

**FARMER'S CLIMATE-RELATED PRODUCTION RISKS AND RESILIENCE IN
THE SEMI-ARID AREAS OF MEATU AND IRAMBA DISTRICTS OF
TANZANIA**

**FOR REFERENCE
ONLY**

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
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ABSTRACT

This study was conducted in Meatu and Iramba Districts which are part of the semi arid regions of Simiyu and Singida Regions. The purpose of the study was to assess the farmer's climate-related production risks and resilience in the semi-arid areas. The study addressed the following specific objectives: i) to characterise climate risks associated with different sources of farmer's income, ii) to evaluate climate risk resilience of smallholder farmers from major income subsector, and iii) To determine the effect of climate change on farm income from major crops. The study design was cross sectional. A structured questionnaire was used to collect data from a random sample of 100 smallholder farmers. Descriptive statistics were used to characterize the climate risks associated with the different sources of a farmer's income, Multi-Criteria approach was used to evaluate the income-based resilience of farmers' with respect to major climatic risks and a distributed lag model was used to determine the effect of climate change on income from major crops. The results indicate that on characterization of the risks it was found that most of the climate risks affected income sources differently; crops by 98%, livestock by 64% and off-farm sources by 43% only. Over three quarters of the respondents (96%) were found to be not resilient to climate risks and majority (96%) of them laid in the medium and high risk categories. The results also indicate that maize was highly affected by rainfall related climate risks by producing 0.88 tonnes/ha compared to other crops such as sorghum (1.09 tonnes/ha) and cotton (0.94 tonnes/ha). Based on the findings the study draws the following policy-relevant recommendations: the government and other agricultural stakeholders should enhance smallholder farmers to diversify their income generating activities through off-farm activities, promote a good agronomic practice among farmers, open a room for a reliable market by intervening and setting up the favorable and stable price for farmers through improving market infrastructures and market information.

DECLARATION

I, Revocatus Kayaga Ntengo, 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.




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DEDICATION

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LIST OF ABBREVIATIONS AND ACRONYMS

DAEA	Department of Agricultural Economics and Agribusiness
DALDO	District Agricultural and Livestock Development Officer
DLM	Distributed Lag Model
DPLO	District Planning Officer
DSI	Development Studies Institute
EC	European Commission
EPINAV	Enhancing Pro-poor Innovation in Natural Resources and Agricultural Value Chains
FGDs	Focus Group Discussions
GCCA	Global Climate Change Alliance
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
MCA	Multi-Criteria Approach
NGOs	Non-Governmental Organisations
SPSS	Statistical Package for Social sciences
SUA	Sokoine University of Agriculture
TSHs	Tanzanian Shillings
UNDP	United National Development Programme
UNFCCC	United National Framework Convention on Climate Change
UNISDR	United Nations International Strategy for Disaster Reduction
URT	United Republic of Tanzania

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Over the past two decades, evidence has mounted showing that the global climate is changing leading to different shocks and that anthropogenic greenhouse gases are largely to blame (Maarten *et al.*, 2007). The unimpeded growth of greenhouse gas emissions has led to the raising in the earth's temperature and rainfall variability which threatens livelihood security for large numbers of people especially in developing countries (Mutsvangwa, 2011). Africa is considered very vulnerable to climatic changes and variability because of the widespread of poverty (Eriksen *et al.*, 2008). These changes affect many key sectors such as agriculture, which eventually lead to large economic costs (Downing *et al.*, 2010).

Increased average temperatures, sea level rise, changes in annual and seasonal rainfall has a large long-term impact on the livelihoods and living conditions of the poor farmers in developing countries such as Tanzania (Urassa *et al.*, 2012). Yet these impacts are not equally distributed or felt among different socio-economic groups and gender (IPCC, 2001a). Evidence from Tanzania clearly reveals that climate change is already impacting the country and the lives of people in rural areas. Climate change is increasingly threatening the income of most rural dwellers with low income, food insecurity and inadequate health services (URT, 2007).

About 80% of poor Tanzanians live in rural areas, where agriculture accounts for more than 75% of rural household incomes (Downing *et al.*, 2010). While most of smallholder farmers depend mainly on rain fed agriculture for production and other resource based

activities, adverse climatic changes affect productivity and income hence in turn affecting the overall well-being of the households (Mutsvangwa, 2011). In addition, agricultural holdings are typically dominated by small scale, subsistence farmers cultivating plots ranging from 0.9 to 3 ha (URT, 2007; Shemsanga *et al.*, 2010).

While the impact is increasing, climate change is disproportionately affecting women, the poor and vulnerable than their counterparts. It is generally acknowledged that interventions to strengthen incomes are more efficient and effective when gender differences are properly understood and addressed because climate change bears different impact on each category (Nelson, 2009; Urassa *et al.*, 2012).

1.2 Problem Statement and Justification

With likely long-term changes in rainfall patterns and shifting temperature zones, climate change is expected to increase the frequency of climate-related risks, such as floods and droughts in Sub-Saharan Africa (Ringler, 2011).

Smallholder farmers are vulnerable to climate change and variability that negatively affect their weather-dependent livelihood activities including agriculture and natural resources. Climate risks such as droughts and floods tend to erode assets leaving people more vulnerable to disasters such as food insecurity, diseases and land degradation (Marion, 2006). Climatic risks reduce the overall farmer's income leaving many rural farmers trapped in a cycle of poverty and vulnerability (Toulmin, 2011; Shewmake, 2011). Deressa *et al.* (2011) also argued that the majority of farmers lack effective responses to climate change shocks, which primarily leads to crop yield declines and eventually asset and income losses.

For farm households, an increase in the frequency of climate-related income risks leads not only to lower expected income, but also to higher income variance among social-economic groups, which in turn cause them to fall below poverty trap thresholds (Shewmake, 2011). For this reason, it is therefore important to understand how a changing distribution of farmer's income due to climate change will lead to increased vulnerability on farmers' income.

Previous studies on the impact of climate change on farmer's income or farm revenues report reduction in farm revenue and farmers' income particularly in tropical regions of developing countries (IPCC, 2001b; Ouedraogo *et al.*, 2006; Jain, 2006; Molua and Lambi, 2006; Mendelsohn *et al.*, 2006; Kurukulasuriya and Mendelsohn, 2007; IPCC, 2007b; Seo and Mendelsohn, 2008). The evidences from these indicate that climate change and variability will have large adverse impacts on farmer's income, especially among smallholders who depend on farm productivity for livelihood and subsistence opportunities which can lead to a rise in poverty levels.

However, there have been many recent public discussions and publications on the effects of climate change on rural areas of developing countries especially on agricultural basis, while trying to explain how generally climatic change has affected smallholder farmer's income, without explaining in detail at what extent are those farmers resilient to those climate risks (Paavola, 2003; Yanda, 2005; Heltberg *et al.*, 2008; Wasige, 2009; Asfaw, 2012). However, the resilience of smallholders vested in different sources of income is inadequately assessed, therefore, this study aims at exploring in detail to what extent, have the income of smallholder farmers been affected by climatic change and to what extent the smallholders farmer are resilient to those climatic risks, then informs policies and actions that will foster farmers risk resilience in the face of changing climate and

increasing vagaries of weather. Not only that but also to add on, to the literature on the economics of climate change on farm income in Tanzania and developing countries in general.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of this study was to evaluate the economics of farmer's climate related production risks and resilience in the semi - arid areas of Meatu and Iramba Districts of Tanzania.

1.3.2 Specific objectives

- i. To characterize climate risks associated with different source of farmer's income
- ii. To evaluate climate risk resilience of smallholder farmers from major income subsectors.
- iii. To determine the effect of climate change on farm income from major crops.

1.3.3 Hypothesis

- i. H_0 : Characteristics of climate risks associated with different sources of farmers income is the same within the sources.
- ii. H_0 : Smallholders farmer are resilient to climate risks.
- iii. H_0 : Climate change has no affect on income from different major crops.

1.4 Organisation of the Report

This report is organised into five chapters. Chapter one covers the introduction with sections on background information, problem statement objectives and hypotheses. The literature pertinent to the study has been reviewed in chapter two, reviewing matters

pertaining to the specific objectives and the model used in the study. The methodology used is described in the third chapter which covers the description of the study area and how the models were used. The findings of the research are presented in chapter four with some discussion from the result obtained, while conclusion and recommendation of the study is narrated in chapter five.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Definitions of Key Concepts

2.1.1 Climate change

According to the IPCC (2007a), climate change refers to the change in the state of the weather that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer, which it may either be due to natural variability or as a result of human activity. United National Framework Convention on Climate Change (UNFCCC, 2007) reports the main characteristics of climate change are increase in average global temperature, change in cloud cover and erratic precipitation particularly over land, melting of ice caps and glacier and reduced snow cover and increase in ocean temperatures and ocean acidity due to sea water absorbing heat and carbon dioxide from the atmosphere.

Generally, climate change is defined as any change in the average daily weather pattern over an extended period of time (typically decades or longer) whether due to natural variability or as a result of human activity (Easterling *et al.*, 2007; IPCC, 2007a).

2.1.2 Risk

Risk is defined as the chance of injury, damage or loss, often expressed as degrees of probability. Agricultural production systems are always complex, especially when combined with variables of climate changes, usually this increases the risks associated (White *et al.*, 2010). Other factors involved are the goals and decision-making skills of the individual farm owner. For an agricultural enterprise to be financially and economically sustainable, farm owners must know the risks associated with various

management decisions, and make those decisions wisely (White *et al.* 2010; White, 2011).

Heltberg *et al.* (2008) also, defined risk as the chance or possibility of something unpleasant such as danger, damage, loss, injury or other undesirable consequences to happen. Elina and Denis (2006), also argued that risk is the result of physically defined hazards interacting with the exposed systems, taking into consideration the properties of the systems, such as their sensitivity or social vulnerability. This drives a need of having a clear distinction between risk and uncertainty, where as risk is where probability distribution is known or can reasonably be assumed, unlike uncertainty where no probability distribution can reasonably be assumed.

2.1.3 Resilience to climate change

When referring to human systems, the term "resilience" can be considered as a synonym of adaptive capacity (World Bank, 2012). IPCC (2007a) defined it as the capacity of a system, community or society potentially exposed to hazards to adapt by resisting or changing in order to reach and maintain an acceptable level of functioning and structure. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

2.1.4 Farm income and income sources

Income refers to the amount of money, return or other gain resulting from goods or services produced in a given period of time, it may be received by an individual or by an entity (Encarta, 2009).

Farm income refers to the monetary and non-monetary income, such as the value of home consumption of self-produced food received by farm operators (McNamara *et al.*, 2005). Its main components includes, the sale of farm products, government payments, other farm income such as income from custom work, value of food and fuel produced and consumed on the same farm, rental value of farm dwellings, and change in value of year-end inventories of crops and livestock (Mishra, *et. al.*, 2002; McNamara *et al.*, 2005).

Moreover, Gomes *et al.* (2002), defined Farm income as the profits and losses incurred through the operation of a farm. A farm profit and loss statement is a summary of income and expenses that occurred during a specified accounting period and this period is usually the calendar year for farmers.

It should also be known that, Income from the farm provides only a partial view of the income situation, as most farm households derive a significant share of their income from other sources, such as non-agricultural on-farm or off-farm activities, investments or social transfers. In fact, an increasing number of farm households earn more of their total income from non-farming sources than they do from farming. All these sources of income in the household should be taken into account (Gomes *et. al.*, 2002; Mishra *et. al.*, 2002; McNamara *et al.*, 2005).

There are various sources of income and are usually described within the private or the public sector of economic activity. In the private sector the four major types of income are wages, the return for labor; rent, the return for use of land; interest, the return for the use of capital; and profit, the return to the business owner. Income in the public sector, called national income, is the money measure of the annual flow of goods and services in

an economy. Income is normally measured in money terms, although non-money definitions are sometimes used (Encarta, 2009).

Household income from the rural communities, that is, smallholder farmers, often comes from agriculture activities and other off farm like remittances etc. The income is needed to meet some household expenses, for example health services from the clinic and education from schools. The income obtained is also often used as capital for agriculture purposes, in buying inputs (Mutsvangwa, 2011).

2.2 Evidence of Climatic Change

Historically, the earth's climate has always had cyclical trends and variations through the centuries, although with constant averages (IPCC, 2001b). Current climatic trends show a deviation from historic trends. The rate of change and the cause of change have been of concern to scientists all over the world. Temperature records collected for over a period of 100 years shows that, the Earth's surface temperature has risen by more than 0.7 degrees Celsius since the 1800s (IPCC, 2007).

