INDIRA GANDHI NATIONAL OPEN UNIVERSITY

SCHOOL OF CONTINUING EDUCATION

ANALYSIS OF THE IMPACT OF CLIMATE CHANGE ON SMALLHOLDER FARMERS AGRICULTURAL PRODUCTION: THE CASE OF MAOKOMO SPECIAL WOREDA OF BENISHANGUL GUMUZ REGION, NORTH WESTERN ETHIOPIA.

BY

SOLOMON WOLDETSADIK

ID1115893

OCTOBER 2015

ADDIS ABABA, ETHIOPIA

ANALYSIS OF IMPACT OF CLIMATE CHANGE ON SMALLHOLDER FARMERS AGRICULTURAL PRODUCTION: THE CASE OF MAOKOMO SPECIAL WOREDA OF BENISHANGUL GUMUZ REGION, NORTH WESTERN ETHIOPIA

A THESIS SUBMITTED TO INDIRA GANDHI NATIONAL OPEN UNIVERSITY, SCHOOL OF CONTINUING EDUCATION (IGNOU), DEPARTMENT OF RURAL DEVELOPMENT IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE MASTER OF ARTS IN RURAL DEVELOPMENT (MARD)

BY

SOLOMON WOLDETSADIK

ID1115893

OCTOBER, 2015

ADDIS ABABA, ETHIOPIA

DECLARATION

I hereby declare that this thesis which is entitled as **"ANALYSIS OF IMPACT OF CLIMATE CHANGE ON SMALLHOLDER FARMERS AGRICULTURAL PRODUCTION: THE CASE OF MAOKOMO SPECIAL WOREDA OF BENISHANGUL GUMUZ REGION, NORTH WESTERN ETHIOPIA"** submitted for partial fulfilment of the requirements for the Masters of Arts in Rural Development to Indira Gandhi National Open University, (IGNOU) is the original work done by me under the supervision of Dr. Wondimagegne Chekol and this thesis has not been published or submitted elsewhere for the requirement of any course of study to the best of my knowledge and belief. Materials or ideas of other authors used in this thesis have been duly acknowledged and references are listed at the end of the main text.

PLACE: ADDIS ABABA, ETHIOPIA SIGNATURE_____

DATE: _____ ENROLMENT NO. ID1115893

NAME: Solomon Woldetsadik

ADDRESS: e-mail: solomonehte@yahoo.com

Telephone: +251 911631481

CERTIFICATE

This is to certify that, Solomon Woldetsadik, a student of Master of Arts in Rural Development from Indira Gandhi National Open University, was working under my supervision and guidance for his project work for the course of MRDP 001. His project is entitled "**ANALYSIS OF IMPACT OF CLIMATE CHANGE ON SMALLHOLDER FARMERS AGRICULTURAL PRODUCTION. THE CASE OF MAOKOMO SPECIAL WOREDA OF BENISHANGUL GUMUZ REGION, NORTH WESTERN ETHIOPIA"** which he is submitting, is his genuine and original work.

Place_____ Signature _____

Date_____ Name:_____

Address of the supervisor: _____

_____

ACKNOWLEDGMENT

I would like to express my deep gratitude to my advisor Dr. Wondimagegne Checkol for his professional guidance, suggestions and encouragement starting from the design of research, during data collections and write up of this thesis.

I am also grateful to my colleagues Dr. Mandefro Aynalem and Mulugeta Worku for their professional, invaluable and critical comments and due concerns while I was conducting the research.

My research could not have been done had it not been for the full cooperation and help of farmers in Maokomo district and government sector officers in the project sites. They have been providing me their valuable help in organizing data collections and have been willing in sharing their life long experience and knowledge which significantly enabled me to conduct successful fieldworks.

I would like to extend my thanks to my organization, Christian Aid and its Country Managers, namely Yitna Tekaligne and Cathy Riley who helped me in advancing loan for my study, in facilitating data collection and in obtaining and accessing the necessary information to complete my work.

My special thanks and love to my family (my wife Birtukan Negash and my children Nathaniya and Eyosias) for their patience, love and endless encouragement during my study, to my parents, brothers and sisters for their inspiration and strong motivation to complete this study.

ACRONYMS

BGRS	Benishangul Gumuz Regional State
BoARD	Bureau of Agriculture and Rural Development
BoEPLAU	Bureau of Environment Protection and Land Use
BRAPA	BRACED Participatory Approach
BRACED	Building Resilience and Adaptation to Climate Extremes and Disasters
CIER	Centre for Indigenous Environmental Resources
CRGE	Climate Resilient Green Economy
CSA	Central Statistics Authority
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
FTC	Farmer Training Center
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GLCA	Global Leadership for Climate Action
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
LDCs	Least Developed Countries
MDGs	Millennium Development Goals

MoARD	Ministry of Agriculture and Rural Development
NAPA	National Adaptation Program of Action
NCCF	National Climate Change Forum
NGO	Non-Governmental Organization
NMSA	National Meteorological Service Agency
NRC	National Research Council
NSF	National Science Foundation
OCC	Office of Climate Change
PPM	Parts Per Million
PVCA	Participatory Vulnerability and Capacity Assessment
SPSS	Statistical Package for Social Science
UN	United Nations
UNCCD	United Nation Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
WHO	World Health Organization
WMO	World Meteorological Organization
WWF	World Wide Fund

ABSTRACT

Climate change is causing the greatest environmental, social and economic threats to all humankind and across borders in many nations. Perception about the cause, impacts and necessary response mechanisms to cope with the impact of climate calamities is important for any population in a given community. In view of this fact, this study assesses local smallholder farmers' perception, focusing mainly on insight of the local people on climate variability and change, its impact, their responses and barriers. The study also analysed rainfall and temperature variability and its impact on agricultural crop production and identifying the corresponding adaptation strategies employed by farmers in the study areas (two sub districts/kebeles namely Kokeb and Yaá/Yabaldigis) of Maokomo Special district found in South Western part of Benshangul Gumuz Region of Ethiopia. It relied on both qualitative and quantitative methods of data collection and analysis. The methodologies employed for primary data collection were Focus Group Discussions, interviews, observation and household survey. The study also used historically recorded rainfall and temperature data from 1979 to 2013. The analysis done on climate variability was triangulated against results from the perception of local communities about the changing climate of the area with reference to climate data from years 1979-2013.

The finding of the study showed that both maximum and minimum temperature had increased, rainfall pattern has been variable through time whereas annual rainfall had slightly decreased and showed inter annual variation. Local people perceived climate variability and change-induced hazards such as erratic rainfall, pests and disease, significant

forest fire, which have been negatively affecting their agricultural production, livelihood and environment. The most common adaptation options include: change in cropping pattern, growing short maturing crops, diversification of livelihood and rain water harvesting.

Key words: Climate variability and change; Perception; Temperature, Adaptation

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE: INTRODUCTION

1.1 Background

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) dispelled many uncertainties about climate change. It is now clear that global warming is mostly due to human induced emissions of greenhouse gases (mostly CO2). Over the last century, atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 parts per million to 379 parts per million in 2005, and the average global temperature rose by 0.74° C. According to scientists, this is the largest and fastest warming trend that they have been able to discern in the history of the Earth.

An increasing rate of warming has particularly taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years. IPCC Fourth Assessment Report: Climate Change 2007, gives detailed projections for the 21st century and these show that global warming will continue and accelerate. Predictions by 2100 range from a minimum of 1.8° C to as much as 4° C rise in global average temperatures.

Africa is already a continent under pressure from climate stresses and is highly vulnerable to the impacts of climate change. According to a Special Report of IPCC Working Group II, 1997, African climate trends and projections indicate that rainfall trends-especially over the past 30 years or so-have had a very large bearing on socio-economic development of the continent since most activities are based on agriculture. Many areas in Africa are recognized as having climate that is among the most variable in the world on seasonal and decadal time scales. African low-lands are characterized by low and erratic precipitation, high temperatures and high rates of evapo-transpiration.

In Ethiopia, minimum temperatures have increased faster than maximum or mean temperatures (Conway et al., 2004; Kruger and Shongwe, 2004). Rainfall exhibits notable spatial and temporal variability (Hulme et al., 2005).

Agricultural production relies mainly on rainfall and will be severely compromised in many African countries, particularly for subsistence farmers and in sub-Saharan Africa. Under climate change, much agricultural land will be lost, due to shorter growing seasons and lower yields. National communications report that climate change will cause a general decline in most of the subsistence crops, e.g. sorghum in Sudan, Ethiopia, Eritrea etc (Fischer et al. 2002).

1.2 Statement of the problem

Despite Ethiopia has developed a Climate Resilience Green Economy strategy (CRGE) at macro level and is striving to operationalize the strategy at micro level, environmental degradation because of rainfall variability, land degradation, soil erosion, deforestation, loss of biodiversity, desertification, recurrent drought, flood and water stress are still the main problems. According to National Meteorological Service Agency (NMSA) (2007) recurrent drought, famine and flood are the main problems that affect millions of people in the country almost every year. Although most disasters are caused by deterioration of natural environment, climate change contributes the lion share of the disasters currently. The main climate change impacts are on agriculture and food security, health, water resource and natural resource degradation.

Although the government recognized the vulnerability of the country to the impacts of global climate change and putting maximum efforts to build the resilience capacity of the population on one hand and is tabling commitment to the UNFCCC to reduce the country's

GHG emission on the other hand, there is still limited research-generated knowledge on impacts of the change, locally available adaptation and mitigation measures and community responses.

Climate change is already impacting populations, livelihoods and ecosystems in Ethiopia, including the study area, Benishangul Gumuz Region. The pace of change in the pattern of climate and different forms of environmental hazards often exceeds the capacity of local institutions to adapt to or mitigate the effects of such changes.

The negative impacts associated with climate change are also compounded by the existence of 'multiple stressors' (environmental degradation, population pressure, etc), which drive vulnerability further.

So far, efforts in the region to respond to the problem of growing climate change-induced hazards have been promising and expanding through time. Despite this, the scale and intensity of climate change-induced hazards (particularly rainfall variability, unseasoned floods, forest fire, disease outbreaks, expansion of invasive weed species) is growing fast and the magnitude of damages from such climatic hazards continue to rise.

In spite of the availability of handful of empirical studies, an in-depth analysis and well-established scientific evidence on the nature and extent of climate variability, magnitude of climate change impact on agricultural production and the likely socio-economic consequences on the livelihoods and food security of the rural poor in the area is virtually lacking. Also most studies focus on drought prone areas and due to the existence of bias that forest based livelihoods are not affected by climate change, less attention is given to such areas.

Hence, the study mainly intends to show the significance and magnitude of climate induced hazards and investigates climate (rainfall and temperature) variability and peoples' perception on the impact climate change on crop yields in district of Benishangul Gumuz region. Household level adaptation actions taken in response to the impact of changing rainfall patterns and temperature rise in the location is also examined.

1.3 General Objectives

The overall objective of this study is to analyze about rainfall variability and temperature patterns and assess farmers' perception about the impact of climate change on agricultural crop production in the study areas.

Specific objectives

1. To assess the perception of local communities about climate change, its impact on crop production and their traditional coping and adaptation mechanisms.
2. To analyze the monthly observed rainfall and temperature variability in the study area and triangulate against farmers' perception.

1.4 Research questions

- What is the level of monthly variation of temperature and rainfall in the study area?
- What is the perception of the farmers about the effect of rainfall and temperature variability on agricultural production in the study area?
- What is the level of awareness of local people about climate change and its impacts?
- What traditional climate change adaptation mechanisms do the local communities use to cope with climate change impacts?

- What are the practices that limited community adaptation?

1.5 Scope and limitation of the study

This study mainly focused on two themes: the first is analysis of climate variability from two climatic parameters (temperature and rainfall) perspective. The second is analyzing farmers' perception about the effect of climate variability (rainfall and temperature) on the production of agricultural food crops in the study area. In addition, the copping strategies developed at community level and indigenous knowledge used in response to climate change effects was assessed in depth. The assessment focused on both secondary data sources exist at district level and primary data that exist at community level.

On the other hand, some important limitations were encountered in conducting the study. One of the limitations is that study lumps all crops under one category i.e. general agricultural crops. Given that different crops have different climate requirements, future studies need to focus on specific crop responses and adaptations, particularly crops which have long-term implications for food security in the region. Another shortcoming of this study springs from the use of one time data of households. The full impact of climate change would better be assessed with time series data on crop production than one-time estimates of production. The study also used long-term climate change data of one nearest weather station due to absence of weather stations in the area.

1.6 Definition of Concepts and Terms

- **Climate** is defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of

time. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).

- **Weather**: Is a short-term phenomenon, describing atmosphere, daily air temperature, pressure, humidity, wind speed and participation. (IPCC, 2007).
- **Climate change**; refers to any change in climate over time, whether due to natural variability or as a result of human activity. The United Nations Framework Convention on Climate Change (UNFCCC) defines 'climate change' as 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.
- **Climate variability**: Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (Fussel and Klein, 2006,).
- **Adaptation**; Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation. (IPCC AR5, 2014)
- **Mitigation**; A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs) (IPCC AR5, 2014)
- **Ecosystem**; The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, biomes at the continental scale or small, well-circumscribed systems such as a small pond. (IPCC AR4).

- **Resilience**; the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change. (IPCC 2007, WGII)

CHAPTER TWO: LITERATURE REVIEW

2.1 Global climate change: An overview

Climate change is increasingly recognized as a critical challenge to ecological health, human well-being and future development (IPCC, 2007). It is one of the greatest challenges of humanity, affecting both current and future generations. According to the IPCC fourth assessment report, warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (IPCC, 2007). Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global surface temperature (since 1850). According to IPCC (2007), the global average temperature has risen by 0.74 ^{0} c and the global sea level has risen by 17cm during the 20th century, primarily due to melting of snow and ice from the mountains and Polar Regions.

Based on climate change models, global average temperature is projected to increase by 1.4 to 5.80c by the end of the present century (CIER, 2008). Sea level is expected to rise by 0.09 to 0.88 meter from the 1990 level by the end of this century and precipitation extremes are projected to increase more than the average in the future (WMO, 2003).

In response to the changing climate the world community took initial steps in 1992 (United Nations Framework Convention on Climate Change-UNFCCC), in 1997 (Kyoto Protocol) and then again in 2009 (the Copenhagen Climate Change Conference) to curb global greenhouse gas emissions.

Many worldwide regional summits have dedicated discussion sessions on climate change based on the recognition that global climate is subject to increasing change and this has become more evident in recent years (Aklilu and Alebachew, 2009).

However, these efforts have produced only modest gains in a handful of countries. The resulting emission reductions are nowhere near, what they should be in order to halt or slow the pace of climate change (GLCA, 2009).

2.2 Causes and impacts of climate change

Climate change is a reality; it has changed in the past, it is changing at the present, and it will change in the future (Burroughs, 2007). The change of climate could be slow and gradual, rapid and catastrophic, short-term or long term, could be at local, regional and global scales; and it could be due to natural factors or anthropogenic factors. The overwhelming majority of climate change researchers have reached on an understanding, based on decades of evidence, modeling, and debate, that it is extremely likely that human activities are responsible for the rising temperatures on Earth. Human behavior will continue to be a major factor in climate change (UN, 1992; NSF, 2009).

The human factors that contribute to climate change are in the form of greenhouse gas (GHG) emissions and land-use/cover changes (Aklilu and Alebachew 2009; World Bank, 2008; FAO, 2008). Most important greenhouse gases are emitted from electric power station, various industries, the transport sector and deforestation due to human activities. These activities increase the concentration of different greenhouse gases. The relative share of carbon dioxide, chlorofluorocarbons, methane and nitrous oxides to greenhouse gases emission were 51%, 20% 16% and 16% respectively up to 1990 (Singh and Sweta, 2008).

Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004. Global atmospheric concentrations of carbon dioxide (CO2), methane (CH4), chlorofluorocarbons (CFC) and nitrous oxide (N2O) have increased markedly since 1750 because of human activities. Global increases of CO_2 concentrations are primarily due to increased fossil fuel use and land-use change. It is very likely that the observed increase in CH_4 concentration is predominantly due to agriculture and fossil fuel use. The increase in $N2_O$ concentration is primarily due to agriculture (IPCC, 2007). Thus, the greenhouse gas effect is intensified, resulting in rising temperature on earth.

Anthropogenic effects on the physical and chemical properties of the atmosphere have the potential to affect the quality of life and even the very existence of certain life forms. Weather and climate-related disasters result in high death, a decline in production of food, pollution of waters and land surfaces, and the destruction of production capacity and infrastructure. The data received from many observations indicate that regional climate changes have already affected many physical and biological processes and systems. Examples of observed changes include reduction in glacier cover, thawing permafrost, changes in altitudes of vegetation extent, reduction of populations of some species of plants and animals, expansion of desertification processes (Anon, 2002).

The international communities are scared of catastrophic adverse effects of future and present climatic changes on different spheres of man and nature (Ahmed, 2008; Mendelsohn, et al., 2000).While the regional patterns of future climate change are poorly known, it is clear that the altered patterns of radiative forcing associated with anthropogenic emissions will alter regional climates noticeably, and will have different effects on climate

conditions in different regions. These local and regional changes will necessarily include changes in the lengths of growing seasons, the availability of water, and the incidence of disturbance regimes (extreme high temperature events, floods, droughts, fires, and pest outbreaks), which, in turn, will have important impacts on the structure and function of both natural and human-made environments. Systems and activities that are particularly sensitive to climate change and related changes in sea level include forests; mountain, aquatic and coastal ecosystems; hydrology and water resource management; food and fiber production; human infrastructure and human health (Houghton, et al., 1997).

The effect is more pronounced on those countries that are categorized under third world or developing countries. Because developing countries are most vulnerable to the effects of climate change and they have the least capacity to adapt to these changes (IPCC, 2001 & UNFCCC, 2007). According to IPCC (2007), terrestrial, low laying costal and marine coral reefs are vulnerable ecosystems. In addition, water resource, agriculture and human health are vulnerable sectors. The same literature shows that Arctic, small islands, Asia, Latin America and Africa are the most vulnerable regions in the world.

The continent of Africa is primarily tropical or subtropical (National Research Council (NRC), 1995) which is one of the most vulnerable regions in the world to climate change (Desanker, n.d; Leary, et al., 2008). Africa's high vulnerability to the impacts of climate change is exacerbated by other factors such as wide spread poverty, recurrent droughts and floods, dependence on natural resources and biodiversity, over dependence on rain fed agriculture, a heavy disease burden and the numerous conflicts that have engulfed the continent. Changes in future climate may negatively affect the overall economy of Africa, thus hampering potential for economic growth (Davidson, et al., 2003 cited in Nyong,

2005). The main impacts of climate change will be on the water resource, food security and agriculture, natural resource management and human health (Dieudonne, 2001 cited in Huq, et al, 2003).

Agriculture is the basis for the livelihoods of millions of people in Africa. An average of 70% of the population lives by farming and 40% of all exports are earned from agricultural products (WRI, 1996 cited in IPCC, 2001). In addition, 10% to 70% of gross domestic product (GDP) in Africa is generated by agriculture (Mendelsohn, et al. 2000). However, agricultural production is affected by climate change. The estimate for Africa is that 25% to 42% of species habitats could be lost, affecting both food and non-food crops (FAO, 2007).

According to reports of the IPCC (2007), the projected yield reduction due to climate change in some poor countries could be as much as 50% by 2020. Under climate change, much of agricultural land will be lost, with shorter growing seasons and lower yields. Many countries in tropical and sub-tropical regions are expected to be more vulnerable to warming because additional warming will affect their marginal water balance and harm their agricultural sectors (Mendelsohn, et al., 2000).

