihood strategy a household will pursue (Carney *et al.*, 1999). Livelihoods are not localized phenomena, but connected by environmental and other processes to wider national and global arenas. Agriculture is the dominant sector in the Tanzanian economy that sustains livelihoods by providing food security and household income to over 80% of the population (NAPA, 2007). Climate variability can have increased serious impact on food security and household income among many farming families (Morris *et al.*, 2003). A livelihood will only be sustainable when it can cope with and recover from external stresses and shocks (Carney, 1998). The variability impacts have been pausing significant influence on the production and livelihoods of maize producing households in the study area.

This study looked at food security and household income because; they contribute to local economic development; poverty alleviation and social inclusion. In food security this study looks on food systems which determine food security status by looking food system elements which are food availability, accessibility and utilization (Codjoe and Owusu, 2011).

2.3.1.1 Definition of a household

Household is regarded as the social unit which is the most appropriate for investigating livelihoods. It is a social group which resides in the same place, share the same meals and makes joint or coordinated decisions over resources allocation and income pooling (Ellis, 2000). This study defines household as a total number of all members in the house as a unit.

2.4.1.2 Household income

Income is widely used as a welfare measure because it is strongly correlated with the capacity to acquire many things that are associated with an improved standard of living such as food, clothing, shelter, health care, education and recreation (Morris *et al.*, 1999). In rural areas household is the main source of income. However, income earned through different activities such as selling crops, off- farm employment and other related activities. All of these cannot suffice to obtain adequately family food especially when households own production is affected by unfavourable condition (MoA, 1996).

2.3.1.3 Food security

Food security defined as when all people, at all time, have physical and economic access to sufficient, safe and nutrition's food to meet their needs and food preferences for an active and health life. Food security depends on food availability (production, distribution and exchange), food access (affordability, allocation and preference) and food utilisation which include nutritional value, social value and food safety (FAO, 2001). It is these three facets of the food system that all need to be met in order for food security to be realized. Each of these facets can be impacted by climate variability (Ziervogel *et al.,* 2006). Indicators used to measure food secure are such as meals/day, number of months of self-provisioning, change in diet, percentage total income on food, migration and changes in adult anthropometry (FAO, 2002). Food systems comprise certain activities, resources, and infrastructure that collectively determine the food security status of a region or a group of people (Codjoe and Owusu, 2011). Not only maize are importance as a widely consumed food staple but also important in a nutritional point of view because many popular weaning foods for infants are made from maize (Morris *et al.,* 1999). Food insecurity remains one of the most visible dimensions of poverty and is generally the first sign of extreme destitution. Fighting poverty; ensuring food and nutrition security while protecting the environment still remains as a major challenge facing the global development practitioners (Ayinde *et al.,* 2013).

2.3.1.4 Food availability

Within the context of food systems, food availability refers to the existence of food stocks for consumption, which can be influenced by the state of the transportation network (Ziervogel *et al.,* 2006; Codjoe and Owusu, 2011). Food availability status is calculated by subtracting the food sold from what is harvested. This analysis gives an idea of the food stock available to households for consumption.

2.3.1.5 Food accessibility

Household access is the ability to acquire sufficient quality and quantities of food to meet all nutritional requirements of the members of the household. Factors that determine food accessibility include financial resources as well as by social and political factors (Ziervogel *et al.,* 2006) or other means to purchase, barter or gather food, market price and availability of credit, and food transfers from relatives, community or government (Codjoe and Owusu, 2011). Food access is closely linked to food supply; therefore, food security is dependent on a healthy and sustainable food system. The food system includes the production, processing, distribution, marketing, acquisition and consumption of food (Ayinde *et al.,* 2013). House food accessibility is also determined by factors such as storage, distribution and marketing, cultural behaviour, transport network, real income and pricing policies (Wagao, 1998). Other factors are demographic characteristics mainly household size and education of the spouse these influence the consumption aspects of the household. Frequency of meals per day is an indicator of food accessibility and nutritional status. For those who have access to food they can afford more than two meals per day and under severe shortages one meal per day may not be assured (FAO, 2005).

In recent years individual farmers have started to copy and use improved technologies including machineries and planting of improved seed varieties. International agricultural research institutes and collaborating national partners have developed a number of improved technologies in Tanzania. There is a need for proper diffusion of innovation to farmers according to particular environment, because agricultural production still remains the main source of livelihood for most rural communities in developing countries and Sub-Saharan Africa in particular (Ayinde *et al.,* 2013).

2.3.1.6 Food utilization

Food utilization relates primarily to food processing, storage, sanitation, apportionment of food and frequency of meals, and the nutritional value of food stocks (Codjoe and Owusu, 2011). Utilization of food depends on how food is used, whether food has sufficient nutrients and a balanced diet can be maintained (Ziervogel *et al.,* 2006).

2.4 Effect of Other Factors Rather than Climate Variability on Maize Production

Smallholder maize farmers in Tanzania face challenges on maize production due to climate variability which mainly lead to low productivity. Climate variability has negative and positive impact on maize productivity. Although fall or rising of productivity not only caused by climate variability, but also there are other factors which can determine productivity among smallholder farmers. The impact of climate variability become more pronounced when there is interaction with other non-climatic stressors (Lyimo and Kangalawe, 2010).

Productivity of crops depends on several factors including land type, rainfall distribution (starting and ending), early planting, weeding, moisture distribution, pests and farm management practices (Sayed *et al.*, 2014). Oseni and Masarirambi (2011) reported that, climate variability affects maize production; however, it is important to state that other factors such as poor accessibility to inputs partly due to increased prices may have also contributed to decline of maize yields.

Generation of maize technologies have brought about significant increase in farm productivity (Morris *et al.*, 1999). An understanding of the relationships between climate variability and other factors is essential in order to compare and to know the relative importance of each on maize productivity in the study area. Most other factors which influence maize production are farmer's age, education, access to extension services, access to credit, agro-ecological zones, land size used for maize cultivation, famer's family size, gender, tenancy, market access, and farmers' access to improved technologies such as fertilizer, agrochemicals, tractors and improved seeds either through the market or public policy interventions.

According to Morris *et al.* (1999), most farmers who cultivate their fields by hand, plant their maize in a random pattern. In contrast, most of the farmers who cultivate their fields using animals or tractors, plant their maize in rows. Similar contention was made by Kirway *et al.* (2000) cited by Lyimo *et al.* (2014) that, framers who use hand hoes for planting, reduce the seed rate as compared to using tractors or oxen. Since food insecurity is not solely about climate, it is also, about a range of social, economic, and political factors that are linked to physical factors (Ziervogel *et al.*, 2006). Thus strategies other factors rather than climate variability had an impact on maize production.

2.5 Coping Strategies to Climate Variability on Maize Production

In as much as climate variability is inevitable, maize production systems should be able to adapt to the weather fluctuations and climatic aberrations in order to minimize their negative effects (Oseni and Masarirambi, 2011). Coping with or managing climate variability in maize production systems requires a combination of measures that involve the choice of maize variety, understanding of climate science by agricultural experts and the community, crop management and changing the maize variety to plant (such as planting a drought-tolerant, early-maturing variety or the use of genetically modified (GM) maize seeds).

Coping strategies are mechanisms which are used by people as measure to tackle some difficulties in the community or household (Ishika, 2005). Coping strategies differ from one place to another according to several reasons such differences in ecological zones, society, age, economic activities and climatic conditions in the particular area. Coping and adaptive strategies are important in reducing the implications of climate variability on maize production and livelihoods in vulnerable social group. Coping strategies are short terms while adaptation strategies are long term developed alternatives activities to cope in order to secure food or income (Low, 2005). An indirect consequence of climate variability impacts is increased pressure on natural resources like forests leading to deforestation and increased soil erosion as people turn to charcoal and agricultural expansion as coping strategies (Hepworth, 2010). Coping refers to the short-term responses that are utilised to face a sudden, unanticipated climatic risk; whereas, adaptation is a more long-term process that entails some socio-economic and institutional changes to sustain livelihood and food security (Orindi and Eriksen, 2005).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Geographical location

The study was carried out in Mbozi District (Fig. 2) specifically in Senjele, Idunda, Utambalila and Isalalo Villages. Choice of the study area was based on high maize production potential in Mbeya Region (FAO, 2007). Mbozi District is among the six Districts of Mbeya Region which are: Ileje, Momba, Mbarali, Chunya, Mbeya Rural and Mbozi. Mbozi District is located at the south western part of Mbeya Region, between latitudes 80 and 9^0 12' South of the Equator and Longitudes 32^0 7' 30'' and 33^0 2' 0'' to the East of the Greenwich Meridian. It is bordered by Chunya District to the North, Ileje District to the South, Mbeya Rural to the East and Momba District to West (MDC, 2013).

3.1.2 Area and Administrative Subdivisions

According to Mbozi District profile (MDC, 2013), the District occupies 340 400 hectares ha generally classified as:-Arable land 255 300 ha (75%), forest reserves 34040 ha (10%), settlement and other uses 44 252 ha (13%), and area covered by water 6 808 ha (2%). The District is administratively divided into 4 divisions namely Iyula, Vwawa, Igamba and Itaka, and one township authority known as Vwawa which has got 18 wards (Nambinzo, Itaka, Isansa, Ruanda, Iyula, Nyimbili, Mlangali, Myovizi, Igamba, Halungu, Msia, Mlowo, Vwawa, Isandula, Ihanda, Ipunga, Nanyala and Bara ward) and 101 villages, and 579 hamlets.

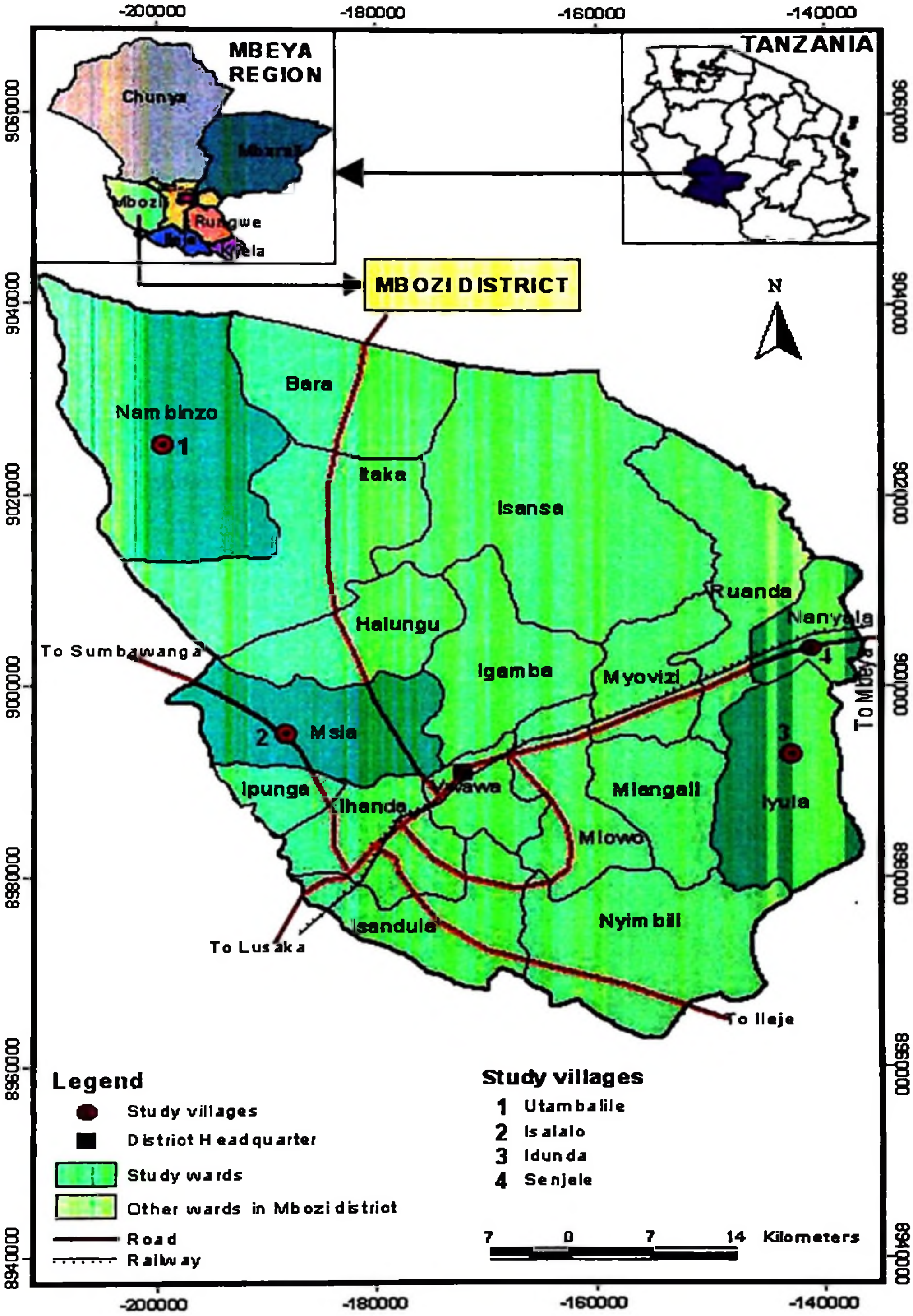

Figure 2: **The map of Mbozi District**

Source: **Remote Sensing and GIS Laboratory at SUA (2014)**

3.1.3 Physical features and climatic conditions

Mbozi District lies between 900 – 2750 meters above sea level. Its topography is characterized by several hills with rivers and fertile valleys which are suitable for irrigation. Within the valleys three types of soil are found: volcanic soil and clay soil with a good mixture of sand and alluvial loam and silt soil. Though the vegetation cover has been widely removed through agricultural activities, some natural vegetation is still observed especially along the river valleys. Its climate is characterized by moderate temperature and high rainfall. Due to these characteristics, major crops grown in this zone include coffee, maize, beans, bananas, and to a small extent paddy and potatoes (Irish and sweet potatoes).