The warming of the atmosphere is also supported by the IPCC (2001a) which reports that, globally, the 1990s were likely the warmest decades over the past millennium and the trend shows that, the warming has gone beyond the 1990s to 2000s. Records from WMO (2004) indicate that, nine out of ten warmest years on record occurred between 1995 and 2004, with 1998, 2002, 2003 and 2004 being the warmest. Effects of this temperature rise include, the melting of the polar ice caps leading to a rise in sea levels and flooding in some regions especially areas near the coast. In regions where high temperatures have been the generally normal, like the semi arid tropics, occurrence of droughts and dry spells seems to increase (Eriksen *et al.*, 2008).

2.3 Climatic Risks in Agriculture

The economic stability of an entire rural area can be jeopardized by crises caused by different types of natural disasters, from climatic events to livestock or plant diseases. Economic crises caused by the changes of market conditions may also endanger farm's viability (Wasige, 2009).

2.3.1 Climate risks and production

However, it is well known that weather is an important production factor in agriculture. Unfortunately, this production factor can hardly be controlled. In fact, weather risks are a major source of uncertainty in agriculture. Fluctuations of temperature and precipitation even increased in the last decade due to global climate changes (UNISDR, 2004). Droughts and excess rain leading to flooding are responsible for bad harvests all over the world. Perhaps the most obvious impact of weather risk is on crop yields, but its relevance is not limited to crop production. The performance of livestock farms, the turnover of processors, the use of chemicals and fertilizers and the demand for many food products also depend on the weather. Hence, large parts of the agribusiness are affected by weather risks (Wasige, 2009).

Climate risks denote the result of the interaction of physically defined hazards with the properties of the exposed systems, i.e. their sensitivity or social vulnerability. Risk can also be considered as the combination of an event, its likelihood and its consequences, i.e. risk equals the probability of climate hazard multiplied by a given system's vulnerability (World Bank, 2012).

Producers can try to compensate the negative economic consequences of bad weather events by buying insurance, but also, since the mid-nineties a new class of instruments,

namely weather derivatives. Generally spoken, weather derivatives and index based weather insurance are financial instruments that allow to trade weather related risks. Some developing countries decided to help the stabilization of their agriculture by supporting the agricultural insurance schemes but in particular due to global climate change the volatility of weather and the occurrence of extreme weather events increased and lead to destabilization of farm incomes in particular, in countries with strong yield variability (UNDP, 2013).

2.3.2 Types of agricultural risk

The agriculture sector is characterised by high exposure to risk, often but not only, coming from climatic events. This part summarizes the different types of risk that agriculture faces and the tools available to manage these risk exposure in most of the developing countries agricultural system (UNDP, 2012). Some risks farmers have in common with other business, others are unique to farming (UNDP, 2004; UNISDR, 2004).

As you think about managing any agricultural enterprise's risk in order to stabilize farm income, there are several sources of agricultural risk which are climatic and non climatic agricultural risk which should be should consider i.e. Production risks and environmental risks as the climatic risk, marketing risks, human resource risks and institutional risks as non-climatic risks, and from each of these sources there are different tools and strategies that can be used to manage it. (Thurow *et al.*, 1999; Shiller, 2003; Embrechts *et al.*, 2007; White *et al.*, 2010; White, 2011; UNDP, 2013).

2.3.2.1 Production risks

White (2011) argued that the Major sources of production risk are a weather and climate change which represents a long term issue that deserves an in-depth specific analysis, e.g. drought, severe winter, excessive rainfall at harvest and pests, insect and disease damage. This can be minimized by; farming diversification by Growing more crops of different varieties or get used to off-farm activities, Crop insurance can also stabilize income when used with a sound marketing program not only that but also technology adoption to protect against weather events, including irrigation and tile drainage (Shiller, 2003; White *et al.*, 2010).

2.3.2.2 Environmental risks

These are risks which affect the environments due to climate change e.g. Global warming and land degradation, Such kind of risks can be minimized by the use of good agricultural practices to limit environmental risk such as the use soil testing and pest scouting to make sure that inputs are only applied when, and to the extent, needed. Increasingly, growers need to document their pest and fertilizer applications. Careful storage and disposal of toxic materials is also a must. Minimize spray drift (Thurow *et al.*, 1999; UNDP, 2013).

2.3.2.3 Marketing risks

These are non-climatic risks which the value of an investment decreases due to the movement in market risk factors. E.g. Price risk due to change in supply or demand, changes in interest rates, stock indices, commodity prices and foreign exchange rates, loss of market access due to the relocation or closing of a processing plant, loss of marketing power due to small size of farm sellers relative to buyers. They can be managed by; developing a comprehensive marketing plan and/or a business plan, Forming or joining in a marketing cooperative which may enhance or at least stabilize prices and guarantee a

market, Finding an off-farm employment for a spouse or other family member (Embrechts *et al.*, 2007; White *et al.*, 2010).

2.3.2.4 Human resource risks

According to Embrechts *et al.* (2007), the major Sources of human resource risk includes the three D's, which represents Divorce, Death, or Disability of an essential owner, manager, employee, poor communications and people management practices in any enterprise. Embrechts *et al.* (2007) and White *et al.* (2010) suggested that these kinds of risks can be managed by; developing excellent human resource management practices, for family as well as outside employees and having life insurance is also helpful.

2.3.2.5 Institutional risks

UNDP (2013) reveal that Institutional risks are associated with policy changes which intervene with agricultural issues and that can have a negative impact on farm revenue. Eg. Policy changes, Subsidies changes, etc. And such kind of risks can only be dealt in a good manner by forming a Good policy with consistency evaluation of it (Shiller, 2003; White, 2011).

2.3.3 Risk management strategies

Strategic risk planning is important because we cannot accurately forecast the future. The use of strategic risk management plan to guide the decision making is of vital important. A strategic risk plan includes contingency provisions, and these are just as important as the specifications for things that are known. Making better use of scientific information and new approaches to agricultural practices and farm management also will reduce the adverse of the risks (White *et al.*, 2010; Embrechts *et al.*, 2007).

2.3.4 Climate risk impacts on agriculture

Climate risk is understood as the probability of negative impacts on farmers, the environment and crop production resulting from the interaction of climate hazards and conditions of vulnerability (UNDP, 2013). The effect of climate change to farmers considers much to the exposure of smallholder farmers and crops to climate risks and the different elements of vulnerability, namely sensitivity and adaptive capacity taking into account, whenever possible, both the current situation and future trends (UNDP, 2012). When climate, changes and varies there is high possibility of causing damages, danger or disaster to mankind (white, 2011). Heltberg *et al.* (2008) affirmed that risk associated with climate change can adversely affect humans through a variety of direct and indirect pathways such as change in mean and variance of rainfall and temperature might lead to extreme weather events, changes on agricultural production and prices, hunger, disease, decrease of farm income which could trigger potentially dramatic increase in chronic poverty and violent conflict in many developing countries unless the risk management capacity of households, communities and nations is strengthened.

Thus, events such as drought, floods, storms and hurricanes and spells of extremely high or low temperatures are recognized as major risks associated with climate change and variability, moreover as time goes it becomes more frequent and more severe (Heltberg *et al.*, 2008).

According to Oxfam (2008), most of the East African countries are increasingly exposed to the following changes: Irregular and erratic seasons, Changes in the timing, frequency, coverage and amount of climate hazards, Irregular rainfall distribution within the season, Shorter and more intense rains, Heavy rains and landslides, More frequent and prolonged droughts, Higher temperatures etc.

2.4 Overview of Climate Change in Tanzania and its Impact

Tanzania's economy is very dependent on the climate, because a large proportion of GDP is associated with climate sensitive activities, particularly agriculture. Current climate variability, i.e. extreme events such as droughts and floods, already lead to major economic costs in Tanzania. Individual annual events have economic costs in excess of 1% of GDP, and occur regularly, reducing long-term growth and affecting millions of people and livelihoods (Downing *et al.*, 2010).

The wider global climate change trends are greatly reflected in Tanzania's climate. Because of her geographical location and the topographical characteristics (Shemsanga *et al.*, 2010), climate change has badly affected the country i.e. declining of agricultural productivity due to climate change (Yanda, 2005).

Studies show that in Tanzania mean annual temperatures and average daily temperatures will rise by between 2 to 4 C by 2075 as a direct consequence of climate change (URT, 2003).

Apart from temperature data, change in rainfall patterns is likely to be more torturous and with immediate severe effects. In most of the African tropical countries, rainfall models indicate that rainfall will become less predictable and their intensity more volatile (IPCC, 2007a), leading to an increase in extreme weather events and inevitably severe consequences to the society such as repeated droughts and floods, cyclones, tropical storms all of which are projected to be more intense, frequent and unpredictable, some of which are already happening (IPCC, 2001a; URT, 2007).

The impacts of climate variability on agriculture sector in Tanzania include shifting in agro-ecological zones, prolonged dry episodes, unpredictability in rainfall, uncertainty in cropping patterns, increased weed competition with crops for (moisture, nutrients and light) and ecological changes for pests and diseases (Paavola, 2003; URT, 2007).

2.5 Impact of Climate Change on Smallholder Farmers' Income

Agriculture including livestock is of central importance to smallholder farmer's livelihoods, providing income and employment to the majority of rural population in developing countries (Yanda, 2005). Climate change affects agriculture and food production in complex ways. It affects food production directly through changes in agro-ecological conditions and indirectly by affecting the growth and the distribution of incomes (Schmidhuber *et al.*, 2007). As the sector is dominated by rain-fed and subsistence production, it is particularly vulnerable to climate variability and change (Ehrhart, 2006).

According to IPCC (2007b), in many African countries access to food will be severely affected by climate change and yields from rain fed agriculture could be reduced by up to 50% by 2020. Kurukulasuriya and Mendelsohn (2007) found that net revenues fall as rainfall falls or as temperatures warm across all the surveyed African countries. Seo and Mendelsohn (2008) also showed that as temperatures increase, farm incomes from crop-only farms or livestock-only farms fall, with decreases in rainfall, farm incomes from rain-fed farms or livestock-only farms falls also. With a hot, dry climate scenario, the Ricardian model predicts that farm income will fall by 50-70% in Africa (Asfaw, 2012),

The associated impacts of high temperatures, altered patterns of rainfall and possibly increased frequency of extreme events such as drought and floods, will probably combine

to depress yields and increase production risks in many regions, widening the gap between rich and poor countries (IPCC, 2001b).

2.6 A Review of Approaches and Methods Used

2.6.1 Quantitative approach to evaluate climate risk and social vulnerability: Multi-criteria/Multiple indicators approach

Multi criteria analysis (MCA) is an approach to decision support that uses more than one criterion to assess performance and rank various options or interventions (GCCA, 2011). The term actually covers a wide range of methods, some of which rely more on establishing qualitative hierarchies, while others rely more on quantitative methods. Usually, various options or interventions are assessed against a pre-determined set of criteria (GCCA, 2011). Qualitative ratings or quantitative scores, sometimes both are given to each option or intervention against each criterion, then rules are applied to rank the assessed options/interventions; where numerical scores are used, they can be added up to calculate a total score with the possibility of applying different weights to different criteria (EC, 2003; Niang-Dop and Bosch, 2004).

2.6.1.1 Assumptions of quantitative approach to evaluate climate risk

The approach assumes that climate impacts could be a chain of consequences whereby its vulnerability is the function of sensitivity, exposure and coping capacity of the risk associated and is a result of multiple stresses, climate and non-climate.

It further assumes that the impacts of climate change follows a certain order of effect whereby it first lead to fluctuation in temperature and in onset rainy season, damage / decreases the farm production, decrease the household/farmer's income, and then at last it deteriorate household livelihood.

It also assumes that overall concept is based on risk assessment and risk comparison. The approach improvises for the quest to understand risk and social vulnerability to climate change impact and other changes in socio-economic condition.

Lastly, it assumes that the Risk could change over time, for the current risk will not be similar to the future risks. By comparing these risks from climate impact, the current risk is often used to predict the future risk (Chinvanno, 2008).

2.6.1.2 Limitation of quantitative approach to evaluate climate risk

Firstly, the approach is not able to explain risk, vulnerability of household and community in site specific assessment though it is good for community base study, Secondly, it not more capable to captures assessment at the macro level but too much of local context. Thirdly, it uses only single proxy of climate change impact though could be added. Fourthly, it does not capture the dynamism of future socio-economic development – need socio-economic scenarios in the process. Fifthly, it does not capture the multi-years accumulative impact of climate threat (Chinvanno, 2008).

2.6.2 Distributed lag model

In statistics and econometrics, a distributed lag model (DLM) is a model for time series data in which a regression equation is used to predict current values of a dependent variable based on both the current values of an explanatory variable and the lagged (past period) values of this explanatory variable (Almon, 1965).