Africa is one of the most vulnerable continents to climate change and climate variability, a situation is aggravated by the interaction of 'multiple stresses', occurring at various levels, and low adaptive capacity (high confidence).(IPCC Fourth Assessment Report: Climate Change 2007.) Africa's major economic sectors are vulnerable to current climate sensitivity, with huge economic impacts, and this vulnerability is exacerbated by existing developmental challenges such as endemic poverty, complex governance and institutional dimensions; limited access to capital, including markets, infrastructure and technology; ecosystem degradation; and complex disasters and conflicts. These in turn have contributed

to Africa's weak adaptive capacity, increasing the continent's vulnerability to projected climate change. For precipitation, the situation is more complicated. Rainfall exhibits notable spatial and temporal variability (e.g., Hulme et al., 2005). Inter-annual rainfall variability is large over most of Africa and, for some regions; multi-decadal variability is also substantial.

Africa contains about one-fifth of all known species of plants, mammals, and birds, as well as one-sixth of amphibians and reptiles. These species compose some of the world's most diverse and biologically important ecosystems such as savannahs, tropical forests, coral reef marine and freshwater habitats, wetlands and montane ecosystems. These globally important ecosystems provide the economic foundation that many Africa countries rely on by providing water, food, and shelter. However, because of climate change, these ecosystems and the livelihoods that depend on them are threatened (WWF, 2006; McMullen & Jabbour, 2009). Climate change affects biodiversity by influencing species distribution, composition and function directly and indirectly (Aklilu and Alebachew, 2009). Up to 50% of Africa's total biodiversity is at risk due to reduced habitat and other human-induced pressures (Boko, et al., 2007). Climate change, in particular rising temperatures, can have both direct and indirect effects on animal production. Heat stress (caused by the inability of animals to dissipate environmental heat) can have a direct and detrimental effect on health, growth and reproduction. Changes in the nutritional environment (e.g. the availability of livestock feeds, and the quantity and quality of livestock pastures and forage crops) can have an indirect effect (FAO)

Moreover, the continent is vulnerable to a number of climate sensitive diseases including malaria, tuberculosis and diarrhea (Guernier, et al., 2004). Under climate change, rising temperatures are changing the geographical distribution of disease vectors, which are migrating to new areas, and higher altitudes, for example, migration of the malaria mosquito to higher altitudes will expose large numbers of previously unexposed people to infection in the densely populated east African highlands (Boko, et al., 2007). Future climate variability will also interact with other stresses and vulnerabilities resulting in increased susceptibility and risk to infectious diseases (e.g. cholera and diarrhea) and malnutrition for adults and children (WHO, 2004).

Climate change causes degradation and loss of important natural resources. The increasing occurrence of climate extremes (for example heat waves, droughts, heavy precipitation) is having an impact on land degradation processes, including floods, mass movements, soil erosion by water and wind and salinization in all parts of the globe. Climate variability, climate change and land degradation are intimately linked and are generating unexpected effects on soils, water, forest and wetlands (Sivakumar and Ndiang,,ui, 2007). According to the report of IPCC (2007), climate change caused decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes.

Climate change also affects forest resources. Extensive changes in the area of forests due to deforestation can seriously affect the climate in the region of change. Changes in carbon dioxide, temperature or rainfall associated with climate change can have a major impact on the health or structure of forests that can in turn affect the climate (Houghton, 2009).

2.3 Global responses to climate change

Climate change is a global issue that requires an urgent international response. Governments, industries, communities and organizations across the globe are working together to develop and implement measures to reduce greenhouse gas (GHG) emissions and avoid dangerous climate change (office of climate change (OCC), 2010). Several international conferences, seminars, symposia and workshops have been held. Some of them were; the first World Climate Summit (1979) in Geneva, Conference on Industries and Climate (1980 in Vienna), Vienna convention (1985, in Austria), Montreal Protocol (Canda 1987), constitution of IPCC by UNEP and WMO in 1988, First Earth Summit (1992 Brazil), Kyoto Protocol (1997, Japan) and so on (Singh and Sweta, 2008).

The United Nation Framework Convention on Climate Change (UNFCCC) is an international environmental treaty produced at United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro in 1992. The objective of the treaty is to stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. As a framework treaty, the convention set no mandatory limit GHG emissions for individual nations and contained no enforcement provisions; it is therefore considered non-binding. Rather, the treaty includes provisions for updates (called "protocols") that would set mandatory emission limits. (Aklilu and Alebachew, 2009a).

The Kyoto Protocol, adopted in December 1997, is an international agreement, which builds on the UNFCCC and sets legally binding targets for cutting GHG emissions of industrialized countries. Like the UNFCCC, the Kyoto Protocol aims to stabilize GHG emissions in the atmosphere. The major distinction between the two documents is that while

the convention encouraged developed countries to stabilize GHG emissions, the protocol commits them to do so. The protocol sets out emission reduction targets for developed countries because they have been responsible for the vast majority of the world's human-induced GHG emissions (OCC, 2010). The protocol was entered in to force on 16 February 2005. As of November 2009, 187 states have signed the protocol. Copenhagen Accord was forged at the 15th Conference of the Parties, held in Copenhagen in December 2009, towards a new agreement beyond the Kyoto Protocol (UNFCCC, 2009). The Accord is significant because it is the first global agreement on climate change, involving the major developed and developing countries. The United States and major developing economies, such as China, Brazil and India, played a key role for the first time (OCC, 2010).

The UNFCCC and the Kyoto Protocol have faced several challenges to achieve their prime objectives of reducing emissions. For instance, despite the Kyoto Protocol's ambitious goals, even countries that have shown to be its leading advocates, such as Japan, Canada and the members of the European Union had not able to meet their targeted reductions of emissions. In addition, the Australian government still refuses to ratify this agreement and along with the United States of America remain the only Annex I countries of the United Nations Convention on Climate Change not to ratify the Protocol (CamWalker, 2006).

Climate change is one of the all-encompassing global environmental changes that have deleterious effects on natural and human systems, economies and infrastructure. The risks associated with it call for a broad spectrum of policy responses and strategies at the local, regional, national and global level. The United Nations Framework Convention on Climate Change (UNFCCC) highlights two fundamental response strategies: mitigation and adaptation. While mitigation seeks to limit climate change by reducing the amount of

emissions of GHG and by enhancing "sink" opportunities, adaptation aims to alleviate the adverse impacts through a wide-range of system-specific actions (Fussel and Klein, 2002).

Although mitigation and adaptation measures must be pursued to tackle the climate change problem and to create an effective and inclusive international climate change regime, mitigation has received greater attention than adaptation, both from a scientific and policy perspective. One plausible reason for this could be that climate change emerged as a problem related to the long-term disturbance of the global geo-biochemical cycles and associated effects on the climate system (Cohen, et al., 1998). Given the far-ranging adverse impacts of climate change, adaptation must be an integral component of an effective strategy to address climate change, along with mitigation. The two are intricately linked-the more we mitigate, the less we have to adapt. However, even if substantial efforts are undertaken to reduce further greenhouse gas emissions, some degree of climate change is unavoidable and will lead to adverse impacts, some of which are already being felt (GLCA, 2009).

Adaptation is a focus in developing countries because these countries are dependent on natural resource and so are sensitive to climate change. For vulnerable groups such as developing countries, adaptation strategies are vital, as failure to adapt could lead to "significant deprivation, social disruption and population displacement, and even morbidity and mortality (Downing, et al., 1997). Now adaptation to climate change is recognized as urgent, inevitable, and expensive (Olsson and Jerneck, 2010). This is because of first, no matter how robust mitigation measures are, a certain degree of climate change is inevitable due to historical emissions and the inertia of the climate system (IPCC, 2001). Second, while the effects of mitigation may take several decades to manifest, most adaptation

activities take effect almost immediately. Third, such measures can be applied on a regional or local scale, and their effectiveness is less dependent on actions of others.

Depending on its timing, goal and motive of its implementation, adaptation can be reactive or anticipatory, private or public, planned or autonomous. Adaptations can also be short/long term, localized or widespread (IPCC, 2001). In unmanaged natural systems, adaptation is autonomous and reactive. It is the means by which species respond to changed conditions. In these situations, assessment of adaptation is essentially equivalent to natural system impact assessment. Adaptations undertaken by individuals/communities are the focus here and can be classifies as:

Reactive or Anticipatory: - Reactive adaptation takes place after the initial impacts of climate change have occurred. Anticipatory adaptation takes place before impacts become apparent. In natural systems, there is no anticipatory adaptation.

Private or public: - The distinction is based on whether private (individual households and companies) motivates adaptation or public interest (government).

Planned and Autonomous: - Planned adaptation is consequence of deliberate policy decision, based on the awareness that conditions have changed or are expected to change and that some form of action is required to maintain a desired state. Autonomous adaptation involves changes that systems will undergo in response to changing climate irrespective of any policy, plan or decision (Huq, 2005).

Each of the levels of potential adaptation options comes with a relevant set of very real constraints (Ziervogel and Ericksen, 2010). In addition, identifying those adaptations that favor most vulnerable groups is difficult (Bewket, 2010). Patino (2010) identified four major barriers to adaptation: the perceived lack of leadership and action by governments,

existing governance and institutional arrangements, policy and regulatory issues and uncertainty and lack of understanding.

2.4 Climate change impacts and responses in Ethiopia

Ethiopia is highly vulnerable to climate variability and change. This is because of very high dependence on rain fed agriculture, which is very sensitive to climate variability and change, under-development of water resources, low health service coverage, high population growth rate, low economic development level, low adaptive capacity, inadequate road infrastructure in drought prone areas, weak institutions and lack of awareness (NMSA, 2007). Vulnerability assessment based on existing information and rapid assessments carried out under National Adaptation Program of Action of Ethiopia (NAPA) has indicated that the most vulnerable sectors to climate variability and change are agriculture, water resources and human health. Agriculture is the most important sector in the Ethiopian economy (Temesgen, 2007). However, productivity and competitiveness of this sector is increasingly constrained by temporal and spatial variability of climate (NCCF, 2009). In addition, both droughts and floods are already common in Ethiopia. Most of the country is prone to drought (NMSA, 1996, Degefu, 1987). Droughts destroy farmlands and pastures; contribute to land degradation, causes crops to fail and livestock to perish. During the 1984–5 drought, the GDP declined by about 10 percent and the 2002-3 drought cause over 3 percent decline. Flooding in turn causes significant damage to settlements and infrastructure, livestock and animal health, and the water-logging of productive land undermines agriculture by delaying planting, reducing yields and compromising the quality of crops, especially if the rains occur around harvest time (WB, 2006). Changes in temperature and rainfall have had many negative impacts on human and livestock health. For example, serious disease outbreaks

including cholera, acute water-borne diarrhea (AWD), meningitis and malaria have been reported due to altered temperature and rainfall patterns (NMSA 2006, Assefa 1996, McMichael, et al., 2006 cited in Aklilu and Alebachew 2009). The same literature adds that livestock were also affected by diseases like schistosomiosis, trypanosomiasis, yellow fever and tick-borne hemorrhagic fevers.

Climate change is expected to have adverse ecological, social and economic impacts. The NMSA (2007) summarizes the impact of Climate change for selected sectors in Ethiopia as follows:

Table 1: Impacts of climate change for selected sectors in Ethiopia (NMSA, 2007)

Sector	Potential impact
Agriculture	• Shortening of maturity period and decrease in crop yield • Grassland and Livestock • Change in livestock feed availability • Effects of climate change on animal health, growth and reproduction • Impacts on forage crops quality and quantity • Change in distribution of diseases • Changes in decomposition rate • Change in income and prices • Contracting pastoral zones in many parts of the country
Forests	• Expansion of tropical dry forests and the disappearance of lower wet forests; • Expansion of desertification

Water Resources	• Decrease in river run-off • Decrease in energy production • Flood and drought impacts • Human Health • Expansion of malaria to highland areas
Wild life	• Shift in physiological responses of individual organisms • Shift in species distribution from one to the next • Shift in biomes over decades/centuries • Shifts in genetic makeup of population • Loss of key wetland stopover and breeding sites for threatened bird species; and in general endemic and threatened species of flora and fauna are front line victims

Impacts of climate change in Ethiopia are severe and climate change adversely affects the efforts to achieve Millennium Development Goals (MDGs). Falling of agricultural outputs and deteriorating conditions of rural areas caused by climate change will directly increase poverty of households in poor countries like Ethiopia (Diao, et al., 2005). Current experience of extreme whether events underlines how devastating droughts and floods can be for household incomes.

The Ethiopian government has recognized the adverse effect of climate change on the country's development agenda. As a result, the country ratified the UNFCCC (in May 1994), UNCCD (in June 1997) and Kyoto Protocol (February 2005). Within these frameworks, Ethiopia prepared National Adaptation Programs of Action (NAPA) against

the impacts of climate change and desertification (Aklilu and Alebachew, 2009). Ethiopia had developed Climate Resilient Green Economy Strategy with the objectives of addressing both mitigation and adaptation though, unlike the case of developed nations, the country is not historically responsible for the current level of global warming.

The people of Ethiopia are struggling against the impact of climate variations. They have been facing the impacts in various forms over millennia and have developed a range of coping mechanisms to deal with the impacts (McKee, 2008 cited in Aklilu & Dereje, 2010). The most important coping mechanisms widely used include: changes in cropping and planting practices, reduction of consumption level, use of inter-household transfers and loans, collection of wild foods, increased petty commodity production, temporary and permanent migration of people and animals, hidden secure grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land/ taking credit from merchants and money lenders, use of early warning systems and appeals for food and other forms of aid (NMSA, 2006 cited in Aklilu & Dereje, 2010).

Most of the coping mechanisms are based on local knowledge and cannot be able to cope with all of climate change impacts. However, local perception of people should be the base for the choice of adaptation strategies. Unfortunately no or little is known about local perception of people. Hence, there are no appropriate adaptation strategies to cope with the impact of climate change in the country particularly in vulnerable regions/ districts under this study.

2.5 Climate change and Agriculture

Climate change causes climate variability of temperature and precipitation as well as the frequency and severity of weather events.

Climate change will affect agriculture through effects on crops; soils; insects, weeds, and diseases; and livestock. Climatic conditions interact with agriculture through numerous and diverse mechanisms. Mechanisms, effects, and responses include, for example, eutrophication and acidification of soils, the survival and distribution of pest populations, the effects of CO_2 concentration on tissue- and organ specific photosynthate allocation, crop breeding aims, animal shelter requirements, and the location of production (Brunnert and Dämmgen, 1994). Variation of agricultural and climatic conditions across the world leads to different local and regional impacts. Historically, agriculture has proved to be highly adaptive to changing conditions, but uncertainty remains with regard to adaptation to potential climate change.

Some indirect effect of climate change includes changes in soil moisture, land and water condition, change in frequency of fire and pest distribution. This in turn will have wide-ranging effects on the environment, on socio-economic and related sectors, on water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Moreover, rising temperatures will cause shifts in crop growing seasons which affects food security. Temperature increases will potentially severely increase rates of extinction for many habitats and species (UNFCCC, 2007). .

2.6 Ethiopian agriculture

Ethiopian economy is predominantly agrarian and the majority of the population in the country is engaged in agriculture. It is the single biggest employer with 70.4% of the economically active population engaged in the sector (CSA, 2000). Accordingly, it contributes about 41% to the Gross Domestic Product (GDP). Ethiopian agriculture is predominantly characterized by traditional methods of farming with very little change in

farming practice over the past few centuries. The continuous use of such farming practice over a long period of time with little or no soil conservation measures has significantly eroded the fertility of the soil and agricultural outputs (Degefe, 2000).

The major factors behind the poor performance of Ethiopian agriculture are diminishing farm size and subsistence farming, soil degradation, inadequate and variable rainfall, climate-related disasters, weak agriculture research base, lack of financial system, imperfect agriculture markets and poor infrastructure. Ethiopian farming largely produces only enough food for the peasant holders and their family for consumption, leaving little to sell. Crops are the major production and sources of food in the country since most of the population depend on agriculture (Degefe, 2000).

2.7 Agriculture in Benishangul Gumuz Region

The main stay for the economy of almost all of the population of the region particularly of those dwelling in rural areas is agriculture. The sector is mostly practiced in a very traditional way through hoe culture as keeping oxen for the purpose is much difficult. It was noted that trypanosomiasis is the most important livestock killer in the region (Regional Bureau of Agriculture and Rural Development, 2005). Thus, the economic return from the sector is not much more than subsistent.

The natural resource base and the diverse fauna and flora of the region have got diminished than ever before due to recurrent forest fire where stock of the woody biomass has got dried through temperature rise. Nowadays since the dry season is becoming longer, due to climate change, the frequency of the forest fire has increased to twice a year. (MoARD, Guideline for forest fire protection and control, 2003)

With regard to crop cultivation, the impact could be recognized in terms of diminished agricultural productivity, recurrent occurrences of rat plagues and out breaks of locust and grasshopper. A report from MaoKomo Special district office indicates the destruction of 560 hectares of maize and haricot bean with a damage level of up to 90% (, UNDP, 2002). The rats feed on succulent shoots of bamboo trees in the natural ecosystems. Following the drying of the bamboo, the rats shift to destroy crops.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Study Area Description

3.1.1 Biophysical features

Benishangul Gumuz Regional State (BGRS) is one of the regional states of the Federal Democratic Republic of Ethiopia (FDRE). The region is divided into three administrative zones with one special and other 20 woredas (districts). It is located in the North West part of country and bordered with Amhara in the North and North East, Oromia in the East and South East, Gambella in the South and Sudan in the West. Geographically it is found along the Sudanese Border roughly over a length of about 377.4 Km, between 090 17‘and 120 06‘N latitude, 340 10‘and 370 04‘East longitude and divided by the Blue Nile (Abay) into two halves. The area of the region is roughly estimated to be about 50,381 Km2.

