ADAPTATION STRATEGIES TO CLIMATE CHANGE AND VARIABILITY OF SMALL SCALE RICE PRODUCERS IN MASWA 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

Climate change (CC) is a worldwide problem affecting agricultural sector. The pattern and amount of rainfall affect agricultural production. Rice farming is vulnerable to the risks and impacts of CC, resulting in losses and decreased crop yield. The purpose of this study was to assess adaptation strategies to climate change and variability as experienced by small-scale rice producers in Maswa District. The study examined farmers' perception to CC, CC trends, the effects of CC on rice yields, identify and document short and long term adaptation strategies undertaken by communities. Purposive sampling of 120 respondents was used. Primary data were collected using structured questionnaires; secondary data were collected from TMA and DALDO's offices. Data were analysed using Mann Kendall Test and MS excel computer programme. Link between climate variables and rice yield was determined through linear regression model. Short and long term adaptation strategies were identified using descriptive analysis using SPSS. Results indicated that rainfall trend was decreasing over 30 years particularly April and May had decreased by -2.438 and -1.593 respectively which was significant at $|Z| \geq 2$. Temperature increased over the period, specifically in February, April and May with significant increase at $|Z| \geq 2$. There was significant relationship between rice production and rainfall which increased by 1.19 tons ha^{-1} for every increase in one unit of rainfall at $p < 0.05$. Identified adaptive strategies were: use of early maturity varieties, diversification of crops, growing drought tolerant varieties, adopting irrigation technologies i.e. long and shallow wells or canals and changing sowing dates. This study recommends appropriate interventions by farmers leading to sustainable use of adaptation technologies for sustainable production. Efforts and resources should be directed towards supporting research for developing more rice varieties which are drought tolerant, water efficient user and developing technologies to reduce Greenhouse gas emissions.

DECLARATION

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

25/11/2014

Jojianas Kokulamka Kibura **Date**

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The above declaration is confirmed

25.11.2014

Dr. Jumanne M. Abdallah **Date**

Supervisor

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DEDICATION

I dedicate this work to God Father, God son and God Lord Spirit and to my dear parents the late Francis and Clementine Kahangwa, for laid the foundation for my education.

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LIST OF ABBREVIATIONS AND SYMBOLS

ADB	Asian Development Bank
AGRA	Alliance for Green Revolution in Africa
CC	Climate Change
CCSP	Climate Change Science Program
CH_4	Methane
Co_2	Carbon dioxide
CV	Climate Variability
DALDO	District Agricultural and Livestock Development Officer
EAAPP	Eastern African Agricultural Productivity Programme
FAO	Food and Agriculture Organization
FSRP	Farming System Research Program
FYM	Farm Yard Manure
GDP	Gross Domestic Product
GHF	Global Heritage Fund
GHG	Greenhouse Gas
ha	hectare
IIED	International Institute for Environment and Development
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
IRRI	International Rice Research Institute
IWMI	International Water Management Institute
kg	kilogram
LVEMP	Lake Victoria Environmental Management Project
MAFSC	Ministry of Agriculture and Food Security

mm	millimeters
MSG	Michigan Sea Grant
MDPO	Maswa District Planning Office
N_20	Nitrous Oxide
NAP	National Agricultural Policy
NAPA	National Adaptation Programme of Action
NBS	National Bureau of Statistics
NGOs	Non Governmental Organizations
NPRS	National Poverty Reduction Strategy
^oc	Degrees centigrade
REDD+	Reducing Emissions from Deforestation and Forest Degradation
REPOA	Research on Poverty Alleviation
RLDC	Rural Livelihood Development Company
RWH	Rainwater Harvesting
SPSS	Statistical Program for Social Science
SUA	Sokoine University of Agriculture
SWC	Soil Water Conservation
TMA	Tanzania Meteorological Agency
tons	Tonnes
UNESCO	United Nations Education Scientific and Cultural Organization
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
USAID	United States Agency for International Development
WHO	World Health Organization

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Global warming is projected to have significant impacts on conditions influencing agriculture, including temperature, carbon dioxide, precipitation and the interaction of these elements (IPCC, 2007). The impact of climate change resulting from increased greenhouse gas concentrations has the potential to harm societies, agriculture, water resources and ecosystems (Cornelius *et al.*, 2009). Human societies have shown a strong capacity to adapt to different climatic and environmental changes. In Ethiopia, for example, various adaptive strategies have been used to address the impact of climate change. These strategies include: dam constructions, rain water harvesting and release of new cultivars (Admassie, 2008).

In most African countries farming depends entirely on the quality of the rainy season, a situation that makes Africa particularly vulnerable to climate change (Lyimo *et al*., 2009). It has been reported that increased droughts could seriously impact the food availability, as happened in the Horn of Africa and Southern Africa during the 1980s and 1990s (IPCC, 2001). Many areas in Africa especially those located in semi arid, coastal regions of Eastern Africa, and many of the drier zones of Southern Africa are already vulnerable due to other stressors, and climate change will likely to have more additional impact (IPCC, 2007).

According to URT (2009) agriculture contributes 45% to GDP and about 60% of export earnings in Tanzania economies. The sector particularly in Africa is sensitive to weather conditions, and is one of the most vulnerable sector to the risks and impacts of climate change and variability (Adams *et al.*, 1999). Insufficient and unreliable rainfall in addition to existing socio-economic stresses has contributed to decline of rice production in spite of farmers' effort to achieve higher output (AGRA, 2009). The effects of current cycle of droughts have led to low crop production for some years in Maswa district (Ndalahwa, 2010). In Tanzania, rice is one of the widely grown crops and is the second most important food crop in terms of number of households, area planted and production volume (URT, 2009). A study by Majule (2009) on drought and famine in Dodoma Districts showed that the presence of dry spells in critical periods for most crops contributed considerably to crop failure and famine. Given the over-dependence on rain-fed agriculture by the majority of people living in rural areas, climate change and variability has been one of the major limiting factors in agriculture production thus resulting in food insecurity and low-income generation (Lema and Majule, 2009).

The changes in rainfall patterns and amounts have led to loss of crops and reduced livestock production (Rosenzweig *et al.*, 2002). Indigenous knowledge arises out of continuous experimentation, innovation and adaptation, blending many knowledge systems to solve local problems (UNFCCC, 2003). Climate change is a global phenomenon while adaptation is largely site-specific. The main problem for local coping and adaptation strategies is that they are often not documented, but oral hold at various levels in communities (Lema and Majule, 2009).

1.2 Problem Statement and Justification of the Study

Inadequate rainfall in terms of both amount and distribution together with long-lasting drought spells have augmented the crisis of moisture stress (Paavola, 2004) resulting into many restrictions on rice production systems in Tanzania. However, very little is known to what extent and how climate change and variability affects rice productions and adaptations taken by the community in Maswa district. Rice farming is sensitive to climate change and is one of the most vulnerable crop to the risks and impacts of climate change (FAO, 2008). Rosenzweig *et al.* (2002) cited that changes in rainfall patterns and amounts have led to loss of crops and reduced livestock production.

Increasing impacts of climate change and variability specifically drought and floods on agriculture have been associated with various adaptation and coping mechanisms (Gwambene, 2007). Kajiru *et a*l. (2011) and Aktar *et al.* (2008) reported that a 30% reduction of rains per season can reduce yield by 25 – 75% of rice. Adaptation appears more inductive in nature, based on the existing coping strategies of communities and individuals to risk (Huq, 2007). It is very important to clearly understand what is happening at household level, because farmers are the most climate vulnerable group (Majule *et al.*, 2009). However, little has been done in Maswa District to assess climate change and variability and adaptation strategies used by small scale farmers on rice production due to climate change. This study intended to document the copying strategies practiced in Maswa district as well as assessing the climatic effect on rice production. Also, the study aimed at examining the trend in climate change and variability at Maswa district on rice production.

1.3 Justification of the Study

This study is important due to the fact that there is scarce information related to impact caused by climate changes in Maswa District. Thus, the finding derived from this study and its recommendation will be an important tool for different stakeholders, especially policy makers and development practitioners to better design intervention strategies or fine-tune their policies aimed at promoting sustainable land resources in the selected villages in Maswa District. The results from the study will help researchers, planners, policy makers and other development agencies to get the insight on the coping and adaptive strategies which will ensure sustainability of rice production in the district. The study will also improve agricultural methods used by farmers in order to increase production in Maswa and other parts of the Lake Zone. Also will provide room for further studies on the methods and strategies to climate changes because it is a continuous process as modification and other updates is needed. Finally the information from the study will be helpful to the other researchers to update technologies on the adaptations technologies to climate change and variability and this work will help to know the gaps on climate change and variability which is still not worked on for further research.

1.4 Objectives

1.4.1 Overall objective

To assess the effect of climate change and variability and adaptation strategies practiced by small-scale rice producers in Maswa District

1.4.2 Specific objectives

i) To examine awareness of people to climatic change and variability in Maswa District.

ii) To examine the climatic change and variability trend in Maswa District.

iii) To examine effects of climate change and variability on rice production in Maswa District.

iv) To identify and document short and long term strategies related to rice production undertaken by communities to cope with climatic changes and variability.

1.4.3 Research questions

i. To what extent people of Maswa aware on the occurrence of climate change and variability?

ii. What is the trend of temperature and rainfall for past 30 years?

iii. What are the trends of rice production in Maswa?

iv. What are the effects of climate changes on rice production?

v. What measures are taken by farmers to cope with climatic changes?

vi. What climatic adaptation strategies are taken by the community to adapt to climate change?

1.5 Conceptual Framework for the Study

Conceptual framework indicates the connection between variables in this study. The conceptual framework presented in Figure 1 reveals the affiliation and interrelationship among variables, independent variables and dependent variables. Small scale rice farmers are adversely or beneficially affected by related climate stimuli and related hazards/risks that affect rice production (Hahn *et al.*, 2009). In attempt to minimize the climate impacts rice producers (farmers) plan and practice coping strategies in response to the impacts. The study specified the factors of climate change and variability particularly rainfall and temperature changes that have considerable to have directly impact in rice production. The considerable effects on reduction or fluctuation in rice yield necessitate farmers' to develop coping strategies and adaptations to minimize these adverse consequences. However, coping strategies at the farm level show a divergence from household to household or farmer to farmer depending on the household or farmer's perceptions. Farmers' perception depending on age, education, wealth (land size, labour force and income) and access to understand technologies, access information, access to resources and other social characteristics and accessibility to institutional factors of the household (Masika, 2002).