3.1.4 Population size, growth and ethnicity

According to the 2012 Tanzania National Population Census (URT, 2013), Mbozi District had a population of 446 339 people of which 213 217 were the males and 233 122 females. The intercensal growth rate for Mbozi District was 2.8% which is slightly higher than the national annual average growth rate of 2.7%. The overall sex ratio is 91 males for every 100 females. High population growth rates above national level are caused by: high rate of immigrants looking for fertile soil and pasture and high fertility rate due to low practice of family planning (MDC, 2013).

The population distribution pattern in the District is large and influenced by land fertility, climatic conditions and availability of social economic services. This explains the concentration of people in the two township centres (Vwawa and Mlowo) and wards within the highland zones. The major ethnic groups in terms of their number are Nyiha which accounts for over 50% of the total population. Other ethnic groups include: Nyamwanga, Wanda, Nyakyusa, Kinga, Ndali, Lambya, Malila, and Safwa (MDC, 2012; URT, 2010).

3.1.5 Agriculture

Agriculture is the main economic activity in the district whereby about 88% of its inhabitants depend on agriculture and livestock production. Agricultural production accounts for over 80% of the district earnings. Agricultural production is mainly done by smallholder farmers (Peasants) of whom 50% use hand hoes, 40% use animal draught power and 10% using motorized equipment such as tractors. Crop production depends on availability of rainfall and hence, production is mostly unstable with a slight trend increase over the years. The major food crops include maize, potatoes and beans; while the major cash crop is coffee which is produced in the highland zone.

3.2 Research Design and Sampling Procedures

A cross-sectional research design was applied in this study whereby data were collected at single point in time (Babbie, 1994). This design is favourable because of time and resources limitations. Three divisions (Iyula, Igamba and Itaka) were selected purposively for study. Further, four wards (Nanyala andIyula wards from Iyula division, Nambinzo ward from Itaka division and Msia from Igamba division) were also selected purposively for study. Selection was based on maize production and the climatic conditions of the particular area. From each ward, one village was selected randomly. Senjele and Idunda villages were selected to represent the highland agro-ecological settings while Utambalila and Isalalo represented the valley bottom altitudes (Liwenga *et al.*, 2007. A complete and numbered list of all maize farming households in the respective villages was collected from field agricultural officers in respective village. Key informants which included four village agricultural extension Officers, four village executive officers (VEO), District environmental specialist, District Agricultural, Irrigation and Cooperative Officer (DAICO), District water engineer officer and District natural resource officer (DNRO) were selected purposively for discussion.

3.3 Sample Size

Matata *et al.* (2010) argued that, a sample size of 80-120 is adequate for social studies in Sub-Saharan Africa. Hence, in this study, 30 respondents were picked randomly from each of the four villages to make a total of 120 respondents and 12 key informants.

3.4 Data Collection

Both primary and secondary data were collected in order to address the specific objective of the study.

3.4.1 Primary data

3.4.1.1 Household interview

Primary data were collected according to specific objective. Primary data that address objectives 3, 4 and 5 were collected by using structured questionnaires (Appendix VI) which were directed at household respondents while a checklist (Appendix VII) was directed at key informants. To increase data validity and reliability, farmers were interviewed by the researcher and experienced extension officers using a structured questionnaire developed by the researcher.

The interview was conducted to collect information direct from 120 respondents by administering a structured questionnaire, whereby, data on socio-economic characteristics, crops grown, maize production, maize harvested, sold and consumed as well as farm inputs in the last farming season, and house-hold income for four years, farm management options, tillage techniques, extension services were collected. Moreover, questions related to food availability, accessibility, marketing and storage, number of meals eaten per day, were asked and noted. In addition, questions about climate variability and its impact on maize production as was perceived by farmers; as well as questions on the coping strategies practiced by farmers in the study area were also asked and information recorded. This work was done by researcher with assistance of a team of trained enumerators who used to pay visit to individual household maize farmers in their homes and farms.

According to Yin (1994), reliability and validity of indicators are very import for any research work; hence, it is important to assess them before carrying out the actual study. Due to this then, a pilot study was conducted prior to the main study to pre-test the questionnaire whereby, 15 respondents were interviewed to be certain of the time planned for completing the interview and to observe reactions of respondents to certain questions and also make all necessary corrections and modification of the questionnaire.

3.4.1.2 Focused Group Discussion (FGDs)

The focused group discussion was conducted in order to get general information on the study variables whose information would not have been exhaustively covered through household interview with a questionnaire. According to Matthew and Ross (2010), a focus group is a semi-structured facilitated discussion with a small group of people. Focus groups are used to gather data which are generated in a discussion between group members with the help of a facilitator. A focus group usually consists of between 5 and 13 participants plus the facilitator and often a recorder or note taker.

Focussed group discussion, in this study, involved the use of checklists of items designed for key informants and FGDs to collect relevant information. Thus FGDs was done purposely to supplement the qualitative information obtained from the administered questionnaire. Qualitative data are data which describe items in terms of some quality or categorization (Dodge, 2003). In this study only one FGDs consisting of 8 participants was held for each village whereby village government offices were used as venues for discussion. During the FGDs, the participants were free to expose their feelings on the problems relating to implications of climate variability on maize production and livelihoods in the study area while the researcher facilitated the discussion.

3.4.1.3 Researcher's direct observation

Participant observer is described as the one who seeks to go beyond outward appearances and probe the perceptions, motives, beliefs, values and attitudes of the people studied (Njana, 2008). According to Mafupa (2006), participant observation is always essential to keep one's eye open when visiting community and to check what you are told against what you see. Hence, in this study, the researcher tried to be part of the community in order to see maize farming activities in the study area. Participant observation helped the researcher to see different maize farming activities (tillage techniques, farm management practises, maize storage facilities and size of land used for maize cultivation) within the fields.

3.4.2 Secondary data

According to Dodge (2003), secondary data are the data that are collected by someone else or for the purpose other than the current one. Vogler *et al.* (2008) defines secondary data as the data which have been collected and already analysed, but still available for other researchers to use and explore their own research questions. For this study, secondary data for addressing objectives 1 and 2 was collected from Tanzania Meteorological Agency (TMA) station located at Mbimba Coffee Research Institute of Mbozi District; and Mbozi District agricultural office where the respective time series data on temperature, precipitation and Maize yields over 30 years were collected. Other secondary data sources included published and unpublished information collected from various such as Sokoine National Agricultural Library (SNAL) and internet searches.

3.5 Data Analysis

3.5.1 Descriptive statistics

Descriptive analyses involved determination of means, frequencies and making cross tabulation, multiple response analysis and mean explore, whereby descriptive statistics such as mean, frequencies, maximum, minimum, standard deviation and coefficient of variation. As stated by Amaza *et al.* (2009), descriptive statistics are used to examine the socio-economic characteristics of the respondent's household. Statistical Package for Social Science (SPSS) software and Microsoft Office Excel (MOE) were used for analyses on patterns and trends of rainfall and temperature for the past 30 years. Likewise, minimum and maximum values were also computed and data presented in tables, charts and graphs.

3.5.2 Climate variability trend analysis

The trends of climate variables (Temperature and Rainfall) was determined from secondary data inputted in the Ms Excel programme, whose analysis generated trend model equation 1 with values showing positive /negative sign to indicate the direction of trend and amount to indicate the magnitude of climate variability variable over time, while the generated R-square indicated the magnitude of variations in climate variables due to changes in season.

$$Y = bX + a \qquad (1)$$

Where Y= rainfall or temperature trend

b = the trend magnitude

a = the trend in climate variability if time remains constant (intercept)

X =time (in years)

3.5.3 Relationship between maize production and climate variables

The relationship between maize production and climate variables was conducted in order to estimate the possible impact of climate variability on maize yields over 30 years in study area. Linear regression analysis (equation 2) was used to determine this relationship. Maize production in terms of annual maize productivity (tones/ha) was regressed on the climate variables in order to estimate their effects on the maize yield as Lobell *et al.* (2010) argue that climate variables (temperature and rainfall) are used as independent variables in such relationships. The analysis was performed in SPSS software.

$$M_{YIELDt} = \beta_0 + \beta_1 TEMP_t + \beta_2 RAIN_t + \varepsilon \quad \text{.......................................} \quad (2)$$

Where:

M_{YIELDt} =The Average Annual Maize yield recorded over 30 years (tones ha^{-1})

$\beta 0$ = Maize yield in absence of all the specified independent variables

β_1, β_2 = the estimated influences of climate variability

$TEMP_t$ and $RAIN_t$ =Average temperature and precipitation respectively

t = Time dimension (Years)

ε = A random error term for unknown variations in M_{YIED}

In order to make sure that the model variables were linearly related, the model was transformed into logarithmic form According to Benoit (2012) that, a regression analysis model should be transformed so as to handle situations when there is non-linear relationship existing between the independent and dependent variables. The common transformation used is logarithm transformation which is a convenient means of transforming highly skewed variables into one that are more approximately normal (*ibid).*

3.5.3.1 Multicollinearity test

Multicollinearity is defined by O'Bren (2007) as a statistical phenomenon in which two or more predictor variables in a multiple regression model are highly correlated, meaning that one can be linearly predicted from the others with a non-trivial degree of accuracy. In this situation, the coefficient estimates of the multiple regressions may change erratically in response to small changes in the model or the data. Thus, a multiple regression model with correlated predictors can indicate how well the entire bundle of predictors predicts the outcome variable, but it may not give valid results about any individual predictor, or about which predictors are redundant with respect to others (O'Bren, 2007; Kock and Lynn, 2012; Martz, 2013).

In order to be sure that independent variables were not correlated (do not suffer from multicollinearity), factors that may reduce the validity of results, the degree of autocorrelation was assessed by performing correlation analysis and collinearity diagnostic test based on the Variance inflation factor (VIF) whose value should be less than 5 (O'Bren, 2007; Martz 2013)., Otherwise, if there should be serious problems of multicollinearity among the specified independent variables of the regression model of analysis, the problems may result into insignificant values of the independent variables better (β) estimates for the independent variables. Moreover, Martz (2013) continued to argue that when the VIF is equal to 1 there is no multicollinearity among factors, while a VIF value of greater than 1 suggests that there may be some moderate correlation among the predictors which are not enough to be overly concerned about. But a VIF value of between 5 and 10 indicates high correlation that may be problematic and hence becomes an indication of poorly estimated regression coefficients due to multicollinearity (*ibid*).

3.5.4 Effects of climate variability on maize production and livelihoods

Descriptive statistical analysis such as frequency and cross-tabulation were conducted for analysing the relationships between climate variability and household livelihood (household income and food security). Such analysis was used by Xenarios *et al.* (2012), where cross-tabulation analysis was applied in order to get a better understanding on the potential relation between land ownership status and practical alleviation measures for the mitigation of climate change impacts at a household level. Then the chi- square test was employed to explore the relationship between the household income level categories and what was experienced by the farmer on the amount of rainfall reported through farmer memories.