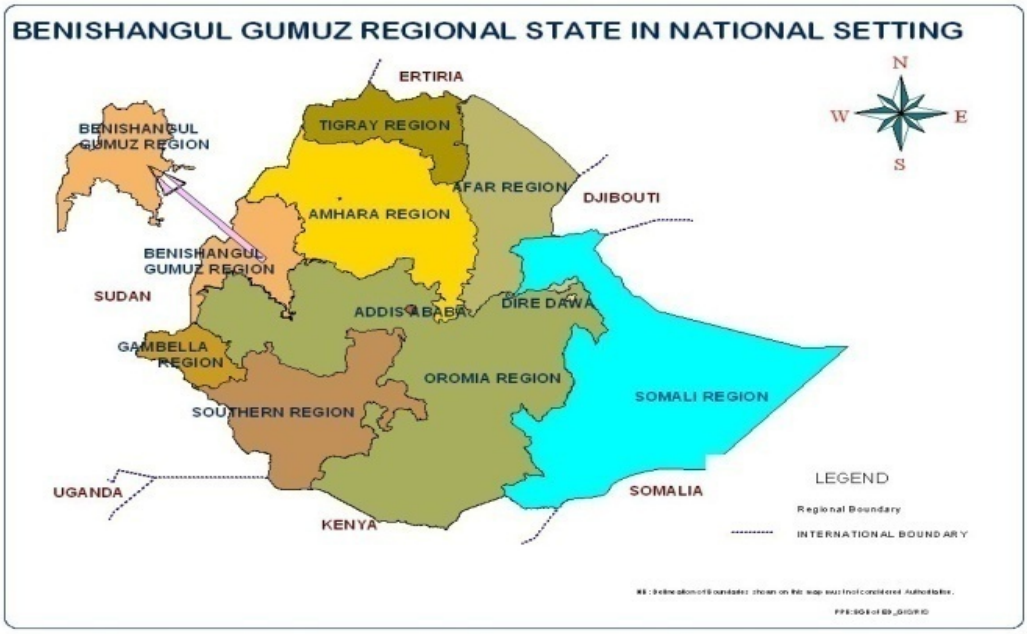

Figure 1: Geographical location of BGRS

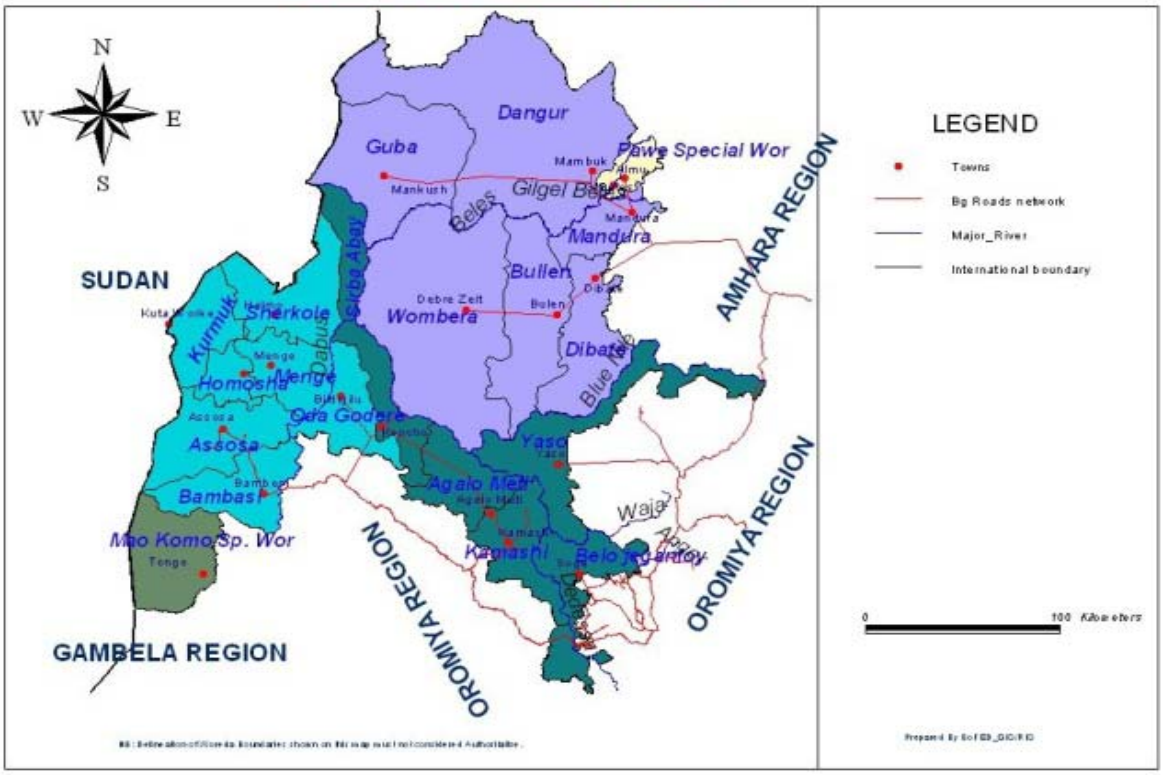

Figure 2: Administrative map of the region

Moakomo special district/*woreda* is one of the districts of the region and has 29 rural and urban peasant associations/*kebeles*/sub districts. The total population of the district is estimated to be 42,050 with an average density of 14.21 persons per km (Bureau of Finance & Economic Development, regional profile, 2012). The average family size for the region is 4.5 persons per household. Hence, the number of household is estimated to be (42,050/4.5) = 9345. The number of households per *kebele*/sub district is nearly 390.

The district is composed of different land features dominantly of plain to undulating lowland (80%), mountainous (12%) and steep sided and wide gorges (18%) , perennial rivers (Maokomo Special District Facts, 2014).

In Maokomo about 15,296 hectare of land is under agricultural activities; and of this 89.5% covered by temporary crops, 1.69% by permanent crops, 0.75% by fallow lands, 6.29% by grazing land, 1.52% by woody/tree plantations and other agricultural activities (CSA, 2007). The overall mean crops yield is not greater than 10qt/ha and low compared to national mean 13qt/ha of similar agro-ecology.

3.1.2 Livelihoods

Nearly the livelihood of 92.2% of the population of the district depends on agriculture. The crop farming in the district is less diversified and intensified compared to more settled agriculture part of the country (Facts about BGRS 2007). Crop farming is mostly based on hoe-culture and few use oxen. Shifting cultivation practice is common in the district that is based on the traditional knowledge of the community. The main annual crops grown in the district include: maize, sorghum, haricot bean, sesame, niger seed, millet and peanut. (Regional profile by Bureau of Finance and Economic Development of BSGR, 2003)

In addition, traditional livelihoods such as "wild food" collection and honey gathering, and hunting are being practiced in the forest ecosystem of the district.

3.1.3 Climate

The district's rainfall is uni-modal and its mean annual rainfall ranges from 900 to 1400mm. The duration of the rainy season extends from five to six months and the length of the rainy season varies from place to place and erratic. The highest mean annual temperature ranges from 17 to 27 ^{0} C and the lowest is 12^{0} C. The length of growing period lies between 130-180 days (Regional Conservation Strategy draft Volume I, Aug, 1997).

3.1.4 Ecosystem and Biodiversity

The region is considered one of the regions with abundant biodiversity where variety of vegetation and wild life exist. But in recent years the resource is diminishing from time to time due to, among other reasons, changing settlement and land use patterns.

The deep rooted habit of the community in setting forest fire is one of the chronic challenges accounted for a significant destruction of the ecosystem and biodiversity (BGRS-BoEPLAU (2011)

3.1.5 Water Resource

The region is known particularly for its surface water potential. The existence of the region within the Abay and Baro-Akobo river basins accounts for this. According to the study conducted in 2003 by the regional bureau of agriculture and rural development, there were 28 identified streams proposed for small scale irrigation. ‘

3.2Methodology

3.2.1 Sampling and sampling procedure

The combination of multi-stage proportionate stratified sampling, simple random sampling and purposive sampling techniques were used in the selection of study site and sample households. At first stage, stratified random sampling (SRS) was employed to select one district and two *kebeles*/sub-districts from different agro-ecological zones; namely lowland and midland. At the second stage sample villages were selected from sample sub districts by purposive sampling. At stage three, households were selected from those villages based on stratified random sampling technique for structured household survey. The households were

stratified into male and female to include the view of both sex and to know the most affected segment of the community. Concerning the sample size determination, Bartlett, et al., (2001) sample size formulae was used. As the total populations of the household in the selected areas are nearly 780 and the sample size for continuous data is nearly 76 for low, 104 for medium and 166 for high, a medium sample size was applied for the study. Accordingly, for household survey, 104 households were selected randomly using *kebele*/sub-district registration lists that obtained from district office.

Table 2: Sample size for household interview, KII and FGD

District/Woreda	Agro-ecological zone	No of sample kebeles	No of houseohlds	No of key informants, Community Elders	FGD	Questionnaire to district agriculture and rural development experts
Maokomo	Woina Dega/midland	Yaá/Yabaldigis	52	2	1	6
	Kola/lowland	Kokeb	52	2	1	

3.2.2 Data Source and Data Collection Method

Three sets of primary data namely: ***climate*** (temperature and rainfall), ***socio-economic*** and ***data on climate change perception and traditional climate change adaptation mechanisms*** were collected. Additionally, valuable secondary data were also collected from various sources including previous scientific studies and reports from district/regional level agricultural bureau and other concerned organizations. Detailed description and analysis of data collected from different sources and for each group of data are presented below.

Climate variables, temperature and precipitation

Monthly rainfall and daily temperature data were obtained from the Ethiopian Meteorology Authority, for the years 1979 to 2013 in order to attribute to farm-specific information from station level observations in the nearest meteorological station of Assosa. The climate change and weather measures used in the analysis are then constructed from rainfall and temperature data.

Data on socio-economy and traditional coping mechanisms; the survey was conducted on the selected 104 households in two *kebeles* with different agro-climatic conditions. The survey consisted of 3 main parts: collection of demographic data and socio economic data, local peoples' perception of climate change and its cause, communities' understanding of the impacts of climate change induced hazards and the responses of local people. An in-depth household survey, using a semi-structured questionnaire and in-person interview, were employed to collect both the detailed socio-economic data and the traditional climate change adaptation and coping mechanism of the households. In order to check the validity and appropriateness of the semi-structured questionnaire a pre-test was don prior to the actual interview of the total sample households. 4 data collectors/ enumerators, mainly Development Agents and sector office experts who have better knowledge of the local tradition and language, were hired and trained on how to make interview, discussed on each questions and they were given with a chance to interchangeably practice on how to conduct interviews before the actual survey.

Key Informant Interview; Key informant interview was also conducted with 6 agricultural and rural development experts and it was focused on the impacts of climate variability and

change in the study area, responses of the government and level of participation and role of the community to tackle the impact.

Focus group discussion: Key informants and community leaders were identified for focus group discussions with the help of the district agricultural bureau and local development agents. Accordingly, two focus group discussions were carried out in 2 Kebeles (with different agro-ecology, *Kola*/lowland and *Woina Dega/*midland), consisting of 12 farmers in each kebele. The main purpose of the focus group discussions was to get insights on and understand the perception of the people about climate change, its impacts, causes and their responses. The major discussion topics were local communities' perception of climate change, types and impact of climate extremes and its cause, major hazards and adaptation strategies and barriers to employ them effectively. In addition, issues related to natural resource management, changes overtime to their natural environment and causes of the changes were focused.

Document review: various documents available at regional, zonal and district level were reviewed and used to generate secondary data. Scientific studies, researches, policy and strategy documents, census reports, activity progress reports, climate distribution, and economic information etc were reviewed and used to supplement the primary data.

3.2.3 Data analysis and presentation

Master coded sheets were prepared for coding purpose, after verifying and organizing the reviewed schedule for data collected from village households. Data obtained from various sources were analyzed using qualitative and quantitative data analysis techniques. Raw data was entered in to statistical software package (SPSS) for data management and further analysis.

The qualitative information gathered using focus group discussion and key informant interview were analyzed and transcribed using qualitative techniques, whereas the quantitative data generated by questionnaire and meteorological data were analyzed using descriptive statistics. Descriptive statistics based on summary counts of the questionnaire structure were used to assess farmers' perception about the impact of climate change on agriculture, adaptation options and barriers they faced to adapt. For substantiating the perception of smallholder farmers, further comparison was made by undertaking linear trend analysis of annual mean of temperature, and total annual rainfall of 26 years record obtained from National Meteorological Agency.

CHAPTER FOUR: RESULTS AND DISCUSSIONS

This chapter discusses and presents analysis of climate variability and change, local peoples' perception of climate change, impacts of climate change, coping mechanisms and adaptation practices and barriers to adaptation in the study area based on results obtained from household survey, rainfall and temperature records found from meteorological station produced by NMA and qualitative information generated from various groups of the community and district agricultural and rural development experts through FGDs and interviews.

4.1Profile of the respondent households

Table 3 : Characteristics of the respondents

Characteristics of the respondents		**Frequency**	**% of respondents**
Sex of household	Male	68	64
	Female	38	36
Marital Status	Married	101	95.5
	Single	2	1.1
	Divorced	2	2.2
	Widow/er	1	1.1
Education	Illiterate	91	86
	Literate	11	14

The survey results reveal that out of the total household heads included in the survey, 64 % and 36% were male respondents and female respondent households respectively. The age

distribution of the respondents ranges from 25 to 75 years of age. The percentage of respondents whose age is between 25 to 35 accounts 46 %, from 36 to 50 is 37% and the percentage of respondents above 51 years age is 17%. Regarding marital status, 95.5% of the respondents are married, while the remaining are either single or divorced.

More than half of (86%) of the household heads were illiterate with no formal education of any kind and thus are unable to read and write. Only 14% of the respondents stated that they could only read and write.

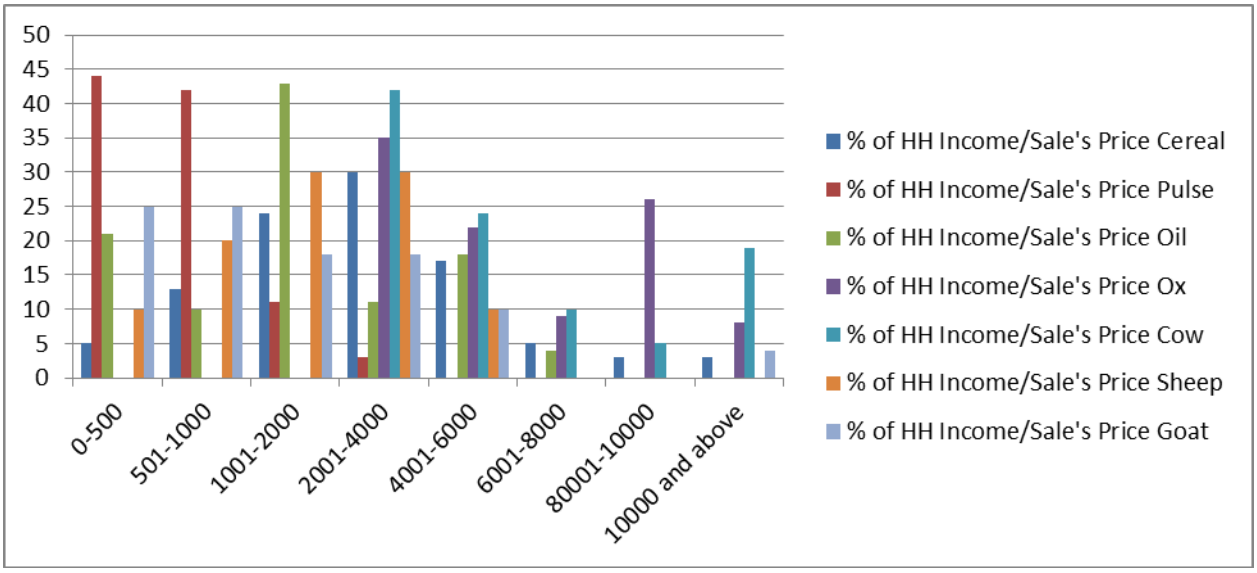

Figure 3: Household Annual Income/Price

Regarding household income, the sample households were asked about the amount of crop production they harvest per year and the monetary value of their livestock and this was converted to Ethiopian currency, birr, based on the current market price. Accordingly, the amount of income distribution of the respondents ranges from Ethiopian birr 300 to 12,750 for cereal crop with an average income of 3150 birr per year, from birr 40-2860 from sales of pulse, with an average income of birr 600, from birr 100-7600 from sales of oil crop with an average income of 1750. As it can be seen from figure 3, almost all households get

income from diversified livelihood sources. With respect to the land size cultivated for cereal production, 26% of the household cultivates less than 1 hectare, 45% cultivates 1 hectare and only 18% cultivates around 2 hectare.

4.2 Diversity of Income/livelihood

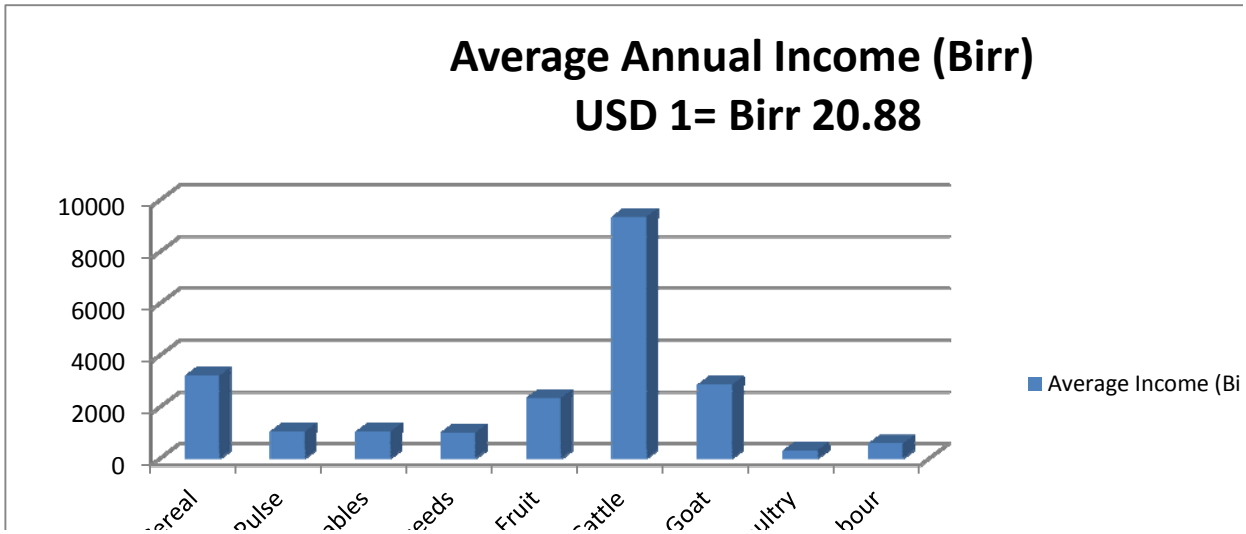

Figure 4: Diversity of Livelihood Income

From the sampled household, respondents indicated that the significant amount of earning is generated from the sale of cattle followed by sale of cereal crops. In addition, it can be observed from the response that the majority of the population is getting income from different sources which are the sale of livestock, crops and by engaging in wage labor.

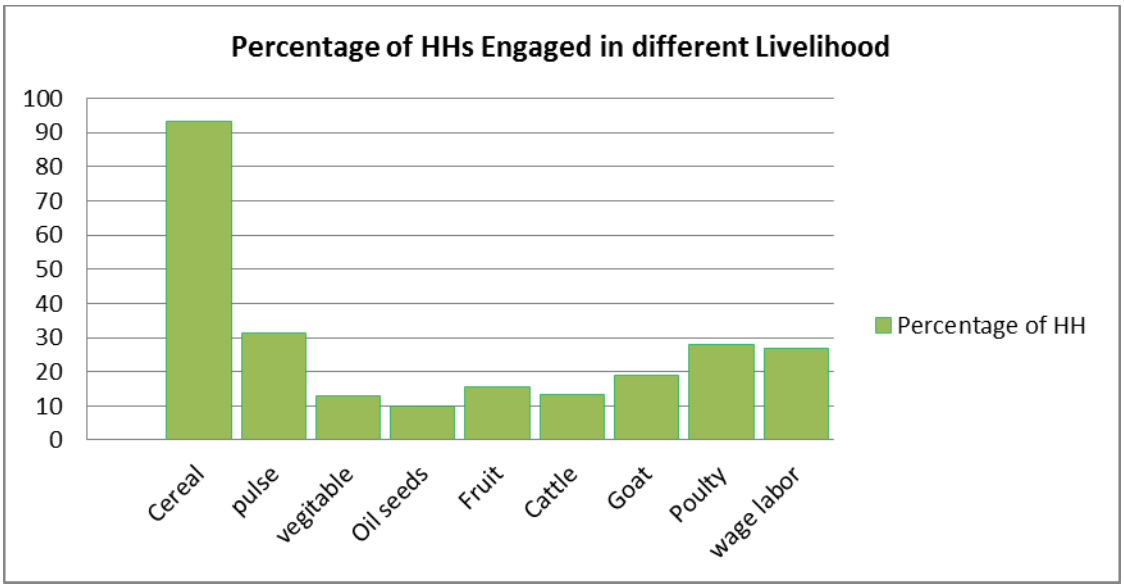

Figure 5: Percentage of households (HH) engaged in different livelihood.

