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School of Graduate Studies

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The Impact of Rainfall Variability on Rural Livelihood and Coping Strategies in Ethiopia: The Case of Arsi Robe Woreda of Oromia National Regional Sate

By: Fikre Alemayehu

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A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Arts (Environment and Development)

Advisor: Abdulhamid Bedri (PhD)

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INSTITUTE OF DEVELOPMENT STUDIES (IDS)

Title

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By

Fikre Alemayehu

DEVELOPMENT STUDIES

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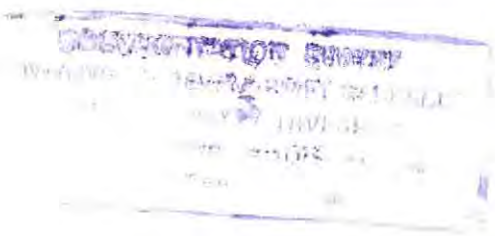


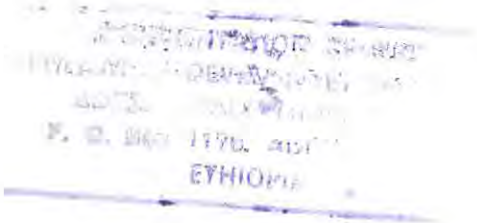
Acknowledgement

First and foremost, I would like to express my sincere appreciation and deepest gratitude to my thesis advisor, Instructor Abdulamid Bedri (PhD) for his unreserved assistance, valuable, and critical comments. Without his support this study would have not been a reality and follow the right track.

I wish to acknowledge my families; Asnake Alemayehu, Alem Tola, Eyuel Fikre, Kasahun Tamire and Henoke Asnake for their continuous encouragement have made this work possible. Moreover, all these have been by my side and with whom I shared all my inconveniences, worries, and challenges in the course of my research work.

Thanks are also due my friends Mr.Asmamaw Legass, Mr.Tesfaye Jima, Mr.Menberu Tshome, and Mr. Kumela Gudeta for their persistence help to me for the completion of my work with frequent interaction and feedback from them.

Finally, I would like to thanks all families of Mr.Tesfaye Jima, especially my sister Abyiot and Shewit Kinfe with their hopeful son Ebba Tesfaye for their warm look and support to me during my research work.



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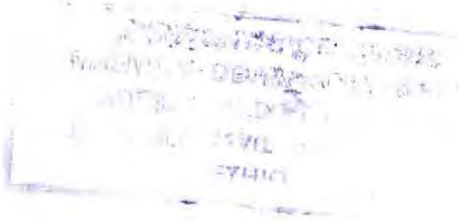

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Acronyms and Abbreviations

ACE: Atmosphere, Climate and Environment

NOAA: National Oceanic and Atmospheric Administration

ITCZ: Inter Tropical Converge Zone

IPCC: Intergovernmental Panel on Climate Change

WRSI; Water Requirement Satisfaction Index.

FEWS: Famine Early Warning System

NMSA: National Metrological Service Agency

EPA: Environmental Protection Agency

NCCF: National Climate Change Forum

FAO: Food and Agricultural Organization

UNEP: United Nations Environmental Program

NSF: National Science Foundation

WMSA: *Woreda* Metrological Service Agency

BoFED: Bureau of Food and Education Development

KII: Key Informant Interview

FGD: Focus Group Discussion

UN: United Nations

DA: Development Agent

GDP: Grass Domestic Production

CSA: Central Statistical Agency

Definitions of Selected Local Terms

Zone: Local administration next to region

Woreda: Administrative unit, one level higher than kebele and a level below zone

Kebele: Local government, the smallest administrative unit

Kiremt: Main rainy season in Ethiopia (summer rain)

Belg: Short rainy season in Ethiopia from March to May

Habtam; Rich man

Mekakelenga: Middle income person

Daha: Poor

Mehir; The main harvesting season in Ethiopia following *kiremt*/summer/rain

Attala: Residue/by product/ of local beer and *Areke*

Goti; Division or units of a *kebele*

Equb; local rotating saving group

Idir: local social and economical organization developed by interested group

Birr: Ethiopian currency USD$1 =Birr 17

Abstract

Rainfall variability becomes norm at present time and the pressure that induced by it increasing from time to time in different parts of the country. The impact is become more serious in areas of highly depending on rain fed agriculture Like Robe *Woreda.* So, understanding the impacts on rural livelihood and mounting different coping and adaptation strategies are the only solution to overcome the challenges. Hence, the overall objective of this paper is focused on assessing the impacts of rainfall variability on rural livelihood.

To achieve these objectives and to expanding understanding the impacts of rainfall variability on rural livelihood the researcher utilizes both qualitative and quantitative methods .The primary data was collected from Focused group discussion, key informant interview, field observation, and questionnaire. The secondary data was collected from NMSA and WMSA. Moreover, understanding of the impacts of rainfall variability on rural livelihood; principally crop and livestock production was helps to employed and developing different coping and adaptation strategies.

Agricultural production systems and especially the complexities associated with the variability and distribution of rainfall are essential elements in improving livestock and crop production and agricultural planning decision making. In the at hand paper, knowledge from the analysis of historical rainfall records and predictive information were based on the "response farming" for rainfall variability in the future. From the analysis of the rainfall records good relationships are found between rain onset dates, seasonal rain amounts and duration and crop and livestock production. Crop and animal production increase or decrease in relation to rainfall distribution, the better the distribution and intensity and low rainfall variability the higher production and productivity.

The finding of this research indicates serious impacts of rainfall variability on crop and livestock production which led to food insecurity. Farmers' perception also varies in rainfall variability as well as the employed coping and adaptations strategies. Most farmers employed three major coping and adaptation strategies; intensification, diversification, migration. However, all methods were not successful all the time due to poor and customary of the coping strategies.

Chapter One: Introduction

1.1 Background

Seasonal variations in rainfall and temperature are common phenomena in the world. It has been a common occurrence around the sphere in the past because of the effect of the earth orbiting around the sun. The tilt of the earth relative to its plane of travel about the sun is what causes seasons; division of the years. Seasonal migration of the sun towards North and South of the equator causes change in temperature, in atmospheric circulation and increased evapo-transparation and water vapor. In turn this resulting in precipitation increase, more intense precipitation, more storms and sea level rise. An increase on the average global temperature has been the likely to lead to changes in precipitation and atmospheric moisture (ACE, 2001; NOAA, 2009).

The air circulation and their seasonal shifts strongly influence the climate of many areas. For example, at the global scale, it has been verified abundant rainfall where the air rises and very little where the air sinks. Consequently, areas of high rainfall exist in the tropics, where humid air rises in conjunctions to ITCZ. Another zone of high rainfall is the region between 40^0 and 55^0. Where middle latitude in the vicinity of subtropical high and the polar front force air upward. Areas of low rainfall are found near 30^0 latitudes in the surrounding area of the subtropical high and the Polar Regions where the air is cold and dry (Tesfaye, Getachew, 2005).

Recent models also suggest the change in rainfall distribution and the increase in global average annual precipitation during the twenty first century (IPCC, 2001and 2007), although changes in precipitation will vary from region to region. An increase in the intensity of precipitation events, particularly in tropical and high latitude regions, including Ethiopia, that experience overall increase in precipitation is also predicted. Tropical storms and hurricanes are likely to become more intense, produce stronger peak winds, and produce increased rainfall over some areas due to warming sea surface temperature which can energize these storms (IPCC, 2007; R.Gommes and F.Petrassi, 1996; Martin, 1990).

There are wide differences in rainfall distribution which is caused by temperature difference and atmospheric circulation. If we look at average temperature around the earth in January and July, in January, lowest temperatures occur over the northern hemisphere which is vice versa to

rainfall. Rainfall also varies at local level, the highest rainfall total occur near the equator where warm air rises and falls again due to convention (Jakson, 1991; Getachew, 2005).

Tropical countries typically have prolonged heavily showers and thunderstorms in the afternoon. While, at very high latitudes example Greenland precipitation is very low because the air is too cold to continue much water vapor. Subtropical high pressure regions also have low rainfall, as they experience generally stable conditions of descending air. The northern temperature mid latitude has moderate amounts of rainfall, mostly association with fronts and depression (ACE, 2001).

East Africa is characterized by low rainfall and high rainfall variability. The time series displays a typical pseudo-periodic behavior with a cycle of 4 to 5 years. The region as a whole experienced good rainfall in 1989, but the last run of good years goes back to 1981-1983. Bad years tend to have relatively less negative effect at the higher elevations which characterizes central Ethiopia and parts of southern Kenya. 1973 and 1984 were cited as the poor years in parts of the region. The region has more than one cropping season, and drought does typically affect *mehir* or *belg* more seriously than the other. Small amount of rainfall and high temperature which is responsible to dust formation in highland region plays an important role in human misery to the people of sub-Saharan Africa (Andrew, 1999).

Similarly, intensity, amount, and distribution of rainfall also vary in space and time in Ethiopia. Western Ethiopia, particularly the western highlands (*Wolega, Illubabora, Jimma and Gambela)* receives considerable rainfall throughout the year. Annual mean rainfall ranges from about 2000 mm (SW) to about 100mm (NE lowlands of Afar). Present average precipitation is 2.04 mm per day, annual averages between 1961-1990.Most of which is Orographic and conventional rainfall due to altitude and location near the equator. However, the eastern lowlands and the northern part of Ethiopia receive (500mm and 1000mm) of rainfall on yearly average respectively (Getachew, 2005; Tesfaye, 2005).

The agricultural export economy and agricultural production geared towards domestic consumption is constantly subjected to weather variability. In 1992 for example, IMF 'Statistics indicate that Ethiopia produced 51,850m quintal of cereals, mostly for domestic consumption, whereas the following year the cereals output dropped to 47,404m quintals- a decline of 8.6%

which was largely the result of rainfall variability (Hailu, 2010).According to Von Braun (1991), cited by (Woldeamlak, 2006).10% decrease in seasonal rainfall from the long-term average generally leads in to 4.4% decrease in the country's food production. This is because agriculture is rain fed which accounting half of GDP and more than 80% of job and livelihood of the Ethiopian economy is highly sensitive to climate variability, particularly variation in rainfall (World Bank, 2005).

Because of variability and unusual rainfall, drought and floods are already endemic events in Ethiopia and its frequency of occurrence increases in recent years. Current trend in level of hunger is largely determined by the onset of adequate and timely rainfall pattern. In fact, the frequency and severity of drought have increased from time to time. Most vulnerable areas have started experiencing drought on yearly basis during this decade, since 1990s as opposed to 2-4 years on average during the past decade (Tasew, 2005).

Here the erratic nature of rainfall and decline levels seems to be the norm rather than the expectation. Growing periods in most localities will be shortened and habitats will shift towards higher elevations and altitudes. In addition livestock and crop disease increase, access to water declined and runoff will increase, and decline in agriculture yields. Ethiopia is heavily dependent on rain-fed agriculture and its geographical location and topography in combination with low adaptive capacity entail of a high vulnerability to the adverse impact of climate change (Belay, 2009).

Woldeamlak (2006), for example stated that the intensity and distribution of rainfall is generally the single most important determinant inter-annual fluctuation in national crop production levels. According to the water requirement satisfaction index (WRSI),crop specific performance indicator taking rainfall and soil characteristics in to account, indicates extreme and increasing variability in recent years(FEWS,2003).

Not only rainfall variability but also higher temperature eventually reduces yields of desirable crops, while, encouraging weed and pest proliferation. Change in precipitation patterns increases the likelihood of crop failure and production declines. although there will be gains in some crops in some regions of the country, the overall impacts of climate change on agriculture are expected to be negative, threaten local and national food security (Bekure,2005).

Higher resolution analysis of Ethiopia suggests a range that spans both increases and decreases in overall rainfall averages. This also suggests an increase in rainfall variability with the potential for a raising frequency of both extreme events; flooding and drought that seriously affect the production and food security of the nation (Belay, 2009).The occurrences of drought are becoming endemic to Ethiopia by affecting crop and livestock production. It's severely affecting the livelihoods of millions of people in the rural area directly and urban indirectly. Moreover, the frequency and intensity of its occurrence increasing in recent years according to Oxfam international (2010).Virtually all food crop agriculture in Ethiopia depends on rainfall that is frequently erratic and unpredictable.

1.2 Statement of the problem

Since 1990s rural Ethiopia, Arsi Robe is exceedingly affected by rainfall variability impacts. The productivity of land and livestock deceasing and as a result food security becomes great problem. Temporal and spatial rainfall variability is imposing significant challenge on the areas of food security, water availability, and resource degradation and occurrence of disaster in different parts of Ethiopia (NMSA, 2007). In Robe *Woreda*, where more than 95% of population is engaging in rain fed subsistence agriculture rainfall variability puts more pressure on food security and water availability. The people have been highly exposed for food insecurity, water shortage, and low productivity. Moreover, in the study area still there is lack of conducted research to solve the problem on rainfall variability impacts, coping strategies, and efforts towards rainfall variability impacts on crop and livestock production.

The impact is more serious on the agricultural sector which is prominently subsistence and rain fed in character. Even insignificant variation in the duration and amount of rainfall can cause severe crop failure and loss of livestock production. So, it is crucial to understand the nature of rainfall variability and associated impacts and the coping strategies of societies in minimizing the adverse impacts.

In regard to this issue very limited research was carried out in Oromia National Region State in general and almost no single research has been conducted yet in, Robe *Woreda* particularly in the six drought prone *kebeles* including the study area. The study area is one of the seriously affected *kebeles* by rainfall variability. The frequent rainfall variability during the *kiremt* and *belg* season

1990, 1993, 1996, 2003, 2006, and 2009 has affected the livelihoods of the local farmers by food insecurity (WMSA, 2009).

Therefore, this research, intends to assess the impacts of rainfall variability on the rural livelihood and the coping strategies used by the local people against the challenge. The dependence of the local people on rain fed agriculture and the recurrent occurrence of rainfall variability in the last five or six years has been one of the reasons to exposure the people to high food insecurity in the *Woreda*. For example, in January 2003, regular food distributions have been taken place for almost 20% of the population who were vulnerable to the problem. Hence, this research attempts to examine the impact of rainfall variability and associated problems in the study area.

1.3 Objectives of the study

The study comprises of general and specific objectives. The general objective of this study is to identify the impacts of rainfall variability on principal rural livelihoods and coping strategies. The specific objectives of this research paper are to:

I. Assess the impact of rainfall variability on crop production
II. Analyze the impact of rainfall variability on livestock production
III. Assess the perception of the local people towards rainfall variability and identify the ways community responds to the impact of rainfall variability on rural livelihood

1.4 Research questions

Based on the stated objectives the study tired to answer the following basic research questions

- To what extent rainfall variability affect crop production?
- How rainfall variability affect livestock production?
- How household farmer heads perceive rainfall variability and what are the major coping and adaptation strategies employed by the household farmers head?

1.5 Significance of the study

It is obvious that outputs of an every well done research finding have its own contribution in the social, economic, political and environmental situations of a given area. Likewise, is expected this study a significant contribution in Arsi-Robe *Woreda* farmers in particular and in the regional and national levels in general for those highly depend on rain fed agriculture. The agricultural sector, in Ethiopia and Oromia region is the major anti-poverty strategy. It is significantly important to alleviate rural poverty, improve the well-being of the poor and move them into better economic sectors through the promotion of agricultural productivity through proper and a well managed policies and strategies. Thus, the importance of the study can be outlined as follows:

First, so far no detailed study has been carried on the impacts of rainfall variability on subsistence agricultural sector in Oromia National Region State in general and Arsi Robe *Woreda* in particular, therefore, study can a springboard for various researches related to the topic.

Second, output of the study identifying the dominant challenges affecting subsistence agriculture and rural livelihood and their respective causes in Arsi zone, Robe *Woreda.*

Third, it helps to understand the perception and awareness of subsistence farmers towards the impact of rainfall variability on their agricultural productivity and livelihoods as well as the way they are responding to overcome this challenge.

Fourth, the result of the study is also significant to avail basic information on problems of rainfall variability on subsistence farming for policy makers, government institutions, NGOs and other stakeholders which are interested on the issues. Besides, it helps to alert local authorities in finding solutions for such challenges.

Finally, this research is significant to depict the issues that need special attention and further research on this area.

1.6 Scope of the study

The case study was carried out in two *kebeles, (Sedika Burka and Sedika)* 7^0, 44' latitude and 40^0, 12' longitude) to see the impact of rainfall variability on rural livelihoods as well as the responses which have been undertaken in Robe *Woreda* Oromia regional national state. The vicinal location of the study area is about 260km far to southeast of Addis Ababa. This study is focuses on rainfall variability impacts on crop and livestock production and adaptation mechanisms in the study area. But it has vitality if the study was focused beyond the site since rainfall variability is common problem in the *Woreda.*

1.7 Limitation of the study

The research assesses the impacts of rainfall variability only on principal rural livelihood; crop and livestock production and its consequent impacts household food shortage. The effect of rainfall variability on soil fertility, vegetation distribution and other aspects of water availability, social conflict were not addressed in this research. There is also a problem regarding timely information since the data were not well recorded on the actual crop and livestock production which was lost due to rainfall variability.