3.5.5 Climate variability effects in relation to other variables on productivity

Analysis of the relative importance of climate variability as it affects productivity when compared to other variables was conducted using a multiple regression model variables in as presented by equation 3. In this analysis, the multiple regression model was a tool that was used to estimate the contribution of other factors than climate variability on maize yields. Multiple regression analysis was done to assess independent variables which significantly contributed to maize productivity. This procedure was selected because of its wide use in the social and natural sciences research, and that it's easier to handle (Chianu and Ajani, 2008) cited by (Hatibu, 2010). Dependent and independent variables of the model are shown in Table 1 and equation 3.

Furthermore, issues of multicollinearity were handled as described in section 3.5.3.1 whereby independent variables which had significant correlations among themselves were removed from the model equation 3. The remaining variables were: use of crop rotation (ROTA), use of tractor (TRACT), household size (HHS), use of fertilizer (FERT), access to extension services (EXT), land size under maize production (LSIZE), use of improved maize seeds (SEEDS) and access to credits (CRED) which are presented in equation 6 of section 4.5.

$$Y= \beta_0+ \beta_1X_1 + \beta_2 X_2+ \ldots + \beta_{12} X_{12}+\mathcal{E} \quad \ldots\ldots (3)$$

Where: Y= the Average Annual Maize Yield;

$\mathcal{E}$ = A random error term for unknown variations in Y.

$\beta 0$ =Maize yield in absence of all the specified independent variables;

β_1, $\beta_2 \ldots \beta_{12}$ = The Estimated influences of the specified independent variables;

X_1, X_2, to X_{12} = Independent variables other than climate variables as shown on the Table 1.

Table 1: Factors influencing maize production apart from climate variability

Variable	Description on magnitude/ unit	Expected sign
X1= Crop rotation	1= Practiced, 0= Otherwise	±
X2 = use of improved seeds	1= use improved seeds, 0= Otherwise	±
X3=Till 1(Tractor ploughing)	1= use tractor , 0= Otherwise	+
X4=Till 2(ox ploughing)	1= use ox-plough, 0= Otherwise	+
X5= Till 3 (hand hoe tillage)	1= use hand hoe, 0= Otherwise	-
X6= Extension services	Number of visits by extension staff per year	+
X7=Area under maize	Number of Hectares	+
X8= Fertilizer use	1= use fertilizer, 0= Otherwise	+
X9= House hold size	Number of household members providing farm labour	+
X10= Sex of household head	1=Female, 0=male	±
X 11= Education level	Number of years in school	+
X12= Access to credit	1= access to, 0= Otherwise	+

3.5.6 Community coping strategies against climate variability effects

The analysis of coping strategies used by the communities in response to the effects of climate variability on maize production and livelihood, involved descriptive analyses of the variables after being coded and entered into SPSS programme. Descriptive analysis such as multiple responses was conducted to get descriptive statistics such as frequencies and percentages which helped to determine the score of each strategy used by farmers within study area. Then used the scores to identify which among the strategies was dominant coping strategies used by the community. This was followed by organizing and summarised the results into tables after which results were discussed and concluded for recommendations.

3.7 Limitations of the Study

The researcher faced several limitations in the study area during the period of conducting research. One of the limitations was that, much of the primary information depended on individual's memory whereby respondents rarely kept records of their activities. Therefore, there were some difficulties for the respondents to give answers on questions which demanded income generated from maize for the past four years; amount of maize harvested for the past four years; amount of maize stored and sold; and occurrence of events for the past 30 years (such events like flood and drought). Hence, the researcher resolved this by making careful probing which enabled the respondents to disclose and remember more information about the subject matter.

The study also was conducted during the time when farmers were preparing their farms for crop production; therefore, many of the respondents were not available to provide information during the morning hours, whose solution was to get hold of the best time for the respondent to be interviewed by contacting respondents on their best preferred time and sometimes interviewing them while they were on their farms.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents findings and discussions of the study on the implications of climate variability on maize production and livelihoods in Mbozi District. Section 4.1 describes the socio-economic and demographic characteristics of the respondent farmers, while sections 4.2 to 4.7 describe the major findings of the study.

4.1 Socio- economic and Demographic Characteristics of the Respondents

Socio economic and demographic characteristics of the respondents have influence on farmers' production decisions (Sulo *et al.,* 2012). Hence, these were also among the factors conceptualized in this study and thought to be influential on the side of the farmer's decisions in responding to climate variability stimuli. Such characteristics described in this section include sex, marital status, education level of respondents and household size. Thus, as far as the importance of socio-economic and demographic characteristics is concerned, it was imperative to conduct the analysis whose results have been presented in Table 2.

Table 2: Distribution of respondent across sex, marital status, education level and household size (n=120)

Variable	Categories	Frequency	Percent
Sex	Male	93	77.5
	Female	27	22.5
	Total	**120**	**100.0**
Age	26-45 years	53	44.2
	46-59 years	47	39.2
	>59 years	20	16.7
	Total	**120**	**100.0**
Marital status	Married	86	71.7
	Single	1	0.8
	Divorced	7	5.8
	Widow	18	15.0
	Separated	8	6.7
	Total	**120**	**100.0**
Education level	No formal education	38	31.7
	Primary education	74	61.7
	Secondary education	7	5.8
	College education	1	0.8
	Total	**120**	**100.0**
Household size	1-3	36	30.0
	4-6	65	54.2
	7-9	18	15.0
	>9	1	0.8
	Total	**120**	**100.0**
Household land size (Ha)	0.4-2	75	62.5
	2.4-4	18	15.0
	4.4-6	6	5.0
	6.4-8	5	4.2
	>8	16	13.3
	Total	**120**	**100.0**

4.1.1 Sex

Findings show that 77.5% of the respondents were males and 22.5% were females (Table 2). The reason for women being fewer was the fact that the interview focused on the heads of households which traditionally are males, otherwise females are considered heads of their households in cases where one is divorced, single or widowed. These evidences imply that, the involvement of women in maize production decision were smaller than men. This also indicates that, women decision making on implications on climate variability on maize production and livelihoods are quite minimal and hence become the first to be impacted with it. The findings are similar to those reported by Nzunda (2013), who observed that in Mbozi District, majority of the heads of households were male. Also Morris *et al.* (1999) in the study on adoption and impacts of improved maize production technology conducted under Ghana Grains Development Project (GGDP) asserted that on average, male farmers cultivate and own a significantly larger maize area than women farmers. Thus, sex was an important respondent characteristic in this study because being male or female in the social context of Tanzania has an implication on production, access and control over resources within households and also understanding of the issue related to climate variability.

4.1.2 Age

Findings from the study (Table 2) show that, many (44.2%) respondents were aged between 26 and 45 years, while 39.2% of the respondents were in the age group between 46 and 59 years old; however, very few respondents (16.7%) were the old aged individuals with aged above 59 years old. These findings indicate that most of the respondents in the study area were matured enough to make proper decisions in response to implications of climate variability on maize production. These findings on age are comparable to the report by the National Household Survey (2007) cited by Kessy and Njana (2009) where it was asserted that, about 37.8% of household heads in rural areas on average age range between 30-44 years old, and that, about 31.8% are aged between 45-64 years old. Age is very important aspect as it determines individual's knowledge and experience according to Overholt *et al.* (1991) in the study on gender analysis framework, whereby the authors observed that, knowledge and experience as well as the measure of maturity of individuals are determined by age. Additionally, Damisa and Yohanna (2007) found that, increased participation in farm decision making increases with age. Therefore, age is an important parameter in most societies, since it can determine different sets of activities and therefore important in understanding the way farmers perceive and copy with climate variability implications on maize production.

4.1.3 Marital status

The findings on marital status (Table 2) show that, most (71.7%) of the respondents were married and very few (0.8%) were single. On the other hand, divorced respondents and widows accounted for only12.5% and 15% respectively. According to key informants interviewed, it was revealed that, most of the households were headed by the male, and that the only female headed households were either households by the separated, divorced or widowed female individuals. Similarly, there were no female household heads in unbroken marriages. This implies that marital status is an important variable that influence maize production decisions especially in decision making on the issues relating to the implications of climate variability. The findings concur with Kidagho (2009) who found that, majority (95%) of respondents were married, and only few (3%) were single. The large number of married individuals in rural farming households has socio-economic implication. Damisa and Yohana (2007) they asserted that, marital status can influence maize production mainly in decision making. Thus, marital status plays an important role in maize production in the study area as it was the indication of who make decision within household which in turn do influence the way farmers perceive and cope with the effects of climate variability.

4.1.4 Education level

Findings on education level indicated that majority (61.7%) of the respondents had primary school level, while 31.7% had informal education, 5.8% secondary education level and that very few (0.8 %) respondents had attended college education (Table 2). The findings on education show that, most of the respondents were educated at the level of the basic education. However, the level of education varied from primary to secondary and tertiary. The large percent of individuals with primary education implies that, most of the farmers were able to read and write and thus able to comprehend much of the education extended through extension services within the study area which in turn would be expected of minimizing the impact of the effects of climate variability on maize production and therefore adopt sustainable production coping strategies.

The findings of this study on education are similar to Morris *et al.* (1999) who argued that, farmers' average level of education often plays a crucial explanatory role in technology adoption because better-educated farmers have greater ability to understand and manage complex technologies. Moreover, it also agrees with what Kajembe and Luoga (1996) who reported that, education is important to the farmers because it creates awareness, positive attitude, values and motivation, and therefore perceived as one of the factors that influence an individual's perception and decision making on a particular development. Thus, understanding education levels of respondents was imperative as it is an important aspect in assessing their skills and knowledge in judging and reasoning concerning different issues including the effects of climate variability and how best they would cope with. This is because of the fact that, one's education level was assumed to have positive impact in maize production through increased knowledge that is important in adoption of improved maize production technologies as the result of being more receptive to advice from extension workers or able to deal with technical recommendations.

4.1.5 Household size

The findings on household size (Table 2) indicate that, there were many (54.2%) respondent households whose sizes were between 4-6 household members, while very few (15%) of the households had sizes between 7- 9 household members. The large number of household members implies that, the amount of family labour available for household activities was reasonable, although, in some households, the number of household members included even the children, very old aged people and physically disabled individuals who do not participate in the income generating activities; and therefore, large household size implies high consumption units within the household.

The average number of household members from this study was 7 persons above the Tanzanian national average household size of 4.6 according to the report by Tanzania 2012 National Population Census (URT, 2013). This study results on household size is similar to what was found by Kwai (2013) in the study on the contribution of savings and credit cooperative societies to income poverty reduction conducted in Mbozi District of Tanzania that, the average household size was between 6-10 household members. According to Tuan and Tinh (2013), the household size correlates with the income and living costs of each household, and thus, households with more family members may have more labor available to make a living for the family.

4.1.6 Household land size

This study findings show that majority (62.5%) of the respondents had land size ranging between 0.4 and 2 hectare (ha), while 15 % of the respondents were owning land size that ranged between 2.4 and 4 ha. On the other hand, land size above 8 ha was owned by only 13% of all the respondents, while the other 5% and 4.2% of the households owned land size ranging between 4.4 - 6 ha and 6.4 – 8 ha respectively. The findings imply that most of maize farmer owned less than 10 ha. This study results on land size agree with what was reported by Katinila *et al.* (1998) that, about 85% of the maize produced in Tanzania is grown by peasants with farms less than 10 ha.

Similarly, these findings are concur with the report by Barnett *et al.* (2011) who found that in Mbeya, maize is commonly rain-fed which is grown in small fields of 0.5 to 1.5 ha per household. Furthermore, it is also in line with Mnenwa and Maliti (2010) who found that, most (67%) households owned between zero and 0.8 Ha of cultivated with only few (one third) of households owned more than 0.8 ha. All these imply that, in any production land is among the limiting factors which should be used sustainably by minimizing disturbances which could devastate climatic conditions which in turn would result into severe climate variability impacting on maize production, and this could be possible through increasing awareness among farmers on the implications of climate variability in relation to sustainable land use and use of sustainable coping strategies.