As indicated on figure 5, 93% of the households are engaged in the production of cereals crops followed by production of pulse (31%) and poultry for their livelihood. Though the percentage of households who are engaged in other livelihood activities are relatively small, nearly all have diversified their income by involving in such agricultural activities as production of oil seed, vegetables, rearing of cattle, goat and in wage labor to supplement their income.

4.3Patterns of the local climate

In general, meteorological stations in Benishangul Gumuz regional government are few in number and finding data from other stations was difficult and incomplete. Hence, 26 years observed data (for some years the data was incomplete and average data was used for analysis) from Assosa weather station was used since this station is the nearest station to the study area. Accordingly, monthly rainfall and temperature data of 26 years, from 1979 to

2013, for Assosa district was obtained from National Meteorological Service Agency (NMSA).

Inter annual and inter seasonal rainfall variability and trend

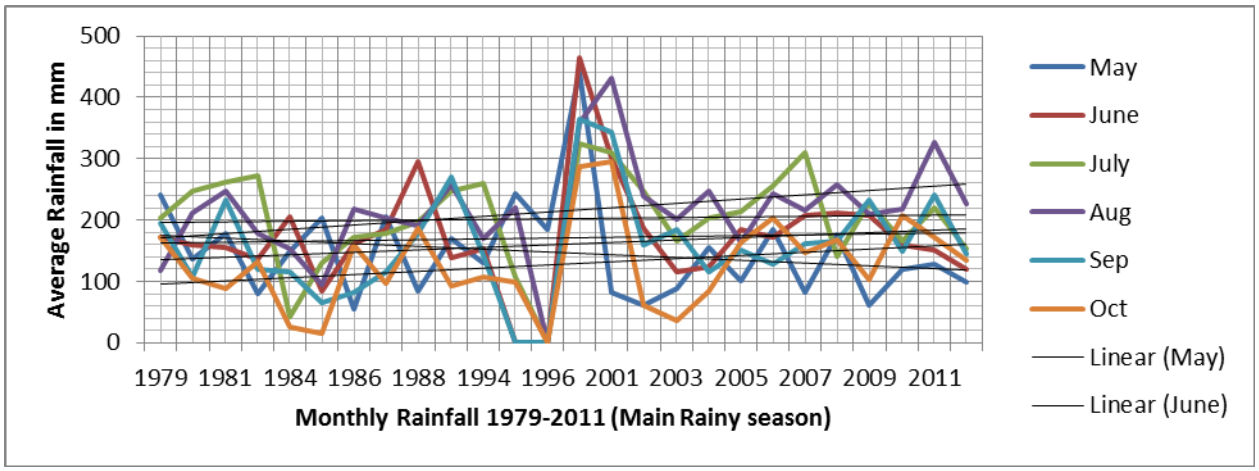

Figure 6: Inter-annual Rainfall Patterns of main rainy months and Trends of Change

Based on inter-annual rainfall amount records, analysis for Maokomo district indicates that the rainfall is uniformly erratic and was showing irregularity. It has shown a drastic decrease in year 1996 and has been continuously irregular during the past couple of decades. The overall amount of rainfall during these periods is characterized by significant increase in year 2000 and substantial decrease since year 2002 (Figure 6).

Inter-annual Total Rainfall Patterns and Trends of Change

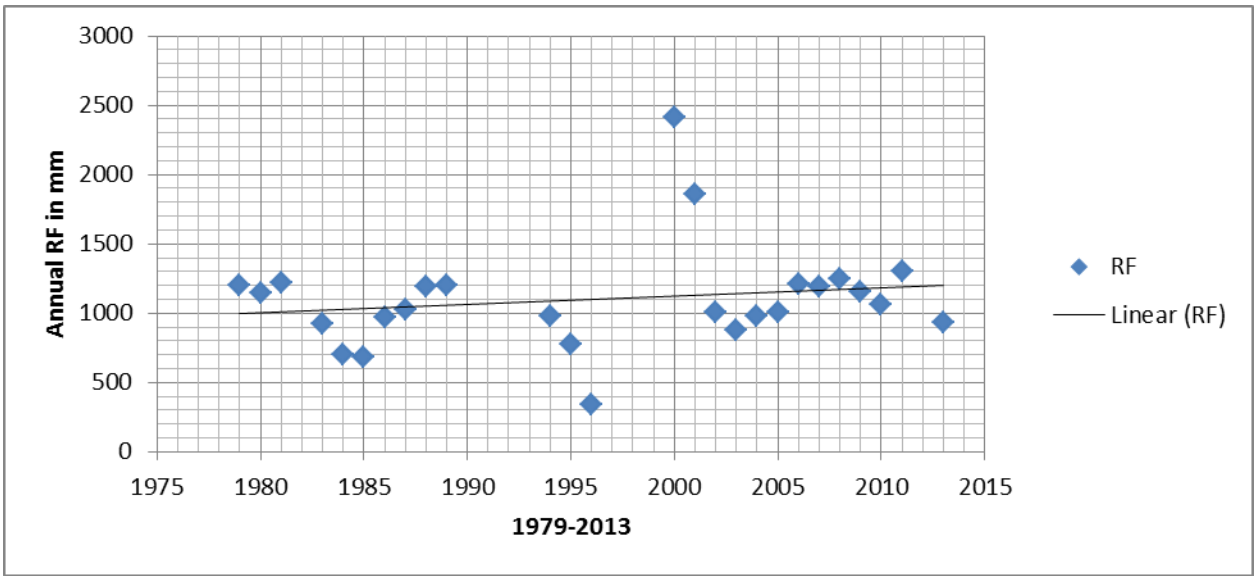

Figure 7: Inter-annual Total Rainfall Patterns and Trends of Change

Data source: NMA

The annual average rainfall of the district is 1178 mm and the rainfall is characterized by alternation of wet years and dry years in a periodic pattern. Of the 26 years of observation, 15 years (58%) recorded below the long-term average annual rainfall amount while 11 years recorded above average. Most of the negative anomalies have occurred during the 1980s and from 2002-2005. Between 1980 and 1996 the annual rainfall has been below the long-term mean, except the years of 1988 and 1989 when rainfall was slightly above the mean. The 1996 rainfall amount emerges as the lowest on record in the district, showing the worst drought year in the region. Rainfall has shown some recovery since 2000, from the low values of the 1996 to the highest value in the region.

Metrological drought in the study area

The National Meteorological Service Agency of Ethiopia (NMSA, 1996a cited in Demeke, 2010), defined meteorological drought years based on seasonal rainfall anomaly. According

to NMSA drought occur over a region if the negative anomaly from the mean seasonal rainfall is19% or more, but less than 21%. Further droughts are classified as moderate and sever if the seasonal rainfall deficiency is between 21% to 25% and more than 25% respectively.

Based on this criterion, it was found that the area has experienced a number of drought years. In the period between 1979 and 2013, 4 sever (1984,1985, 1995,1996 with 36%,38%, 30% and 69% seasonal deficiency from mean annual rainfall) droughts and 1 moderate drought with 20% anomaly occurred in the main rainy seasons. This indicates the frequency of drought has been once in every 10 years. This clearly indicates that the frequency and severity of drought increased over time. Generally, as can be seen from figure 7, the frequency and severity of drought has increased in main rainy season.

Changes in the seasonality, distribution and regularity of rainfall were more of a concern than the overall amount of rainfall. The main rainy season is also seen as becoming progressively shorter - it starts later and finishes earlier than it was – and the rain in general are becoming more unpredictable. The 26 years data reveals that in 58% of the years, the rain has begun late and in 63% of the years, the rain has stopped earlier than the main rainy season.

Temperature variability and trends

According to NMSA (2007), the average annual minimum temperature over the country has increased by about 0.37 ^{0}c, whereas, average annual maximum temperature has increased by about 0.1^{0}c every decade (NMSA, 2001). The observed temperature distribution in the region in which the study area is found (Mankush, Sherkole, and Kamashi meteorological stations) was characterized by a general trend of increase and vivid inter-annual variability.

As depicted in figure 8 below, the average of maximum and minimum temperature has increased by about .34^{0}c and .1^{0}c from the base year 1979 which is much closer to the national average.

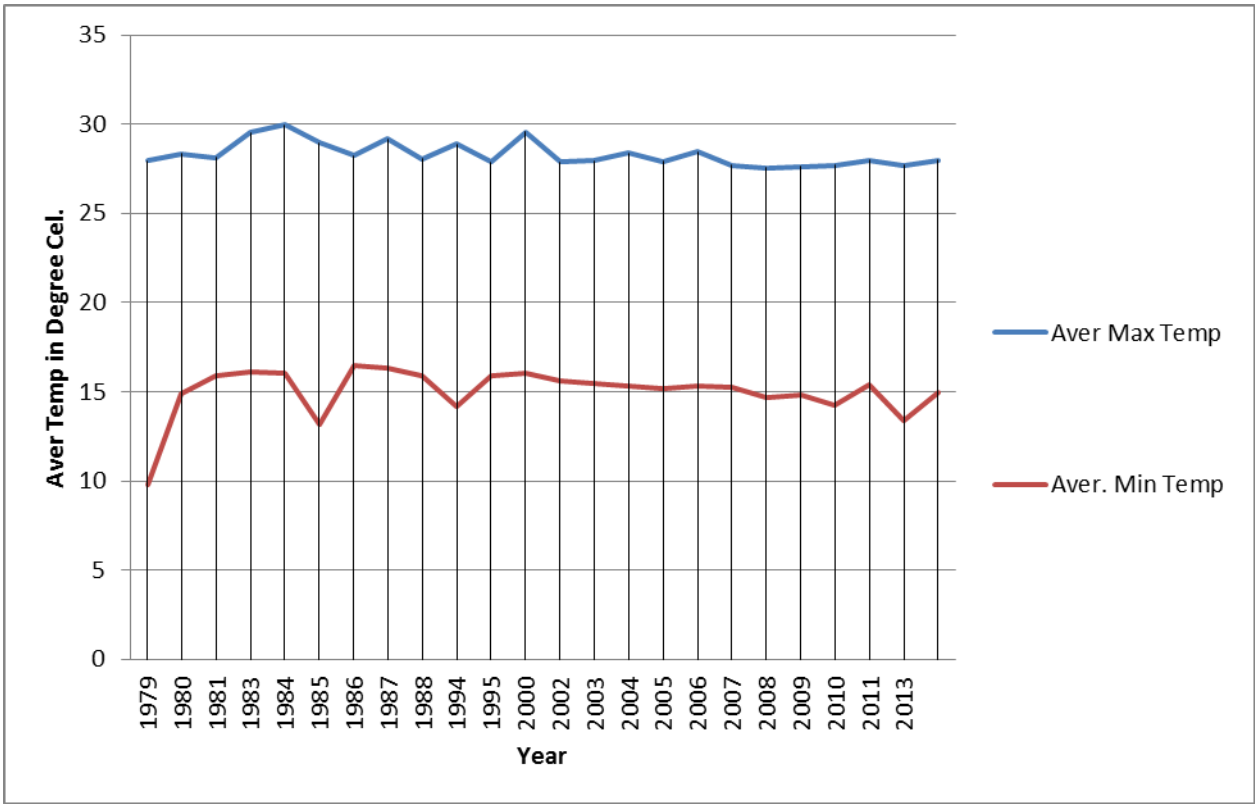

Figure 8: Patterns of annual average maximum and minimum temperature in the study area.

Data source: NMA

This findings, which is done on the basis of meteorological observed data for temperature and rainfall is found to be consistent with the perception of local people in which they indicated that there has been an increasing trend of temperature and rainfall variability in their area.

4.4Local peoples' perception of climate change

Understanding of local peoples' perception to climatic variation is crucial to designing appropriate adaptation and coping strategies to climate change and variability for many poor countries that are highly vulnerable to the impact of climate change and variability (Maddison, 2006 cited in Demeke, 2010). In line with this, FGD participants, key informants and household respondents were asked about their understanding of climate change and its impact. Most of the respondents reported that there have been a number of years with rainfall variability (intensity, magnitude, distribution etc) over the past 20 years with varying degrees of effects and implications on food, feed and water security and the sustainable livelihoods. In addition, the respondents have expressed their opinion about the changing climate and described it through irregularity of rains, decrease of river flows, increase of temperature, emergence of new livestock and human diseases, reduction of agricultural production, increase of wild animal invasion such as apes and wild rat and by increased incidences of wild fires. According to their response, in the past the climatic situation of their area was suitable for many livelihood activities of the community on which they depend up on. For instance, harvests from agricultural activities were sufficient for household consumption and marketing the surplus production. This was mainly due to the availability of reliable and sufficient rainfall (before 20 years) and absences of extreme hazards associated with climate change such as animal disease and crop pests. Besides, as a result of good rainfall, they mentioned that the perennial rivers have supported them to undertake multiple cropping practices. Moreover, the existence of dense and vast forest was vital to stabilize the micro-climate and was used as a source for many wild foods to support the communities' food need during bad times.

The below summary points from FGDs clearly show the manifestation of increased frequency and magnitude of climate variability and corresponding impact in recent years in the special district of Maokomo: These are;

- Erratic and uneven rains;
- Crop failure and a general reduction in agricultural production and productivity;
- General water stress and scarcity; leading to travel over long distances by women and children in search of water
- Increased heat waves
- Increased land degradation, mainly due to forest fire and disappearance of some important indigenous tree species with medicinal and nutritional value for humans and animals
- Increased livestock disease and decreased disease resistance and productivity of livestock,
- Food insecurity and increased human diseases

All participants of FGDs, key informant and expert interviews recognized that there has been continuous change on the amount of rainfall, its timing and distribution in the study area over the past 10-20 years.

Table 4 : Local communities understanding of climate change and its impact

Questions	% of respondents
Climate in Maokomo has changed when compared to years before 10-20 years	97.9%
Representation of climate change in Maokomo by respondents	
Air became hot than it used to be	83%
More amount of Rainfall (RF) than it used to be	39%

Low amount of RF than it used to be	79%
Sometimes high and sometimes low RF than it used to be	83%
Late start of RF than it used to be	72%
Late ending of RF than it used to be	53%
Short rainfall period than it used to be	71%
Long RF period than it used to be	41%
More mosquito and other disease outbreak than it used to be	69%
Crop yield decline	87%
Death of livestock	69%
Extreme flooding than before	49%

The survey result reveals that 97.7% respondent household heads included in the survey perceived a long-term change in the climate of the area, particularly change in pattern of rainfall amount and distribution. Most of the household heads (79 %) showed that rainfall amount in Maokomo district in the past 10 years showed a decreasing trend, 83% of the respondent indicated that the rainfall patter has been variable than it used to be, 72%, responded that the rainfall starts at late period of rainy season and 71% perceived the rainy season to be too short.

Moreover, in the survey, local people were asked to tell indicators they have been using to understand about changes in rainfall over the last decade. Accordingly, 87% of the respondents indicated that there has been a decline in crop yields, 69% indicated increased loss of livestock, 49% increased frequency of occurrence flood and 69% showed the

incidence of mosquito and other diseases outbreak than it used to be in the area over the past 20 years.

The result of trend analysis made using climate data on precipitation is in harmony with the respondents' perception about decrease of rainfall amount and general rainfall variability, increase in flood and drought frequency, shortened growing period, decreased available water, decline in agricultural yields, loss of some animal and plant species and change in the timing of rains. Besides, the findings from peoples' perception is in congruence with the result indicated in the analysis of meteorological data which reveals that in 58% of the years, the rain has begun late and in 63% of the years, the rain has stopped earlier than the main rainy season.

Analysis from household survey reveals that almost all of the respondents perceived that there has been long-term change in climate over the past 20 years. Out of which, 83% recognized that there has been an increase in temperature.

In the survey, participants of the study were asked to identify some of changes they have observed in the environment resulting from changes in temperature over the past couple of decades. Consequently, they witnessed the prevalence of newly introduced human and animal disease, introduction of new plant and animal diseases that were not common in the area, drying up of perennial rivers and streams and damage of crops caused by pests to be some of indicators. FGD participants also showed increasing water stress, loss of indigenous seeds and foods as indicators of increasing temperature in the area. In the FGDs and key informant interviews, elders and government experts indicated that the temperature pattern has been changing in an increasing trend and intensity.

4.5 Peoples' perception of impacts and tangible actions for building resilience

Table 5 : People's perception of impacts of climate variability

Impacts of climate variability	% of respondents	Year of Occurrence
Crops are sometimes failing	92%	Since 1996
Crops are totally failing	64%	1996
Production per ha is decreasing	89%	1996/2002
Production per ha is increasing	10%	
Crop disease and weeds are increasing	69%	1996
Increased problem of livestock disease	65%	1996
Increased problem of seasonal flooding	49%	

Most of the household survey respondents in the study area associated the cause of climate change to be due to human induced actions. With respect to the impact of climate change, 92% of the respondents showed that there has been crop failure sometimes, whereas 64% indicated about total crop failure especially in year 1996. Significant (89%) portion of households also explained that has been decrease in production of crop per hectare since year 1996 when the amount of rainfall was completely far below the average and where the rainfall anomaly deviated by 69% from mean annual rainfall. Related to this, 69% the survey participants responded that there has been an increasing incidence of crop diseases and weeds and 65% mentioned about increased occurrence of livestock related diseases

During a key informant interview, when a 65 years old man was asked about the trends of the climatic condition before 10-20 years from now, he explained that the climatic condition of the area was suitable for their livelihood activities, since rain was coming and going on

regular basis, in addition to its normal distribution and intensity. Besides, during dry seasons, rivers were providing them with sufficient amount water to support irrigation scheme. Moreover, the soil was fertile and used to support agricultural practices to produce enough food for the household consumption and marketing surplus. Above all, the weather condition was convenient for human lives since the temperature was conducive. But since 20 years, change in climate is happening and this has been manifested through irregularity of rains, increased temperature, occurrences of new livestock diseases (blacklegs, anthrax, trypanosomosis) and human diseases (vector born like malaria, water-borne diseases), increased infestation of crop and fruit disease and pests, reduction of crop production, reduction in the availability of wild fruits and roots and invasion of wild animals. The informants mentioned some of the reasons for climate change to be deforestation activities for firewood, timber production, agricultural land expansion and wildfires.

Moreover, during FGDs, the respondents indicated that previously rainfall begins in February and ends in October but now the actual start date is pushed forth by at least two or three months and its distribution and intensity is also reducing. The temperature is showing increasing trend since the forest coverage and density is deteriorating when it is compared to the past time. These all have resulted in the loss of harvest, crop failure in agricultural fields, death of livestock and reduction in their productivity, among others, and have been affecting families' food security status and resulted in asset depletion. The community members were surviving the situation by selling livestock, by changing household food consumption pattern and variety and through share cropping with farmers who have irrigation scheme were some of the options adopted and deployed to survive such bad periods.

Survey result of household respondents on the perception of the communities about the causes of climate change is related to human activities. More than 80% of the respondents showed that loss of forest due to forest fire and change in land use are the main causes of climate change in the study area (Fig 9). The remaining 20% of the respondents attributed the cause of climate change to failure of development actors to undertake various afforestation works.

