DILLA UNIVERSITY

COLLEGE OF SOCIAL SCIENCES

DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES

Impact of Climate Change and Variability on Smallholder Farmers' Livelihood: the Case of Mareko Woreda, Gurage Zone, SNNPR

M.SC Thesis

By: Wolde Nurga

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Dilla, Ethiopia

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Advisor: Yimer Mohammed

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This is to certify that the thesis presented by Wolde Nurga, entitled: Impacts' of climate change and variability on smallholder farmers livelihoods: the case of Mareko woreda, Gurage Zone, SNNPR, Ethiopia and submitted in partial fulfillment of the requirement for the degree of Master of Science complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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External Examiner ---------- **Signature** ---------- **Date** ----------

Advisor ---------- **Signature** ---------- **Date** ----------

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Abbreviations and acronyms

IPCC	Intergovernmental panel for Climate Change
ISET	Institutional for Social and Environmental Transition
GHG	Green House Gases
HIV	Human Immunodeficiency Virus
SSA	Sub Saharan Africa
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
MOFED	Ministry of Finance and Economic Development
NMSA	National Meteorological Service Agency
GOE	Government of Ethiopia
CC	Climate Change
GOs	Governmental Organization
NGOs	Nongovernmental Organization
UNFCCC	United Nation framework convention on climate change
UNDP	United Nations Development
IFPRI	International food policy and research institution
CSA	Central statistics Agency
SNNPR	South Nations Nationalities Peoples Region
BOFED	Bureau of financial and Economic Development
NMA	National Meteorology Agency
CBA	Community based adaptation
PSNP	Productive Safety Net Program
FEWS NET	Famine, early warning systems Net work
HDR	Human development report

PERCEPTION ON CLIMATE VARIABILITY, ITS IMPACT ON THEIR LIVELIHOODS AND ADAPTATION MEASURES IN MARKO WOREDA, GURAGE ZONE, SNNPR.

ABSTRACT

Climate change and variability is an emerging serious global environmental problem affecting many sectors in the world. This study was conducted to assess impacts of climate change and variability on smallholder farmers' livelihood, the case of Mareko woreda, Gurage zone, SNNPR, Ethiopia. Primary data was collected using household questionnaire (from 141 households), focus group discussions, and key informants interviews. The collected data was analyzed using SPSS V.20 and Excel. The results showed that the major livelihood activities are mixed farming, being rainfall dependent. From the survey, it was noted that most of the respondents were not food self sufficient and safety net program was the source of additional food requirement. Finding showed that both of smallholder farmers and analysis of climate data indicated a change in temperature, rainfall amount, rainfall timing, and increase in frequency of drought. The empirical analysis of rainfall suggested declining rainfall trends. The result showed that there was a reduction of rainfall with the variability on set and off set of rainy seasons. The average maximum and minimum temperatures were increasing by 0.0156^0c and 0.0302^0c per year respectively. The changes have resulted in depleting of water resources and declining agriculture productions and, thereby, having negative effects on food security. And the main source of income in the study area is rain fed agriculture which is being adversely affected by unpredictable and decreasing rainfall, hailstorms and flooding, high temperature etc. To adapt to the changing climate of the area, farmers are already practicing coping mechanisms and adaptation strategies along with some government interventions in response to the climate change and variability, but it is not adequate. Depending on the finding of the study, the following recommendations are forwarded: increasing farmers' awareness on how to use agricultural technologies, restoring the degraded environment, facilitating access to credit services, diversifying crop varieties (legumes with cereals, vegetables etc), agro forestry, improved forage production, drought tolerant and early mature crop varieties, strengthen forest low, building the capacity of farmers & encouraging community based adaptation strategies as the main sustainable growth and poverty reduction approach.

Key words: livelihoods Climate change/variability, Impacts, coping mechanisms, adaptation strategies**.**

CHAPTER ONE: INTRODUCTION

1.1. Background

Climate change has become one of the great challenges to the development of countries. It is now affecting agriculture and food production worldwide. There is evidence of declining crop yield due to climate change in many countries (Muamba and Kraybill, 2010; Orindi *et al.*, 2006 and Stige *et al.*, 2006). This challenge appears to be more devastating in the case of low-income countries. This is partly because of high vulnerability of poor countries to climatic shocks due to their limited capacity to adapt and agriculture accounts for a larger fraction of their economy. Agriculture in these countries is climate sensitive which is largely rain-fed. As a result, significant proportions of people living in poor countries are facing the risks of food insecurity.

The fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2007) dispelled many uncertainties about climate change. Scientific community reached on consensus that global temperature is increasing and the main cause is the accumulation of carbon dioxide and other greenhouse gases in the atmosphere as a result of human activity, (Carr., *et al*, 2005).

According to the IPCC 2014, 2013 working group III and working group I respectively ‘‘warming of the climate system is unequivocal’’ and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen. It is now clear that global warming is due to man-made emissions of green house gas (GHG), mostly CO2.

The negative effects of climate change are threatening to reverse development gains in many parts of the world especially in Sub-Saharan Africa. It is now an accepted scientific phenomenon that the global climate is changing. Rainfall and temperature patterns are changing. In the Sub-Saharan region rainfall patterns have become less predictable, rainfall has decreased on average, and temperatures are rising (Holmgren & Oberg, 2006). Evidence shows that the upward trend of the already high temperatures and the reduction of precipitation levels will increasingly result in reduced agricultural production in Sub-

Saharan Africa (Mano & Nhemachena, 2007). Over the coming decades, global climate change will have an impact on food and water security in significant and highly uncertain ways, and there are strong indications that developing countries will bear the brunt of the adverse consequences, particularly from climate change (Oxfam2007). This is largely because poverty levels are high, and developing-country capacity to adapt to global change is weak. Furthermore, the rural populations of developing countries for whom agricultural production is the primary source of direct and indirect employment and income will be most affected (Ringler, *et al*, 2011).

Africa has been identified as one of the continents most vulnerable to the impacts of climate change. The reasons are the exposure of its population to climate variations and extremes, people's dependency on natural resources and the underdevelopment of much of the region. Africa is already affected by climatic extremes such as floods and droughts, which will be exacerbated by climate change. Such events are having a negative impact on livelihoods, especially those of the poor. Given the degraded environments, food insecurity, poverty and HIV/AIDS already affecting large parts of Africa, climate change poses a monumental problem for the region (Jones and Rahman, 2007).

Climate change and variability are likely to impose additional pressures on water availability, water accessibility and water demand in Africa. About 25% of Africa's population (about 200 million people) currently experience high water stress. The population at risk of increased water stress in Africa is projected to be between 75-250 million and 350-600 million people by 2020 and 2050, respectively (Boko *et al*, 2007).
In some countries harvests may be reduced to half the normal yield (IPCC, 2007). Agricultural production will decline and access to food will become less secure so that more people may go hungry. Africa's vulnerability to climate change is also exacerbated by the multiple other stresses it faces such as natural resources degradation, high dependence on rain fed agriculture and inadequate infrastructure, also low levels of technology, widespread poverty, weak governance and thus low level of adaptive capacity to climate variability and change.
Smallholders in many parts sub-Saharan Africa (SSA) generally face widespread problems related to inappropriate cultivation, overgrazing and deforestation, resulting soil erosion and

soil fertility decline, also water scarcity, lack of pasture and livestock feed and the fuel wood crisis.

There is much concern that the fragile African ecosystems (mountains, dry lands and Coastal areas) will undergo noticeable changes under future climate scenarios (FAO, 2011).

Ethiopia is found in the Horn of Africa and it is one of the world's developing county. About 45% of the country is defined as high land areas that are at least 1500 meters above mean sea level (Hakansson, 2009). Since Ethiopia is mountainous country, nearly half of the country (503857.35 sq.km) and 90% of Ethiopians live on the highlands (Hawando,T. 1995), (CSA, 2010). Agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 1% of the country's total cultivated land of 12.9 million hectares (CSA, 2013/2014). The dependency of most of the farmers on rain fed agriculture has made the country's agricultural economy extremely vulnerable to the adversities of weather and climate. Agriculture in the country is exposed to the effect of failure of rains or occurrence of successive dry spells during the growing season, which could lead to food shortage (MoFED, 2010). Rainfall is highly variable across the country from season to season and from year to year.

Adaptation to climate change is critical to many proposed strategies, for reducing the negative impacts of climate change. Building adaptive capacity is increasingly embraced by governments and other institutions as a means to improve economic and ecological resilience, sustainable development and will require action across multiple sectors at all levels (*Bishaw et al*, 2013).

The adaptation of humankind to climate change and variability is probably as old as humankind itself. Throughout human history, societies have adapted to climate variability through alternating settlements, agricultural patterns, and other sectors of their economies and lifestyles. Nevertheless, the record of collapsed societies shows that not all cultures have had the possibility to change their patterns of life in a timely manner, and were not successful in surviving in face of climate and environmental changes,(Andrade, Herrera and Cazzolla, 2010).

Even though adaptation is inevitably local, their reference to the local situation is very limited (Semu and Abebe *n.d, p.11).* Adaptation should therefore be, systematically mainstreamed into socio-economic development policy and planning at national, regional

and continental levels. At a local level, adaptation programmers should involve and give ownership to communities at the grassroots, moving steadily towards a community-based adaptation approach. It is imperative that local government incorporates indigenous knowledge into adaptation policies and analyses and takes account of models of best practice and adaptation approaches at a grassroots level (Chevalier, 2010).

1.2. Statement of the problem

The scientific knowledge on impacts of temperature and rainfall variability is increasing all the time, as are practical experiences in responding to adaptation needs. As in other regions of the world, climatic and ecological changes caused by global warming have resulted in several negative consequences for people‘s health, the economy and livelihoods in Ethiopia (Eriksson, 2006).

Despite the development of environmental policy in Ethiopia, environmental degradation because of land degradation, soil erosion, deforestation, loss of biodiversity, desertification, recurrent drought, flood and water pollution are still the main environmental problems. Although most disasters are caused by deterioration of natural environment, temperature and rainfall variability currently contributes their own share to the disasters. Temperature and rainfall variability impacts are on agriculture and food security, health, water resources and natural resource degradation. The impact of temperature and rainfall variability is further aggravated by poverty and population pressure. Rainfall and temperature variability, their cause, impacts and the necessary response mechanisms to cope up with climate calamities are important for any population in a given community. Level of awareness determines the scope of implementation that needs to be taken to tackle the problem. Lower awareness will make intervention mechanisms to be very slow and untargeted. For instance, local people have a range of strategies to cope with drought. However, these traditional coping mechanisms are based on local knowledge and not supported by research. Therefore, they may not be able to counter all of the challenges imposed by rainfall and temperature variability in the future. Studies have shown that climate variability has potential to have several negative impacts on human welfare, natural resources and development activities in the country (IPCC, 2007).

Ethiopia demonstrates diverse geo-physical and climatic conditions within relatively small areas. It is, therefore, an ideal place to study temperature and rainfall variability impacts on natural and socio-economic spheres. Such a study will contribute towards a better understanding of the intensity and impacts for local and regional government and also for researchers who want to further study. According to agriculture and natural resource development office of the Mareko Woreda (ANRDO, 2017), serious soil degradation, deforestation, loss of biodiversity, shortage of rain, temperature increment, drought year to year , erratic rainfall are the main problems in most kebeles of the woreda.

According to ANRDO (2017) the community in the area is food insecure, because of temperature and rainfall variability. Understanding temperature and rainfall variability, its cause, impacts and the necessary adaptation mechanisms is very important. People in the woreda have a range of indigenous strategies to cope with environmental hazards. However, these indigenous coping mechanisms are based on local knowledge and not supported by research. Therefore, to fill this gap, it is necessary to carry out scientific research that focuses on understanding the perceptions of people, local impacts of climate variability and adaptation strategies of the community.

1.3 Objectives of the study

The general objective of the study is to assess the impacts of climate change and variability on the livelihoods of smallholder farmers.

The study specifically tries to;

1. Assess local people's perception towards variability and change in temperature and rainfall pattern.
2. Assess impacts of climate change and variability induced shocks on people's livelihoods and the environment.
3. Identify ongoing adaptation strategies employed in response to perceived variability and changes in temperature and rainfall.
4. Identify barriers of adaptation strategies to the variability's of temperature and rainfall.

1.4. Research Questions

1. What are smallholder farmers' perception on climate change and variability?
2. What are the impacts of climate change and variability on the livelihoods of small holder

farmers' in Woreda?

3. How do smallholder farmers respond to the impacts of climate change and variability?
4. What are the determinants of adaptation strategies to climate change and variability in the study area?

1.5. Significance of the Study

Climate change and variability has become a serious challenge for the implementation of the country's development strategies. Even though climate change is affecting the whole world, the extent differs from region to region and from locality to locality. Similarly, the coping mechanism differs from community to community. These together indicate the fact that local studies are necessary to understand the extent of variability and climate change at different levels and different coping mechanisms that may be replicated and used as remedial measures in other similar occasions. As the majority of Ethiopia's economy depends on rain fed agriculture, it would be imperative to enable farmers better understand and adapt to the changing climate of the country.

Cognizant of this fact, over the last few years, the Government of Ethiopia (GoE) has been implementing a reform program aimed at poverty reduction through rapid economic growth and macroeconomic stability, which would enable the smallholder farmers better adapt to the adverse effects of Climate change & variability. As the issue is the concern of the entire world, especially those of developing countries, which have limited adaptive capacity to respond to the adverse effects of climate change and variability, context based adaptation is imperative. Therefore, this study may contribute to the community about how to cope up and adapt the effects of climate change and variability in this particular area. Furthermore, the outcome will be used for formulating future environmental policies and strategies at the local, zonal, regional level, and the finding can help researchers initiate and undertake further research in the area.

1. 6. Limitation of the study

Insufficient finance and duration were major problems that hinders the in depth analysis of the problem. The problem could have been better explained and investigated if enough time and finance were available. Hesitance and unwillingness of selected respondents to be

interviewed was another problem faced by the researcher while conducting house hold survey.

1.7 Delimitation of the study

Livelihood is very wide concept including many elements and explanatory valuables that are related to each other in a complex way. And climate change and variation can affect all elements of livelihood resources like natural capital, human capital, and social capital. However, this study focused only the effects of climate change and variability on agricultural production both crop production and animal rearing and natural resources in the study area.

1.8. Organization of the paper

The paper has been organized into 5 chapters, including the introduction and conclusion and recommendation. Chapter one presents introduction, statement of the problem, objectives and significance of the study. The second chapter provides review of some related literature, including the general frame work of the study. Research methodology, sampling method and sample survey, types of data, and methods of data collection and analysis along with description of the study area is also presented in the third chapter. Chapter four deals with the main body of the paper, it presents result of data analysis and their interpretation. The last chapter is about conclusions and recommendations of the study.

CHAPTER TWO: REVIEW OF RELATED LITRATURE

2.1. Concepts and Definitions

Climate change

Climate is a narrow sense usually 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 from months to thousands or millions of years. Climate change refers any change in climate over time through natural variability or as a result of human activities (IPCC 2007).

Climate change refers to a change which is attributed directly or indirectly to human activity that alter the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time period (UNFCCC 1992).

Africa is highly stressed, low adaptive capacity and easy vulnerable to climate change. The main consequences of this negative impact of climate change or current climatic hazards are poverty, unequal access to resources, food insecurity, globalization trends, social and political conflicts and incidences of diseases such as malaria, tuberculosis and HIV/AIDS. This impact of climate change presents a substantial challenge to regional agricultural development. The sub Saharan Africa countries have low adaptation mechanism and vulnerable to the widespread effect of climate change. With this big serious problem, in the coming 2100 year in most part of the continent, GDP is predicted to decrease. For instance 2-7 percent in part of sub Saharan Africa, 2-4 percent in west and central Africa and 0.4- 1.3 percent in north and southern Africa (FAO 2009)

Climate Variability

Climate variability refers to the climatic parameter of region fluctuating from its long-term mean. Every year in specific time period, the climate of specific location is different. Some years have average rainfall; some have below average or above average rainfall.

Unlike global warming, which refers to the increment of surface temperature of the earth's, climate variability refers to changes in precipitation, temperatures, and cloud cover and so on. According to some scientific experts in the field of climatology, climate variability is

caused by human activities that have resulted in an increased concentration of greenhouse gases, in our atmosphere, including carbon dioxide, water vapors, methane, Ozone, and nitrous oxide (IPCC, 2007).

The forth assessment report of IPCC defined climate variability as a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity.

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

Adaptation

Is the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderated harm or exploits beneficial opportunities (UNFCCC, 2009, cited by SAGUN, 2009). Various types of adaptation exist, e.g. anticipatory and reactive, private and public, and autonomous and planned. Local community- based adaptation practice is an urgent issue particularly in developing countries. However, little is known about local community perception of climate variability and adaptation worldwide (Adane, 2009).

Perception

As Ban and Hawkins (2000) defined perception, it is the process by which we receive information or stimuli from our environment and transform it into psychological awareness. It is interesting to see that people infer about a certain situation or phenomenon differently using the same or different sets of information. Knowledge, interest, culture and many other

social processes that shape the behavior of an actor who uses the information and tries to influence that particular situation or phenomenon (RECOFTC 2001, Cited by Banjade, 2003).

Impacts: The effects of climate change on natural and human systems (IPCC, 2007). Depending on the consideration of adaptation, one can distinguish between potential impacts and residual impacts:

- Potential impacts: all impacts that may occur given a projected change in climate, without considering adaptation.
- Residual impacts: the impacts of climate change that would occur after adaptation.

2.2. Causes and Manifestations of Climate Change

Earth's climate is a complex system that is constantly changing. During the last centuries natural factors such as volcanic eruptions or the amount of energy released from the sun have affected the Earth's climate on a smaller scale. By the 1950s and early 1960s, it was becoming clear that human activities were releasing CO_2 fast enough to significantly increase its atmospheric abundance (Dessler & Parson, 2006).

The probability that human activities are the main cause for the increase in temperature since the mid-twentieth century has risen from 66 % in 2001 to more than 90 % in 2007(Keshav and Niraji, 2013).

The scientific community has reached consensus that this changes cause a warming of the atmosphere and therefore influencing the Earth's climate. Continuation of greenhouse gas emissions can result in additional warming over the 21st century up to 4.5 °C by 2100, (Mosbrugger, et al, 2008).

The variability 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. Human behavior will continue to be a major factor in climate variability (UN, 1992; NSF, 2009). The human factors that contribute to climate variability 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.

According to reports of the IPCC (2007), the projected yield reduction due to climate variability in some poor countries could be as much as 50% by 2020. Under climate variability, much agricultural land will be lost, with shorter growing seasons and lower yields.

Climate variability 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 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, 2007).

Land-use and land- cover changes influence carbon fluxes and GHG emissions (Houghton, 1995; Braswell et al. 1997), which directly alter atmospheric composition and radioactive forcing properties. They also change land-surface characteristics and, indirectly, climatic processes. Established evidence links land degradation to the loss of biodiversity and climate change, both as cause and effect. Climate change might exacerbate land degradation through alteration of spatial and temporal patterns in temperature, rainfall, solar radiation, and winds (Sivakumar, 2011).

Rising fossil fuel burning and land use changes have emitted, and are continuing to emit, increasing quantities of greenhouse gases into the Earth's atmosphere (UNFCCC, 2007). These greenhouse gases include carbon dioxide (CO2), methane (CH4) and nitrogen dioxide (N2O).

Deeper understanding about manifestations of climate change and variability has paramount importance to understand its impact on different sectors. The main characteristics of climate change are increases in average global temperature (global warming); changes in cloud cover and precipitation particularly over land; melting of ice caps and glaciers and reduced snow cover; and increases in ocean temperatures and ocean acidity due to seawater absorbing heat and carbon dioxide from the atmosphere (Ibid).

The effects of climate change on agricultural production is manifested through shortening of maturity period and then decreasing crop yield, changing livestock feed availability,

affecting animal health, growth and reproduction, depressing the quality and quantity of forage crops, changing distribution of diseases, changing decomposition rate, contracting pastoral zones, expansion of tropical dry forests and expansion of desertification, etc. Rainfall is highly erratic, most rain falls with high intensity, and there is a high degree of variability in both time and space.

Climate change affects all countries, but those likely to be worst affected are the world's poorest countries, especially poor and marginalized communities within these countries. Ironically it is these poor countries and people who have contributed least to the problem of climate change, because of their very low greenhouse gas emissions, but who will suffer most from its consequences (Hannah, et al, 2010). The foregoing argument shows that climate change can no longer be sidelined as a development issue. The effect that climate change has on the poor communities in sub-Saharan Africa is increasingly prominent (Dube, 2013).