Therefore, the analysis is made depend upon the available few data from the respondents and direct estimation during field survey. These two methods may not indicate the actual crop and livestock loss caused by rainfall variability. Moreover, since there is no research conducted on rainfall variability impacts on crop and livestock production it is too difficult to get materials and experiences from others.

1.8 Definition of Concepts

Impact - is change or a potential change in one or more areas of economic, environment, social, health and well-being (Belay, 2009).

Rainfall variability- refers to variation in the intensity and distribution of rainfall both in temporal and special scales (IPCC, 2001).

A livelihood -comprises the capabilities, assets (stores, resources, claims, and access) and activities required for a means of living (Chamber and Conway, 1992).Almost in similar manner, Ellis, (2000) suggests a definition of livelihood as 'the activities, the assets, and the access that jointly determine the living gained by an individual or household.

Vulnerability- refers to the set of condition and processes resulting from physical, social, economic and environmental factors, which increase the susceptibility of households to the impact of climate hazards (IDSR, 2004).

Adaptation strategy- is long-term strategies in which a society responds to change in their livelihood trough either autonomous or planned way (Berkes and Jolly, 2001).

Coping strategy -is a short-term response to crisis on livelihood systems in the face of unwelcome situation (Jolly and Berkes, 2001).

Drought-is a period of insufficient water initiated by reduced precipitation for extended time of the month. Or a seasonal moisture deficit significantly below long term average levels for a given locality (Webb, 1994).

1.9 Organization of the study

The study was organized into five chapters. Chapter one deals about the introduction, statement of the problem, objective of the study, research questions, significance and scope of the study. chapter two deals about review of related literature which comprises basic terms; rainfall and rainfall variability, impact of rainfall variability, on subsistence Agriculture, etc while, chapter three deals with the description of the study area (population, location, Climate, soil type and research methodology of the study). In chapter four the data analysis and interpretation is presented and the last chapter presents the conclusion and recommendation.

Chapter Two: Review of Related Literature

2.1 Rainfall variability

Rainfall variability refers to variation in the intensity and distribution of rainfall both in temporal and spatial scales (IPCC, 2001).Climate change and rainfall variability is not recent phenomena rather it goes an ice age time. But it is getting attention of the governments early twenty first century because it is accelerated by human activities and the adverse impact of it becomes nastiest (Andrew, 1999).In many parts of the world rainfall is noticeably variable and seasonal in character, in some parts of the world there is scarcity of water availability at certain time of the year. While, at some other time these parts of the world may have excessive rainfall which leads to occurrence of farther extreme events (flooding and soil erosion) to be happened (Jackson, 1989). Rainfall is not only varying from place to place but also from season to season and year to year. These seasonal variations put some influence on water availability and any existence of human life (Getachew, 2005).

During the past time global climate change, rainfall and temperature variability was occurred due to the result of seasonal migration, apparent movement of the sun, and volcanic eruption. However, recently climate change, temperature and rainfall variability is occurred at global level due to the emission and concentration of carbon produced intensively by developed countries since the beginning of industrial revolution. The concentration of carbon, which causes raise of global temperature and increase precipitation, increased in the atmosphere from time to time. For example the accretion of carbon in the atmosphere before the industrial revolution was 280ppm.While, it was reached 379ppm in 2005(IPCC, 2007).

2.2 Impacts of rainfall variability

The impact of rainfall variability and its effects vary from region to region and country to country. Most developing countries of Africa, Asia, and Latin America are disproportionably affected by adverse impact of climate change and rainfall variability. This is because of highly depending on climate sensitive economic sector and low autonomous adaptive capacity. The impact of climate change and variability on agricultural production, food security, water resources, health, physical infrastructure and ecosystems is unequivocal. Due to the combination

of already delicate environment the situation is more sever in countries like Ethiopia (Belay, 2009).

Climate change impacts as a whole and rainfall variability at particular are expected to bring, economic, social, and environmental problems, all of which will causes even more poverty and less development affecting all countries especially the least developing countries.

There are convincing facts that countries still disproportionably affected by the adverse impacts of climate change, rainfall and temperature variability and brought about the carbon intensive development paths of developed countries over the past century (EPA, 2008; NCCF, 2009). Rapid population growth, decline land holding size, growing landlessness, soil erosion, deforestation, poor technical knowledge, and rainfall dependant agriculture are some of the root causes of drought and vulnerability in Ethiopia (Tasew, 2005).

The degree of climate change, rainfall and temperature variability is different among different sectors depending on sectors or regions, depending degree of sensitivity of system, and adaptive capacity. Countries differ widely in the extent, to which their economy is reliant up on climate susceptible activities such as agriculture, forestry, fisheries. In general, the greater the degree of reliance on climate sensitive activities is the greater the vulnerability to climate change; conversely, the greater the portion of the economy in secondary and territory, the lower the vulnerability (IPCC, 2001; common wealthy secretariat, 1998; FAO, 2007).

Poorer developing countries of the developing world are more vulnerable to climate change and extreme weather events like drought and flooding because there geographical exposure, low incomes and greater reliance on climate sensitive sectors, particularly agriculture. Moreover, the state of environmental conditions-land degradation, deforestation, population pressure coupled with climate change and rainfall variability becoming a threat in increasing countries vulnerable to climate change and variability (IPCC, 2007; IPCC, 2001; UNEP, 2009).

Climate change and increasing climate variability, as well as other global environmental issues such as land degradation, loss of biodiversity, and stratospheric ozone depletion have threatened human development. These may include inadequate food, water, energy, safe shelter, and a healthy environment. To address these challenges, it is important to integrate the issues of rainfall variability and climate change into resources use and development decision. Decreasing

the vulnerability through a more formed choice policy parties, and technologies will, in many cases reduce its long-term vulnerability to climate change. Example, the introduction of seasonal climate and weather forecasts into management decision can reduce the vulnerability of agriculture to floods and droughts caused by air oscillation and rainfall variability (Yilma, 1995).

2.3 Impact of rainfall variability in Ethiopia

Ethiopian history is highly punctuated by drought and famine since long years ago (250 BC) (Webb, 1994). However, the impacts of climate change and variability, rainfall and temperature are highly variable both spatially and temporal (IPCC, 2007). Here less developing countries like Africa, Latin America, and Asia will be particularly vulnerable due to low adaptive capacity and climate sensitive economic sector. Extreme weather events like recurrent drought and floods have resulted in loss of life and property as well as the migration of people.

Food related disaster can be traced as far back as 250 BC in Ethiopia. At different time drought and famine occurred as a result of rainfall variability in Ethiopia. Since half of the 20^{th} c there were very common famine occurred as a result of rainfall variability. For example in the 1957 rainfall failure caused the occurrence of locust and epidemic which in turn caused famine and death of livestock. Moreover, 1971-1975 sequence of rainfall failure estimated four million dead and 50% livestock loss. Due to *belg* rainfall failure in 1978-1979 there was great loss of human and livestock. While late *mehir* rainfall failure in 1982 similarly caused many death.1983-1985 due to sequence of rain failure eight million affected and estimated one million dead and much livestock loss.1990-1992 rain failure and regional conflicts caused for eight million people suffering food shortage (Webb, 1994).

Drought frequency is predicted to increase insertion stress on already vulnerable production systems. The number of people affected due to drought has increased from 1.5 in 1974 to 12.6 million in 2005(Belay, 2009).little amount of rain failures have great contribution to crop and livestock failure ,hunger and even famine in the past. Relatively speaking small amount of rainfall during the growing season, like too much or too little at the wrong times, can spell disaster (Oxfam International, 2010).

2.4 Why Ethiopia is vulnerable to rainfall variability

Like many less developing countries, Ethiopia is also highly vulnerable to climate change and weather abnormality, since it is heavily reliant on rain fed subsistence agriculture. Ethiopia is vulnerable to climate change and variability because large segments of population are poor, dependent on income opportunity that are highly sensitive to the weather, and have low access to modern education, information, technology, and health service (Oxfam International, 2010). (Alemneh, 2003), cited by Belay the country's natural resource base, its land ,water, and biodiversity that is the foundation of the country's economic development and food security are highly vulnerable to both anthropogenic and natural induced climate changes and rainfall variability.

The condition is exacerbated by wide spread poverty, and low level of development. Constraints in new technology options, limited infrastructure, skills, education and links to markets further intensify vulnerability to climate change, temperature and rainfall variability stress. The intense pressure on the natural resource base from population growth and inappropriate traditional farming practices are additional stress of climate change and variability in the country (Tasew, 2005).

According to World Health Organization, (2003) an increase in global temperature in turn leads to increase in rainfall intensity and rainfall variability. The assistance of extreme weather events, increase in drought, hurricanes, flooding, and temperature in turn likely to exacerbate the frequency and magnitude of epidemics from water borne diseases. A warmer environment could open up new areas of malaria, rise of 1-3^{o}c will enable mosquito to act on higher latitudes (Houghton, 1998; FAO, 2005).

2.5 Rainfall variability in Ethiopia

Rainfall variability in Ethiopia is not a new phenomenon in the country rather it was occurring for many years than present (NMSA, 2001).from time to time the impact of rainfall variability put more pressure in Ethiopia than the average decrease and increase of rainfall amount and intensity for more years (Meze-Hausken, 2004).Country's trend analysis of a yearly rainfall indicates that rainfall remained somewhat similar on average all over the country. However, regional declining trend have been observed over the northern half of the country and south

western Ethiopia While, an increasing trend in yearly rainfall has been observed in central Ethiopia (NMSA, 2007).

Ethiopia is affected by different weather system scales because of its tropical location, from Micro, Meso-scale, and Regional scale. The principal rain bring wind system for summer rainy season which starts on June and offset on September is highly influenced by inter-tropical converge zone of low pressure system area. The small rainy season of *belg* which mostly onset on March and offset on early May is the result of eastward moving trough, which is facilitated by the interaction of middle latitude cold air and the tropical warm air. These pressure differences cause unstable conditions for the moisture that comes in Ethiopia from the Arabian Sea during the *belg* season (NMSA, 2001).

Some extreme weather events, like inter-annual variability of rainfall within Ethiopia are common incidence. According to Diriba, (2005) there is a link between El Nino and La Nina phenomenon and Ethiopia rainfall variability. According to Endalkachew, (2000), cited by (Demeke,2010) the El Nino event expected to reduce rainfall activity of summer season and increase the probability of elongated dry spell over drought prone areas and increases the chance of rains in the small season as well as the dry season of Ethiopia.

The La Nina contrary to El Niño, event reduces the rainfall activity of small rain season or *belg* while, increase the possibility of excessive in the main season or summer. Mesfin (2007) also point out that tropical oceans sea surface temperature anomalies contribute 50% to the short rain season or *belg* rainfall over Ethiopia. Annual variation of rainfall over Ethiopia and Eritrean highlands are strongly linked to production of rain fed agriculture and this rainfall variations are also induced fluctuations of the Nile discharge ,warm ENSO events are generally characterized by drought in Ethiopia(Yilma,1995).

For example, weather variability can freeze or affects crop. Such circumstances give rise to low productivity in regions of subsistence agriculture. Shortage of moisture often reinforced by high temperature that influences many of soil physical and chemical characteristic (Andrew, 1999). Bekure, (2005) stated that the existence of abnormal rain fall distribution and hot temperature create suitable conditions for the existence of crop pests, and livestock diseases. Even though some factors like overgrazing, over cultivation and deforestation have great contribution

indirectly for the reduction of rainfall in Ethiopia by disturbing hydrological cycle, and the major droughts of Ethiopia are associated with the occurrence of El Nino and La Nino events (Tesfaye, 2001;Bekure,2005).

2.6 Impacts of rainfall variability on crop production

Current climate change and variability as a whole and rainfall in particular is already imposing a considerable pressure on Ethiopia economy. Rainfall variability has been affecting mainly agricultural sector which supports more than 85% of Ethiopian population. Inter-annual and seasonal rainfall extended dry spell in the growing seasons late offset or onset, early offset or onset significantly affecting Ethiopian agricultural activities which is highly depending on rain. This in turn may leads to food insecurity in rural farm households (NMSA, 2007).The condition is more aggravated when unusual rainfall amounts and distributions usually leads to poor harvest and/or complete crop failure as well as shortage of pasture and animal feeds.

Yearly and seasonal variation in rainfall is high and droughts are frequent in parts of Ethiopia. Throughout Ethiopian history rainfall variability has been the major causes of food insecurity and famines. Drought, has affected Ethiopia for many years. For example; the 1957-58, 1964-65, 1992-93 and 1983 droughts had devastating impacts on the country (NMSA, 1996; Webb, 1994).

The degree of yield variability over time is changed in accordance of the amount of rainfall and the pattern and frequency of the rainfall cycle (NMSA, 2007).According to Woledamlak (2005) there is a significant correlation between seasonal rainfall variability and crop production in Amhara region. Inter-annual and seasonal rainfall variability causes agricultural output fluctuation in Ethiopia (Bluffstone, *et al,* 2008).

The degree of climate change, rainfall and temperature variability is different among different sectors depending on sectors or regions, degree of sensitivity of system, and adaptive capacity. Countries differ widely in the extent, to which their economy is reliant up on climate susceptible activities such as agriculture, forestry, fisheries. In general, greater the degree of reliance on climate sensitive activities are the greater the vulnerability to climate change; conversely, the greater the portion of the economy in secondary and territory, the lower the vulnerability (IPCC, 2001; common wealthy secretariat, 1998; FAO, 2007).

Poorer developing countries of the developing world are more vulnerable to climate change because there geographical exposure, low incomes and greater reliance on climate sensitive sectors, particularly agriculture. Moreover, the state of environmental conditions-land degradation, deforestation, population pressure coupled with climate change and variability becoming a threat in increasing countries vulnerable to climate change and variability (IPCC, 2007; IPCC, 2001; UNEP, 2009).

The impact of rainfall variability is worst for African peasant farmers particularly for those who depend on rain fed and have no opportunity to irrigation. According to writers like Orindi and Eriksen (2005), "if there is no rain one year there will be no food in Africa". Society's adaptive capacity is highly depend on the magnitude and rate of occurrence of climate change and variability.

Rainfall variability has the capacity to hinder the society's development. Increases in rainfall variability resulting from changes in global climate can rapidly reduce productivity and alter the composition of grassland plants, according to scientists funded by the National Science Foundation (NSF). Although the diversity of plant species is increased in this scenario, the most important or dominant grasses were more water-stressed and their growth was reduced. Carbon dioxide release by roots and microbes below ground also was reduced (NSF).

There is growing evidence that indicates there is an increased frequency and intensity of climate related hazards, and the level and patterns often interrelated risks that exacerbate the level of variability for poor (IPCC, 2007; UNEP, 2009).risks and uncertainties, often associated with seasonality, are typically impending agricultural practices that in turn worsen vulnerability of the poor to food security (IPCC, 2007).

Ethiopian agriculture is mostly rain fed, where as inter-annual and seasonal rain fall variability is high and droughts are frequent in many parts of the country. Rainfall variability has historically been considered as a major cause of food insecurity and famines in the country (Tasew, 2005). Surprisingly, according to Wolldeamlak (2009), however, the relationships on rainfall variability and fluctuations in agricultural production at regional and sub-regional scales have not been studied well yet.

The Ethiopian agriculture is characterized by extreme dependent on rainfall, low output of modern agricultural inputs and low output level. Likewise, according to (Van Braun 1991) cited by Woldeamlak (2009), for instance, a 10% decrease in seasonal rainfall variability from the long-term average generally translates in to 4.4% decrease in the country's food production. Rainfall in much of the country is, on the other hand, often erratic and uncertain, and rainfall variability and associated droughts have historically been major causes of food shortages and famine (Wood, 1977; Pankhurst and Johanson 1988) all are cited by Woldeamlak, 2009).

2.7 Livestock production

At the commencement of 1990s, agriculture and livestock rising` were the main sources of livelihood in east Africa like, Sudan for about 61 percent of the working population. Agricultural products regularly accounted for about 95 percent of the country's exports in east Africa; Sudan, Ethiopia, Kenya. Industry was mostly primary and light, agriculturally-based, accounting for 15 percent of GDP in 1988. The average annual growth of agricultural production declined in the 1980s to 0.8 percent for the period 1980-87, as compared with 2.9 percent for the period 1965-1980. Similarly, the sector's total contribution to GDP declined over the years, as the other sectors of the economy expanded.

Livestock production plays a significant role in Ethiopia's economy. Estimates for 1987 indicated that livestock production contributed one-third of agriculture's share of GDP, or nearly 15 percent of total GDP. Hides and skins constituted the second largest export earner, averaging about 15 percent of the total export value during the period 1984/85 to 1988/89; live animals averaged around 3 percent of the total value of exports during the same period (Yadeta Asha, 1999).

Although varying from region to region, the role of livestock in Ethiopian economy was greater than the figures suggest and greatly increasing in recent years. Almost the entire rural population was involved in some way with animal husbandry, whose role included the provision of draft power, food, cash, transportation, fuel, and, especially in pastoral areas, indicating social status. In the highlands, oxen provided draft power in crop production (Webb, 1994)).

Ethiopia's estimated livestock population of about 78.4 million in 1988 was believed to be Africa's largest. There were approximately 31 million cattle, 23.4 million sheep, 17.5 million goats, 5.5 million horses and mules, 1 million camels, and 57 million poultry.