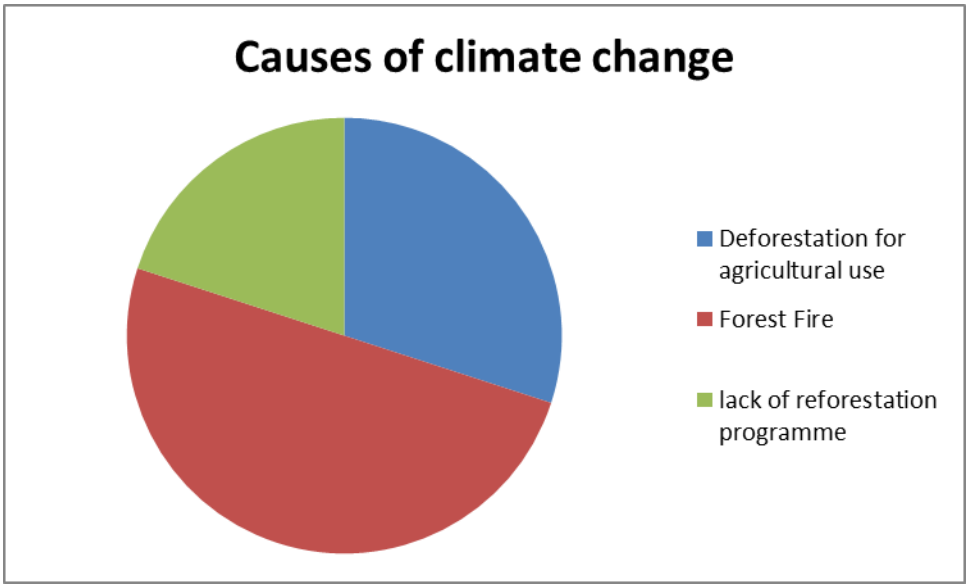

Figure 9: local peoples' perception of cause of climate change in Maokomo Special District, 2015.

4.5.1 Main Hazards due to changing climate

In the study area, rainfall variability, pests and disease and forest fire are recurring problems affecting agricultural activities and human wellbeing. Nearly all of the respondents assured the existence of the following climate change induced hazards.

Rainfall variability; is not a new phenomenon in Maokomo district. The area experienced several periods of rainfall variability over the past years. According to a FGD conducted in 2 sub-districts (kebeles), the respondents stated that the recurrence interval of variability of

rain has changed in recent periods. The re-occurrence interval has become more frequent and takes only 4-5 years, giving no sufficient time to recover from its past impacts. The rainfall variability was characterized by insufficient amount of rainfall, uneven distribution over the rainy season, late coming and early ceasing of rain and this has been one of the most important causes of acute food insecurity in the area.

The district's rainfall is uni-modal and obtains rainfall from May to October but featured by poor distribution, late coming by at least 2 month and insufficient amount. This has adversely affected land preparation and sowing of long cycle crops.

Considering 26 years' annual total rainfall data of Assosa meteorological station, the average annual rain fall was found to be between 340mm and 2417 mm respectively. This implies that the rain fall amount for the area that changes in the seasonality, distribution and irregularity of rainfall were more of a concern than the overall amount of rainfall.

Pests and diseases; according to Benishangul-Gumuz Region Food Security Strategy document 2011, many people are seen to be exposed to human induced and natural disasters. Long cycle crops, maize and sorghum, do cover the lion share of food needs of the region in terms of annual production. Unfortunately, the delay in planting of these crops, due to the delayed onset of the rains necessitates an extension of the rains up to mid-November. Delayed plantation subjects the crops to insect pests, weed infestation and poor field management due to overlapping of agricultural activities. These in turn forced farmers to undertake inadequate crop field management activities like weeding and cultivations useful for better crop production. Invasive weeds and species such as striga, partinum and dodder and seasonally invading rodents/termite/worms are the most important hazards that

undermined crop production and food security. Pests are doing lots of damage to crops. Shifting cultivators have been at risk due to their continuous movement in search of virgin land where these pests are more likely to occur. Smallholder farmers have also limited financial capacity and options to mitigate the impact of climate change on prevalence and spread of pests and diseases (Aklilu & Alebachew, 2009a).

In line with this, as explained during FGD, among observed new diseases of livestock in the areas include are Anthrax, Black leg and Trypanosomosis are the main diseases that are affecting the major livestock assets owned. These diseases where not common to the area in the past, but in recent years, they are becoming more and more prevalent and are affecting livestock reserve. Besides, such disease like Newcastle disease which was not very widespread is also becoming more prevalent and is killing poultry species. In addition, pests which were not known to the area are being seen and are affecting banana production, the important fruits of farmers both as income and food sources. According to the perception of the group discussants, all these incidences are caused due to the changing climate as a result of human induced activities such as rampant forest fire and deforestations. Currently, crop pests are seen every year and these are becoming more challenging on the efforts being made towards household food security and profit making by damaging and reducing harvests. In the past, animal diseases were sporadic but now becoming epidemics and thus they are resulting in the loss of assets and drought powers.

Forest Fire; the natural resource base and the diverse fauna and flora of the area have got diminished than ever before due to recurrent forest fire where stock of the woody biomass has got dried through temperature rise. Nowadays since the dry season is longer, due to

climate change, the frequency of the forest fire has increased to twice a year. Due to a deep rooted habit of the community in setting forest fire, this hazard is one of the most chronic challenges accounted for a significant destruction of the ecosystem and biodiversity. (BGRS-BoEPLAU (2011). According to FGD with the communities, the main causes for forest fire was found to be human induced which is aggravated by intense heat waves caused by increasing temperature. Some of the causes of forest fire, which are exacerbated by heat wave and dry moisture, are burning of grasses (Savannah grasses) by communities with the purpose of getting new grasses for their cattle, paving ways that give access in to the forests, lack of understanding about the impact of fire on their forest resources, land preparation for agriculture, self-protection from reptiles, honey collection, cooking wild roots etc.

4.5.2 Impacts on agricultural production and livelihoods

Climate change and variability have had serious impacts on crop and livestock production in Maokomo Special district as the livelihood of the people is dependent on crop production and animal husbandry. According to interview result with Maokomo Agricultural office experts, climate change and reoccurrence of climate variability, early cessation and late onset of rain, heavy and unseasoned rain and pests have caused massive crop failure, shortage of animal feed, animal and crop disease which as a result led to reduction of production and productivity. As per household survey respondents' opinion about the impacts of climate change induced hazards in Maokomo, as shown in table 5, the most commonly mentioned impacts of climate change were found to be crop failure, decrease in crop production per hectare, increase in crop disease and weeds, increased problem of livestock disease and increased problem of seasonal flooding .

Similarly, some of the impacts of climate change on livelihood of the people reported by FGD participants include; reduction of crop and animal production, intensification of pests and diseases, drying up of perennial rivers, scarcity of feed for animals, loss of some indigenous trees such as bamboo. During the discussion, one participant indicated that they have lost their means of production which are cattle due to animal diseases and are forced to plough by hand. In general, the group discussant mentioned that, some 15 years back, their community used to have sufficient food for their families, but these days they are almost food insecure.

Generally, the households in Maokomo are facing declining trend of crop and animal production because of erratic rainfall, intensified occurrence of pest and diseases and increased temperature. As a result, considerable portions of the households are exposed to food shortage.

4.5.3 Impacts on natural resources and the environment

Focus group discussion participants, community representatives and district experts indicated that natural resources like rivers, land and forests, which are the most important resources for their agricultural activities, are showing progressive decline in quantity and quality from time to time and this was explained through the following changes:

- Reduction of water volume of rivers and drying up of steams which have been providing them with ecosystem services such as for irrigation activities and other economic activities.
- The area used to have dense forest coverage of indigenous tree plants but now due to dry moisture and heat waves which has exacerbated the forest fire and uncontrolled farming

practices, the resource has been diminishing. As a result of this, soil degradation, reduction of land productivity and increase of temperatures have been observed.

Furthermore, participants of the group discussion indicated that soil erosion and degradation is one of the most common phenomena in the area and consequently this is affecting the productivity of crop production. Coupled with this, livestock rearing activity is facing difficulty due to shortage of feeds and animal diseases. Moreover, due to rampant deforestation and forest fire, wild edible foods which were more abundant in the area in the past, are becoming scarce and thus this has been a challenge for households' and communities' coping mechanisms, as wild foods (roots, fruits and leaves) were one of the sources used to fill the food gaps during the time of food in security.

In order to maintain these resources which are the base for many of their livelihood activities, communal and household level natural resource management initiatives are being exercised with the support and facilitation of different development actors like government, Non-government organizations such as Green Development Institution, Christian Aid, Education for Development and Assosa Environment Protection Associations.

The added benefits of these actors include awareness raising on natural resource management, rehabilitation of degraded lands, establishment of nursery sites, distribution of native tree seedlings, promotion of agro forestry activities.

4.5.4 Community groups affected

According to district expert group interview, it was indicated that women and children are found to be the most vulnerable group of the community due to the fact that they have several household responsibilities and dependent on low level of income generated from

crop and livestock production, which are both dependent on climatic conditions. In addition, they are taking care of young children, fetching water, collecting firewood and cooking food for the family. Hence, the impacts of climate change has created additional burden on women and children. In addition, the Regional Health Bureau (2007) indicated that women, specifically lactating and pregnant mothers are the most susceptible social groups, since according to the existing cultural beliefs; women are the last to eat in terms of intra household food allocation.

4.6 Responses to climate change

4.6.1 Adaptation Strategies to the impact of climate change

For many years, the local people of the study area have been struggling against the impact of different types of natural hazards. In order to adapt to the impact of climate change hazards, which are noted in the preceding sections, the local communities have been applying different adaptation strategies. However, the increased frequency and intensity of climate change impacts have reduced the capacity of local people to adapt and cope with the problems. As per the findings from FGD and KII, the important activities being undertaken by farmers to adapt to changing climate are use of irrigation technologies, applying different soil and water conservation methods, use of improved seed varieties, shifting their plantation time, use of early maturing seed varieties, use of inter cropping, applying agricultural inputs like herbicides and insecticides and treating and vaccinating animals are among the vital strategies used. In addition, it was explained that the communities are using such coping mechanisms as planting of diversified crop varieties and integrating fruit trees, engaging on off farm activities such as petty trades are the main strategies being applied by

the community. Moreover, the participants explained that they are using the following coping and adaptation mechanisms to the impacts of climate extremes;

- Changing of food preferences,
- Selling of livestock to withhold the situation temporary ,
- Reduce the number of meals,
- Use of stored food,
- Access credit from relatives
- Feed the most susceptible groups like children and young first,

In line with actions taken, household respondents were asked the following questions for the adaptation practices.

Table 6 : Adaptation strategies of small holder farmers

Actions taken by household to adapt to rainfall variability impacts?	**% of respondents**
I constructed hand-dug wells for irrigation and HH consumption	31%
I started to employ small scale river/stream diversion irrigation	42%
I started to use drip irrigation	17%
I constructed water harvesting reservoirs	22%
I constructed soil and moisture conservation structures such as terraces, micro basins, etc	42%
I started to use short maturing crop varieties	58%
I have started to grow less water requiring crops	37%
I have adjustments in time of planting and harvesting in response to time and quantity of rainfall	42%
I started to grow marketable agricultural products such as vegetables and fruits	34%

I started to preserve fodder and use cut-and-carry method for livestock feeding	39%
I started to preserve grains to use them during food shortage	31%
I started non-farm livelihood options	24%
I started to deposit/save money in financial institutions	25%
I reduce the number of livestock by selling and/or slaughtering before the impact of drought occurs	17%
I constructed shelter for livestock to reduce heat stress	41%
I have involved in community actions for drought impact reduction	79%

Local people adopted a wide range of response measures to counteract the impacts of climate change induced-hazards. According to their responses 42% of them engaged in conservation activities such as reforestation, terracing, micro basin construction, 58% started growing short maturing crops and 42% have adjusted time for planting and harvesting in response to time and quantity of rainfall, while 34% started to grow marketable agricultural products such as vegetables and fruits, 31% started to preserve grains to use them during periods of food shortage and 42% implement small scale river/stream diversion for irrigation.

In addition, it was indicated that 58% of the respondents changed their cropping pattern and 42% applied the uses of early maturing varieties. Since rainfall in the study area is becoming very erratic and unpredictable in recent years, farmers could not be certain about rainfall condition even after the onset of rain. According to them, even after the onset, rainfall could be heavy or light or it may stop earlier than the expected time.

Growing short maturing crops**:** More than 58 % of the households plant early maturing crop types. According to FGD participants, early maturing crop are planted due to shortened growing season in the study area.

Rainwater harvesting for growing crops is another viable option to compromise scarcity of water. Hence, 22% of the respondents are practicing rainwater harvesting to curb the problem of food scarcity that resulted from erratic rainfall by growing vegetables in homesteads.

Diversification of household income sources is a method used by local people to increase their income to compensate the amount of earnings lost due to decreased agricultural productivity. The household survey showed that about 22% of the total households reported that they were engaged in non-farm activities because of climate change (Table 6). Of the total respondents 33% engaged in wage labour by migrating to other areas.

Result of FGD, community representatives and agricultural office experts also showed that local peoples were more engaged in non-farm activities to subsidize their agricultural income. Wage labour, petty-trading, charcoal making, firewood selling, handcraft and others are among the activities in which local people engaged.

In addition, the local communities are using such coping and adaptation mechanisms as reducing numbers of meal, selling assets, receiving loans, earning money or else from daily labour at time of food shortage, reducing the number of livestock by selling and/or slaughtering before the impact of drought occurs, preserving fodder through cut-and-carry method for livestock feeding, and growing marketable agricultural products such as vegetables and fruits

4.6.2 Coping strategies to climate change impact

Contrary to adaptation strategies adopted, as shown above, by the small holder farmers which is planned, long term and continuous process, they have also been using various traditional coping mechanisms which are short-term and immediate, oriented towards survival and motivated by crisis. These coping mechanisms have often been degrading the resource base of the farmers and prompted by a lack of alternatives.

According to the house hold survey result, 66% of the respondents indicated that they were forced to reduce the quantity of household meals, 39% were obliged to shift their farming lots and 40% of the households had to use grain stored at home. In addition, some of them (28%) reduced the number of their livestock as a coping mechanism and 33% had temporarily migrated in search for wage labour.

Table 7 : Farmers' coping strategies to changing climate

No	Coping Strategies	Percentage
1	Reduced quantity of household meals per day	66%
2	Change crop variety	44%
3	Shifted my farming lot	39%
4	Early planting of crops	44%
5	Late planting of crops	32%
6	Diversified crop cultivation	27%
7	Shift from crop to livestock	14%
8	Sold livestock	22%
9	Reduce number of livestock	28%
10	Sold other assets	23%
11	Used grain stored at home	40%
12	Used money deposited	31%
13	Walked long distance to fetch water	23%
14	Temporarily migrated in search of wage	33%
15	Borrowed money to meet HH needs	14%
16	Sought gifts from relatives/friends/networks	9%
17	Permanently migrated	9%
18	No adaptation method used	18%

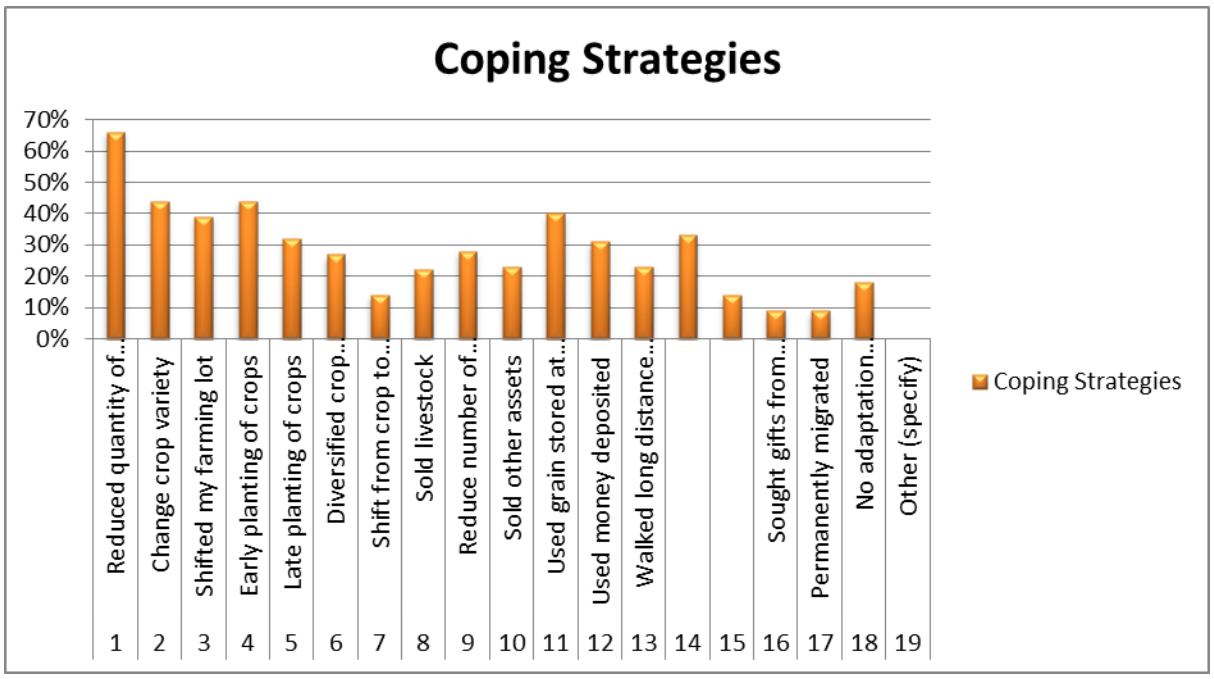

Figure 10: Traditional coping mechanisms of small holder farmers

4.7Barriers to adaptations

As shown in the above sections, a large number of local people perceived that climate has become hotter and drier. In light of this perception, significant number of respondents has been employing various adaptation strategies and has been using coping mechanisms. Regardless of all these efforts, local adaptation options have not sufficiently addressed their challenges and not fully helped them to build their resilience capacities due to several barriers. 89% of survey respondents confirmed that they have multiple constraints to adapt to the impact of climate change**.**

The survey assessed about local peoples' perceived barriers to use various adaptation options and the results obtained from household respondents, FGDs, experts and key informants shows that poverty, lack of appropriate input supply, expensiveness of

technology options, lack of information about the weather or long-term climate change, lack of knowledge on how to adapt and poor potential of land for irrigation were found to be some of the major constraints of adaptation for many peoples in the study area.

Table 8 : Barriers to adapt to climate change

No.	Main constraints to adapt to the impact of climate change	Percentage
A	Lack of weather and climate information	68%
B	Lack of knowledge on how to adapt	71%
C	Poor potential of land for irrigation	91%
D	There is no hindrance to adaptation	13%
E	Others	

Information found from FGD and KII clearly focused on the following barriers that have been compromising the adaption capacities of local communities. These are;

Lack of Access to information*:* - FGDs and KII respondents indicated that access to information about improved agricultural related practices and market information to be one of the problems to undertake adaptation options. According to them, access to information about different crop varieties that can better tolerate rainfall scarcity and variability and use of improved agricultural methods and technologies are among the information they lack. They indicated that improved variety seeds (crop) and fertilizer are being distributed (delivered) to them through quota system. Respondents also reported that there is lack of market information for their production, which discouraged them not to be more productive.

Lack of climate information*:* - This is one of the most significant barriers to adapt in the study area. The respondents and agricultural experts found in the area mentioned that lack of access to timely meteorological reports (information) is one most pressing constraints for making adjustment to their planting dates. Weather forecasts related with onset and/or offset of rains have been only communicated irregularly and less frequently. They also mentioned

that the weather information that they rarely get for pre-harvest is very general and lack specificity. This adversely affected the accuracy, trustworthiness and acceptability of meteorological reports.

Lack of agricultural technologies and inputs*:* - Substantial number of respondents considered lack of appropriate agricultural technologies and inputs as a barrier that constrained them not to change cropping pattern by introducing new and high value crops, diversify crops in their farms, improve farm productivity and use of fertilizers.

Water Stress*:* - Water stress was mentioned as one of the most critical constraints to climatic change adaptation. Irrigation, digging water wells and rainwater harvesting are some of the potential adaptation measures to reduce climate related impacts especially rainfall variability. Although the farmers are well aware of the importance of application of small-scale irrigation, digging wells, etc., most farmers could not employ them because of financial constraints and lack of access to credit facilities in the area.