Econometricians use regression analysis to make quantitative estimates of economic relationships. Regression analysis is a statistical technique that attempts to explain movements in one variable, the dependent variable, as a function of movements in a set of

other variables, the independent or explanatory variables (Studenmund, 2006). The analysis helps to predict both the direction and magnitude of change in the dependent variable that is due to change in the independent variable(s). It is a dynamic model in which the effect of a regressor x on y occurs over time rather than all at once (Speaker *et al.*, 1989). In the simple case of one explanatory variable and a linear relationship, we can write the model as;

$$Y_t = \alpha + \beta_1(L)X_t + V_t = \alpha + \sum \beta_s X_{t-s} + V_t \dots\dots\dots(1)$$

Where, V_t is a stationary error term. The lag on the right-hand side is applied to the explanatory variable x rather than to a white-noise process ε . The individual coefficients β_s are called lag weights and the collectively comprise the lag distribution. They define the pattern of how x affects y over time. Distributed lag models include lagged values of the independent variables and not lags of Y_t .

2.6.2.1 Types of distributed lag model (DLM)

There are specifically two types of Structured distributed lag model which are

- Finite DLM
- Infinite DLM

Finite distributed lags allow for the independent variable at a particular time to influence the dependent variable for only a finite number of periods. Infinite distributed lags allow the value of the independent variable at a particular time to influence the dependent variable infinitely far into the future, or to put it another way, they allow the current value of the dependent variable to be influenced by values of the independent variable that occurred infinitely long ago; but beyond some lag length the effects taper off toward zero (Greene, 2003).

Finite distributed lag;

$$Y_t = \alpha + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-2} + V_t \dots\dots\dots (2)$$

Infinite distributed lag;

$$Y_t = \alpha + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-2} + \dots\dots + \beta_n X_{t-n} + V_t \dots\dots\dots(3)$$

Where, Y_t is the value at time period t of the dependent variable, α is an intercept term to be estimated, and β_i are the lag weight (also to be estimated) placed on the value i periods previously of the explanatory variable X .

In the first equation, there are only a finite number of lag weights, indicating an assumption that there is a maximum lag beyond which values of the independent variable do not affect the dependent variable; a model based on this assumption is called a finite distributed lag model. In the alternative, second, equation, the dependent variable is assumed to be affected by values of the independent variable arbitrarily far in the past, so the number of lag weights is infinite and the model is called an infinite distributed lag model (Greene, 2003).

In an infinite distributed lag model, an infinite number of lag weights need to be estimated; clearly this can be done only if some structure is assumed for the relation between the various lag weights, with the entire infinitude of them expressible in terms of a finite number of assumed underlying parameters. In a finite distributed lag model, the parameters could be directly estimated by ordinary least squares (assuming the number of data points sufficiently exceeds the number of lag weights); nevertheless, such estimation may give very imprecise results due to extreme multicollinearity among the various lagged values of the independent variable, so again it may be necessary to assume some structure for the relation between the various lag weights (Almon, 1965; Hamilton, 1994).

2.6.2.2 Model estimation

Consider the equation below:

$$Y_t = \alpha + \beta_1 X_t + \beta_2 X_{t-1} + \beta_3 X_{t-2} + \dots + \beta_n X_{t-n} + V_t;$$

It is difficult to estimate an infinite number of β coefficients in the equation above. One practical method is to truncate the lag in the eqn. to finite length q , which is appropriate if the lag distribution is effectively zero beyond q periods. Another approach is to use a functional form that allows the lag distribution in the eqn. above to decay gradually to zero. So a form with one or more lags of Y_t on the right-hand side will allow infinite-length lag distributions while requiring estimation of only a small number of parameters (Speaker *et al.*, 1989). One difficulty that is common to all distributed-lag models is choice of lag length, whether this be choosing the point q at which to truncate a finite lag distribution in the eqn. above or choosing how many lagged independent variables to include (Romer, 2012).

The simplest way to estimate parameters associated with distributed lags is by ordinary least squares, assuming a fixed maximum lag q , assuming independent and identically distributed errors and imposing no structure on the relationship of the coefficients of the lagged explanatory variable with each other. However, multicollinearity among the lagged explanatory variable often arises, leading to high variance of the coefficient estimates (Keele *et al.*, 2005; 2006).

2.6.2.3 Advantage and disadvantage of the modeling

In cases where the effect of x on y dies out quickly, it may be feasible to estimate equation (i) directly. The finite distributed lag model has several advantages. The coefficients can be estimated by OLS, assuming that X is strictly exogenous. Interpretation of the β s

coefficients is straightforward using the FDLM. Since there are no restrictions imposed on the $q + 1$ lag coefficients, any finite pattern of lag weights can be estimated (Jorgenson, 1966; Keele *et al.*, 2006).

There are two major disadvantages to the finite distributed lag model. The first is multicollinearity. Even if x is stationary, it may be highly auto correlated, meaning that x_t and x_{t-1} are strongly correlated, as are x_{t-1} and x_{t-2} , x_{t-2} and x_{t-3} , etc. High levels of correlation among the regressors imply multicollinearity, which leads to unreliable coefficient estimates with large variances and standard errors (Schmidt, 1974). Estimation of finite distributed lag models with strongly auto correlated regressors often leads to lag distributions in which the sequence of lag coefficients bounces around between large and small and sometimes positive and negative values in ways that are not consistent with economic theory. When this happens, econometricians often try to restrict the estimated β coefficients to satisfy prior assumptions of smoothness (Box *et al.*, 1976).

The second disadvantage of finite distributed lags is that they can be problematic when the lag length is long, especially in small samples. If we have data for observations from $t = 1$ through T , then the earliest observation that can be included in the estimating sample is $t = q + 1$, because we need to have data for q periods before the beginning of the estimating sample for the lagged terms on the right-hand side (Almon, 1965; Keele *et al.*, 2005). Not only that but also, this effect is magnified if there are two or more regressors for which we must estimate lag distributions (Keele *et al.*, 2006).

In summary, the finite distributed lag model is most suitable for estimating dynamic relationships when lag weights decline to zero relatively quickly, when the regressor is not highly auto correlated and when the sample is long relative to the length of the lag distribution and vice versa is true for the infinite distributed lag model (Keele *et al.*, 2006).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Conceptual Framework

The study was based on a conceptual framework (Fig.1) that has been modified from various concepts that have been used to assess the economic impacts of climate risks on agriculture (IPCC, 2001a; Ford and Smit 2004; Deressa *et al.*, 2008; Senbeta, 2009; Kauti, 2009; Mutsvangwa, 2011).

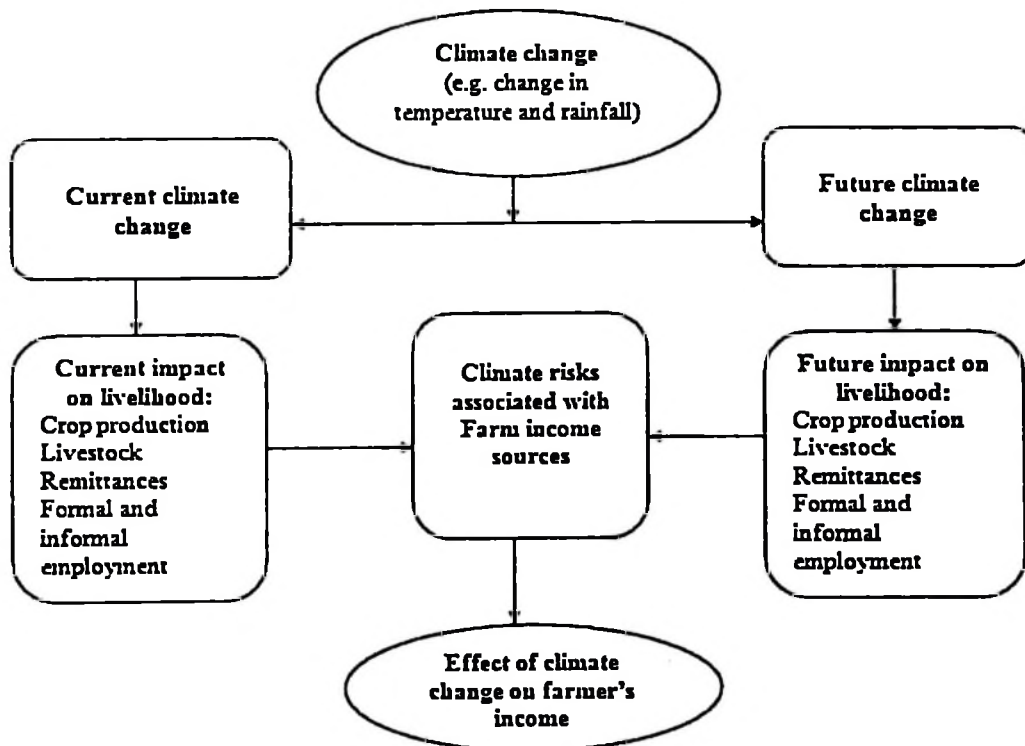


Figure 1: Conceptual framework

As shown in Fig.1, smallholder farmers are exposed to climate change (mainly temperature and rainfall), which is affecting them currently and in the future time. The future climate change is expected to expose farmers to higher frequencies and intensities of climate-risk which highly affects the overall livelihood of the farmer, i.e. effect on farmer's income from crop production and livestock.

3.2 Description of the Study Area

The study was done in two semi-arid districts of Meatu and Iramba belonging to the central Simiyu and Singida Regions, respectively. The selection of the districts was based on the fact that they are in semi-arid zone exposed to climate change and variability. According to Barrow *et al.* (2003) Shinyanga Region of which the Simiyu Region is a part, is a semi-arid experiencing less rainfall below 900mm and high temperature up to 32⁰C per year. On the other hand Singida Region which is in more or less in central Tanzania shares the semi-arid conditions of Shinyanga with less rainfall below 850mm and maximum temperature of 29⁰C per year. High temperature accelerate evapo-transpiration which stresses most of the crops.

3.3 Meatu District

3.3.1 Geographical location and size

Meatu District is one of the five districts of Simiyu Region others are Bariadi, Italima, Maswa and Busega. It lies between latitude 2⁰ 57' and 4⁰ 9' South of Equator and Longitude 34⁰ 8' and 34⁰ 49' East of the Greenwich Meridian. The altitude varies between 1000 and 1400 meters above sea level. The district is bordered with Bariadi District to the north, Ngorongoro and Karatu Districts to the East, Mbulu and Iramba Districts to the South and Maswa and Kishapu Districts to the west. The Districts cover a total surface area of 8835 Km², almost half of it is occupied by the reserved areas (4253 Km²), Maswa

game reserve with 2094 Km², Makao Open area with 1,330 Km², Serengeti National Park with 694 Km² and Ngorongoro Conservation Area with approximately 135 Km². The rest of the district area (4582 Km²) comprises with agricultural land and pastures (DPLO, 2012).

3.3.2 Climate and topography

Meatu District is classified as semi-arid, with a decrease in rainfall distribution from north to south. The temperature is relatively warm throughout the year where by the mean annual temperature ranges between 18^oC to 21^oC and the maximum annual temperature ranges between 28^oC to 32^oC. The Southern half of the district receives a mean annual rainfall of 400 mm, while the Northern half receives up to 900 mm per year. The rainfall pattern is bimodal, with most rain in November to December and March to April. The climate of the district encourages high amount of evaporation causing most of the rivers to be seasonal and only hold surface water during or shortly after the rains. A constraint, especially for the agricultural sector, is the great variance of rainfall in space and time. It tends to fall in heavy localized rainstorms separated by dry spells, however rainfall in area differs tremendously over space from year to year (DPLO, 2012).

Topographically, a large extent of the District area is a flat terrain with an altitude sloping down from north to south causing most of the river to flow southwards and discharge in Lake Kitangiri or in the Sibiti River to Lake Eyasi, a salt lake. Most rivers are seasonal and only hold surface water during or shortly after rains. The most dominant soil type is Black-Cotton soil which is a mixture of clay and silt characterized by cracks during dry seasons. Vegetation of the area is very rare, with exception of shrubs and thorny trees scattered or clustered in some areas. Other areas include cultivated land, forest woodland, bush land, grassland and mixed natural vegetation with scattered crop (DPLO, 2012).

3.3.3 Socio-economic activities and productive Sectors

The main economic activities and productive sector which operate in Meatu District include; agriculture, livestock rearing, mining, forestry and beekeeping, trade and commerce, financial institutions and infrastructure (DPLO, 2012)

3.4 Iramba District

3.4.1 Geographical location and size

Iramba is one of the four Districts in Singida Region; others are Singida Municipalit council, Singida District council and Manyoni District council. It lies between 4°.0'S to 4°.3' S Latitude and 34° E to 35° E Longitudes. Its Plain altitude ranges from 1000 meters to 1500 meters above the Sea level. The District is bordered with Meatu and Mbulu Districts to the North, Hanang' District to the East, Singida District to the South, Shinyanga Districts to the West and Maswa and Meatu to the North West.