4.2 Climate Variability Trends in the Study Area

4.2.1 Findings on trends in rainfall for Mbozi District

The rainfall trend analysis for the period of 30 years (1982-2012) presented in Fig.3. The graph of the mean annual rainfall is plotted against the production. The findings show that there had been negative trend in rainfall in the study area over the period under the study. The analysis shows that, in 1983 the study area received an annual mean rainfall of about 300mm, which was below the annual mean received in 10 years (1983-1992) after which the mean annual rainfall increased to 301.1mm in the year 1993. The mean annual rainfall continued to rise 316.3mm in 1994 to after which the mean dropped in 1995, and slightly increased in 1996. This was followed by the highest amount of 361.7mm in 1997; this was the year which was reported to have El Nino rains.

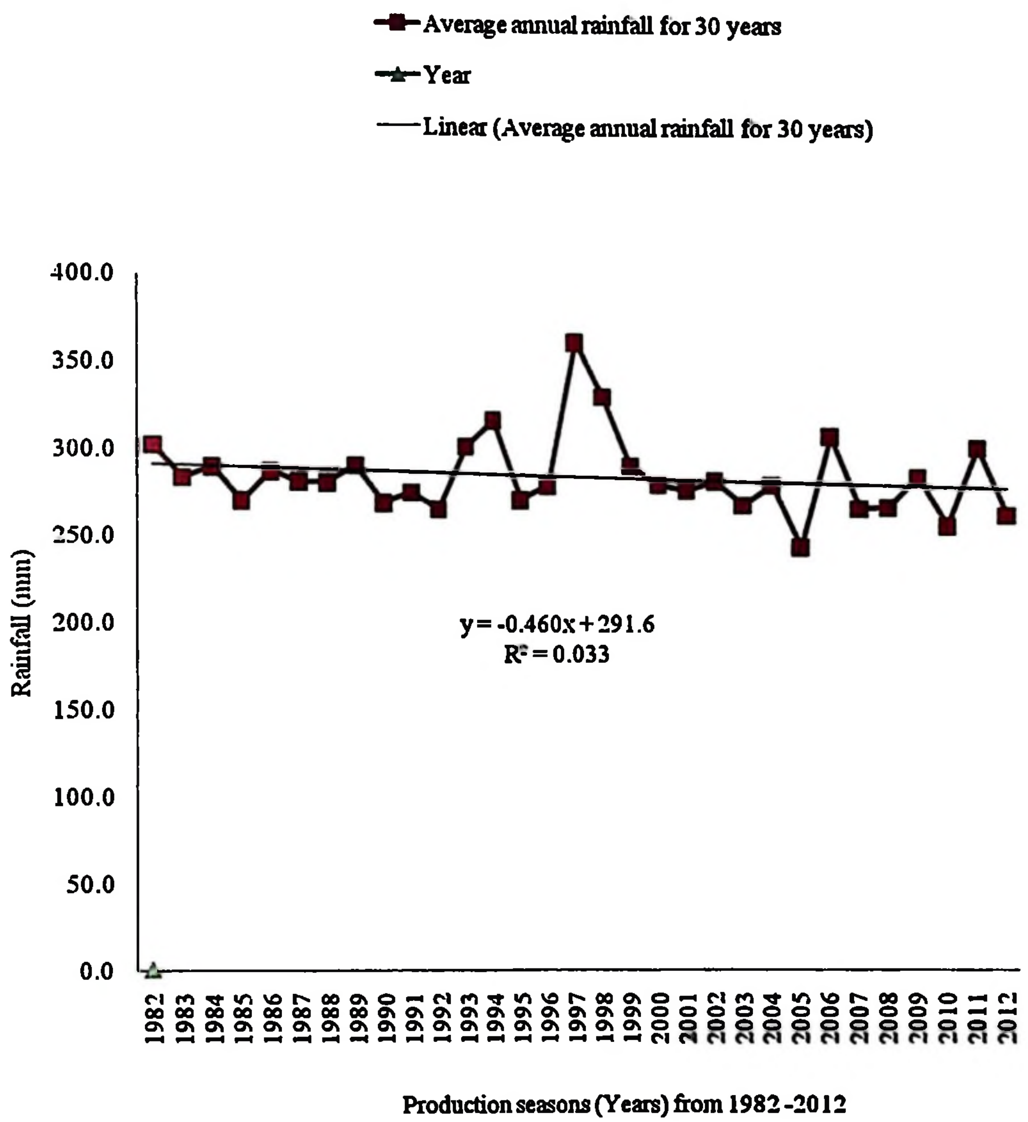

Figure 3: Rainfall trend for Mbozi District Tanzania

Source: Tanzania Meteological Agency, Mbimba station 2013

The equation Y= - 0.4604X+291.63 refers to the trend line equation generated from the graphical presentation of the Mean annual rainfall against production seasons (30 years period) for Mbozi District (Fig. 3); Where Y= Rainfall trend, X= Production seasons (time in years). From this equation it is found that, there has been significant trend decrease in the mean annual rainfall of about 0.4604mm which amounted to 13.812mm for 30 years period equal to 46.04% decrease in the mean annual rainfall as the result of climate variability. This estimated amount of the decrease in the annual mean rainfall is a substantial amount of rainfall. Thus, if the trend of decrease in the rainfall continues it will imply having very huge negative impact on maize productivity. Consequently, over years there shall be severe droughts which will affect maize yields in the study area if measures are not taken.

Furthermore, observing from the line graph, results show that there were cyclical variations of rainfall from year to year. According to the line graph (Fig. 3), the maximum rainfall amount that was received between 1982 and 2012 was 361.7 mm, while the minimum was 234.5 mm in 2005. These findings imply that climatic conditions of the study area experienced unpredictable variations whose impact caused great variations in the maize yields. The findings are similar with those reported by Mongi *et al.* (2010) that, rainfall is the important variable on maize production; this is because, any significant variability in rainfall could lead to greater variations in the annual maize yields. This shows that it is important to know the rainfall trend of a particular location for proper planning of relevant intervention to be effective and sustainably reduce climate variability impacts in crop production specifically in the rain-fed areas like Mbozi.

4.2.1.1 Rainfall variability during Months of maize growing season

Fig. 4 presents findings of monthly variations in the mean monthly rainfall for the months of November, December, January and February for the 30 year period. These months are very important as they reflect the major rain periods in the year for maize production in the study area. Findings on rainfall variability in these months indicate that the month of

November for year 1997 was dry period with no rains at all which was followed by very heavy rains in December whereby the study area received up to 800mm. However, in January in the same production season the area received lower amount of rainfall of about 200mm, which rose to more than 200mm but less than 300mmin February in the same year. Even though the month of November in 1997 was very dry, in 2006 the same month received heavy rains of about 300 mm which increased in December to about 500mm of rainfall in the same year. However, in January and February, the study area received less amount of rainfall below 200mm and 00mm respectively. Other months and years experienced cyclical fluctuations in rainfall which were even unpredictable (Fig. 4).

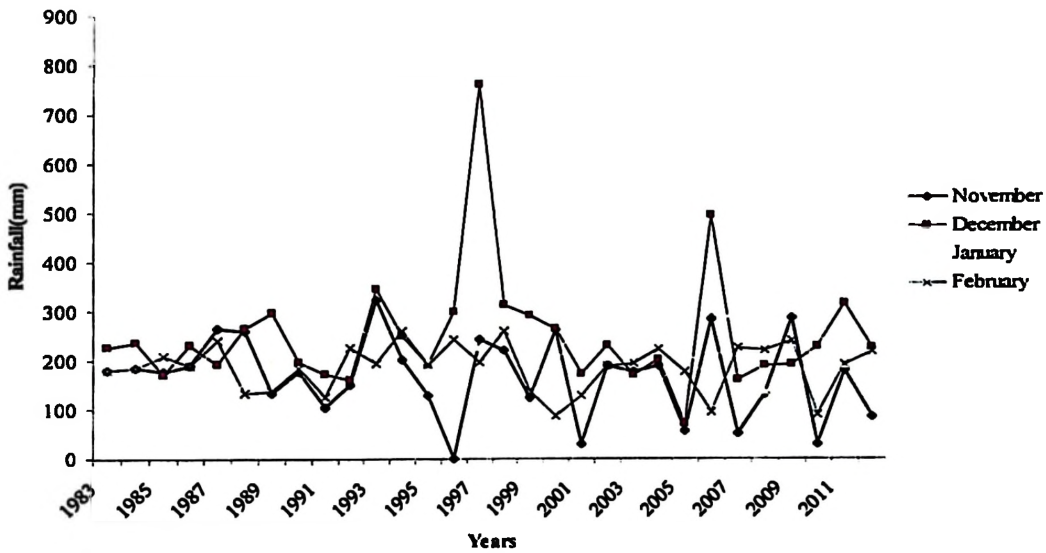

Figure 4: Rainfall variability during Months of maize growing season

Source: Tanzania Meteological Agency, Mbimba station 2013

This study results on the monthly rainfall experienced in the study area imply lack of uniformity the rainfall onset and planting dates for maize in the study area, which lead to failure of the farmers on planning for their farm operations. This resulted into incurring of costs associated with buying of seeds ploughing and replanting as seeds failed to germinate as reported by the key informants that, unpredictable rains and drought affected them in their effort for maize production.

These findings are similar to Oseni and Masarirambi (2011) where it was found that variations in spatial and temporal patterns of both total annual and planting season rainfall significantly affected crop production including maize crop which is rainfall dependent. Similarly, the study by Kangalawe (2012) reported that there had been decrease in rainfall which is associated with the disappearance of short rains that used to be received around September in the study area. Therefore, variations in rainfall had adverse impact on yields. This has negative implication on planning for maize production and choice of the coping strategy if farmers are not well informed and stakeholders do not participate in provision of relevant intervention. Thus, it important to understand the nature and behaviour of rainfall variations in study area so that adaptive technologies can be thought of disseminated and adopted by farmers for increased maize production, household income and livelihoods in the study area.

4.2.1.2 The annual rainfall trends in the study area as per farmers' experiences

Fig. 5 presents findings on the rainfall trends according to what had been experienced in the study area regarding the trends in the onset, intensity and variations of rainfall that the farmers had observed over the previous four years. Findings show that, many (89%) respondents experienced decreasing trend of the rainfall over time. Farmers' experiences on the trend decrease in the annual rainfall over the four years supports what was observed from the trend analysis of the study area climatological data (Fig. 3).

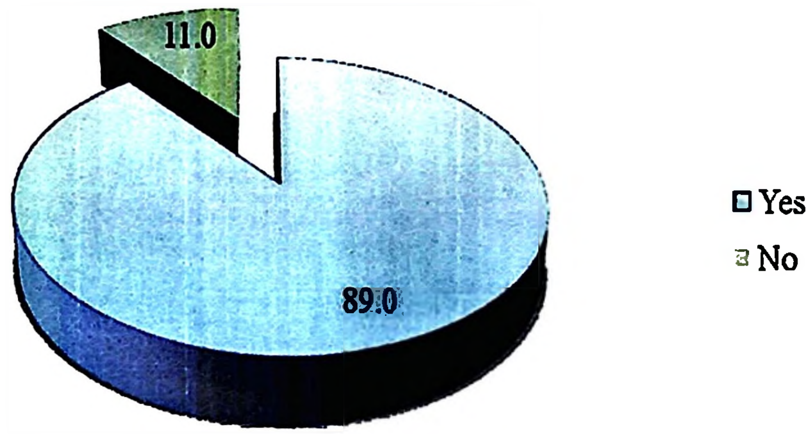

Figure 5: Farmers experience on decreasing amount of rainfall

Farmer's awareness of the variations in the climate that had been taking place in their area is a leeway for planning relevant valuable interventions which aims at improving maize production in the study area. These findings are similar to Gbetibouo (2009) who reported that, 97% of the respondents observed changes in rainfall patterns over the past 20 years, and 81% a decrease in the amount of rainfall or a shorter rainy season. Furthermore, findings confirm Simelton *et al.* (2011) where they reported that, farmers said that rainfall was becoming more erratic or more unpredictable with regard to temporal variations.

4.2.2 Findings on Trends in mean annual temperature for Mbozi District

Fig. 6 presents the findings for trend analysis conducted for the annual mean temperature observed over a period of 30 years in the study area. The graphical presentation (Fig. 6) of the mean annual temperature against production seasons (years) show that, there had been rising in the mean annual temperature over the period of 30 years. Although in some years the trend line appears to fluctuate showing an increase and decrease in temperature. However, there was more decrease in temperature than increase, for example, in 1982 the mean annual temperature was 24.5^{0}C which increased to about 24.6 ^{0}C in 1983 followed by a decrease in the mean annual temperature about 23.5 ^{0}C in1984 after which the mean temperature dropped to about 23.1 ^{0}C (Fig. 6).