2.3. The Impacts of Climate Change

Climate change is considered as the biggest environmental challenge for the twenty-first century. Consequences of climate change are already felt throughout the earth system. The effects of climate change are already occurring on all continents and across the oceans (IPCC, 2014). The world, in many cases, is ill-prepared for risks from a changing climate. Climate change is already affecting rainfall amounts, distribution, and intensity in many places. This has direct effects on the timing and duration of crop growing seasons, with concomitant impacts on plant growth. Rainfall variability is expected to increase in the future, and floods and droughts will become more common. Changes in temperature and rainfall regime may have considerable impacts on agricultural productivity and on the ecosystem provisioning services provided by forests and agro forestry systems on which many people depend (Thornton & Lipper, 2014).

The rising year-to-year variability and in both droughts and heavy precipitation events lowers agricultural production with corresponding negative effects on food security.

The availability of clean drinking water is likely to decrease due to the increasing evaporation and the increasing variability of rainfall events. Furthermore, a large number of plant and animal species is threatened by extinction, as climate conditions are changing too

quickly for them to adapt, incidences of malaria in areas of the highlands where malaria was previously not endemic. The warming is further expected to cause an increase in cardio-respiratory and infectious diseases.

As indicated in IPCC (2007) report, climate change impacts on water demand are predicted to be highly significant in Africa. The number of people facing water scarcity due to unreliable rainfall and drying up of springs and rivers is expected to be between 75 to250 million people at risk by the 2020s (Bates et al 2008). Furthermore, this is likely to have severe impacts on crop yields, as the majority of the African population (over 85 percent in the case of Ethiopia) depend on rain fed agriculture, (IPCC, 2007). Climate change will aggravate the water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress (IPCC, 2007).

2.4. Climate Change in Ethiopia; Observed patterns & projections

Like other parts of Africa, Ethiopia has become warmer over the past century and human induced climate change will bring further warming over the next century at unprecedented rates, (EPA, 2011). Climate projections suggested that an increase of rainfall variability with a rising frequency of both severe flooding and droughts due to global warming (World Bank, 2010). The Intergovernmental Panel on Climate Change (IPCC, 2007) findings suggests that developing countries like Ethiopia will be more vulnerable to climate change due to their economic, climatic and geographic settings. In parallel, Zenebe *et al*. (2012) reported that its low adaptive capacity, geographical location and topography make the country highly vulnerable to the adverse impacts of climate change.

According to the UNDP climate change country profiles, the average annual temperature in Ethiopia increased by 1.3^0C between 1960 and 2006 (McSweeney et al, 2010). Daily temperature observations also show an increase in the average number of 'hot' days and 'hot' nights per year.

The International Panel on Climate Change (IPCC) Fifth Assessment Report WGII found that recent reports from the Famine Early Warning Systems Network (FEWS NET) indicate that there has been an increase in seasonal mean temperature in many areas of Ethiopia (IPCC, 2014).

Over the past three decades, Ethiopia has experienced countless localized drought events and seven major droughts, five of which resulted in famines (World Bank Group, 2010). A recent mapping on vulnerability and poverty in Africa, by Yusuf et al (2008), put Ethiopia as one of the countries most vulnerable to climate change with the least capacity to respond. Cycles of drought create poverty traps for many households, constantly thwarting efforts to build up assets and increase income. The country faces considerable hurdles in coping with the adverse impacts of long-term climate change. As explained in NMA (2007), baseline climate that was developed using historical data of temperature and precipitation from 1971-2000 for selected stations in Ethiopia, showed a very high year-to-year variation in rainfall for the period 1951 to 2005 over the country expressed in terms of normalized rainfall . Over those periods (1951-2000), some of the years have been dry resulting in droughts and famine while others were characterized by wet conditions.

Studies also indicate that there has been a very high temperature variation and change in its trend over time. Annual minimum temperatures for the period 1951 to 2005 expressed in terms of temperature differences from the mean and averaged over 40 stations showed a very high variability (NMA, 2007). The country experienced both warm and cool years over those 55 years even though the recent years are generally warmest compared to the early periods. According to NMA (2007) forecast, the country will experience an increasing level of temperature and precipitation in the coming decades. Using the software MAGICC/SCENGEN (Model for the Assessment of Greenhouse-gas Induced Climate Change)/ (Regional and global Climate Scenario Generator) coupled model for three periods centered around the years 2030, 2050 and 2080, NMA (2007) generated that the mean annual temperature will increase in the range of 0.9-1.1°C by 2030, in the range of 1.7-2.1°C by 2050 and in the range of 2.7-3.4°C by 2080 over Ethiopia for the IPCC mid range emission scenario compared to the 1961-1990 normal.

According to the National Meteorological Agency, long-term climate change in Ethiopia is associated with changes in the patterns and variability of rainfall and temperature, which could increase the country's frequency of both droughts and floods.

2.5. The Impacts of Climate Change & Variability in Ethiopia

Ethiopian climate is characterized by a history of climate extremes, such as: droughts and floods; and increase and decreasing in temperature and precipitation, respectively. Low economic development, inadequate infrastructure, and lack of institutional capacity all contribute to the country's vulnerability to the adverse impacts of climate change (IFPRI, 2010).

The most drought prone and affected areas of the country are in the northern, eastern and southern parts (WFP, 2014). Total failure or shortage of rainfall is often cited as the major cause for the recurring droughts and harvest failures. Such a problem or situation is further exacerbated by the social, economic and ecological situations (Dawit & Habtamu, 2011).

Continued climate change is expected to bring greater variability, and extreme weather events (e.g. droughts) which will further drive degradation of the country's ecosystems. The impact of climate change in Ethiopia is already apparent in increasing temperature and declining rainfall, particularly in northern parts which are exceptionally vulnerable to drought (Cesar and Ekbom, 2013).

Ethiopia is also vulnerable to the health impacts of climate change, and to climate induced damage to transportation infrastructure. There are strong links between environment and health concerns in Ethiopia, particularly related to malnutrition, indoor air pollution and water-related diseases (Cesar and Ekbom, 2013). The implications of future climate change will be felt throughout these particularly vulnerable sectors, although secondary impacts will be felt more widely, for example in education and gender equity. A recent study by the World Bank projects that, unless steps to build resilience are effective, climate change will reduce Ethiopia's GDP growth by between 0.5 and 2.5% each year (CRGE, n. d, 2010).

Ethiopia is especially vulnerable to climate variability and change because large segments of the population are poor and depend on agricultural income, which is highly sensitive to rainfall variability. Most have low access to education, information, technology, and basic social and support services, and as a result have low adaptive capacity to deal with the consequences of climate variability and change (Oxfam 2010), The World Bank Group 2010, Regassa et al, 2010, cited in Bishaw et al., 2013).

Eighty percent of Ethiopian population dependent on rain- fed agriculture, during drought years, the country suffered significant production deficit of about 20% in the agricultural

sector, resulting in a significant decrease of total annual production, mainly involving the most produced (stable food) crops which are cereals and pulses 63% and 11% of the total cultivated of the country respectively (UNDP, 2008), CSA (2014).

Ethiopia is particularly vulnerable to weather - related shocks. Although the Intergovernmental Panel on Climate Change (IPCC) predicts only a modest change in Ethiopia's rainfall patterns in future (Christensen et al, 2007), this can still adversely affect very poor small farmers– especially if such decreases are concentrated in the growing season (Oxfam International, 2010). Over the past six decades, Ethiopia has been particularly susceptible to drought, with a drought occurring every three to five years. Serious droughts and often famine, either widespread or localized, have occurred several times and affected millions of people. It is common that many farmers in the country either die due to hunger or depend on foreign food aid to sustain their lives (Temesgen. et al., 2010).

Environmental degradation and poor natural resource management together with a reduction in size of average landholdings due to high population growth and, conflict, governance and institutional capacity issues – have exacerbated the impacts of these droughts. All of these factors have contributed to the destruction of the productive assets and coping capacities of households and communities.

Food insecurity is widespread and food aid needs have been sizable, fluctuating between 0.4 - 2.5 percent of GDP between 1996 and 2001 (World Bank/Unite d Nations, 2010).

2.5.1. Impacts on Agriculture

2.5.1.1. Crop production

Climate change can affect agricultural production in a variety of ways. Temperature and precipitation patterns, extreme climate conditions, surface water runoff, soil moisture and CO2 concentration are some of the variables which can considerably affect agricultural development (IPCC, 2007; Zhai and Zhuang, 2009).

Ethiopian agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 1% of the country’s total cultivated land of 12.5 million hectare (Ethiopian Bellmon analysis 2015/2016-USAID). Thus, the amount and temporal distribution of rainfall and other climatic factors during the growing season are critical to

crop yields and can induce food shortages and famine (CSA, 2008). Like many other developing countries, agriculture (with the largest number of livestock in Africa) is the single largest livelihood of an overwhelming majority in Ethiopia, 85% of the population (ibid). During drought and delay in the onset of rain land becomes dry and difficult to plough, forage deficit leads to weakness and oxen mortality (engine of subsistent cultivation), and lack of precipitation hinders seed cultivation and germination of cultivated seeds. Even weeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households' livelihood (Abate, 2009).

2.5.1.2. Impacts on Livestock Production

Similar to crop production, the impact of climate change and variability in the livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock, with significant effects on milk production and reproduction in dairy cows, and swine fertility (Nigus, 2011). Drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures (Abate, 2009).

According to ONRS (2011), climate change and variability in Ethiopia poses particular risks to poor farmers and pastoralists who have an immediate daily dependence on climate sensitive livelihoods and natural resources. In addition to the physiological effects of higher temperatures on individual animals, loss of animals as a result of droughts and floods, or disease epidemics related to climate change may thus increase. Indirect effects may be felt via ecosystem changes that alter the distribution of animal diseases or the supply of feed. As reported by ANRS (2010) all pastoral regions in Ethiopia are highly prone to the adverse impacts of climate change. Similarly, a study by Kassaye (2010) accounted that livestock production in already marginal ecosystems in Ethiopia is severely affected by climate change induced disasters. MacDonald and Simon (2011) also reported that farmers living in Ethiopia's semi-arid and arid lowlands that have less diversified assets and are heavily reliant on rain-fed agriculture are, along with their livestock, particularly vulnerable to climate change. Thus, there is no doubt about the victim of livestock sector by climate change.

2.5.2. Impacts on Water Resources

Water is an essential resource for all life and a requirement for good health and sanitation. It is a critical input for industry and essential for sustainable growth and poverty reduction. Climate change will alter patterns of water availability by intensifying the water cycle. Droughts and floods will become more severe in many areas. The economy of Ethiopia mainly depends on agriculture, and this in turn largely depends on available water resources. The country has a fragile highland ecosystem that is currently under stress due to increasing population pressure and land degradation.

A major effect of climate change is likely to be alterations in hydrologic cycles and changes in water availability. Increased evaporation, combined with changes in precipitation, has the potential to affect runoff, the frequency and intensity of floods and droughts, soil moisture, and available water for irrigation and hydroelectric generation. In addition, watershed hydrology is affected by vegetation types, soil properties, geology, terrain, land use practices, and the spatial pattern of interactions among these factors and with climate (van Roosmalen et al.,2009)

2.6. Responses to Climate Change in Ethiopia

Ethiopia's diverse agro ecological zones are characterized by a dazzling variety of microclimates and corresponding weather patterns. Over centuries, its people have developed agricultural systems adapted to Ethiopia's diverse environment. Societies are dynamic and they use all possible strategies to reduce the vulnerability to climatic impacts. There are two kinds of responses to crisis that overlaps across the temporal scale, coping mechanisms and adaptive capacity. Coping mechanisms are the actual responses to crisis on livelihood systems in the face of unwelcome situations, and are considered as short-term responses (Berkes& Jolly 2001, as cited in Abate, 2009).

Adaptation to climate change is a response (processes) through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides (Burton 1992, cited in Niguse, 2011).
As already mentioned, for many centuries, Ethiopia has been characterized by climate variability and change and the local people have developed different adaptation strategies. These include early planting, indigenous soil and water conservation techniques, diversification of crop and livestock species, mobility, reciprocity, customary conflict

resolution etc. Thus, the historical accounts indicate that adaptation had been practiced in Ethiopia before the concept of "climate change" was developed (OECD, 2009). According to Sorhaug., A., (2013) locally the most widely practiced coping and adaptation strategies to climate change in Ethiopia includes: crop diversification, mixed farming, tree planting, off farm activities, soil and water conservation, selling of assets, use of improved seeds Inset production, food aids and irrigation as the most widely practiced adaption strategies by individuals in response to climate change and variability effects in Ethiopia.

According to (2007) NMA report, traditional and contemporary coping mechanisms to climate variability and extreme in Ethiopia include changes in cropping and planting practices, reduction of consumption levels, collection of wild foods, use of inter household transfers and loans, increased petty commodity production, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, food appeal/aid, etc.

Communities and societies in general have long been responding or adaption measures to climate changes, but these adaptations have typically been discrete and reactive. The idea that adaptation to climate change should be planned, proactive, and anticipatory is relatively new and is an important element of CBA (UNDP, 2010). Although climate change is universal phenomenon, its indicators and manifestations are entirely local.

However, until recently, most efforts to help countries adapt focused on national planning and top-down approaches based on climate change modeling. Remarkably little attention has been paid to the ways in which poor people have been coping with climate variability and extremes for decades. There has, thus, been increasing emphasis on the bottom- up approach that climate change studies should be conducted at the local level where adaptation ultimately takes place (Maharaja & Joshi, 2013). Community-based adaptation (CBA) as a response to climate change has evolved as a systematic, participatory, bottom-up approach. And it strengthens the resilience of communities and the ecosystems, upon which they rely in light of climate impacts, (Mannke, 2011). The use of genuine participatory processes is important if CBA is to fit with community priorities and build on existing practices or those used in the past.

Participatory tools are sometimes used as a way of collecting local information about vulnerability and climate change to be used and analyzed by outsiders and it is not uncommon for the priorities and interests of outsiders to over ride those of communities in any subsequent planning,(Reid, Huq and Murray ,2010). The aim of CBA is to enable the community to understand and integrate the concept of climate risk into their livelihood activities in order to increase their resilience to immediate climate variability and long-term climate change. Community-based adaptation is essentially an action research approach to the problem of climate change impacts on livelihoods, (Ensor and Berger, 2009). Incorporating or integrating adaptation to climate change into planning processes is a necessary strategy for sustainable development over the long term. Climate change impacts do not happen in isolation; impacts in one sector can adversely or positively affect another; sectors can be affected directly and/or indirectly by climate change. In order that real progress can be made, key governmental departments need to be involved in the development of adaptation strategies, (UNFCCC, 2007).

Ethiopia's Productive Safety Net Program (PSNP) is a large national social safety net (SSN) program that responds not only to chronic food insecurity among Ethiopia's poor, but also to shorter- term shocks, mainly droughts. It targets a highly climate- vulnerable population, offering a practical model of how SSNs can be designed to meet the social protection needs of the most vulnerable, while simultaneously reducing the risks from disaster and climate-related impacts.

The PSNP incorporates a number of interesting features, such as: public works activities geared towards improving climate resiliency; a risk financing facility to help poor households and communities to better cope with transitory shocks, including households outside of the core program; and the use of targeting methods that assist the most climate-vulnerable community members to obtain the full benefits of consumption smoothing and asset protection.

The program also works through, and focuses on strengthening, existing government institutional systems at all levels– rather than creating separate systems. The combination of a secure and regular /predictable entitlement of poor households to a government transfer, protection of poor households against natural hazard shock impacts and significant improvements in the management of the natural environment that contributes to these risks

has enabled the program's core beneficiaries to meet consumption needs, mitigate risks and avoid selling productive assets during times of crisis (e.g., droughts). There is evidence that livelihoods are stabilizing and food insecurity is being reduced among these households.

2.7. Conceptual framework

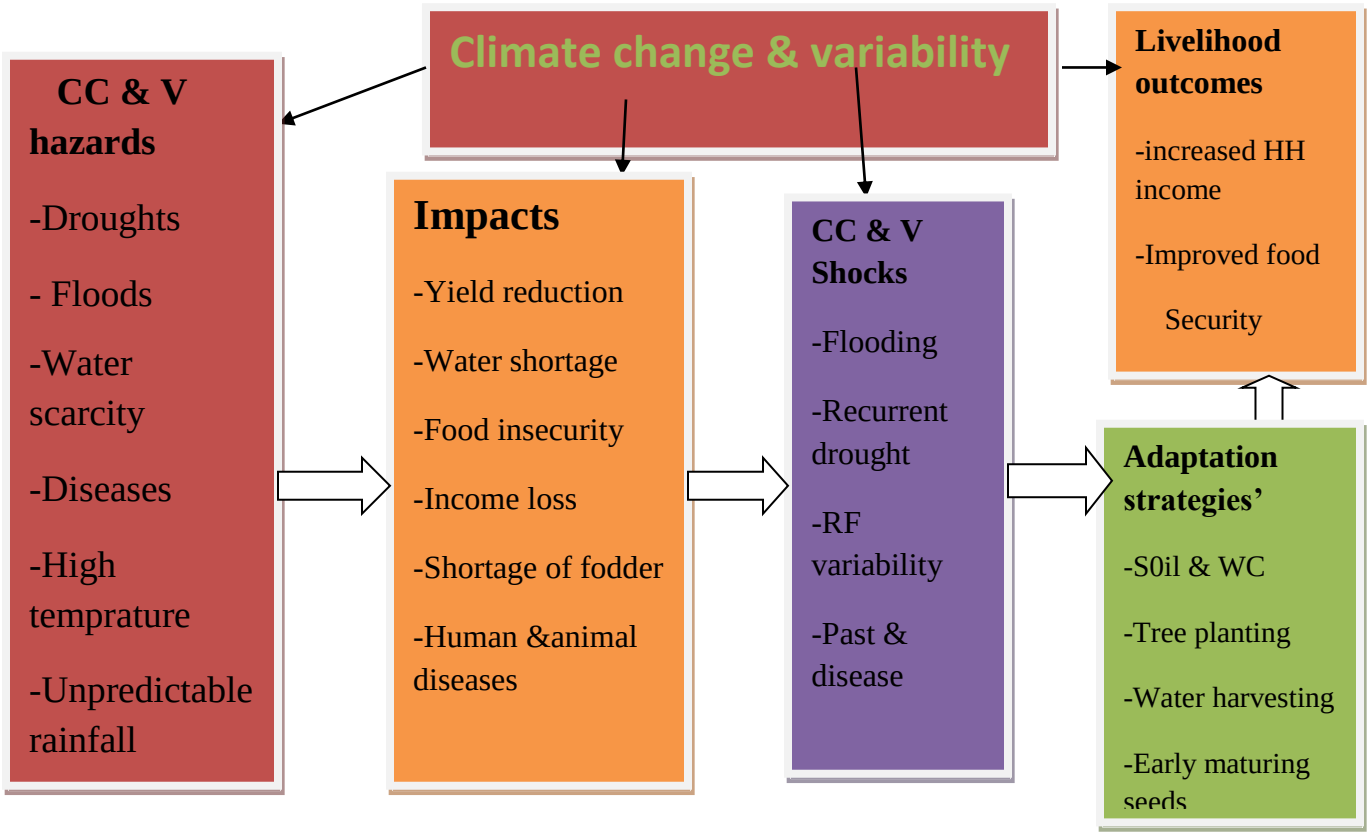

Figure.2.1. conceptual frame work: Source; adapted from Temesgen. et al. (2010).

There is scientific evidence that the climate is changing. Observations of the Earth's average surface air temperature indicate evidence of planetary–scale warming National Academy and Royal Science, 2014; (IPCC, 2013). According to the Intergovernmental Panel on Climate Change (IPCC, 2013), some events are directly related to climate change, namely ocean warming, ice loss from glaciers, sea-level rise (over the period 1901 to 2010, the

global mean sea level rose by 0.19 [0.17 to 0.21] m), and change in the global water cycle. The climate-related and weather-driven hazards considered are flooding, storms, droughts, he3at waves, sea-level rise, and alpine hazards. These hazards each bring different risks with different impacts on economic, social and natural systems.

The three resulting changes of the climate are precipitation, temperature and extreme events such as droughts and floods. The impact of climate change is felt by farmers mainly in the "timing, frequency and intensity of rainfall events, and in the distribution of these events within a season of growth" (Blignaut et al, 2009). Annual average temperature and precipitation are important in assessing climate changes but do not provide adequate indication of the impact these changes have on individual farmers.

In most studies there is a strong negative relationship between temperature and precipitation. The declining rainfall and increasing temperature affect crop production. This negative relationship between these two variables implies that rain-fed field crop production and livestock keeping will become more and more vulnerable.