Ethiopia has great potential for increased livestock production, both for local use and for export. However, expansion was constrained by inadequate nutrition, disease, a lack of support services such as extension services, insufficient data with which to plan improved services, and inadequate information on how to improve animal breeding, marketing, and processing. The high concentration of animals in the highlands, together with the fact that cattle are often kept for status, reduces the economic potential of Ethiopian livestock. Both the imperial and the Marxist, and Federal governments tried to improve livestock production by instituting programs such as free vaccination, well-digging, construction of feeder roads, and improvement of pastureland, largely through international organizations such as the World Bank and the African Development Bank.

Agriculture in Ethiopia is the largest contributor to overall economic growth and poverty reduction. Accounting for about 45 percent of national GDP, almost 90 percent of the goods exports and 84 percent of the labor force, agriculture remains the economy's most important sector. The livelihood of most of the rural population, of which about 39.3 percent live below poverty line, is fully or partially dependent on agriculture. Ethiopia has significant agricultural potential because of its water resources, its fertile land areas, and its large labor pool but the potential remains underdeveloped (UN, 2009).Currently livestock production affected by climate change, especially rainfall variability and lack of water. Loss of livestock as a result of water and fodder scarcity was increase from time to time in Robe *Woreda* since 1990th.

2.8 Adaptation and coping strategies

Adaptation to elements of climate variability is defined differently by different scholars based on the countries level economic development and types of economic activities. The most familiar definition which was given by IPCC (2001), states that it is an adjustment in natural or human system in response to the actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities. Adaptation is a process by which the adverse impacts of climate variability like rainfall and temperature is reduced by the people (Berkes and Jolly, 2001).

Depend on time, goal, and motives of its implementation adaptation may be classified as reactive and pro-active. Reactive adaptation takes place after the impacts of climate change; changes in rainfall and temperature variability have been occurred. In contrary to this pro-active adaptation take place before the impact are apparent (Klein,1999).According to Maciver (1999),autonomous adaptation in both system (natural and human) is reactive, while, planned adaptation in human system can be considered as both reactive and pro-active.

According to many other researchers there are no clear boundaries between adaptation and coping strategies. For this matter some researchers used the terms interchangeably. However, it is not right using these two terms interchangeably since they have some differences. For example, according to Berkes and Jolly (2001), coping strategies are taken as actual response to crisis on livelihood system in the face of unwelcome situation are considered as short term.

Whereas adaptation strategies in which a society responds to change in their livelihood through either autonomous or planned. However, it is true that coping strategies may develop later gradually into adaptation strategies. Both coping and adaptation strategies working on the reduction of the adverse impacts of climate variability (rainfall and temperature) even though they are classified as short term and long term measures respectively.

According to Davis cited by Adgar (1996), coping may be defined as acting to survive within the given rules and systems; whereas adaptation involves changing the institutional arrangements and livelihood strategies. National growth and transformation plan would enable the nation to double the agricultural economic growth by registering 14.9% growth on average (Ethiopian five year development plan (2010/11-1014/15)"Growth and Transformation Plan).

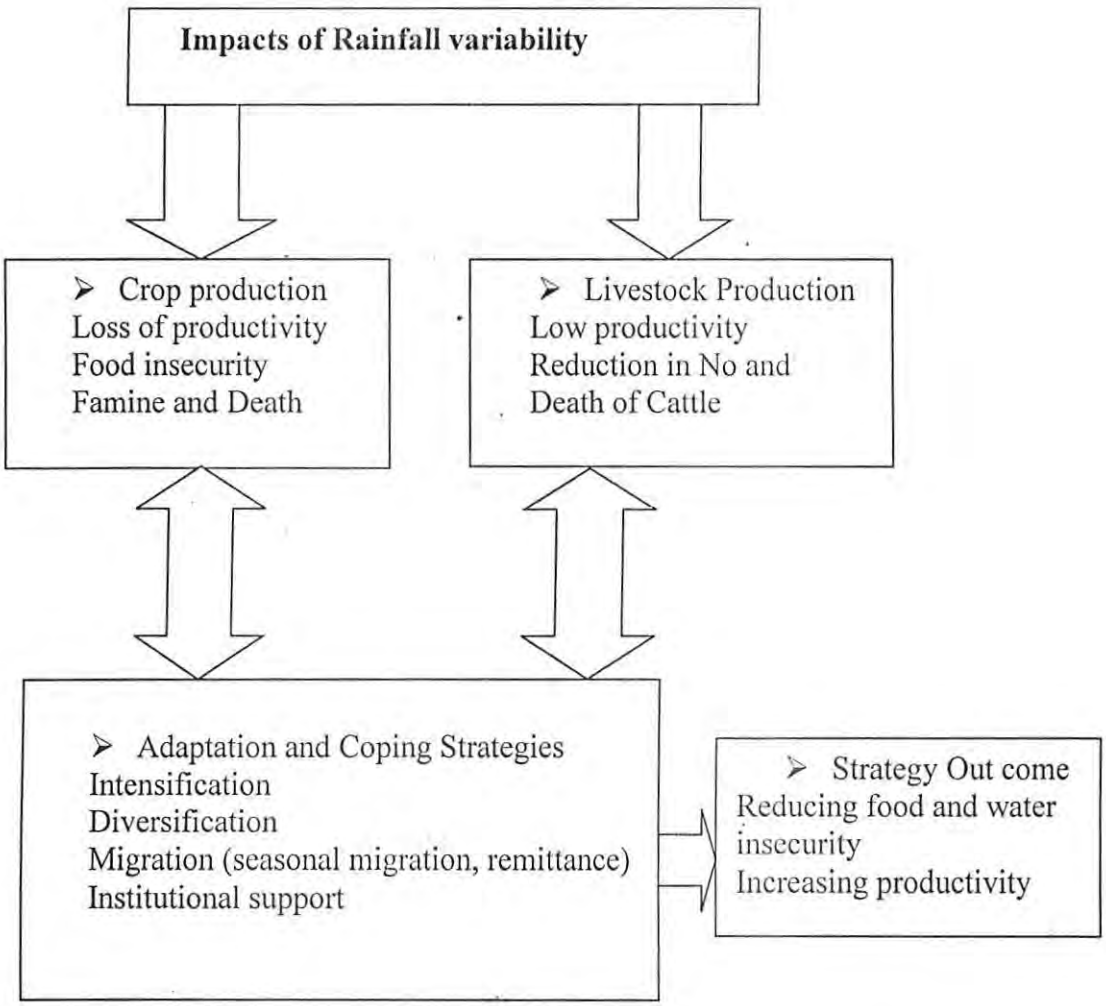
Slegers (2008) in her studies about 'farmers' perception of drought in Ethiopia and Tanzania" used adaptation and coping strategies separately. She used the term adaptation strategies to refer the farmers' strategies to cope with unreliable rainfall in their region over a long period whereas, coping strategies to refer agronomic and food security strategies that were used by farmers when they faced with unwelcome rainfall situation that lead to vulnerability of their livelihood.

Here, I want to use coping strategies to refers to farmers short-term measures (Re-sowing, cultivating drought resistance crop, using fertilizers, late sowing, intercropping) that were practiced when they are faced with rain shortage and their livelihood damages and lead to further food shortage. Coping measures may not be practiced by farmers in all years but when they are faced with actual crisis due to climatic variability. On divergent to this adaptation strategies used to refer those long term measures that have been taken by farmers to reduce the vulnerability of their livelihood to the impacts of rain fall variability.

Generally farmers in the study area use three adaptation and coping strategies; intensification, livelihood diversification, and migration. Intensification includes the use of agricultural inputs, late and early sowing, as well as sowing drought resistance, intercropping and early maturing crop. Livelihood diversification encompasses practicing non-farming activities, like petty trading, daily work, sale of water and wood etc, While, migration may done at seasonal and permanently to reduce the impacts of rainfall variability through working and income generation.

Conceptual Framework

To achieve the research objectives, the researcher developed a conceptual frame work. The concept of rural livelihood is very broad. However, the researcher tried to handle on, the impacts of rainfall variability on crop and livestock production on rural livelihood. Hence,. from the framework one can see the relationship between the impacts of rainfall variability on crop and livestock production and the coping and adaptation strategies applied by local people at a time of adversity.



Conceptual framework

Chapter Three: Research Methodology

3.1 Description of the study area

3.1.1 Location

The case study was conducted in Robe *Woreda*, Arsi administrative zone of Oromia National Regional State. Robe is a town found in 9^0, 36'North -39^0, 08'East with an elevation of 2435m above sea level in south eastern of Ethiopia, named after the nearby Robe river. Robe is bordered on the south by Shebelle River which separates it from the Bale Zone, on the southwest by Sherka, on the west by Tena on the north by Sude, on the northeast by Amigna, and on the east by Seru.

Sedika is a small town in central Ethiopia located in Arsi Zone and one of the two known towns in Robe *Woreda*. It is named after the clan of the Arsi Oromo who lived there and center for many local divisions surrounding it. Sedika is located approximately 260 km in the south east of Addis Ababa. The town had only one secondary school recently got upgraded to 10^{th} grade and one health center.

Many children in the local drop out of school due to the difficult life there, mainly those living in the area, which depend on farming, have less access to education. The last five years, the residents in it and surrounding have been affected by extreme rainfall variability and drought one after another year. This area is known for its crop production mainly *teff* and wheat in addition to livestock. The lack of market access for their products has affected the life of many farmers and they live in very bad situation even if they are working hard (CSA, 2005).

3.1.2 Relief, land use and land cover

The altitude of the *Woreda* ranges from 1200 to 4000 meters above sea level. Rivers include 45 kilometers of the Hulull and 40 kilometers of the Wabe; the gorge of the Wabe is a local landmark between Arsi and Bale Zone. A survey of the land in this *Woreda* shows that 51.1% is arable or cultivable, 27.7% is considered swampy, mountainous or otherwise unusable, 16.3% forest, and the remaining 4.9% is pasture. Oil seeds, specifically flax, N*ueg* (Niger) and rape seed, are important cash crops; Robe is one of the major producers of oil seeds in the Zone (Government of Oromia Region, 2006).

3.1.3 Climate

According to Ethiopian NMSA report (2009), the climatic condition in Robe *Woreda* varies from season to season. However, generally small *belg* rain season rains from March to April, while, long and heavy rains of summer onset mostly on June and offset on September. Long dry season of the years covers the period from October to February. Similarly based on the records (WMSA,1999),the mean annual temperature between 1990-2009 was 3.5°c minimum to 25.4°c maximum, but according to the daily report of meteorological agency in Robe *Woreda* there is an increasing of temperature in recent time. The daily range of temperature variation is largest during the dry season of the year than the summer. The rainfall duration and intensities also vary and increase from year to year.

3.1.4 Population

Based on figures published by the Central Statistical Agency in 2005, this *Woreda* has an estimated total population of 168,043, of whom 84,551 were males and 83,492 were females; 22,947 or 13.66% of its population are urban dwellers, which is greater than the Zone average of 12.3%. With an estimated area of 1,322.50 square kilometers, Robe has an estimated population density of 127.1 people per square kilometer, which is less than the Zone average of 132.2.

The two largest ethnic groups reported in Arsi Robe were the Oromo (82.93%), and the Amhara (15.38%); all other ethnic groups made up 1.69% of the population. Oromiffa was spoken as a first language by 80.01%, and 19.19% spoke Amharic; the remaining 0.8% spoke all other primary languages reported. The majority of the inhabitants were Muslim, with 59.33% of the population having reported they practiced that belief, while 39.95% of the population said they professed Ethiopian Orthodox Christianity.

3.2 Research methodology

The case study was intended to examine the impact of rainfall variability on subsistence agriculture and rural livelihoods in Ethiopia; a case of Robe *Woreda*, Arsi Zone. To undertake this study the researcher was employed both qualitative and quantitative methods. The reason why qualitative method was selected that qualitative method was employed to investigate the true, rich, and deep data to have wide range of understanding about the perception and awareness

of the local people. While, quantitative method was employed to examine the relation between seasonal rainfall variability and crop and livestock production. Moreover a combination of various methods was employed to generate information for the study.

3.3 Sources and types of data

Vital information about this study was gathered from both primary and secondary data. As a primary data sources interview, focus group discussion, and structure questionnaires was employed for this study. The data was collected from elders, Development agency workers, farmers, and community leaders. As a secondary data the researcher was review different historical rainfall records of 20 years and time serious data that have relevant information about rainfall Change and Variability. Moreover relevant documents were assessed to get supplementary information about crop and livestock production.

3.3.1 Primary Data

Questionnaire -The questionnaire was designed based on the objectives of the study in such a way as to enable obtaining the maximum available information from the respondents. It was first designed in English and then translated to Oromifa so that the assistances and the researcher use it. Prior to conducting the main survey, some pre-tests were made by distributing some questions to some farmers, experienced people and colleagues. Changes were made in the design of some of the questions on the base of the comments before the survey. Completing the questionnaire was done by the researcher and assistants.

Focus group discussions – this was conducted with key informants farmers, extension workers, *kebele* leaders, to collect more relevant information on similar ideas. For this purpose 5-7 member was involved.

Direct observation – this was used to gather direct information by directly looking at the events related to impacts of rainfall variability and adaptation strategies to overcome the problems faced by subsistence farmers in the study area. For example, in the 2009/10 harvest season due to prolonged summer rain in Robe Woreda, most farmers' covers more than 95% of their farm land by *teff* than any other crops.

Key informant interview - key informant interview was employed on issues of which relevant information could not be acquired from other informants, such as weather station workers about temperature and rainfall variation, peaty merchants, water and wood sellers, fertilizer distributors, peasant association lookers

Interview-The interview questions was provided to governmental and non-governmental experts and illiterate household heads within the sample population. Moreover, in order to get additional information and to maintain usefulness and reliability of the data and/or information, the researcher was used observation and key informant interview for some individuals from government and non-government representatives. Interviewees from the local farmers were selected through random sampling technique to collect data with regard to their efforts undertaken to overcome the impacts of rainfall variability on subsistence agriculture and rural livelihood. To get information on the criteria of selecting the strategies to increase the productivity of subsistence agriculture, the extension workers, *kebele* leaders, and other stakeholders was interviewed.

3.3.2 Secondary Data

As part of qualitative and quantitative research methods, both primary and secondary data sources were employed for this study. To collect the secondary data, some relevant books, thesis, office documents as well as web sites was consulted. Data on the number of household heads was obtained from the *Woreda* Administration Office and types of activities farmers engaged in was collected from the *Woreda* Office of Agriculture and Rural Development.

Some statistical figures on population were collected from 2007 Population and Housing Census of Ethiopia Results for Oromia Region and Annual Statistical Bulletin of the Regional Finance and Economic Development Bureau (BoFED) was used. To investigate the special and the temporal rainfall variability of robe *Woreda* during different seasons (Kiremt, Belg & Bega) the Seasonal mean rainfall from Robe and NMSA and WMSA since 1990-2009 was used. Few missing data was filled up using long term mean rainfall.

3.4 Sampling techniques and sample size

Taking the whole people is economically expensive and needs much time and energy although complete information can be obtained from each person in the population under study (Deaton, 1998). Accordingly, for this study data was collected from the sample population of household farmers' farmers in Arsi Robe *Woreda.*

Selection of the Study kebeles: According to (Deaton,1998) stratification, selecting the strata and then a sample household from each stratified *kebeles* has advantage of cost effectiveness; providing representative and reliable data; facilitating revisit or asking supplementary questions about previous responses and monitoring the progress of the work except its difficulty during analysis (Samuel; 2004).

***Kebele selection*;** First, the *Woreda* was stratified based on *kebele* administrations. In Robe *Woreda* there are 28 *kebeles* and in each of them the impacts of rainfall variability on crop and livestock production is different. Based on micro climate and dependability on rain fed agriculture from 28 *kebeles* of the *Woreda* the most affected by rainfall variability were six. Therefore, taking into account the impacts from these six *kebeles* two *kebele* (*Sedika and Sedika Bureka*) was selected.

***Village selection*;** By taking into account the resource limitation and time constraints the researcher was again purposefully decide to cover four villages from each of selected two *kebeles* regardless of the number of villages in the *kebeles.*

Finally, the researcher was deciding to employ purposive and snowball (chain referral) sampling technique. The researcher was focused on purposive sampling helps to approach development workers, beneficiary, religious leaders, and knowledgeable people to acquire relevant information. While, snowball sampling helps the researcher to collect the information individual at first contact who again leads the researcher to still more information to be interviewed in the process up to the study is exhausted.

Therefore, the researcher decide to take a sample of 90 household heads found on four villages(*Robe,Indeto,Jara and kesiamba*) The selection of 90 sample house hold heads was made purposefully by the researcher to get more information Depend on age of respondents. The selection of 90 sample household farmers focused purposefully on all economic level. Rich,

intermediate, and poor samples were selected. Moreover, four DA workers, four village leaders, two metrological workers, and five religious leaders were participated. Economic classification was made according to local farmers' economic status.