Moreover, it is observed that the mean annual temperature started rising to about 24.4 ^{0}C in 1987 and dropped to about 23.6 ^{0}C in 1989, and thereafter increased to 24.2 ^{0}C (1993) followed by sharp increase to about 25.1 ^{0}C in 1995. Additionally, the temperature was 24.4 ^{0}C in year 1996 after which there was an increase in the mean annual temperature to about 25.0^{0}C in 1998 which then dropped to 24.2 ^{0}C in 1999. However, in 2001 the mean annual temperature was 24.7 ^{0}C which slightly dropped to 24.4 ^{0}C but rose to 25.2 ^{0}C which was the maximum mean annual temperature that was experienced in the study area. The mean annual temperature in other years is as presented in Fig.6. This persistent rise in temperature implies the effects of climate variability which has implication on the production of crops specifically maize in the study area.

The trend analysis generated an equation Y= 0.010X+23.96; (Fig. 6) which indicate that, there was an increasing trend in the mean annual temperature in the study area over the period of 30 years from 1982 to 2012. Thus, for each unit increase in time (from year to year), the mean annual temperature had been increasing by 0.01^{0}C. Which implies that, for 30 years period the increasing trend had led to substantial increase in the mean annual temperature of about 0.3 ^{0}C.

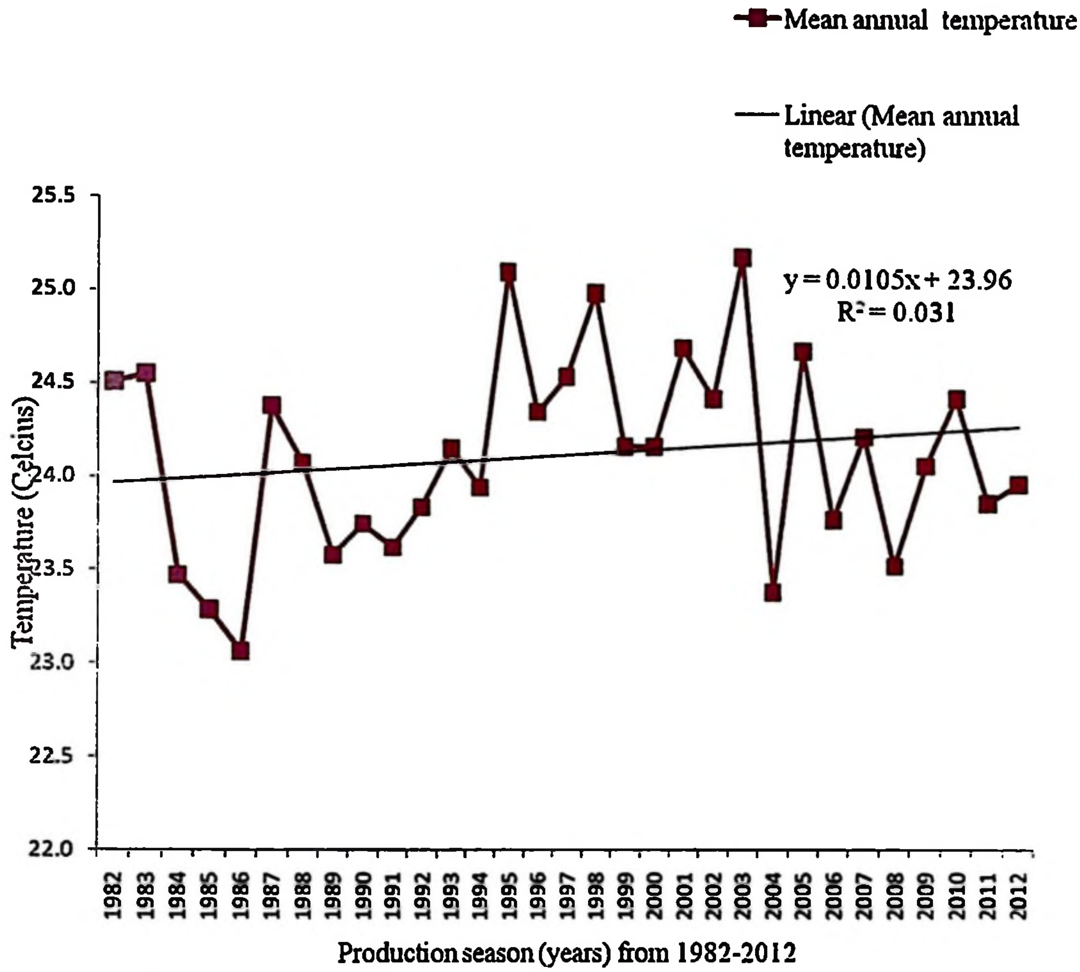

Figure 6: Mean annual temperature trend for Mbozi District Tanzania

Source: Tanzania Meteological Agency Mbimba Station (2013)

This trend increase in the mean annual temperature implies that there will be negative impact on maize crops which shall lead to severe droughts that will consequently affect maize yields in the study area. These findings are similar to the study by Mary and Majule (2009) in which they reported that temperature had been increasing over time. Also these findings on temperature trends are similar to those reported by NAPA (2007) that, there had been upward trend of temperatures in Tanzania. Thus, it is important to understand the trend in temperature as it is among the important climate variables whose changes results into great impacts for both rainfall and maize productivity in the study area, and that, knowledge on the trend could help maize farmers and stakeholders to make proper efforts in planning for interventions and coping strategies that would minimize the effects of the variability in climate as the result of increased temperature.

4.3 The Relationship between Climate Variability and Maize Production

Before performing regression analysis, the assessment of the degree of multicollinearity was performed as stated in section 3.5.3.1 and the results were presented in Table 3.

Table 3: Collinearity Diagnostic test results for the regression model variables (n=30)

Correlation analysis for Log RAINt and Log TEMPt	Collinearity statistics for CV variables		
Correlation (r) coefficient and p-value	Variable	Tolerance	VIF
r = 0.165	Log Tempt	0.762	1.312
p = 0.383NS	Log RAINt	0.783	1.277

Study results indicated that, climate variability variables (temperature and rainfall) were not collinearly related (r=0.165, p=0.383, VIF=1.277 and 1.312) and thus had the acceptable VIF values.

The linear regression analysis results for annual maize productivity (dependent variable) and climate variables are presented in Table 4.

Table 4: Regression analysis results showing the relative influence of climate variability on maize productivity (Model 1)

Model variables	Coefficients			Test statistics	
	Unstandardized Coefficients		Standardized Coefficients	t-value	p-value
	β	Std. Error	Beta		
(Constant)	-1.649	0.852		-1.935	0.0064**
Log Average annual rainfall	0.855	0.061	1.003	14.081	0.000**
Log of average annual temperature	-2.018	0.750	-0.192	-2.690	0.012*

*Significant at p<0.05; **Significant at p<0.01; R-square = 0.886, F=104.761, p=0.0064

Results show that, the overall linear regression model was statistically significant at $p < 0.05$ (F=104.761, p= 0.0064), hence the model had high predictive capability (Cohen *et al.*, 1983). The coefficient of determination (R-Square) was 0.886, which implies that, 88.6% of the variations in maize production were due to the effects of the independent variable (climate variability) whereas; only 11.4% of the remaining variations in maize production were due to unexplained factors.

The estimates of the coefficients (parameters) of respective climate variability variables (rainfall and temperature) were 0.855 and -2.018 respectively with constant value of-1.649 Table 4. Results in Table 4 show that, estimated coefficients presented in the linear regression equation were statistically significant at $P < 0.05$. The constant, -1.649 implies that, without considering the effect of climate variability, productivity would be significantly reduced by -1.649 metric tones per hectare (MT ha^{-1}). However, one unit increase in the amount of rainfall would lead to an increase in productivity for 0.855MT ha^{-1}. Moreover, a unit increase of the annual mean temperature was associated with significant decrease in maize productivity by -2.018MT ha^{-1}.

$$M_{YIELDt} = -1.649 - 2.018TEMP_t + 0.855RAIN_t \qquad (4)$$

These results imply that rainfall is positively related to productivity while temperature is negatively related to productivity.

The results in Table 4 show that, maize production is significantly related to climate variability and that variability in climatic condition was the major cause of fluctuations of maize production in the study area over the 30 years period between 1982 and 2012. These results are similar to those reported by Ege *et al.* (2009) who reported that, rainfall is the common yield-limiting factor since it limits use of chemical fertilizers and other agricultural inputs due to the fact that, there is high correlation between cereal production and rainfall. Also similar to those reported by Gouse *et al.* (2006) these authors report that, maize production increases as the season receives optimum amount of rainfall and temperature. This is because; high production of maize depends on proper distribution of rainfall throughout the growing season.

4.4 Effects of Climate Variability on Household Livelihood in Mbozi District

4.4.1 Effects of climate variability on livelihood by sex, education and age

4.4.1.1 Perception on climate variability effects on livelihood across gender

The perceived effects of climate variability on food security and income are as presented in Table 5. Findings show that, increase in food and income problems were among the problems emanating from climate variability as reported by most of the respondents. This problem was reported by 96.8% of the male respondents and 96.3% female respondents. The chi square test was performed as statistical test on whether there were significance differences between the female and male respondents on the effects of climate variability on food security and income. Results presented in Table 5 show that there were no significant differences between the two groups of respondent farmers regarding their perception on the effects of climate variability on food security and income at $p < 0.05$ (Table5). This implies that both male and female perceived the same that it was a serious problem affecting their wellbeing.

Table 5: Effects of climate variability on food security and income (n=120)

Sex		Increased food and income problems			Test statistic	
		Yes	No	Total	χ^2	p-value
Male	Count	90	3	93	0.015	0.903
	% within Sex	96.8%	3.2%	100.0%		
	% of Total	75.0%	2.5%	77.5%		
Female	Count	26	1	27		
	% within Sex	96.3%	3.7%	100.0%		
	% of Total	21.7%	.8%	22.5%		
Total	Count	116	4	120		
	% within Sex	96.7%	3.3%	100.0%		
	% of Total	96.7%	3.3%	100.0%		

These results concur with what was reported by Nelson and Stathers (2009) that, the increase in drought affected both men and women as a result of less predictable, but more intense sunshine and heat which was equally experienced by both men and women.

4.4.1.2 Perception on climate variability effects on livelihood across education level

Farmers' perception differences on the effects of climate variability on food security and income was tested on education level basis results presented in Table 6. Results show that, 97.4% of those with no formal education agreed that the increase of food and income problems were among the problems that emanating from climate variability, while 95.9% of respondents who had primary level of education agreed to the contention that increased food security and income problems were among the problems emanated from climate variability. Moreover, respondents who had similar opinion were those with secondary education (100%) and college education (100%).

These results show that, almost all the respondents regardless of their education levels were aware and perceived climate variability effects in the study area. This is the case with Chi-square (χ^2) test results which indicate that, there are no significance differences among the farmers in their education levels on the perceived effects of climate variability at 5% level of significance (Table 6). This implies that, climate variability is a critical problem whose effects are vivid to every person irrespective of his or her education level. This knowledge is important for determining awareness which could assist planners of interventions to act appropriately and timely for sustainable crop production and reduced income and food problems.

Table 6: Perceived climate variability effects on food security and income

Education level	Increased food and income problems			Total	Test statistic	
		Yes	No		χ^2	p-value
No formal education	Count	37	1	38	0.453	0.929
	% within Education level	97.4%	2.6%	100.0%		
	% of Total	30.8%	.8%	31.7%		
Primary education	Count	71	3	74		
	% within Education level	95.9%	4.1%	100.0%		
	% of Total	59.2%	2.5%	61.7%		
Secondary education	Count	7	0	7		
	% within Education level	100.0%	.0%	100.0%		
	% of Total	5.8%	.0%	5.8%		
College education	Count	1	0	1		
	% within Education level	100.0%	.0%	100.0%		
	% of Total	.8%	.0%	.8%		
Total	Count	116	4	120		
	% within Education level	96.7%	3.3%	100.0%		
	% of Total	96.7%	3.3%	100.0%		

The findings of this study do not agree with those of Sayed *et al.* (2014) who reported that, the effects of prevailing climatic condition on food security and household income is dependent on sex, education level and age. Although there had been no significant differences among farmers on the perception on climate effects as observed in this study, yet, it is important to emphasize more awareness campaigns which will keep the entire community aware of the climate variability effects that it can increase adoption rate of improved technologies increased maize production through advice from extension workers.