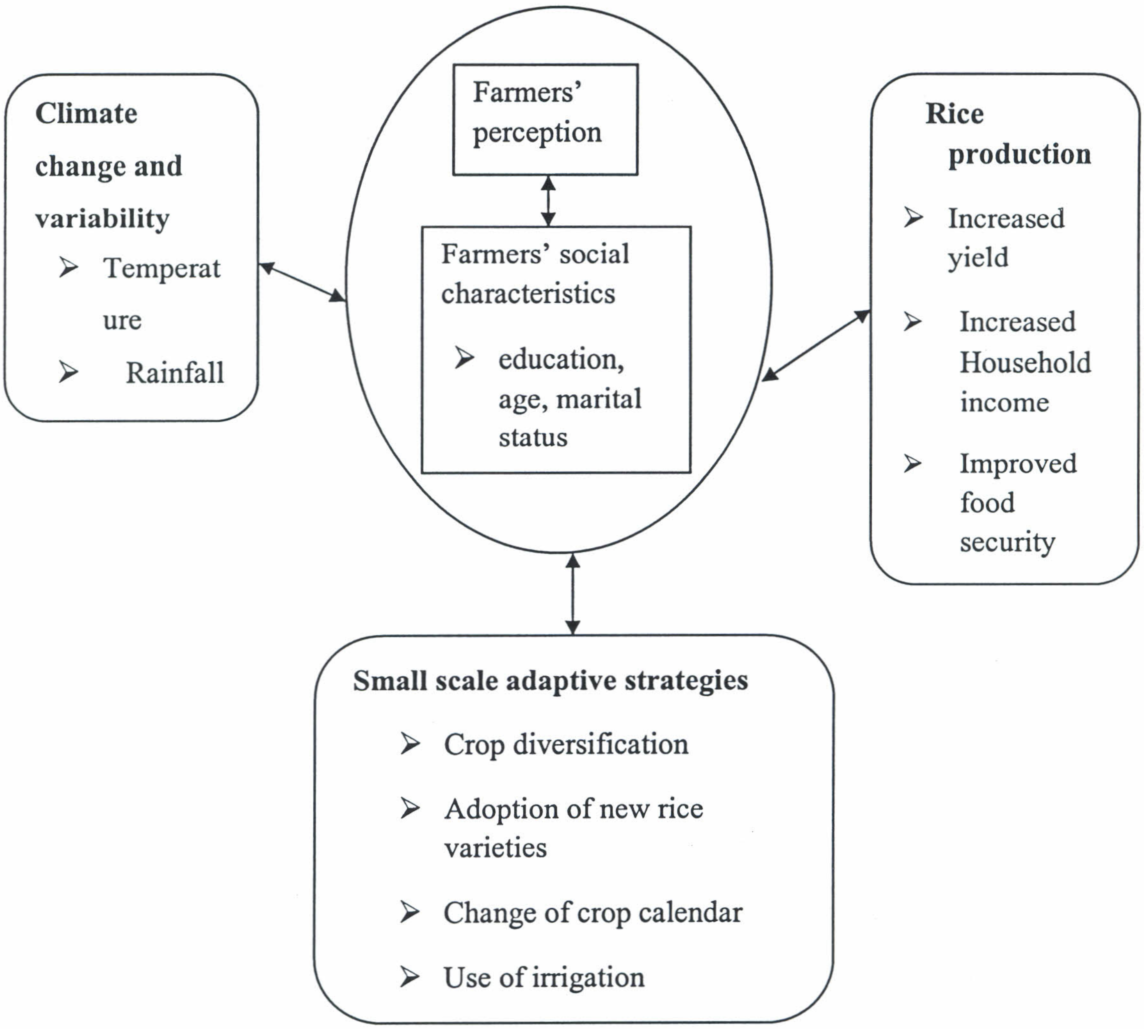

Figure 1: Conceptual framework

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definition of Key Concepts

2.1.1 Climate change

The intergovernmental panel on climate change (IPCC) defines climate change as any change in climatic over time, weather due to natural variability or as result of human activities. Or Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability persisting for an extended period (IPCC, 2001).

2.1.2 Climate variability

Climate variability refers to changes in climatic patterns such as precipitations, temperatures, drought, weather and climatic patterns (Wilson, 2006). Climate variability is the variations around the average climate, including seasonal variations in atmospheric and ocean circulation such as El Nino. According to Orindi and Murray (2005), climatic variability is the shift from the normal experienced rainfall pattern of the seasons to abnormal rainfall pattern. The same is reported to temperatures in some areas experience high temperature but the same season and place experienced the different amount of temperatures either low or high. In many regions inter-daily temperature variability has a tendency increasing and decreasing (Fischer, 1999). Climate variability refers to the climatic parameter of a region varying from its long-term mean. Every year in a specific time period, the climate of a location is different. Some years have below average climate, some have average or above average. There is no assurance of getting the same amount every year. The actual climate (rainfall or temperature) varying from the mean represents drought and flood conditions.

2.1.3 Drought

Drought most generally is defined as a temporary reduction in moisture availability significantly below the normal for a specified period (UNDP, 2000). Droughts are the result of acute water shortage causing severe and sometimes catastrophic economic and social consequences (Blaikie *et al.*, 1994). Out of all the natural disasters common in the region, droughts affect more people and larger areas than any other.

2.1.4 Adaptive capacity

Adaptive capacity is the ability of system to adjust to climate change (including climate variability and extreme) to moderate potential damage, to take advantages of opportunity or to cope with the consequences (IPCC, 2001). It includes adjustments in both behaviour and in resources and technologies. The presence of adaptive capacity has been shown to be a necessary condition for the design and implementation of effective adaptation strategies so as to reduce the likelihood and the magnitude of harmful outcomes resulting from climate change (Brooks and Adger, 2005). Adaptive capacity also enables sectors and institutions to take advantage of opportunities or benefits from climate change, such as a longer growing season or increased potential for tourism.

Much of the current understanding of adaptive capacity comes from vulnerability assessments. Even if vulnerability indices do not explicitly include determinants of adaptive capacity, the indicators selected often provide important insights on the factors, processes and structures that promote or constrain adaptive capacity (Eriksen and Kelly, 2007). One clear result from research on vulnerability and adaptive capacity is that some dimensions of adaptive capacity are generic, while others are specific to particular climate change impacts. Generic indicators include factors such as education, income and health.

Indicators specific to a particular impact, such as drought or floods, may relate to institutions, knowledge and technology (Yohe and Tol, 2002; Adger and Kelly, 2005).

Technology can potentially play an important role in adapting to climate change. Efficient cooling systems, improved seeds, desalination technologies, and other engineering solutions represent some of the options that can lead to improved outcomes and increased coping under conditions of climate change.

2.1.5 Coping

Use of existing resources to achieve various desired goals during and immediately after unusual, abnormal, and adverse conditions of a hazardous event or process (Nelson, 2007). The strengthening of coping capacities, together with preventive measures, is an important aspect of adaptation and usually builds resilience to withstand the effects of natural and other hazards (Agrawal, 2008).

2.1.6 Adaptation

Adaptation is defined as ecological, social, or economic systems adjustments in response to actual or expected climatic stimuli and their effects or impacts (IPCC, 2003). This term refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate. It involves adjustments to reduce the vulnerability of communities and activities to climatic change and variability (Mathew, 2010). Variability is the prolonged periods of drought and changes in the seasonal patterns of rainfall (Herrerro *et al.,* 2010).

2.3 Magnitude, Character and Rate of Climate Change and Variability

The climate of Tanzania varies from place to place in accordance with geographical location, altitude, relief and vegetation cover. Predictions show that the mean daily temperature will rise by 30°C – 50°C throughout the country and the mean annual temperature by 20°C – 40°C . There will also be an increase in rainfall in some parts while other parts will experience decreased rainfall. Predictions further show that areas with bimodal rainfall pattern will experience increased rainfall of about 5% – 45% and those with unimodal rainfall pattern will experience decreased rainfall of 5%– 15% (NAPA, 2007).

In Maswa district the occurrence of climate change and variability are also confirmed that there is a decrease of the rainfall that have an impact on crop production and water resource (Kajiru *et al.*, 2011). The average annual precipitation in Maswa was 600 mm – 800 mm for example, in year 2000/01, 2005/06 and 2008/09 it was 450, 421 and 630 mm respectively per annum. The decrease in precipitation during the growing period have an effect on the yield on rice production wilting of leaves, less spikelets may occur which is resulting into low yield of rice.

Rising temperature and changing rainfall affect agricultural production and water resources availability, hence threatening lives and livelihoods for millions of poor people (Orindi and Murray, 2005). But most of statistics and trends in relation to climate change and variability provided in Tanzania are too general and lack specifics example in a certain geographical area such as Maswa District.

2.4 Adaptation to Climate Variability in Agriculture

Adaptation can prevent future risks, reduce present adverse effects and refers to individual or collective action (GHF, 2009). According to Parry *et al.* (2007) recommended that even if there are small amount of warming could have profound implications for human enterprise, and a thorough understanding of these potential impacts is central to planning appropriate responses/adaptation.

The great role to play is by employing the strategies aiming to reduce human dangerous activities through research findings of the most vulnerable household, community, national and international levels so as to enhance the already existing coping and adaptation strategies while designing the new ones (NAPA, 2007). A wide variety of adaptive actions may be taken to lessen or overcome adverse effects of climate change on agriculture (Rosenzweig and Hillel, 1995).

Various types of adaptation exist, for example, anticipatory and reactive, private and public, and autonomous and planned" (IPCC, 2007b). Autonomous adaptation, for example, represents a response of a farmer to changing precipitation patterns, through crop changes or using different harvest and planting/sowing dates, using new varieties, crop rotation and intercropping. Planned adaptation measures indicate conscious policy options or response strategies targeted towards altering the adaptive capacity of the agricultural sector.

Households and communities are known to have developed some alternative activities in which households engage in order to secure food or income during extreme climate events (Low, 2005). In dealing with climate variability farmers respond in the short run or immediately designated as "coping strategies and in long run term designated as "adaptation strategies. The coping strategies are those used for short term and during the extreme events while the adaptation is used before during and after the events and is a long term strategy (Tasesse, 2013). However, the extent of adaptation is more observed at macro level, but on local geographical level like Maswa is still lacking.

2.5 Impacts of Climate Change on Crop Productivity

Cline (2007) highlights agriculture as the sector that is experiencing the most serious impact of climate change. The impact is projected to vary within the country and across countries, with the expectation that undeveloped countries will be more severely impacted. Increased warming, without the implementation of appropriate protective mechanisms, is likely to reduce yields associated with traditional agricultural practices, due to increased levels of evaporation. Drought and floods result in crop damages and failure (Kangalawe and Liwenga, 2005); and in combination lead to chronic food shortages. However the extent of climatic and weather variation on crop production in Tanzania is too general there is a need to quantify in small geographical area like Maswa.

2.6 Rice Productivity Trend in Rain-fed Agriculture

The term rain-fed agriculture is used to describe farming practices that rely on rainfall for water. It provides much of the food consumed by poor communities in developing countries. For example, rain-fed agriculture accounts for more than 95% of farmed land in sub-Saharan Africa, 90% in Latin America, 75% in the Near East and North Africa; 65% in East Asia and 60% in South Asia (IWMI, 2010).

In sub-Saharan Africa countries, rain-fed agriculture has been the leading source of food production (Rockstrom, 2001). It is likely to remain so for the foreseeable future, since more than 95% of the agricultural farmland is under rain-fed agriculture (Rosengrant *et* *al.,* 2000*)*. The common characteristics of rain-fed agriculture, especially in the tropical and the semi-arid agro ecosystems are low crop yields far below potential yields attainable in the regions, and high on-farm water losses. For example, in tropical and semi-arid sub-Saharan Africa, cereal yields from rain-fed cultivation have been reported to be generally around 1 ton per hectare (Rockstrom *et al.*, 2003) as against potential yields attainable in the region, which are reported as 3-5 tons per hectare (Barron, 2004).

Rain-fed lowland rice is grown in bounded fields that are flooded with rainwater for at least part of the cropping season. About 60 million ha of rain-fed lowlands supply about 20% of the world's rice production (IRRI, 2009). Rain-fed rice environments experience multiple abiotic stresses and high uncertainty in timing, duration, and intensity of rainfall (IRRI, 2009).

2.7 Climatological Normals Average

Climate isn't defined by any particular timeframe, however scientists typically use average weather conditions over 30-year time intervals to track climate. These 30-year averages are called climatological normals, and are used to determine, monitor or represent the climate – or a specific slice of climate – at a particular location. Thirty years of data is long enough to calculate an average that is not influenced by year-to-year variability (Dinse, 2011).

Normals can be calculated for a variety of weather variables, such as temperature or precipitation based on data from weather stations in the region of interest. There is significant year-to-year variability around these 30-year averages. For example, in 1982 maximum average temperature may be 29°C, in 1985 may be 31°C this year to year fluctuations around the normal is climate variability (MSG, 2009).

2.8 Trend Analysis

Climate change is a cumulative change in weather patterns over a period of time. Trend analysis using non-parametric Mann-Kendall test may help to determine the existence and magnitude of any statistically significant trend in the climatic data (Rahman and Begum, 2013). Another index called Sen's slope may be used to quantify the magnitude of such trends (Bandyopadhyay *et al.*, 2011).

In sequence overtime analysis involving comparison of the same item such as monthly temperatures or rainfall figures over a significantly long period to detect general pattern of a relationship between associated factors or variables and project the future direction of this pattern (Bandyopadhyay *et al.*, 2011). Trend analysis means looking at how a potential driver of change has developed over time, and how it is likely to develop in the future (Rimi *et al.*, 2006).

Rational analysis of development patterns provides a far more reliable basis for assumption and prediction than reliance on mere intuition (Mondal *et al.*, 2012). Several trends can be combined to picture a possible future for the sector of interest, such as schooling. Trend analysis does not predict what the future will look like; it becomes a powerful tool for strategic planning by creating plausible, detailed pictures of what the future might look like. The knowledge of increasing/decreasing or no trend of an individual climatic parameter may lead to safer designs, proper planning, required corrective measures, and sustainable practices. Many researchers have investigated the nature and pattern of trends of different climatic parameters (IPCC, 2001).