Feed and Forage scarcity*:* - both crops and animals have been susceptible to climate change and variability and diseases. It was pointed out that in time of forage and water stress, livestock have been found to be less resistant to such diseases as trypanosomaisis.

Lack of health services*:* - A considerable proportion of the respondents and FGDs participants indicated the lack of animal health care centres and poor service in the area as one of the major constraints to adjust and improve livestock management. Due to increase of temperature from time to time, livestock have been exposed to different animal diseases. According to reports produced by the region, malaria is the number one cause of mortality due to favorable climate and the topography of the region (Facts about BGRS, 2007). The Regional Bureau of Health (2007) also noted malaria as the major cause of illness and death

in the region. The prevalence and trends of malaria has been severe during pre-harvest time, from July-October, when the rural majority face food shortage and during the entrance and end of the rainy season where the conditions favor vector multiplication. In addition, according to study conducted by the region, (Regional Bureau of Agriculture and Rural Development, 2005) animal health threats specifically trypanosomiasis, has been severely undermining livestock production and thereby household food security. It was noted that trypanosomiasis is the most important livestock killer in the region

CHAPTER FIVE: CONCULUSION AND RECOMMENDATIONS

5.1 Conclusion

The survey result reveals that most of the smallholder farmers perceived long-term change in pattern of rainfall variability, distribution and change in season and an increasing trend of temperature. Their perceptions about climate change and variability is in line with the result of historical climate data. Communities of Maokomo district have been facing climate variability and change which impacted their agricultural production and this impact has become more serious as there has been more climate variability and change-induced disasters as compared to the situation in the past. Generally, the people in Maokomo district are facing declining trend of crop and animal productivity because of erratic rainfall, increased temperature, increased incidence of forest fire, intensified occurrence of pest and diseases and environmental degradation.

The rainfall variability cycle and reoccurrence interval has become shorter and prevails almost every 4- 5 years. The assessment results indicated that crop pests and human and livestock diseases are becoming common phenomena across the district. However, climate change resulted in an increase in the frequency of occurrence of pests and diseases in recent years. The disasters have caused increased vulnerability to poverty, food insecurity and loss of productive assets. Production of crops and the number of livestock owned by households has decreased considerably over the past two decades.

Women and children are most affected by the impacts of climate variability and change-induced hazards in the study area. Since girls and women are responsible for carrying-out routine household activities, the hazards have created additional burden and made them more vulnerable to the impacts.

In order to adapt to the impact of climate change hazards the households and local communities have applied different adaptation strategies. However, increased frequency and intensity of climate change impacts have eroded the capacity of local people to adapt and cope with the problems. The ever-increasing climate variability and change have challenged the coping and adaptation strategies. Some of the coping strategies such as selling assets, charcoal making and fuel-wood selling are not only unsuitable but would also cause more depletion of assets, resource degradation and even desertification. Hence, institutional support is vital to reduce the impacts of the hazards. The NGOs operating in the study area have been providing some assistance to communities in terms of introducing climate smart agricultural practices and technologies, supporting community innovations that help them to build resilience, practices of ecosystem maintenance, asset protection, livelihood diversification and natural resource management.

Though the contribution is encouraging, most of the efforts are not sufficient enough in comparison to the magnitude of the problem in the region. The government has also been playing significant role in introducing adaptation strategies to climate variability and change impacts. The government encouraged communities to mitigate climate variability and change by way of introducing and/or enhancing soil conservation measures, climate smart agriculture, building health centres, developing small-scale irrigation and rain water

harvesting schemes, expanding fertilizer use, enhancing access to markets, education and training (farmers training centres, formal education), strengthening off-farm activities and establishing local meteorology stations, monitoring and publishing climate data, developing climate forecasts, and formulating planned and anticipatory adaptation strategies.

Without strong coordination and cooperation among all actors and stakeholders, neither the farmers' responses nor NGOs and government intervention will sufficiently address the complex impacts of climate variability and change. In this regard, all governmental, private sectors (who are engaged in agricultural and non-agricultural investment activities) and non-governmental institutions have fundamental role to play in developing appropriate adaptation strategies to climate variability and change impacts.

5.2Recommendations

On the basis of this study, the following recommendations are drawn to reduce the effect of climate variability within the study area:

- ***Forest ecosystem protection and maintenance*:** The areas that need immediate intervention, among other things, are prevention and control of forest fire, which is one of the major causes for the loss and damage of forest biodiversity, reduction in the availability of water resources, deterioration of soil fertility and hence contributed to the decline of agricultural productivity. In addition, there need to be efforts for rehabilitation of degraded lands and introduction of new climate smart agricultural systems**.**
- ***Improve Agricultural Production systems*:** With the ever-increasing climate variability, the problem is assumed to continue in the future unless appropriate measures are taken. Hence, crop diversification, selection of appropriate variety of crops, improving method

of cultivation, introduction of agro-forestry practices and agricultural technologies and promotion of integrated pest management are areas of critical concern. Moreover, ***irrigation activities*** should be implemented in areas where there are still perennial rivers, as this helps to overcome the hazards created on agricultural sector in the periods of rain variability.

- ***Introduction of areas specific weather forecasting method***s and information dissemination systems through different development actors and establishment of weather stations are needed to exactly record climate variables. High level coordination among institutions responsible for weather forecasting and organizations that can provide timely and location specific information and local development actors who can facilitate the implementation of practical actions is required. Given that different types of crops have different weather requirements, weather forecast information need to focus on specific crop responses and adaptations strategies.
- ***Improve the*** **coverage and quality of climate data**: Meteorological stations in Ethiopia are few in number; hence density of networks of stations is very sparse. Data for most of the stations is very scant and incomplete. Due to this fact, there is no reliable detailed information on aspects of weather forecast services and climate of the area. Climate data is necessary to enhance the understanding, analysis and prediction of climate change and its impacts and for improved preparedness and adaptation. It is therefore necessary to improve the coverage and quality of climate data in the study area in particular and in the country at large.
- ***Diversification of livelihood and asset protection*****:** The recurring and increasing trend of rainfall variability and temperature rise and associated reduction in agricultural

production in the project areas have forced the community to use unsustainable agricultural strategies. These have consequently eroded the households' resilience capacity and have increased vulnerability to further shocks. Protecting the vital livestock, prevention and control of forest fire and rehabilitation of environmental resources, in order to enhance local adaptive capacity and resilience, needs to be focused. Diversification of household income sources on the basis of available resources, community knowledge/skills and market availability is also a necessary step to minimize vulnerability to climate variability and change shocks. For this to be materialized, farmers should be encouraged to take part in off-farm activities such as petty-trading, traditional gold mining, engage in handcrafts and value addition activities. Improving extension services and training and credit facilities are also some areas of major concern that largely require the attention of development actors.

- ***Use such sustainable livelihood models as Thriving and Resilient Livelihood Framework*** of Christian Aid to develop/design new livelihood interventions for diversification. The model analyses and evaluates new interventions from different perspectives and pillars. It focuses on the aspects of ***profitability*** (including backward and forward linkages), ***sustainability*** (both environmental and business), ***resource and risk management*** capacity of the farmers, ***adaptability*** to the changing climate, ***health and wellbeing***, where the livelihood intervention should allow people to live with dignity and does not compromise their health.
- There ***should be promotion and education activities to enhance*** farmers' ***awareness*** and ***participation*** as it is highly needed to understand vulnerabilities, causes of their vulnerabilities and to draw community action plans. Such tools as Participatory

Vulnerability and Capacity Assessment (PVCA) and (BRACED Participatory Approach (BRAPA) which are commonly used by organizations like Christian Aid can help communities to participate and to understand climate vulnerability and find comprehensive solutions. These approaches have been found to be very effective especially in designing and implementing climate change adaptation efforts.

- ***Empowering local people with information and education*:** Creating and expanding awareness among the population, private sectors and policy makers about climate change, its causes and consequences by providing reliable and up to-to-date information are important steps to take appropriate adaptive measures.
- ***Build on traditional adaptation strategies and practices*** and indigenous knowledge on such areas as natural resource management, protection of forest fires etc. Interventions need to build on existing knowledge and coping strategies in order to ensure sustainability of their activities. Therefore, before planning interventions, a proper assessment of locally available adaptations options and coping strategies should be considered and build upon indigenous knowledge. Development practitioners have to use different models and approaches for assessing vulnerabilities, capacities of the communities and understanding of indigenous adaptation strategies.
- **Foster institutional linkages for livelihood sustainability**: Concerted actions by the national and regional governments and NGOs are needed to tackle the impacts of climate change. The ever-increasing climate variability and change impacts would require institutional involvement and integrated effort to enable rural livelihoods survive in the changing climate and its adverse impacts. FTC expansion and strengthening will enable development agents (DAs) to render better extension services to farmers.

- In the future, similar studies should be conducted which adequately address the issue of vulnerability to climate change, adaptation and the relative merit of each adaptation option to better inform policy options for adaptation to climate change and to develop a locality specific adaptation menu, which is able to account for impacts of climate change and variability of the target community. In addition, the detail impact of climate change on agricultural production would be better studied with time series climate data. Hence continuous climate data collection and recording should be maintained.

REFERENCES

- UNFCCC (2007); Climate Change: Impacts, Vulnerabilities and Adaption in Developing Countries.
- United Nations Development Programs Emergencies Unit for Ethiopia (2002); Joint Situation Assessment Mission to Benishangul-Gumuz Region; Assosa,
- Ahmed, A.U., 2008. Assessment of vulnerability to climate change and adaptation options for the costal people of Bangladesh. Bangladesh: Practical action.
- Aklilu and Dereje. 2010. An Overview of climate change impacts and responses in Ethiopia. Ethiopian Environment review, volume 1, 2010.
- Befekadu Degefe and Berhanu Nega (eds). 1999/2000. Annual Report on Ethiopian Economy. Vol. I. The Ethiopian Economic Association.
- Aklilu, A. and Alebachew, A., 2009a. Assessment of Climate change Induced hazards, impacts and responses in the Southern Lowlands of Ethiopia. Forum For Social Studies (FSS) Research Report No. 4. Addis Ababa, Ethiopia.
- Aklilu, A. and Alebachew, A., 2009b. Community perspective on Climate change impacts and the responses in the Southern Lowlands of Ethiopia. Forum For Social Studies (FSS) and Cordaid. Addis Ababa, Ethiopia.
- Bartlett, T. et al., 2001. "Organization Research: Determining Appropriate sample size in survey research." Information Technology, learning and performance journals, vol 9.
- (Conway et al., 2004; Kruger and Shongwe, 2004). , sited in Working Group II, Contribution to the Forth Assessment Report of IPCC, 2007

- Hulme et al., 2005; Impacts, Adaptation and Vulnerability, sited in IPCC Fourth Assessment Report: Climate Change 2007 , Working Group II.
- Fischer et al. 2002; sited in UNFCCC (2007); Climate Change: Impacts, Vulnerabilities and Adaption in Developing Countries
- Bryan, E. Temesgen Deressa, Gbetibouo, G.A. and Ringler, C., 2009. Adaptation to climate change in Ethiopia and South Africa: options and constraints. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1462901108 001263
- Burroughs, W.J., 2007. Climate Change: A multidisciplinary approach. 2rded. Cambridge: Cambridge university press.
- CamWalker., 2006. The Kyoto Protocola global response to a global crisis. FoE Bulletin. Available at: http://www.foe.org.au/climate-justice/issues/the-kyoto-proto col2 013-a-global-respo nse-to-a-global-crisis
- CIER., 2008. Climate change and first nations south of 60: impacts, adaptation, and priorities. Canada: CIER.
- Cohen, S., Demeritt, D., Robinson, J., and Rothman, D., 1998. Climate Change and sustainable development: towards dialogue, Global Environmental Change, Vol. 8(4), pp. 341–371.
- David, K., 2009. Coping with Climate change: Understanding local communities‟ knowledge and their coping strategies to climate change. A project report to System for Analysis, Research and Training. Bird life international.
- Degefu, W., 1987. Some aspects of meteorological drought in Ethiopia. Drought and Hunger in Africa. Cambridge: Cambridge University Press.

- Demeke, H., 2010. Climate variability and change impact on rural livelihoods, and local adaptation and coping strategies: The case of Wereilu wereda, south Wollo zone, Amhara region. M.A. Thesis, Addis Ababa University.
- Desanker, P.V., n.d. Impact of climate change on life in Africa.Center for African development solution. Johannesburg, South Africa. Available at: http://www.worldwildlife.o rg/climate/Publications/WWFBinaryitem4926.pdf
- Downing, T. E., Ringius L., Hulme M. &Waughray, D., 1997. Adapting to climate change in Africa: Mitigation and adaptation strategies for global change.
- FAO., 2007. Adaptation to climate change in agriculture, forestry and fisheries: Perspective, framework and priorities. Rome, Italy.
- FAO., 2008. Climate change adaptation and mitigation in the food and agriculture sector. High Level Conference on World Food Security - Background Paper HLC/08/BAK/1. Available at: ftp://ftp.fao.org/docrep/fao/meeting/013/ ai782e.pdf
- FAO., n.d. Climate change: implications for food safety. Available at: http://www.fao.o rg/ag/agn/agns/files/HLC1_Climate_Change_and_Food_Safety.pdf
- Fussel, H.M., and Klein, R.J.T., 2002. "Assessing the Vulnerability and Adaptation to Climate Change: An Evolution of Conceptual Thinking", Paper presented at the UNDP Expert Group Meeting on Integrating Disaster Reduction and Adaptation to Climate Change, Havana, Cuba.
- GLCA., 2009. Facilitating an International Agreement on Climate Change: Adaptation to Climate Change. Available at: http://www.unfoundation.org/assets/pdf/adaptat ion_to_climate_change.pdf

- Guernier, V., Hochberg M. E., Guegan J.F., 2004. Ecology drives the worldwide distribution of human diseases. PLOS Biology. Oxford.
- Houghton ,T.J. MeiraFilho, L.G. David, J. Griggs, D.J. & Maskell, K., 1997. eds. Stabilization of Atmospheric Greenhouse Gases: Physical, Biological and Socio-economic Implications. IPCC Technical Paper III.
- Houghton, J., 2009. Global warming: The complete briefing. Cambridge: Cambridge university press.
- Huq, S., 2005. Adaptation to Climate Change in the context of Sustainable Development: Background Paper. Available at: http://www.teriin.org/events/docs/a da pt. pdf
- Huq, S. et al., 2003. Mainstreaming Adaptation to Climate Change in Least Developed Countries (LDC‟s), Russel Pres, Nottingham, UK. Available at: http://www.iied.org/pu bs/pdfs/10004IIED.pdf
- IPCC., 1998. The Regional Impacts of Climate Change: an Assessment of Vulnerability. Cambridge: Cambridge University Press.
- IPCC., 2001. Climate Change Impacts, Adaptation and Vulnerability. IPCC Working Group II, Third Assessment Report. Cambridge, Cambridge University Press.
- IPCC., 2007. Fourth Assessment Report. Available at: ttp://195.70.10.65/publications_an d_data/publications_ipcc_fourth_ assessment_repo rt_synthesis_report.htm
- Leary, N., et al. eds., 2008. Climate Change and Adaptation. The International START Secretariat. UK and USA, Earth scan.
- McMullen, P.C. & Jabbour, J., 2009. Climate change science compendium. Available at: http://www.unep.org/pdf/ccScienceCompendium2009/cc_ScienceCompendium2009_full _en.pdf

- Mendelsohn, R., Dinar, A. & Dalfelt, A., 2000. Climate Change Impacts on African Agriculture. Yale University.
- NCCF., 2009. Proceedings of the First National Climate Change Conference. UNECA conference center. Addis Ababa, Ethiopia.
- NMSA., 1996. Climatic and agro climatic resources of Ethiopia. Addis Ababa. Internal Report. Meteorological Research Report Series, No. 3, Addis Ababa, Ethiopia.
- NMSA., 2001. Initial National Communication of Ethiopia to the UNFCCC. Addis Ababa, Ethiopia.
- NMSA., 2007. Climate change National Adaptation Program of Action (NAPA) of Ethiopia. Addis Ababa, Ethiopia.
- NRC., 1995. Natural climate variability on decade-to-century time scales. Washington, D.C., National Academy Press.
- NSF., 2009. Solving the puzzle: Researching the Impacts of Climate Change around the World. Available at: http://ccsl.iccip.net/nsf09202.pdf
- Nyong, A., 2005. The economic, developmental and livelihood implications of climate induced depletion of ecosystems and biodiversity in Africa. IPCC 4th Assessment Working Group 2; Faculty of Environmental Sciences.Nigeria, University of Jos.
- OCC., 2010. International response to climate change. Department of environment and resource management. Available at: http://www.climatechange.qld.gov.au/pdf/inlandfloodstudy.pdf
- Olsson, L. & Jerneck, A., 2010. Farmers fighting climate change: from victims to agents in subsistence livelihoods. WIREsClim Change, Volume 1, pp. 363–373 : John Wiley & Sons.

- Patino, L., 2010. Understanding Climate Change Adaptation and Adaptive Capacity: Synthesis Report. Canada.
- Selvaraju, R. Subbiah, A.R. Baas, S. and Juergene, I., 2006. Livelihood adaptation to climate change variability in drought-prone areas of Bangladish. FAO and ADPC; Rome.
- Sivakumar, M.V.K. & Ndiang,,ui, N. eds., 2007. Climate and land degradation. New York: Springer Berlin Heidelberg.
- Temesgen, T., 2007. Measuring the Economic Impact of Climate Change on Ethiopian Agriculture: World Bank Policy Research Working Paper No. 4342. Available at: http://ssrn.com/abstract=1012474.
- UN., 1992. United Nations framework convention on climate change. Available at: http://unfccc.int/resource/docs/convkp/conveng.pdf
- UNFCCC., 2007. Climate change: Impacts, vulnerabilities and adaptation in developing countries. Climate Change Secretariat (UNFCCC) :Bonn, Germany.
- UNFCCC., 2009. Copenhagen Accord. Available at: http://unfccc. int/r eso ur c e/docs /2009/cop15/eng/l07.pdf
- WHO., 2000. Climate change and human health: Impact and adaptation. Geneva: WHO.
- WHO., 2004. The World Health Report 2003: shaping the future. World Health Organisation. Geneva. Available at: http://www.who.int/whr/20 03 /e n/index.html
- WMO., 1992. Climate change, Environment and Development: World Leaders‟ viewpoints. Secretariat of WMO. Geneva, Switzerland. No. 772.
- WMO., 2003. Our Future Climate. Geneva, Switzerland.
- World Bank. 2008., Agriculture and rural development: Sustainable Land Management Sourcebook. Washington DC.

- WWF., 2006. Climate change impacts on East Africa: A review of the scientific literature. Gland, Switzerland: WWF.
- Ziervogel, G. & Ericksen, P.J., 2010. Adapting to climate change to sustain food security. WIREs Climate Change, Volume 1, pp. 525–540: John Wiley & Sons, Ltd.
- BGRS-BoEPLAU (2011), Regional program of Plan on Adaption to climate Change, RAPA, January, 2011, Assosa.
- (MoARD, 2003, Guideline for forest fire protection and control; Addis Ababa
- BGRS-Rural development coordination office (2006); Addis Ababa.
- BGRS (2003); A Strategic plan for the sustainable development, conservation, and management of the woody biomass resource; final report, December 2003, Addis Ababa.
- BGRS (2011); BoARD annual report; June 2011.
- BGRS (2011); BoARD, Sustainable Land Management Project (SLMP); annual report; June 2011.
- BGRS (2011); Office of food security and early warning, annual report, June 2011.
- BGRS (2011); Bureau of Water, Mine and Energy Resource Development Report; June 2011.
- BGRS (2007); Facts about Benishangul-Gumuz Regional state; April 2007, Assosa.
- FAO (1984, 1986); Land-Use classification of Ethiopia.
- FDRE-CSA (2007); Analytical Report; Addis Ababa, Ethiopia.
- National Metrological Agency (2007); National Program of Plan on Adaption to Climate Change; NAPA, June 2007, Addis Ababa, Ethiopia.
- RMA (2010); Regional Meteorological Report, BGRS Meteorological Agency, December 2010, Assosa.