The District has an area of 7900 square kilometers or 790 000 hectares where as the arable land occupies 3500 square kilometers or 350 000 hectares (44.3% of the total land) but land under utilization is between 1500 to 2000 square kilometers (19 to 25% of the total land), Grazing land has an area of 3370 square kilometers (42.7% of the total land/area), area with forest covers 73 592 square kilometers of land (9.3% of the total land), area covered by rocks and water occupies 29 408 square kilometers. This gives a total surface area of 7900 sq km where by 7878 sq km is land area and the remaining 22 sq km is covered by water bodies (DALDO, 2012).

3.4.2 Climate and topography

Iramba District is a semi-arid area which mostly receives early rainfall varies between 500 mm to 850 mm per annum with a temperature that ranges between 15°C in July to

30°C during October each year. District rainfall usually starts in mid-November up to mid-May. The Rainfall pattern is monomial and rain season is interrupted by two notable dry spells in mid-February and mid March.

Topographically, a large extent of the District area is a plane surface. Soils are generally red brown with fairly high fertility status, underscore that its productivity is limited by low and poor distributed rainfall. They include black soil, loam and sandy soil covering the whole District, the District vegetation is rich in a variety of natural vegetation which are found in it, which includes Miombo wood lands, acacia wood lands and grasslands (DALDO, 2012).

3.4.3 Socio-economic activities and productive Sectors

The main economic activities and productive sector which operate in Iramba District includes; agriculture, livestock keeping, natural resources (mining, forestry beekeeping, fisheries), wild life, and infrastructure (DALDO, 2012).

3.5 Research Design

The study used a cross-section research design. This design allows data to be collected at a single point in time from a sample. The design is suited for descriptive studies and for determination of relationship between and among variables. It is also economical in terms of time and financial resources (Babbie, 1993). The target population for the study included all smallholder farmers within the selected districts.

3.6 Data Sources and Instrument for Data Collection

Both primary and secondary data were used in the study. Primary data were obtained from farmers by using questionnaire focus group discussions (FGD). The questionnaire sought to gather information on demographic household characteristics, agriculture production (i.e. crops grown, yields obtained, livestock owned, price of output and inputs) and Income sources (i.e. sale of crops or livestock. On the other hand secondary data were collected from the two districts agricultural and natural resources offices, district planning office and metrological stations. Such data included time series data of temperature, rainfall, crop production trends, crop and livestock prices trend of a certain period of time and relief assistance offered to households in the study area.

3.7 Sampling Procedure and Sample Size

Simple random sampling technique was used in selecting 100 respondents. From three villages of Meatu (2) and Iramba (1) districts, i.e. 33 farmers from each village, Mwamanimba, Mwashata and Kidaru for these villages have been randomly selected because they are more affected by climate change and variability compared to the other villages.

3.8 Data

3.8.1 To characterize climate risk associated with different source of farm income

In characterizing climate risk associated with different sources of farm income, data on income from different sources were collected from respondent farmers. The data were used to identify the risk associated with those income sources with respect to climate change and variability. Descriptive analysis was used to characterize the climate risks associated with different source of farm income.

3.8.2 To evaluate climate risk resilience of smallholder farmers from major income subsectors

Multi-criteria analysis, also known as multiple indicators analysis, was used to evaluate the climate risks resilience of smallholder farmers from major income subsectors; basically the approach measured the sensitivity of different income source to climate risks. Criteria like household economic condition, household dependency on on-farm production and coping capacity were used based on respective indicator variables.

Table 1: Multi-criteria analysis for evaluating climate risk resilience

Criteria	Indicator	Sensitivity to climate threat		Min score	Max score
		measurement	Scoring		
<i>Household economic condition</i>	HH Sustainability condition	$\frac{THHI}{THHE}$	>1=0 1 - 0.7=1 <0.7=2	0	2
	HH Production	Farmland own / rent	Own = 0 Rent = 1	0	1
	Resource Condition	Farmland/capita (ha)	> or = 0.65 = 0 < 0.65 = 1	0	1
	Sub-total			0	4
<i>Exposure to climate threat</i>					
<i>Household dependency on on-farm production</i>	Ability to use non-climate sensitive income to support household livelihood	$\frac{THHC}{(IFL + TOFI)}$	>1=0, 1 - 0.7=1, <0.7=2	0	2
	Dependency on farm production to sustain basic needs.	$\frac{TFP}{THHE}$	=1=0 <1 - .7=1 <0.7=2	0	2
	Sub-total			0	4
<i>Coping capacity to climate threat</i>					
<i>Coping Capacity</i>	Ability to use non-farming income to maintain livelihood	$\frac{(THHC \div TCP)}{(THHS + TOFI + IFL)}$	< or =1 = 0 >1-1.3 = 1 >1.3 = 2	0	2
	Ability to use non-farming income to Maintain household basic needs	$\frac{THHE}{(THHS + TOFI \div IFL)}$	< or =1 = 0 >1-1.3 = 1 >1.3 = 2	0	2
	Sub-total			0	4
Total				0	12

Source: Adopted and modified from Chinvano, (2008).

Where by:

HH= Household, TFP=Total Farm Production/output, TCP=Total cost of production, THHI=Total Household Income, THHC= Total Household Consumption, THHE=Total Household Expenditure, THS= Total household saving, IFL= Income from Livestock, TOFI= Total off-farm income Operationalizations of individual components were as follows:

(a) Total farm output (TFO)

Total farm output was obtained after summing up all the revenues obtained from each major crop grown by a farmer.

$$\text{TFO} = \sum (\text{PQ}) \dots\dots\dots (4)$$

Where, TFP-Total farm output, P-Price, Q-Quantity produce, i and j represents the types of crops grown by a farmer.

(b) Total cost of production (TCP)

Total cost of production was calculated by summing up all the costs incurred when producing all the major crops such as input cost, farm preparation to harvesting and transportation costs.

$$\text{TCP} = \sum (\text{PX, F, T}) \dots\dots\dots (5)$$

Where, TCP-Total cost of production, P-Price, X-Quantity of input, F-Farm management costs, T-Transport cost.

(c) Household livestock income (IFL)

Household livestock income was computed from the number of livestock sold within the year of the study, then the entire amount from each type of livestock sold i.e. cattle, goat and poultry was summed up to come up with a total household income from livestock.

$$\text{IFL} = \sum (\text{PY, R}) \dots\dots\dots (6)$$

Where, IFL-Income from livestock, P-Price of livestock a or b, Y-Number of livestock sold, R-Income from poultry sold. The value of livestock appreciates with time and has residual value that was formed from the past, then on realizing the real value of the livestock sold during the year of study, the following computation was used in order to avoid an over valuation of its value;

$$K = \frac{\text{Number of Livestock} \cdot \text{Price}}{\text{Years kept}} \dots\dots\dots(7)$$

Where, K-is the value of livestock sold in the year of the study in Tshs.

(d) Total off-farm income (TOFI)

Total off-farm income of a farmer was calculated from all the other non agricultural sources of income such as small business, wage, employment, remittances, casual labour, money from friends. Then its summation brought about total off-farm income as follows;

$$\text{TOFI} = \sum (\text{Is, Ie, Iw, Ir, Ia}) \dots\dots\dots(8)$$

Where, Is-Income from small business, Ie-Income from employments, Iw-Income from casual work (wages), Ir-Income from remittances and Ia- Income from artisan works.

(e) Total household income (THHI)

Total household income was computed from all the major sources of income of a farmer, narrated in detail above i.e. income from crop production, livestock and other off-farm sources. And then all of them were summed up to obtain the total income of a farmer as follows;

$$\text{THHI} = \sum (\text{Icp, Iv}) \dots\dots\dots(9)$$

Where, THHI-Total household income, Icp-Income from quantity of crop production sold and Iv-Income from livestock and poultry sold.

(f) Total household saving (THHS)

On calculating the total household saving farmers were asked how much they save per year in any form and then the item saved per year was valued. And to those who kept the animal as a saving, the actual income from IFL was included.

(g) Total household consumption (THHC) and total household expenditure (THHE)

Total household consumption was calculated from the total quantity that a farmer consumed within a year of study from crop production, livestock, poultry and from other sources of income from consumption.

Factor scores were combined to come up with the total scores from the measurement formula and scoring criteria of three extreme scales which are as follows, if;

- The household which its total risk score is between 0-4 is classified as low risk category.
- The household which its total risk score is between 5-8 is classified as moderate risk category.
- The household which its total risk score is between 9-12 is classified as high risk category (Chinvanno, 2008).

3.8.3 To determine the effect of climate change on farm income from major crops

A distributed lag model (DLM) was used to determine the effect of climate change on farm income from major crops, where by the annual outputs of major crops for 29 years was regressed with respective climate variables (i.e. rainfall and temperature). The annual outputs of major crops for 29 years was obtained from districts agricultural office but only Meatu Districts had enough data that covers all the 30 years while Iramba had only the record of less than 10 years hence it was difficult to use such a short term production data instead the study used the production trend data from Meatu for these two districts shares the same agro-ecological situation and bears the same climatic condition.

It was found difficult to use temperature in the model because temperature data were not having variation that could be regressed and give out the consistent estimates. Seasonal

temperature data were also not used because of lack of variation, the temperature data of the two districts were almost constant changing.

Therefore, annual production trend of major crops for 29 years was taken as a proxy variable which have direct impact to the individual farm incomes and was regressed with lagged values of rainfall. The study used the annual production trend for 29 years of maize, sorghum and cotton as the major crops grown in semi-arid area in relation with the data availability.

Distributed lag models for maize, sorghum and cotton annual production are as follows:

$$M_t = \beta_0 + \beta_1 R_t + \beta_2 R_{t-1} + \beta_3 R_{t-2} + \varepsilon_{tm} \dots\dots\dots(10)$$

$$S_t = \beta_0 + \beta_1 R_t + \beta_2 R_{t-1} + \beta_3 R_{t-2} + \varepsilon_{ts} \dots\dots\dots(11)$$

$$C_t = \beta_0 + \beta_1 R_t + \beta_2 R_{t-1} + \beta_3 R_{t-2} + \varepsilon_{tc} \dots\dots\dots(12)$$

Where:

M_t , S_t and C_t = Annual production of maize, sorghum and cotton in (tonnes/ha) respectively, in a period of time t .

β_0 = is the intercept or constant term to be estimated. β_1 , β_2 , and β_3 = are the lag weights (also to be estimated) placed on the value t periods previously of the explanatory variable R .

R_t , R_{t-1} , and R_{t-2} = are the rainfall lagged values (in mm) in a period of time t , $t-1$ and $t-2$ as the independent variables influencing the dependent variable.

ε_{tm} , ε_{ts} and ε_{tc} - are the error term of maize, sorghum and cotton DLMS in a period of t .

In the three equations above, the dependent variable is assumed to be affected by values of the independent variable (lagged rainfall values), so the number of lag weights is finite

by only three finite numbers of lag weights, indicating an assumption that there is a maximum three lags beyond which values of the independent variable do not affect the dependent variable, and a model based on this assumption is called a finite distributed lag model.

On determining the lag length to be used in the model, a statistical significance test method was used to determine the number of lags to be used. As Greene (2003), explained that , an obvious way to choose the length of a lag is to start with a long lag test the statistical significance of the coefficient at the longest lag—the “trailing lag”—and shorten the lag by one period. We continue shortening the lag until the trailing lag coefficient is statistically significant, but Keele *et al.* (2006) also argued that a statistical tests of significance is to start with a very short lag and successively add lag terms, continuing to add lags that are statistically significant and stopping when the marginal lag coefficient is not statistically significant.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Respondent's Social- Economic Characteristics

The study assessed social economic characteristics of the respondents in terms of age, sex, marital status, education level, household size and household main activities. Results are presented in tables below.

4.1.1 Age of the respondent

Table 2 shows the distribution of the respondent by age. Since the sampled population was composed with the household heads, nobody was of the age below 18 for it is a school age bracket. Also the study revealed that majority (71%) of respondents were aged between 18 – 45, this implies that majority of the respondents in the surveyed area were matured people within the active working age group who can take responsibilities. Age influences the income generating capacity of an individual, as it was stated by Regnard (2006) that in total the accumulation of wealthy is highly depending on the age of an individual. However, age determines individual maturity and ability to make rational decisions.