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

Maswa is one of the three districts of Simiwi Region, Tanzania. It covers an area of about 3398 km^2 of which 2375 km^2 is arable land, 177 km^2 is forest, and the rest is mountainous and covered with stunted shrubs and bush. Maswa District lies between Latitudes 2.45° and 3.15° South and Longitudes 33.0° and 34.7° East. Altitude is about 1200 – 1300 m and rainfall between 600 and 1000 mm per year (Kajiru *et al.*, 2011). Deforestation accompanied by soil erosion is causing environmental degradation problems. The district is divided into three administrative divisions with 18 wards and 77 villages (REPOA, 2007). It falls within the extensive central semi-arid agro ecological zone, which is characterized by gently undulating plains with long slopes and wide valley bottoms. Availability of adequate soil-moisture for plant growth is a major constraint, mainly due to the occurrence of long dry-spells during the growing season. The land use pattern is linked to the recurrent topo-sequence of soils known as Sukumaland catena as first described by Milne (1936). Up to the 1980s, common crops grown were cotton and other drought resistant crops such as sorghum and millet. Most of the people belong to the Sukuma tribe. Agriculture and livestock keeping are the main occupations. The main food crops are maize, rice, sweet potatoes and groundnuts, with smaller amounts of millet, cowpeas, green grams and chick peas. Cotton and rice are the major cash crops (Rwehumbiza *et al.,* 1999).

This study was conducted in two villages of the Maswa District. Ngh'aya and Buyubi villages from Mwamashimba and Buchambi wards respectively. The selected villages were reported to be major areas for rice production in Maswa District (REPOA, 2007). About 95% of farmers involved in the study area engaged in rice production.

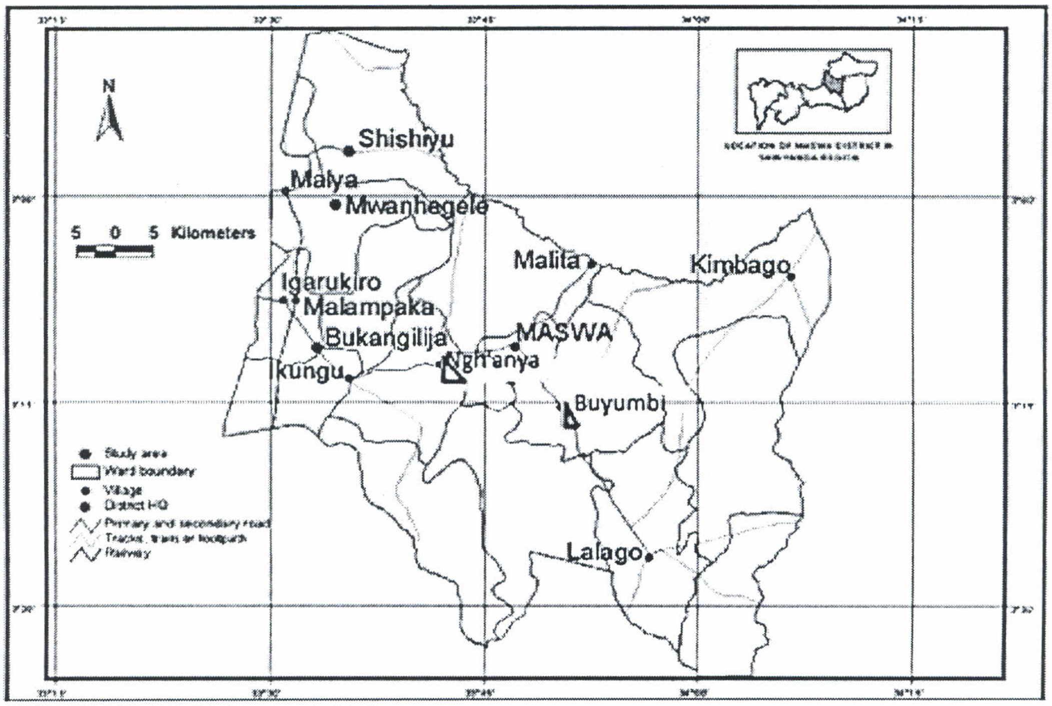

Figure 2: Map of Maswa District

Source: REPOA report (2007)

3.1.1 The Biophysical environment

3.1.2 Physiographic

The physiography and soils of the Maswa District have been described well by Ngailo *et al.* (1994). The main physiographic units are the granitic hills, pen plains and bottomlands or *mbuga*. The steepest slopes (>16%) are found in the hills. Generally with the exception of the hills, the slopes in the majority of the district do not exceed 6%. The Sengerema division in the Maswa District, the main area covered by in this study, is predominantly undulating plains, interrupted by wide and narrow valley bottoms, which are very important for rice cultivation.

3.1.3 Soils

The soils in the Maswa District bear common names similar to those used in the rest of Sukumaland. In fact the natural soil forming processes which seem to have been similar or related in most parts of the Sukumaland, have caused a series of soils to develop in succession from the hilltop to the valley bottoms. Such succession of soils in the same climatic conditions along the top sequence forms the so-called *catena* (World Bank, 2001).

The soils encountered along the *catena* depend on factors such as parent material, water movement and presence or absence of soil salts. The phenomenon has significance in land use in Sukumaland because the different soils on the top sequence have been assigned local names, which also have a bearing on the type of crop. However, the local names do not in any way indicate the potential of the particular soil (REPOA, 2007).

3.1.4 Climate

There are a number of rainfall recording stations in the district with varying lengths of the recorded data. Rainfall data collected for over 30 years from the Maswa and recording stations revealed an average of 900 mm a year for the northern part of the district. The rainfall pattern decreases from about 1 400 mm a year in the northwest to less than 500 mm/year in the southeast. The average maximum temperature ranged from 28^0C to 32^0C and average minimum temperature ranged 17^0C to 18.9^0C (Maswa District planning Office, 2000).

3.1.5 Crop production

The district grows both food and cash crops. Crops include rice, maize, sorghum, green grams, chick peas, sunflower, cotton and sweet potatoes. Maize is more affected by low rainfall and poor rainfall distribution sometimes interrupted by pronounced dry spells (REPOA, 2007).

3.2 Research Methods

3.2.1 Research design and sample size

The study used cross section research design for data collection. This method allows the collection of data at one point in time (Creswell, 2003). The choice done based the mode of collecting the data at one time. Respondents from each village were purposely selected, from village register generated from the village government offices. The selection of villages was based on the existence of rice production farms and resident who stayed in the village for not less than 30 years. A sample size of 120 households was drawn from rice farmers in each of the two randomly selected villages in the study area. The unit of the study was households.

3.3 Climatic Data Collection

Climate data for rainfall and temperature were collected from the Tanzania Meteorological Survey Agency (TMA) located within Maswa District in Tanzania. Weather data for a period of 30 years from (cropping seasons of 1982/2012) were collected for developing the historical trend of productivity of rice for the rain-fed areas. Crop yield data and area cultivated grain rain-fed crops were obtained from Maswa District Agricultural and Livestock Development Officer (DALDO) official records that were available in Maswa District. Both the annual crop yield and total area under rice production records during the 30 years cropping seasons were collected from DALDO office and TMA station at Maswa District.

3.3.2 Primary data collection

Data were collected using a well-structured questionnaire (Appendix 1) to capturing information related to respondents' characteristics, small scale farmers' perceptions of climate change and variability, coping and adaptation strategies.

3.4 Data Analysis

Rainfall and temperature data were analyzed using Mann-Kendall Trend Tests (Makesens) and Excel programme to generate patterns and trends of rainfall and temperature. Primary data from obtained through interview survey was analyzed by using the Statistical Program Social Science (SPSS) which used to analyze data on household demographic and socio- economic characteristics, awareness on climate change and variability and the magnitude of coping and adaptation strategies.

Temperature and precipitation data for 30 years was used to address objective two of this study. Relationship between the precipitation, temperature, land size and socio-economic variables on rice yield were estimated by use of the Cobb-Douglas Production function model. For linear estimation, natural logarithmic transformation was performed, followed by regression analysis.

Cobb-Douglas functional form of production functions is widely used to represent the relationship of an output to inputs.

The Cobb Douglas Function Model used was as shown in equation 1 below.

$$Y= AT^{\beta 1}minT^{\beta 2}maxLS^{\beta 3}RE^{\beta 4} \qquad (1)$$

Natural logarithm applied to make Y linearly related to its independent variables. Thus results into equation 2;

Then regressed Y on the independent variables to obtain estimates of the parameters β_1 to β_4. Natural log transformation gave a linear regression equation 2.

$$\ln Y = A + \beta_1 \ln T_{min} + \beta_2 \ln T_{max} + \beta_3 \ln LS + \beta_4 \ln RE + \acute{\varepsilon} \quad \text{...(2)}$$

$$Y = A + \beta_1 Tmin + \beta_2 T\ max + \beta_3 LS + \beta_4\ RE + \acute{\varepsilon} \quad \text{...(3)}$$

Where:

Y=Yield (Dependent variable)

LS = Rice acreage (ha)

T_{min}= Effective minimum temperatures

T_{max}= effective maximum temperatures;

RE = Effective rainfall,

A = a mere constant,

β_1 to β_4 = The estimates of the effects of the independent variables to Y;

$\acute{\varepsilon}$ = a random for any given set of error.

Pearson's correlation analysis was then used to determine strength of association between climate and variability and rice production data. Pearson's correlation coefficient when applied to a sample is commonly represented by the letter *r* and may be referred to as the sample correlation coefficient or the sample Pearson correlation coefficient. To obtain r, the formula represented by equations 3 and 4 were used as shown below:

$$r = \frac{\sum_{i=1}^{n}(X_i - X)(Y_i - Y)}{\sqrt{\sum_{i=1}^{n}(X_i - \bar{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}} \quad \text{...(4)}$$

An equivalent expression gives the correlation coefficient as the mean of the products of the standard scores. Based on a sample of paired data (X_i, Y_i), the sample Pearson correlation coefficient is given by:

$$r = \frac{1}{n-1}\sum_{i=1}^{n}\left(\frac{X_i - X}{s_X}\right)\left(\frac{Y_i - Y}{s_Y}\right) \quad \text{...(5)}$$

Where;

$$\frac{X_i - X}{s_X}, \bar{X}, \text{ and } s_X \quad \text{..(6)}$$

Equation 4, 5 and 6 are the standard score, sample mean, and sample standard deviation respectively.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Household Demographic and Socio-economic Characteristics

Household demographic and socio- economic characteristics described here include: age of household head, sex of the household head, household size, marital status of the household head, education level of the household head, and the main occupation of the household head.

4.1.1 Age of the household head

The ages of respondents were grouped into three major groups, which are 18-35, 36-59, and above 60 years old. According results presented in (Table 1) the age group 36-59 years had 71.7% of all respondents by number, whereas, those aged 60 years and above comprised of 4.1% of the total number of respondents interviewed in the study area.

The number of respondents with age group 18-35 years for Buyubi was relatively equal to that for Ngh'aya village (that is, 12.5% and 11.7% respectively). Similarly, age group 35-59 years for the same villages had almost equal number of respondents (34.2% and 37.5% respectively). The age from 60 years and above for the two villages was 0.8% and 3.3% in Ngh'aya and Buyubi respectively. This indicted that majority of rice producers in both villages are aged between 35 – 59 years old. This age is potential for production work because at this age people are energetic so they can produce (REPOA, 2007).

Table 1: Age of household (n=120)

Village	Parameters	Categories	Frequency	Percent
Buyubi	Age groups	18-35 years old	15	12.5
		36-59 years old	41	34.2
		60 and above years old	4	3.3
Ngh'aya		18-35 years old	14	11.7
		36-59 years old	45	37.5
		60 and above years old	1	0.8
		Total	**120**	**100**

4.1.2 Sex of the household head

The results from this study revealed that, there were relatively equal numbers of female respondents selected from both villages. Though, the number of males was more than that of females in both Buyugi (11.7% females and 38.3% males) and Ngh'aya (10.0% females and 40.0% males) villages (Table 2). This indicates that majority of rice producers households are headed by males than household that headed by female. Although rural women and men play complementary roles in guaranteeing food security, women tend to play a greater role in natural resource management and ensuring nutrition (FAO, 2003). Women often grow, process, manage and market food and other natural resources, and are responsible for raising small livestock, managing vegetable gardens and collecting fuel and water (FAO, 2003). Men, by contrast, are generally responsible for cash cropping and larger livestock and they are decision makers in the household. So any intervention should aim to empowerment of women to enhance adaptations and coping strategies to be done in Maswa district. This concurs with Twinomugisha (2013) who argued that there is a need to empower women in the agriculture sector to faster adaptations to climate change because they contribute a lot on agricultural activities.