Changes in rainfall patterns should be assessed in terms of timing - whether there are changes in the rain seasons (time for start and ending), intensity of the rains – droughts and floods and frequency. Increased frequency and severity of drought and floods may reduce crop and livestock and changes in the seasons and timing of the rains create difficulty in timing the planting of crops which in turn result in reduce crop production and livestock products such as milk and meat. The resulting impact of these changes and variations in temperature and rainfall is food shortages, disruption of agriculture yields and productivity and reduced income for farmers.

Determinants of adaptive capacity, understood as the main features of communities that seem to determine their adaptive capacity that can be grouped as follows (IPCC, 2014; EEA, 2008; Yohe and Moss, 2000):

- Economic wealth, in terms of the availability of resources and their distribution across the population. Resources include economic assets, capital resources, natural capital and financial means. It is widely recognized that poverty is directly related to vulnerability.
- Technology, i.e. the range of technological options available for adaptation. This element is crucial to ensure that a country can implement adaptation options.

- Information and skills refer to the stocks of human capital (i.e. education and personal security) and the stocks of social capital (i.e. definition of property rights).
- Infrastructure acts both as an enhancing factor in terms of adaptive capacity (see for instance flood defenses) and as a limiting factor, as it can increase the economic damage following extreme events.
- Institutions affect the ability to implement effective adaptation options, to manage information, and the credibility of the decision-makers themselves.
- Equity including the availability of resources and their access to vulnerable subsectors of a population.

As reported by different researchers, Deresa et al. (2008), Yusuf et al. (2008), there are many climate change adaptation livelihood strategies, including changes in crop variety and planting dates, crop diversification, irrigation development, water harvesting, tree planting, herd splitting, herd mobility, cattle breeding, migration, etc. Therefore, understanding the diverse and dynamic rural livelihoods strategies helps to identify appropriate intervention (adaptation measures) so as to improve the wellbeing of livelihood out comes.

Smallholder farmers will suffer by impacts of climate change that will be locally specific and hard to predict. The variety of crop and livestock species produced by any one household and their interactions, and the importance of nonmarket relations in production and marketing, will increase the complexity both of the impacts and of subsequent adaptations. Small farm sizes, low technology, low capitalization, and diverse non-climate stressors will tend to increase vulnerability, but the resilience factors - family labor, existing patterns of diversification away from agriculture, and possession of a store of indigenous knowledge - should not be underestimated.

Social-scientific study of the future impacts of climate change on poor rural people in developing countries has tended to be concerned with the increased frequency of extreme events with generalized impacts. This is understandable given the short to medium term importance of extreme events, and the difficulties of predicting any trends, climate-related or otherwise, in the longer term. However, there now must also be a genuinely interdisciplinary attempt to apply the rapidly growing scientific knowledge of the effects of climate change on crops and livestock to the “complex, diverse and risk-prone” farming

systems of developing countries. This will not only improve knowledge of impacts, but just as important, aid in building adaptive capacity at all levels including that of farmers themselves.

CHAPTER THREE: METHEDOLOGY OF THE RESEARCH

3.1 Description of the study area

3.1.1. Location of the study area

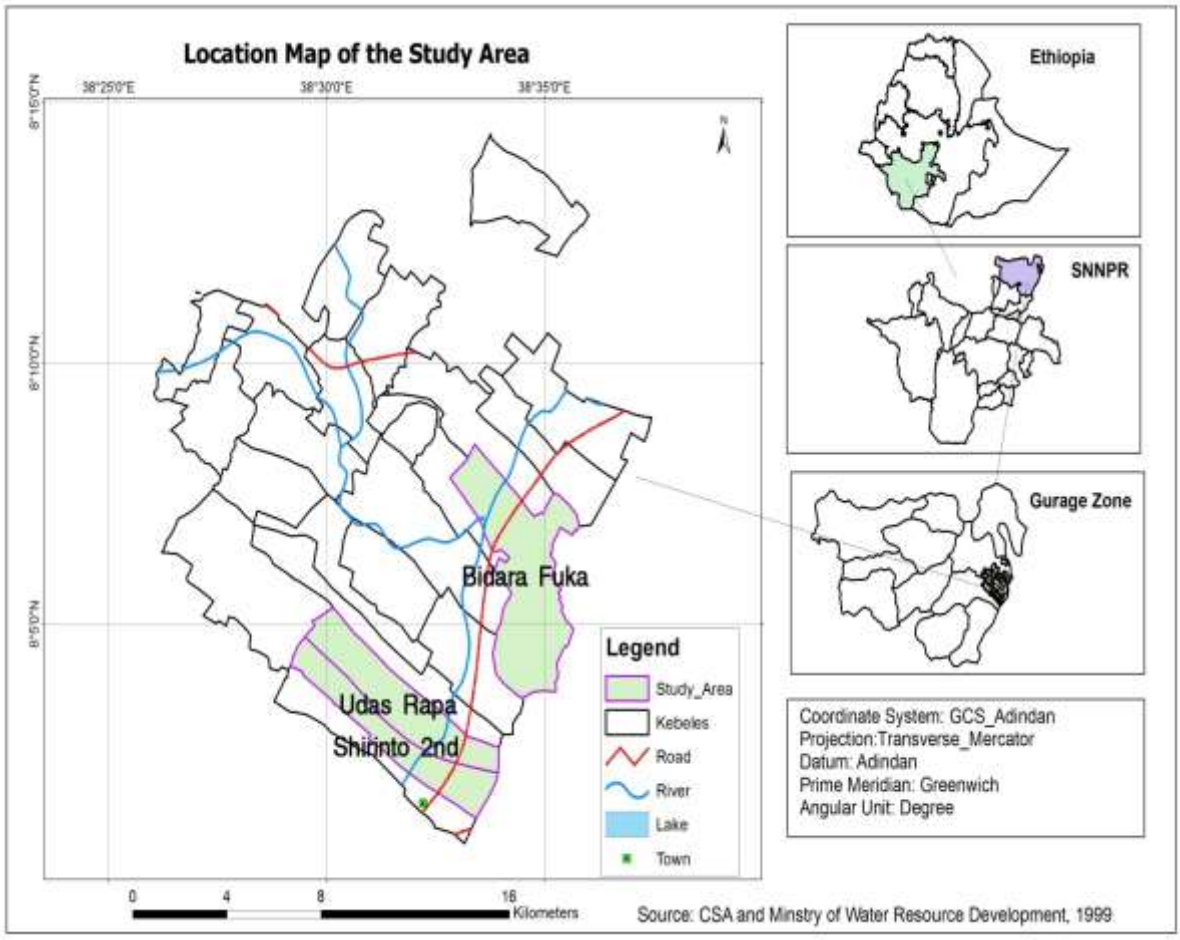

Figure 3.1 Map of study area

The study was conducted in Mareko Woreda, Gurage administrative zone, South Nations and Nationalities Peoples Regional State, Ethiopia. It lies between 7° 54’ to 8° 96’ North latitude and 38°31’to 39°72’East longitude. It is divided into 1 town and 25 rural Kebele administrations. The seat (capital) of Woreda administration is Koshe town which is located

at 145 kms distance from the Regional capital city of Hawassa, and 110 kms from capital city of Gurage zone which is Wolkite. Mareko Woreda borders in the South, by the Silti Woreda, in the West and north west by Meskan Woreda, in the East, North east and south east by the Kebeles of Oromia region.

3.1.2. Biophysical conditions

The physiographic setting of the study area is characterized by 80% flat and 20% mountains area. Its elevation ranges from 1800 to 2076 meters above sea level. Agro-ecological zone of the study area is occurring 100% in Woina Dega (Agriculture and Natural resource Development Office, 2017). Average annual rainfall amount of 10 years was 800 mm and average annual temperature varies between 15^0c in July and 27^0c December (ANRDO, 2017). According to ANRDO, the major soil types in the woreda are clay, clay loam, sandy loam, and silt. According to FAO soil classification two predominant soils which are moderately dark, A horizons with modest additions of organic matter and the B horizons have brown or reddish colors, the C horizons are slightly pale.

According to the information obtained from the ANRDO (2017), land use system of the area shows the following pattern. Out of the estimated total land area of 32750 hectare; 22276 hectare cultivated land, 3374 ha grazing land, 4485 ha forest and shrubs 2615 hectare others.

3.1.3. Socio-economic characteristic

Mareko Woreda has a total population of 81892 of which 41586 (50.8%) were male and 40306 (49.2%) were female. About 71880 (87.77%) were rural settler and 10012 (12.23%) were urban dweller (ANRDO2017). Population density of the Woreda was 150 persons per square kilometer.

Most of the people in the area were engaged in mixed agriculture. Crop cultivation and livestock production was generally practiced in the area. Crop production was entirely rain fed, except in very specific and small areas where vegetables were cultivated based on traditional and small-scale irrigation. There were two rainy seasons, summer, and winter; farmers were used for the cultivation of both long and short cycle crops. The dominant crops of the study area were maize, wheat, barley, teff, haricot bean, sorghum, tomato, pepper, onion and potato (ANRDO, 2017). Land preparation was carried on using mainly ox-plowing. Land degradation, deforestation, depletion of both ground and surface water,

increasing infertility of soil and natural hazards like variability of rainfall, temperature, disease, pest infestation, and livestock diseases were among the major problems in the study area (ANRDO, 2017).

3.2. Research Design

With respect to the objectives and nature of the research question, the research adopted a mixed research design. A mixed method research design is a procedure for collecting, analyzing and mixing both quantitative and qualitative methods in a single study to understand research problem (Creswell, 2012).

Among four mixed method designs (convergent parallel, explanatory sequential, exploratory sequential and Embedded) convergent parallel (triangulation) research design was used (Creswell), 2012). The purpose of convergent (concurrent) mixed design was to simultaneously collect both quantitative and qualitative data and use the result to understand a research problem. The main reason to use this design in this research was that one data collection from one method supplies strength to offset the weakness of the other, and that the more complete understanding of research problem results from collecting both data. Data gathered through both forms was analyzed separately and results were compared as to whether they support or contradict each other.

3.3. Data sources

The research employed primary and secondary sources of data. The primary data was gathered from households, key informants and focus groups. Similarly time series monthly rainfall and maximum and minimum temperature data's from 1998 to 2016 was obtained from the National Metrological Agency (NMA) Hawasa branch office. Documents, books, and journal research papers were secondary data sources utilized in the study.

3.4. Sample size and sampling techniques

In the study, two sampling strategies were used to select sample Kebeles and respondents. In the first stage, three kebeles were selected out of 25 rural kebeles in Mareko Woreda purposively based on the intensity of the climate change and variability which are Bidara Faka, Udasa Rebi and Shirinto second that are located under the same water shade. The selection of the kebeles and intensity of the area was done by Mareko Woreda crop and natural resource team leaders and experts. Sample respondents of smallholder farmers were

then selected from each of three rural kebeles, by using systematic sampling method, from listed households in the heads of each kebeles agriculture and natural resource development offices. From the three kebeles with a total of HHs 1513, about 27.5 – 39.7% i.e. 141 (9.3%) of HHHs were selected for questionnaire survey. According the recommendation of Conroy (2004) and GHIN (2006), precision level of (0.08) has been used.

$n = N/1+N (e)^2$ $n = 1513/1+ 1513 (0.08)^2 = 141$ Where, N is total household = 1513, e is standard error = 0.08 and n is sample size = 141

For focus group discussion (FGD) 6 male and 2 female in Bidara Faka, 5 male and 3 female in Shrinto second and 8 male and 2 female in Udasa Rebi kebeles a total of 26 individuals were selected, based on age, sex and socio-economic status. And finally 6 DAs in the study kebeles and 3 experts from the woreda's agriculture and natural resource development office were selected for in depth interview as key informants.

Table.3.1. Household, sample size and sampling techniques

S. No	Kebele	Target household		Sample size	
		No	%	No	%
1	Bidara Faka	415	27.5	39	27.5
2	Shirinto second	601	39.7	56	39.7
3	Udasa Rebi	497	32.8	46	32.8
	Total	1513	100	141	100

Source: Mareko Woreda Agriculture and Natural resource development office (2017)

3.5. Data gathering instruments

3.5.1. House hold survey

Sample survey method was applied to collect primary data from sampled households/farmers through structured questionnaire. The information collected included farmers' perception of historical climatic extremes, trend of temperature and rainfall, the situation of climate variability, its impact and adaptation methods which they used to cope up with the changes and variability.

3.5.2. Focus group discussions (FGDs)

One focus group discussion was conducted in each three kebeles of the study area. During discussion, the perception of farmers about climate change in the area, indicators of climate change and variability, particularly rain fall variability, pattern and reliability and the change in temperature and occurrence of extreme events were given an emphasis. And also discussed on coping mechanisms, adaptation strategies and the main challenges of the society to cope up and adapt well to the changing climate of their locality.

3.5.3. Key informant interview.

Key informant interview was one of the data collection methods which carried out with knowledgeable and experience rich experts from the woreda's agricultural and natural development office and kebele DAs. Through the interview the climate change and variability, its impacts on the livelihoods of the smallholder farmers and adaptation methods were emphasized.

On the other hand, reports, journals, and books, which assumed to be relevant to the objectives of the study, were used as supplementary materials. Rainfall and temperature values (data) were collected from NMSA, Monthly total rainfall and temperature values were computed.

3.6. Methods of data analysis

Data obtained from various sources were analyzed by using statistical package for social science (SPSS version20) and descriptive statistical methods such as mean, percentages and standard deviations were employed to analyze multiple responses.

In order to confirm whether there is significant difference of perception towards climate change and variability among farmers who are living in the study area or to measures of statistical significances, Excel, chi-square (x^2) test were used. The qualitative information that was gathered from focus group discussion, open-ended questions, and key informant interview was analyzed and interpreted using qualitative techniques. Metrological data was calculated by Excel and presented in graphs and charts. The results of the studies are presented by using graphs, tables and figures.

CHAPTER FOUR: Results and discussion

4.1. Socio-economic characteristics of Respondents

4.1.1. Sex, Age and Marital Status of respondents

Out of the total of 141 (Table 4.1) HHHs 46 (32.6 %) were from Udasa Rebi, 56 (39.7 %) of them from Bidara Faka, remaining 39 (27.7%) respondents were from Shirinto second kebles. As the sex composition of the survey indicates, from Udasa Rebi 33 (71.7 %) were male and 13 (28.3%) were female headed households. The remaining two kebeles, Bidara Faka and Shirinto second took 50(89.3%) male and 6 (10.7 %) female and 28 (71.8%) male and 11 (28.2%) female household heads respectively. According to the survey, most of the HHHs were between the ages of 30 to 49, which were followed by age group of 50-59. This entails most of surveyed HHHs were economically active and it can be assumed that they were well aware of their area and prevailing environmental problems very well, and can have low vulnerability due to lab our force.

Table.4.1. Sex, age, marital status, HH family size of respondents

Variables		Udasa Rebi		Bidara Faka		Shirinto Second		Total	
		No	%	No	%	No	%	No	%
Sex	Male	33	71.7	50	89.3	28	71.8	111	78.7
	Female	13	28.3	6	10.7	11	28.2	30	21.3
	Total	46	100	56	100	39	100	141	100
Age	20-29	4	8.7	5	8.9	1	2.6	10	7.1
	30-39	13	28.3	22	39.3	17	43.5	53	37.6
	40-49	16	34.8	21	37.5	14	36	50	35.5
	50-59	7	15.2	6	10.7	6	15.3	19	13.5
	60&above	6	13	2	3.6	1	2.6	9	6.4
	Total	46	100	56	100	39	100	141	100
Marital status	Single	2	4.3	2	3.6	0	0	5	3.5
	Married	36	78.3	46	82.2	32	82	116	82.3
	Divorced	6	13	4	7.1	4	10.3	12	8.5
	Widowed	2	4.3	4	7.1	2	5.6	8	5.7
	Total	46	100	56	100	39	100	141	100
HH Family size	1-2	4	8.7	17	30.4	0	0	21	14.9
	3-5	21	45.7	29	51.8	22	56.4	72	51
	6-8	18	39.1	9	16	13	33.3	40	28.4
	9-10	1	2.2	0	0	4	10.3	5	3.5
	11 & above	2	4.3	1	1.8	0	0	3	2.2
	Total	46	100	56	100	39	100	141	100

Source; Field survey (2017).

As the survey result also indicates, from the total respondents, 82.3% were married, 5.7 % widowed, 8.5% divorced and only 3.5 % were single. When it comes to the kebele level, at Udasa rebi Keble 78.3% married, 4.3% widowed, 13 % divorced and 4.3% were single. And from Bidara faka kebele 82.2 married, 7.1% divorced and 7.1% widowed and 3.6% were single. In the case of Shirinto Second 82 %) married, 10.3 % divorced and 7.7% widowed. The average household size was 4.9 persons.

Marital status data shown that there was different marital status, from single to married, this was important to perceive information from sample HHs, weather they had different concept of climate change in their locality based on their livelihood, and also marital status has implication for adaptation strategies and practices.

4.1.2. Educational status

The survey data on table 4.2 indicates, from the total respondents 42.6 % of HHs can read and write and followed by illiterate level which was 34% of respondents. 14.2% of the respondents achieved primary level and 9.2% of sample HHs was achieved secondary school. Farmer's education has serious implication with regard to adoption of technologies and practices in agriculture and for adapting Climate Change & variability in particular.

Table.4.2. Educational status of household heads

variables		Kebeles of sample respondents						Total	
		Udasa Rebi		Bidara Faka		Shirinto second			
		Freq	%	Freq	%	Freq	%	Freq	%
Educational status	illiterate	25	54.3	6	10.7	17	43.6	48	34
	Write& read	13	28.3	27	48.2	20	51.3	60	42.6
	Primary level	7	15.2	13	23.2	0	0	20	14.2
	Secondary level	1	2.2	10	17.9	2	5.1	13	9.2
	>12	0	0	0	0	0	0	0	0
	Total	46	100	56	100	39	100	141	100

Source: Field survey; (2017)

4.1.3. Means of Livelihood

Land is the major determinant factor for applying adaptation strategies. Farmers' adaptive capacity differs with average land holding they own. According to the survey data, the size of land was very fragmented and it differs among individual farmers.

As shown in the table 4.3 from sample HHs of 26 (18.4 %) have 0.25 – 0.5 ha, 45 (31.9 %) of HHs have land holding size of 0.75 - 1 ha, 34 (24.1 %) HHs have 1.5 - 1.75 ha, 27 (19.1%) house HHs have 2 – 25 ha, 6 (4.3%) HHs owned 3 – 3.5 ha and 3 (2.1%) of HHs have 4 - 4.5 ha of agricultural lands. As indicated of the survey result 50.4% of the farmers hold land size of 0.25 to 1 ha, which shows land shortage in the area.

Table.4.3. Land holding size of the study area

No	Land holding in ha	Frequency	Percent	Cumulative percent
1	0.25 - 0.5	26	18.4	18.4
2	0. 75 - 1	45	31.9	50.3
3	1.5 - 1.75	34	24.1	74.4
4	2 - 2.5	27	19.1	93.5
5	3 - 3.5	6	4.3	97.9
6	4 - 4.5	3	2.1	100
	Total	141	100	

Source: Field survey (2017)

Household heads were asked about their major source of livelihood, 14 (9.9%) were dependent on only crop production, while majority of the HHs 123 (87.3%) depends on crop and livestock (mixed farming) and 4 of (2.8%) HHs depends on crop, livestock and off farm.