3.5 Methods of data analysis and procedures

Once this data was collected, the next task was to process the collected data and/or information and analyze taking them into account the objectives of the study. The data from questionnaire were tabulated, organized and analyzed using tables manually and some statistical software (SPSS). Quantitatively, percentages, averages, medians, modes, maximum and minimum values was used to show temperature and rainfall variations, crop production characteristics of subsistence farmers and their livelihoods; while information from interviews, observations and focus group discussions was used either as an explanatory notes for the results from the questionnaire or as the descriptive part of the study.

Chapter Four: Result and Discussion

From critical examination and categorization of the collected data or information the following organizing themes were identified. Demographic characteristics, educational and economic status of the respondents, trends of rainfall and temperature variability(late and early offset and onset, duration, distribution, late and early cessions of rainfall), impacts of variability on crop and livestock production, coping and adaptation strategies in the study area. Moreover, farmers' perceptions on rainfall variability and drought, water sources for crop and animal production, access to farm land, drought frequency, adaptation capacity of farmers, and soil type were discussed.

4.1 Demographic characteristics of the respondents

4.1.1Age and sex distribution of the respondents

In many rural parts of Ethiopia, gender differences are very common factors in practicing diverse work and sharing responsibility. So, understanding the age and sex characteristics of rural household is very vital to investigate the impacts of rainfall variability on rural livelihood and their copying strategies. Likewise, looking at the sympathetic distribution of sex and age in the study area contributed a lot to considerate rural household economic, social, and political conditions. According to sample respondents interviewed 95.6% were male headed, while, the remaining 4.4 were women.

This indicates the dominance of male headed household responsibility in outdoor activities. Most family heads in the study area were male and meanwhile, according to the tradition in the area most family heads are responsible for generating income for their family members. As a result family heads have more responsibility than other family members in protecting rainfall variability impacts.

Age distribution in Sedika and surrounding varies from the youngest (24 years old) to the oldest (80 years old). However, most respondents (90%) fall from 40-60 years old with the continuation of frequency disparity from one age group to another. Most aged farmers bother about the impacts of rainfall variability and its different adaptation and coping strategies. However, their perception varies from farmer to farmer. Old farmers perceive variability as a punishment from

God (*yegzihaber quta*) due to human evil practices such as working on holydays, conflict between people, Jules, violating the rules of God.

To see the change in rainfall variability and its impacts on rural livelihood of the study area, considering both old and young age farmers is vital. Old age farmers noticed great inter-annual and seasonal rainfall variability had been experienced from year to year and season to season. Young farmers relatively did not understand the long term change in temperature and rainfall distribution. However, they have some awareness regarding seasonal rainfall variability and its impacts on crop and livestock production.

In rural Arsi, Robe *Woreda* most women are highly engaged in household activities: in fetching water, collecting firewood, looking for children, cooking food and others. Women have some idea about rainfall variability through its adverse impacts on food insecurity, water scarcity, low productivity, and low dairy products. Most women waste much of their time; three to four hours per day in collecting water for home consumption and watering the cattle. The condition is very severe for women during winter season where most males engaged in harvesting crop and local ponds and springs become dry and waste more than six hour in searching water.

4.1.2 Marital status of respondents

Knowing the marital status of the respondent is very imperative to understand rainfall variability and its impacts on rural livelihood because the response, perception, and vulnerability of rural farmers to climate change and its impacts vary from farmer to farmer. From the interviewed respondents the majority (91.1%) were married, while small proportions were single. In addition the perception to rainfall variability and coping strategies also varies depending on family size of the farmers.

Old age and married farmers who have large family size relatively had better perception on rainfall variability and its impact than young farmers. This is done to the fact that married farmers with large family size understood the problem of food insecurity and water availability. The more perception they have the better coping strategies they develop to overcome the challenges. However, farmers considered rainfall variability as a result of punishment from God as a consequence of evil things that human kind has practiced and resource degradation in study area.

4.1.3 Educational status of respondents

Education plays a significant role in creating awareness about climate change and develops different coping and adaption strategies of rainfall variability. The more farmers are educated, the better awareness they have about causes of rainfall variability and better adaptation and coping strategies. Educational status of the respondents varies from illiterate to secondary education. Nearly 43% of the respondents (42.2%) can read and write and 26.7% of them completed primary education.

The remaining 17.8% attended up to secondary education and 13.3% were illiterate. Understanding their educational status is vital to know about their perception of rainfall variability as well as coping strategies of farmers applied during shortfall and long wet season. Those educated farmers have more knowledge about causes of rainfall variability and develop better coping strategies than illiterate farmers. Moreover, educated farmers have better awareness in developing different adaptation and coping strategies.

4.1.4 Economical status of respondents

The economic status of the surveyed respondents for this research varies according to local classification; rich (*habtam*), intermediate (*mekakelenga*), and poor (*daha*) based on their livestock asset and land; principally oxen, cow and farm land possession. Farmers who have more than two oxen, cows with three and more hectors of farm land were considered as rich, while, those farmers having two oxen and two cows and two to three hector of farm land were intermediate class farmers. Farmers with no or one ox and cow and less than two hector of farm land were considered as poor. The largest proportion which for accounted 60.8% of the respondents were rich and middle income group farmers according to local classification of economic status. However, the remaining 39.2% of the respondents were poor.

Table 1 Local economic status classification criteria

Number of livestock	Rich	Mid	Poor
Oxen	>2	=2	≤1
Cow	>2	=2	≤1
Sheep	≥8	=5-7	≤4
Land	>3 hectare	2 -3 hectare	<2 hector

Source; Field survey, 2010

Economically, active and rich farmers have employed better coping and adaptation strategies to rainfall variability and its impacts than economically unproductive and poor farmers. In the study area, family size influences the vulnerability of farmers to rainfall variability and its impacts; such as drought and food insecurity. Most households in the study area had five to seven family sizes. However, some families have more than seven family sizes. Higher family size farmers are exposed for sever impacts of rainfall variability. On the other hand, it doesn't mean that small family sizes are/were not exposed to the impacts of rainfall variability.

4.2 Rainfall variability and shortage

Now days, there is inter-annual and seasonal rainfall variability in Ethiopia (NMSA, 2010). Meanwhile, both seasonal and inter-annual rainfall variability exist in the study area and put more pressure on rural livelihood and economic activity of the *Woreda*. The amount of rainfall varies from 644.5 mm in 1993 to 1310.5mm in 2001(WMSA, 2010). However, the mean annual rainfall amount was 955.17 mm in the last 19 years (from 1990-2009).

Similarly, the sample respondents also confirmed the condition by informing that, nearly the entire respondents (95.6%) said that there is variability in rainfall in the study area. However, 4.4% sample respondents reported that non occurrences of rainfall variability in the local area. According to the majority of the respondents in the study area, Arsi Robe rainfall variability is a common occasion and has become norms. Because of this reason and nearly 98% of the population is engaging in subsistence agriculture, the impact is very immense in the *woreda.*

Accordingly, according to the survey result, larger proportion (53.3%) of the respondents said that there is no shortage of water except abnormal condition of rainfall. For example, in 1993 there was unusual maximum winter rainfall (315.8mm) in February which is not common event during *Belg* season. While the duration and intensity of summer rainfall also reaches at its peak point in August 1991(386.2mm).The rest (42.2%) of the respondents noticed rainfall inadequacy in some month of the year especially during winter season in the study area. However, 4.4% of them have no idea about scarcity rain.

At the same time, they noticed that irregular and infrequent distribution of rainfall throughout the year and within the year is main problem in the area at present than the past time. This indicates that more or less there was no rainfall shortage in the study area in general, although there is an

indication of inadequacy in some degree in some months of the year especially during winter and drought season. Most of the observation indicated that the distribution of rainfall varies from year to year and the impacts also vary from season to season in accordance with the duration and the intensity of rainfall in the survey area.

Inter-annual and seasonal rainfall variability became common incidence in Ethiopia (NMSA, 2009).Consequently, from the total respondents interviewed about long-term rainfall change in Robe *Woreda;* nearly (98%) believed that they have alertness about long-term mean rainfall change. However, the smallest proportions (2.2%) of them replied that they have no awareness of the long-term change and impacts due to high engagement on non-farming activities. This implies that almost all farmers have better awareness about the changing nature of rainfall in the study area.

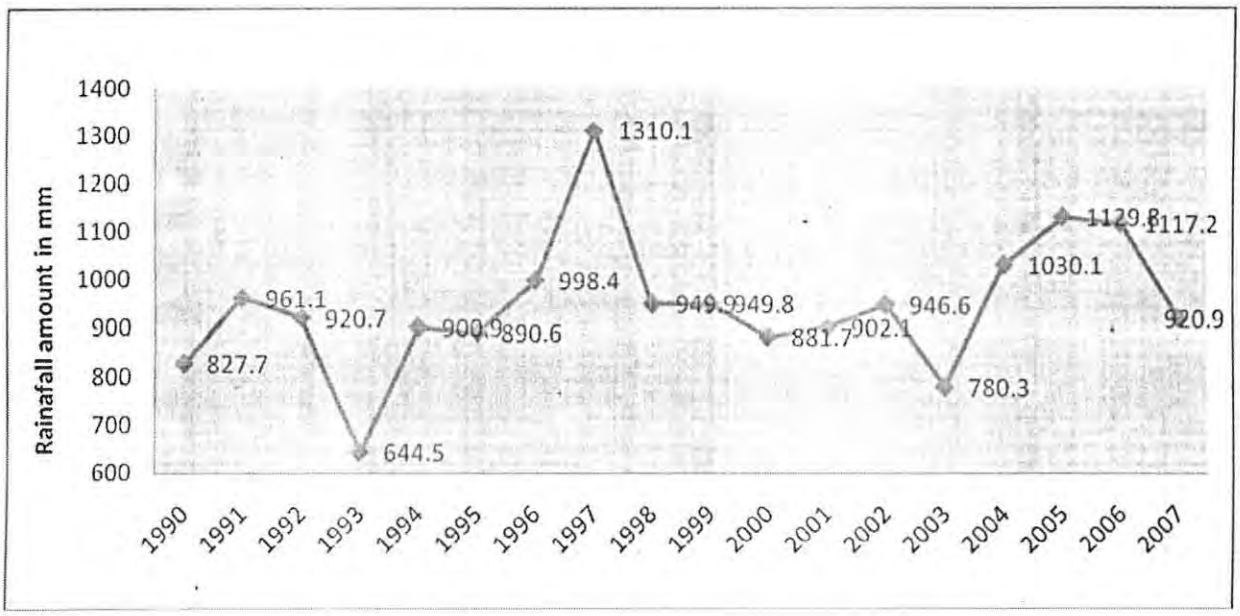
60% participants of the study area, in Robe *Woreda,* understood general disparity in distribution of rainfall during winter, summer, and belg season. The rest (24.5% and 15.6%) of the respondents reported that there was total increase and absence of rainfall distribution change respectively. One common thing in the study area was that there was variation among farmer perception about rainfall variability. Metrological data reviled that the general decreasing of summer rain and increasing of unusual and winter rain in Robe *Woreda* from 1996-2001. Moreover, metrological data also shows that general increasing tendency of total annual rainfall in the area.

Like many parts of rural Ethiopia, in the study area, subsistence agriculture has a lion's share of economy and totally depends on rainfall. Hence, the amount of crops harvested by farmers per quintal varies from year to year in accord with rainfall distribution, time, duration and intensity.

The optimal and timely distribution of rainfall gives better harvesting of crop and animal production. From the total sample respondents nearly 96% have farm in year (2007/8) and harvested good crop product. This year was good year since 1990 -2009 while, 1990, 1993, 1997, and 2003, 2009 were bad years in the *Woreda.*

The rest 4% of the participants reported that they didn't cultivated in the year (2007/8); however, they had noticed the presence of good harvest of crop and livestock than 2009/10.Hence, there was good cultivation and harvesting of crop in 2007/8 in which most farmers on average harvested from 20 to 30 quintals of wheat. The most common recent droughts in the *Woreda* were in 1993, and 2003, and prolonged rain in 1997, and 2010.

Fig 1 Year to year annual rainfall variability at Robe *Woreda* from 1990-2007



Source; Adapted by the writer from NMSA 2010

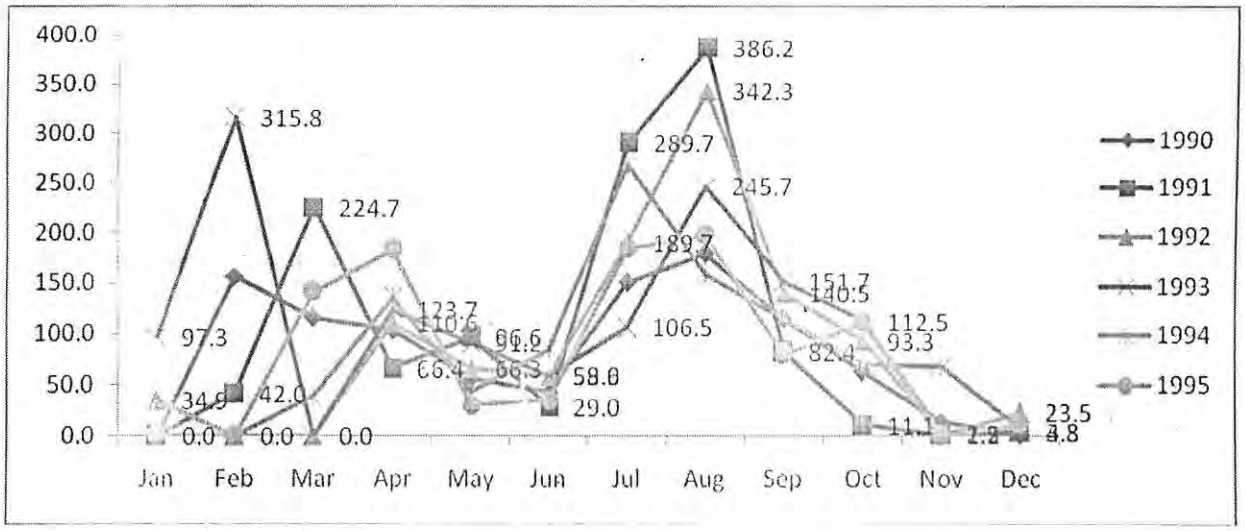
The distribution, intensity, and duration of rainfall variability are common incidence at present time in Robe *Woreda*, Sedika and its surrounding *kebeles*. However, inter-annual (late or early onset and offset, abnormal) rainfall variability is imposing more significant impact on rural livelihood than seasonal variation. The seasonal distribution, intensity, and duration of rainfall are highly deviated from the long term mean and increase the occurrence of some extreme circumstances (Flooding, drought, untimed rain).

For example, in 1997 maximum amount of rainfall was recorded (1315.5mm) and highly deviated from the long term mean. In divergent to this, 1993 was memorized as great drought year (644mm) and shortage of water. Due to this up and down in the year nearly 55% of the population was exposed to food insecurity and looking for food AID from different bodies. The

general trends of rainfall distribution were varying inter-annual and seasonal as indicted on the fig 1,2and 3.

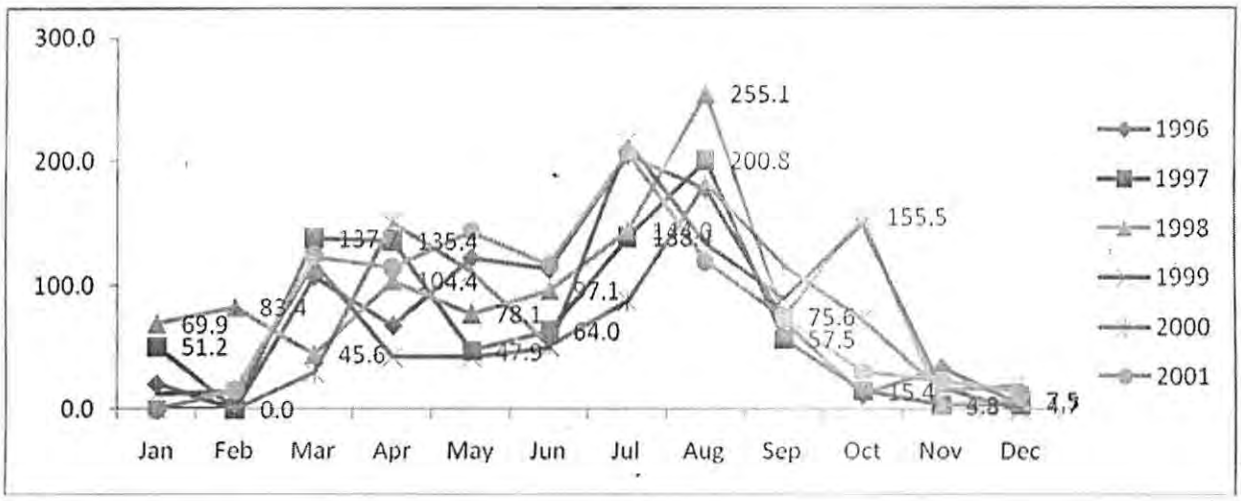
In fig 2and 3 the distribution of *Belg* and *kiremt* rainfall is maximum from1990 to 1995 in general. However the monthly distribution of rain fall in *belg* and *kiremt* season relatively decreasing from 1996-2001 and increased especially during winter and outman. From 1990-2001 maximum (315.8mm) winter rain was recorded in February 1993 while, maximum summer rain (386.2mm) was received in August 1991.