Table 2: Sex of the household (n=120)

Village	Parameters	Categories	Frequency	Percent
Buyubi	Gender	Female	14	11.7
		Male	46	38.3
Ngh'aya		Female	12	10.0
		Male	48	40.0
		Total	**120**	**100.0**

4.1.3 Household size

Household size was among the demographic variables of interest in this study. Ngh'aya village had large number of the household in a range of 6-9 household members. This household size accounted for 53.3% of the total number of households in the sample. Conversely, household size of more than 13 household members, Ngh'aya had the lowest number (1.7%) while Buyubi had 6.7% households.

The percentage of households whose members were between 2-3 was higher for Buyubi (36.7%) than it was for Ngh'aya (20%) for the same household size (Table 3). The household size above 5 household members is above the national household size of 4.8 from the 2012 Tanzania National Census (URT, 2013). This is an indicator for high rate of population growth within study area. Thus could increase the environmental destructions which are reported to cause the climate change and variability. Increasing population in rural areas of Tanzania contributed to changes in land use/cover patterns, land fragmentation and livelihood insecurity (Kangalawe and Lyimo 2010). Increasing demand for food, energy and other environmental services has contributed to expansion of agriculture, and deforestation, often leading to environmental degradation. The high urban demand for food and biomass energy from rural areas has also contributed to rural deforestation and overall environmental degradation. Thus, calls upon interventions which could be made through sensitization on family planning programmes among households within the study area (Agrawal, 2008).

Table 3: Household size (n=120)

Village	Parameters	Categories	Frequency	Percent
Buyubi	Household size	2-5 household members	22	36.7
		6-9 household members	28	46.7
		10-13 household members	6	10
		above 13 household members	4	6.7
Ngh'aya		2-5 household members	15	25
		6-9 household members	32	53.3
		10-13 household members	12	20
		above 13 household members	1	1.7
		Total	**120**	**100**

4.1.4 Marital status of the household head

Marital statuses described include the status of the household head as either being single, married, divorced or widow. From this study, it had been found that, most of the household heads in both villages were married (35% Buyubi and 35.8% Ngh'aya). Married household head accounted for 70.8% of the total number of respondents in the study area.

Results showed that, very few household heads were widows in Buyubi village about 0.8% of the total sample size who found to cultivate small plots of rice about 0.5 acre using few adaptive measures to climate change. But the number of divorced in Buyubi was higher (5.8%) when compared to 1.7% of divorced women in Ngh'aya. It is believed that marital status of household heads could have an influence on the adaptation strategies against climate related shocks. Obviously household head with marital status shall have more stable situation in farming activities and off-farm activities and hence agricultural and non-agricultural production (Tasesse, 2013).

Table 4: Marital status (n=120)

Village	Parameters	Categories	Frequency	Percent
Buyubi	Marital status	Married	42	35
		Single	10	8.3
		Divorced	7	5.8
		Widow	1	0.8
Ngh'aya		Married	43	35.8
		Single	13	10.8
		Divorced	2	1.7
		Widow	2	1.7
		Total	**120**	**100**

4.1.5 Education level of the household head

From this study, it has been revealed that, about household (41.7%) of Buyuni village had primary level of education while (37.5%) household from Ngh'aya village. Generally primary level for both villages accounted for 79.2% of the total sample size. The large number of primary education level shows that many had the basic education for them to at least learn new agricultural innovations if given opportunity to do so (Table 5).

On the other hand, Buyubi had no household with college and university level of education when compared to household of Ngh'aya village which had 0.8% for the same levels of education (Table 5). Moreover, the level of illiteracy was higher in Ngh'aya (9.2%) than it was in Buyubi (5.8%).

Education is an important variable as it determine the capacity of an individual to comprehend and utilize resources within environment to improve one's life standards (UNDP, 2000). And it is very important to the farmer in the course of acquiring technologies brought through extension services in the farming communities (Rolling, 1994). This calls for intervention to improve adult literacy, which would improve farmers' ability to adopt agricultural innovations for increasing farm yields.

Table 5: Educational level (n=120)

Village	Parameters	Categories	Frequency	Percent
Buyubi	Education Level	Illiterate	7	5.8
		Primary school	50	41.7
		Secondary school	3	2.5
		Collage	0	0
		University	0	0
Ngh'aya	Education Level	Illiterate	11	9.2
		Primary school	45	37.5
		Secondary school	2	1.7
		Collage	1	0.8
		University	1	0.8

4.1.6 Main occupation of the household head

Buyubi and Ngh'aya villages were among the villages with higher of income generating diversified activities. Among the economic activities conducted were: crop production, livestock keeping, crop and livestock production, and employed and farming. Results, showed that, 79.1% of households engaged in both crop and livestock production. From both villages the number of household heads who were engaged in crop and livestock production as the main occupation was less similar, that is, 38.3% (Buyubi) and 40.8% (Ngh'aya).

Households that had crop production as a sole income generating activities were few (8.3% for Buyubi, and 7.5% for Ngh'aya). Ngh'aya village had the smallest number of household heads who had farming and government employment as their main occupation. This accounted for 0.8% of the total number of respondents, when compared to household in Buyubi on the same occupation (1.7%).

These results showed that agriculture is the major employer in most of the rural areas as majority of households were both farmers and livestock keepers. These results then, are in line with what was reported in URT (2004) that, the majority of the Tanzania labour force (79%) is employed in agriculture. Also REPOA (2007) found that on average more than 80% of the population was depending solely on agriculture. The main crops that are considered by farmers as major earners of cash are rice and cotton.

Table 6: Main occupation of households (n=120)

Village	Parameters	Categories	Frequency	Percent
Buyubi	Main occupation	crop production	10	8.3
		livestock keeping	2	1.7
		Crop and livestock production	46	38.3
		Employed and farming	2	1.7
Ngh'aya		crop production	9	7.5
		livestock keeping	1	0.8
		Crop and livestock production	49	40.8
		Employed and farming	1	0.8
		Total	**120**	**100**

4.1.7 Farmers awareness and perception on climate change and variability

The presence of climate change and variability was well understood among most of the farmers (97.5%) whereby 50% were from Ngh'aya and 47.5% from Buyubi. However, very few farmers (2.5%) reported no change in rainfall and temperature (Table 7). In studying adaptation to climate change in agriculture understanding farmers' perception is indeed important. Gbetibou (2009) divulged that farmers' ability to perceive climate change is a key precondition for their choice to adapt. This is to say adaptation involves a two-stage process: first perceiving change and then deciding whether or not to adopt by taking a particular measure. Senkondo (2000) pointed out that risk perception influence farmers objectives and ultimate choice cropping system; in addition to that Mutabazi (2007) reported that the perception and attitude to risks shape the way farmers react to risk., the course of actions taken by an individual decision – maker depends on their perceptions and attitude to risk with regard to expected outcomes of given sources of risk.

Table 7: Farmers' awareness on prevailing climate change and variability (n=120)

	Responses			
Village name	**No. farmers noted changes on temp and rainfall**		**Farmers not noted any change on temp and rainfall**	
	Frequency	**Percent**	**Frequency**	**Percent**
Buyubi	57	47.5	3	2.5
Ngh'aya	60	50	0	0
Total	**117**	**97.5**	**3**	**2.5**

Findings presented in Table 8, showed that, farmers perceived climate impacts differently. The majority of respondents from Ngh'aya (35.8%) and Buyubi (24.2%) reported poor rainfall distribution while (12.5% Buyubi and 8.3% Ngh'aya) reported increased drought incidences was due to climate change and variability. But very few (0.8%) in both villages said it was extreme temperatures. However, increased floods and rain falling very early and lasting within short time period were reported to be climate impacts only in Buyubi village for 1.7% each. Other climate change impacts reported are presented in (Table 8). According to Adger (2003) findings, farmers living in drier areas with more frequent droughts are more likely to describe the climate change to be warmer and drier than farmers living in relatively highland areas with less frequent droughts. In general, increased temperature and declined precipitation are the predominant perceptions in the study areas.

Table 8: Indicators to the presence of climate change (N=120)

Notable impacts	Increased drought incidence		Increase floods		Poor rainfall distribution		Extreme temperatures		Rain falls very early and for few days	
Villag	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
Buyub	15	12.5	2	1.7	29	24.2	1	0.8	2	1.7
Ngh'ay	10	8.3	0	0	43	35.8	1	0.8	0	0
Total	25	20.8	2	1.7	72	60	2	1.7	2	1.7

Moreover, farmers were able to remember climate events such as prolonged droughts which happened in years 1984, 1994 and 2005, that resulted into severe hunger. It was also within the memories of farmers for the high rains which happened during 1998 the impact of El Nino that had both negative and positive impact in agriculture. During this event other farmers got high yields of rice while in other their farm flooded hence reduced yields. Few farmers knew the reason on why climate is occurring: mentioned the human force such as cutting trees (deforestation), increased human activities and natural forces.

4.2 Climatic Change and Variability Trends in Maswa District

4.2.1 Rainfall trends

The study results as shown by Figure 3, indicated rainfall trends over 30 years in the Maswa district with a gradual decrease by 1.467 mm of average rainfall. However, extreme droughts were observed in years 1999-2002 and 2005-2006 where rainfall ranged between 450 – 500 mm. In years between 1997 and 1998, there was extreme rainfall measured above 1000 mm. Generally, the amount of rainfall received between the various periods varied and had different magnitudes. This result is in line with what reported by Yanda *et al.* (2008), that rainfall in the lake zone had been decreasing and increasing at different rates with different amounts.

The observed trend showed great variations between seasons such that, the majority of households reported that planning for agricultural activities in the semi arid areas like Maswa is increasing becoming difficult. Moreover, Maswa district experienced unimodal rainfall type which according to Munishi *et al.* (2006) had been experiencing the decrease in rainfall for about 3% to 15% per annum.

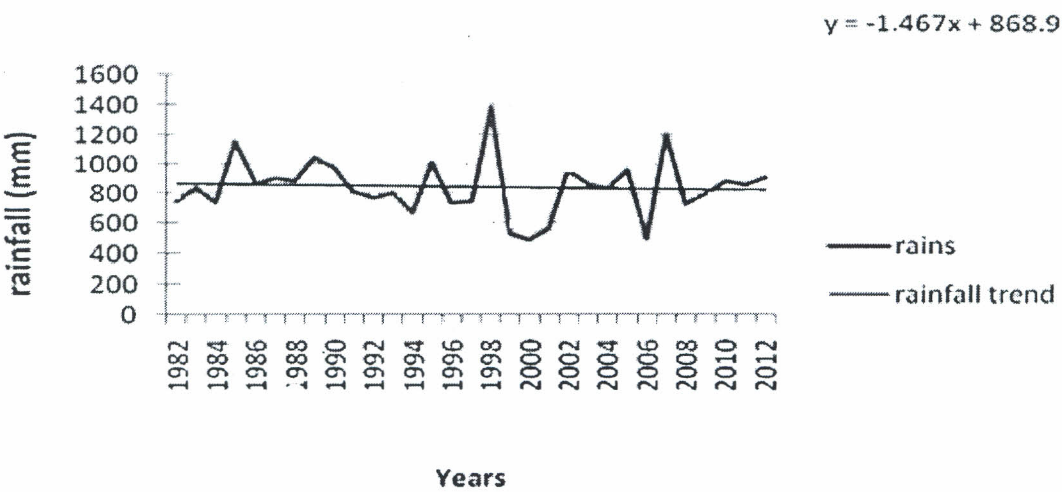

Figure 3: Rainfall trends in Maswa district for 30 years

Rainfall distribution has considerable negative and positive implications on various farm activities (FAO, 2001). With this respect, rice production within the study area had been at risk, because of lack of reliable rainfall which is also poorly distributed. This makes planning for land preparation for rice is extremely hard. Because, the normal production season within study area has to start early in October to November, hence any change in weather has bad implication.

Study results (Fig. 3) have shown that, year 1998 was reported an extreme event of rainfall recorded in the study area. Rainfall amount received was more than 1000 mm. This was the time when *El Nino* occurred. According to Challinor *et al.* (2007), *El Nino* is the sign for climate variability as the most observed consequences of change in weather. Therefore, occurrence of the same situation within study area justified the presence of climate variability.

The effects of extreme events like *El Nino* was reported by Sinclair and Rufty (2012) as, among the climate change variability challenges facing small-scale producers. The impact of *El Nino* had been great deal of disasters on crop destructions. Such negative impacts, included soil erosion; damage to crops and infrastructure; reduced market access caused by flooding; increased morbidity due to increased human waterborne diseases; and increased livestock mortality due to disease (USAID, 2012).