Table 2: Age of the respondent (n=100)

Age category	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
18 - 35	28	41.8	7	21.2	35	35.0
36 - 45	24	35.8	12	36.4	36	36.0
46 - 60	12	17.9	11	33.3	23	23.0
>60	3	4.5	3	9.1	6	6.0
Total	67	100.0	33	100.0	100	100.0

4.1.2 Sex of the respondent

Sex of the respondent has implication on the roles and responsibilities in the society thus it has a good link with household income generation. The distribution of sex is shown in (Table 3) from which the study indicated that majority of the respondent were males by (76.1%) in Meatu District and (72.7%) in Iramba District while (23.9%) and (27.3%) were females in Meatu and Iramba Districts respectively, accounted for the total of (75%) males and (25%) female of the total respondents, which implies that most of the income generating activities in the study area are headed by males compared to females, hence males plays greater role in household income generation compared to females concurrently with the FGDs.

Table 3: Sex of the respondent (n=100)

Sex	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Male	51	76.1	24	72.7	75	75.0
Female	16	23.9	9	27.3	25	25.0
Total	67	100.0	33	100.0	100	100.0

4.1.3 Marital status of the respondent

Marital status was categorized as single, married, divorced and widowed. The findings in (Table 4) shows that majority of the respondents in Meatu and Iramba Districts were married, i.e. (88%) in Meatu and (82%) in Iramba Districts respectively. Having (86%) married respondents out of all respondents from the study findings. As Shimbe (2008) argued married status may persuade someone to work hard due to family responsibilities. Married men are being tasked with family obligations; they tend to engage much in productive activities in order to generate income to meet various family needs.

Table 4: Marital status of the respondent (n=100)

Marital status	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Married	59	88.1	27	81.8	86	86.0
Single	2	3.0	2	6.1	4	4.0
Widowed	6	9.0	4	12.1	10	10.0
Total	67	100.0	33	100.0	100	100.0

4.1.4 Education level of Respondent

Education level plays an important role in ensuring household access to basic needs such as food, shelter and clothing, where as education and skills improve working efficiency likely to result into more income. Moreover, education is important in order to manage any productive activities efficiently as well as in decision making. The results in Table 5 indicate that majority of the respondents in both districts were characterized by a low level of literacy, i.e. 77.6% of respondents from Meatu District and 90.9% of respondents from Iramba attained primary education level.

Table 5: Respondent education level (n=100)

Education level	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Primary	52	77.6	30	90.9	82	82.0
Secondary	2	3.0	1	3.0	3	3.0
Diploma	0	0.0	1	3.0	1	1.0
Illiterate	13	19.4	1	3.0	14	14.0
Total	67	100.0	33	100.0	100	100.0

4.1.5 Household family size

The results indicate that the minimum household size both in Meatu and Iramba District was 3 individuals, Meatu had a maximum of 11 individuals and Iramba a maximum of 9 individuals within a family (Table 6). However, the mean household sizes for Meatu and Iramba Districts were 6 and 5 individuals, respectively. As far as the results are concerned

Meatu District is said to have large household size compared to Iramba District due to cultural differences.

Table 6: Household family size

Household size	District		Total
	Meatu	Iramba	
Minimum	3	3	3
Maximum	11	9	11
Mean	6	5	6
Mode	6	5	5

4.1.6 Household main activity

The results in Table 7 show that most of the interviewed respondents (64%) were involved both in crop production and livestock keeping while (34%) and (2%) practice only crop production and livestock keeping respectively. Engaging much in both crop and livestock keeping implies farming diversification in order to reduce risk associated with it. This implies that majority of the people living in the study area depends much on both crop production and livestock keeping more than livestock keeping only.

Table 7: Household main activity

Main activities	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Crop Production	25	37.3	9	27.3	34	34.0
Livestock Keeping	2	3.0	0	0	2	2.0
Both Crop and Livestock	40	59.7	24	72.7	64	64.0
Total	67	100.0	33	100.0	100	100.0

4.1.7 Major crops grown by the respondents

The study further revealed that in the category of crop production, maize and cotton were highly grown in Meatu District by (73.1%) and (89.5%) as the major food and cash crops respectively, sorghum and sunflower were highly grown in Iramba District by (90.9%)

and (78.8%) as the major food and cash crops respectively. Among all the crops grown in both districts cotton (61%) was highly grown as a cash crop followed by maize (58%) as a main food crop compared to other crops due to their soil type difference.

Table 8: Major crops grown by the respondents (n=100)

Crop type	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Maize	49	73.1	9	27.3	58	58
Sorghum	22	32.8	30	90.9	52	52
Cotton	60	89.5	1	3	61	61
Sunflower	0	0	26	78.8	26	26
Total	>67	>100	>33	>100	>100	>100

*The frequencies and percentage of respondent exceed 67, 33 and 100% respectively because some of the respondents grow more than one crop type.

4.1.8 Reason and experience for engaging in crop production

The study found that majority (85%) of the farmers do engage in crop production for both domestic and commercial purpose in order to generate more income as indicated in Table 9, while (9%) engaged for domestic (food) purpose only and (6%) engaged for commercial purpose only. However, the study revealed that most (84%) of respondents have been cultivating for more than 10 years while 15% of the farmers have been cultivating within 5 to 10 years and only 1% engaged in cultivating business less than 5 years.

Table 9: Reason and experience for involving in crop production (n=100)

<i>Purpose/Reason</i>	District					
	Meatu		Iramba		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
For Domestic	4	6	5	15	9	9
For commercial	6	9	0	0	6	6
Both	57	85	28	85	85	85
Total	67	100	33	100	100	100
<i>Duration</i>						
Less than 5 years	0	0	1	3	1	1
5 to 10 years	12	18	3	9	15	15
More than 10 years	55	82	29	88	84	84
Total	67	100	33	100	100	100

4.1.9 Major livestock type kept by the respondents

The study assessed the major livestock which were kept in the study area and the findings in Table 10 shows that majority (58.2%), of the respondents in Meatu District were keeping cattle followed by goats (56.7%), sheep (47.2%), poultry (46.3%) and only 4 respondents kept donkey as a labour work animal, (69.7%) of the respondents kept cattle, followed by goats (66.7%), pigs (39.4%), poultry (27.3%) and only 14 respondents (21.2%) who kept both sheep and donkey in Iramba. The study further revealed that cattle (62%) and goats (60%) are the major livestock which were being kept in the study area.

Following the short discussion with some of the respondents it was revealed that in most cases, poultry (chicken and duck) were kept for household consumption and donkey for labour working while cattle, goats, sheep and pigs were kept for household consumption especially during festivals and social functions such as religious and traditional festivals as well as for commercial purposes.

Table 10: Major livestock type kept by the respondents (n=100)

Livestock type	District				Total	
	Mcatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Cattle	39	58.2	23	69.7	62	62
Goat	38	56.7	22	66.7	60	60
Sheep	32	47.2	7	21.2	39	39
Pig	0	0	13	39.4	13	13
Donkey	4	6	7	21.2	11	11
Poultry	31	46.3	9	27.3	40	40
Total	>67	>100	>33	>100	>100	>100

*The frequencies and percentage of respondent exceed 67, 33 and 100% respectively because some of the respondents keep more than one type of livestock.

4.1.10 Reason and experience for involving in livestock keeping

According to Table 11, the study found that majority (97%) of the livestock keeping households reported that they are keeping livestock for both domestic and commercial purpose as a way of diversifying income, while the remained (3%) of them kept livestock for commercial purpose only. Livestock keepers (83%) have been involved in livestock keeping for more than 10 years.

Table 11: Reason and experience for involving in livestock keeping (n=66)

Purpose/Reason	District				Total	
	Mcatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
For commercial	2	5	0	0	2	3
Both	40	95	24	100	64	97
Total	42	100	24	100	66	100
Duration						
Less than 5 years	3	7.1	2	8.3	5	8
5 to 10 years	4	9.5	2	8.3	6	9
more than 10 years	35	83	20	83.3	55	83
Total	42	100	24	100	66	100

4.1.11 Land ownership

The study revealed that majority (52%) of the respondents in Meatu and Iramba Districts uses their own land as shown in Fig. 3, while 39% of the respondents depends on their own and rented in land. Following the discussion with some of the respondents it was also observed that most of the farmers had enough land for agricultural activities but the climate was not conducive for them to use all of what they have instead they had to use some of theirs and rent some other plots which are near water availability.

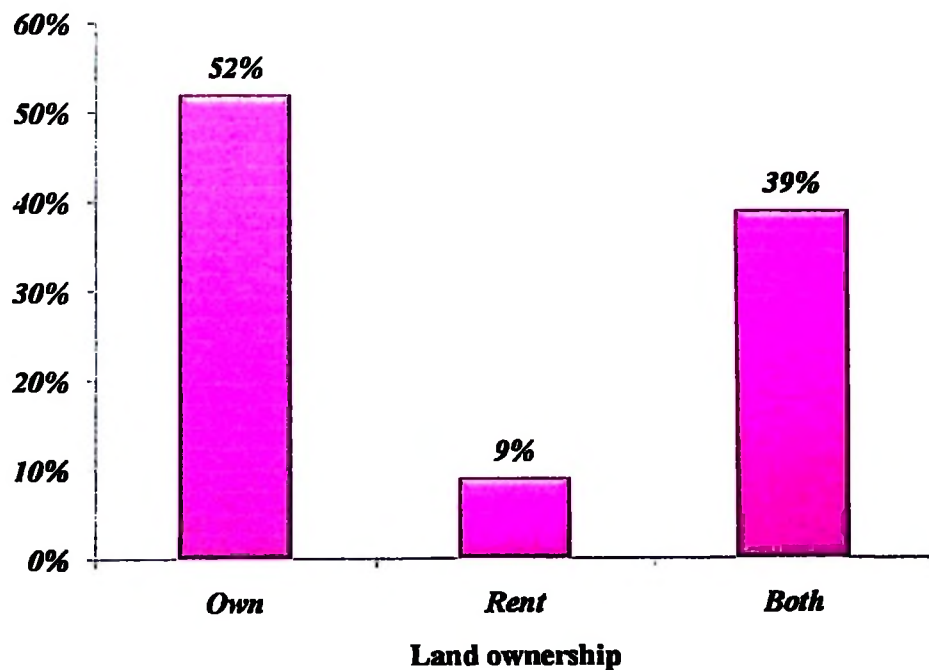


Figure 3: Respondents land ownership in Meatu and Iramba Districts

4.1.12 Major income sources

The findings in Table 12 shows that majority (64%) of the respondents had both crop production and livestock keeping as their main source of income followed by crop production (34%).

Table 12: Household major income sources

Major Income sources	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Crop Production	25	37.3	9	27.3	34	34.0
Livestock Keeping	2	3.0	0	0.0	2	2.0
Both Crop and Livestock	40	59.7	24	72.7	64	64.0
Total	67	100.0	33	100.0	100	100.0

4.1.13 Household major off-farm sources of income

According to the Table 13, the study found that (67.2%) of the respondents in Meatu Districts depends much on wages as their off-farm source of income and (54.5%) of the respondents depends much on business as their major off-farm source of income in Iramba District. However, the findings show that (56%) of the all the respondents in both districts depends much on wages that comes from casual work of other farmer's farms as their main off-farm income source.

Table 13: Household major off-farm sources of income

Major Off-farm Sources	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Business	26	38.8	18	54.5	44	44
Income from land rent	33	49.3	5	15.2	38	38
Wages	45	67.2	11	33.3	56	56
Salary from employment	2	3.0	4	12.1	6	6
Artisan work	4	6.0	3	9.1	7	7
Total	>67	>100	>33	>100	>100	>100

*The frequencies and percentage of respondent exceed 67, 33 and 100% respectively because some of the respondents had more than one off-farm income sources.

4.1.14 Descriptive measure of household income distribution

Table 14 presents the descriptive measures of household income distributions from major sources of income. The findings show that the mean income (TZA 1 205 771) from crop production is greater compared to that of livestock (TZA 906 016) and the mean income from total off-farm income (TZA 261739). However crop production has been proved to

generate huge amount of income (TZA 4 968 000) followed by livestock (TZA 3 850 000) and off-farm (TZA 1 000 000), while the minimum income observed from the off-farm income (TZA 20 000) was the lowest income compared to those from livestock (TZA 30 000) and crop production (TZA 73 000). The deviation from mean income within the farmers was found to be greater to those who participate in crop production compared to those who participate in livestock keeping and in off-farm activities.