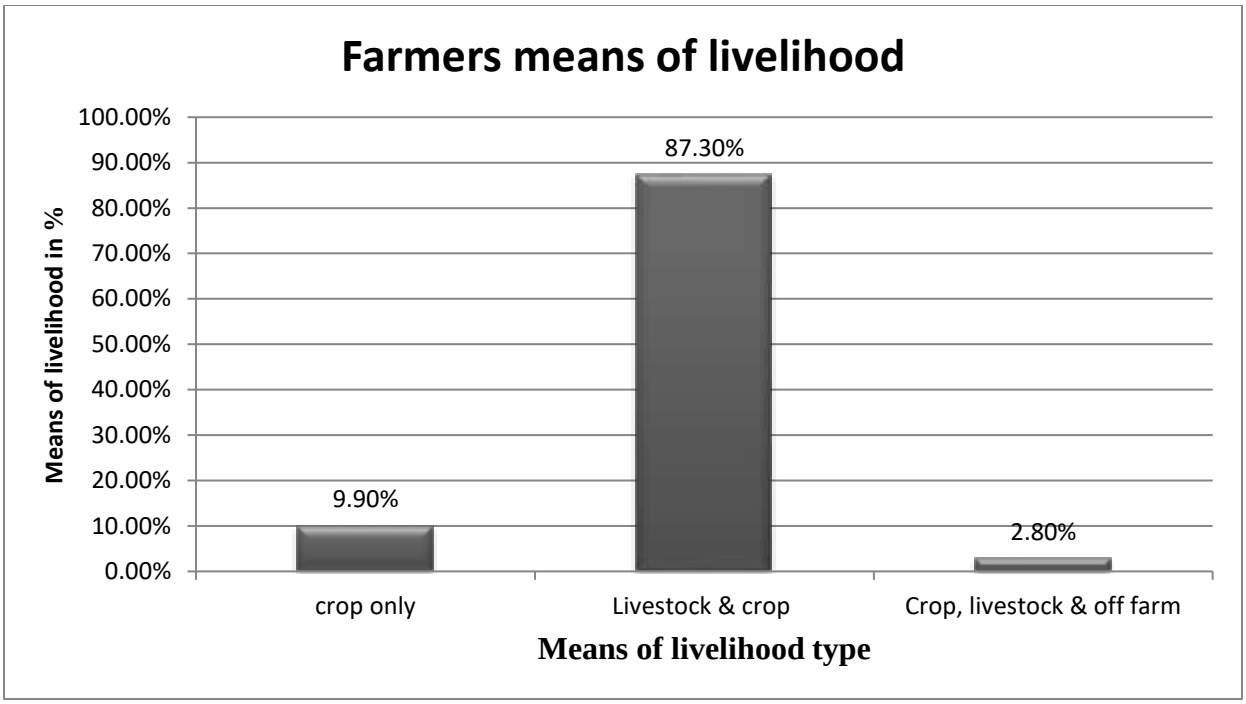

Figure.4.1. Farmers' means of livelihood

Source: Field survey (2017).

Livestock possession of HHs

As the data on table 4.4 shows, before twenty five years, the total tropical livestock unit of cows were 386 and in 2016 reduced to 129 (66.6%), number of oxen reduced from 267 to 128(52%), Goats, sheep, donkeys, horses reduced from 69 to 23 (66.6%), 44 to 17(61.4%), 70 to 53(24.3%), 30 to 7(76.7%) respectively. Generally tropical livestock unit of the area decreased from 866 to 357 (58.8%). The study indicated that shortage of pasture land because of population pressure, reduction of bushy trees for goats, high temperature and water lose for all livestock's and diseases were the main causes of reduction tropical livestock unit in the study area.

This was supported by studies on livestock production (Abate, 2009) for instance, indicated that climate change and variability has adverse impact on the livestock composition and compromise the return from livestock as the availability and quality of pasture and water are highly affected by climate variability. Moreover, recurrent droughts and heat spells would create favorable condition for the spread of infectious diseases that would eventually increase loss of livestock.

Table.4.4. number of livestock possess by the sample households (1998- 2016).

Livestock type		Udasa Rebi N=46	TLU	Bidara Faka N=56	TLU	Shirinto Second N=39	TLU	Total N=141	Total TLU
		Mean		Mean		Mean		Mean	
Cow	Before 25 years	257(6)	180 (45)	125(2.2)	88(4)	169(4.3)	118(52)	3.90	386(44.6)
	2016	51(1)	36(41)	87(1.6)	61(32)	45(1.2)	32(40)	1.29	129 (36)
Oxen	Before 25 years	191(4)	134(33)	111(2)	78(33)	79(2)	55(24)	2.	267(30.8)
	2016	45(1)	32(36)	99(1.76)	69(37)	39(1)	27(34)	1.29	128(35.8)
Goat	Before 25 years	304(7)	30(7.5)	224(4)	22(9)	170(4.4)	17(8)	4.95	69(8)
	2016	43(1)	4(4.5)	136(2.4)	14(7)	48(1.2)	5(6.3)	1.60	23(6.4)
Sheep	Before 25 years	141(3)	14(3.5)	201(3.6)	20(8)	99(2.5)	10 (4)	3.12	44(5)
	2016	8(0.2)	.8(.9)	121(2.2)	12(6.3)	36(0.9)	4(5)	1.17	17(4.7)
Donkey	Before 25 years	59(1.3)	30(7.5)	42(0.8)	21(9)	37(0.9)	19(8)	0.98	70(8)
	2016	25(0.5)	13 (15)	55(0.98)	28(15)	24(0.61)	12(15)	0.74	53(14.8)
Horse	Before 25 years	18(.39)	14(3.5)	12(0.21)	10(4)	8(0.2)	6(2.7)	0.26	30(3.5)
	2016	2(0.04)	2(2.3)	6(0.1)	5(3)	0(0)	0(0)	0.05	7(2)
Overall average	Before 25 years	970(21)	402	715(13)	239	526(14)	225	16.72	866
	2016	174(4)	88	504(9)	189	192(4.9)	80	6.1	357

Source: field survey 2017

4.2. Climate Change and variability

4.2.1. People Perceptions of climate change and variability

As Ban and Hawkins (2000) defined perception, it is the process by which we receive information or stimuli from our environment and transform it into psychological awareness. It is important to have an insight of peoples view on temperature and rainfall trends of and their adaptation options. In line with this, in the study area sample respondents, FGD participants and key informants were asked about their perception of climate change and

variability. Figure 4.5 shows that 82.3 % of the respondents perceive that there has been climate change, 17% of the respondents informed that climate has been completely changed and o.7% of them said that the climate has not changed. FGD and key informants agreed that climate change and variability of the study area completely changed.

Table.4.5. Respondents perception about climate change

	Kebele respondents						Total	
Perception to climate change	Udasa Rebi		Faka Rebi		Sherinto second			
	N= 46		N= 56		N= 39			
	Freq	%	Freq	%	Fre	%	Freq	%
There is climate change	46	100	44	78.6	26	66.7	116	82.3
Climate has not change	0	0	1	1.78	0	0	1	0.7
Climate is totally changed	0	0	11	19.8	13	33.3	24	17
I have no idea	0	0	0	0	0	0	0	0
Total	46	100	56	100	39	100	141	100

Chi-square test of the respondents

		Kebele respondents			Total	Ch^2	P -value
Perception to climate change		Udasa Rebi	Faka Rebi	Sherinto second			
There is climate change	Observed	46 (37.8)	44(46)	26 (32)	116	10.56	12.56
Climate has not change	Observed	0(0.32)	1(0.39)	0(0.27)	1		
Climate is totally changed	Observed	0(7.8)	11(9.5)	13(6.6)	24		
There is no observable of CC	Observed	0	0	0	0		
Total		46	56	39	141		

Source: Field survey (2017)

The chi-square test employed to analyze association between perception and living environment (kebeles). The calculated x^2 value with 6 degrees of freedom and significance level of 0.05 is less than P- value. Accordingly, the null hypothesis is accepted therefore, it could be concluded that there is no significant difference of perception towards climate change and variability among farmers who are living in their locality. This implies that climate change and variability is becoming the problem of all communities and environmental conditions.

4.2.2. Local Indicators of Climate Change and variability

From the total surveyed HHs of the study area 28.5% of the respondents' perceived recurrent drought as an indicator of climate change and variability and this was followed by 23.8% HHs, who responded as there has been an increase in average temperatures in the past 20-25 years. The results also indicated that 20.7% of the respondents perceived that there has been unpredictable rainfall. 15.4% respondents also perceived a decrease in water resource and 11.6% flooding as major indicators of climate change and variability (Figure.4.2).

FGD and key informants reported that continuous drought and unpredictable rain fall were forcing for bad livelihood of the community in the area.

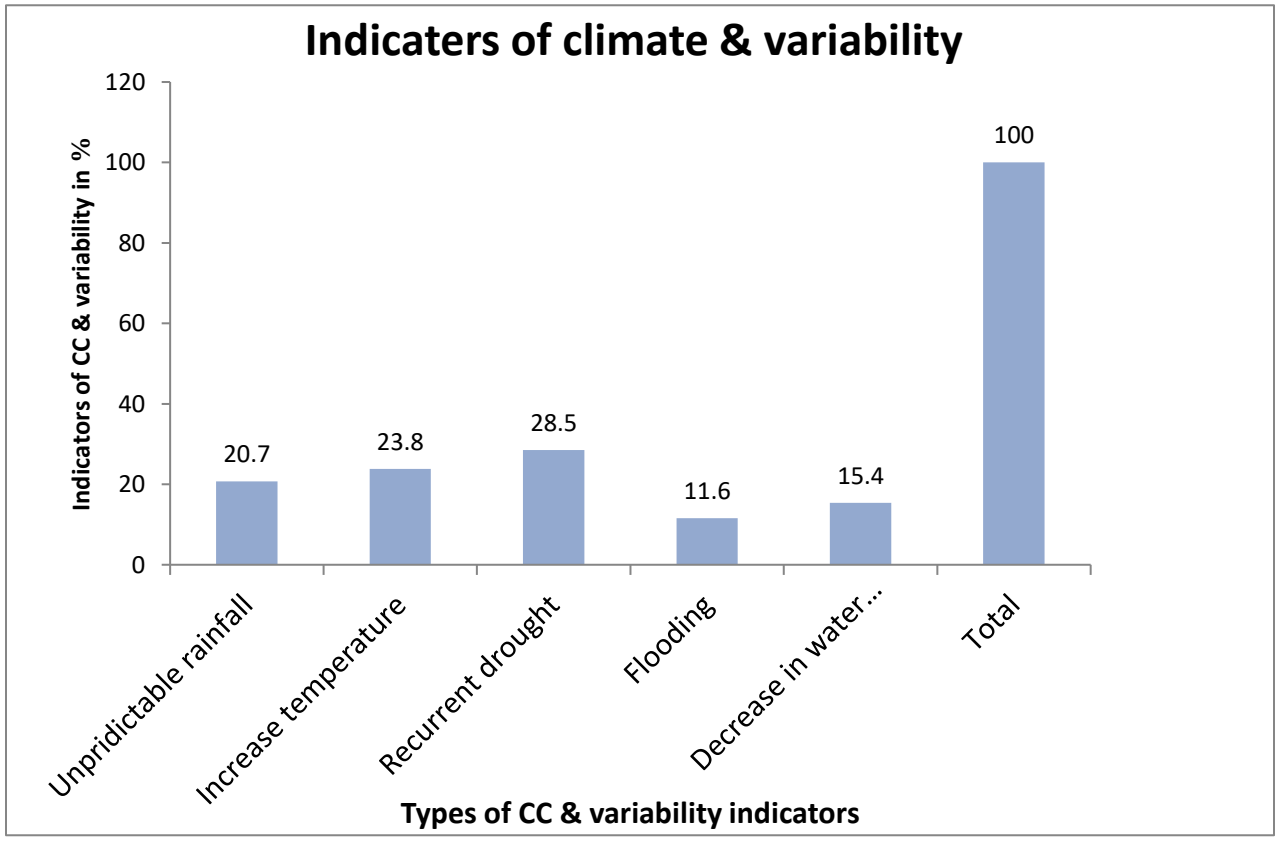

Figure .4.2.Local indicators of climate change and variability.

Source: Field survey: (2017).

4.2.3. Local people's perception on causes of climate variability

Most of the people in Ethiopia consider climate change and variability as an act of natural causes. However, a few people associated climate change and variability with anthropogenic

factors. The overwhelming majority of climate change and variability researchers have reached the 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 (UN, 1992; NSF, 2009).

In the study area most of the respondents associated climate Change and variability with human action. The responses disclosed that about 86.5% of the respondents associated climate variability with human action. Of the total respondents, 12.8% of them relate it to human and natural factors. Only 0.7% considers climate change and variability as an act of natural causes of soil depletion.

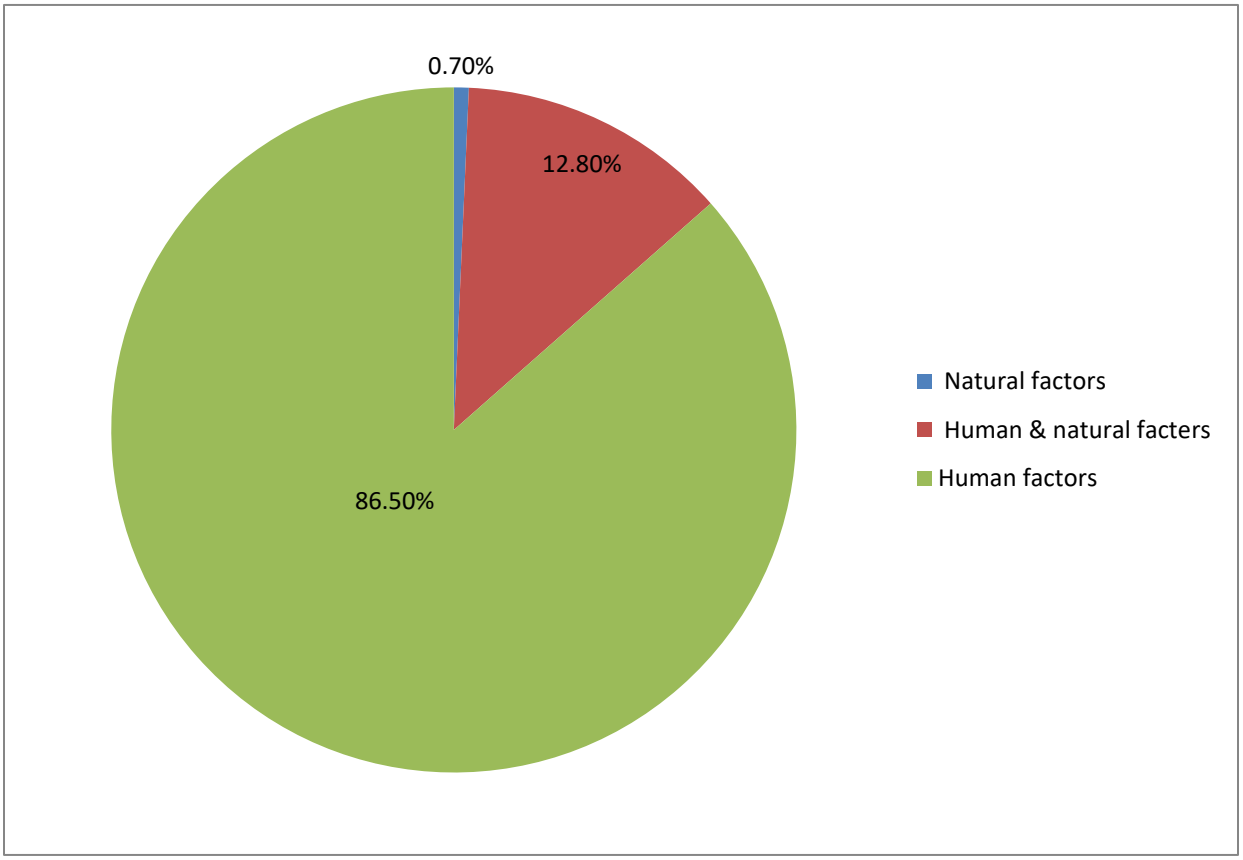

Figure.4.3. local people's perception of causes of climate change and variability

Source: Field survey (2017).

Respondents listed down deforestation (27.6%), over cultivation (23.9%), population pressure (22.2%) and overgrazing (20.4%) were some of the main human activities, which

affected the local climate change and variability. Most of FGD and key informants interview also identified similar ideas.

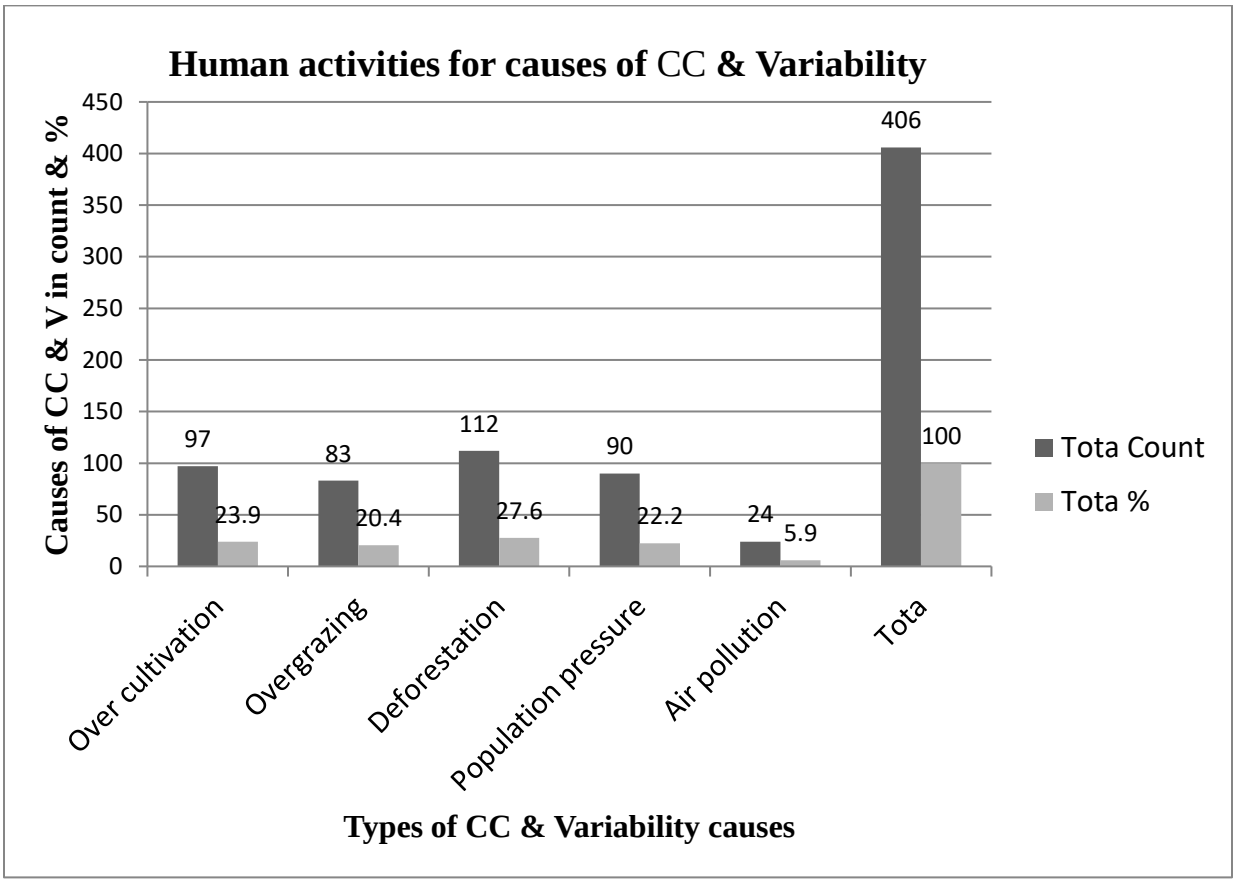

Figure.4.4. Local people's perception on human activities for causes of CC& variability

Source: field survey (2017)

4.2.4. Rainfall and temperature pattern of the Mareko Woreda

4.2.4.1. People's perception and trend of temperature variability

According to the UNDP climate change country profiles, the average annual temperature in Ethiopia increased by 1.3^0C between 1960 and 2006 (McSweeney et al, 2010). Daily temperature observations also show an increase in the average number of 'hot' days and 'hot' nights per year.

Respondents in the study area reported that temperature has been increased in their local areas in the past 20-25 years, and also reported that, the main indicators of temperature has been decreased of crop and livestock production (30.9%), declining rainfall amount (22.2%), dry up of rivers and streams (21%), deteriorated of vegetative covers (12.2%),

prevalence of newly introduced human and animal diseases (11.4%) and extinction of indigenous habitat (2.2%).

Key informants and FGD participants agreed that temperature was increasing day and night and caused declining of community livelihoods.

Table.4.6. people's perception of temperature variability

State of temperature variability		Udasa Rebi N= 46		Bidara faka N = 56		Shrinto/ S N = 39		Total	
		Freq	%	Freq	%	Freq	%	Freq	%
Change of temperature	Increased	46	100	56	100	39	100	141	100
	decreased	0	0	0	0	0	0	0	0
	No change	0	0	0	0	0	0	0	0
Indicators of temperature change									
Dry up of rivers and streams		39	22.3	18	13.6	30	28.5	87	21
Decreased crop & livestock production		43	24.5	52	39	33	31.5	128	30.9
Prevalence of newly introduced human &animal diseases		25	14.3	14	10.6	8	7.7	47	11.4
Decreased in rainfall amount		37	21.2	36	27	19	18	92	22.3
Extinction of indigenous habitat		1	0.6	5	3.8	3	2.8	9	2.2
Deteriorated of vegetation cover		30	17.1	8	6	12	11.5	50	12.2
Total		175	100	133	100	105	100	413	100

Source: Field survey (2017).