Fig 2 Monthly Rain fall Distribution in Study Area (Sedika) from 1990 -1995



Source; adapted by the writer from NMSA (2010)

Fig 3 Monthly Rain fall Distribution in Study Area (Sedika) from 1996 -2001



Source; Adapted by the writer from NMSA (2010)

Based on the data computed from NMSA, 2010 and the quartile analysis method, the distribution of rainfall since 1990-2001 indicated more of variable. Hence, the first quartile 888mm is less than and far from the mean, 1016.3mm, while the fourth quartile (1310.5) is greater than the mean. However, the second and the third quartile result indicate near the average.

Similarly, according to quartile analysis method (Edwards 1979) the annual rainfall data is ranked (lowest to highest) and divided into four 25% bands. The analysis of the quartile method indicates great deviation from the mean. It is calculated as Qn=nN/4.The definition of quartile values and quartile analysis result according to Edwards(1979),zero is minimum,1st quartile is below average,2nd quartile is median,1st to 3rd average, greater than 3rd quartile is above average, and quartile 4th is maximum.

4.3 Onset, offset, early, and late cessation of summer rain

4.3.1 Onset of summer rain

In general Ethiopia experienced three main rainy seasons: all year round rain, summer, and *belg* rain. However, inter-annual and seasonal variability of rainfall is a widespread incidence in recent time. The onset of summer rain varies from year to year and *kebele* to *kebele* in Robe *Woreda.* According to the sample respondents, the largest percentage 80% of the respondents confirmed that summer rain starts at the end of June or early July. Here the rainfall accumulated

over 3 consecutive days is at least 20 mm and when no dry spell within the next 30 days exceeds 7 days (Stewart, 1987).

The remaining small proportion of the respondents established that mostly the summer rain onset on early July though it varies from year to year. Generally the summer rain onset varies from late June to early July in Robe, *Woreda.* The impact also varies on crop and livestock production and productivity according to the onset, offset, and, rainfall intensity and amount. When the summer rain started on late June, it has optimal distribution in intensity and amount, Wheat cultivation is common than *teff* and relatively the number and productivity of livestock increased.

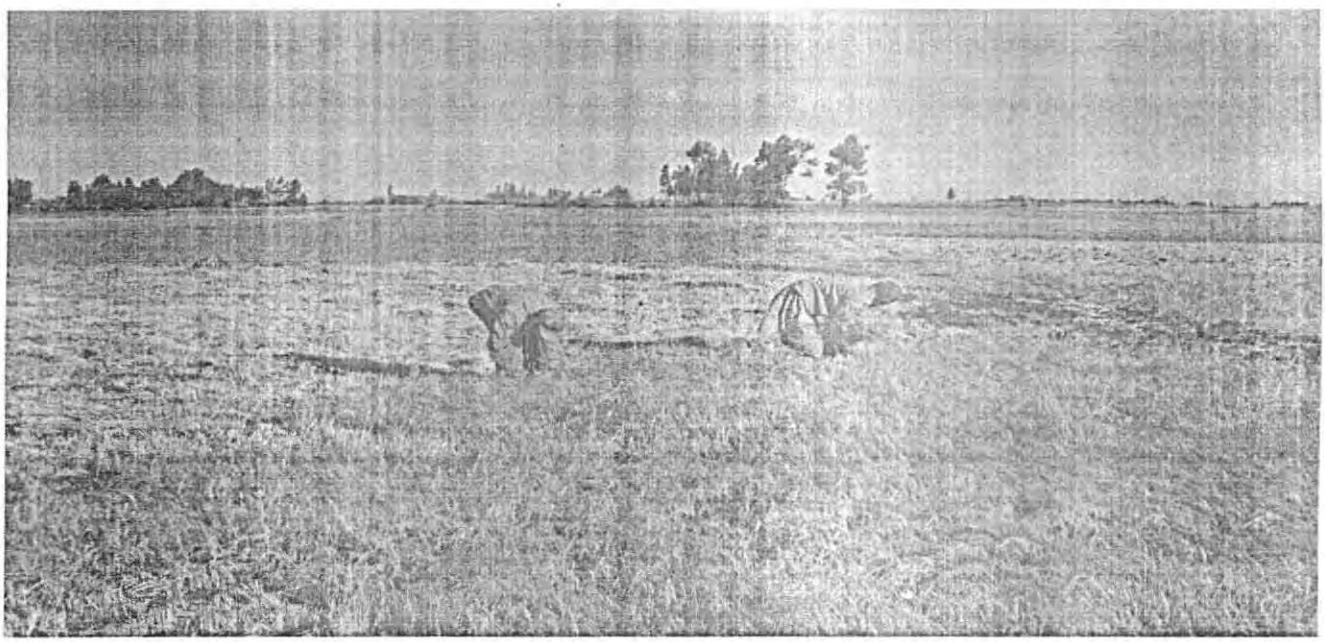
When summer rain starts at the middle of June and early July, most farmers cultivate *teff* and number of livestock increases. The higher the distribution of rainfall is optimal in intensity and amount, the better the production in *teff* than wheat. For example, in 2009/10 there was maximum rainfall distribution, duration and intensity and there were more harvesting production in *teff* and livestock than wheat production.

By its very nature *teff* crop has the capacity to resist prolonged and high amount of moisture in the soil than other cereal crops like wheat during germination. For example, in 2008/9 there was an optimal rainfall distribution in the study area and most farmers on average harvested from 25-30 quintal of wheat and from 5 to 10 quintals of *teff* per farmer. In divergent to this in the harvest year 2009/10 rainfall distribution was not optimal and prolonged wet season from June to October occurred in the study area. As a result most farmers were cultivating *teff* and got relatively better production than wheat. In the same year, farmers were collecting on average from 5 to 8 quintal of *teff* and 2 to 3 quintal of wheat per farmers. It is bad year at which low production was harvested in the area

The overall food security conditions in the study area have shown less improvement due to unsatisfactory *mehir* harvest and ongoing *belg* rainfall variability (onset on late may 2011). Hence, in the *Woreda* different *kebeles* are faced with food insecurity, particularly in Sedika and surrounding areas where the *mehir* harvest failed. Early onset of rainfall can spoil some crop like Maize, Niger, *teliba*, pea and increase the regeneration and fast growth of grass. Moreover, the preparation of farm land becomes difficult for the next harvesting season due to absence of *belg* rainfall. So, if there is no good preparation of farmland and application of different coping

strategies to overcome the problem, it would likely become more persistent and the impacts become enormous due to absence of belg rain up to late may 2011.

Fig 4 Farmers harvesting *teff* on farm land 2009/10



Source; Field survey 2010

4.3.2 Offset of the summer rain

Understanding the onset of summer rain is not the only solution to see the impact but also knowing when the summer rain ends have immense impacts on subsistence agriculture. From the total household majority of the respondents in the survey area 64.4% replied that summer rainfall offset on late September. The rest 35.6% of the respondents noticed that it was offset early October. From this point of view and metrological data sources, even though there is a disparity of offset of rain; one can realize that the offset of summer rainfall varies from year to year and has huge impact on type of crop production and number of livestock.

When the summer rain extends until October with large amount and intensity and it is difficult to cultivate most cereal crops like wheat and barley, rather farmers cultivate and rely on *teff,* fast maturing, and drought resistance crops like chicken bean, and vetch (*Guaya).* The final date of rains is considered as that date after mid September or early October following with no rain occurring over a period of 20 days (Sivakumar, 1988).

In 2( )/1(. the summer rain started on early July and has extended up to October, and the culti- ation of crop become difficult and nearly 90% of the farmers cultivated *teff.* Moreover, the production of wheat was not common due to prolonged impact of the wet season in the study area and from cultivated wheat farmers harvested from one hector only three to four quintals. In good years (2008) most farmers harvest twelve to fifteen quintal of wheat and five to eight quintal of *teff* per hector.

4.3.3 Late cessation of summer rain

Respondents have different understandings about the time of summer rainfall late cessation. From the total respondents nearly, 69% of them said that there was an increasing of late onset of summer rain. Some 28.9% of the respondents said that there was a decreasing of late cessation of the summer rain, while small proportion of (2.2%) understood that the late cessation of summer rain is the same. Here fast growth and regeneration of grass and the production of cereals per area decrease due to the maximum amount of water in the soil.

When farmers were asked about the existence of dry spell, 80% of the respondents witnessed the increasing of dry spell in wet season, while 17.8% of the respondents noticed decreasing of dry spell in wet season. Still some respondents (2.2%) reported the absence of change in dry spell in wet season now and before. When the summer rain late cessation most farmers are forced to cultivate fast maturing and drought resistance crops. This may lead to the reduction of most staple crops (wheat and *teff*) in the area for subsistence or advertise.

Long period of dry spell between the summer and *belg* season can cause less crop growth and the land preparation becomes difficult for *mehir* harvest (Feyissa, 2009; Demeke, 2010).This in turn leads to the shortage of drinking water for both human and livestock population. Moreover, because of limitations in productivity, they had to devote very high proportion of their resources to increase agricultural productivity.

4.4 Impacts of rainfall variability

Food insecurity is an integral part of poverty in Ethiopia. Rainfall variability and change is projected to reduce yields of wheat, staple crop by 33% (NAPA, 2003).The summer *(mehir)* rainfall variability especially early cessation and late onset has become frequent and great challenge in crop production in the study area. It leads to crop failure and poor grass regeneration

for cattle, outbreak of disease, and pest that result in loss of crop production. In 2009/10 prolonged rain during summer decrease the production of wheat by about 90% in Sedika and its surroundings. Moreover, prolonged dry spell during belg season led to farther low productivity and difficult preparation of land for the next harvest season (2011).

Almost the entire respondents noticed that they have faced with impacts of rainfall variability at different times of the year directly or indirectly. The impacts decrease both crop and livestock production. Especially in 1979 and 1984 was unforgettable drought in the study area. The most recent drought years were 1990, 1993, 2003, 2006, and 2009, which caused the death of many livestock and loss of crop yields.

Farmers' perception about causes of rainfall variability ranges from punishment from God up to poor land management. Accordingly, about 51.1% of the total respondent considered the punishment of God as a cause of rainfall variability. Causes of rainfall variability extended towards depletion of forest (26.7%) and natural resource degradation (20%). Limited proportions of the sample respondents (2.2%) were caused by poor land management. Farmers understanding about rainfall variability and its adverse impacts vary from household to household. So, creation of good awareness about causes of rainfall variability is important to create common sense of understanding and employ appropriate coping and adaptation strategies at local level.

4.5 Rainfall variability and crop production

Since Ethiopian agriculture is rain fed and subsistence in character, the impact of rainfall variability in crop production is grand. Accordingly the majority of the respondents, (91.1%), noticed high relationships between rainfall variability and crop production. Small proportion of the respondents about (6.6%) said that there was low relationship. Still very small proportion (2.2%) of the respondents reported medium relationship between crop production and rainfall variability.

Almost the entire respondents have noticed apparent relationship between crop production and rainfall variability. The higher and better distribution of rainfall and lower the rainfall variability is the better productivity. Comparing the past and present production in general, 51.1% of the respondents noticed an increasing of production per area since the application of technological imputes in 1980s. The rest 48.9% of the respondents reported the decreasing of crop production

per area since late 1990s. Those farmers applied agricultural inputs on their farm land noticed that there was an increasing of production per hector since late 1970s. While, those who did not use inputs noticed that there was reduction of production per hector in 2000s than the 1980s.

Current trend in level of hunger is largely determined by the onset of adequate summer rain and timely rainfall pattern. In fact, the frequency and severity of drought have increased from time to time. Most vulnerable areas have experienced drought on yearly basis during the past decades (late 1990s). The decline and erratic nature of rainfall become the norm rather than the expectation in many parts of Ethiopia (Tasew, 2004).

The main reason why crop production increase today as compared with the time before 20 and 30 years is the result of modern agricultural inputs (fertilizers, insecticide, pesticide, improved seeds and professional advice from DAs).In contrary to this the failure of crop production at present occurred because of climate change especially unusual rain and seasonal rainfall variability. From the total respondents Sedika and its surroundings 77.8% of them confirmed that the decline of crop production was caused by unusual rainfall.20.2% of the respondents have considered soil erosion as the cause for loss of crop production. The rest, 2% of the respondents have no idea about increasing or decreasing of crop production in the past and present.

The majority, 66.7% of the local farmers did not use synthetic chemicals to reduce the impacts of rainfall variability on crop and animal production. About 33.3% of the respondents were applying different synthetics chemicals to reduce the impacts of rainfall variability on crop and livestock production. The main reason explained by the local farmers for not using synthetic chemicals was its increasing cost and farmers lack of ability to buy during summer season. For example "one old farmer inform me that to buy one liter pesticide for *wage* he spent from 500-600 Ethiopian birr" or 29.4-35.2 USD. So, application and buying synthetic chemicals are expensive and even sometimes difficult to get at a right time.

Almost all farmers tried to practice crop management to reduce impacts of rainfall variability. About 60% of the total respondents used both pesticide and insecticide crop management.40% used only pesticide for crop management. Farmers apply different types of coping strategies in the study area. The effectiveness of crop management may vary depending on the educational status of the respondents and economic capacity.

Farmers' access to meteorological information is one coping strategy in protecting the impacts of rainfall variability on rural livelihood. Nearly 60% of the respondents had access to meteorological information via mass media like radio or DAs and from school as announcement for students. 40% of them have no access to meteorological information. Access to meteorological information creates some sort of differences between farmers. The higher the access to the meteorological information is the lower to the impacts of rainfall variability and vice versa. For example, when farmers have information about unusual rain most farmers work in group and harvest within shortest possible time.

In addition to accesses to metrological information farmers traditionally know and estimated roughly the amounts of rainfall, onset, offset, and its duration, via different mechanisms. Accordingly, the majority of the respondents, (60%), used the wind direction and (40%) used the nature of the cloud. Still others traditionally observe the sky to predict amount of rain and its duration. For example, When wind blows from southwest (*Wabe* river) to east (Seru) they expected more rain and long summer.

Farmers informed that, when there were great impacts of rainfall variability, there was no enough credit in the form of providing food crop and money to overcome the hardship. 80% of the respondents informed that the absence of credit assistance either in the form of food aid or money and 20% of the respondents noticed that there was credit assistance when there were rainfall variability impacts even though it was not sufficient. Nearly all respondents informed that the *Woreda* agricultural office provides oil, improved crop seeds and credit to the people who are living in the drought affected area.

However, the distribution was not in accordance with the impacts and family size, rather it is distributed evenly for all peoples. For example in 2006/7 farmers were given only ten KG (hulet quena) of wheat and a liter of oil for two successive months. All farmers who are highly affected and not affected by drought share the crop and oil equally which was full of corruption. Even according to the focus group discussions, the distribution of improved seed, training on adaptation mechanism, water harvest technique and fertilizers were not distributed free of bias, rather *kebele* workers and those who have good personal and close relation to the *kebele* officials got better privilege than an ordinary farmer.

At present, almost all the rural people rely entirely on rain fed agriculture. So; rain water harvesting is a necessary and not an option in alleviating food crisis in Ethiopia as a whole and in the study area in particular. Possible alternatives to attain food security and food self sufficiency in the country is to maximize the use of available rain water through different harvesting techniques including runoff retention, soil moisture conservation etc. This option focuses on harvesting and utilizing as much rain water as possible to increase production and productivity of land.

Farmers also used different coping strategies to overcome the shortfall of rainfall.84.4% of the respondents used different coping strategies (group harvest, browning from relative, mortgaging their land, sell their last asset, like oxen and home equipments, selling wood, water, etc) to reduce the impacts and 15.6% of the respondents have no idea whether they use coping strategies or not during rainfall shortage. Accordingly, 37.8% used sowing drought resistance crop when there were rainfall shortage. Late sow as well as sow varied crops in one season and intercropping account for 28.9%) and 22.2% of the sample respondents respectively. Others still use early sowing and job diversification as means of coping strategies.

Rain water harvesting is considered as one means of coping strategies for the shortage of rainfall for crop and livestock production.RWH involves the harvesting of water directly from rainfall using different means. This collected water is diverted to various uses from domestic to watering livestock, and supplemental irrigation. This method offer farmers the possibility of coping water stress thereby reduce risks of crop and livestock failure.

When farmers face with early crop failure due to maximum rainfall they use a mechanism of re-sowing, developing canal, and adding fertilizers especially UREA to the crops. In sharp contrast to this during the shortage of rain at early stage of cropping time, farmers' use sowing drought resistant crop and fast maturing crops like *Guaya,* and chicken pea. Generally, 84.4% of the sample respondents used re-sowing as coping strategies whereas 15.6% of the respondents used fertilizers as coping strategies during maximum rain.

In any case, farmers used different coping strategies in accordance with their perception and choice. Most farmers did not use irrigation to increase production and reduce the impacts. Farmers did not use irrigation in the study area mainly due to the absence of permanent source of

water like, river and ponds. However, lack of capital and information how to use rain water by harvesting for crop and livestock production are other factors.