Table 14: Descriptive of household income

Measures	Sources of income		
	Crop production	Livestock keeping	Off-farm income
Mean	1205771	906016	261739
Standard Deviation	958730	676397	240195
Median	907600	620000	200000
Maximum	4968000	3850000	1000000
Minimum	73000	30000	20000
Frequency (n)	98	64	88
Total	100	100	100

4.1.15 Contribution of major sources of farmer's income to total household income

The results presented in (Table 15) and (Fig. 4) present the contribution of major sources of farmer's income to household total income. The findings indicated that salary from employment has been ranked first, contributing (33%) to the total household income while crop production which is the main activity in the study area was ranked second, contributing (27%) to the total household income. This was due to the fact that salary from employment is not affected by the extent of climatic changes while crop production is very vulnerable to any climatic change. Livestock keeping was ranked third; contributing (21%) to the total household income for it is also very vulnerable to any climatic change, followed by small business which was fourthly ranked contributing only

(7%) to the total household total income, this was due to the fact that most of the farmers depend much on crop production in order to have enough income as far as climate change is concerned their purchasing power decreased which affected the small businesses men and women. Income from land renting, wages and artisan work was fifthly, sixthly and seventhly ranked respectively while contributing only (6%), (4%) and (2%) in the household total income respectively.

Table 15: Contribution of major sources of farmer's income to total household income

Source of income	Frequency (n)	Average amount earned per year (TZS)	Contribution to total income (%)
Salary from Employment	6	1440000	33
Crop Production	98	1205771	27
Livestock Keeping	64	906016	21
Business	44	324000	7
Income from Land rent	38	279872	6
Wages	56	180000	4
Artisan work	7	81333	2
Total	>100	4416992	100

*The frequencies exceed 100% because some of the respondents had more than one off-farm income sources.

4.2 Characteristics of Climate Risks

4.2.1 Climate change situation in the study area

Prior before identifying the associated climatic risks which affected farmers the study seek to understand if farmers perceived that, were any climatic changes in the study area. Majority (100%) of the respondents accepted that there was a change in climatic condition compared to the previous time. Respondents argued that temperature is highly increasing while rainfall is decreasing. Again all respondents (100%) reported that they were affected with those climatic changes.

4.2.2 Biophysical climate related risks - temperature and rainfall

4.2.2.1 Rainfall trend in Meatu and Iramba districts since 2000 – 2012

Figure 4 presents an annual rainfall trend of Meatu and Iramba Districts of over 10 years ago. Rainfall has been decreasing as time goes in both districts, Meatu and Iramba. For example in the year 2001, Meatu District received an annual rainfall of about 879 mm while Iramba received 899 mm of rainfall, after 11 years i.e. 2012, the amount of rainfall decreased from 879 mm to 355 mm in Meatu District and from 899 mm to 499 mm in Iramba District, proving a decrease of 524 mm in Meatu District and 400 mm in Iramba District. This proves that the rate of annual rainfall in the studied area has been decreasing in conformity to local perceptions. Moreover, the trend shows that Meatu District always receives a minimum annual rainfall per year compared to Iramba District. This shows that farmers in Meatu District are more exposed to rainfall related climate change risks compared to Iramba Districts.

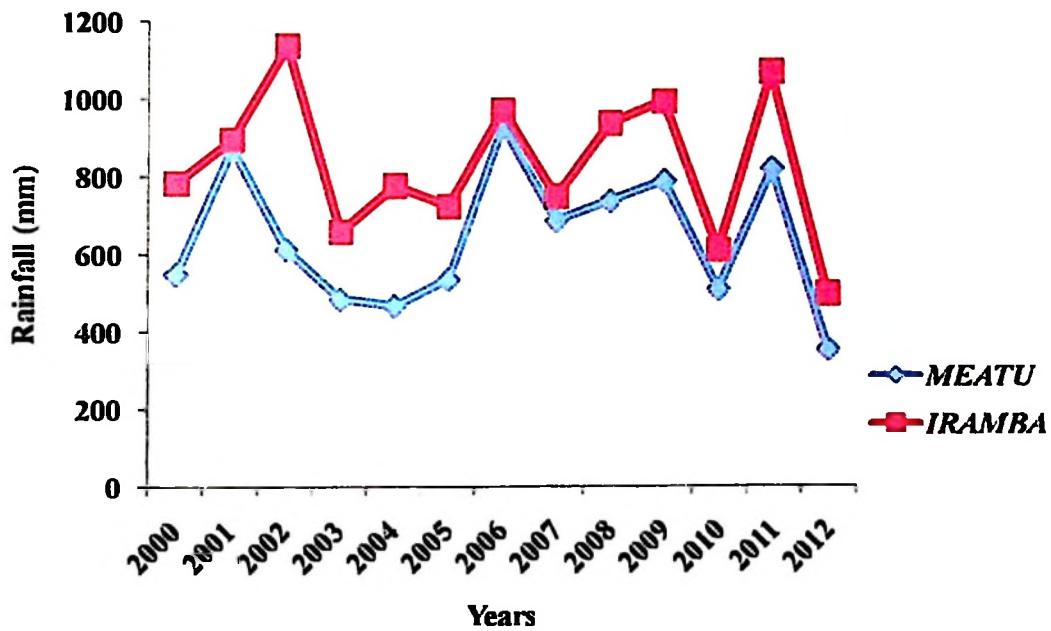


Figure 5: Rainfall trend in Meatu and Iramba districts since 2000 – 2012

4.2.2.2 Average temperature trend of Meatu and Iramba Districts since 2000 – 2012

As it is observed in figure 6 in the year 2000 a minimum temperature in Meatu and Iramba was 18°C and 15°C respectively as time goes in the year 2012 both minimum temperatures increased by 1°C, i.e. 19°C and 16°C respectively. Similarly in the year 2000 the maximum temperature in Meatu and Iramba Districts was 30°C and 26°C respectively, after 12 years (i.e. 2012) both maximum temperature increased one by 1°C and that of Iramba increased by 2°C reaching to 31°C by 28°C respectively, proving that temperature has been increasing in the study area. However, the trend shows that Meatu District is always characterized by high temperature (31°C) compared to that of Iramba District (28°C) leaving most of the farmers in Meatu Districts potentially vulnerable to climatic changes compared to those living in Iramba Districts in some ways.

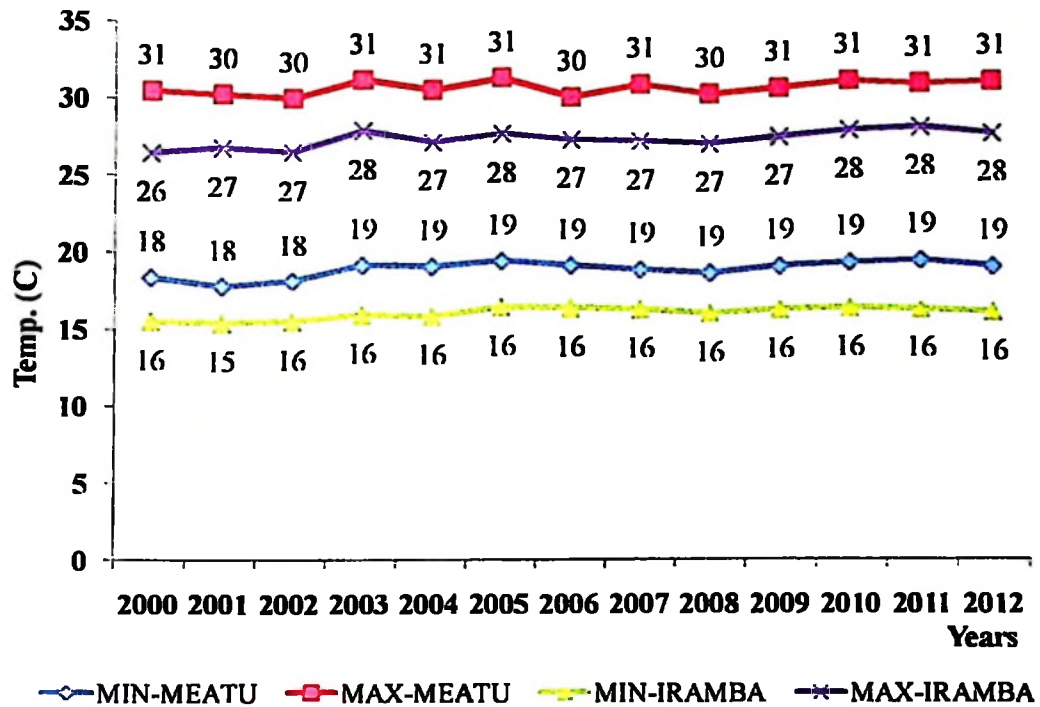


Figure 6: Average temperature trend of Meatu and Iramba districts since 2000 – 2012

4.2.3 Climate related risks

4.2.3.1 Rainfall - production trend from 2000 to 2012

Figure 7 shows that maize and sorghum production trend is positively affected by rainfall changes while as rainfall tend to increase cotton production tend to decrease, which is different for maize and sorghum production.

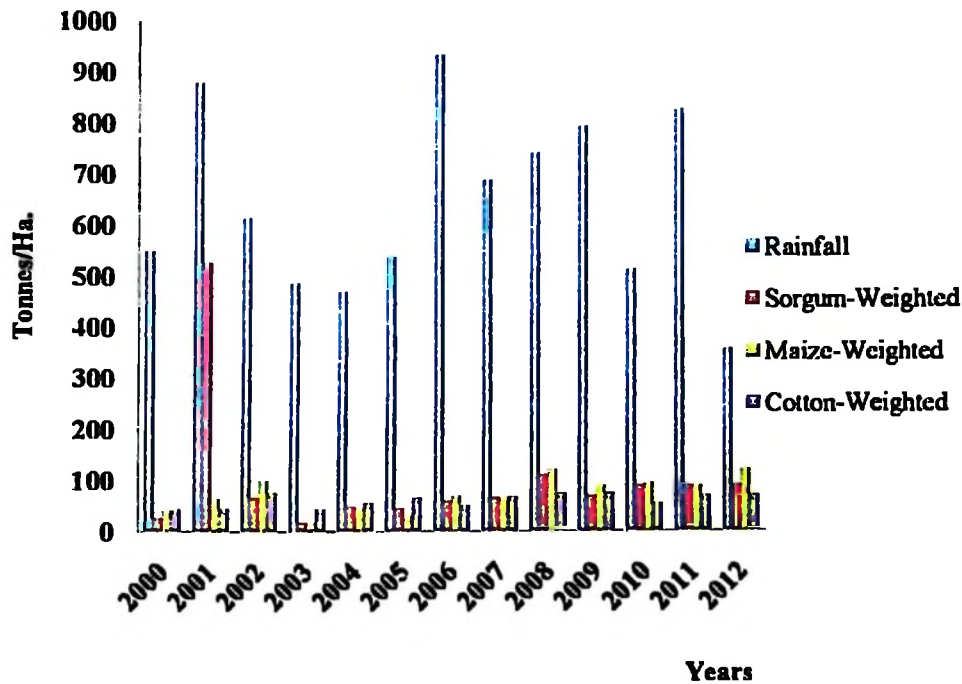


Figure 6: Rainfall - Production trend of Meatu and Iramba districts from 2000 to 2012

4.2.3.2 Temperature – Production trend

Figure 7 shows that the average temperature over the past 10 years was almost the same, and where there was a change it was only for 1°C in some two or three years. The relationship shows that in all most all the crops as the average temperature tend to increase production tend to decrease in tonnes/ha and vise versa is true.

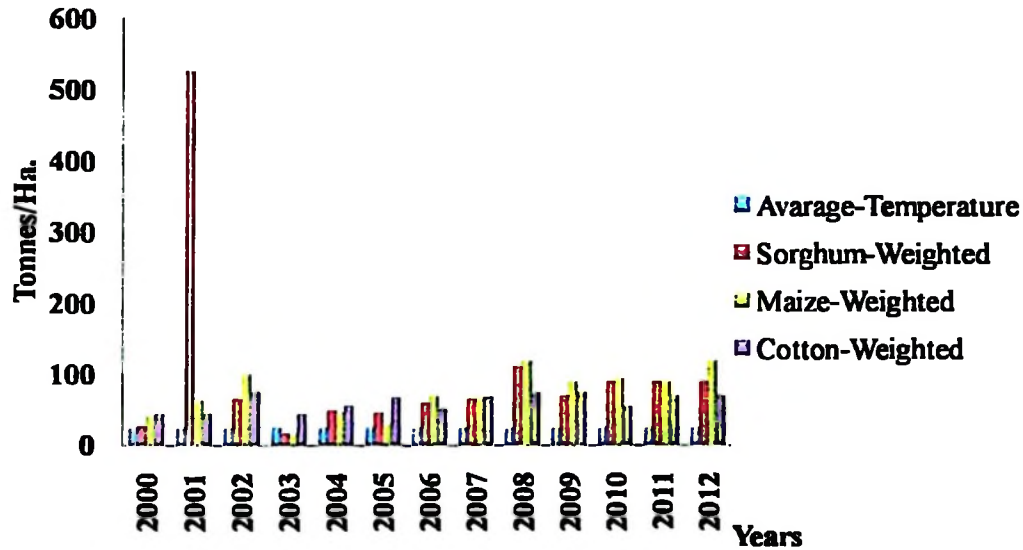


Figure 7: Average Temperature - Production trend of Meatu and Iramba districts from 2000 to 2012

4.2.4 Effect of different major climatic risks in different major income sources

4.2.4.1 Effect in crop production (farmers)

Table 16 shows that climatic risk in both Meatu and Iramba farmers was associated with poor harvest which was mentioned (98%) of all the respondents followed by increase in drought (89%) of all the respondents, followed by increase in hunger (80%), increase in crop disease (52%) and price fluctuation of crops (49%). This implies that climate risks have a greater impact on crop production which seems to be accelerated by the increase of drought. Following the discussion with farmers in both districts it was revealed that as drought increases the amount of crops to be harvested decreases also which lead to hunger. Considering crops as their major source of income generation, as the harvest decreases their income is likely to decrease also hence this affects their income generating power or decreases it at all.