On the other hand, decrease in rainfall leads to changes in farming habit by small scale farmers. The livelihoods of large numbers of the rural poor are at risk for the reason that vulnerability to food insecurity increases when agricultural productions are affected by climate change (ILO, 2007). Hence, continued trend of climate change in the future could have repercussions in the sustainability of poor surface water resources and groundwater recharge and therefore resulting in low rice yield (Green *et al.*, 2011).

4.2.2 November Mean Rainfall

Since November is very critical period for Maswa district because in this month rice farmers are required to plant or weed their rice fields. Results showed that, there were very high variations in the rainfall received within November from 1982 to 2012 (Fig. 4).

For example, the rains for November in some years were very high (Years 1999-2001), while in other years rains were zero (2005 and 2009). These variations observed in this study could have negative implications on rice yields.

Study findings revealed that, rainfall distribution in Maswa was greatly skewed within seasons, for example, November months in the period of 30 years had been found to be varying year to year. These results agreed to what was stated by Kajiru *et al.* (2011) that, rainfall variation is inevitable, and that one of the common features of the rainfall pattern is its greater variability in cycles which results in either increased or decreased. Thus, decrease in rainfall results into prolonged droughts, decreased rice production, as it largely impact crop production and water resource (Yanda and Mubaya, 2011).

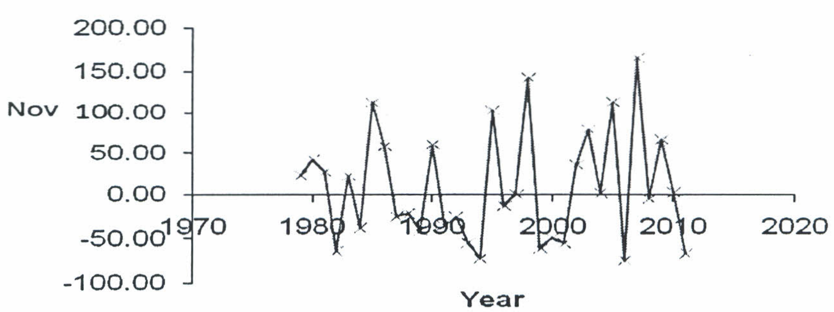

Figure 4: Rainfall on November months from 1982 – 2012 in Maswa District

4.3 Mann Kendall Test Results on Annual Mean Rainfall

The result showed that, in month of April and May there were rainfall trend decrease by -2.438 and -1.593 for 30 years respectively. This trend was statistically significant at $|Z| \geq 2$. Sen's slope estimates show that, rainfall trend was changing by decreasingly in the study area for 30 years, but significant rainfall seasonal changes occurred in the months of April and May. These results justify the presence of climate change because as defined by

IPCC (2001) "Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability persisting for an extended period (typically decades or longer)"

The rest of the months had gradual changes, but not statistically significant. Sen's slope estimates show three positive increase seasonal trend for January, December and August, and decreasing seasonal rainfall trends for months of February to May, and September to November which were not statistically significant (Table 9). However, in June and July indicated zero trends which mean that these months are dry spell period. This finding from Mann Kendal Test implies that, rainfall trend had been decreasing in most of the months. But rainfall trend increase was observed only in few months (December, January and August) as presented by Sen's slope values (Table 9). This study findings agree with what was observed by Onoz and Bayazit (2012) that, precipitation trend was decreasing over the 30 years period. Additionally, result showed that, there was rains deficit to support agricultural activities such as rice farming in the study area. Since most of the small scale farmers in Maswa depend on rain fed agriculture, a decrease in rainfall could result into poor rice productivity for the reason that rice crop requires enough precipitation for high yielding.

Conversely, the findings on climatic trends were not in line with what was reported by Karmeshu (2012) in the study conducted in Northeast US on the trend detection of annual temperature and precipitation using Mann Kendall Test. In Karmeshu (2012), rainfall trend was reported to have been increasing for 30 years period.

Table 9: Rainfall trend in the study area

Mann-Kendall trend test						Sen's slope
Time series	**First year**	**Last Year**	**N**	**Test Z**	**Significance**	**Q**
JAN	1982	2012	30	1.44		1.019
FEB	1982	2012	30	-0.05		-0.058
MAR	1982	2012	30	-0.20		-0.389
APR	1982	2012	30	-2.60	**	-2.438
MAY	1982	2012	30	-2.00	*	-1.593
JUN	1982	2012	30	0.09		0.000
JUL	1982	2012	30	-0.28		0.000
AUG	1982	2012	30	1.54		0.169
SEP	1982	2012	30	-0.33		-0.084
OCT	1982	2012	30	-0.08		-0.124
NOV	1982	2012	30	-0.45		-0.774
DEC	1982	2012	30	0.36		0.506

4.4 Temperature Trends

Analysis of average minimum and maximum temperatures over the last 30 years (between 1982 and 2012) is presented in figure 5 and 6. Results showed that, there was a gradual increase in minimum temperature by 0.031^0C` for 30 years, whereas, the maximum temperature increased by 0.04^0C for 30 years. Both the maximum and minimum temperatures were found to be raised with maximum temperature i.e. inclined towards rose than minimum temperature.

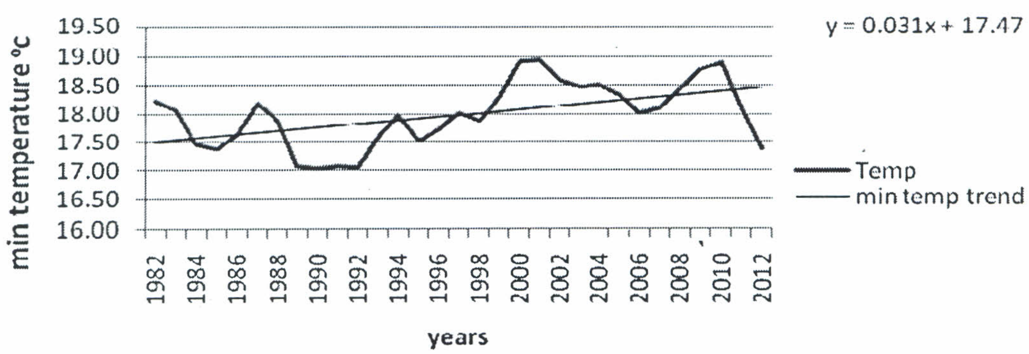

Figure 5: Minimum temperature in Maswa District

The minimum temperatures on average were above 17.47°C for 30 years, ranging from 17.0°C–18.9°C, while the maximum temperatures ranged from 28°C- 32°C (Fig. 6). For example in year 2002, there was an increase in the minimum temperature up to 18.9°c, while the maximum temperatures reached to 32°C in the same year. This trend increase in temperature is supported by Easterling *et al.* (1999) report that, there is a clear evidence for an observed increase in global average temperature and change in rainfall pattern during the 20th century around the world. This trend increase in temperature has negative impact on the small scale rice farmers' incomes and livelihood since it affects rice productivity (Redfern, 2012).

The trend increase in temperature has negative impacts not only to rice crop but also to the environment and habitats of other organisms as it was reported by Karmeshu (2012) that, any trend increase in temperature can lead to a shift in species habitat for forests and insects. Because, increase in temperature results into intense heat waves that could be challenging for aging and other vulnerable populations within a given environment.

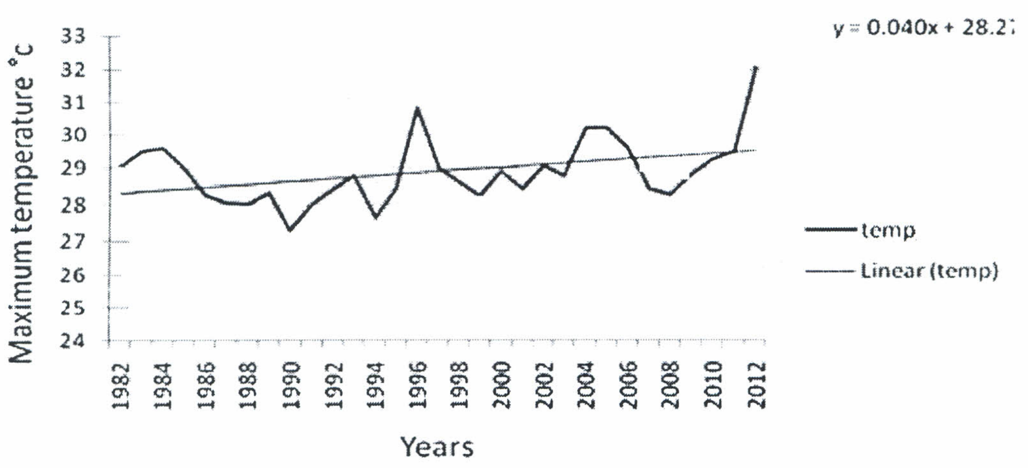

Figure 6: Maximum temperature trend in Maswa district

4.5 Temperature Trend Results by Mann Kendall Test

Mann Kendall Test temperature trend results showed that, there were significant trend increases in temperature for February, April and May months for 30 years. The increase of temperature per year was 0.076°C, 0.067°C, and 0.055°C for these months which was statistically significant at $|Z| \geq 2$. Temperature trend was increased for almost all months except September, which showed a decreasing trend. The trend was not statistically significant at $|Z| \geq 2$. Sen's slope estimates revealed presence of variations in the temperatures between months (Table 9).

The trend increase in temperature which was revealed in this study concurs with what reported in other studies. For example, the climate change study in India revealed that, the annual mean temperature has increased by 0.48 °C in the past 100 years (Srivastava, 2007). Munishi (2009) reported that, 'there will be an increase in temperature trend in the country and it is expected to rise between 3^0C–5^0C throughout the country and the mean annual temperature may increase by 2^0C–4^0C'. This also concurs with what Karim *et al.* (1995), reported that 3% increase in the temperature result into crop decrease up to 42%.

Table 10: Mann Kendal test on average temperature

	Mann-Kendall trend					Sen's slope estimate	
Time series	**First year**	**Last Year**	**N**	**Test Z**	**Significance**	**Q**	**Qmin99**
JAN	1982	2012	30	1.14		0.036	-0.058
FEB	1982	2012	30	1.99	*	0.076	-0.022
MAR	1982	2012	30	0.92		0.029	-0.056
APR	1982	2012	30	2.96	**	0.067	0.012
MAY	1982	2012	30	2.55	*	0.055	0.000
JUN	1982	2012	30	1.50		0.027	-0.028
JUL	1982	2012	30	1.34		0.029	-0.029
AUG	1982	2012	30	0.24		0.010	-0.067
SEP	1982	2012	30	-0.80		-0.012	-0.071
0CT	1982	2012	30	0.39		0.011	-0.067
NOV	1982	2012	30	1.92		0.043	-0.013
DEC	1982	2012	30	1.57		0.045	-0.038

4.6 The Relationship between Temperature and Rice Production

Changes in temperature regimes greatly influence not only the growth duration, but also the growth pattern and the productivity of rice crops (Peng *et al.,* 2004). The optimum temperature for rice production is between 21.00^{0}C-29.67^{0}C, but in Maswa the maximum temperatures increased up to 32°C. This trend increase in temperature was mostly associated with January, July and December months for in every year.

The experiences from African countries showed that, many rain-fed crops are not temperature tolerance, such that yields are likely to fall sharply for even small climate changes and therefore result into fall in crop productivity of up to 30% over the 21st century (IPCC, 2001). Moreover, other studies on rice productivity under global warming have predicted decrease in the productivity of rice and other tropical crops as global temperature increases (Mohandrass *et al.*, 1995). This study has pointed out that a unit increase in maximum temperature was linked to an insignificant increase in the rice crop by 0.93 tones ha^{-1}.

Lobell and Burke (2008) observed that 1% increase in temperature tends to increase rice productivity by 2.3 %. But, the report by ADB (2009), reported that, a decrease of 10% in rice yield was associated with every 1 °C increase in temperature. Similarly Peng *et al.* (2004) revealed that, the yield of dry-season rice crops in Philippines decreased by 15% for each 1 °C temperature increase in rice crop.

Rice crop performs better in location that receives full sunlight, as it grows better with bright light and warm temperatures for at least mean average of 17^{0}C. However, the temperature in Maswa was about 18.9°C which exceeds the recommended level of temperature for support rice production (Fig. 5). According to Lur (2011), spikelet fertility depends on temperature with the average daily minimum temperature and daily maximum temperature of 17^0c and 28^0c respectively at heading stage. The low spikelet fertility and high chalky rate are the main factors for the low grain yield and quality in response to high temperature (Huang, 2000).