Farmers used different measures and coping strategies to overcome the challenges. From the total sample respondents, 86.7% of the respondents said that they had an idea about what would happen in the future. Small proportion of the respondents did not understand what will happen if rain stop early in the cropping season. Most farmers expected the existence of drought in the future because of rainfall failure in the early cropping season of the year. When there is a rainfall failure in the early season of the year farmers use different coping strategies. Such as re-sowing drought resistance crop (44.4% of the respondents), 29% of them used re-sowing fast matured crops for the second time. Share for others may vary from 17.8% and 8.8% applying water from other sources as coping.

From the total respondents 88.9% of them said that there was high relationship between coping strategies and effectiveness. However, 6.7% and 4.4% of the respondents reported that there were medium and low relationship between coping strategies and their effectiveness. Farmers also noticed that there were different factors which hold back the practice of coping strategies. Such as lack of access to meteorological information, lack of capital, lack of credit, shortage of labor, and poor extension service were among the problems mentioned by the farmers.

Most Farmers fell in failure of crop yield because of rainfall variability. The most common rainfall variability that occurred in the study area roughly in the year 1990, 1993, 1997, 2003, and 2010.For example, in 2010, rainfall variability caused at least the loss of 75-80% of the wheat crop yield according to focus group discussion. Similarly an old farmer confirmed me the seriousness of the problem as follow.

> *Oh my son seasons are not as in the past. When we say there was enough rainfall it was not rain and when we say it was not rain there was rain. The farmer tried to explain the adverse impacts of rainfall variability based on his tangible examples. In the year 2006/7 10 quintal of wheat were collected from the farm land which is one hector. On the some land in the year 2007/8 I have collected 24 quintal of wheat .However, in 2009/10 the farm land only produce 3 quintal of wheat. So, do you think this is normal? It was not, a punishment that*

comes from God because of our evil things. Any how it is better to waiting forgiveness from God nothing else.

The majority of the farmers faced food shortage during the year (2010/11). However, food shortage varies from farmer to farmer, year to year and month to month. For example, most farmers faced with food shortage between July and September. Those farmers who have much money and crop might be exposed for two months especially between September and October. In the study area, the rural livelihood of the people is highly dependent on subsistence agriculture. Thus, crop production and livestock rearing are the principal means of rural livelihoods in the area. Most farmers have cultivated crop for home consumption and selling for taxation, schooling, clothing, medicine, and other social life purposes.

However, the amount of harvesting varies from year to year depending on rainfall variability. When the rainfall is distributed well in its time, amount, and duration; the farmers collect on average from 20 to 30 quintals per year per farmers. But when there was rainfall variability and uneven distribution throughout the year, most farmers collected from 5-10 quintals on average and most farmers were exposed to food insecurity. For example, in 2008 there was good rainfall distribution throughout the year, and almost (91.1%) of the farmers harvested 20 to 40 quintals per farm land on average. But in the next years (2009/10), most farmers harvested from 5 to 8 quintals per farmers due to the impacts of prolonged summer rain.

The farmers' responses regarding their taking aid from the government and non-governmental organization vary from farmer to farmer. Accordingly, nearly 76% of the respondents said that they have received AID. However, due to small proportion of wheat and oil farmers were not considered as received AID.24% of the respondents confirmed that received of food aid even though it was not satisfactory. Farmers noticed that both those who had crops and those who had not crops shared the aid equally without understanding the effects of the drought on family.

4.6 Rainfall variability and livestock production

Rainfall variability via season and inter-annual level put more impacts on livestock production and their number. From the total respondents interviewed about their rearing habit of livestock nearly 98% of them said that they rear livestock in one or other why for subsistence purpose. The rest 2.2% were not rearing animals. Those who have enough grazing land rear from 5-10 cattle on average and those who do not have enough grazing land do not rear cattle excluding two or

one oxen/ox for their agricultural purpose. Most farmers confirmed that there were feed and water shortage for their cattle in different years due to rainfall variability for the last fifteen years.

During the summer season when there is rain most farmers have got enough feed and water for their cattle. However, when there is scarcity of rain in contrast to the summer season most farmers are exposed for fodder and water scarcity for their cattle. To overcome these challenges all farmers have used different coping strategies. Sell the cattle during shortage of rain, using silage, cactus stem, creeps from the tree, livestock diversification, and use *atela* as source of food in addition to natural grass, and seasonal migration towards neighboring *kebele* were common.

Despite these extreme preservation and copying strategies, loss of production and animal mortality increase from time to time in *Sedika* and *Sedika burka* during the famine years. Moreover, productivity of livestock also decreases. For example in the *Sedika* and its surrounding the best milk yield from local cows held by sample household during good year (2008) and summer was four letter per day per cow. However, according to recall data, average output decrease in to a litter and below per day per cow during the worst of food crisis, with large number of cows drying up altogether. In absolute measuring rich household were losses more livestock than the poorest during the time of shortfall. However, due to relatively large number of cattle rich farmers resist more than poor farmers during the time of adversity. Poorest household with few animals took some of the most extreme measures to keep animals alive, and were most of the time highly successful in their measures.

Fig 5 Hay for cattle during winter season 2010

Source; Field survey, 2010

Moreover, some coping strategies put some sort of negative impacts on livestock production. When farmers completing cultivating their farm land of the year they can start to sell all or some oxen, this in turn leads to market saturation and low price of the year. Again when the time of land cultivation approaching farmers trying to buy oxen/ox. Which, this leads to the increasing of cattle price and scarcity of ox in the market. These up and down market price prohibit the farmers to have enough assets and bring sustainable development.

The variations of cattle cost vary from year to year and season to season. When the respondents were interviewed about the cost of cattle, most of them replied that there were great differences in the cost of cattle between the years and within the year. On the some way the cost of cattle now and before is not similar in the local market. However, very small proportion of the sample respondents said that there is no much difference in the cost of cattle except decreasing of the purchasing power of money.

The majority of the respondents noticed that an increasing or decreasing of the cost of cattle was mainly related to rainfall variability. When the summer rain starts on time and there is enough natural grass the cost of cattle increase. While, when there is scarcity of rain and shortage of natural grass the cost of cattle decease. However, the cost of dairy products increases at local market. Moreover the local market can play a vital role in increasing or decreasing the cost of cattle. When the cattle come from Bale their cost in a single market decrease and if not it is increasing all the time.

When the respondents were asked about their cattle number and their productivity whether it was increasing or decreasing because of rainfall variability, most farmers reported that there was a relationship between the number of cattle, productivity, and rainfall variability. Accordingly, 62.2% of the respondents said that their cattle number was decreasing because of rainfall variability especially at a time drought. The optimum distribution of rainfall throughout the year indicates leads to large number of cattle number by providing enough natural grass and water for cattle. In contrast to this 37.85 of the respondents noticed that there is not relationship between the numbers of cattle, productivity and rainfall variability rather employing different coping and adaptation strategies were the factor.

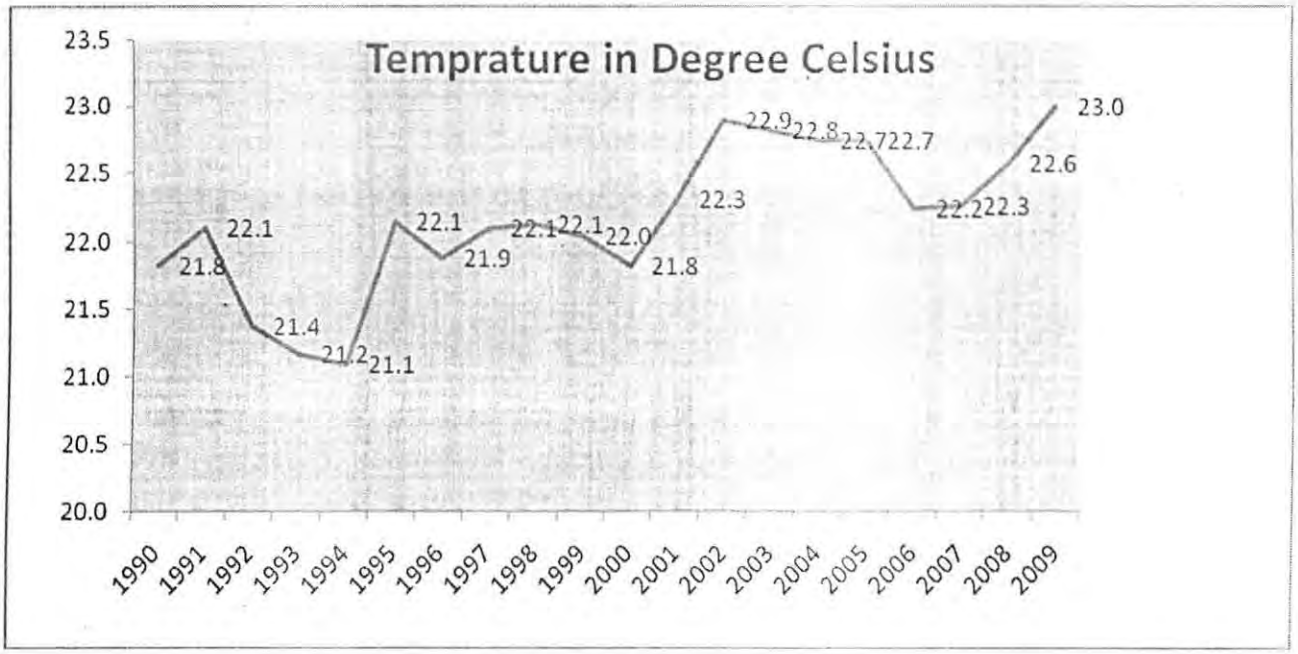
When the respondents were asked about the source of food for their cattle they mentioned different sources. For, almost half of the respondents (61.1%), their source of food for their livestock are entirely natural grass. Others use silage (27.8%), artificial grass (8.9%), and industrial output (2.2%). However, all sources are directly or indirectly affected by rainfall variability.

When there is no rain there is no enough natural grass, artificial grass and silage even though the impact was not much in industrial outputs. The effectiveness of the coping strategies depends on farmers' awareness and level of economic development. This means, which are rich and educated farmers, can use diverse coping strategies than the poor and illiterate. In general different farmers applied adaptation and coping strategies to overcome the impacts of rainfall variability. Most common adaptation strategies are selling the cattle during winter season, rain water harvesting, and seasonal migration with cattle, sending the cattle to the relatives, collecting silage and fodder and buying by product of oil seeds.

4.7 Temperature change and variability in Robe *Woreda*

Temperature distribution becomes erratic from season to season in the survey area. As nearly (95.6%) of the respondents renowned, there is long term temperature increase in the study area. The remaining small percentage (4.4%) of the respondents explained the absence of long-term temperature change or they had no idea about it. Metrological data also confirm that deviation of temperature from the long term average. Different crops need an optimum, upper and lower limit temperature to grow and produce more yields. However, when the temperature deviated from the normal and decreases the soil moisture crops start to wilt and finally become dry. To overcome the impacts of temperature in the study area, farmers were using different coping strategies. Planting trees to conserving soil and water, increase soil moisture, decreasing evaporation and evapo-transpirations, sowing drought resistant crops at local level was done by farmers to overcome water shortage for germination and growth of crops.

Fig 6 Year to year, variability of annual maximum temperature distribution in Robe *Woreda* 1990-2009 expressed in temperature difference

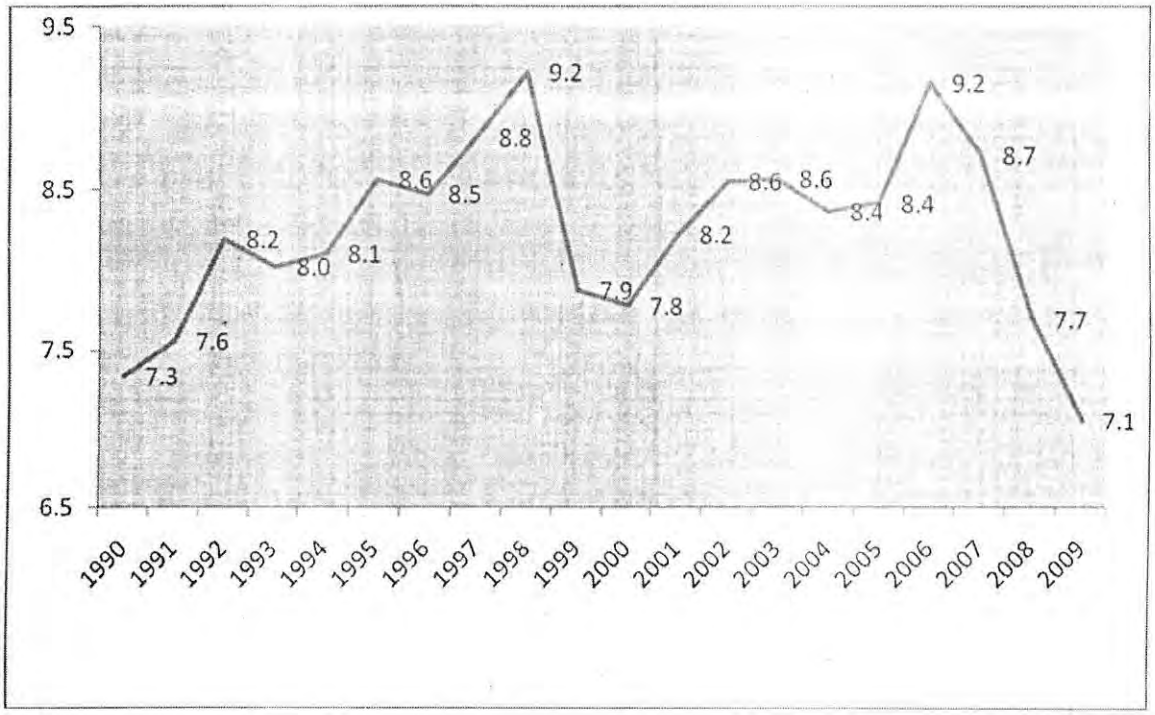


Source; Adapted by the writer from WMSA 2010

According to the survey, the respondents have different perceptions about the current temperature change. However, the largest proportion of the respondents (88.9%) believed an

increase of average and daily temperature as well as daily pattern which is very high in the winter season than summer. Small proportion of the respondents (6.7% and 4.4%) noticed that there is no much temperature increase or decrease and have no idea about it whether it increase or decrease respectively. Farmers' perception about temperature increases or decreases varies according to their educational level and exposure to mass media. The existence of long-term temperature change in the study area is also indicated by *Woreda* station report on 2010.

Fig; 7 Year to year variability and trend of annual minimum temperature in Robe *Woreda* 1990-2009



Source; Adapted by the writer from WMSA 2010

4.8 Survey on farmers access to farm land

Access to land for farmers varies from farmer to farmer at the local level depending on the farmer age and their background. Hence, this is very vital in order to know the degree of rainfall variability and its impact on crop and livestock production. From the total respondents about half of them certified as they farm their own land. They are followed by 42.2% in which the source of their land is share cropping land from others and mortgaging land. The rest of the respondents fall under purchase of land for crop production

Those farmers, who have owned their land, relatively lower risk to impacts of rainfall variability since they use more adaptation and coping strategies. Those farmers who have not their own land and shared from others exposed to rainfall variability impacts and use coping strategies than adaptation. Less interest to use adaptation strategies is the result of lack of time and their own land to practice adaptation strategies for a long time.

4.9 Farmers perception meaning of rainfall variability and drought

Different farmers have different perception about inter annual and seasonal rainfall variability and its impacts. Accordingly, nearly 96% of the respondents recognized that there was much inter-annual rainfall variability. The other 2.2% have understood the absence of rainfall variability while the remaining 2.2% had no idea about it. The seasonal rainfall variability does not significantly deviate from the long term mean, rather inter-annual rainfall variability is highly deviating from the mean and affects the rural livelihoods. The more the amounts of rainfall deviation from the long term mean the higher food insecurity.

Nearly 66.7% of the respondents reported that an increasing of late onset and 28.9% decreasing onset of rainfall. The delay of onset of this *mehir* rain spoil the germination of dry planted crops likes barely, maize, and oil seeds. According the information disclosed from focus group discussion, for example, in 2006/7 harvest season there was a loss of 20-30 % of the production due to late onset of rain. The rest 4.4% of the respondents had no idea about rainfall variability in the study area. Similarly, about 76% of the respondents have an idea of decreasing of early cessation of summer rainfall.

The rest of the respondents (24.4%) recognized an increasing of early cessation of summer rainfall. Early cessation of rainfall accompanying scarcity of water resulted the reducing of the productivity of most cereals, lack of maturation of natural grass and lack of fodder for cattle.

As research revealed farmers have an idea about the onset, early or late cessation of summer rainfall. Most of the respondents (60%) of them have an idea about decreasing of the early onset of summer rain fall and 37.8% of them understood an increasing of the time of early onset of summer rainfall. Very small proportion of the respondents (2.2%) reported the absence of changes on the early onset of summer rain.

Early onset and offset as well as early cessation decrease the productivity of crops and livestock by exposing them to disease and pests. When interviewed about rainfall variability in relation to the impacts of seasonal variation in rainfall 84.4% of the respondents reported that the impact is more common in the *Mehir* season of the year. Here, the impact of rainfall variability does not exist only in *Mehir* season but also in *belg* season though it is not common as of *kiremt* rain. From the total sample respondents, 15.6% of them said that the rainfall variability is more common in *belg* than *mehir* season. Since almost all of the entire farmers in the Robe *Woreda* are *Mehir* harvesters the impact is more series in summer season both in crop and livestock production than in *Belg*.