Christian Aid Briefings, October 2012, Thriving, Resilient Livelihoods: Christian Aid's Approach

ANNEXES

Annex 1: Household Interview Schedule for Household Characteristics (HC)

HC1	Woreda								
HC2	Kebele								
HC3	Respondent Code								
HC4	Respondent Name								
HC5	Sex (circle one)	M					F		
HC6	Age								
HC7	Marital Status (circle one)	Married				Single		Divorced	Widow/er
HC8	Education (circle one)	Illiterate				1-4		5-8	Above 8
HC9	Family size (put number in the below row)	Male				Female		Total	
HC10	Family age Composition in numbers	Less than 7		7 to 17		18 to 30		31 to 60	Above 60
HC11	No of Family members attending school (put number in the below row)	Male		Female		Remark			
HC12	Family Education attainment in numbers for respective grade (put number in the below row)	1-4		5-8		Above 8			
		M	F	M	F	M		F	

Annex 2: Household Interview template for Crop Production in rain-fed agriculture (CP-RF)

CP-RF1	Do you grow crops using rain?					yes	No
CP-RF2	If yes, Which crops do you grow and what is their productivity during the preceding harvesting season?						
	S.No	Type of crop (includes, staple cereals, pulse grains, vegetables, fruits)	Land area (Ha) for the specific crop type only	Qty of harvest (Qt)	Money value of harvest		Brief remark if any?
					ETB	GBP	
	A						
	B						
	C						

	D						
	E						
	F						
	G						
	H						
	I						
	J						

CP-RF3	Do you use soil fertilizers and other inputs to increase production under rain fed farming?	yes	No

If yes, to which crop? What fertilizers? What amount you applied in the preceding cropping season?

CP-RF4	S.No	Type of crop (includes, staple cereals, pulse grains, vegetables, fruits)	Land area (Ha) for the specific crop type only	Type and quantity of farm input applied under rain-fed farming						
				DAP (Qt)	UREA (Qt)	Compost (Qt)	Farmyard manure (Qt)	Improved seed (Kg)	Herbicides (Kg)	Insecticides (Kg)
	A									
	B									
	C									
	D									
	E									
	F									
	G									
	H									
	I									
	J									

CP-RF5	From where do you access farm inputs?	Type of farm input	Source	Brief remark if any
		DAP & UREA		
		Improved seeds		
		Insecticides and herbicides		

Annex 3: Household Interview template for Livestock Production (LP)

LP1	Do you have Livestock?				yes	No
	If yes, Which livestock do you possess and what is their money value					
	S.No	Type of Livestock	Number	Money Value		Brief remark if any?
				ETB	GBP	

LP2	A	Oxen					
	B	Cows					
	C	Heifers					
	D	Steers					
	E	Calves					
	F	Sheep					
	G	Goat					
	H	Horses					
	I	Mules					
	J	Donkeys					
	K	Camels					
	L	Poultry					

LP3	Do you produce Milk?							yes	No
LP4	If yes, from which livestock, what amount, and its money value?								
	S. No	Type of milking animal	No of milking animals	No of milking months per year	Milk yield per day (Litres)	Money value of milk per Litre		Brief remark if any?	
						ETB	BGP		
	A	Cows							
	B	Goats							

Annex 4: Household Interview template for Savings (S)

S1	Do you have savings?								yes	No
S2	If yes, What amount (in ETB)?									
S3	When you started saving (Ethiopian year)?									
S4	Where you deposit your savings (name of financial institution or other?									
S5	What are sources of income for your savings (circling more than	Crop sales	Livestock sales	Livestock product sales	Wage labor	Smiting	Mining	Firewood or charcoal sales	Remittance	Other (Specify)

	one choice is possible)?									
S6	Which are the three most important sources of income for your savings?									
S7	Why you decided to save?									
S8	What benefits or values you get from savings?									

Annex 5: Open-Ended interview template to collect data on existing level of understanding on climate change (CU-CC)

CU-CC2	Understanding about climate change				
A	If you are given a range from 0 (no understanding) to 10 (complete understanding), which value do you assign for your level of understanding on weather and climate?				
B	Can you provide some description regarding climate and weather?				
C	Do you think that climate in Maokomo has changed when compared to 10 years before (circle either)?		Yes	No	No idea
D	If your answer to "C" is yes, what is your representation of climate change in Maokomo?				
	D1	Air became hot than it used to be			
	D2	More amount of Rainfall than it used to be			
	D3	Low amount of RF than it used to be			
	D4	Sometimes high and sometimes low RF than it used to be			
	D5	Late start of RF than it used to be			
	D6	Late ending of RF than it used to be			
	D7	Short Rainfall period than it used to be			
	D8	Long RF period than it used to be			
	D1	More mosquito and other disease outbreak than it used to be			

	0		
	D11	Crop yield decline	
	D12	Death of livestock	
	D13	Extreme flooding than before	
	D14	Other (Specify)	

E	What effects you observed due to climate change in Maokomo woreda?	

F	What do you think to have caused climate change?		
CU-CC3	Climate change related actions		
A	Have you taken actions to respond to the effects of climate change	Yes	No
B	If "yes" to question "A", what are those actions and what you learned from them?		
C	If "no" to question "A", why not?		

Annex 6: Household survey template for gathering impact of climate change and tangible actions for building resilience to rainfall variability related shocks (R-D)

R-D1	Has this variability or seasonal change affected your livelihoods?	Yes	No	Since when	Additional Remark if any?
R-D2	If you your answer is yes to this question, what kind of impact do you see?				
1.	Crops are sometimes failing				
2	Crops are totally failing				
3	Production per ha is decreasing				
4	Production per ha is increasing				
5	Crop disease and weeds are increasing				
6	Increased problem of livestock disease				
7	Increased problem of seasonal flooding				
R-D3	How often do you observe? Put your response in the remark column				
a	Incidence of insects				
b	Crop diseases				
c	Weeds				
R-D4	Is crop growing period similar in the last 10 years?				
R-D5	When does rain come and go during these periods? Is there a change in season?				
R-D6	Once, it starts to rain, does it change its intensity? Is it stopped ahead of the time it used to stop?				
R-D7	Is the amount of precipitation sufficient for full cropping during short rainfall?				
R-D8	If yes to R-D1, have you/your household taken actions to adapt to rainfall variability impacts?				
R-D9	If yes to R-D2, what actions?				
A	I constructed hand-dug wells for irrigation and HH consumption				
B	I started to employ small scale river/stream diversion irrigation				
C	I started to use drip irrigation				
D	I constructed water harvesting reservoirs				
E	I constructed soil and moisture conservation structures such as terraces, micro basins, etc				
F	I started to use short maturing crop varieties				
J	I have started to grow less water requiring crops				
H	I have adjustments in time of planting and harvesting in response to time and quantity of rainfall				
I	I started to grow marketable agricultural products such				

	as vegetables and fruits				
J	I started to preserve fodder and use cut-and-carry method for livestock feeding				
K	I started to preserve grains to use them during food shortage				
L	I started non-farm livelihood options				
M	I started to deposit/save money in financial institutions				
N	I reduce the number of livestock by selling and/or slaughtering before the impact of drought occurs				
O	I constructed shelter for livestock to reduce heat stress				
P	I am involved in community actions for drought impact reduction				
Q	Others (specify).....				

Annex 7: Household survey template for type and diversity of livelihood options (DLO)

DLO 1	**Type of Livelihood options**	**Current money value**		**Remark if any?**
		ETB	**GBP**	
A	Grow staple cereals (sorghum, teff, millet, maize, wheat, barley)			
B	Growing pulse cereals			
C	Growing vegetables			
D	Growing fruits			
E	Rearing cattle			
F	Rearing shoats			
G	Rearing equines			
H	Rearing poultry			
I	Livestock trading			
J	Grain trading			
K	Petty trading			
L	Bamboo making			
M	Gold mining			
N	Smithing			
O	Charcoal making/wood selling			
P	Wage based employment			
Q	Carpentry			
R	Garment making			
S	Quarrying			
T	Other (Specify)			

Annex 8: Household survey template for gathering household coping strategies to climate change impact (temperature rise, rainfall variability and seasonal change) (C-DF)

C-DF1	Has rainfall variability affected your livelihoods?	Yes	No	Since when	Additional Remark if any?
C-DF2	If yes to C-DF1, what immediate action you took to respond?				
A	Reduced quantity of household meals per day				
B	Change crop variety				
C	Shifted my farming lot				
D	Early planting of crops				
E	Late planting of crops				
F	Started to use irrigation				
G	Diversified crop cultivation				
H	Shift from crop to livestock				
I	Sold livestock				
J	Reduce number of livestock				
K	Look for off-farm jobs				
L	Build a water-harvesting scheme				
M	Implement soil conservation techniques				
N	Sold other assets				
O	Used grain stored at home				
P	Used money deposited				
Q	Walked long distance to fetch water				
R	Temporarily migrated in search of wage				
S	Borrowed money to meet HH needs				
T	Sought gifts from relatives/friends/networks				
U	Temporarily migrated in search of food				
V	Permanently migrated				
W	No adaptation method used				
X	Other (specify)				

Annex 9 HH Survey templates for gathering perceived constraints to adapting to climate change (CN)

CN-1	Do you think that there are constraints to adapt to the impact of climate change?	Yes	No	Since when	Additional Remark if any?
C-DF2	If your answer to CN-A is yes, What are the main constraints to adapt to the impact of climate change?				
A	Lack of weather and climate information				
B	Lack of knowledge on how to adapt				
C	Poor potential of land for irrigation				

D	There is no hindrance to adaptation				
E	Others				

Annex 10 Checklists for Focus Group Discussion

I. Perception on climate change

1. Do you believe the climate in your area is changing?
2. How do you explain/describe the change in climate?
3. How is it different from original situation?
4. What are the main changes that have taken place in the locality in the last few years? How did you measure (indicator)?
5. Are there observed changes in the livelihoods and lives of your community due to changes in climate regimes (example: time of onset and cessation of RF, RF duration, crop type, cropping season, animal species, vegetation forms, etc? if yes, how they describe?
6. To what factors do you attribute the change in climate?

II. Types and impact of climate extremes

1. What climatic hazards/extremes are often occurring in your locality?
2. Have you noticed changes in temperature and rain fall? If yes, ask for each of the changes?
3. Which hazards/extremes are more severe than others? Why?
4. How do they describe trends of these hazards in terms of frequency and intensity?
5. What impacts (death, loss, damage, etc) these hazards brought? When?

III. Coping and Adaptation to the impacts of climate extremes

1. What immediate measures do you take to cope after hazard strikes?
2. What long term actions do you undertake to adapt to the impacts of climatic hazards?
3. Which long term actions and/or technologies are found most useful than others? Why?
4. What do you think is/are the best way(s) to cope with such change?
5. Can such coping mechanisms be applied in the present context (Elaborate)?

IV. Natural Resource Management

1. What are key natural resources for your community?
2. Have these natural resources changed over time?
3. If yes, how do you describe the change in status of natural resources?
4. What factors contributed to changes in natural resources?
5. How changes in natural resources affected your livelihoods and lives?
6. How do you describe the importance of natural resources for your resilience to climate extremes?
7. What actions do community members undertake to improve the status of natural resources?
8. Which institutions are involved in natural resource enhancement activities?
9. How do you describe the roles and added benefits of these institutions in natural resources enhancement?

Annex 11: Key informant interview

1. In your opinion what is climate change?
2. How would you describe the climate over the past 10 – 20 years?
3. Have you seen any long-term changes of temperature and rainfall for the last 20 years? If you say yes,
    a. How do you detect, and what is the reason to change?
    b. How could you explain the change to rain? Stayed the same, comes late, stops early, increased, or declined?
    c. How could you explain the change to temperature? Stayed the same, increased, or declined?
4. Have you ever faced any climate related impact in your life time? If yes, what type of climatic impact?
5. If your answer for Q4 is yes, did it affect your cattle or/and crop? Yes/No, if yes how much?
6. To what extent that has affected you and/or your family and, how did you cope or what did you do to cope with the situation?
7. Have you seen any changes in the number and types of disease and pest/weed cases on animal and agriculture over the last 20 years? If your answer is yes what were the causes (explain)
8. Have you seen changes in the vegetation/forest cover over the last 20 or more years? (Please explain)
9. What are the general strategies that are undertaken and will be taken to adapt the impact of climate change on agriculture activities?
10. What were the main constraints/ difficulties in changing the farming way to adapt climate change?
11. What coping mechanisms in your farming have you made to these long-term shifts in rainfall and temperature? Please list of them.

Annex 12: Questionnaire for agriculture and rural development office experts

1. Name ……
2. Position/profession ……
3. What is the agro-ecology of your district/peasant association?_____

4. Have you noticed of existence of climate change in your zone or district? _____
5. If the answer to Q4 is yes, would you explain the extent of climate change and variability impact on crop and livestock of your district/peasant association?

   _____
   _____
   _____
   _____

6. What is the impact of climate change and variability on the livelihood of the people there?

   _____
   _____
   _____
   _____
   _____

7. Whom do you think are more vulnerable to the impacts?

   _____
   _____
   _____

8. What local coping/adaptation mechanisms have you noticed of being implemented to reduce the impacts?

   _____
   _____
   _____

9. Would you please explain your institutions effort to reduce future impacts?

   _____
   _____
   _____

10. What are the main challenges to adapt to the fluctuations of temperature and rain fall and how do you think they can be improved?

    _____
    _____
    _____
    _____

11. As an expert, could you say that farming activities have been changed in response to the climate? If Yes, Explain those perceived changes?

_____
_____
_____
_____
_____
_____

Annex 13: Secondary data collection sheet for Temperature (T)

Name of Woreda: _____

Year	Maximum, Minimum, and Mean monthly temperature (Degree Celsius)											
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec

Annex 14: Secondary data collection sheet for rainfall (RF)

Name of Woreda: _____

Year	Monthly rainfall (mm)											
	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec

SUBMISSION OF MARD PROPOSAL FOR APPROVAL

Signature :_____

Name : _____

Address of Guide : .....……..……

……....

Name and address of the student: **Solomon Woldetsadik**

: Addis Ababa, Ethiopia

: e-mail, solomonehte@yahoo.com

: Mobile, +251 911631481

Enrolment No. **: ID1115893**

Date of Submission **: 31 Jan, 2015**

Name of the Study Center : ……

Name of Guide : ……

Title of the project : **ANALYSIS OF IMPACT OF CLIMATE CHANGE ON SMALLHOLDER FARMERS AGRICULTURAL PRODUCTION: THE CASE OF MAOKOMO SPECIAL WOREDA OF BENISHANGUL GUMUZ REGION, NORTH WESTERN ETHIOPIA**

Signature of the student :……..

Approved/Not Approved : ……

Date : ……

1. INTRODUCTION

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) dispelled many uncertainties about climate change. It is now clear that global warming is mostly due to man-made emissions of greenhouse gases (mostly CO2). Over the last century, atmospheric concentrations of carbon dioxide increased from a pre-industrial value of 278 parts per million to 379 parts per million in 2005, and the average global temperature rose by 0.74° C. According to scientists, this is the largest and fastest warming trend that they have been able to discern in the history of the Earth.

An increasing rate of warming has particularly taken place over the last 25 years, and 11 of the 12 warmest years on record have occurred in the past 12 years. The IPCC Report gives detailed projections for the 21st century and these show that global warming will continue and accelerate. The best estimates indicate that the Earth could warm by 3° C by 2100. Even if countries reduce their greenhouse gas emissions, the Earth will continue to warm. Predictions by 2100 range from a minimum of 1.8° C to as much as 4° C rise in global average temperatures.

Africa is already a continent under pressure from climate stresses and is highly vulnerable to the impacts of climate change. African Climate trends and projections indicate that rainfall trends-especially over the past 30 years or so-have had a very large bearing on socioeconomic development of the continent because most activities are agriculturally based. Many areas in Africa are recognized as having climate that is among the most variable in the world on seasonal and decadal time scales. African low lands are characterized by low and erratic precipitation, high temperatures and high rates of evapo-transpiration.

In Ethiopia, minimum temperatures have increased faster than maximum or mean temperatures (Conway et al., 2004; Kruger and Shongwe, 2004). Rainfall exhibits notable spatial and temporal variability (e.g., Hulme et al., 2005).

Agricultural production relies mainly on rainfall and will be severely compromised in many African countries, particularly for subsistence farmers and in sub-Saharan Africa. Under climate change, much agricultural land will be lost, with shorter growing seasons and lower yields. National communications report that climate change will cause a general decline in most of the subsistence crops, e.g. sorghum in Sudan, Ethiopia, Eritrea etc (Fischer et al. 2002).

2. STATEMENT OF THE PROBLEM

Climate change is already impacting populations, livelihoods and ecosystems in Ethiopia, including the study area, Benishangul Gumuz Regiona. The pace of change in the pattern of climate and different forms of environmental hazards often exceeds the capacity of local institutions to adapt to or mitigate the effects of such changes.

The negative impacts associated with climate change are also compounded by the existence of ‘multiple stressors’ (environmental degradation, population pressure, etc), which drive vulnerability further.

So far, efforts in the region to respond to the problem of growing climate change-induced hazards have been promising and expanding through time. Despite this, the scale and intensity of climate change-induced hazards (particularly rainfall variability unseasoned floods, forest fire, disease outbreaks, expansion of invasive weed species) is growing fast and the magnitude of damages from such climatic hazards continue to rise.

Despite the availability of handful of empirical studies, an in-depth analysis and well-established scientific evidence on the nature and extent of climate variability, magnitude of climate change impact on agricultural productivity and the likely socio-economic consequences on the livelihoods and food security of the rural poor in the area is virtually lacking. Also, most studies focus on drought prone areas, due to the existence of bias that forest based livelihoods are not affected by climate change and less attention are given to such areas.

Hence, the study is mainly intended to show the significance and magnitude of climate induced hazards and to investigate climate (rainfall and temperature) variability and farmers perception on the impact of climate change on crop yields in Maokomo district of Benishangul Gumuz region. Household level adaptation actions taken in response to the impact of changing rainfall patterns and temperature rise in the location will also be examined.

3. SIGNIFICANCE OF THE STUDY

The research can generate empirical evidence and provide valuable and scientific knowledge to inform development actors upon which they can make basis for any development interventions, to inform policy makers so that they can develop viable climate change strategies, in response to the rising climate change impacts in the region and to support farmers to manage climate extreme risks and enhance their adaptive capacity.

Furthermore, the study will sizably contribute in providing scientific evidence to the enduring efforts of ensuring food security and climate-smart agriculture systems of the region in order to improve the livelihoods of people in the study area and beyond. Hence, the results can be used to infer implications of rainfall variability and temperature rise on

targeted crops in the area. Moreover, findings of this research can play significant role to enhance and facilitate exchange of climate knowledge and information among local communities, field experts, policy makers and researchers.

In this regard, the study will analyze people perception on impacts of climate change on agricultural production and adaptation strategies that can be used as an insight for future studies on the issue.

4. GENERAL OBJECTIVES

The overall objective of this study is to analyze about rainfall variability and temperature patterns and assess farmers' perception about the impact of climate change on agricultural crop production in the study areas.