4.2.4.1.1. Temperature Trends

A perception of farmers with respect to increasing temperatures as well as increasing rainfall variability was in line with empirical analysis of rainfall and temperature trends using the data obtained from meteorological station. The analysis of rain fall data obtained from NMSA tends to support the perception of sample respondents regarding rainfall and temperature trends.

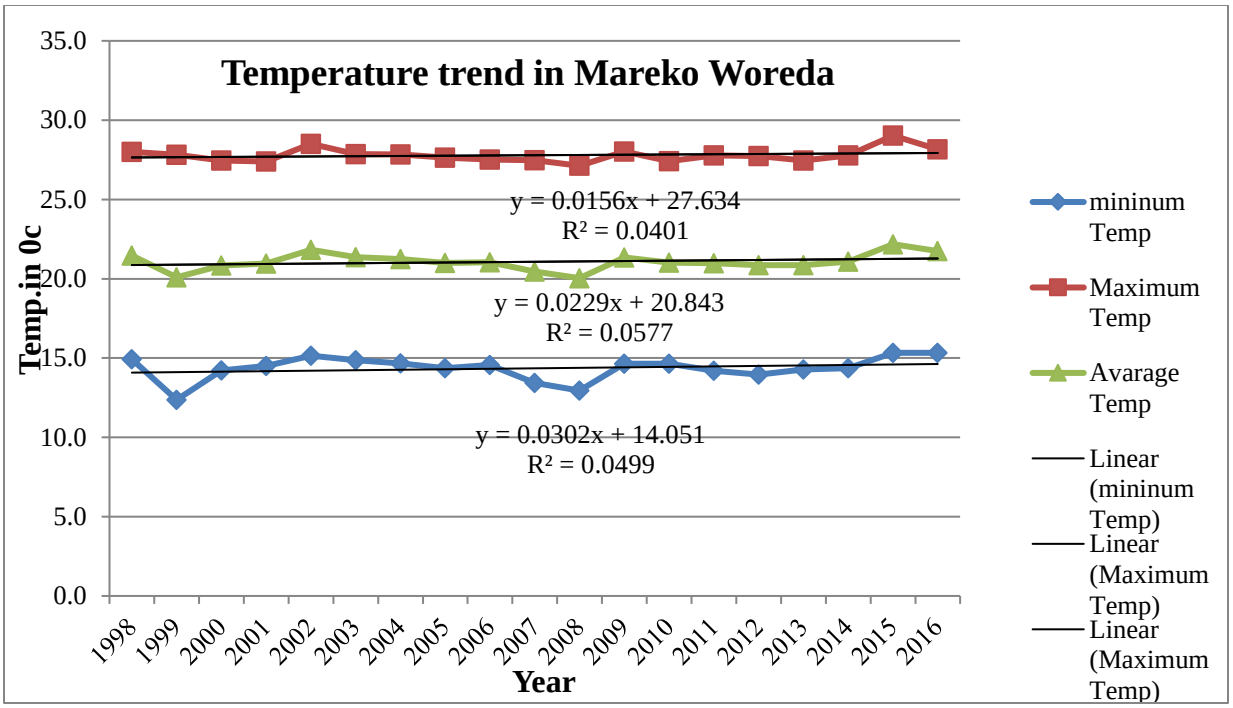

Fig.4.5. Annual temperature trend in Mareko Woreda (1998-2016)

Source: NMSA (2017).

	Annual temprature			Belg tempersture			Meher temperature		
	Max	Mini	Avarage	Max	Mini	Ave	Max	Mini	Ave
Mean	27.8°C	14.4°C	21.1°C	29.5°C	15.4°C	22.3°C	26.6°C	15.3°C	21°C
SD	0.4°C	0.8°C	0.5°C	0.6°C	0.9°C	0.5°C	0.7°C	0.8°C	0.6°C
CV	1.5%	5.3%	2.6%	2.1%	6.1%	2%	2.7%	5.1%	2.9%
Max	29°C	15.3°C	22.2°C	30.4°C	16.7°C	23.5°C	28.3°C	16.2°C	22.9°C
Min	27.1°C	12.4°C	20°C	28.2°C	13°C	21.4°C	25.7°C	12.7°C	19.8°C

The figure 4.5 indicates that both the maximum and minimum temperature was increasing by 0.0156 ^{0}C and 0.0302 ^{0}C per decade respectively. Also in the table above shown that the mean annual maximum temperature was 27.8°C, the standard deviation from the mean was 0.4°C and the result of maximum and minimum temperature coefficient of variation (CV) was 1.5%, the mean annual minimum temperature was 14.4°C, the standard deviation 0.8°C and coefficient of variation was 5.3%. Average annual, standard deviation and coefficient of variation were 21.1°C, 0.5°C and 2.6% respectively.

Belg season maximum temperature, standard deviation and coefficient of variation were 29.5°C, 0.6°C and 2.1% respectively. Mean of belg minimum temperature, standard deviation and coefficient of variation were 15.4°C, 0.9°C and 6.1% respectively. Average belg temperature 22.3°C, 0.5°C, and 2% respectively.

Meher season maximum temperature, standard deviation and coefficient of variation were 26.6°C, 0.7°C and 2.7% respectively. Mean of meher minimum temperature, standard deviation and coefficient of variation were 15.3°C, 0.8°C and 5.1% respectively. Average meher temperature 21°C, 0.6°C, and 2.9% respectively.

According to the annual, belg and meher data analysis has been shown that both maximum and minimum temperature increment. The increment of both maximum and minimum temperature indicates that night and day times are getting hot. Minimum temperature is increasing much faster than the mean maximum temperature.

In Ethiopia, it is assumed that the temperature has been increasing annually at the rate of 0.2°C over the past five decades (Yohannes, 2009). The annual time series of minimum and maximum temperature for 40 stations averaged over Ethiopia reveals a warming trend in temperature and it is evident that the average annual minimum temperature is increasing much faster than the average annual maximum temperature (HDR, 2007).

4.2.4.2. People's perception and trend of rainfall variability:

Overwhelming number (100%) of respondents perceived that rainfall has been declining in the past 20-25 years. About 90% of the farmers perceived that, in the past 20-25 years, there has been a noticeable change in the duration of the rains that begins lately and ends early, while 9.3% and 0.7% respondents reported the rainfall begins early and ends early, begins lately and ends lately respectively. It implies that the area is becoming more and more prone to droughts due to declining rainfall as perceived by the farmers.

4.2.4.2.1. Annual rainfall Trend and Variability

Rainfall and temperature are important meteorological variables that determine water availability and production of crops and livestock rearing or food production processes in countries where agriculture is more dependent on rainfall (Abebe, 2013). In the study area, the annual average rainfall (1998-2016) is 761.1 mm with standard deviation of 194.1 mm (table 4.9). The annual rainfall ranges from289.9 mm in (2015) to 1076.5 mm in (2005) with

25.5% coefficient of variation; this shows that monthly rainfall was varied by 25.5% in the study area for the long period of time. Annual rainfall was showing decreasing trend by -5.7mm (fig 4.7). Annual rainfall was below average in the years 1999, 2000, 2002, 2003, 2004, 2009, 2011, 2012, and the driest year was 2015. This explains the frequent droughts and food insecurity of the area.

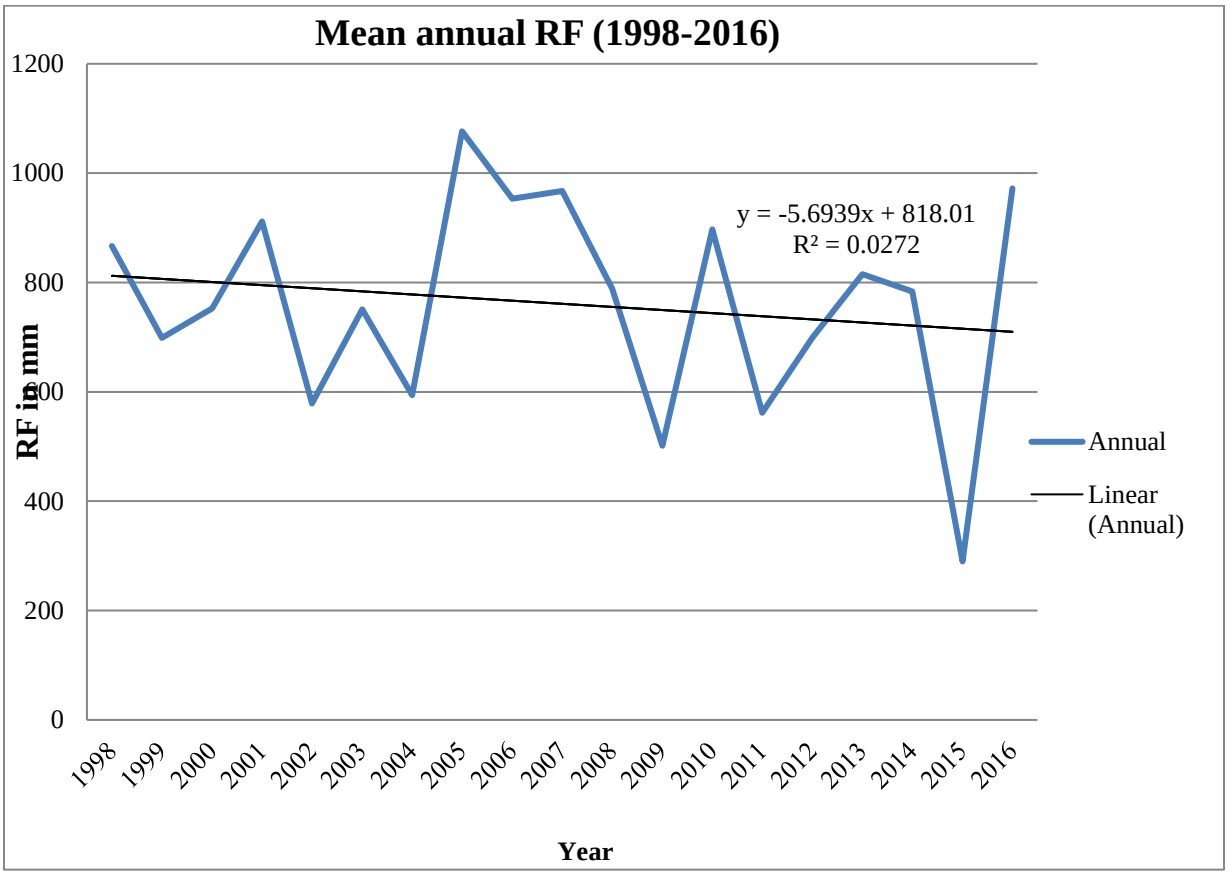

Fig.4.6.Mean annual rainfall trend in the Mareko Woreda (1998-2016)

Source: NMSA, (2017)

4.2.4.2.2. Seasonal Rainfall Variability

The study area receives bimodal rainfall which are belg ,a small rain period (February, March, April, and May) and meher, major rain period (June, July, August, September) seasons.

As shown in figure 4.9 belg rain shows a high seasonal variability between the years 1998-2016 and similarly, the meher rain shows relatively high seasonal variability in the same years and more of decreasing trend. Therefore, the variable and reduced belg and meher

rainfall has a critical implication on rural livelihoods. Traditional and indigenous crop seeds are disappearing due to decreased rainfall and increasing temperature.

The maximum and minimum rainfall of belg season was 504.5 and 74.5 respectively, and the mean rainfall was 228.1 mm, the standard deviation was 136.9, and coefficient of variation (CV) shows 60%. This shows bulg rainfall variability within months was high. The same true to that maximum and minimum rainfall of meher season was 632.9 and 159.0 respectively, and the mean of meher rainfall was 445.1mm, the standard deviation was 118.1 and coefficient of variation (CV) shows 26.5%. The variability was relatively high.

The trends of belg and meher rainfall were showing decreasing by -0.90mm and -2.5mm respectively (fig4.8).

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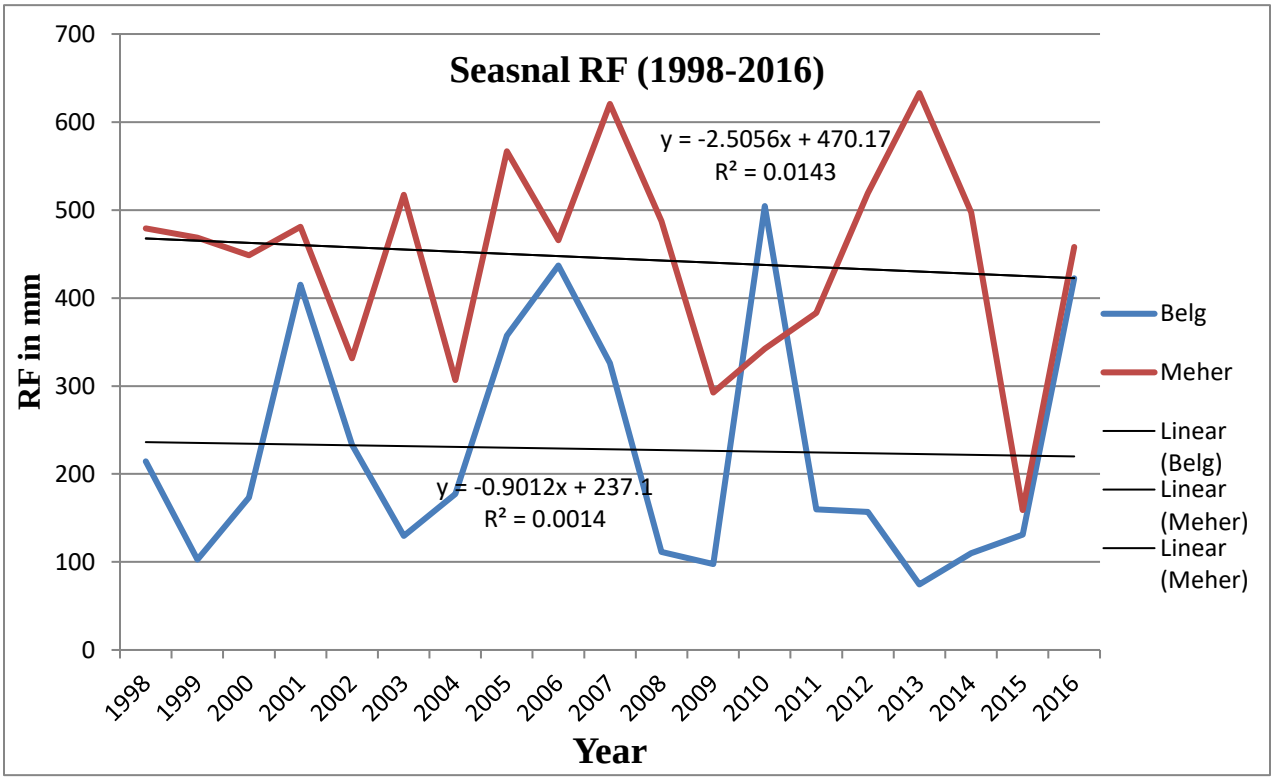

.Fig.4.7. Meher and belg rainfall trends in the Mareko Woreda

Generally in the study area annual rain fall was highly variable from year to year with its general decreasing trend. The rainy seasons were shrinking making growing periods shorter. These situations make farmers vulnerable to food insecurity because they were totally dependent on rainfall to produce their food.

Evidences show that the increasing trend of the already high temperatures and the reduction of rainfall levels will increasingly result in reduced agricultural production in Sub-Saharan Africa (Mano & Nhemachena, 2007).

4.3. Impacts of Climate Change & variability on Small holder farmers livelihood

4.3.1. Impacts on natural resources and the environment

According to HHHs, key informants and group discussants, climate change has had negative consequences on productive capacity of agricultural land, spread of human and animal diseases, drought, flooding, and supply of water, grazing land, forest production and density and food security, etc.

In the study area 96.5% of the respondent households indicated that the forest cover over time has been decreased. While 3.5% of them responded that forest cover is increased. About 90%, of the respondents argued that soil erosion problem has been increased and 10% decreased. 89.4% and 10.6% of the respondents assured that water availability has been decreased and increased respectively. As of 85.8% of HHs the land degradation has been increased and 14.2% of farmers reported that land degradation has been decreased (Table.4.7).

Key informants and the FGD said that water shortage, soil erosion, decreased in forest cover and land degradation increased in the recent years.

Climate variability causes degradation and loss of important natural resources. The increasing occurrence of climate extremes (for example heat waves, droughts, heavy rainfall) is having an impact on land degradation processes, including floods, mass movements, soil erosion by water and wind 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, 2007).

Table.4.7. Perceived effect of CC and variability on smallholder farmer's livelihood

Effect on livelihood attributes		Perceived change on smallholder Farmers' livelihood (%)				X^2 value	P-value (DF= 2)
		Udasa Rebi	Bidara Faka	Sherinto second	Total		
Water availability	Decreased	42 (41)	50 (50)	34 (34.8)	126	0.36	5.99
	Increased	4(4.9)	6(5.95)	5(4.2)	15		
Forest cover	Decreased	45(44.4)	52(54)	39(37.6)	136	2.36	
	Increased	1(1.6)	4(1.98)	0	5		
Soil erosion	Decreased	7(4.56)	5(5.56)	2(3.87)	14	2.50	
	Increased	39(41.4)	51(50.4)	37(35.1)	127		
Land degradation	Decreased	8(6.5)	9(7.9)	3(5.5)	20	1.95	
	Increased	38(39.5)	47(48)	36(33.5)	121		

Source: Field survey (2017).

Chi-square test in the table 4.7 showed that calculated x^2 value with two degrees of freedom and significance level of 0.05 is less than p-value, therefore, perceived effect of Climate change and variability effect of livelihood attributes on smallholder farmers livelihood. This means we accept the null hypothesis, because there is no significant difference of farmers perception towards effects of climate change and variability among them, and implies that water availability, forest cover change, soil erosion, land degradation are becoming the problem of communities.

4.3.2. Impact of Climate Change on crop Production

During drought and delay in the onset of rain land becomes dry and difficult to plough, forage deficit leads to weakness and oxen mortality, and lack of precipitation hinders germination of planted seeds. Even weeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households' livelihood (Abate, 2009).

Most of the respondents (77.3%) were responded that there was decreased of crop yield, where as 22.7% of them were responded increased of crop production (figure 4.8).

As of seven years collected secondary data from Mareko Woreda ANRDO (2017) indicates that there has been total harvested and individual major (teff, wheat, maize and sorghum)

belg and meher crops yield variability (fluctuation) or there has not been sustainable crop production and productivity growth (Figure 4.11and 4.12).

Table.4.8. Chi-square test in effect of Climate Change in crop Production

Effect on livelihood attributes		Perceived change on smallholder Farmers' livelihood (%)				X^2 value	P-value (DF= 2)
		Udasa Rebi	Bidara Faka	Sherinto second	Total		
Crop yield	Decreased	34 (35.6)	47 (43.3)	28 (30.2)	109	2.32	5.99
	Increased	12 (10.4)	9 (12.7)	11 (8.9)	32		

Chi-square test above shown that calculated x^2 value with 2 degrees of freedom and significant levels of 0.05 is less than P- value. Therefore we accept the null hypothesis which shows that there is no significant different perception between HHs about decreased of crop yield from their area.