4.7 Trends of Rice Production in Maswa

The trend of the equation line showed that, increase of one unit of year was associated with 0.004 tones ha^{-1}. However, study results (Fig. 7) showed that, rice yield had been fluctuating over 30 years. For example in Year 1988/89 and 1997/98, there were high rice yield of about 2.2 tonsha^{-1}, though in year 1988/89 rice yield was below 2.0 tonsha^{-1} . Very low rice yield lower than 0.5 tons ha^{-1} was recorded in year 1999/2000 (Fig. 7). This poor yield might have been due to long dry spells. These results showed the impact of climate change on rice yield.

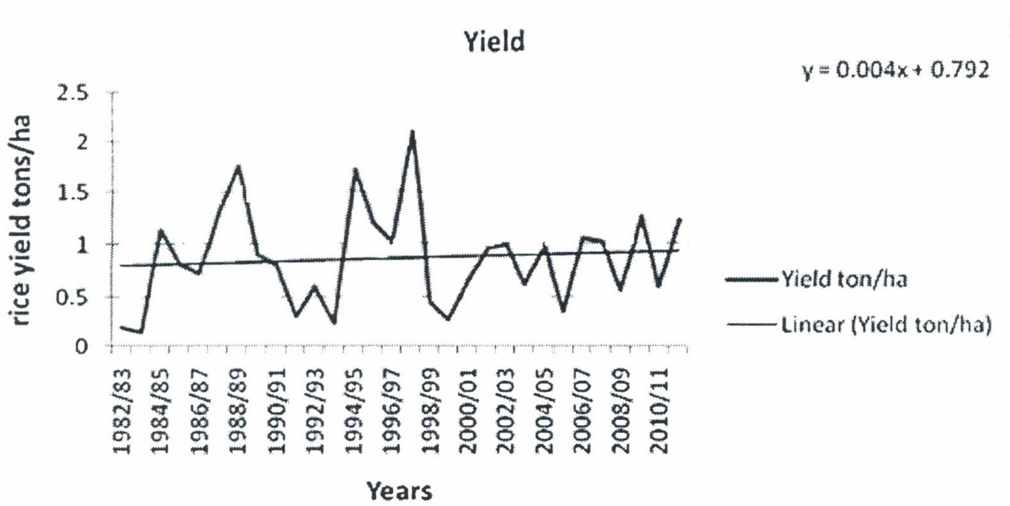

Figure 7: Rice yield trends in the Maswa District for the period of 1982 – 2012

This study revealed an increasing trend of rice yield in some of the years when rainfall was satisfactory. The study done by Agarwal (2008) showed decreasing trend in rice yield associated with trend decrease in the rainfall. According to the study done by Kawasaki and Herath (2011), levels of rice yields depended not only on the climatic conditions, but also on field soils and capability of management (crop, irrigation, fertilizer, tillage and harvest).

4.7.1 The link between rainfall and rice production

Results presented in Table 6 showed that rice yield increased significantly by 1.19 tons ha^{-1} for every increase in one unit of rainfall. This was also supported by the correlation analysis results which showed positive significant correlation between rice harvested and effective rainfall ($r = 0.616$, $p=0.000$). Increase in rice yield when rainfall was facing declining trend might have been due to other factors such as soils, and use of improved variety. This is because some farmers were using SARO 5 rice variety which could have improved their rice yields.

Rice yields trend increase had not always been steady over the years (Fig. 7). For example, in year 1981 and 1999 low rice yield of about 0.5 tons ha^{-1} of rice per annum was reported. The reasons for declining yields could have been due to low rainfall indicated by trend decrease. Decline in rice yield was also reported by REPOA (2007), the main cause for the low production was mentioned as low rainfall.

Moreover, it was reported that, in the years 1988/89, 1995/96 and 1997/98 there were rice bumper harvest as the result of good amount of rainfall received. This agrees with correlation results in which the rainfall was positively correlated with rice production (r = 0.616). This indicates that, production of rice primarily depends on the amount of rainfall received, since rice yield increases as soil moisture increases (CCSP, 2008).

The variations of crops harvests either between seasons or years indicate variations of moisture contents in the soil in the respective time as far as plant water relationship is concerned. However, good harvests of different food crops with high water requirements indicate high rainfall availability, and low moisture content with low harvests (FAO, 2012).

According to Kashyap (2013), the average rainfall indicates average moisture content which results into moderate harvests. This is due to the fact that, rice has a semi-aquatic ancestry and hence, very sensitive to water shortages (Kashyap, 2013). When the soil water content drops below saturation point, most of rice varieties develop symptoms of water stress (IRRI, 2009; Rhoades, 2009). The study done by Garrity *et al.* (1986), found that, 50% of rain-fed lowland and all rain-fed uplands were drought-prone. However, severe and mild droughts often occurred in predominantly rain-fed rice areas (Tuong, 2003). This indicates that the lower the rainfall the lower the yield, for the case of Maswa rice yield for example in 1993/1994 was 0.4 tons/ha which were below the expected rice potential of 1.5 – 2.0 tons/ha and rainfall was 640mm per annum (Fig. 3 and Fig. 7).

The average yield reduction in rain-fed drought-prone areas was reported by IRRI (2009) to have ranged from 17 to 40% in severe drought years, leading to production losses and food scarcity. Although climate change has some positive impacts, yet, the vast majority of its impacts and the overall impact on rice are likely to be negative (IRR, 2009).

4.7.2 The Link between temperature and rice production

This study revealed that, Maswa District had 0.031^{0}C trend increase in temperature for each unit increase in year. This incremental temperature was equivalent to 3% rise in temperature amount. Increase in temperature has got negative impact on crop yield, especially on rice. According to Vien (2012) 3% increase in the temperature is expected to cause decrease in rice yield up to 42%. Conversely, the studies done by Lobell *et al.* (2008) and Peng *et al.* (2004) reported that, one per cent increase in temperature tends to increase rice productivity by 2.3 %.

Rice is the crop that performs better in location that receives full sunlight, as it grows best with bright light and warm temperatures of at least mean minimum average of 17^{0}c. However, the temperature in Maswa District was sometimes exceeding above the recommended amount of temperature to support rice growth. For example in the year 2012, temperature was higher as 32°C.

Higher temperatures have negative impact on rice spikelet's fertility (Lur *et al*, 2006), because, spikelet fertility is assured at an average daily minimum temperature and daily maximum temperature between 17^{0}C-28^{0}C during heading stage, otherwise the fertility becomes low, and hence, low rice grain yield and quality due to low fertility and chalky rate in response to higher temperatures (Huang, 2000).

Although, the optimum temperature for rice production is between 21.00^{0}C- 29.67^{0}C, Maswa District, had the temperature above the optimum level for rice cultivated cultivars. According to the result, increasing trend in temperature was mostly observed in January, July and December. The experiences from other African countries, show that, many rain-fed crops are not temperature tolerance such that , yields are likely to fall sharply for even small changes in the climate, and therefore resulted into fall in agricultural productivity of up to 30% over the 21st century are projected (IPCC, 2001). Other studies on rice productivity under global warming have predicted decrease in the productivity of rice and other tropical crops as global temperature increases (Mohandrass *et al.*, 1995).

4.8 Effect of Climate Change and Variability on Rice Production in Maswa District

The results showed that R-square of 64.1% of the variations in rice yield were due to the factors specified in the regression model, the remaining variations in rice yield were due to other factors. The regression equation shows that rice yield could be reduced by 4.75tons ha^{-1} if all factors specified in model equation were to be equal to zero (Table 11).

Table 11: Results on the effect of rainfall, temperature and land size to rice yield (n=30)

Model variables	Unstandardized coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-4.75	11.587		-0.410	0.686NS
Ln AREA	0.41	0.1600	0.228	2.562	0.015**
Ln Rainfall	1.19	0.425	0.520	2.789	0.010**
Ln-min temperature	0.002	2.733	0.000	0.001	1.000NS
Ln-max temperature	0.93	3.387	0.051	0.274	0.786NS
Dependent Variable: Ln YIELD; R-square=0.641					

*significant at p<0.05 ** Significant at p <0.01; significance level, ***significant at p<0.001 and NS= Not significant at p<0.05

The model results (equation) have shown that one unit increase in effective rainfall was resulted into an increase in rice yield by 1.19 tones ha^{-1} which was statistically significant at p<0.05. Land under rice production was positively related to the rice yield and statistically significant at p-value<0.05. The increase in one unit of land was associated with an increase 0.41 tonsha^{-1} of the rice yield. Moreover, results have shown that, both minimum and maximum effective temperatures were positively related to rice yield, nevertheless, the relationship was not statistically significant at $p<0.05$. These results differ from what was observed by Siwar *et al.* (2013) that, increase in temperature had positive significant influence on rice productivity.

4.9 Correlation between Yield, Rainfall and Area

Results from correlation analysis showed that, rice yield and effective rainfall were positively correlated ($r^2 = 0.616$), with strong relationship which was statistically significant increasing at $p < 0.05$. Likewise area under rice production showed positive relationship with the rice rice yield. But the relationship between area and rice harvested was strong related (0.537) and significant at $p<0.05$ (Table 12).

The relationship between rice yield and minimum temperature was weak and negative but not significant. Additionally, the maximum temperature and rice yield had weak positive relationship which was not statistically significant (Table 12).

Table 12: Correlation results for rice production, raifall, temperature and area (n=30)

Rainfall		Maximum temperature	Minimum temperature	Area cultivated
Pearson Correlation (r)	0.616	0.018	-0.028	0.537
Sig. (2-tailed)	0.000	0.923	0.882	0.002

4.10 Farmers' Coping Strategies and Adaptations to Climate Change and Variability

4.10.1 Farmers' coping strategies to climate change and variability

The coping strategy refers to the strategies used by farmers for short term solutions emanating from the extreme events due to climate change and variability impacts. Results indicated that, most of the small scale farmers were using various short term coping indicated that, most of the small scale farmers were using various short term coping strategies (Table 13). The coping strategies practiced by most of the farmers was labor selling was about 17.3% and 9.3% in Buyubi and Nghaya respectively in order to get either food or money for their household use.

Coping strategies to climate change and variability included: buying food during hunger, storage of enough food. This result was in line with what observed in Uganda by Twinomugisha (2013) that, in order to survive during climate hazards, farmers try to secure household food security using food reserves kept in granaries, basket and sacks, doing non- farm activities, government food aids and selling livestock. Traditionally, farmers laid livestock such as small ruminant animals and birds. For instance, the sale of goats or chickens is often the first line of defense in cases where families need cash for emergencies (Twinomugisha, 2013).

According to Feenstra *et al.* (1998) coping strategies help farmers in time of disasters. In order to be assured of sustainable production, coping strategies to climate variability should be environmental friendly (Droogers and Aerts, 2005). Other people were not doing any option to cope with weather variability but according to Bird and Shepherd (2003), the failure of total crop shall make farmers forced to succumb effective local or national level support mechanism such as food relief and selling labor.

Murindi and Murray (2005), reported other coping strategies as: selling of burnt bricks, doing handcraft, collecting and selling honey, charcoal burning, collecting wild fruits, doing non-farming activities and offering casual labour are the coping strategies by smallholders during drought and other climate extremes.

Table 13: Short term coping strategies (n=120)

Short term copping strategies	Buyubi village		Ngh'aya village		Overall	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Buying food during hunger	6	8.0	8	10.7	14	18.7
Seeking government aid	6	8.4	8	10.7	14	19.1
Selling livestock	3	4.0	5	6.7	8	10.7
Food storage for future use	1	1.3	3	4.0	4	5.3
Eating of un liked food	1	1.3	1	1.3	2	2.6
Doing off farm activities	7	9.3	6	8.0	13	17.3.
Selling own labour	13	17.3	7	9.3	20	26.6
Total	**37**	**49.2**	**38**	**50.8**	**73**	**100**

4.10.2 Farmers' adaptations to climate change and variability in Maswa District

Farmers in Maswa had developed different long-term strategies to cope with both unexpected and expected variability of rainfall and temperature. These strategies are mainly related to local production systems and adaptation of local people to their environment. The study identified the following adaptation strategies which include: use of drought tolerant varieties, irrigation, crop diversification and afforestation, Crop diversity, afforestation as an adaptation strategy and use early maturity varieties. Farmers who perceived climate change but failed to adapt gave many reasons as barriers to adaptation, which included lack of information on adaptation methods, lack of money, shortage of labour, shortage of land and poor potential for irrigation. Farmers should be able to adapt in order to reduce the negative impact of climate change. Adaptation to climate change is a two-step process which requires that farmers perceive climate change in the first step and respond to changes in the second step through adaptation. Different socio-economic and environ- mental factors affect the abilities to perceive and adapt o climate change (Deressa, 2011).