4.4.1.3 Perception on climate variability effects on livelihood across age

Differences in farmers perception on the effects of climate variability on food security and income was tested on age basis and the findings are as presented in Table 7. According these results, 98.1% of the respondents aged between 26 - 45 years agreed that the increase of food and income problems were among the problems that emanated from climate variability, while 93.6% of respondent farmers aged between 46 - 59 years agreed to the contention that increased food security and income problems were among the problems emanating from climate variability.

Table 7: Climate variability effects on food security and income across age

Age groups	Increased food and income problems				Test statistics	
		Yes	No	Total	χ^2	p-value
26-45 years	Count	52	1	53	0.390	0.303
	% within age groups	98.1%	1.9%	100.0%		
	% of Total	43.3%	.8%	44.2%		
46-59 years	Count	44	3	47		
	% within age groups	93.6%	6.4%	100.0%		
	% of Total	36.7%	2.5%	39.2%		
>59 years	Count	20	0	20		
	% within age groups	100.0%	.0%	100.0%		
	% of Total	16.7%	.0%	16.7%		
Total	Count	116	4	120		
	% within age groups	96.7%	3.3%	100.0%		
	% of Total	96.7%	3.3%	100.0%		

Moreover, respondents who had similar opinions were those aged above 59 years (100%). These results show that almost all the respondents regardless of their age were aware and had already experienced climate variability effects in the study area. This was also shown by the Chi-square test results which indicated that there were no significant differences among farmers in their age on perceived effects of climate variability at 5% level of significance (Table 7). This implies that, there are comparable perceived effects of climate variability on household income and food security across the respondents' age groups.

These results on perceived effects of climate variability within study area are different from the findings by Nelson and Stathers (2009) who reported that different age groups differ in their perceptions on climate variability since age is a factor that determines individuals' vulnerability; and thus, children and elders are the most vulnerable to climate variability because of their increased inability to secure food in times of drought. Moreover, Siebert and Sieber (2010), agreed with the later authors that among the rural population, there are certain groups of villagers who tend to suffer more severely than others from weather-related shocks affecting agricultural production. However, according to this study findings on farmers' perception of climate variability effects, any development programme that aims at minimizing effects of climate variability, should take into consideration all the people of all age groups in order to have effective and efficient use of the coping strategies that will ensure sustainable agricultural production.

4.4.2 Effects of climate variability on food security

4.4.2.1 Food availability

An analysis of food availability was calculated by subtracting the food sold from what is harvested to get amount of food stored, and results on the effects of climate variability on food security are as presented in Fig. 7. According to these results, most (79.2%) of the farmers stored less than 1.022 tons of maize for household consumption; while very few (20.8%) of them were able to store amount of maize between 1.022 and 2.022 tons for their household annual consumption (Fig. 7).

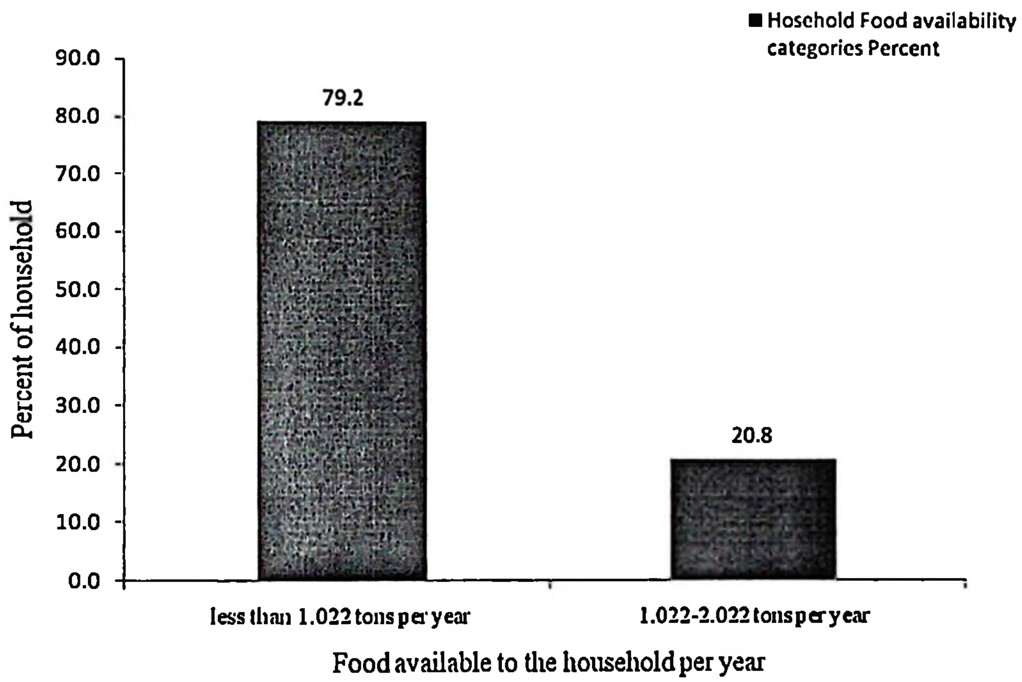

Figure 7: The annual average amount of food stored by household in Mbozi District (2010-2013)

Findings in Fig. 7 imply that most of the households suffered on food insecurity as a result of climate variability. According to FAO (2004), cited by Seyid *et al.* (2014), the recommended daily amount of cereals requirements is set to average food needs at about 400 grams of cereal crops per person per day (140 -146kg/years per person), as an indicator to household food security at the household level. Based on Gouse *et al.* (2006) and Lyimo *et al.* (2014) a single household that have seven people needs about 1022 Kg-1480Kg (1.022-1.480 tons) of maize per year. On this regard then, it is therefore very evident that, most of the households in the study area are food insecure (Fig. 7) as 78% of them fell below 1.022 tons of stored food for consumption per year.

The findings of this study on household food availability are similar to Barreiro (2012) who asserted that, maize food availability had been decreasing steadily since 2000. However, these findings are different from what was reported by Matshe (2009), citing FAO (2004) that, when productivity increases, food availability also increases at the household level which is not the case in this study, as the majority households did not have enough amount of the food that was available at household level for the households to become food secured.

4.4.2.2 Sustaining status of food security from maize harvest

Fig 8. presents findings on the sustaining status of food security from maize harvest as reported by respondents who were responding to the question whether household maize harvest could have sustained them (households) the whole year. Findings indicated that, very few households had enough quantity of maize for food which could sustain them for the period of ten to twelve months although majority of them had the quantity that could make them at least sustain their households for six to nine months only (Fig. 8). This is different from what was found by Tegeje (2014) that, majority of the households had the food that could sustain them until the next harvest while few were not able to reach the next harvest. This could be due to the fact that, the severity climate variability effects is location specific, and thus differ across locations.

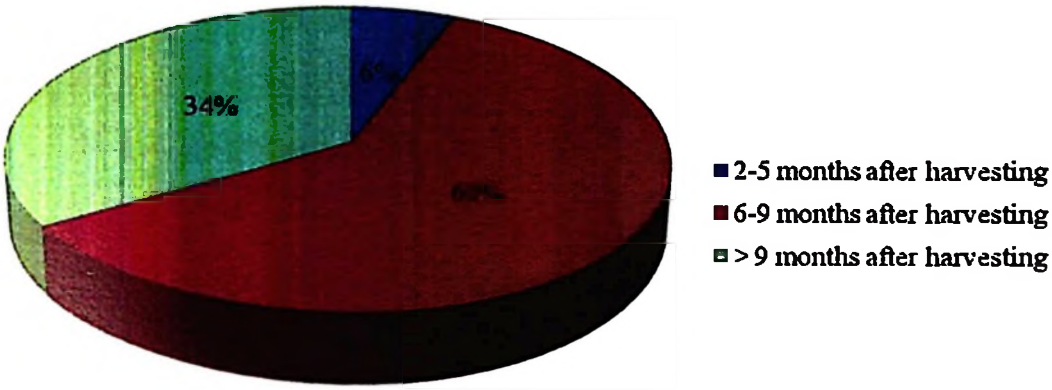

Figure 8: Sustaining status of food security from maize harvest

From these findings it is clear that, there is little maize for sustaining most of the farmers' households in the study area which indicates food insecurity that was very critical for three months period between the months of January to March similar to the food insecurity months that were also reported by Temu *et al.* (2011). According to the key informants, food shortages mainly resulted from significant costs associated with the forms of coping strategies to climate variability. These costs emanated from coping strategies reduced farm profits and, thus household incomes from farm outputs. This study findings are in line with what was reported by Molua (2002) that, food shortage and variation in farm incomes can be attributed not only to changes in output prices, but also to changes in rainfall during crop growth. Similarly, the use of improved tillage, rotation practices and fertiliser by the farmer also contributes to the costs which reduce farm profits (*ibid*).

Food shortage could also be due to costs that farmers incur on buying inputs like fertilizers as argued by FAO (2011) that, substantial increase in fertilizer prices over longer time, make the cost of fertilizer becomes closer to the gross value of production, and thus need larger and larger increase of the output prices to compensate. Furthermore, Kansiime *et al.* (2013) in the study on perceived and actual rainfall trends and variability in eastern Uganda, reported of increased cost production as a result of re-ploughing and replanting which farmers perform because of droughts and un-predictability of rainfall which results from climate variability, contrary to what Kangalawe (2012) argued that, food insecurity, mainly comes from farmers selling of their crop produce to recover cost of production.

4.4.2.3 Other problems associated with climate variability in the study area

Other identified problems emanating from climate variability in the study area presented in Table 8. According to the findings of this study in Table 8, the main perceived climate variability problems by the majority include: increased crop pests and diseases which have reduced the quality and quantity of crop products, increased social distress among the households due to economic problems, reduced quantity and quality of food, increased health/ diseases to livestock and increased rural urban migration as reported by the majority. However, very few respondents reported of existence of climate variability problems like increased environmental pollution which has resulted into human health problems, increased rural urban migration among the youths especially women, and increased malnutrition among the children. These findings imply that climate variability had led to economic, social and environmental problems in the study area which requires concerted efforts of various stakeholders' intervention for sustainable maize production, increased household income and food security.

These findings are similar to the findings by Mbwambo *et al.* (2012) and Mbilinyi *et al.* (2013) who found that, migration of the young people into urban centers (towns) in search for employment was the result of climate variability effects that affected their rural farm outputs; and that most of the families had separated parents in search of employments as fathers of the families opted to move and look for employment elsewhere.

Table 8: Perceived problems which emanated from climate variability

Climate variability problems	Reported to happen		Reported not happened	
	Frequency	Percent	Frequency	Percent
Increased crop pests and diseases which have reduced the quality and quantity of crop products	86	78.9%	34	21.1%
Increased environmental pollution which has resulted into human health problems	26	23.9%	94	76.1%
Increased health/ diseases to livestock	61	56.0%	59	44.0%
Increased human diseases	43	39.4%	77	60.6%
Reduced quantity and quality of food	81	74.3%	39	25.7%
Reduced income among many households	94	86.2%	26	13.8%
Increased rural urban migration among the youths especially men	57	52.3%	63	47.7%
Increased rural urban migration among the youths especially women	16	14.7%	104	85.3%
Increased malnutrition among the children	37	33.9%	83	66.1%
Increased destruction of infrastructures due to floods	18	16.5%	102	83.5%
Increased social distress among the households due to economic problems	83	76.1%	37	23.9%

4.5 The Relative Importance of Climate Variability versus Socio-economic Variables

In order to test for multicollinearity, the multiple regression analysis was preceded by correlation analysis to test whether there were collinear relationships among the independent variables. Results on correlation analysis presented in Table 9, show that there were collinear relationships among some independent variables and thus correlated ones were omitted from being in the specified model. However, only three independent variables were not correlated to any of the independent variables (Table 9).

Table 9: Correlation matrix for testing multicollinearity

Variable	Significantly Correlated to	Correlation coefficient (r)	p-value
Marital status	Sex	-0.69	0.000***
Household size	Age	0.465	0.000***
	Land size	0.471	0.000***
Age	Household size	0.465	0.000***
	Land size	0.333	0.000***
	Education	-0.382	0.000***
Education	Age	-0.382	0.000***
	Hand hoe	0.247	0.007**
	Sex	0.218	0.017**
Hand hoe	Education	0.247	0.007**
	Ox-plough	-0.440	0.000***
	Fertilizer	-0.216	0.017**
	Tractor	0.364	0.000***
	credit	-0.180	0.049*
Use ox-plough	Hand hoe	-0.440	0.000***
	Sex	-0.188	0.040**
	Tractor	-0.304	0.000***
Extension services	None	NS	NS
Rotation	None	NS	NS

*significant at $p < 0.05$; **$p < 0.01$; ***$p < 0.001$; NS= Not significance.