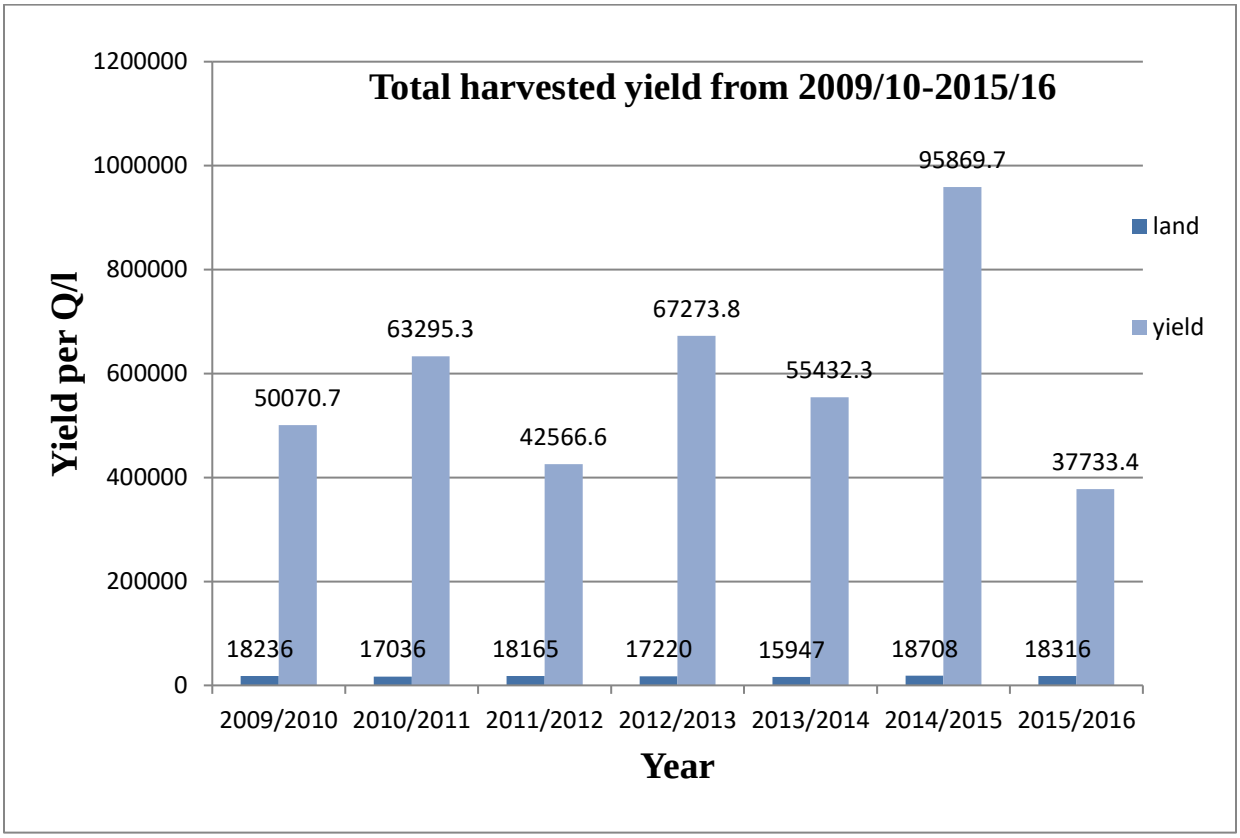

Figure 4.8.Total harvested yield of the Mareko Woreda (2009/2010 -2015/2016)

Source: ANRDO (2017).

The concept of agriculture is sustainable development of productivity and production. But in the study area both production and productivity was showing variability. In 2009/10 crop physical year land planted was 18236 hectares and yield harvested was 50070.7quintals, in the year 2015/16 area plated was 18316 hectares and yield harvested was 37733.4 quintals. This shows that land increased by 80 hectares but yield harvested decreased by 12337 quintals, and yield productivity was 3 quintals per hectare. In the year of 2010/11 total productivity of the crops was 3.7quintals, and in the year of 2011/12 was 2.3 quintals per hectare, that was decreased by 1.4 quintals. In the year of 2012/13 productivity was 3.9 quintals that was increased by 1.6 quintals, but in the year of 2013/14 productivity was decreased to 3.5 quintals per hectare. In the physical year of the 2014/15 yield productivity was 5 quintals per hectare but decreased to 3 quintals per hectare in the year of 2015/16. Therefore, in the study area total crop production and proclivity was showing decreasingtrend.

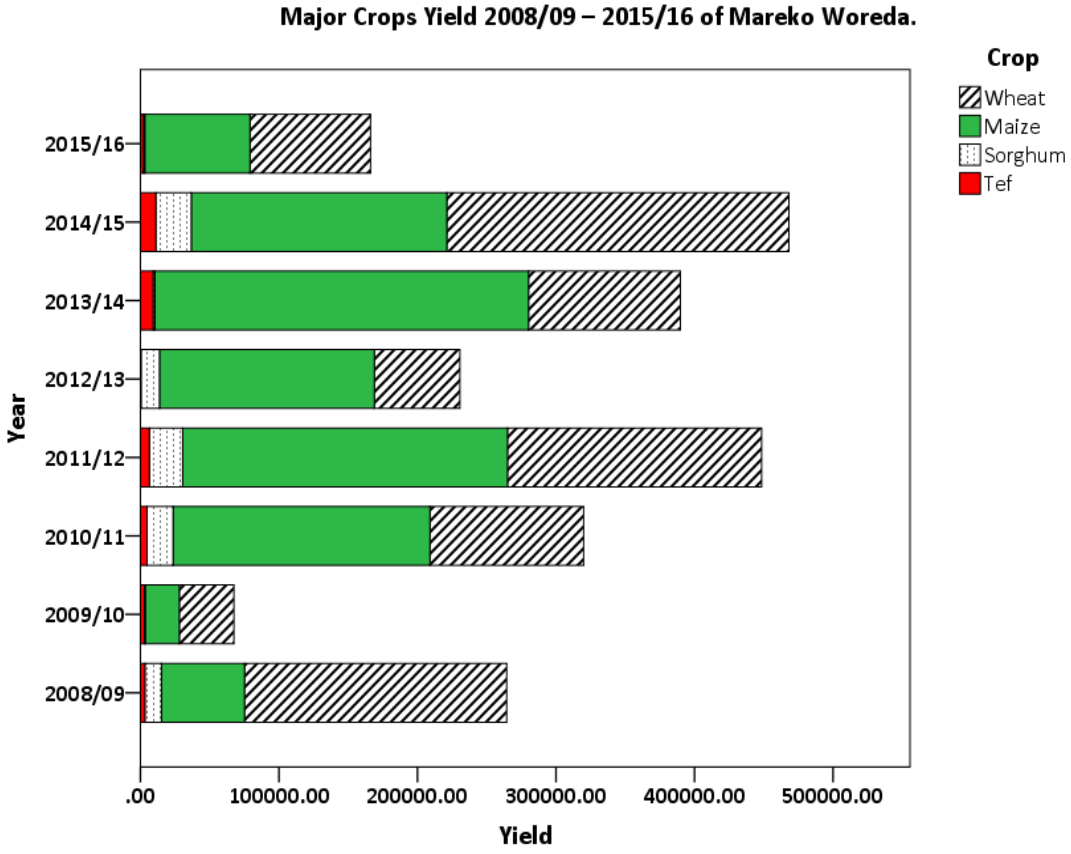

Figure 4.9 Major crops yield harvested (2008/2009 - 2015/2016)

Source: Mareko Woreda agriculture and natural resource management office.

Table 4.9 Major crops land planted & yield harvested (2008/2009 - 2015/2016)

	maize				Sorghum			
year	land	yield	Prod*	d/ce*	land	yield	Prod*	d/ce*
2008/09	2909	59861	21	0	750	12000	16	0
2009/10	2904	24624	9	-13	109	604	6	-12
2010/11	7463	185406	25	16	1027	18768	18	13
2011/12	5775	234447	41	16	1016	24031	24	5
2012/13	4138	155120	38	-3	906	13320	15	-9
2013/14	5060	269724	53	16	55	1375	25	10
2014/15	5220	184422	35	-18	800	25600	32	7
2015/16	3819	75998	20	-15	270	918	3	-29
	wheat				Teff			
year	land	yield	Prod*	d/ce*	land	yield	Prod*	d/ce *
2008/09	7585	189337	25	0	359	3231	9	0
2009/10	2320	39440	17	-8	817	2892	4	-5
2010/11	4939	110987	22.5	5.5	757	4779	6.3	2.3
2011/12	5025	183470	37	14	803	6514	8.1	1.8
2012/13	2577	61848	24	-13	28	392	14	5.9
2013/14	3576	109642	30.7	6.7	664	9073	13.7	-0.3
2014/15	5182	246974	47.7	17	857	11140	13	-0.7
2015/16	4485	87009	19.4	-28.3	947	2179	2.3	-10.7

*prod= productivity *d/ce= productivity difference (variation)

Source; ANRDO (2017).

*d/ce= productivity difference (variation)

Maize is one of the major food crops of the mareko woreda, as shown in the table 4.9 production and productivity was varied year to year, more of decreasing trend. In the year of 2008/09 land planted was 2909 hectares, yield harvested was 59861 quintals, and yield productivity was 21 quintals per ha, in the year of 2009/10 planted land was 2904 ha, yield harvested was 24624 quintals, productivity decreased from 21 to 9 quintals per ha, in the year of 2010/11 and 2011/12 productivity was increased from 9 to 25 and 41quintals per ha respectively, but in the year of 2013/14, 2014/15 and 2015/16 productivity was decreased from 53 to 35 and from 35 to 20 quintals per ha respectively. Yield productivity of 2015/2016 was decreased by 1 quintal from 2008/09.

In the physical year of 2008/09 sorghum crop planted 750 ha, and harvested 12000 quintals, the productivity was 16 quintals per ha, but in the year of 2015/16 land planted 270 ha, yield

harvested was 918 quintals per hectare, after 7 years productivity was decreased from 16 to 3 quintals per ha.

7585 hectare of land was covered by wheat crop in the year of 2008/09, and 189337 quintals of yield was harvested, productivity of the crop was 25 quintals per ha, in the physical year of 2009/10 to 2015/16 land planted, yield harvested and productivity of the crop was showed variation. But productivity of the crop was decreased by 5.6 quintals in the year of 2015/16 compare to 2008/09. Teff crop production and productivity also decreased as of maize, wheat and sorghum (table 4.9)

Therefore, data collected from field survey and secondary data obtained from agriculture and natural resource development office of mareko woreda has shown similar result of crop yield reduction trend.

42.6% of HHs were reported that the major causes of yield reduction in the study area were unpredictability of rain fall, inadequate farm land (19.8%), poor soil fertility (17.8%), high temperature (12%) and 7.8% pest and diseases (Table 4.10).

Table.4.10. Factors affecting crop production in the study area.

Factors affecting crop production	Udasa Rebi N= 46		Faka rebi N= 56		Sherinto Second N= 39		Over all	
	count	%	count	%	count	%	count	%
Unpredictable rainfall	19	41.3	25	44.6	16	41	60	42.6
Inadequate farm land	10	21.7	10	17.8	8	20.5	28	19.8
Increased pest and diseases	6	13	5	8.9	0	0	11	7.8
High temperature	5	10.8	7	12.5	5	12.8	17	12
Poor soil fertility	6	13	9	16	10	25.6	25	17.8
Total	46	32.6	56	39.7	39	27.6	141	100

Source: survey result (2017)

FGD and Key informants also listed a number of reasons for yield reduction, among these declining soil fertility, frequent droughts (high temperature), low and unpredictable rainfall, and increased number of pests in cropping seasons.

4.3.3. Impact of Climate Change and variability on Livestock production

In the study area households used livestock as source of livelihood in addition to crop cultivation. According to the survey data, household heads responded that shortage of grazing land (46.5%), shortage of water for animals (32.3 %), livestock disease (10.6%) and high temperature (10.6%) affected livestock production and livelihood of the communities.

Table 4.11.Change in livestock production

Variables	Kebele respondents						Total	
	Udasa Rebi		Bidara Faka		Sherinto second			
Decrease/Increase of livestock	count	%	count	%	count	%	count	%
Decreased	38	82.6	47	83.9	33	84.6	118	83.7
Increased	8	17.4	9	16.1	6	15.4	23	16.3
reason for decrease of livestock								
livestock disease	21	77.7	0	0	6	22.3	27	10.6
Shortage of water for animals	25	30.5	31	37.8	26	31.7	82	32.3
Shortage of grazing land	31	26.3	49	41.5	38	32.2	118	46.5
High temperature	3	11.1	0	0	24	88.9	27	10.6
Total	80		80		94		254	100

Source: Field survey (2017).

Table.4.12. Perception of smallholder farmers to livestock production

Perceived change on smallholder Farmers' livelihood (%)				X^2 value	P-value (DF= 2)
Udasa Rebi	Bidara Faka	Sherinto second	Total		
38(38.5)	47(46.9)	33 (32.6)	118	2.20	5.99
8 (7.5)	9 (9.2)	6 (6.4)	23		

Source: Field survey 2017

Farmers' perception of livestock production declining was checked by chi-square test. Calculated x^2 value with 2 degrees of freedom and significant levels of 0.05 is less than P-

value. This shows that no significant difference between HHs concepts that was reported livestock production was decreasing (null hypothesis accepted).

Focus group discussion participants pointed out that some people had lost some of their cattle during drought period. The number and types of cattle were decreasing from year to year. Since much of the requirements for household consumption are derived from livestock or exchange with livestock products, the loss of livestock is serious risk for the livelihoods.

The impact of climate change and variability in the livestock production is generally negative. Heat stress and its impact on seasonal water availability have a variety of detrimental effects on livestock production. Drought and delay in the onset of rain led to poor grass regeneration/forage deficit, water shortage and heat stress on livestock, and consequently increased the mortality of the livestock, vulnerability to diseases and physical deterioration due to long distance travel for water and pastures (Abate, 2009).

4.3.4. Impact of Climate Change and variability on Livestock Feeding

According to the survey data, majority (90 %) of the household heads said that the source of cattle feed before some 25-30 years was pasture and 10% was pasture and crop residue. Showing the change in livestock feeding, however, majority (95%) replied that the feeding for their cattle now is crop residue, and 5% of farmers responded that they feed their cattle by crop residue and pasture. Members of FGD also pointed out that, shortage of adequate fodder and under feeding of livestock have increased the vulnerability of livestock to disease risks and death associated with drought and climate stress. Disease risks and death associated with drought and climate stress.

Figure 4.10. Photo shows heaped dried maize stock and cows feeding dried maize stock in the Shrinto Second Kebele. Source: own survey in the study area (2017).

As researcher observed in the study area, the commonly used livestock feed source is crop residue and natural pasture in small amount. Cultivated improved forage and industrial by products are insignificant in the area. Key informants reported that animals in the Woreda are predominantly depending on crop residue and natural pasture. Nevertheless, natural pasture and crop residue are mainly known for their low quality and quantity production in the area. As a result, livestock production in the area is mainly characterized by low production per animal, which is predominantly constrained by malnutrition and under nutrition.

4.3.5. Impact of Climate Change on water source and availability

Water source and access to water determines the range of household capacity to resist the impacts of Climate Change & variability. The assumption is that if a household or a community has access to enough water and if there are rivers, natural springs, and good ground water potential, the household or the community can cope with short term water scarcity caused by climate variability. The responses of the HHHs and researcher observation showed that no river was found in the study area and drying up of springs, water harvested from rain (pond water) and public bono charged in the ground were the only

sources of water and not enough for the year and also not cleaned. Major months which were critical to water scarcity are December, January, February and March.

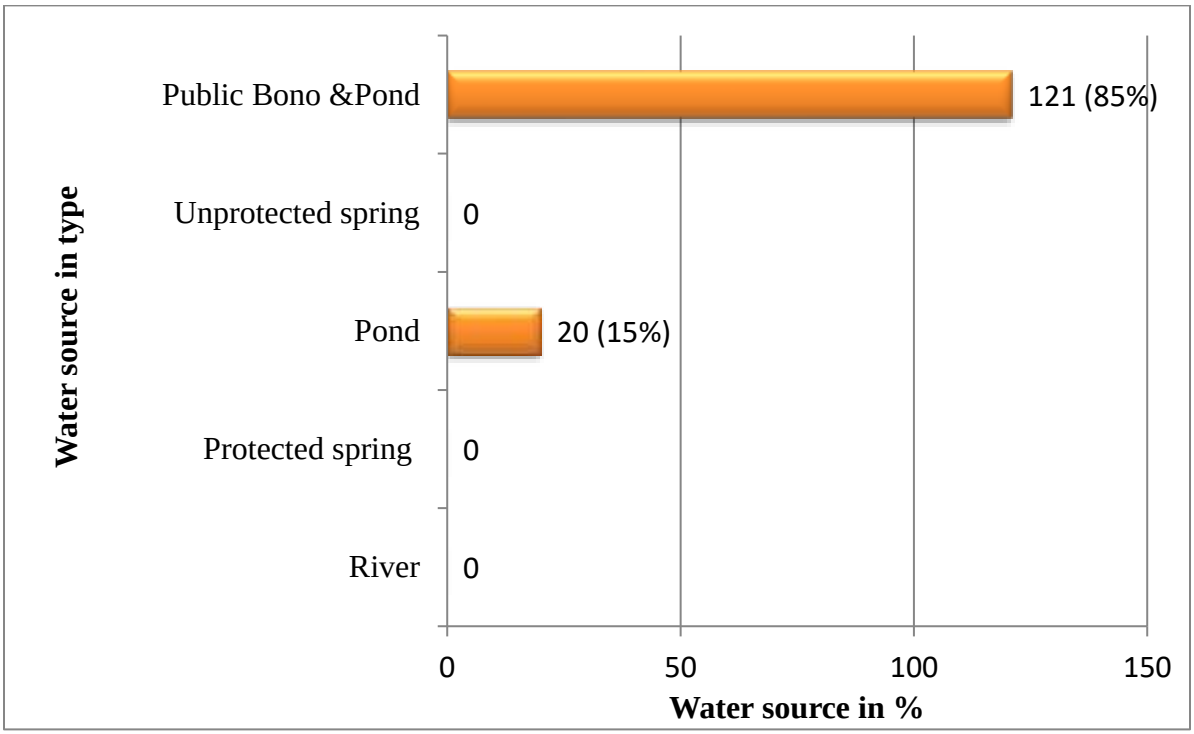

Fig.4.11.Water source in the study area; Source: Survey 2017

Key informants and FGD focused that the frequently occurring drought and low annual rainfall had led to water scarcity in the area. The available soil moisture has decreased due to frequent shortage of rainfall, resulting in low recharging ground water and filling of the available small ponds for households demand.

Figure.4.12. Photo shows pond water harvested from rainfall for consumption in the Bidara Faka Kebele.

Source: field survey (2017).

The number of people facing water scarcity due to unreliable rainfall and drying up of springs and rivers is expected to be between 75 to250 million people at risk by the 2020s (Bates et al 2008). Furthermore, this is likely to have severe impacts on crop yields, as the majority of the African population (over 85 percent in the case of Ethiopia) depend on rain fed agriculture, (IPCC, 2007).

4.3.6. Impacts on timing of rainfall and Variability

As most studies demonstrated, changes in rainfall patterns increase the likelihood of short-run crop failure and long-run production declines. As rainfall patterns become more

unpredictable as climate changes, plants will be subjected to increasing fluctuations in soil moisture availability. The timing and reliability of rain fall in the study area has been significantly unpredictable. In the last 25-30 years the belg rain used start in late March and extends up to late May, farmers use this rain to cultivate the main food crops like maize, Finger millet (zengada) and cash crop like pepper. These crops were harvested starting from June and leaving some parts for meher cultivation of mainly wheat, teff and other crops. Majority (89.4%) of the surveyed household heads agreed that currently the belg and meher rain comes late and goes early in September increasing moisture stress and making cultivation difficult and eventually causes crop failure, while (9.6%) of the respondents said that the rain comes early and goes early.

The world, in many cases, is ill-prepared for risks from a changing climate. Climate change is already affecting rainfall amounts, distribution, and intensity in many places. This has direct effects on the timing and duration of crop growing seasons, with concomitant impacts on plant growth (Thornton & Lipper, 2014).

4.3.7. Impact of Climate Change and variability on Food Insecurity

The current and future situation of the climate is very likely to affect the livelihood of peoples in the area. The single most important source of livelihood for the local people is agriculture which is entirely dependent on rainfall. The reduced growing seasons, unreliable rain fall, late onset of rainy season, recurrent drought and flood are seriously harming the food security status of the households. For the question “what makes people food insecure in this area?” according to the respondents 35.2% by shortening of seasons, 26.6% by flooding, 20.3% by causing drought and 17.9% by unpredictability of rainfall was affected their food security.

Table4.13.Climate change impacts and their consequence on food security.

Types of effect	Sample Kebeles							
	Udasa Rebi		Bidara Faka		Sherinto Second		Total	
	Count	%	Count	%	Count	%	Count	%
Drought	30	50.8	28	47.5	1	1.7	59	20.3
Flooding	30	38.9	23	29.9	24	31.2	77	26.6
Shortening of seasons	23	22.5	40	39.3	39	38.2	102	35.2
Unpredictability of rainfall	19	36.5	20	38.5	13	25	52	17.9
Total	102	35.1	111	38.3	77	26.6	290	100

Source: field survey (2017).

Key informants also strongly underlined that the only case that makes the household to fear becoming food insecure in the future is the probability of lack of rainfall and the occurrence of drought. Farmers in the target kebeles, who are dependent on belg-crops like maize and sorghum and meher crops like wheat and teff, highly compromised by poor and unreliable rainfall for their food security and affecting their general well being. The researcher also observed that recurrent drought was causing low production of cereal crops and shortage of livestock feeds which resulted in loss of livestock.

The dependency of most of the farmers on rain fed agriculture has made the country's agricultural economy extremely vulnerable to the adversities of weather and climate. Agriculture in the country is exposed to the effect of failure of rains or occurrence of successive dry spells during the growing season, which could lead to food shortage (MoFED, 2010).

4.3.8. Impacts of soil Erosion

From field observation and discussion with local agricultural experts, it was noted that soil erosion is serious problem in the study areas. Surface run off making the area infiltration of water and efficiently using the soil moisture..