4.9.1 Farmers' perception the meaning of drought

Understanding framers perception about the meaning of drought varies according to their educational status and access to mass media. Although drought is a normal feature of climate and almost occurring in all parts of the planet earth, its appearance varies from region to region. It is too difficult to put one central definition for drought since it depends on regions, and disciplinary perspectives. In general sense, drought originates from the scarcity of rain for a long period of time, which also results in shortage of water

Similarly, from the total respondents who were interviewed about their understanding about drought, most of the sample respondents have clear understanding that drought means there is no rain. While 22.2% and 11.1% have understood the meaning of drought as shortage of rain during the time of germination and late onset and early offset respectively. So, generally speaking, all farmers have understanding about drought even though they have perceived it differently.

Drought in Arsi, Robe *Woreda* has direct impacts on crop and livestock production. That is, strong relationship between increasing or/and decreasing productivity and rainfall intensity, distribution, and duration since almost all of the entire population is dependent on rain fed agriculture. For example, in the year 1972 more than 75% of livestock productions were lost due to the prolonged dry spell season in Arsi Robe.

4.9.2 Drought frequency

The frequency of drought in Ethiopia is increasing from time to time since 1500 AD up to and it may continue in the swift manner unless immediate action should be taken. From the sample

respondents who were interviewed about drought frequency 98% of them said that there was a change in drought frequency. However, small proportions of the respondents reported that there was no change of drought frequency. Similarly, when they interviewed about increasing or decreasing of drought, frequency about 91.1% of the respondent respond that there was an increasing of drought frequency in the study area. The two most well known droughts in the study area were the year 1979 and 1984. The three most recent drought in the study area occurred in 2002/3, 2006/7, 2009/10 harvest season.

However, the remaining 8.9% of the respondents said that there was a decreasing of drought in the study area. From the respondents survey one can easily understand that the frequency of drought increase from year to year. The area has suffered from frequent famines in the past and continues to face drought and shortage of food on continues basis. Appeal for food aid is a common occurrence. Thus, although the provision of food aid and emergency medical care has saved many lives, the root causes of vulnerability have not been addressed and the problem has continued to persist. Chronic food vulnerability is associated with environmental challenges like rapid population growth, climate change, rainfall variability and temperature change which are difficult to reverse easily.

4.9.3 Water source for their farm land

Most farmers used rain water as main source of water for crop and livestock production. Nearly 92% of the respondents are entirely dependent on rain water. Other 8% of the respondents used water from other sources in the form of irrigation from underground and artificial ponds. One can easily understands that from this almost all the farmers dependent on rainfall water for their agricultural activities even though very limited farmers used irrigation water from other sources. To bring changes and sustainable development for the increasing population working with farmers at grass root at rain water harvesting is vital.

Crop requires and transfer massive amounts of water for their entire development systems and activity. This makes water the major limiting factor for agricultural production in tropical area. Depending on the crop, the location and efficiency level, producing one tone of cereal requires between 2500 and 4000 tons of water (Webb, 1994). Since one tones of cereal covers the annual consumption of about eight persons on an average.

Different farmers have different perceptions regarding the amount of rainfall for their farm activities. Accordingly, from the sample respondents who were interviewed for about existence of enough rainfall for their farming purpose, nearly 91.1 of the respondents said that there is no enough rainfall at right time for their farming purposes. The rest 8.9% noticed that there is enough rainfall for their farming purpose even though it varies from year to year. Data from National Meteorological Service Agency indicate that there is rainfall variability or uneven distribution and unusual rainfall (NMAS, 2009).

4.9.4 Survey about farmers soil type

Knowing and understanding about soil type and its fertility is very important to see the total impacts on crop and livestock production. Accordingly, from the total respondents who were interviewed about soil type, nearly 98 % of the respondents replied that their soil color is black (*Merere)* while, the remaining of the participants noticed that there is brown (*Daro*) soil color in their farm land.

When asked about an advantage and disadvantage of soil color and characters in crop production they noticed that, during the rainy season and prolonged rain duration and long summer time, brown soils have more advantages than black soil in increasing water infiltration capacity and easy cultivation. However, with shortage of rainfall, black soil have great advantageous than brown soil since it saves soil moisture. This is because brown soil has great filtration capacity than black soil. In contrary black soil has great water holding capacity than brown soil and it's not more productive in rainy seasons of the year. During drought season, shortage of rain, black soil becomes cracking and difficult to cultivate and produce more production.

In addition to soil type and rainfall variability, knowing and understanding the degree of fertility of soil contributes a lot, in adopting coping strategies and adaptation mechanisms. With regard to this, accordingly, from the respondent's interview 71.1% of them said that their soil fertility status was relatively moderate. Also from the sample respondents about 24% noticed that the soil status of their farm land was poor, while, the rest 4.4% of them respondents said that their soil status is fertile. From the total sample of respondents who were interviewed about their relief type of their farm land, nearly, 73.3% of them thought that their farm land were plain and only 22% of them noticed that their farm land were moderate. However, small proportions of the

respondents said them their land is sloppy. From the three types of relief, sloppy farm lands are highly exposed for rainfall variability impacts than plain and moderate relief types due to exposure for high soil erosion and runoff at a time prolonged rainy season.

4.9.5 Water source for agricultural purpose

Both rain and irrigation water has the potential and actual sources to produce more food per unit area of farm land. Though rain fed agriculture is practiced by many poor farmers in Robe *Woreda*, farmers are highly affected by erratic and inadequate nature of rain. To overcome food insecurity, increasing yields from rain fed and irrigation types of agriculture is must. For the application of irrigational agriculture, the use of permanent water source is mandatory and not optional. So, looking the existence of permanent water source in the study area is very vital to decide whether the farmers are using irrigation for agriculture or not.

Thus, from the respondents' point of view, about the majority 87% have no permanent water source for their agricultural purpose. The remaining 13% of the respondents noticed that they have temporary water source for their agricultural function. Here, since there is no permanent water source and rivers for their agricultural activity, farmers should develop the habit of water harvesting and developing artificial lakes.

From the total respondents, about 97% of them said that they could not use permanent water source for irrigation purpose. However, very limited respondents have used harvested rain water as source of irrigation. From their use, here it can understand that majority of the respondents have no permanent water source for their irrigation purpose. Moreover, because of the absence of perennial rivers in the study area, the farmers lack experience in harvesting rain water. Increasing farmers' awareness about water harvesting system and developing private or community level pond should be taken as the source of solution to reduce rainfall variability impacts.

4.9.6 Inputs to reduce the impacts of rainfall variability

Recently the application of different types of coping and adaption strategies to reduce the impact of rainfall variability has become common activity in Ethiopia. Like many coping strategies, farmers also using agricultural inputs to reduce the impacts of rainfall variability.

From the total sample respondents, 57.8% of them said that they used agricultural inputs as coping strategies. Most farmers have the habit of using UREA fertilizers, pesticides, and insecticide during bad harvesting season, maximum and high intensity of rainfall, while, the remaining 42.2% of the respondents reported that they were not in a position to use agricultural inputs for reducing the impact of rainfall variability.

Due to high cost of these agricultural inputs most farmers were not ready for applying of these inputs. The cost of insecticide, pesticide and fertilizer is very expensive when compared to the past 20 years. Moreover, the entire respondents have used fertilizers for cereals like wheat and ***teff*** than other types of crops. However, it is not counterfeit that some farmers have used fertilizers for vegetables, bean, pea, and oil seeds in some extent. Farmers' application of compost and cultivation system to reduce the scarcity of rainfall and its variability is the long term experience in the study area practiced by many farmers.

The application of fertilizer for crop production especially for cereals is very common in all areas of our country. However, the applications of fertilizers vary from region to region and person to person in accordance with their economy and educational status as well as their awareness about the importance of fertilizer. According to the sample of respondents interviewed in the study area, the starting time of application of fertilizers vary based on age and their awareness. The respondents application of fertilizers varies from five to twenty years.33.3% of the respondents replied that they have been used fertilizers for fifteen years, while, 26.7% of the respondents have used fertilizers for ten years. The remaining 24.4% and 15.6% were using fertilizers for twenty and five years respectively.

4.9.7 Adaptive capacity of crops

Passionate about common crops and their character in the study area contributes much to its productivity. Rainfall variability and its impact on crop production vary from crop to crop. The respondents' survey indicates that two most common cereal crops such as *teff* and wheat are highly cultivated in the area for home consumption. However, oil seeds, maize, pea, are other crops cultivated in small amount for sell. The share of these two crops varies from year to year based on the duration and intensity of rainfall in the area. For example, the share of these two crops in the year 2009/10 was 95.6% and 4.4% for *teff* and wheat respectively. However, almost the inverse was true for these figures in the year 2008/9.

4.9.8 Coping strategies for water shortage

Coping and adaptation strategies which are practiced in the area can be classified in to three. These are: diversification (petty trading, daily working, selling cattle, take food and money from relative), intensification (using technological inputs, fertilizers, and improved seeds), and seasonal and permanent migration (remittance). Recently almost the entire rural population of Ethiopia relies on rain fed agriculture (i.e. for crop and livestock production).So, to increase crop and livestock productivity as well as to ensure food security, rain water harvesting is must and it is not an option in alleviating food crises in the country.

Promising alternatives to attain food security and food self sufficiency in the country is the aim of the government. Maximizing the use of available rain water via harvesting techniques including artificial ponds, flood water diversion, on farm runoff retention, soil moisture conservation, and improving in the storage structure are the ways to increase crop productivity. For livestock production, seasonal migration, reduce number of cattle, diversification, focus on quality harvesting silage, hay, and using *atela* and *fagulo* during scarcity of natural grass are some of coping strategies.

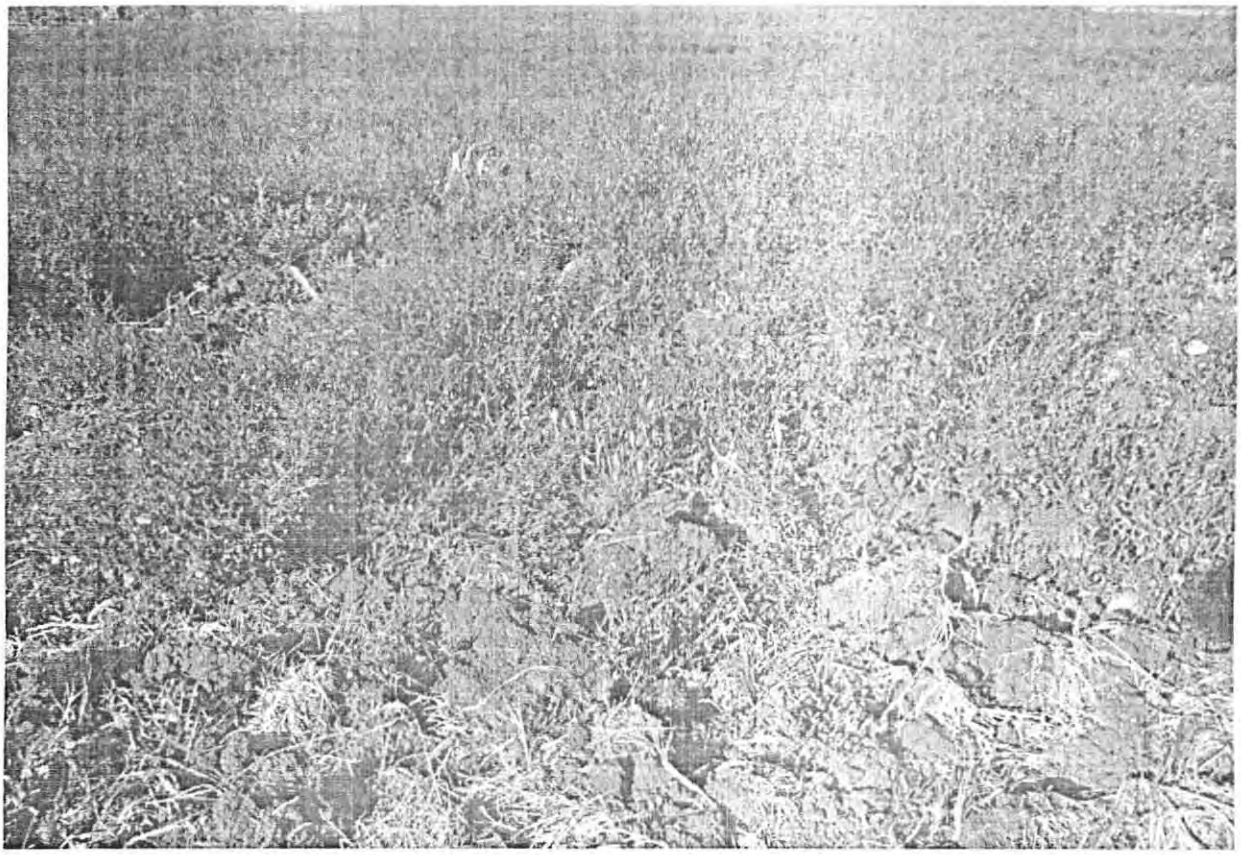
All these strategies and options focuses on harvesting and using as much rain water as possible and making maximum use of it in order to increase production and productivity.RWH storage system offers the farmers a possibility of coping water stress thereby reducing risks of crop failures. Small storage systems especially planned, designed and constructed for livestock water supply are needed at many places. It has been widely noticed that a large part of the required increase in food production for the future fast growing population will come from irrigated agriculture.

This common argument that the higher output is predictable from encouraging areas for more productivity which include irrigation agriculture, and that this output can be achieved at reasonably lower food prices which are of course in the attention of both urban and rural consumers. Rain water harvesting for crop and livestock production is considered as principal coping strategies in most rural livelihood. Knowing and tolerating the impact of rainfall variability is not enough solution for increasing crop production and food security in rural Ethiopia. Rather it is very important to use different copying strategies to reduce the impact of

rainfall variability during shortfall of rain. Here, in the study area, farmers are using different adapting and coping strategies.

Accordingly, nearly 69% of the sample respondents have used livelihood intensification mechanisms, and cultivating drought resistant crops to overcome the challenges. Some of the respondents (26.5%) were using cultivating short maturing crops and 4.4% of them were using late sowing and early sowing respectively. Rain water harvesting for crop and livestock production, seasonal migration, selling the cattle during bad year, giving some cattle to relatives, hay and ground water collecting are among other strategies. But this does not mean that these are the only coping and adaptive strategies, but the major one.

Fig. 8 Drought resistance crops in the study area



Source: Field Survey, 2010

Chapter Five: Summary, Conclusion and Recommendations

5.1 Summary

This paper attempts to spot the impacts of rainfall variability on rural livelihoods, crop and livestock production as well as recommends the coping strategies based on community based indigenous knowledge approach in Robe *Woreda,* Arsi. The present inter- annual and seasonal rainfall variability and adverse impacts produce more pressure in rural livelihood of Arsi by posing problems of water scarcity, low productivity, and food insecurity. This incidence has become more familiar in different corner of the *Woreda* and its intensity is increasing from time to time.

The adverse impact is more serious in the study area particularly in climate sensitive sectors. In the *woreda* subsistence agriculture is practiced nearly by total population. However, most farmers leading hand to mouth life. Here in the study area, absence of rain for one year means any food in the next year. Studying about rainfall variability impacts on crop and livestock production has direct relationship sustainable development and improving the lives of rural people. Currently different adaptation and coping strategies are traditionally employed to reduce the impacts.

However, these coping strategies were not more successful and even have some negative impact on the long run. For example, most farmers have used selling cattle as coping strategies during the time of adversity, and they misuse the money without plan and accumulating asset become difficult which means there is no saving and has negative impact on sustainable development. This condition also leads to market saturation during selling time and scarcity during buying cattle for agricultural activity. So, creating awareness to farmers how to save their money when they sell their cattle is vital.

Understanding the complexities of rainfall distribution, intensity, and variability is the major elements in employing different adaptation and coping strategies. Improving crop production via agricultural policy planning and decision making is the main solution to solve problem of low productivity. It is not much difficult to understand the role of rainfall in subsistence crop and livestock production. It is one of the single most significant factors affecting the sustainability of rural livelihood.

The objectives of this research was to see the impacts of rainfall variability on rural livelihood, crop and livestock productions, farmer's perception on rainfall variability, and coping and adaptation strategies employed by local farmers. To achieve the designed objectives, the researcher employed both qualitative and quantitative methods (quartile methods).Data was gathered via focus group discussion, key informants interview, questionnaire, and field observation. In addition to these, secondary data was collected from mass media, magazines, thesis, and data from NMSA.

The study showed that there was rainfall variability in the study area during summer and *belg* seasons. However, the variability and impacts were more serious during the *mehir* season and inter-annual than *belg* and seasonal variability respectively. Since almost the entire population in the study area dependents on *mehir* harvest, the impact of rainfall variability becomes more serious at this time.

Here, the generated data clearly supports the application of many adaptation and coping strategies employed, confirmed by local farmers without the support of scientific innovation which affects the sustainability of rural livelihood development. The policy makers should consider an indigenous knowledge to bring change at all. Positive relationship between policy makers, developers, and practitioners at grass root level leads to secured food sustainability by reducing the impacts.