4.2.4.2 Effect in livestock keepers

A number of associated climatic risks affecting in both Meatu and Iramba livestock keepers were mentioned, some of which were looking similar to those of crop producers as per (Table 16). The study revealed main climatic change associated risk was steady decrease in pastures which was mentioned by (64%) of all the respondents, followed by steady decrease in livestock selling price (43%), increase in livestock disease (36%), increase in number of livestock death (32%) and decrease in livestock health (27%) of all the respondents respectively. Following the discussion with the livestock keepers also they argued that as climate changes pastures do decrease which lead to poor health of their animal which lead to cheap prices when selling their livestock hence reducing their income.

4.2.4.3 Effect on off farm sources and income per se

The findings in (Table 16) indicate that majority of the farmer's income (100%) adversely decreased leaving them in a very poor condition. While only (3%) of all the respondents accepted that climate change had an impact on the off-farm sources compared to farming activities. This implies that off- farm sources are not highly affected by climate changes.

This empirical evidence leads to the rejection of the hypothesis that assumed that the effect of climate risk associated with the different sources of farm income is the same within the sources, following the results it has been clearly proved that each income source of a farmer differently affected by climatic risk.

Table 16: Climate risks affecting different income sources

Climate risks	District					
	Mcatu		Iramba		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
<i>Crop-production</i>						
Very poor harvest	65	97	33	100	98	98
Increase in drought	60	89.6	29	87.9	89	89
Increase in crop disease	27	40.3	25	75.8	52	52
Increase in hunger	57	85.1	23	69.7	80	80
Crop and food price fluctuation	34	50.7	15	45.5	49	49
<i>Livestock</i>						
Steady decrease in pasture	40	59.7	24	72.7	64	64
Increase in livestock disease	20	29.9	16	48.5	36	36
Decrease in livestock health	15	22.4	12	36.4	27	27
Increase in no. of death of livestock	20	29.9	12	36.4	32	32
Steady decrease in livestock selling price	27	40.3	16	48.5	43	43
<i>Off-Farm</i>						
Abnormal local alcohol fermentation	0	0	3	9.1	3	3
High and adverse decrease in income	67	100	33	100	100	100
Total	>67	>100	>33	>100	>100	>100

*The frequencies and percentage of respondent exceed 67, 33 and 100% respectively because some of the respondents mentioned more than one effect.

4.2.3.4 Extent of climate risks affecting different income sources

The study assessed the extent to which the major climatic risk affected the major income generating sources and respondents were required to rank the extent from very much, much to not much then the results were presented in (Table 17), the findings show that (100%) of the respondents ranked very much for drought and (90%) for disease while majority (76%) of the respondents ranked not much for flood. Hence drought and disease was revealed to be the most climatic risk which had a greater impact in the major sources of farmer's income sources compared to flood. This implies that as drought and disease increases farmer's income will decrease and vice versa. This has been proven in (Table 16) where it was seen that as drought increases there were poor harvest and decrease in pastures which eventually lead to decrease in farmers' income.

Table 17: Extent of Climate risks affecting different income sources

Climate Risk	Response	District					
		Meatu		Iramba		Total	
		Frequency	Percent	Frequency	Percent	Frequency	Percent
Drought	Very much	67	100	33	100	100	100
	Total	67	100	33	100	100	100
Flood	Very much	0	0.0	2	6.1	2	2.0
	Much	2	2.9	20	60.6	22	22.0
	Not much	65	97.0	11	33.3	76	76.0
	Total	67	100	33	100	100	100
Disease	Very much	63	94.0	27	81.8	90	90.0
	Much	4	6.0	5	15.2	9	9.0
	Not much	0	0.0	1	3.0	1	1.0
	Total	67	100	33	100	100	100

4.3 Evaluation of Farmer's Resilience to Climate

Multi-criteria/multiple indicator analysis was used to evaluate the resilience of farmers over climatic changes and its risk associated. Where information (different farmer's income from different sources, size of the land, land ownership etc) were calculated accordingly and the results were summarized in (Table 18), the table shows that majority (91%) of all the respondents from Meatu and Iramba Districts falls under the category of (5 – 8) scores while (4%) and (5%) of all the respondents from both districts falls under the category of (0 – 4) and (9 -12) scores respectively. Following the analysis that a household falling under (0 – 4) scores is classified as low risk category, (5 – 8) as moderate risk category and (9 - 12) as high risk category; whoever falls under low risk category (0 - 4) seem to be resilient to climatic change risks compared to those who falls under moderate (5 - 8) and high (9 - 12) risk category), according to the results i.e. (91%) of all the respondents from Meatu and Iramba Districts falls under moderate risk category (5 – 8), this imply that majority (91%) of the respondents in both districts are not resilient to climatic risks/threats while only (4%) of all the respondents seem to be resilient to climatic risks/threats for they lie under low risk category (0 – 4). This empirical

evidence leads to the rejection of the hypothesis that assumed that smallholders farmer are resilient to climate risks, following the results it has been clearly proved that smallholder farmers are not resilient to climatic risk.

Table 18: Climate risk resilience percentages

Resilience Categories	District				Total	
	Meatu		Iramba		Frequency	Percent
	Frequency	Percent	Frequency	Percent		
Low risk	3	4.5	1	3.0	4	4.0
Medium risk	61	91.0	30	91.0	91	91.0
High risk	3	4.5	2	6.0	5	5.0
<i>Total</i>	67	100	33	100	100	100

4.4 Results of the Distributed Lag Model Analysis

The results in Table 20 shows that the F-values for maize, sorghum and cotton production for all the explanatory variables were proven statistically significant at 1%, ($p < 0.01$) in explaining the variation of maize, sorghum and cotton production trend respectively.

Adjusted R^2 was found to be 57%, 49% and 50% for maize, sorghum and cotton production trend respectively. This indicates that the explanatory variable (i.e. rainfall) explains about 57%, 49% and 50% of the variation in production of maize, sorghum and cotton respectively, while 43%, 51% and 50% of the variation in production of maize, sorghum and cotton was explained by the other explanatory variables which were not included in the model.

Following the results of adjusted R^2 , it was clearly shown that rainfall contributes much on maize production (57%), compared to cotton (50%) and sorghum production (49%) because sorghum and cotton are somehow resistant to drought compared to maize.

The results in Table 19 show the variable, coefficients, SE, T-statistics, p-values and VIF of all the three models for maize, sorghum and cotton production trend. The result shows that the coefficient of intercept for maize, sorghum and cotton production trend is 0.88, 1.09 and 0.94 respectively, this imply that when all the explanatory variable (i.e. lagged rainfall) is equal to zero, the average value for maize, sorghum and cotton production will be equal to 0.88 tonnes/ha, 1.09 tonnes/ha and 0.94 tonnes/ha attributed by other factors respectively.

Also, according to the result in the same Table 19, at most all of the three lags had an effect on maize, sorghum and cotton production trend, but only two lags were statistically significant in maize and sorghum production trend model (i.e. first and second lags of the maize production trend model and first and third lags of the sorghum trend model) while only one lag was statistically significant in cotton production (i.e. first lag) out of all the three lags.

4.5 Test for Presence of Multicollinearity

To investigate multicollinearity the Variance Inflation Factor (VIF) was used. Variance Inflation Factor is a measure of multicollinearity based upon regressing one of the independent variables on all of the remaining independent variables (Halcoussis, 2005). It is also argued that a VIF greater than 5 indicates a serious multicollinearity problem. One point to note is that if the R^2 from regressing one dependent variable on other independent variables is greater than 0.75 the VIF will be greater than 5 (Koops, 2009). From the results in (Table 20) it could be seen that there is no any element of multicollinearity between time trends because the VIF of all the explanatory variables is less than 5, (i.e. 1.037, 1.010 and 1.008 respectively to all the lags) and the R^2 of all the

models are less than 0.75, (i.e. 0.57, 0.49 and 0.50 respectively to all the models); hence there is no multicollinearity between the trends.

Table 19: Distributed Lag Model-Results

<i>Crops</i>	<i>Variable</i>	<i>Coefficient</i>	<i>Std. Error (SE)</i>	<i>T-Statistics</i>	<i>P-Value (Sig.)</i>	<i>VIF</i>
<i>Maize</i>	Constant	0.88	237	1.471	0.153	
	Lagged R1	(36.569)***	2.359	5.751	0.000	1.037
	Lagged R2	(-13.077)*	2.382	-2.049	0.051	1.010
	Lagged R3	-3.676	2.362	-0.578	0.568	1.008
<i>Sorghum</i>	Constant	1.09	5268	0.734	0.469	
	Lagged R1	(-58.8)***	5.678	-2.844	0.009	1.037
	Lagged R2	-11.603	5.753	-0.559	0.581	1.010
	Lagged R3	(83)***	5.687	4.012	0.000	1.008
<i>Cotton</i>	Constant	(0.94)***	198	4.510	0.000	
	Lagged R1	(-28.7454)***	0.987	-5.650	0.000	1.037
	Lagged R2	-2.554	1.106	-0.500	0.621	1.010
	Lagged R3	-5.840	1.090	-1.147	0.262	1.008

Dependent variable: Maize, Sorghum and Cotton output (*Tonnes/ha.*)

***, **, *: Significance at 1%, 5% and 10% respectively.

Table 20: Distributed Lag Model-Results

<i>Model</i>	<i>Maize</i>	<i>Sorghum</i>	<i>Cotton</i>
Multiple R	0.762	0.731	0.741
R-Square	0.613	0.539	0.554
Adjusted R-Square	0.568	0.485	0.502
F-Statistics	(6.511)***	(3.258)***	(3.651)***
Durbin-Watson	1.358	1.984	1.210
Observations	29	29	29

***, **, *: Significance at 1%, 5% and 10% respectively for F-Statistics

4.6 Gender analysis: Control and Access

4.6.1 Land ownership

Findings in (Table 21) indicate that men had higher (96%) control and access to land in both districts, Meatu and Iramba than other groups/member of the household. This was supported by the discussion made in during the FGD where by majority of women argued that it were only men who are the main controller of the land and not women.

4.6.2 Production asset ownership

The findings in Table 21 show that majority (78%) of the respondents from Meatu Districts argued that men have higher control in any family production assets compared to women in the family unlike the sample from Iramba Districts whom majority (61%) argued that both men and women have equal right and control to any family production assets compared to that of Meatu District.

4.6.3 Accrued benefits

As far as profit is concerned the study seeks to understand who have control access to any liquidity benefit or profit obtained in the family. The findings in Table 21 show that most (84%) of the respondents from Meatu Districts pointed men as the one who have higher control to any family profit or benefit obtained compared to women while (58%) of the respondents from Iramba Districts said both men and women have the same control in any liquidity profit or benefit obtained in the family.

4.6.4 Total income obtained

The findings in the Table 21 showed that all of the respondents (100%) from both districts, the income obtained is accessed and used by the family.