All respondents' accepted that deforestation, over cultivation and overgrazing was the most important cause of soil erosion. According their report 68.4% Land productivity (yield) decline, 21.4% change in type of crops grown and 10.2% reduction of farm size were effects of soil erosion (Table 4.14).

Table4.14.Effects of soil erosion

Variables	Sample Kebeles responde						Total	
	Udasa Rebi		Bidara Rebi		Sherinto Second			
	Count	%	Count	%	Count	%	Count	%
Land productivity (yield) decline	45	33.6	51	38	38	28.4	134	68.4
Change in type of crops grown	21	50	5	12	16	38	42	21.4
Reduction farm size	20	100	0	0	0	0	20	10.2

Source: Survey result 2017

4.3.9. Community & Their Concerned shocks

4.3.9.1. Shocks on economic and Health of the community

As noted by different studies and researchers, Climate Change and variability are posing a serious threat on the health and socio economic condition of the societies. Climate change is likely to have major effects on human health via changes in the magnitude and frequency of extreme events, floods, droughts, diseases and wind storms. In order to obtain information regarding the adverse effects of climate change and variability on the communities' health and economic in the study area, HHHs were asked the question was that Climate Change & variability shocks on their economic and health. All most all respondents (97.7%) agreed that climate change and variability has been adversely affected their health and economic.

Table 4.15.Climate Change and variability related shocks among the sample kebeles.

Types of shocks	Sample Kebele responses						Total	
	Udasa Rebi		Bidara Faka		Shrinto Seccond			
	Count	%	Count	%	Count	%	Count	%
Recurrent drought	22	25.9	28	30.7	1	1.5	51	21
Erratic rainfall &flooding	39	45.9	23	25.3	24	36.4	86	35.5
Pest &disease	10	11.7	0	0	2	3	12	5
Rainfall variation at crop growing season	14	16.5	40	44	39	59.1	93	38.5
Total	85	100	91	100	66	100	242	100

Source: Field survey (2017)

As shown on the table 4.7.above, the shocks experienced by communities vary among the sampled kebeles in terms of frequency and intensity. Accordingly from total respondents 38.5% were claimed that rain variability is the major concern of the shocks, and followed by 35.5% flooding, 21% recurrent drought and 5% pest and diseases. According to the information obtained from interview of key informants agreed that small scale households suffering from major shock mentioned above.

Participants of FGD in the study area highlighted that climate change and variability is posing negative effects on health of their families. They reported that flooding, high temperature, pest and diseases and rainfall variation at crop growing season were the main drivers of health and economic shocks of their families and communities. In addition to this, they pointed out that due to shortage of food and milk, babies and elderly are being affected by diseases.

According to Cesar and Ekbom, (2013), Ethiopia is vulnerable to the health impacts of climate change, there are strong links between environment and health, particularly related to malnutrition, indoor air pollution and water-related diseases.

4.4. Farmers Responses to Climate Change and variability

Studies have confirmed that climate change is happening, and societies must take the necessary adaptation strategies to the impacts of climate change and variability. For poor countries like most African nations, adaptation is not an option rather it is a necessity,(Boko, *et al*, 2007).

4.4.1. Farmers' adaptation strategies related to crop production

The most widely cited adaptation strategies in Climate Change literature related with crop production, such as new varieties of seeds like early maturing seeds with higher yields per a plot, drought resistant crops that are suitable in drought prone areas, use of inter cropping, practicing irrigation farming in areas where water is available, wise storage of seeds and receiving food aid from government are used to assess whether farmers are practicing adaptation strategies or not.

The distribution of farmers by their crop production adaptation practice presented in Table 4.16, revealed that 37.6% participated in growing drought tolerance crop varieties, and 31.8% of them participated in use of early maturing crops varieties, 11.7% of the sample

respondents participated receiving aid from safety Net, and also 11.4% of them participated in wise storage of grains (saving), and 7.5% of the sample respondents participated in inter-cropping system activities.

Table .4.16.Farmers adaptation strategies related with crop production

Adoption strategies	Sample Kebeles							
	Udasa Rebi		Bidara Faka		Shrinto Sucond		Total	
	Freq	%	Freq	%	Freq	%	Freq	%
Receiving aid from safety Net	23	25.3	9	8.3	3	3	35	11.7
Inter-cropping system	11	12.1	5	4.6	6	6.2	22	7.5
Wise storage of grains (saving)	8	8.8	12	11	14	14.3	34	11.4
Use of early maturing crops varieties	18	19.8	39	35.7	38	38.8	95	31.8
Growing drought tolerance crop	31	34	44	40.4	37	37.7	112	37.6
Total	91	100	109	100	98	100	298	100

Source: field survey, (2017)

Key informants from the woreda agriculture office also confirmed that the government is supplying new varieties of crop seeds, inorganic fertilizers, early maturing varieties, seasonal training, etc. But the study has revealed that the existing adaptations are not enough to adapt the contemporary impacts of climate change and variability.

4.4.2. Farmers' Adaptation strategies Related to Shortage of Water

As indicated in table (table.4.16) below, the result of survey questionnaire of HHs summarized their adaptation strategies related with water problem. In Udasa Rebi kebele HHs used rain water harvesting (28.6%), used recharging ground water (35.9%) and 23.3% farmers used water from ponds to respond Climate Change and variability effects on water resource. In Bidara Faka rain water harvesting (40.8%), charging ground water (33.3%), and 50.7% of respondents used water from constructed ponds. In Sherinto Second kebele (30.8%) HHs were used recharging ground water, 30.6% of them used rain water harvesting, and 26 % of the respondents were used pond water.

Table.4.17. Farmers Adaptation strategies related to water

Sample Kebeles	Farmers Adaptation strategies related to water problem						Total	
	Rain water harvesting		Charging ground water		Use of water from ponds			
	Freq	%	Freq	%	Freq	%	Freq	%
Udasa Rebi	28	28.6	14	35.9	17	23.3	59	28.1
Bidara Faka	40	40.8	13	33.3	37	50.7	90	42.9
Sherinto Second	30	30.6	12	30.8	19	26	61	29
Total	98	100	39	100	73	100	210	100

Source: Survey, 2017

FGD participants were agreed that water availability is generally decreasing as a result of reduced rainfall amounts. They noted that several water points that were used to provide water for animals and people had dried up.

4.4.3. Farmers Adaptation strategies related to livestock production

Respondents discussed that livestock production adaptation strategies practice presented in Table 4.17, revealed that 29.8% of them reduced their livestock number, and followed by sale of weak and old animals (27.5%), livestock diversification (22.3%), improved animal forage (16.1%) and seasonal migration to search animal forage and water (4.3%).

Focus group discussion participants pointed out that some people had lost some of their cattle during drought.

Key informants discussed that to improve animal forage, decrease livestock number and livestock diversification to escape climate variability and sustainable development were necessary.

Table.4.18. Farmers Adaptation strategies related to livestock production

Adoption strategies	Sample kebeles						Total	
	Udasa Rebi		Bidara Faka		Sherinto			
	Freq	%	Freq	%	Freq	%	Freq	%
livestock diversification	24	23	9	13.8	1	2.4	34	22.3
Seasonal migration	4	3.8	5	7.7	0	0	9	4.3
Sale of weak &old animals	22	21.2	23	35.4	2	4.7	47	27.5
Decrease livestock number	35	33.6	16	24.6	12	28.6	63	29.8
To improve animal forage	19	18.4	12	18.5	27	64.3	58	16.12
	104	100	65	100	42	100	211	100

Source: Survey, 2017

4.4.4. Adaptation strategy measures related with soil erosion hazards

In the study area HHHs were asked the question that does you practice physical and biological soil conservation methods in your farm to overcome the observed Climate Change & variability impacts"? 58.9% of the respondents replied "Yes" and 51.1% reported "No". Activity measures taken by sample farmers in their own farm were soil and water conservation 47.8%, tree planting 25.9%, area closure 10.7%, and cover crop 15.6% to overcome climate change and variability.

Table.4.19. Farmers Adaptation strategies related with soil erosion Hazards

Adaption strategies		Kebele respondents							
		Udasa Rebi		Bidara Faka		Sherinto		Total	
		count	%	Count	%	Count	%	Count	%
Do you practice physical &biological soil conservation methods	Yes	26	56.5	35	62.5	22	56.4	83	58.9
	No	20	53.5	21	37.5	17	53.6	58	51.1
Measures have been taken by farmers									
Soil and water conservation		14	19.2	50	61.7	34	66.7	98	47.8
Tree planting		25	34.3	28	34.6	0	0	53	25.9
Area closure		20	27.4	2	2.5	0	0	22	10.7
Cover crop		14	19.1	1	1.2	17	33.3	32	15.6
Total		73	100	81	100	51	100	205	100

Source: Survey, 2017

4.4.5. Access to Credit

The severity of the existed risks or impacts of Climate Change & variability can be minimized by extending supports among the community through gifts, credits and other social self helping programs.

According to the survey data, 132 (93.6%) of the HHHs replied 'NO' and (6.4%) of them responded 'Yes' for the question which was stated "Do you have access to get credits from institutions to deal with climate related shocks or hazards?" This clearly shows that farmers' adaptation efforts to the changing climatic was being constrained by shortage of access to credit services in the study area.

4.4.6. Information Access

Temperature information, unreliable rainfall pattern and amount, were major factors for farmer's decision making process on what and when to crop planting. Traditionally farmers adjust to variability in rain fall pattern by replanting their land or taking other measures. But, they may not be doing this at the right time or with the right farming measures, if they get appropriate and timely information they can be much effective. So access to information is one way to reduce climate change & Variability impacts.

Out of the total respondents 29.1% reported that they do not receive any information. 70.1% of the respondents reported that they received information from local government institutions.

Members of the FGD reported that, the woreda's office of agriculture and natural resource development is trying to provide climate information, but this is minimal when compared with the adverse effect that they are suffering from the existing Climate Change and variability.

Based on the findings of the study developing effective early warning system with ever increasing weather unreliability and unpredictability, effective delivery of climate information and service is crucial. There should be a mechanism through which farmers are informed about the coming weather problems and what they can do to minimize the effect. The early warning system should be integrated with the extension system so that farmers can get proper and timely agro-climatic information and advices.

4.4.7. Government Responses to Climate Change & Variability

Over the last 20 to 25 years the government of Ethiopia has put in place a number of policies, strategies and laws that are designed to support sustainable development, and the country is set to move for wards to a green economy. Environmental problems such as climate change and variability, land degradation, over grazing, deforestation, air and water pollution, loss of biodiversity and ecosystem services, are identified as a serious obstacles to achieve the county's green economy plan,(Cesar and Ekbom, 2013).

According to the information obtained from study area respondents, key informants and focus group discussants of the Mareko Woreda, soil and water conservation, a forestation, water pond construction, ground water charging, road construction, Safety Net program, introduction of early maturing and drought tolerant crop varieties are already initiated by government and taking place to adapt climate change and variability hazards.

According to the information from officials of the Mareko woreda (ANRDO), the government has been trying to introduce and accomplish various adaptation strategies in response to water shortage due to climate change and variability. Some of these are rain water harvesting, constructing water ponds and localized pumping from groundwater. Key informants and FGD emphasized that the government has to work more to bring sustainable activities to change Climate Change and variability hazards for the poverty reduction and sustainable development.

4.4.8. Farmers recommendation to government for mitigating impacts of Climate Change and variability

In the study area sample farmers recommended to strengthen soil & water conservation (13.9%), a forestation (13.4%), water harvesting (12.8%), Drought tolerant &early maturing crops (12.5%), pond construction (12.4 %), Strengthen forest protection low (10.7), awareness creation/training (9.4 %), Financial credit (8.6 %), horticultural crop production (6.3).

Table.4.20.Farmers recommendation to government for mitigating the impacts /effects of Climate Change and variability

Adoption strategies	Respondent farmers							
	Udasa Rebi		Bidara Faka		Shrinto Second		Total	
	Freq	%	Freq	%	Freq	%	Freq	%
Strengthen soil & water conservation	46	15.7	50	13.2	39	13.4	135	13.9
A forestation	40	13.7	52	13.6	36	12.3	128	13.4
Water harvesting	46	15.7	45	11.8	33	11.3	124	12.8
Pond construction	32	10.9	48	12.6	39	13.4	119	12.4
Horticultural crop production	15	5.2	25	6.6	21	7.3	61	6.3
Financial credit	16	5.5	35	9.2	32	10.9	83	8.6
Drought tolerant &early maturing crops	38	13	46	12	37	12.7	121	12.5
Strengthen forest protection low	34	11.7	37	9.7	32	10.9	103	10.7
Awareness creation /training	25	8.6	43	11.3	23	7.8	91	9.4
Total	292	100	381	100	292	100	965	100

Source: Survey (2017)

4.4.9. Community Responses to Climate Change and variability

In the study area respondents were asked the question 'did you take any community based measure to overcome the observed Climate Change & variability impacts?' and they were required to select an answer from two options 'yes' or no'. Accordingly 99.3% of the respondents replied yes, while only 0.7% of the respondents answered 'no'. The survey data reveals that the respondents involved in Soil and water conservation (34.2%), planting trees (26.7%), participated in road construction (22.2%), protecting water reservoirs (6.5%) and participated in other activities (10.4%). According to the researcher observation in the study area, all farmers were not practicing the above measures, the hazard was serious. Therefore communities in the area should work hard.

Community-based adaptation (CBA) as a response to climate change and variability has evolved as a systematic, participatory, bottom-up approach. And it strengthens the resilience of communities and the ecosystems, upon which they rely in light of climate impacts, (Mannke, 2011).

Table.4.21. community based climate change and variability adaptation strategies

Adaption strategies		Kebele respondents							
		Udasa Rebi		Bidara Faka		Sherinto Second		Total	
		count	%	Count	%	Count	%	Count	%
Do you take any community based measure to overcome the observed CC&V impacts	Yes	46	100	55	98.2	39	100	140	99.3
	No	0	0	1	1.8	0	0	1	0.7
Measures have been taken									
Soil and water conservation		38	32.7	29	37.2	38	33.6	105	34.2
Tree planting		26	22.5	28	35.9	28	24.8	82	26.7
Protecting water reservoir		20	17.3	0	0	0	0	20	6.5
Construction of roads		18	15.5	20	25.6	30	26.6	68	22.2
Others		14	12	1	1.3	17	15	32	10.4
Total		116	100	78	100	113	100	307	100

Source: field survey (2017)

4.4.10. Obstacles of farmers' adaptation to climate change/variability

Several socioeconomic obstacles have been hindering farmers' effort to undertake various adaptation mechanisms to response to the existing climate change and variability effects on their livelihoods. The data from survey questionnaire reveals that the major obstacles that impeded farmers' endeavor to adjust themselves and their livelihood to climate change and variability include; Lack of sufficient financial resource (16.2%), Limited access to improved seeds (15.5%), shortage of land to implement the given strategies (15.1%), lack of skills required to implement the strategies (14.9%), Limitation of seasonal climate related information and awareness creation (11.2%), Low level of education (10.7%), Limited access to crop /livestock treatments (9.6%) and Low and fluctuation of product prices (6.8%).

Despite all efforts to minimize the changes in climate change and variability, the world needs to adapt to the upcoming changes as well. This adaptation to climate change is necessary to prevent societies from disasters and disruption (Roggema, 2009).

Table.4.22. Obstacles of farmers' adaptation to climate change and variability

	Respondent farmers							
	Udasa Rebi		Bidara Faka		Shrinto/ S		Total	
	Freq	%	Freq	%	Freq	%	Freq	%
lack of skills required to implement the strategies	38	15.4	27	16.7	21	12.7	86	14.9
Limitation of climate related information and awareness creation	35	14.3	0	0	29	17.5	64	11.2
Lack of sufficient financial resource required to implement the strategies	37	14.9	22	13.6	34	20.5	93	16.2
shortage of land to implement the given strategies	29	11.7	43	26.5	15	9	87	15.1
Low and fluctuation of production prices	18	7.4	7	4.4	14	8.5	39	6.8
Low level of education	24	9.7	23	14.2	15	9	62	10.7
Limited access to improved seeds	37	14.9	27	16.6	25	15	89	15.5
Limited access to crop /livestock treatments	29	11.7	13	8	13	7.8	55	9.6
Total	247	100	162	100	166	100	575	100

Source: Survey (2017)

Key informants and FGDs discussed to taking up adaptation options indicate that poverty, water scarcity, lack of information about the weather or long term climate variability, forage and feed scarcity, lack of agricultural technologies, weakness of implementation of natural resource management especially forest protection measure..

Poverty of the community: - Most of the communities in the area are poor, adaptation needs costs, but poor households have low adaptation capacity. Discussants argued that poverty as a major constraint for not taking up the following adaptation options. Changing crop pattern, diversified drought tolerant crops, digging water wells and rain water harvesting, to implement different water and soil conservation measures.

Water scarcity in the area: - water scarcity was mentioned as one of the most critical constraints to climatic variability adoptions. Irrigation is one of the poverty reduction options but in the study area it was practicing very low amount, because of water source problem in the study area.

Discussants reported that in addition poverty lack of energy source except wood of forest trees and crop residues were other obstacles for Climate Change and variability adaptation in the area.

Lack of meteorological information*:* - Lack of information is one of the most important barriers to adapt in the study area. The respondents and agricultural experts found in the area declared that lack of access to timely meteorological reports (information) is one most pressing constraint for making adjustment to erratic or reduced rainfall to adjust planting dates. Weather forecasts related with onset and/ offset of rains have never been communicated. They also said that the weather information that rarely delivered to them for pre-harvest is very general and lack specificity.

Other barriers in the Study area*:* - The survey results showed that lack of appropriate institutions that can assist and facilitate desired changes, high dependency on rain feed agriculture were some of the problems reported by the respondents and the community members, participants of FGDs and key informant interview also similar responses to barriers in the study area.

CHAPTER: FIVE

5. Summary, Conclusion and Recommendation

5.1. Summary

The international consensus of the scientific society led by IPCC, agreed that the global temperature is increasing and the main cause of this is the accumulation of CO2 and other GHGs. The negative effects of Climate change and variability are threatening to reverse development strives in many parts of the world, in the coming decades. Global Climate Change will have a serious threat on livelihood of human being.

In Ethiopia agriculture is heavily dependent on rain fall, and it is the main sector of economic source, but it has been adversely impacted by various extreme weather events. In the past Ethiopia experienced several droughts and flooding due to climate change and variability. Thus this study intended to assess the impacts of climate change and variability on Smallholder farmers' livelihood and their adaptation methods in Mareko Woreda, Gurage zone, in SNNPR of Ethiopia. The main findings of the research are summarized below.

The livelihood of surveyed HHHs, depend on crop and livestock 87.3%, on crop production 9.9% and depend on crop, livestock and off-farm activities2.8%. Majority of the respondents possess a land size which extends from 0.25 to 1 ha (46.1%), while very few of the respondents possess a land holding of 3 to 4.5 ha. Unpredictable rainfall, increase in temperature, recurrent droughts, flooding and decrease in water source are mentioned as the major indicators of Climate Change and variability.

Forest biomass production and density, productive capacity of agricultural land, spread of human and animal diseases, drought, flooding, and supply of water, grazing land, food security are mentioned as the most frequently affecting negative effects of climate change and variability.

Decrease in crop and livestock production are attributed to unpredictable rainfall, low fertility of the land, shortage of water, loss of livestock due to lack of fodder, pests and diseases are mentioned.

According to the survey data, rainfall variability, flooding, recurrent drought, pest and diseases are main drivers of shocks of the community to Climate Change and variability,

and the major causes for the shocks include deforestation, low fertility of the farm lands, land use change/land cover, over cultivation, and absence of sustainable agricultural practices.

The major coping mechanisms used by respondents include; sale of livestock, receiving food aid from government, decreasing the number of livestock, sale of old animals, livestock diversification etc.

At the community level, various initiated adaptation actions were being practiced. Some of these were soil and water consevation, tree planting, protection water reservoir and construction of roads etc.

According to the information obtained from key informants and focus group discussants of the Mareko Woreda, soil and water conservation, a forestation, water harvesting pond construction, ground water charging, road construction, Safety Net program, introduction of early maturing and drought tolerant crop varieties were initiated by government to adapt climate change and variability hazards. However, increased frequency and intensity of climate change and variability impacts have reduced the capacity of people to adaptation and cope with the problems.

Lack of skills, Limitation of climate related information and awareness creation, Lack of financial credit, shortage of land, Low level of education, limited access of improved seeds and limited access to crop /livestock treatments are identified by respondent farmers as the major obstacles of adaptation to CC and variability.