Hence multiple linear regression analysis was performed using independent variables which were not significantly correlated and results are as presented in Table 10.

The findings of this study show that the overall multiple linear regressionmodel was statistically significant at $p < 0.05$ and $p < 0.01$ that the model fitted the dependent and independent variables (F=15.763, p = 0.000). The coefficient of determination (R-Square) was 0.214, while the estimated parameters of respective socio economic variables were -0.195, 0.129, -0.104, 0.333, 0.088, 0.509, 0.076, 0.131, 0.176, -0.003, -0.023, 0.075 and 0.094 with constant value of 1.010. The estimated regression equation was as shown in equation 5.

The value of R-square indicates that climate variables determined some variations in maize production for about 21.4% of the total variations. Some of the estimated coefficients presented in the multiple linear regression equation 6were statistically significant at $P<0.05$ and $P<0.01$ (Table 10) while others were not due to the fact that independent variables associated with them suffered multicollinearity. The constant, 1.010 indicates that without considering the effect of socio economic factors, productivity would be significantly increased by 1.010 metric tons per hectare (MT ha^{-1}).

Y=1.01 + 0.129 ROTA+ 0.333 TRACT + 0.088 HHS + 0.509 FERT + 0.076 EXT + 0.176LSIZE - 0.023 SEEDS + 0.094 CRED .... (6)

Findings (equation 5) showed that, the use of tractor by the farmer significantly increased maize productivity by 0.333 MT per ha above not using tractors at $p < 1\%$ level of significance. Likewise, the unit increase in household member significantly increased maize productivity by 0.088 MT per ha ($p <0.01$), while a unit increase in the area under maize production significantly increased maize productivity by 0.176 MT per ha ($p < 0.001$). On the other hand the use of fertilizers contributed to significant increase in maize productivity for about 0.509 MT per ha at $p < 0.001$.

The multiple regression results in this study imply that increasing maize productivity also goes with investment in land household size and use of tractors and fertilizers. This shows that any intervention geared at improving soil fertility would substantially increase maize productivity in the study area. Furthermore, results have shown that, apart from the influence of climate variability on maize production, there were also other factors associated with maize productivity other non-climatic factors although not having so much effect when compared to climate variability as per this study results.

Table 10: Multiple regression model results showing the influence of other factors on maize production (Model 2)

Model variables	Unstandardized Coefficients		t-value	Sig.
	B	Std. Error		
(Constant)	1.010	0.256	3.941	0.000***
Use of crop rotation by the farmer (1=use; 0=otherwise)	0.129	0.312	0.414	0.680NS
Use of tractor by the farmer (1=use; 0=otherwise)	0.333	0.171	1.949	0.054*
Household size.	0.088	0.030	2.989	0.003**
Use of fertilizer by the farmer (1=yes;0=otherwise)	0.509	0.116	4.369	0.000***
The farmer received extension services (1=received;0=otherwise)	0.076	0.087	0.875	0.383NS
Average area under maize for household (ha)	0.176	0.041	4.287	0.000***
Use of improved maize seed varieties	-0.023	0.043	-0.547	0.585NS
Access to credit (1=if access to; 0= otherwise)	0.094	0.097	0.967	0.335NS

R-square= 0.214, F-statistic= 15.763, p=0.000; *Significant at p<0.05; *** p<0.01 *** p<0.001; NS=Not significant

These results agree with findings by Molua (2002) who reported that, the type of soil tillage applied on the farm has significant effects on farm returns. Further, the results concur with the findings by Barnett *et al.* (2011), who found that, the use of hybrid maize was accompanied with significant increase in fertilizer usage, which resulted into yield increase. Additionally, the findings of this on significant increases in maize productivity due to the use of fertilizers are similar to those reported by NAPA URT(2007) that, the increase in the use of manure and fertilizer, agriculture extension activities and diversification of agriculture result into increased crop production to counteract the effects of climate variability. Thus, the extent to which communities are vulnerable to climate variability depends on both exposure and sensitivity to changes in climate, as well as ability to cope and adapt to new conditions because understanding of the improved ways in which climate variability affects society and the environment is very essential for any attempt to be made for improving agricultural productivity and increase farm incomes.

4.5.1 Various tillage tools and machineries used by farmers in the study area

Maize farmers use various tillage techniques in which they employ different instruments, tools and machineries for land cultivation in the study area. Results presented in Fig. 9, showed that, many (56.7%) of the farmers use ox- plough for cultivation, while 38.2 % used the common traditional tool (hand hoe)for cultivation and few of them (5,1%) used tractors for maize land cultivation (MDC, 2013).

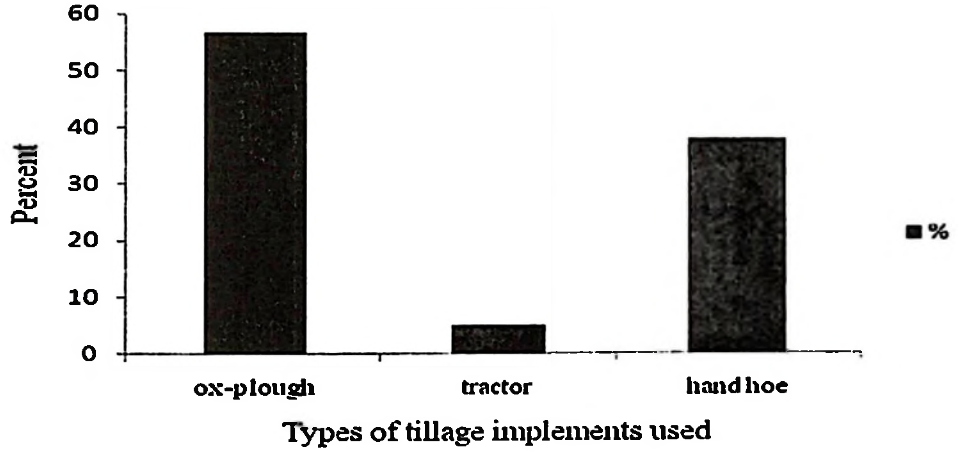

Figure 9: Various types of tillage implement used by farmers in the study area

According Nelson and Stathers (2009), ploughing land using oxen is much faster than by hand, because oxen speed allows maximum use of the short and often intermittent rainy period for crop production, thus, it important that many farmers used the animals for land cultivation instead of using hand hoes. Minor use of tractors emanated from the hiring costs which were associated with tractors than it was the case with oxen.

Plate 1: Ms Marietha Semkonda of Isalalo village in Msia ward of Mbozi District weeding her maize field using hand hoe

Plate 2: Mr. Samuel Mambipile of Senjele village in Mbozi district cultivating maize field using ox-plough driven by 2 oxen

4.6 Coping Strategies by Communities in the Study area

The findings on coping strategies adopted by communities against climate variability in the study area are as presented in Table 11. These findings indicate various coping strategies that were being used by the farmers in the study area. The main coping strategies which are mostly used by the majority farmers include: expansion of the agricultural land area, use of the right quantity and kind of fertilizer according to climate or weather condition of the particular location, use of improved maize seeds varieties according to climatic conditions.

Table 11: Multiple response results showing coping strategies devised by community in the study area (n=120)

Coping strategies for climate variability	Multiple response Frequencies	Percent of Cases
Selling livestock	51	42.5%
Selling forest products	72	60.0%
Hunting	16	13.3%
Eating and selling honey	26	21.7%
Gathering wild roots, fruits and leaves	37	30.8%
Buying foods	83	69.2%
Decreasing meal intake per day	77	64.2%
Receiving remittances from relatives	56	46.7%
Stop selling foods	98	81.7%
Garden irrigations	38	31.7%
Cultivating in wet lands	45	37.5%
Growing drought resistance crops	40	33.3%
use of improved maize seeds	102	85.0%
use of right quantity and kind of fertilizer	104	86.7%
Expansion of agricultural area	106	87.0%
Timing	101	84.2%
Diversify types of crops	30	25.0%
Small business	84	70.0%

Other coping strategies included cultivating in wet lands, growing drought resistant crop varieties, use of garden irrigations, and crop diversification. These findings imply that, farmers within the study area have already developed their own coping strategies against the prevailing climate variability, which enabled them to increase productivity and meet their subsistence life needs.

For example, farmers had been increasing their land under maize cultivation in order to cope with perceived impact of climate variability and hence, increased maize productivity. This is similar on what was reported by Nelson and Stathers (2009) that, in order to obtain sufficient food always farmers cultivated larger areas of land. According to Blench (2003), farmers do minimize climate variability risks through making adjustments in land and crop management practices in order to suit the prevailing conditions as shown hereunder.

Plate 3: Expansion of agricultural land into forest reserved areas as was observed in Isalalo village Mbozi District

Plate 4: Expansion of agricultural land into forest reserved areas as observed in Utambalila village

Although land expansion has been practised for the need to cope with climate variability, yet it has not been a sustainable way of coping with climate variability as it would rather accelerate the situation since it leads to environmental degradations. Similarly, coping strategies like cultivation on wetland areas and expansion of agricultural land had led to wetland deterioration and forest degradation in the study area. These findings are similar to what was reported by Ziervogel *et al.* (2006) who argued that, farmers continued practices of planting maize with increasing planting areas resulting into negative impacts on soil and forest ecosystems.

Many scholars (Alexandrov and Hoogenboom, 2000; Oseni and Masarirambi, 2011; Mbwambo *et al.*, 2012) have argued that, farmers have been responding to climate variability in various ways including use of fertilizers, change of planting dates and crops diversification, common timing of field operations and hybrid selection can reduce the negative impact of potential warming on maize yield. Most of these findings are similar to the findings of this study on the coping strategies. The use of improved maize seed varieties had been accompanied by increased maize production, which is similar to what was asserted by Barnett *et al.* (2011) that, in the Southern Highlands of Tanzania, farmers had reported that use of improved varieties of maize gave them higher yields compared to local varieties.

Coping strategies to climate variability which are non-agricultural activities that were practised in the study area included conducting small business, selling forest products, selling livestock, gathering wild roots, fruits and eating leaves, selling honey and hunting.This implies that, farmers did not only use agricultural activities alone as coping strategies but also used non-agricultural activities to broaden their livelihood options. However, many of the activities like that of selling of forest products had already made negative impacts to forest biodiversity and environmental in general. The findings of this study therefore concur with the report by Ziervogel *et al.* (2006) and Deressa *et al.* (2010) that, farmers had been using non-agricultural activities as coping strategies to climate variability, including selling livestock and agricultural products, gathering of forest products (such as fruits, timber, medicine and honey) for home consumption and for sale.

Although most of these coping strategies had been in use, if not properly managed and controlled by relevant bodies of authority could lead to poor maize production, reduced household income and food security as they shall lead to environmental degradation which finally could result into severe impacts of climate variability if the farmers will not have the best alternative ways of coping with climate variability.

Plate 5: Maize farm in the wetlands of Idunda village

4.7 Contribution of the Study to the Body of Knowledge

Since climate variability is a real problem facing maize producers in the study area, the findings of the study show that, annual mean rainfall has been decreasing while the annual mean temperature has been increasing. There is strong relationship between climate variability and maize production because, an increase in the annual mean temperature negatively impact on the maize productivity in the same way when the mean annual rainfall decreases.

Since maize is the main staple food within study area any factor that decreases its production, reduces household food security and income. Thus, it has been found that climate variability is the major cause of food insecurity and lower income among most of the households as most of them have not been able to sustain their stored food (maize) for the whole year from one harvest to the next harvest. This is because, most of the farmers' food stocks tended to last for seven to nine months from harvest leading to many households suffering from hunger in the months between January to March which was experienced in every year as the result of food shortages. Food shortages occur because, farmers incur a lot of costs on maize production in order to improve productivity as a result total revenue from maize productivity was not able recover total cost of production to most farmers.

Furthermore the findings show that, socio-economic factors have some influence on maize productivity apart from climate variability. Thus, in order to improve productivity significantly, the household must have enough farm labour, use of improved tillage implements and machineries like tractors increase the use fertilizers and expand land under maize production.