Table 21: Gender analysis: Control and Access (n=100)

Activities	Response	Meatu		District Iramba		Total	
		Freq.	Percent	Freq.	Percent	Freq.	Percent
Land ownership	Men	67	100	29	88	96	96
	Women	0	0	3	9	3	3
	Both	0	0	1	3	1	1
	Total	67	100	33	100	100	100
Farming activities	Men	2	3	0	0	2	2
	Both	65	97	33	100	98	98
	Total	67	100	33	100	100	100
Cost of production	Men	55	82	13	39	68	68
	Women	0	0	3	9	3	3
	Both	12	18	17	52	29	29
	Total	67	100	33	100	100	100
Production Asset	Men	52	78	9	27	61	61
	Women	0	0	3	9	3	3
	Both	8	12	20	61	28	28
	Family	7	10	1	3	8	8
	Total	67	100	33	100	100	100
Accrued benefit	Men	56	84	10	30	66	66
	Women	0	0	4	12	4	4
	Both	7	10	19	58	26	26
	Family	4	6	0	0	4	4
	Total	67	100	33	100	100	100
Total Income obtained	Family	67	100	33	100	100	100
	Total	67	100	33	100	100	100

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study assessed the economics of farmer's climate related production risks and resilience in the semi - arid areas of Meatu and Iramba Districts of Tanzania. The specific objectives of the study were: (i) to characterize climate risks associated with different source of farmer's income (ii) to evaluate climate risk resilience of smallholder farmers from major income subsectors and (iii) to determine the effect of climate change on farm income from major crops. In evaluating the economics of climate related production risks in the semi - arid areas a cross-section research design was adopted, primary data were collected using questionnaires administered to 100 smallholder farmers and FGD's with few smallholder farmers randomly selected from the study areas. The time series data of climatic variables from 1984-2012 were also used. The data were analyzed using descriptive statistic, multi-criteria approach (MCA) and regression analysis (DLM) respectively to the specific objectives whereby, the results were presented and discussed on the previous chapter. Basing on the findings presented and discussed in previous chapter, a number of conclusions and recommendations can be reached. Therefore; this chapter briefly highlights these conclusions and recommendations basing on the major findings of the study.

Climate risks associated with different source of farmer's income: It was assumed that the characteristics of climate risk associates with different sources of farmer's income are the same within the sources. The findings of the study have shown that crop production has been affected much by drought (98%) from climatic risks compared to livestock which were much affected by lack of pastures (64%) and other sources of

income (43%). This finding indicates that climate risks behave and farmers are affected differently for different sources of income.

Climate risk resilience of smallholder farmers in both districts: The study hypothesized that Smallholders farmer are resilient to climate risks Contrary to the stated hypothesis, smallholder farmers and their sources of incomes was found to be less resilient to climate risks, for only 4% of the farmers were in the low risk category while majority (91%) of the farmer were at a medium risk category and 5% at a high risk category leaving more farmers less resilient to climate risks. Therefore the null hypothesis that stated smallholders farmers are resilient to climate risks is rejected.

Effect of climate change on farm income from major crops: Basing on the hypothesis that stated climate change has no significant effect on farmer's income, the findings of the study indicate that climate change has a big effect on farmers income for most of the farmers depends on crop production and it was indicated that rainfall was the main problem that affects the farmers sources of income compared to any other climatic variable, hence affect their income. Furthermore rainfall was proved significant at 1% ($p < 0.01$) to all the major crops grown in the study area and had a serious impact on it. Maize was found to be affected much by climate change compared to cotton and sorghum by producing 0.88, 1.09 and 0.94 tonnes/ha respectively with the changes of climate. These evidences are contrary to the null hypothesis that climate change has no significant effect on farmer's income. Therefore this null hypothesis is rejected at 1% level of significance.

5.2 Recommendations

- i. The results of this study have confirmed the importance of climate for crop revenue and the need to take actions to develop new adaptations and promoting better knowledge of climate change. The climate risks and constraints noted by farmers must be considered as a constant to be used by the concerned bodies (Government, NGOs, etc.) because the Tanzanian economy is strongly influenced by the agricultural sector, which is affected by climate. The concerned bodies (Government, NGOs, etc.) should also integrate the strategies which will eventually be adopted by farmers to help in the improvement of the sector. The prevailing high percentage of households (96%) being not resilient to major climatic risks also testifies the importance of creating a strong system of information and sensitization to help farmers adapt to climatic risks so as to increase their income earning and attain a sustainable livelihood.

- ii. The study found that crop production has been affected much by drought from climatic risks compared to livestock and other off-farm sources leading in reduction of farmers income in the study area, then these results suggests that farm income for farmers can be improved by improving the crop farming systems. It is therefore recommended that deliberate efforts should be made by the government and other agricultural stakeholders to promote and improve the performance of crop productions by providing good agronomic practice which do relates with the current – future climate changes, drought resistant crop varieties and provision of education and trainings on how to deal with climate changes which in turn they will increase the productivity and markets of such produces, hence the farm income can be increased beside any climatic changes or risks.

- iii. It was also found that most (96%) of the farmers were less resilient to climatic risks, this was due to much dependence on crop production and livestock keeping which were the most affected sources of income by climate changes. Therefore it is recommended that the government and other stakeholders should take deliberate efforts by enhancing crop production and controlling crop and livestock diseases by improving extension services and land use planning. By implementing subsidy in both crops and livestock inputs and extension services crop production and livestock keeping farm productivity and return can be improved.
- iv. The government should also intervene and regulate the price situation by providing a sustainable market infrastructures and market information on both crop and livestock farming in order to increase the farm income and the general livelihoods of the farmers Not only that but also farmers should be encouraged and facilitated to engage on off-farm activities for these are not highly affected by climate changes or risks.
- v. The study also found that maize was highly affected by climate changes compared to sorghum and cotton, then this results provide an insight that all these crops are necessary in the study are for sustainable food security and household incomes. Therefore it is recommended that the government and all other agricultural stakeholders to provide a more drought resistible maize seed variety which will help farmers to increase their maize productivity despite the existing climatic situation and be able to produce more for consumption and for trading. The study recommends also more resistible sorghum and cotton seed variety to be supplied to the farmers for increasing their produce which helps in improving their sustainability.

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APPENDICES

Appendix 1: Household Questionnaire

A questionnaire to be administered to farmers (households) under a title, titled
'ECONOMIC IMPACT OF CLIMATE CHANGE ON INCOME PORTFOLIOS OF
SMALLHOLDER FARMERS'

INTRODUCTION

Dear household head:

My name is Revocatus Kayaga Ntengo, undertaking master degree on agricultural Economics at Sokoine University of Agriculture. While doing my master's thesis, your household has been randomly selected so as to provide data that could be used to determine the economic impact of climate change on smallholder farmers' income portfolios at your village. All the information you will provide will be for academic purpose and confidential. Thus I appreciate your cooperation to give me your time and truthful response for the success of the study/project. With humbly thanks.

A: General Information

1. Name of interviewer
2. Date of interview.....
3. Questionnaire number.....
4. Name of village....., Hamlet.....Ward.....
Division.....District.....

B: Household Characteristics

5. Name of household.....
6. Age (in years)
7. Gender/Sex..... (1). Male, (2). Female
8. Marital status..... (1). Married, (2). Single, (3). Divorced, (4). Widow,
(5). Other specify.
9. Education level..... (1). Primary, (2). Secondary, (3). Diploma, (4). Higher
education, (6). None

10. Main activities of household.....(1). Crop production, (2). Livestock keeping, (3). Both Crop and livestock production, (4). Others mention.....

11. Do you have children? Yes/no If yes, how many

C: Descriptive

To characterize climate risks associated with different source of farm income

12. What are your sources of income?

NO.	Income sources	Tick
1	Crop production	
2	Livestock keeping	
Off-farm sources		
3	Business	
4	Wages and salary	
5	pensions	
6	Income from renting land	
7	Remittances	
8	Salary from employment	
90	Artisan works	
Other sources, (mention)		
10		
11		
12		

13. What types of crops do you grow?

1= rice []

2= maize []

3= sorghum []

4=sweet potatoes []

5=cotton []

6= others, mention;

14. What types of livestock do you keep?

1= Cows []

2= Goats []

3= Chicken []

4= duck []

5= Pigs []

6= Sheep []

7= others, mention;

15. Was there any climate change ever happen in your village?

1= Yes []

2= No []

16. If yes how do you characterize the climatic condition of this area in terms of its temperature and rainfall?

1= Increasing temperature and rainfall []

2= Decreasing temperature and rainfall []

4= Temperature increase and rainfall decrease []

5= Temperature decrease and rainfall increase []

17. Have you ever faced any climate related impact in your life time? If yes, what type of climatic risks?

<i>Income sources</i>	<i>Associated Climate risks</i>
Crop production	
Livestock keeping	
Off-farm sources	
Others, (mentioned above)	

18. At what extent are these climate risks affected your income earnings;

Climate risks	Extent of effect on income		
	Not much	Much	Very much
Drought			
Flood			
Diseases			
Decrease in crop yield			

D: Mca; Crop and Livestock Production Activity:

To evaluate the climate risk resilience of major farm income subsectors and to determine the effect of climate change on farm income from different sources

Income from crop production

19. Do you own or rent land for farming purpose

1=own []

2=rent []

3=both []

20. Land ownership and usage

Land owned (acre)	land rent (acre)	Total amount of land (acre)	Land used (acre)

20. For how long have you been involving in crop cultivation?

1= Less than 5 years, []

2= 5 to 10 years []

3= More than 10 years []

21. Various crops grown, their total yield, prices, inputs and its input prices.

<i>Variables</i>	Crops							
	<i>Maize</i>	<i>Millet</i>	<i>Cotton</i>	<i>Rice</i>	<i>Sorghum</i>	<i>G/nuts</i>	<i>S/potatoes</i>	<i>Others</i>
Area / land (ha)								
Total output (kg/ha)								
Price per unit (Tshs/kg)								
Amount sold (kg)								
Amount consumed (kg)								
Amount stored (kg)								
TR								
Production costs								
Quantity of input used (kg or Lt)								
Price of input used (Tshs/kg or Lt)								
Total amount of labour (Hrs/day)								
Wage rate which is the same to all (Tshs/man/dy)								
TC								

Income from livestock keeping:

22. For how long have you been raising livestock?

- 1= Less than 5 years, []
- 2= 5 to 10 years []
- 3= More than 10 years []

23. Why do you keep livestock?

1= For commercial []

2= For domestic purpose []

3= Both above []

<i>Enterprises</i>	<i>Amount of livestock owned</i>	<i>Type of produce</i>	<i>Amount produced (Specify units)</i>	<i>Amount sold (Specify units)</i>	<i>Selling price per unit (Specify units e.g. Shs/litre)</i>	<i>Amount consumed</i>
Cattle		Milk				
		Live animals				
		Meat				
		Skins				
		Manure				
Goats		Live animals				
		Meat				
		Milk (if dairy goat)				
		Skins				
		Manure				
Sheep		Live animals				
		Meat				
		Skins				
		Manure				
Pigs		Live animals				
		Meat				
		Manure				
Poultry (Layers, broilers, local chicken)		Eggs				
		Live birds				
		Others (Specify)				

24. Working space for variable inputs incurred in managing livestock enterprises per year

<i>Type</i>	<i>Input name</i>	<i>Quantity used X</i>	<i>Price per unit Px</i>	<i>cost per unit C= XPx</i>	<i>Total for each livestock type TC= CN</i>
<i>cattle</i>					
<i>Goats</i>					
<i>Sheep</i>					
<i>Pigs</i>					
<i>poultry</i>					

E: Income from Off-farm activities

25. How much money does your household earn from the following income sources on a monthly basis?

Source of income	Amount earned per month (Tshs)
Business(Gross income- costs)	
Wages and salary	
pensions	
Income from renting land	
Remittances	
Salary from employment	
Artisan works	
Transfer payments	
<i>Other sources</i>	
<i>Total</i>	

F: Saving and Expenditure

26. How much income do you save and spend?

<i>Variables</i>	<i>Amount in % from the total income earned</i>
Saving (in %)	
Expenditure (in %)	
Total amount (S + EX)	

THANK YOU VERY MUCH FOR YOUR TIME AND CO-OPERATION

Appendix 2: Focus group discussion; Checklist for focus group discussion

1. What do you understand by the term climate change?
2. Is there any change that has occurred currently compared to previous time or years?
3. What are the risks associated with climate change?
4. What were your sources of income in general before the today's climate change?
5. What were your main sources of income before the today's climate changes? Have they affected by it? (To be categorized per % it contribute)
6. If yes, how does these income sources affected by climate change currently, compared to 10 to 15 years back? i.e. crop cultivation, livestock etc, (prices and yields should be identified).
7. Does climate change affect your income in general? If yes how?
8. What are the alternative sources of income since climate change started?
9. How do you compare your current income earning and that of 10 to 15 years before? If not the same, how and at what extent?
10. What are the climate risks that are associated with those sources of income and income? How?
11. Does the current income source provide enough income as far as climate change is concerned?
12. If no, why and how?
13. What ways do you take to solve the problem?

THANK YOU VERY MUCH FOR YOUR TIME AND CO-OPERATION