5.2. Conclusion

The result of the study shows that, climate change and variability are the major drivers of vulnerability in the woreda .The amount and timing of the rain fall in the area is very variable, both maximum and minimum temperature consistently increasing from year to year. This is affecting agricultural practices which are very sensitive to climate change and variability. The smallholder farmers' livelihood problem in the study area is exacerbated because of soil erosion, population pressure, deterioration of vegetation cover and grazing areas, shortage of livestock feeding and decrease in cattle production, by the irregularity in the timing of rainfall affecting the cropping pattern and the whole process of crop production. Generally farmers in the study area are very vulnerable due to climate induced shocks and low adaptive capacity of the climate change and variability. The current

adaptation strategies that the local people used were not planned, coordinated and not sufficient to. So that it could not fully support the local people to sustain their life.

5.3. Recommendation

Based on the nature and finding of the study, the following intervention measures are recommended so as to enhance adaptation capacity of the society. These measures include;

- Restoring the degraded ecosystem in which the local farmers depend for their livelihoods, by applying various mechanisms such as soil and water conservation technologies, aforestation, recharging underground water, building rain water harvesting pools, and like have to be strengthened.
- Farmers perceived Climate Change and variability in their locality, their knowledge on how to adapt is not enough. Therefore, rising awareness about Climate Change and variability effect and how to use modern agricultural technologies is must to increase adaptive capacity of the farmers.
- Farmers in the study area are producing year to year cereal crops like maize, sorghum, wheat but modern and high value crops inter cropping with legumes for soil fertility and agro-forestry agricultural system for sustainable Climate Change and variability is important.
- Improved forage production, drought tolerant and early mature crop varieties have to be encouraged in all farmers plot
- Both belg and meher crop residues have been used for livestock feeding and for fuel consumption, this is one of the soil degradation factor, to protect this alternative energy source for fuel consumption and improved forage crop in the farmers plot is necessary.
- Access to credit and investment is considered as one of the several factors that can affect adaptive capacity of HHs. Thus, to minimize the effects of Climate Change and variability farmers should get access to credit to take adaptation measures.
- Every farm activities both belg and meher season should be planed based on land resource management.

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7. Appendices

I: Introduction

The objective of this questionnaire is to collect information which will be used for the study on the impacts of climate change and variability on smallholder farmers and adaptation strategies in Mareko wereda. This study is going to be conducted for the partial fulfillment of MA degree in Geography and Environmental Studies at Dilla University. Your full support and willingness' to respond to the questions is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and give clear, appropriate and reliable information on the issues. Be sure that the information you provide is only for the purpose of this study.

Thank you in advance

Part I. General characteristics of respondents

Questionnaire number: ----------

1. General characteristics of respondents

1.1. Name of the kebele ----------

1.2. Name of respondent----------

1.3. Date of interview ---------/----------/----------

1.4. Enumerator name ----------

2. Socio-economic and demographic characteristics

2.1. Sex of household: Male ---------- Female ----------

2.2. Age of the respondent (yrs) ----------

2.3. Number of people residing in the household ----------

3. Land holding/farm size (hectares)

Crop ----------

Grazing * --------

Forest ----------

Total size ----------

*other than communal grazing

4. Marital status: Single…….married----------Divorced----------widowed--------

5. Educational level of the respondent

A. Primary school

B. Secondary School

C. Capable to read and write

D. Illiterate

6. Means of livelihood

A. Crop production only

B. Livestock production only

C. Livestock and crop production

D. Livestock and off farm activities

E. Crop and off farm activities

F. Crop, livestock and off-farm

7. Types of crops cultivated before 20- 30 years ---------- ---------- ---------- -------

8. Types of crop cultivating currently ---------- ---------- ---------- ----------

9. Do you have livestock? Yes ---------- No ----------

If yes, livestock holding

Animal type	Number of animals	
	Before 10 – 25 years	2017
Cow		
Oxen		
Donkey		
Horse		
Sheep		
Goats		
others		

Part I: (A) People's Perception of Climate change and variability

10. What is your perception about climate change/ variability at your locality?

A. There is climate variability

B. The climate has not change

C. The climate has totally changed

D. I have no idea

11. If Q No, 10 is 'the climate has changed/ show variability', what are the local indicators of the observed climate change after 20-30 years? (Multiple answers is possible)

A. unpredictable rain fall and hail storm

B. Recurrent drought

C. Increase in temperature

D. Decrease water sources.

E. Floods

F. Others

12. What do you think is/are the main cause/s of climate change and variability?

A. Natural factors

B. Human and natural factors

C. Human factors

D. other (specify)

13. If your answer on question number 12 is "Human factors" which of the following do you think is the major causes of climate change and variability? (Multiple answers is possible)

A. Over Cultivation

B. Overgrazing

C. Deforestation

D. Population pressure

E. Air pollution

14. How do you describe the pattern of current temperature compared to the past temperature pattern that was before 20- 30 year ago?

A. Increased B. decreased C. No observable change. D. Others specify.

15. If your answer to question number 14 is the temperature show variability, what kind of indicators do you use to evaluate the temperature trends in the area? (Multiple answers is possible)

A. Dry up of river and streams

B. Decrease crops and livestock production

C. Prevalence of newly introduced human and animal disease

D. Decrease in rainfall amount

E. Extinction of indigenous habitat

F. Deteriorated vegetation cover

16. How do you describe the current amount of rain fall compared to the past rainfall amount that was before 20- 30 year ago?

A. Increased B. Decreased C. No change

17. Is there a change in the timing of rain in your area? Yes No

18. If your answer is yes, what is the condition of the rain?

A. The rain begins lately and ends early

B. The rain begins early and ends early

C. The rain begins lately and ends lately

D. Difficult to characterize

20. Do you think that crop yield has increased or decreased in your village or locality?

A. Increased B. Decreased C. No change

21. Are you user of Safety Net program? A. Yes B. No

22. Do you have water access for both your house hold as well as livestock for the whole year?

Yes No

23. What is the source of water for your household/ domestic consumption?

A. Rivers (Stream) B. Protected springs C. ponds D. Unprotected springs E. public bono F. Others

24. Do you think that livestock production has increased or decreased in your village or locality? A. Increased B. Decreased

25. If your answer for Q No 25 is decreased, what do you think is the reason?

A. Livestock diseased B. shortage of water for animals C. Shortage of grazing land D. high temperature. E. others (specify)

26. What was the main source of feed for your livestock before 20 – 30 years? (More than one answer is possible

A. grazing pasture B. crop residues C. others (specify)

27. What is your main source of animal feed at the present time?

A. Grazing B. Hay C. Straw D. Maize and Sorghum stock

28. How do you see the problem of soil erosion over time? A, Increased B, Decreased C, No change

29. If your answer is increased which do you think are the major causes of soil erosion in your area?

1) Deforestation _____
2) Over grazing _____
3) Over cultivation _____
4) Poor agricultural practices _____
5) Cultivation of steep slopes _____
6) Excess rainfall _____
8) Others (specify) _____

30. What changes did you observe in forest cover in your area? A. Increased B. Decreased C. No change

31. If you say decreased, what do you think are the causes? (Multiple answers is possible)

A/ Agricultural expansion B/ fuel wood and charcoal C/ the increasing demand for construction material and industrial use D. Limited forest policy regulation

Part I: (B) Assessment of the impact of climate change and variability induced-hazards

32. Which type of impacts of climate change and variability did you observe for the last 20-30 years?

A. Drying up of water,(rivers) B. shortage of pasture land C. Forest fire, D. Disintegration of roads E. others.

33. What are the major challenges that climate change/ variability posed on your livelihood?

A. Shortage of pasture land B. Loss of livestock

C. Crop yield reduction D. Shortage of water for domestic use E. Others (specify).

34. Are you vulnerable to such problems like economic shocks and health?

Yes NO

35. If yes, which one of the following affects your life?

1. Disease 2. High price of goods and commodities 3. Food shortage 4. Others

36. Have you ever faced any climate related disaster over the last 20-30 years?

Yes No

37. If your answer for Question No 36 is 'yes', what type of climate shock is your concern?

A. Recurrent drought B. Erratic rain fall & flooding C. Crop pests and diseases

D. Rain fall variability during crop production season E. others

38. How climate change and variability affects your food security status?

1. By causing drought 2. Flood 3. Shortening of seasons 4. Unpredictability of rain fall

5. Others?

39. What do you think is the consequences of soil erosion?

1. Land productivity (yield) decline 2. Change in type of crops grown

3. Reduces farm plot size 4. Others (specify)

Part I: (C) The major adaptation practices

40. What adaptation methods did you take to minimize the impacts of climate variability on your livelihood?

A. Applying new cropping system and irrigation B. Diversification of crops and Livestock C. Safety net program D. Migration E. Use of early maturing crops F. Growing drought resistance crop verities G. Others (specify).

41. Do you practice physical and biological soil conservation methods at your own farm level?

1. Yes 2. No

42. Did you take any community based measure to overcome the observed climate change/variability impacts?

Yes---------- No, ----------

43. If yes, what is that measure you have taken to overcome climate variability problem?

A. planting trees (aforestation) B. Building flood protection features (ditches)

C. Protecting water reservoirs D. Constructing roads E. Others

44. What are major adaptation strategies you used to overcome climate change / variability impacts on livestock production?

A. Increase livestock diversification

B. Seasonal migration with your cattle in search of pasture & water

C. Sale of weak and old animals before the dry season.

D. Decreasing the number of livestock

E. To improve animal forage

F. Others (specify).

45. Adaptation strategies, you used to overcome climate change / variability impacts related with crop production

A. Receiving aid from safety net B, using new varieties of crops (drought tolerant)

C. Inter- cropping system D, wise storage of crops (saving).

E. Intensive irrigation F, Others (specify).

46. Adaptation related with shortage of water?

A. Rain water harvesting C. Use of recharging ground water

B. Expanding irrigable farm D. Use of reservoirs and ponds

47. Adaptation related with soil erosion hazards

A. soil and water conservation B. Tree planting C. Area closure D. Cover crop

48. Do you have access to get credits from institutions during climate related hazards?

A. Yes B. No

49. Do you get early warning information before the occurrence of climate related shock?,

A. Yes B. No

50. If yes, who do you think is responsible in disseminating information before the occurrence of hazards?

A. local institutions B. NGOs

C. Local government institutions D. Others (specify)

51. What do you think are the locally feasible coping mechanisms that should be taken to reduce climate change / variability impacts on livelihoods? (Multiple answers were possible)

A. Soil and water conservation B. Tree planting C. Area closure D. Agro-forestry E. Water harvesting

52. What interventions can be promoted by the development actors/ community people to minimize effects of climate change? (Multiple answers were possible)

A. Soil and water conservation B. Tree planting C. Early mature cropping D. Water harvesting E. Horticultural crop production F. Improved animal forage

53. What is your recommendation to government/ development agencies/ NGOs, for mitigating the impacts/ effects of climate change?

A. Soil and water conservation B. a forestation C. Water harvesting D. Pond construction E. Provision of early mature cropping F. Forest management regulation

G. Awareness creation H. Financial credit

Part I (D). Barriers to Climate variability Adaptation

54. Please choose your main reasons for not using any of the above strategies from the given alternatives below

A. Lack of skills required to implement the strategies

B. Poor market accessibility

C. Lack of climate related information and awareness creation from the concerned bodies

D. Lack of sufficient financial resource required to implement the strategies E. Shortage of land to implement the given strategies

E. Low and fluctuation of prices

F. low level education

G. Limited access to new improved seeds

H. Limited access to crop/ livestock treatments

I. Others (multiple answers is possible)

Appendix, II Interview Questions for Focus Group discussions (FGD)

55. What are the local indicators of Climate variability or change in your kebele?

56. Do you think climate change or variability posed negative effects on your livelihood? If Yes, Please explain it.

57. Is there any change on water, grazing land, the quality of pasture and arable land over the past 20-30 years in your village?

58. If yes, what are the major causes for the changes on the resources mentioned above?

59. Do you think any measure to avert climate change or variability? Who should have the main responsibilities to do this?

60. Is there any change on livestock number, composition and feeding of your village?

61. How do you perceive your crop production Increasing or decreasing

62. How do you cope up or adopt impacts of climate change /variability on your livelihood?

63. Have there been climate extremes (drought and flooding) in the last 20-30 years?
Which one is your main concern?

64. Have you ever been participated in community based environmental participation in your Keble?

65. What is the role of communities to adapt climate change and variation related hazards?

66. What are the main challenges that hinder your adaptation mechanisms?

Appendix, III Questions for key informant interview

67. Is there any variability of temperature and rain fall in your kebele in the past 20-30 years?

A. Yes B. No

68. What do you think the causes of climate change and variability?

69. What are the observed indicators of climate variability?

70. How do you know (understand) the impacts of climate variability on your livelihood?

71. What are the main impacts of climate change and variability on the community, on the livestock and crop production?

72. Who is responsible to give response to the climate change and variability of climate?

73. How do you overcome or adapt the impacts of climate change and variability on your livelihood?

74. What are the impacts of climate variability on people's health?

75. What is the response of government and non-government Organization?

76. What are the local peoples coping mechanisms used to reduce the impacts?

77. What are the main challenges and how do you think they can be improved?

Thank you so much for the time you spent answering the questions:

Appendix IV

Rainfall and temperature data

National Meteorological Agency

SNNPR Meteorological Serervie Center

Awassa

Station Name :- Koshe ***Element :- Monthly Total Rainfall (mm)***

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	88.8	63.5	58.2	20.3	72.2	78.3	112.7	200.3	87.8	84.9	0.0	0.0
1999	0.0	0.0	60.8	31.2	10.7	109.6	171.2	110.2	77.5	127.5	0.0	0.0
2000	0.0	0.0	7.9	107.3	58.0	94.4	122.7	95.9	135.5	40.0	50.5	40.2
2001	0.0	68.3	141.4	34.5	170.9	79.3	183.1	135.9	82.5	15.9	0.0	0.0
2002	9.3	36.0	70.8	88.4	38.2	46.4	119.6	126.5	39.1	0.0	0.0	4.4
2003	53.3	1.3	23.5	104.8	0.0	55.8	158.4	127.2	175.8	0.0	0.0	50.5
2004	47.4	1.2	61.6	114.3	0.2	66.5	106.8	77.5	55.8	62.9	0.0	0.0
2005	121.4	0.0	92.5	139.7	124.9	61.5	231.0	163.3	110.9	25.7	5.6	0.0
2006	3.3	34.9	105.8	149.9	146.4	76.4	234.2	104.8	50.2	46.5	0.0	1.2
2007	8.7	61.3	52.0	40.6	172.2	141.6	174.2	168.4	136.2	12.3	0.0	0.0
2008	0.0	0.0	0.0	7.9	103.6	83.4	166.2	171.4	66.6	49.1	140.7	0.0
2009	34.6	0.0	58.2	4.5	35.1	25.3	149.4	48.9	69.0	76.6	0.0	0.0
2010	0.0	86.3	173.7	104.8	139.7	56.0	84.1	131.6	70.8	38.3	0.0	11.6
2011	12.5	0.0	65.6	44.1	50.0	108.3	161.8	90.3	22.7	0.0	6.4	0.0
2012	6.5	0.0	61.8	95.1	0.0	80.0	239.6	130.5	69.0	0.0	17.1	0.0
2013	0.0	0.0	49.8	7.8	16.9	99.2	286.7	166.0	81.0	105.4	2.7	0.0
2014	0.0	0.0	37.9	3.4	68.6	30.7	172.5	200.4	93.7	176.2	0.0	0.0
2015	0.0	0.0	20.0	0.0	110.9	6.3	40.5	42.5	69.7	0.0	0.0	0.0
2016	32.3	22.8	2.1	105.0	292.3	120.9	183.9	49.9	103.4	49.6	9.6	0.0

Station Name :- Zeway ***'Element :- Monthly Average Max.Temp.(^{o}C)***

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	27.6	29.3	30.0	31.5	30.5	29.2	25.5	25.0	26.8	26.8	27.0	26.7
1999	27.5	30.2	28.9	31.1	30.4	28.2	25.5	26.4	27.6	25.7	26.3	26.2
2000	27.4	28.9	30.2	29.7	28.6	28.1	25.3	25.1	26.6	26.5	26.6	26.6
2001	26.3	28.6	27.6	29.9	28.2	26.5	25.9	25.4	26.8	29.0	27.3	27.2
2002	26.6	28.9	29.3	30.2	30.5	28.8	28.1	26.8	27.7	29.4	28.5	27.2
2003	27.6	30.0	29.8	28.8	31.0	28.4	24.4	25.2	26.8	28.6	27.7	25.9
2004	27.7	28.0	29.4	28.2	30.9	28.4	26.0	26.2	27.1	27.4	27.7	27.1
2005	27.6	28.6	29.0	29.4	27.5	27.6	25.7	26.6	27.2	28.1	27.3	26.9
2006	27.5	29.3	28.8	27.9	29.3	28.3	25.2	25.2	26.5	28.2	27.6	26.4

2007	27.0	28.7	30.4	29.5	29.7	26.2	25.2	25.0	26.6	27.7	27.2	26.4
2008	27.9	27.8	30.3	29.9	28.9	27.2	24.5	24.7	26.4	27.3	25.3	25.5
2009	26.5	28.6	30.5	29.5	30.2	29.8	25.7	26.1	27.8	27.1	27.9	26.7
2010	27.5	27.6	27.6	29.0	28.7	28.2	25.0	25.9	26.4	28.6	27.7	26.8
2011	27.6	29.2	28.8	31.1	29.6	27.9	25.6	25.1	26.3	28.1	27.3	26.6
2012	28.2	29.1	30.6	29.3	30.8	28.8	24.2	24.8	25.6	27.1	27.2	27.0
2013	27.3	29.2	29.8	29.8	28.3	27.8	24.6	25.1	26.8	27.6	27.1	26.3
2014	27.8	28.5	29.2	30.0	28.7	29.3	26.7	25.8	26.4	26.8	27.7	26.6
2015	27.2	30.0	30.8	31.2	29.8	28.8	27.9	28.2	28.4	29.9	28.5	27.5
2016	27.8	28.9	32.4	29.6	28.5	28.2	25.9	26.8	27.7	28.0	27.6	26.6

Station Name :- ***'Element :- Monthly Average***
Zeway ***Min.Temp.(°C)***

Year	***Jan***	***Feb***	***Mar***	***Apr***	***May***	***Jun***	***Jul***	***Aug***	***Sep***	***Oct***	***Nov***	***Dec***
1998	15.3	16.2	16.4	16.9	17.2	16.7	15.8	15.4	15.2	14.3	10.4	9.4
1999	11.0	12.5	15.2	12.9	11.6	11.2	13.4	13.6	12.8	13.2	10.6	10.4
2000	10.9	11.9	14.6	16.5	16.4	15.9	15.2	15.7	15.0	13.8	13.1	11.6
2001	12.2	13.6	15.5	16.0	16.7	15.8	15.3	15.8	14.8	14.6	12.1	11.7
2002	13.2	13.3	16.0	16.0	17.4	16.3	15.6	15.7	15.0	14.6	13.2	15.3
2003	13.5	14.5	15.9	16.7	17.0	16.6	15.7	15.7	15.2	13.0	13.4	11.3
2004	14.7	13.7	14.5	16.2	16.6	16.1	15.1	15.4	15.1	13.3	12.6	12.6
2005	12.9	13.2	16.1	16.1	16.4	15.8	15.7	15.6	15.3	13.9	12.1	9.3
2006	13.1	15.0	15.6	16.0	16.3	15.9	15.4	14.6	13.9	13.8	12.1	13.0
2007	12.5	14.8	14.0	15.1	15.8	15.1	14.7	14.5	14.3	10.4	11.1	8.8
2008	11.2	11.7	12.2	15.1	15.4	14.5	14.2	14.4	13.6	12.7	10.8	9.7
2009	11.8	13.2	15.1	16.3	16.5	16.8	15.7	15.7	15.6	13.1	11.5	14.6
2010	13.0	15.2	15.0	16.5	17.3	16.4	15.8	15.8	15.0	13.4	11.7	10.6
2011	12.5	13.1	14.9	15.7	16.9	16.1	15.3	14.9	14.6	12.5	13.5	10.3
2012	11.4	11.4	14.3	15.8	16.8	16.2	14.9	15.3	14.7	12.4	12.3	12.1
2013	12.1	13.0	16.3	16.4	16.3	16.2	15.5	15.5	14.2	13.3	12.9	9.8
2014	11.7	14.8	15.3	15.9	16.3	16.2	15.9	15.1	15.1	13.0	12.5	10.7
2015	10.7	12.9	15.4	16.0	21.9	17.0	16.0	16.0	15.7	14.8	13.7	14.0
2016	15.4	14.7	17.3	17.7	17.0	16.3	15.9	15.3	15.6	14.1	12.9	11.6