Finally, the findings show that maize farmers in the study area had been coping with the effects of climate variability by using various strategies like planting drought tolerant maize varieties, timing on farm preparation and planting, use of right quantity and kind of fertilizer according to climate, cultivating on wetland areas, selling charcoal and expansion of agricultural land, and practicing non-agricultural strategies like selling of forest products and conducting small trade activities. Such strategies as cropping on wetland, expansion of land, and selling of the forest products like timber, fire wood, wood, and wood charcoal had had negative impacts on the environment and forest bio-divest and therefore, need to be avoided and use best alternative strategies which are environment friendly for sustainable crop production.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

This Chapter presents conclusions and recommendations on the basis of the study objectives.

5.1 Conclusions

Based on this study it is concluded as follows:

(i) There had been trend decrease on mean annual rainfall during the period (1982 to 2012). Additionally, it was found that, temperature trend had been increasing whereby; the mean annual temperature had been increasing.

(ii) There was a clear relationship between maize production and climate variability (temperature and rainfall).

(iii) Majority of the households faced with food insecure as the result of climate variability effects, which are not able to sustain their stored food to next 12 months from harvest. Also climate variability led to income problems.

(iv) Despite the climate variability impacting maize production, some of socio-economic variables were important on increasing maize production. Such variables are household size, use of fertilizer, land size and use of tractors helped farmers to compromise the maize production.

(v) In the current study a wide range of coping strategies adopted by communities in response to the effects of climate variability were recorded. The coping strategies included both agricultural (expansion of the agricultural land area, use of the right quantity and kind of fertilizer according to climate or weather condition of the particular location, use of improved maize seeds varieties according to climatic conditions and selling of forest products) and non-agricultural strategies (business, selling forest products, selling livestock, gathering wild roots, fruits and eating leaves, selling honey and hunting). Most of the agricultural strategies like selling forest products have negative impacts to forest biodiversity and environment in general and hence perpetuate climate variability effects if appropriate interventions are not operationalized.

5.2 Recommendations

In a view of the findings of this study, the following recommendations are put forward:

(i) Since it was found that climate variability in terms of increasing trend in temperature and declining trend in rainfall is a serious problem in the study area, it is therefore recommended that the relevant authorities (Government and NGOs) must make deliberate efforts in designing and implementing mass education programmes geared towards reducing the effect of climate variability. This should specifically focus on reducing deforestation and forest degradation, aforestation programmes, sustainable utilization of forest products and sustainable agriculture.

(ii) Since most farmers have been facing food insecurity and lower household income problems that emanated from climate variability effects for quite long period of time, it is recommended that, education related to how to store food for future use should be given to farmers by the government and other stakeholders. Similarly, the capacity of farmers to have proper storage infrastructures should be enhanced (built) by the government in collaboration with private institutions. Alternatively farmers and the government should look for a way of having warehouse receipt system which could help farmers store their maize before selling them at reasonable prices.

(iii) Again the government also should look for markets, improve maize crop markets and remove barriers to cross border trade so that farmers can sell their maize at reasonable prices.

(iv) It was observed that socio-economic variables were important on increasing maize production. Thus it is suggested that, The Government, NGOs and Private sector should work together to design and implement a credit mechanism which will enable progressive farmers to accesses loans to purchase agricultural inputs (e.g. fertilizers, improved seeds etc), tractors and hiring labor so as to increase productivity.

(v) It was found that in the study area there are a wide range of coping strategies adopted by communities in response to the effects of climate variability. Therefore it is recommended that farmers should be encouraged to use indigenous and modern coping strategies against climate variability. This could specifically encompass the use of drought resistant crops, agro-forestry practices, alternative livelihood strategies such as beekeeping and tree farms.

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APPENDICES

Appendix 1: Questionnaire for households maize farmers in Mbozi District

Section A; General Research Question

a. Questioner number ...

b. Sex of respondents (Head of Household)

1. Male 2. Female ( )

c. Marital status,

1. Married 2. Single 3. Divorce ( )

4. Widow 5. Separated

d. How many people live in your household.............................?

e. Age of respondents (Head of Household)

1. 15 – 25 Years old 2. 25 – 35 Years old 3. 36 – 45 Years old 4. 46 – 55 Years old ( )

5. 56 Years old and above

f. Education level;

1. Not went to school at all 2. Primary education

3. Secondary school ( )

4. College education

g. Name of Village

1. Senjele (Iyula)	2. Utambalila (Itaka)	3.Idunda (Iyula) 4.Isalalo (Msia) ( )

h. Household size

1. Number of Male adult......................
2. Male youth......................................
3. Female adult....................................
4. Female youth...................................
5. Size of land owned (acres)

Section B. Assessment of rainfall and temperature for the last season in Mbozi District

a. Assessment of rainfall

Please tick for appropriate response.

	Item	*Codes*
i	Did the rainfall come on time?	1.On time 2. Too early 3. Too late
ii	Was there enough rain on your fields at the beginning of the rainy season?	1.Enough 2. Too little 3. Too much
iii	Was there enough rainy on your fields during the growing season?	1.Enough 2. Too little 3. Too much
iv	Did the rains stop on the time on your fields?	1.On time 2. Too early 3. Too late
v	Did it rain near the harvest time	1.Yes 2.No

Assessment of temperature

Item	**Codes**		
How was the temperature during the growing season?	Moderate Too hot	2.	2. Hot
Did the temperature affects your maize crops	1.Yes		2.No
Was there enough temperature on your fields during the growing season?	1.Yes		2.No
Was the temperature too hot during the period of growing season?	1.Yes		2.No
Which month was the temperature too hot during the growing season?...			
Which month was the temperature not hot during the harvesting period?			

b. Have you ever experienced droughts that which caused severe crop losses especially maize?

1. Yes 2. No ( )

c. Have you ever experienced changes in the rainfall staling and end dates from year 1982 to 2012? ....

1. Yes 2. No ( )

d. Which month from 2009 to 2012 did you experience more rainfall and temperature on growing seasons.......................................?

e. What are the impacts of rainfall and temperature to maize production from 2009 to 2012? ....

Section C; Assessment on relationship between climate variability and maize production in Mbozi district.

a. What do you think could have been the impact of climate variability on maize production from your experience?

1. Maize yield has increased dramatically
2. Very little increase in maize yield ( )
3. Yield remained the same
4. yield has been reduced so much
5. Very little decrease in maize yield

Section D. Assessment on the effects of climate variability on household livelihood in Mbozi district

a. Indicate the amount of maize harvested, consumed, stored for how long and sold in last 4 years/cropping seasons?

Year	Amount consumed (kg)	Stored for how long	Amount Sold (kg)	Total revenue
2012/2013				
2011/2012				
2010/2011				
2009/2010				

b. What do you think has been the food security and household income problems which had emanated from climate variability in your area? Choose among the following, you can choose more than one answer (multiple responses)

i. Increased food and income problems ( )

ii. Increased crop pests and diseases which have reduced the quality and quantity of crop products ( )

iii. Increased environmental prolusion which has resulted into human health problems. ( )

iv. Increased death/diseases to livestock ( )

v. Increased human diseases ( )

vi. Reduced quality and quantity of food ( )

vii. Reduced income among many households ( )

viii. Increased rural urban migration among the youths especially men ( )

ix. Increased rural urban migration among the youths especially women ( )

x. Increased malnutrition among the children ( )

xi. Increased destruction of infrastructures due to floods ( )

xii. Increased social distress among the households due to economic problems ( )

c. What is the food security at the household level?

Item	Codes	
vi. Worry about food security for the last 4weeks	1.Yes	2.No
In ability to eat the preferred food in the last four weeks.		
Availability of limited variety of food due to lack of resource in the household	1.Yes	2.No
Ability of household to get the type preferred food		
Availability of smaller amount of meal in the past four weeks		
Missing the number of meals per day for the past four weeks		
Ever no food to eat the past four weeks.		
Sleeping without eating any food in the past four weeks.		
Spending the day and night without eating any food in the past four weeks.		
How long the food stored after harvesting.		

Section E. Assessment on the relative importance of climate variability as it affects productivity compared to other variables in Mbozi District.

a. Did you practise the following on your maize farm in the last year

	Item	Codes	
vii.	Crop rotation	1.Yes	2.No
viii.	Chemical fertilizer application	1.Yes	2.No
ix.	If yes, quantity of fertilizer used during fete for planting and top dressing per Acre was as per requirement.	1.Yes	2.No
x.	Use of improved maize seed varieties	1.Yes	2.No
xi.	If yes what type of improved maize seeds used (mention)	1.Yes	2.No
xii.	Use of hand hoe for tillage on your maize farm	1.Yes	2.No
xiii.	Used ox plough for tilling your maize farm	1.Yes	2.No
xiv.	Used tractor for tilling your maize farm1	1.Yes	2.No
xv.	Received Extension services	1.Yes	2.No
	If yes how many times (per month) 1.once 2.twice other...............................		
xvi.	If yes, service received was of required quality	1.Yes	2.No
xvii.	Accessibility to loan		

b. Do you use part of your land in Maize production

1.Yes 2.No ( )

c. If yes, Mention number of acres

Year	2012	2011	2010	2009
Land area cultivated for maize (acres)				

d. How many bags (100kg) of maize did you harvest per acre for each production seasons (years) mentioned below

Year	Land size cultivated for maize (hectares)	Total harvested
2012/2013		
2011/2012		
2010/2011		
2009/2010		

e. What is the main occupation of your household?

1. Crop production 2. Livestock 3. both ( )
4. Other Specify.....................

f. If crop production, what crops?

1. Maize 2. Beans 3. Coffee ( )
4. Other Specify.....................

What was the price for maize sold each year?

Year	Price/unit (TAS)
2012/2013	
2011/2012	
2010/2011	
2009/2010	

g. What was the cost of production in each production seasons below

Year	Inputs (e.g. seeds, fertilizers, pesticides, herbicides)	Ploughing /land preparation	Planting and weeding	Harvesting and transportation	Total cost
2012/2013					
2011/2012					
2010/2011					
2009/2010					

h. Is there market available for selling maize

1. Yes 2. No ( )

i. Is the maize price able to recover cost of production

1. Yes No ( )

k. What is the household income per year?

l. what is the household income from 2009 to 2012? a.the same b. decreasing c. increased.

Section F. Assessment of coping strategies devised by communities against climate variability in Mbozi district.

a. Did you practice the following coping strategies to overcome climate variability in your area?

Please tick yes when you practice and no if you not.

	Item	Codes	
i.	Selling livestock	1.Yes	2.No
ii.	Selling forest products (e.g. charcoal, timber etc)	1.Yes	2.No
iii.	Hunting	1.Yes	2.No
iv.	Eating and selling honey	1.Yes	2.No
v.	Gathering wild roots, fruits and leaves	1.Yes	2.No
vi.	Buying foods	1.Yes	2.No
vii.	Decreasing meal intake per day	1.Yes	2.No
viii.	Receiving remittances from relatives	1.Yes	2.No
ix.	Stop selling foods	1.Yes	2.No
x.	Garden irrigations	1.Yes	2.No
xi.	Cultivating in wet lands	1.Yes	2.No
xii.	Growing drought resistance crops	1.Yes	2.No
xiii.	Diversify types of crops	1.Yes	2.No
xiv.	Changing planting dates	1.Yes	2.No

Others (mention)...

Appendix 2: Interview guide for Key informants and focused group discussion

1. What was the trend of rainfall for 30 years (1982 – 2012)?
2. What was trend of Temperature for 30 years (1982 -2012)?
3. How long have they worked in the area?
4. Which years from 1982 to 2012 was the rainfall not enough?
5. Which years from 1982 to 2012 was high average amount of the rainfall?
6. Which years from 1982 to 2012 maize was produced leading?
7. What were the onset dates for the rains in the past 4 years?
8. What were the end dates for the rains in the past 4 years?
9. Did you experience rainfall end dates variations from year 1982 to2012?
10. Did you experience seasonal changes in rainfall?
11. If yes, what were the effects on the maize growing seasons?
12. What are effects to maize production?
13. What do you think might have been the causes of drought?
14. What have been the coping strategies to shortage of rainfall on maize production?
15. What have been the coping strategies to food insecurity and reduced house hold income?
16. What was the market price of maize in year, 2009/2010, 2010/2011, 2011/2012 and 2012/13?
17. What should be done by the Government, NGOs and other stakeholders should do in order to minimize the impacts for sustainable maize production and improved household livelihoods?