4.10.2.1 Use of drought tolerant varieties

Study results showed that, most of smallholder farmers within study area used to grow drought tolerant varieties as one of the adaptation strategies. This accounted for 35.8% of the total number of respondents interviewed in two villages. Among them, 20% were respondent farmers from Nghaya, while 15.8% were respondents from Buyubi village. Hybrid rice cultivars having high temperature tolerance help to meet the challenges imposed by changed climate.

The use of drought tolerant varieties was reported by Siwar, *et al.* (2013) that, drought-tolerant cultivar is another means of adaptation to drought prone environments and of increasing water utilization efficient. The varieties which resists drought obtained from research institute namely Ukiriguru. The varieties found in the used by farmers were SARO 5 and Super1. Brylar (2007) asserted that, the choice of rice variety to grown should reflect the availability of water, and that utilization of the best adapted cultivar is important in maximizing yield under limited water.

Similarly the report by Kawasaki and Herath (2011) claimed that, among the adaptations which farmers do, is the use of new adaptive varieties, and use of the rice variety which were considered to maintain rice yields under future climatic conditions. Conversely, this study had revealed that, use of newly introduced varieties of rice was limited by poor taste. For example, farmers reported to prefer Bulungwa (local variety) to SARO 5, because of its palatability. Although, SARO 5 was reported as a high yielding variety, only 15% used to grow the variety, because of poor promotion of this rice variety.

4.10.2.2 Irrigation, crop diversification and afforestation

Other adaptation strategies which small scale farmers practiced were irrigation, crop diversification and afforestation. About 17.5% of the respondents were using irrigation.

Among the 16.7% who used irrigation came from Nghaya village, while 0.8% came from Buyubi village. But those who used crop diversification, 10.0% were from Nghaya, and 7.5% were from Buyubi village. On the other hand those who used afforestation 9.2% were found in Buyubi, and the remaining 8.3% came from Nghaya village. Generally, crop diversification, irrigation and afforestation accounted for 52.5% of the adaptation strategies practiced within the study area (Table 14).

4.10.2.3 Crop diversity

As temperatures increases and rainfall changes over time, the cultivation patterns of food crops tend also to change. When there are relative low rains, farmers tended to engage in cultivating other crops like green grams, chick peas, sorghum, sweet potatoes, and cotton as they tolerate droughts. Cropping practices that are often used to mitigate the effects of drought include: Planting mixtures of crops and cultivars adapted to different conditions either planted formally or informal intercrops. Using crop landraces that are more resistant to climate stresses and using crop trash as mulch. Twinomugisha (2013) reported that crop diversity is used to maximize output as well as protect against climatic risks. In the case of agriculture, for example, diversification, be it increasing the variety of production locations, crops, enterprises, or income sources, is one adaptation that has been commonly identified as a potential response to climatic variability and change (Kelly and Adger, 2000).

4.10.2.4 Use of irrigation

Farmers were using water harvesting such as shallow wells, deep wells and irrigation schemes, for irrigation and feeding their livestock, although their irrigation infrastructures are still poor, for example most of irrigation canals were not working properly. The techniques used by most of the farmers are rainwater harvesting and mainly shallow basins. These were not efficient in handling enough water which could be used for irrigating their small farm, as the techniques only served to collect the run-off water. According to REPOA (2007), some farmers practice supplementary irrigation, while others do not practicing it because, the underground water resources have not yet been fully exploited for agricultural use. For example, in Buyubi villages some canals were not working, the reason was presence of poorly developed infrastructures and shallow wells constructed in villages (Table 14).

Table 14: Long term adaptation strategies (n=120)

Adaptation strategies	Buyubi village		Ngh'aya village	
Long term adaptation strategies	**Frequency**	**Percent**	**Frequency**	**Percent**
Irrigation	1	0.8	20	16.7
Use of drought tolerant varieties	19	15.8	24	20.0
Changing planting date	2	1.7	1	0.8
Planting trees	11	9.2	10	8.3
Adoption of new varieties	4	3.3	7	5.8
Crop diversification	9	7.5	12	10.0
Total	**46**	**38.3**	**74**	**61.7**

4.10.2.5 Afforestation

This result showed that farmers in Buyubi were 9.2% and Nghaya 8.3% who planted trees as their adaptive strategy to climate change and variability. Planting trees the strategy among on a suite of others under the climate change policy known as REDD+ (Reducing Emissions from Deforestation and Afforestation) URT (2007) reported that afforestation is the programme of planting trees in degraded lands using more adaptive and fast growing tree species and these trees are grown for multiple purposes. They also aim to conserve and enhance natural ecological processes and maintain a balance with nature (Twinomugisha, 2013). In many countries afforestation is used for environmental protection, prevention of natural hazards and fires, and climate change mitigation (Laaser, 2009). In some Spanish regions' rural development programmes, afforestation plays an important role (Frelih-Larsen and Vidaurre, 2008). However, afforestation in particular near watercourses, brings benefits for the regulation of water flow, the maintenance of water quality, and the reduction in the intensity of floods and the frequency of droughts.

Other adaptation strategies which were commonly practiced in Maswa district included: change of planting date, planting trees, stop or reduce deforestation, adoption of new varieties, and growing of early maturing varieties. Similar observation on adaptation strategies to climate change and variability were mentioned by Low (2005) as control of overgrazing, and promotion of source of energy such as solar cooker instead of wood and charcoal stoves.

4.10.2.6 Use of early maturity varieties

Due to climate variability in rainfall patterns of which rains were coming either late or early before or after the cropping season, farmers in the study area decided to use early maturity varieties of rice such as Bulungwa (a local variety) which can mature within 3 months before rainfall stopped. Even early mature crops were used such as sweet potatoes and other short varieties of maize which mature within 3 months.

Adaptation to climate change and variability has cost implication that's why not all farmers were able to use the mentioned above adaptations. Thus, according to Twinomugisha, (2013) farmers who lack the capacity to adapt will be at the risk of becoming vulnerable to climatic change impacts. Therefore small-scale farmers need to be supported to make the most of the opportunities on strategies that they may afford.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The first objective of this study was to analyze farmers' perception on climate change and variability. The study has concluded that farmers' are aware on the occurrence of climate change and variability as about 93% of the respondents said temperatures have risen and rainfall has decreased in the study area over last 30 years. This supported by the analyzed data on trends of rainfall and temperature which showed the same results.

Objective two was to assess the trend of climate (temperature and rainfall) the trend indicates the presence of changes in climate whereby rainfall was decreasing by -2.61 mm and temperature was increasing by 0.031^0C over 30 years.

The third objective was to examine the effects of climate change and variability on rice production, there was a significant relationship between rice production and rainfall which increased by 1.19 tons ha^{-1} for every increase in one unit of rainfall at $p < 0.05$. So as the rainfall increases the yield of rice increased.

Fourth objective was to identify and document the coping and adaptation strategies, the study concluded that farmers use early maturity varieties, diversification of crops, growing drought tolerant varieties, adopting irrigation technologies i.e. long and shallow wells or canals and changing sowing dates as adaptation strategies.

Finally study findings have revealed that, selling of own labor was the most common coping strategy practiced by small scale farmers in the study area, while other coping strategies were: doing off farm activities, buying food during hunger, food storage, doing non- farm activities, government food aids, selling livestock, change of planting date.

5.2 Recommendations

i) In order to reduce the incidence of climate change more intervention of different stakeholders are recommended to educate farmers to enable farmers to adapt the appropriate adaptation strategies.

ii) An appropriate intervention is required for sustainable rice production through developing and disseminating adaptation technologies which will be easily applied to small scale farmer.

iii) Irrigation infrastructures should be improved to make small scale farmers reduce their dependence on rain-fed agriculture which had been the common practice. To make this strategy sustainable there is need to construct deep wells that could provide sufficient volumes of water to all community members throughout the year. There is urgent need to support irrigation schemes in Maswa district. This should be done by the government through local government council, NGOs and farmers themselves.

iv) Sustainable rice production need the intervention of stakeholders' support specifically research institutions to development rice varieties which are drought tolerant with good aroma.

v) Farmer's knowledge base on climate change and variability impacts should be uplifted through awareness campaigns, and build their adaptive capacities by providing them with all the necessary support.

vi) Moreover, Tanzania Metrology Agency should be active to collect accurate data and provide information to farmers as early warning to bad weather.

vii) Enhancement of forest seed banks and the development of new plant varieties for planting trees (afforestation) should be encouraged conserving the environment.

viii) It is recommended to carry out a study on comparative analysis on effectiveness of various adaptation strategies to climate change and variability among small scale farmers in semi arid areas.

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APPENDICES

Appendix 1: Temperature trend in Maswa District from 1982 – 2012

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1982	17.8	18.1	18.6	17.9	18	16.7	15.9	16.8	18.2	18.2	18.3	18.9
1983	18.2	18.7	18.9	17.8	17.8	17.4	16.7	14.9	18.2	18.6	18.6	18
1984	16.8	17.3	17.3	17.1	15.6	15.3	16	17	17.6	18.5	17.5	17.5
1984	17.5	16.8	16.6	16.3	16	14.5	14.1	14.2	17.2	18.1	17.2	17.6
1985	17	18.6	16.8	17.1	15.6	15.2	14.6	15.6	17.8	18.7	18.5	17.1
1986	17.1	16	18.5	18.3	17.5	16.1	16.1	16.9	19	19.3	18.9	18.5
1987	18.3	18.5	18.3	18.6	17.7	15.8	15.9	17.1	18.1	18.8	18.2	17
1988	16.4	16.5	16.6	16.4	15.6	14	13.5	14.8	16.9	17.4	17.5	16.7
1989	16.8	16.8	17	17	16.5	14.1	13.3	15	16.3	17.5	17.3	16.8
1990	16.4	17	17.6	16.6	16.9	15.7	14.2	15.3	17.2	16.9	17.1	16.7
1991	17.2	17.2	17.4	17.3	15.7	15.8	14.4	14.5	16.7	17.6	17.3	16.9
1992	17.2	16.9	16.1	16.8	16.8	15.5	13.8	16.5	17.2	18.7	18.9	18.9
1993	18.1	17.8	17.5	17.6	17.3	15.9	15.4	15	17.7	18.5	17.8	17.9
1994	17.3	17.6	17.2	18	16.9	16.4	15.1	15.6	17.3	18.5	17.3	17.1
1995	16.7	16.9	17.7	16.8	16.5	16.2	14.9	15.5	17.2	17.7	18.1	17.5
1996	17.6	17.7	18.5	19.8	16.3	18.5	20.3	16.9	18.4	18.6	18.1	17.6
1997	18	17	18.1	18	17.3	15.2	13.8	15.8	17.9	18.1	18.4	18.4
1998	17.4	17.9	16.6	18.2	18.1	17.5	16.2	17	17.7	18.9	18.4	18.2
1999	18.2	19	18.3	19.9	19.5	17.7	17.8	17.8	19.1	19.3	19.2	18.8
2000	18.9	19.2	19.1	19.2	18.8	18	17.6	18.2	18.1	18.9	18.5	18.6
23-Jun	18.7	19.1	18.5	19	18.6	18.4	17.7	17.5	18.5	19	18.3	18.2
24-Jun	18.2	18	18.9	18.4	18.6	18.6	15.5	17.5	18.3	18.6	18.7	18.4
2003	18.8	18.4	18.5	18.1	18.1	17.1	17.3	18	18.4	18.1	18.5	17.9
2004	18.5	19.1	18.8	18.6	18.3	17.2	16	17.2	17.5	18.3	18.2	18.4
2005	18.4	17.8	17.9	17.9	17.5	15.6	14.3	16	17.4	18.6	17.9	17.7
2006	18.1	18	17.5	17.6	17.4	15.7	15.6	16.3	17.6	18.9	19.1	18.2
2007	18.2	18.1	18	17.5	17.5	15.7	15.9	17.1	18.6	18.9	18.5	18.7
2008	18.6	18.5	18.7	18.4	17.8	15.8	15.5	16.5	18.8	19.1	18.8	18.5
2009	18.8	19.1	19	19	18.5	17.4	15.7	16	18.5	19.4	19.5	18.3
2010	18.3	19.2	18.8	18.6	18.7	17.8	17.3	18.4	18.7	18.9	17.6	17.3
2011	16	17.5	17.3	17	16.3	15.1	14.2	15.6	18.8	18.9	17.6	17.3