Specific objectives

1. To assess the perception of local communities about climate change, its impact on crop production and their traditional coping and adaptation mechanisms.
2. To analyze the monthly observed rainfall and temperature variability in the study area and triangulate against farmers' perception.

5. RESEARCH QUESTIONS

- What is the level of monthly variation of temperature and rainfall in the study area?
- What is the perception of the farmers about the effect of rainfall and temperature variability on agricultural production in the study area?
- What is the level of awareness of local people about climate change and its impacts?
- What traditional climate change adaptation mechanisms do the local communities used to cope with climate change impacts?

6. SCOPE AND LIMITATION OF THE STUDY

The scope of this study will mainly focus on two themes: the first is analysis of climate variability from two climatic parameters (temperature and rainfall) perspective. The second is analyzing smallholder farmers' perception on the impact of climate variability on the productivity and production level of agricultural crops in the study area. In addition, the copping strategies developed at community level and indigenous knowledge used in response to climate change effects will be assessed in depth. Furthermore, any limitation that will be encountered during research work will be captured.

The assessment will focus on both secondary data sources exist at regional level and primary data that exist at community level.

7. LITERATURE REVIEW

a. Important terms used in the project title.

- ***Climate*** is defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. These quantities are most often surface variables such as temperature, precipitation, and wind. Climate in a wider sense is the state, including a statistical description, of the climate system. The classical period of time is 30 years, as defined by the World Meteorological Organization (WMO).
- ***Weather***: Is a short-term phenomenon, describing atmosphere, daily air temperature, pressure, humidity, wind speed, and participation. (IPCC, 2007).
- ***Climate change***; refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate

change' as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.

- ***Climate variability***: Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events (Fussel and Klein, 2006,).
- ***Adaptation***; Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory, autonomous and planned adaptation. (IPCC AR5, 2014)
- ***Mitigation;*** A human intervention to reduce the sources or enhance the sinks of greenhouse gases (GHGs) (IPCC AR5, 2014)
- ***Ecosystem***; The interactive system formed from all living organisms and their abiotic (physical and chemical) environment within a given area. Ecosystems cover a hierarchy of spatial scales and can comprise the entire globe, biomes at the continental scale or small, well-circumscribed systems such as a small pond. (IPCC AR4).
- ***Resilience;*** the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization, and the capacity to adapt to stress and change.

b. Climate change and Agriculture

Climate change causes climate variability of temperature and precipitation as well as the frequency and severity of weather events. Some indirect effect of climate change includes changes in soil moisture, land and water condition, change in frequency of fire and pest

distribution. This in turn will have wide-ranging effects on the environment, on socio-economic and related sectors, on water resources, agriculture and food security, human health, terrestrial ecosystems and biodiversity. Moreover, rising temperatures will cause shifts in crop growing seasons which affects food security. Temperature increases will potentially severely increase rates of extinction for many habitats and species (UNFCCC, 2007).

c. Ethiopian agriculture

Ethiopian economy is predominantly agrarian and the majority of the population in the country is engaged in agriculture. It is the single biggest employer with 70.4% of the economically active population engaged in the sector (CSA, 2000). Accordingly, it contributes about 41% to the Gross Domestic Product (GDP). Ethiopian agriculture is predominantly characterized by traditional methods of farming with very little change in farming practice over the past few centuries. The continuous use of such farming practice over a long period of time with little or no soil conservation measures has significantly eroded the fertility of the soil and agricultural outputs (Degefe, 2000).

The major factors behind the poor performance of Ethiopian agriculture are diminishing farm size and subsistence farming, soil degradation, inadequate and variable rainfall, climate-related disasters, weak agriculture research base, lack of financial system, imperfect agriculture markets and poor infrastructure. Ethiopian farming largely produces only enough food for the peasant holders and their family for consumption, leaving little to sell. Crops are the major production and sources of food in the country since most of the population depend on agriculture (Degefe, 2000).

d. Agriculture in Benishangul Gumuz

Benishangul Gumuz Regional State (BGRS) is one of the regional states of the Federal Democratic Republic of Ethiopia (FDRE). The region is divided into three administrative zones with one special and other 20 woredas (districts). It is located in the North West part of country and bordered with Amhara in the North and North East, Oromia in the East and south east, Gambella in the South and Sudan in the West. Geographically it is found along the Sudanese Border roughly over a length of about 377.4 Km, between 090 17‘and 120 06‘N latitude, 340 10‘and 370 04‘East longitude and divided by the Blue Nile (Abay) into two halves. The area of the region is roughly estimated to be about 50,381 Km2.

Nearly the livelihood of 92.2% of the population of the region depends on agriculture. The crop farming in the region is less diversified and intensified compared to more settled agriculture part of the country (Facts about BGRS 2007). Crop farming is mostly based on hoe-culture and few use oxen. Shifting cultivation practice is common in the region that is based on the traditional knowledge of the community. Shifting cultivation is a complex cultivation practice that adopted by local people in tropical forest ecosystem. The main annual crops grown in the region include: maize, sorghum, haricot bean, sesame, niger seed, millet and peanut. (Regional profile by Bureau of Finance and Economic Development of BSGR).

In the region, rain normally starts in April and continues up to the end of September/October and crop produced during this period were part of an overall subsistence strategy.

8. SAMPLING AND SAMPLING PROCEDURE

a. Population and Farming System

Maokomo special woreda has 24 rural and urban peasant associations/kebeles. The total population of the Woreda is estimated to be 42,050 with an average density of 14.21 persons per km (Bureau of Finance & Economic Development, regional profile, 2012). The average family size for the region is 4.5 persons per household. Hence, the number of household is in Maokomo is estimated to be (42,050/4.5) = 9345. The number of households per kebele is nearly 390. Rain-fed agriculture, mainly cereal cropping followed by oil crops such as niger seed, sesame, and groundnut are the major sources of food and income for maintaining the livelihoods.

b. Sampling Design and Sample Size

In order to collect a robust data needed to achieve the objectives of the research, stratified random sampling (SRS) will be employed to select 2 kebeles from different agro-ecological zones in such a way that the kebeles can represent the woreda in the main farming practices, crop varieties, socio-economic status, climate problems and disasters. Sample villages will be selected from sample kebeles by simple random sampling. The selection of respondent households for survey will be done through simple random sampling.

Accordingly, 2 kebeles will be selected to represent kola and woina dega through stratified sampling. Out of estimated 390 average households in each kebele and 780 households for the 2 kebeles altogether, 104 households will be identified and surveyed.

For determining the sample size, a given table developed by Bartlett, et al., (2001) sample size formulae will be used. As the total populations of the household in the selected areas

are nearly 780 and the sample size for continuous data is nearly 76 for low, 104 for medium and 166 for high, a medium sample size will be applied for the study.

c. Data Source and Data Collection Method

Four sets of primary data namely: ***climate and soil data*** (temperature, rainfall and soil characteristics), ***socio-economic***, ***agricultural production data***, and ***data on traditional climate change adaptation mechanisms*** will be collected. The first group of data (climate data) will be obtained from the National Metrology Agency regional office. The second group of data (socio-economic and climate change adaptation mechanisms) will be collected from household survey. Additionally, valuable secondary data will also be collected from various sources including previous scientific studies and reports from woreda/regional level agricultural bureau and other concerned organizations. Detailed description of the data collection methods that will be used for each group of data are presented below.

Climate data; observed climate data on climate variables mainly temperature and rainfall, from 1981-2010, of the study area will be obtained from the National Metrology Agency of Ethiopia regional office.

Data on socio-economy and traditional coping mechanisms; an in-depth household survey, using a semi-structured questionnaire and in-person interview, will be employed to collect both the detailed socio-economic data and the traditional climate change adaptation and coping mechanism of the households. Key informants and community leaders will be identified for focus group discussions with the help of the woreda agricultural bureau and local development agents. Accordingly, one focus group discussion will be carried out at Kebele level which will contain 10-12 farmers in a particular kebele. Then one key

informant interview will also be carried out at Kebele level to generate general information on the main research problem. Following the key informant interview, the semi-structured questionnaire already prepared for the study will be amended before the actual household survey. In order to check the validity and appropriateness of the semi-structured questionnaire, three households from each kebele that are outside of the research sample will be identified and interviewed for a pre-test prior to the actual interview of the total sample households. Data collectors/ enumerators and research assistants who have better knowledge of the local tradition and language will be contacted and trained before conducting the survey.

9. DATA PROCESSING AND ANALYSIS

Various master coded sheets will be prepared for coding purpose, after verifying and organizing the reviewed schedule for data collected from village households. Focus Group Discussion will be analyzed independently as supportive information. Raw data will be entered to statistical software package (SPSS) for data management and further analysis. Findings will be presented in different ways such as summary tables, matrices, graphical illustrations, narrative descriptions etc.

10. CHAPTER PLAN

Chapter 1

This chapter will contain introduction part of the main report and will focus on the theoretical background of climate change, climate hazards, impact of climate change on the socio-economic and ecosystem etc. The review of past studies which are related to the topic will also be discussed. In addition the chapter will discuss about;

- Statement of the problem
- Significance of the study
- Scope and limitation of the study
- Important concepts used in the investigation and assessment
- Objectives of the study

Chapter 2

This chapter holds about the review of literature which is relevant to issues of climate change and its impact on the livelihood systems of small holder farmers. Critical examination of the relationship among various researches will also be presented here.

Chapter 3

Under this chapter, detail socio-economic description and demographic characterization of study area, research methodologies and design used in the study, sampling method, tools and methods of data collection, data verification and encoding and data analysis will be dealt with.

Chapter 4

The findings from the study will be analyzed, interpreted and presented in different forms. In addition, adaptation mechanisms for known climate change, strategies chosen, analysis community perception, analysis of meteorological information on rainfall, temperature will be presented under this chapter.

Chapter 5

Summary of major findings, conclusions, recommendations, comparisons of findings with literature review, remarks and recommendation for further action for field practitioners, policy makers, researchers etc will be discussed under chapter 5.

The annexes will include the interview questionnaires, in FGD questions…

11. REPORT WRITING

The report will have preliminaries, main bodies with findings and conclusion and references. Each section will have its main and sub-topics and outlines in the chapter plan coupled with tables, figures, and presentations.

CARRICULUM VITAE

I. PERSON SPECIFICATION

Name	Wondimagegne Chekol
Date of Birth	January 20, 1957
Place of Birth	Gonder, Ethiopia
Nationality	Ethiopian
Sex	Male
Marital Status	Married
Language	Amharic, English, German

II. EDUCATION

PhD in Agriculture, Goettingen University, Germany, 1989-1994

MSc in Agriculture, Goettingen University, Germany, 1983-1987

BSc in Plant Science, Addis Ababa University, Alemaya College of Agriculture, Alemaya, Harar, 1977-1980

Bahir Dar Secondary School, 1969-1972

Bahir Dar Elementary School, 1963-1969

II. **TRAINING and Study Visit**

Leadership and Management at St. Mary's University College (2011)

Soft ware package for social science at St, Mary's University College (2011)

Project Cycle Management at St. Mary's University College (2010)

Three-month researches leave at Bonn University, DAAD, Germany (2013)

Three-month researches leave at Bayreuth University, DAAD, Germany (2009)

SAQA (South African Qualification Authority (2008)

Quality Assurance Mechanism in Higher Education Institutions, Addis Ababa (2007)

Management of Vocational Education, Tianjin University of Technology and Education, Tianjin, Peoples Republic of China (2007)

Leadership and Management, Ethiopian Management Institute, Addis Ababa (2003)

Three-month researches leave at Bayreuth University, DAAD, Germany (2005)

Project planning and Monitoring, ASARCA, Nairobi, 2004

Monitoring and Evaluation, EARO, 2002

Identifying and calcifying local indicators of soil fertility, CIAT, Arusha, Tanzania

SAS Software and Basic Biometry, EARO, 2002

Three-month researches leave at Bayreuth University, DAAD, Germany (2005)

Three-month researches leave at Osnabrueck University, DAAD, Germany (2001)

Three-month research leaves at Osnabrueck University, DAAD, Germany (1999)

Addis Ababa Teacher Training Institute, 1973, Ethiopia

III. WORK EXPERIENCE

Assistant Professor and Dean of Institute of Agriculture and Development Studies, School of Graduate Studies , St. Mary's University, March 2014 to date

Assistant Professor and Director of Center for Educational Improvement, Research and Quality Assurance, St Mary's University College since September, 2009 to 2014

Member of the task force to produce "The Ethiopian National Qualification Frame work", Representative of Higher Education Sector. Produced Ethiopian National Qualification Framework and Implementation Documents for the Ministry of Education

Senior Expert and team Leader Quality Audit in Higher Education Relevance and Quality Agency, since December, 2006

Worer Research Center Director, 2003 -2006

Associate Researcher I EARO, Worer Agricultural Research Center 1999-2006

- Soil research Section Head, Worer Agricultural Research Center 1999-2003

- Dry land natural resource management research program coordinator, EARO, Worer Agricultural Research Center, 2001-2006

- Drainage Research Project Coordinator, 2001-2004

Team leader of Prosopis juliflora management task force at Worer Research Center 1999-2006

Assistant Lecturer, Alemaya College of Agriculture, 1982

Assistant Administration Head of the Department of Plant sciences, Alemaya College of

Agriculture, 1982

Graduate Assistant, Alemaya Agricultural University, 1981, Ethiopia

Guest Lecturer Awassa College of Agriculture, 1981/1982, Ethiopia

Graduate student, International Live stock Center for Africa (ILRI), 1988, Addis Ababa,

Ethiopia

High school teacher, Arbaminch Secondary School, 1974-1976, Ethiopia

V. RESEARCH

Publications

Wondimagegne Chekol, 2014: *Prosopis julifor*a Management in Afar Regional State, Stakeholder Analysis: Paper Presented on IGAD International Workshop May 1-3, 2014 Submitted for publication, July 30, 2014

Wondimagegne Chekol and Imfred Neumann, 2014: Prosopiss , Parthenium Elements for an Integrated Strategy of Alien Species (IAS) Control in Afar Region State: Paper Presented on IGAD International Workshop May 1-3. 2014, Submitted for publication on July 30, 2014

Wondimagegne Chekol and Abere Menalu, 2012: Selected Physical and chemical characteristics soils of irrigated farm lands, Ethiopia, Ethiopian Journal of Agriculture 127-141

Wondimagegne Chekol 2013: Soil Dynamics and Ecological change in middle Awash and lower Awash basin (unpublished)

Wondimagegne Chekol and Daneil Alemayehu 2013: Physical Characteristics of natural resources and land use patterns of Awash Basin (unpublished)

Wondimagegne Chekol and Tigist Belay 2010: State of Educational Quality in Ethiopian Higher Education Institutions, Proceedings of the national conference on Quality of Education in Ethiopia, 2010: 48-61.

Wondimagegne Chekol, Solomon Alemu, Sisay Tekele, Bob Campbell et al 2008: Gonder University Institutional Quality Audit Report. HERQA Publication Series 029

Wondimagegne Chekol, Solomon Alemu, Kassahun Kebede , H. Kevin et al 2008: Jimma University Institutional Quality Audit Report. HERQA Publication Series 031

Wondimagegne Chekol, Solomon Alemu, Kassahun Kebede , H. Kevin Asefa Abegaz et al 2009: St Mary's University College Institutional Quality Audit Report. HERQA Publication Series 035

Wondimagegne Chekol, Solomon Alemu, Kassahun Kebede , Asefa Abegaz et al 2009: Addis Ababa University Institutional Quality Audit Report. (Unpublished)

Wondimagegne Chekol, 2009: Constructing the Third – Generation Ethiopian National Qualifications Framework, Proceedings of the national conference on Linking Higher Education with Industry, 2009: 48-61.

Wondimagegne Chekol, Asmare Demelelew, Keevy James et al: 2008 Concept and implementation framework of Ethiopian Qualifications, Ministry of Education of Ethiopia

Wondimagene Chekol and Heluf G/Kidane et al, 2006: Chemistry, Properties, Evaluation Management and Reclamation of salt affected soils and irrigation Waters in Ethiopia, ERO Publications

Wondimagegne Chekol, 2005: The effects of NP fertilizer on the yield of cotton, annual research repot, EARO.

Wondimagegne Chekol and Alemayehu Eshete, 2005: Impact of Irrigation on socio economic and environment in the middle and lower Awash River basin, annual research report, EARO.

Wondimagegne Chekol, 2004: Characterization of the soils of Lower and Upper Awash Basin, Ethiopia, annual research report, EARO.

Wondimagegne Chekol, 2003: Characterization of the soils of Southern Hledeghe Range Land in Middle Awash Basin, Ethiopia, annual research report, EARO.

Wondimagegne Chekol, 2002: Soil types: their potential and constraint for crop production in the Middle Awash Basin, Ethiopia, annual report, EARO.

Wondimagegne Chekol and Engida Mersha (eds) 2000: Proceedings of the fifth conference of the Ethiopian Society of Soil Science, Addis Ababa, Ethiopia.

Wondimagegne Chekol, 1994: Boden-catenen der basaltruecken-intramontanebenen-landschaft in der fusszone des Choke-bergmassives in hochland Aethiopian province Gojjam (PhD Desertation), Goerg-August University, Goettigen, Germany.

Wondimagegne Chekol, 1987: Das Boden-Brennen (Guie) in Aethiopian untersuchung zur veraederung der boden-eigenschaften insbesondere der naehrstoff reakitivitaet. MSc Thesis) Georg-August University, Goettingen.

Tamire Hawando, Wondimagegne Chekol et al, 1982: Soil fertility studies on major soils occurring in Hararghae Highlands (published in summary results of a soil science research program).

Tamire Hawando and Wondimagegne Chekol and et al, 1982: Effects of soil and water conservation on the yield and growth of sorghum in Hararghae Highlands, annual report soil science research program, Alemaya College of Agriculture.

Tamire Hawando, Wondimagengne Chekol et al 1981: Land use planning, soil fertility and soil conservation studies in Harerghe Highlands; summary research report, Alemaya College of Agriculture, Ethiopia

Extension work, Legambo Project (FAO funded), main activities were: soil classification and mapping, Land use planning, soil conservation and Agro-forestry, Alemaya College of Agriculture 1979-1982, Ethiopia

VI SKILL and ATTITUDE

Computer literate, Word and Excel

Aware of HIV/AIDS and Gender Equality

Familiarity with Afar community and culture and their way of working

VII OTHER ACTIVITIES

Vice President of the Ethiopian Soil Science Society since 2010

Editor in chief of the Ethiopian Society of Soil Science, since 2000

Chairman of the African and Asian Academician, George-August University, Germany (1990-1994)

Coordinator in the scaling up of modern Agricultural Technology in Afar Regional State (2003-2006)

Serves as Advisor and Co-advisor of MSc students at Hawassa and Haremaya Universities, since 2003 to date)

Member of the screening committee for German Academic Exchange Service (DAAD) PhD Scholarship candidates

Member of the advisory committee of the DG of Ethiopian Agricultural Research (2003) Institute

Partner for the implementation of Afar Livestock Recovery Project of FAO Funded by Norwegian Development Fund (2003- 2006)

Resource Person of Farm Africa Projects in Afar Regional State (1999-2006)

Partner for the implementation of PCDP Project in Afar Regional State (2003-2006)

Partner for SASAKA Global Rice Research and seed production since 2005 to date

Vice Chairman of the Ethiopian Soil Science Society since 2010
Secretary of the Ethiopian Soil Science Society since 2010 -213

Member of Ethiopian Agricultural Society

Member Ethiopian Soil Science Society

Member of German Soil Science Society

Reference:

Dr. Tareke Berehe, ATA
Dr. Berga Lemga, ATA
Dr. Kidane Georgis