To improving the rural poor in every aspect i.e. socially, economically, politically and reducing the impacts of rainfall variability and increasing food security are not a one party's responsibilities. So, working with the society at threshold level is highly expected from the concerned bodies. Community based training programs should be developed by the regional and local government. The entire community should practice the indigenous knowledge at all levels. Thus, rich and poor, educated and illiterate farmers to increase both economical and political self efficiency at the local area may give change at regional and national level as a whole.

In the study area, educational status, economic condition, and family size play significant role in the perception of rainfall variability, adverse impact, and developing adaptation and coping strategies. The more educated and the more economically strong farmers have relatively the capacity to overcome shortfall than those farmers who were not educated and low economic

status. The main thing here is that perception of people has about rainfall variability and its impacts which highly vary from farmer to farmer.

Generally, the entire farmers employed three types of copying strategies: intensification, diversification of livelihood, and migration (temporary and permanent migration). In the study area, farmers tried to intensify their livelihood via, using technological inputs (fertilizers, insecticide, pesticide, improved seeds), diversification of livelihood (local petty trading, daily working, wood selling, cropping vegetables and etc), seasonal migration for a short period of time (migrate from rural to urban, nearby area for working purpose, relatives), and migration (sending children to Middle East countries, Addis Ababa, and Adama).

5.2 Conclusion

In different areas of Arsi Robe *Woreda,* there is pronounced seasonal and inter-annual rainfall variability. The patterns of rainfall distribution are influenced by seasonal migration of the sun, south and north of the equator, and wind pressure patterns. The annual rainfall, the long-term mean and the general rainfall trend in Robe *Woreda* in the period from 1990 to 2007 are plotted in Figure 1. The annual rainfall in Sedika and surrounding area varies considerably from year to year, and season to season. A very common characteristic in the area from 1990 to 2001, the mean annual rainfall was 1016.3 mm. The lowest annual rainfall of 839.2 mm was recorded in 2000 while the highest annual rainfall in the past 18 years was 1310.5 mm, received in 1993.

This seasonal and inter-annual rainfall variability creates great impacts on rural livelihood, particularly on crop and livestock production. For the local farmers, determining early offset and onset or late offset and onset of summer and *belg* rain determine their productivity. Knowing this helps the farmers to give emphasis on different coping and adaptation strategies, preparation of different crop groups, inputs, land preparation, tillage practice and others in accordance with the level and intensity of rainfall variability.

Traditional farmers in Arsi Zone Robe *Woreda* are aware of the impacts of rainfall variability on crop and livestock production. However, with this dynamic world, they could not go with rainfall variability .The relationship between onset and offset dates, duration, intensity, agro climatic indices, water stress and overall stress as well as crop yields has been satisfactory.

Late onset of rain reduces yield regardless of fertilization, and soil fertility levels. Although some farmers in the region are well aware of the implications of late onset and do respond to it with some measures to insure survival level production, they may be less aware of the good implications of an early onset of rains and how they might benefit from increased input levels and other measures in these years. The information generated from the present study shows that farmers might, for example, better profit from increased inputs levels in early onset years and that could mean improving subsistence level production to economic level production.

As a result of rainfall variability in the study site, Robe *Woreda,* Sedika and its surroundings, high population of household had been highly food insecure in the last 20 years and had, therefore, become relief looker and receipts in 2003 harvest season. Moreover, in 2009/10 harvest season food insecurity and needing aid was occurred.

Households tried copying with this impact by using different strategies like selling cattle, wood, renting some of their land, intercropping, diversification, migrating for work, buying and borrow cereal crops from other areas or from traders. Since 1990s, the area had even sustained crop failure due to rainfall variability or untimely rain, flooding, and pests. The average number of livestock and productivity per farmers has also decreased from time to time due to lack of grazing land and fodder in the study area.

Since the agricultural production that generates income for household is inadequate, many farmers are participating other supplementary non farming activities; like selling wood, water, poultry, grass, hay, seasonal migration and daily work to overcome their persistent food and cash deficit for taxation and schooling. Non-farming activities have a share of 30-35% of their income especially during bad years.

5.3 Recommendations

Rural development activities in poverty reduction and increasing productivity like, rain water harvesting, supply improved seeds, agricultural inputs are conducted by the government in Arsi Zone, Robe Woreda in general and in the research area in particular. However, these conditions were not much satisfactory and farmers are building different traditional coping and adaptation strategies to overcome the adversity even though it was not more successful. Hence; the alternative should be improving the situations by providing credit and micro enterprises which enables the farmers to have assets like; oxen, agricultural inputs, and improved seeds during shortfall time. For example, when the credit is not sufficient farmers are forced to sale their ox to pay the loans and become short of food and cash due to productivity failure and absence of credit. This is done by government and non-government organization as well as local organizations such as *Iqueb and Ider*.

Intensification and livelihood diversification should be given more attention to reduce the impacts of rainfall variability and increase productivity, via agricultural inputs, livelihood diversification, intercropping, livestock diversification, aforstation program, and remittance. Farmers and local government bodies are responsible for this purpose. Even though remittance is considered as adaptation and coping strategy it has negative impacts in the long run. This is because, children may drop out of school and in the future skilled man power and unemployment will become the serious issue.

Collecting hay, silage, and developing artificial ponds to harvest the summer rain helps to increase both the quality and quantity of crop and livestock in the study area than selling the cattle during the time of adversity. Farmers' perception towards the cause of rainfall variability should improve through education and awareness creation by the government and local religious leaders. Here, much is expected from Agricultural Development Agent workers and priests in the study area. When farmers got awareness about the causes of rainfall variability, they have the capacity to develop and appreciate coping and adaptation strategies to overcome the hardship.

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Appendix

Dear Respondents

The aim of this questionnaire is to find out the impact of Rainfall Variability on Rural Livelihood in Arsi Zone Robe Woreda, Sedika and surrounding *kebeles* and to suggest possible recommendation .Please, your information will be kept certainly confidential and hence expect you to complete the information honestly.

I. Demographic Characteristic of Study Area

1. Date of questionnaire Collected_____2. *Kebele* Name_____

3. ***Goti*** name_____4. Name of household_____

5. Sex 1.Male 2 .Female 6. Age_____

7. Marital status 1.Single 2.Married 3.Divorce 4.Windoed 5.Never Married

8. Educational status 1. Illiterate 2. Read and write 3. Primary education 4.Secondary education 5.Specialization

9. Number of Permanent Households 1 Male_____ 2 Females_____

II Questions Related to Rainfall Variability on Crop Production

1. When the summer rain starts?

2. When the summer rain ends?

3. Is there seasonal and inter annual variation of rainfall? 1. Yes 2.No

4. Is there rainfall shortage?

5. What are the most common crops in your *kebele*? Why?

6. Have you recognized any long term changes in mean temperature over the last fifteen years?

7. What happen to the current average temperature of your *kebele*?

1. Increase 2.Decrease 3.No change, 4. I do not know,

8. Have you seen any long term changes in the mean rainfall over the last two decade? 1. Yes 2. No

9. If you say yes, for question no "8" how do you characterized? 1. Increase, 2.Decrease, 3. No change

10. Do you farm during the last farming season? 1. Yes 2.No

11. Your access to land for farming practice is 1. Farmed own land 2. Share cropped and Rented land

3. Free access to some ones land 4. Share crop out of land 5. Purchased land

12. What is the major water source for your faming system? A. Irrigation B. Rain

13. Would you tell me about your farm land soil type?

Type	Fertility status	Relatively relief
1. Black	4 Poor	7. Plain
2. Red	5.Moderate	8. Moderate
3. Brown	6. Fertile	9.Sloping

14. Do you get enough rain throughout the year for farming purpose? 1. Yes 2.No

15. If your answers for question number "14" is no, what are the mechanisms that you applied to overcome the problem? 1. Water harvest 2. Using rivers 3.Cultivate drought resistance crop 4.Others specify_____

16. Do you have permanent water source? 1. Yes 2. No

17. Do you use permanent water source to irrigate your crop land? 1. Yes 2. No 3.If not why? Specify_____

18. Do you use agricultural inputs to reduce impact of rainfall variability? 1. Yes 2.No

19. For what type of crop you use fertilizers? 1. Cereals 2. Coffee 3.Vegtables

4. Chat 5.Pulses 6.Other; specify_____

20. For how many years you use fertilizers? 1. Five 2.Ten 3.fifften 4.Twent 5.more

21. Have you noticed change in the frequency of drought over the last fifteen year? 1. Yes 2.No

22. If you say yes for no, "21" how do you characterized? 1. Increase 2. Decrease 3. No change

23. How do you see drought? 1. Late onset and early offset, 2. No rainfall, 3.Shortage of rainfall,

4. Other specify_____

24. Have you recognized any long term changes in rainfall variability such as late onset, early cessation, heavy rain, extended dry period, over the last fifteen years? 1. Yes 2.No

25. How do you recognize the change in the last 15 years?

Change	Increase	Decrease	No change
Late onset			
Early cessation			
Early onset			
Late cessation			
Extended dry spell in wet season			

26. Have you ever faced any rainfall variability impact in your lifetime? 1. Yes 2.No.

27. If you say yes for Qs number "26"Please identify the year that you faced rainfall variability and mention the impact on you crop and livestock production?

28. Which climatic variability has become a challenge on your livelihood? Put them in order based on degree of severity of its impacts from the highest to the lowest?

Climatic variability	rank
Drought	
Late onset	
Early cessation	
Early onset	
Late cessation	
Extended during wet season	
Heavy rain	
Unusual rain during harvesting season	
Frost, flood, others	

29. In which season rainfall is more unreliable? 1. Main rainy season (*mehir*) 2. Small rainy season (*belg*)

30. How do you think the cause of rainfall variability?

1. Punishments from supernatural force 2. Resource degradation

3. Depletion of forest 4. Poor land management 5. Others specify_____

31. Did you notice the severe drought years in your *kebele*? Please, mention the year_____

32. Have you faced problems in land preparation due to lack of rain or much rain? Please mention the years and explain the conditions?

33. Would you estimate your crop and livestock production annual earnings during no rainfall variability in the year?

Income source	**Estimate value**
Crop production	
Livestock production	
Non-farm activities	
Total	

34. Would you tell me an average annual crop production of every five years?

Type of crops	**Yield in quintal**	**1995**	**2000**	**2005**	**2010**
Teff					
Wheat					
Beans					

35. How did you rate the relation between rainfall variability and crop production? 1. Low 2.Medium 3.High

36. How did you compare the past and recent years of crop production? 1. Increase 2.Decrease.

37. If your answer is decrease for Qs, No, "36"what is the major cause of that?

1. Climate change 2.Soil erosion 3.Land degradation 4.Overgrazing

III. Questions Related to Rainfall Variability Impacts on Livestock Production

1. Do you rear livestock? 1. Yes 2. No

2. How many of cattle do you have? 1. Cow___ 2. Ox___3. Goat____ 4.sheep___others specify_____

3. Have you ever faced with shortage of livestock fodder over the last 15 years? 1. Yes 2. No

4. If, you say yes for Qs No, 3 how you cope up such problems? _____

5. What is the problem associated to livestock? 1. Food shortage 2.shortage of water 3. Disease 4.Other specify

6. is the cost of Oxen, Cows, Sheep, and Goats is similar with amount 10-20 years ago?

1. Yes 2.No. If answer for number 4 is No what is the reason? _____

7. Could do estimate the average amount of crop and livestock production loss during rainfall variability experienced per years? 1. Yes 2. No

8. The increasing and decreasing no of livestock production is related to rainfall variability in the past 10-15 years? 1. Yes 2.No

9. What type of local coping mechanism used for reduce the impacts rainfall variability on livestock production? _____

10. Is the price of livestock is similar throughout the year at the local market? 1. Yes 2.No. if not why? Specify_____

11. From which source you may get food for your cattle throughout the year? 1. Natural grass 2.Artifical grass 3.Idustrial byproducts (Fagulo, Furishika) 4.*Geleba 5* silage

IV. Questions Related to coping and Adaptive Mechanisms

1. Tell me other sources of your livelihoods and why you choose it,

A. _____B._____C._____D. _____

2. Do you use synthetic chemicals on your farm land to overcome rainfall variability? 1. Yes 2.No

3. What crop pest and disease management practices or do you practice to control them?

1._____ 2._____3._____ 4._____

Could you tell me about your livestock?

Type of livestock	number of livestock
Cow	
Ox	
Goat	
Sheep	
Donkey	

4. If the number of livestock you owned increase or decrease in the last fifteen years what is the reason? Please explain_____

5. Do you access meteorological information? 1. Yes 2. No If you say yes, the contact is via

1. Mass media 2.Woreda and agricultural officer 3.Traditional leaders 4 from knowledgeable persons

6. What traditional mechanisms and you use understand the condition of climatic variability?

Wind directions, the nature of cloud, observing the sky, others, specify.

7. Do you have access to credit from financial institutions to cope up difficult situation resulting from rainfall variability? Yes no

8. Did you get assistance from the *woreda* agricultural and rural development office, NGO, and GO to adopt climate change?

9. If you say yes for Q24 what kind of assistance put them in increasing order?

Assistance	yes/no	rank
Methodological information		
Improved seed		
Water harvesting techniques		
Credit facility		

10. Do you use adaptive strategies to reduce climate variability impacts? 1 yes 2.no

11. If you say yes rank the major adaptive mechanisms

1. Sowing a varied crop 2.use drought resistance crop 3.late sowing, 4.early sowing 5 fertilizer applications 6. Land management practice, 7.rain water harvesting 8.small irrigation 9.shift cropping season, 10.planting drought secured plants, 11.job diversification and seasonal migration

12. What are you doing if faced crop failure at early stage of growth?

1. Re-sowing, 2.adding fertilizer 3.others specify

13. Do you use irrigation? 1. Yes 2. No

14. If the answer Q34 is not what is your reason? 1 No river for irrigation 2 lack of capital 3 lack of technology, 4 lack of information 5 lack of interest

15. Do you recognize what happened the years that rain had gone during the critical growth stage of crop? 1 .Yes 2 .no

16. What measures taken for the above challenges? No measure is taken and crops are damaged, applying waters from other sources, re sowing when rain comes again, re-sowing other drought resistance crop again, and re-sowing fast maturing crops

17. How do you rate the strategies effectiveness to reduce rainfall variability? 1High 2 medium 3 low

18. If it is low what do you think the problem? _____

19. What are the major challenges that hinder your agronomic adaptive and coping strategies?

Poor access to, meteorological information, credit, lack of capital, lack of ox, shortage of labor, poor access to extension service, irrigation, shortage of improved seed.

20. If you are not self-sufficient for how many years do you want need food from others up to the next harvesting time?

21. Have you faced crop yield loss due to rainfall variability? Yes no

22. At what year you faced to crop failure and what is the cause?

23. Have you faced with food shortage due to production shortfall caused by rainfall variability? Yes, no

24. Do you employ coping strategies both normal and bad years?

Coping mechanisms

Coping Strategies	1. Yes	2. no
Sell of livestock		
Reducing food consumption		
Borrowing grain		
Consuming low quality food		
Borrowing money from relatives		
Borrowing money from institution		
Daily labor		
Petty trading		
Wood and water sell		
Seasonal migration		
Depend on relief aid		
Using saved grain		
Sell of land		
Mortgaging of land		
Share cropping		
If, others specify		

Food shortage related questions

1. Did your family face serious food shortage in the past? 1Yes 2.No

2. Which months of the Year?

What do you think the cause of Food shortage and what measures did your household take?

3. On what livelihood activity did you or your family mainly depends for living in the past 10-20 years

4. How suggested or what pushes you to practice such action?

5. What are the major sources of your livelihood?

6. Rank them in importance order

7. What is your last year harvest? 1. Good 2.Bad 3.Medium

8. For what purposes you used them during the year?

9. Have you received relief aid to meet your family food shortage? 1. Yes 2. No

Focused Group Discussion for Community Leaders, Development workers and Elders

1. During water shortage how the local community cops with?

2. What do you know about rainfall variability and temperature?

3. Dose rainfall variability affect your community livelihood and how?

4. What type of challenges of your community faced?

5. Who is affected more by rainfall variability poor or rich family?

6. What is the main source of income in your society?

7. How your communities perceive rainfall variability?

8. What kind of support your community get from the government?

9. What kind of livelihood is practice to protect the impact of rainfall variability?

10. How did you cop up the food shortage over the past 15 years?

Interview Guide question for *Woreda* Agricultural Office and kebele DA workers

1. What seems crop and livestock distribution in the *Woreda* and *kebele*?

2. Is there Rainfall variability in your *Woreda*?

3. What is the Impact of rainfall variability of rural livelihood?

4. Which part of the *kebele* in your *Woreda* is highly vulnerable to rainfall variability?

5. What measures taken to reduce the impact of rainfall variability at local level?

6. How did you see the condition of offset and onset of rainfall at your *kebele?*

Declaration

I, the undersigned, declare that this thesis is my original work and has not been presented for a degree in any other university, and that all sources used for the thesis have been duly acknowledged.

Name Fikre Alemayehu

Signature

Date 25/05/2011

This thesis has been submitted to examination with my approval as university advisor

Name Abdulhamid Bedri (PhD)

Signature

Date 25/05/2011