Appendix 2: Rainfall trend in Maswa District from 1982 - 2012

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
1982	102.1	56.6	65.8	174	89.6	4.7	0	1	32.1	58.4	51.8	85.1	745.2
1983	54.8	75.8	141.2	242.3	41.7	0	20.5	1.9	34	30.9	137.3	46.3	825.7
1984	51.4	67.8	97	159.9	6	3.7	22.2	2.2	38.4	144.5	76.5	70.5	750.4
1985	39.3	83.6	211.6	281.3	94.5	0	0	0	50.8	64.7	226.8	98.3	1144.9
1986	82.3	142.4	115.2	84	129.9	8.2	0	0	0	29.2	171.3	112.7	885.1
1987	53.4	190.5	102.8	81.5	16.3	6.8	0	0	67.2	75.9	86.7	220.3	901.4
1988	197	40.7	160.7	199.7	16	5.7	3.6	9.3	49	45.9	89.5	72.4	889.5
1989	67.7	166.7	167.4	170.1	78.5	4.6	0	5	45.6	88.1	69.6	182.3	1045.6
1990	43.3	123.1	134.9	130.5	45.3	1.4	0	28	19	63.2	170.1	218.2	977
1991	91.9	66.8	131.4	105.6	66.3	8.6	0.6	1.9	3.3	80.1	73.5	187.5	817.5
1992	46.5	77	61	138.2	74.1	3.2	0	0	11.6	159.6	82.5	115	768.7
1993	179.5	68.3	57.6	120.7	76.2	15.2	0	0	0.4	59.9	52.3	179.2	809.3
1994	145.7	38.6	158.5	111.5	39.7	5.5	0	44.5	0	53.2	34.2	38.3	669.7
1995	97	75.7	144.1	130.9	89.4	39.7	4.1	0	11.3	53.5	209.5	154.4	1009.6
1996	64.1	120.5	124.1	68.7	40.4	0.4	8.2	2.4	16.3	110.9	92.2	90.4	738.6
1997	62.8	60	97.2	246.2	78.6	5.7	0	4.9	2.2	14.7	104.5	69	745.8
1998	296.2	82	150.2	172.7	113.6	62	0	7	1.3	76.4	246	170.7	1378.1

1999	111.8	35	118.1	130.3	0	0	0	23.3	1.8	46.8	41.2	22	530.3
2000	87.7	40.6	90.1	91.5	17.7	0	0	0	0	22.3	52.5	88.2	490.6
2001	105.7	80.5	73.8	81.3	23.4	0	21.6	0	25.1	10.1	45.8	100.4	567.7
2002	126.4	69.1	142.3	205.8	100.5	0	0	0	5.6	93.5	136.6	79.8	959.6
2003	77.5	79.7	91.4	106.4	91.7	0	0	4.3	1.8	95.5	179.3	137.9	865.5
2004	86	116.5	66.5	149.9	11.3	0	0	27.6	50	22.5	100.5	206.1	836.9
2005	44.3	71.6	115.5	114.5	58.4	0	0	27.7	43.5	125.6	212.1	151.4	964.6
2006	35.6	45.7	116.6	115.4	61.8	6.4	0	16.4	10.8	16.3	22.9	47.7	495.6
2007	114.8	128.7	118.5	137.2	32.9	36.2	1.3	43.4	63.8	27.7	261.8	237.8	1204.1
2008	61.8	135.7	153	96.8	13.2	0	1.3	3.8	30.2	6.5	90.9	136.6	729.8
2009	133.1	37	79.2	107.4	36.6	21.5	0	6.2	8.2	112.7	162.1	98.5	802.5
2010	84.1	132.3	295.5	47.8	60.5	3.5	0	0	6.3	55.2	96.7	107.8	889.7
2011	94.7	42.8	190.5	96.8	44.4	15.6	0.5	90.2	54.2	71.4	26.2	134.2	861.5
TOTAL	7063	6689.6	9327	10613	4947	718.9	317	806.1	1781	4182	8794	8796.6	64034.1
MEAN	94.17	89.195	124.4	141.5	65.96	9.585	4.23	10.75	23.75	55.76	117.2	117.29	853.788

Appendix 3: Rice production trend in Maswa District from 1982 – 2012

S/no	Year	Areas (ha)	Yield (tones)
1	1982/83	10000	8400
2	1983/84	12500	2360
3	1984/85	9560	10946
4	1985/86	11300	12816
5	1986/87	15000	12353
6	1987/88	14700	10624
7	1988/89	10326	30355
8	1989/90	18,194	31449.6
9	1990/91	16092	14483
10	1991/92	14700	11760
11	1992/93	18805	15046
12	1992/94	16697	11600
13	1994/95	10326	29407
14	1995/96	9449	16266
15	1996/97	7560	15120
16	1997/98	20933	39681
17	1998/99	9688	12110
18	1999/2000	9580	4305
19	2000/01	25840	30075
20	2001/02	17956	31423
21	2002/03	14509	13959
22	2003/04	12002	11884
23	2004/05	20716	12976
24	2005/06	9784	14089
25	2006/07	21525	32933
26	2007/08	11740	12679
27	2008/09	10274	15104
28	2009/10	17124	30823
29	2010/11	11987	15103
30	2011/12	13699	19726

Appendix 4: Household Questionnaire: Survey on Climate Change and Adaptation Strategies

Project title: Adaptation Strategies to Climate Change and Variability of Small Scale Rice

Producers in Maswa District

Aim: Understand farmers' perceptions, coping and adaptive capacity to climate change by Maswa smallholders farming communities.

Dear household head,
Your household has been purposively selected so as to provide data that could be used to assess the adaptation strategies to climate variability in rice farming. All the information you will provide will be for academic purposes and be treated confidentially. Therefore, you are kindly requested to respond truthfully and faithfully to the following questions.

I thank you in advance

A. General information

1. Name of respondent interviewer--
2. Date of interview---
3. Questionnaire number---
4. Village number--
5. Ward---
6. Division--
7. District---

B. Household characteristics

8. Household number--
9. Household category: 1 Rich ( ) 2 Middle ( ) 3 Poor ( )
10. Name of household head---
11. Age (in years) ----------------------11. Gender---------------- Male = (1) Female = (2)

12. Marital status------Married = (1) Single = (2) Divorce = (3) Widow = (4) widower (5)

----

13. Level of education of household head --

Illiterate (1) Primary school (2) Secondary school (3)

College (4) Adult education (5) University (6)

14. What is the number of people living in this house?

Total---------Male----------Female-------------Adult--------------Young-----------

15. How long have you been living in this village? -----------------------years

16. What is your major activity?

Farmer(1) Employed (2) Business (3)

Other (specify) -------------------------

17. If you are a farmer what type of farming --------- Crop production = (1) Livestock = (2) Both crop and livestock production = (3) Others (4) (specify) --------------------

C. Farm activities/ rice production

18. Does your household own farming land? Yes (1) No (2)

19. If yes how did you obtained it? Buying (1) Borrowing (2) Given by parents (3) Hiring

( )

20. How many acres do the household own? ---------------- acres

21. How do you use your land? Mention area used for each crop

Crop type	Amount of land

22. In which ways does land size changed in your household over the years-----------

Has increased (1) Has stayed the same (2) Has decreased (3)

23. How many people in your family involved in rice activities -------------------------

24. What crops cultivated for food? Mention according to their importance

CROP	RANK

25. Which crops are grown for cash? Mention according to their importance (1) ------

CROP	RANK

26. When did you start to cultivate rice crop---------------------years

27. What amount are you using for (i) Selling ----------------------- (ii) Food --------?

28. How many varieties of rice do you grow and which is the best (rank)?

VARIETY(indicate if local or improved)	RANK

29. Have you dropped any of the variety -------------- if yes, why---------------------------

----

30. How much rice harvested in the last 5 years?

Year	Land size cultivated	Total harvested (kgs)
2012		
2011		
2010		
2009		
2008		

31. What practices are you using in growing your rice? (Tick) among the following options?

1. Irrigation ( )
2 .Crop rotation ( )
4. Fertilizers ( )
5. Adoption of new varieties ( )
6. Water sources conservation ( )
7. Intercropping ( )
7. Others (specify) ---

47. Are you using fertilizer in rice production? Yes (1) No (2

48. If yes which type of fertilizers

Type of fertilizer	How did you come to know 1. Heard from others 2. Seen at research station 3. Through demo plots 4. Others (specify)…… ……….	Who told you abou t the use of fert.	Where are you using the technolog y	Is it effectiv e Yes (1) No (2)	What are the effects on rice production 1. Decrease yield 2. Increase yield 3. Remain the same 4. Other specify… ……
Manure					
Maize Stover					
Green manure					
Agroforestr y					
Inorganic fertilizers					
Compost					
Grain legumes					

49. What amount of fertilizer you are using?

Type of fertilizer	Amount bought (kgs)	A mount used
Manure		
Maize Stover		
Green manure		
Agroforestry		
Inorganic fertilizers(CAN, SA, UREA, NPK,		
Compost		
Grain legumes		

D. Farmers' perception of Climate change and variability variability

32. Did the rainfall enough ---------------Yes = (1), No = (2)

33. Which year between1980 to 2012 on which the rainfall was not enough, List them-----

----

34. Which year between 1980 to 2012 on which the rice production was not enough -------

----

35. Which year from 1980 to 2012 on which the rice production was more than enough,

list them---

36. Which year from 1980 to 2012 on which the rainfall were average, list them -----------

----

37. Which year from 1980 to 2012 the rice production was average, list them---------------

----

38. What is your view on the amount of rainfall from 2010 - 2012

Enough = (1), Moderate = (2), Inadequate= (3)

39. Which year(s) from 1980 to 2012 the drought caused hunger to your family, list -------

----

40. What are the varieties that tolerate drought ---

----

41. What are varieties that are tolerant to excessive rainfall-----------------------------------

----

42. Have you ever noticed any climate change in your village in the past 5 years?

1=Yes ( )

2= No ( )

43. If yes, how do you notice that the weather/climate is changing?

----

44. If yes what is the change of rainfall in your village

1. Decrease
2. Increase
3. No change

45. Have you noted any change of temperature in you village?

1=Yes ( )

2= No ( )

46. If yes what is the change of temperature in your village

1. Decrease
2. Increase
3. No change

47. What was the major variation?

1 = Drought

2 = Floods

3 = Heavy rainfall

4 = Temperature
5 = All of the above

48. Does the climatic variation have an effect in the rice crop?

1=Yes ( )

2= No ( )

If yes mention those effects i) -------------------------------------- ii) ----------------------

iii) --iv) -------------------------------

49. Have you experienced any crops loss in the past five years?

1=Yes ( )

2= No ( )

50. What other effects of climate change and variability to the community?

i) ---
ii) ---

51. If yes what was the major course of loss?

1 = Drought ( )

2 = Floods ( )

3 = Heavy rainfall ( )

4 = pest attacks ( )

5 = others specify

52. Do you think there is a need of any special initiatives for community to cope with disaster?

1=Yes ( )

2= No ( )

53. If yes, describe the coping options?

1………………………………………………

2……………………………………………..

54. What are the limitations to your existing coping mechanism?

....

55. What new activities do you suggest in order to overcome those limitations?

....

56. How do you respond to rescue the situation of crop loss? (tick options)

1 = reduce number of meals per day ( )

2 = eat less preferred food ( )

3 = sale of family labour ( )

4 = buying after sale of livestock ( )

5 = buying from off-farm money ( )

6= using un-preferred food ( )

57. Have you decided to change your calendar for farm activities?

1=Yes ( )

2= No ( )

58. If yes, why did you decide to change your calendar for farm activities?

1 = Rainfall is delaying

2 = Rainfall is coming early

3 = No reason

59. Do you plant a diversity of crops and crop varieties as a means of coping to crop loss?

1=Yes ( )

2= No ( )

60. If yes indicate the type of crops planted for coping to crop losses

S/No	Type of crop	How long you have grown it	At what type of weather

61. What food is eaten during the period of disaster?

1 = ...

2 = ...

F. Adaptation and Coping Strategies

62. What are the coping strategies during low rice production ---------------------------------

----

63 What are the causes of drought in your village ---

----

64. What are the current solutions to drought in your village ----------------------------------

----

i) Short term solutions

----

ii) Long term solutions

----

65. When did you started to use that solutions---

66. Where did you get the technology (own initiative (1) trained (2) copying from neighbours

(3) Others (specify) --

67.Which technologies are more useful and why (mention them according to the most useful technologies---

----