



**ASSESSING LIVELIHOOD DIVERSIFICATION STRATEGIES IN
RESPONSE TO CLIMATE CHANGE IN WEST BADEWACHO
DISTRICT OF HADIYA ZONE, SOUTHERN ETHIOPIA**

MSc. THESIS

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**HAWASSA UNIVERSITY
COLLEGE OF AGRICULTURE**

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**A THESIS SUBMITTED TO HAWASSA UNIVERSITY, PROGRAM
OF CLIMATE CHANGE AND SUSTAINABLE AGRICULTURE,
COLLEGE OF AGRICULTURE, SCHOOL OF GRADUATE STUDIES,
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SCHOOL OF GRADUATE STUDIES

HAWASSAUNIVERSITY

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(Submission Sheet-1)

This is to certify that the thesis entitled “**Climate change and livelihood diversification in rural West Badewacho District**”, Hadiya Zone, southern Ethiopia. Submitted in partial fulfillment of the requirement for the degree of Master with specialization of climate change and sustainable agriculture has been carried out by Kebede Bekele Woilebo-under our supervision. Therefore, we recommended that the student was fulfilled the requirements and hence hereby can submit the thesis to the climate change and sustainable agriculture MSc program.

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As a member of the Board of Examiners of the MSc Thesis Open Defense Examination, we certify that we have read and evaluated the Thesis prepared by Kebede Bekele and examined the candidate. We recommend that the Thesis is accepted as it fulfilling the Thesis requirements for the Degree of Master of Science in Agriculture (Agronomy).

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Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the Department of Graduate Council (DGC) of the candidate's major department. I hereby certify that I have read this thesis prepared under my direction and recommend that it accepted as fulfilling the thesis requirement.

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DEDICATION

I dedicate this thesis manuscript to my lovely wife Meaza Tesfaye for nursing me with affection and love and for her dedicated partnership in the success of my life.

STATEMENT OF THE AUTHOR

I declare that this thesis is a result of my own work that all sources of materials used for writing have been duly acknowledged and I have not plagiarized the work of others. I solemnly declare that this thesis has not been submitted to any other institutions anywhere for the award of any academic degree, diploma, or certificate. This thesis has been submitted in partial fulfillment of the requirements for an advised M.Sc. degree at Hawassa University and is deposited at the university library to be made available to borrower under the rule of the library. Brief quotation from this thesis may be made without requiring special permission provided that accurate and complete acknowledgement of the source is made. Requests from this manuscript for extended quotation from or replication of the thesis in whole or in part may be granted by the Program coordinator or the Coordinator of Graduate studies when in his or her judgment the proposed use of the material is for scholarly interests. In all other instances, permission must be obtained from the author.

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ACRONYMS

AEZs	Agro-ecological Zone
CCV	Climate Change and Variability
DAs	Development Agents
FAO	Food and Agriculture Organization
FGDs	Focus Group Discussion
GHG	Green House Gases
GO	Governmental Organization
IPCC	Intergovernmental Panel on Climate Change
MBWANRM	Mirab Badewacho Woreda Agriculture and Natural Resource
MDGs	Millennium Development Goals
MNL	Multinomial Logistic
NMSA	National Metrological Services Agency
NPA	National Adaptation Programme
SPSS	Statistical Package for Social Studies
SSA	Sub-Saharan Africa
UNEP	United Nation Environmental Programme
WB	World Bank
WRI	World Resource Institute

TABLE OF CONTENTS

Contents	Page
STATEMENT OF THE AUTHOR	v
ACRONYMS	vii
LISTS OF TABLES	x
LISTS OF FIGURES	xi
LIST OF TABLES IN THE APPENDICES	xii
ABSTRACT	xiii
CHAPTER ONE: INTRODUCTION	1
1.1. Background of the Study	1
1.2. Statement of the Problem	3
1.3. General objective of the Study	4
1.4. Research Questions	5
1.5. Significance of the Study	5
1.6. Scope of the Study	6
CHAPTER TWO: LITERATURE REVIEW	7
2.1 Theoretical Review of Related Literature	7
2.1.1 Concepts of Climate Change and definition of key Terms	7
2.1.2 The Impacts of Climate Change	8
2.1.3. Climate Change in Ethiopia; Observed patterns & projections	9
2.2. The Empirical Review of Related Literature	11
2.2.1 The Impacts of Climate Change & Variability in Ethiopia	11
2.2.2. Farmers' Perception on climate change and variability	14
2.2.3 Climate-change adaptation and livelihood diversification in Ethiopia	15
2.2.4 Income source diversification in Ethiopia	17
2.2.5 Diversification and adaptation	18
CHAPTER THREE: RESEARCH METHODOLOGY	21
3.1. Description of the Study Area	21
3.1.1. Location of the Study Area	21
3.1.2. Bio physical resources	22
3.1.3. Socio-economic resources	23
3.2. Research Design	23
3.3. Sampling Techniques and Size	24

TABLE OF CONTENTS (CONTINUED)

3.4. Data types and Sources	25
3.5. Methods of Data Collection	26
3.5.1. Rainfall and temperature data	26
3.5.2 Socio economic and demographic profile	26
3.5.3. Data collection instruments	26
3.6. Method of Data Analysis and Presentation	28
3.6.1. Inferential Statistical analysis	28
3.7. Variable definitions and hypothesis	29
CHAPTER FOUR: RESULTS AND DISCUSSION	34
4.1 Socio-demographic characteristics of the Respondents	34
4.2 Institutional Information of the Respondents	35
4.3 Trends of Rainfall and Temperature	38
4.3.1 Trends of rain fall variability in the study area	38
4.3.2 Trends of temperature in the study area (1989-2018)	42
4.4. Respondents perception of climate change and variability	44
4.5 Livelihood strategies of the study Area	49
4.5.1 On-farm activities	49
4.5.2 Off-farm and Non-farm Livelihood strategies in the study Area	54
4.5.3 The constraints of the households' choices of non/off-farm livelihood strategies	60
4.5.4 Contribution of livelihood diversification to climate change adaptation	61
CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS	68
5.1 Conclusion	68
5.2 Recommendations	69
REFERENCES	70
APPENDICES	79
BIOGRAGHY OF THE AUTHOR	99

LISTS OF TABLES

Table	page
1.Summary of sample size determination	25
2. Variable description	33
3. Socio-demographic characteristics of respondents (n=147)	35
4. Institutional information of respondents (n=147)	37
5. Sources of land or the means of accessing land	38
6. Coefficient of variance for annual, belg and kiremt rainfall (1985-2017)	39
7. Local indicators that evaluate rain fall patterns in the study area	46
8. The area coverage of crops in hectare	49
9. Failure of crop production	51
10. Livestock types owned by respondents	52
11. Respondents participated into off-farm activities (n=120)	55
12. Respondents participated in to non-farm activities	56
13. The income source (in Birr) from non-farming to the households	57
14. Off-farming as the income source (in Birr) to the households	58
15. The constraints of non/off-farming activities	61
16 Contribution of livelihood diversification to climate change adaptation	62
17.Multinomial logit analysis of determinants of livelihood diversification	65

LISTS OF FIGURES

Figure	Page
1. Conceptual frame work of Climate Change, Variability and Impacts and livelihood diversification	20
2. Map of the study area	21
3.The trends of annual rainfall variability in the study area	40
4. The trends of belg rainfall in the study area	41
5. The trends of kiremt rainfall in the study area	42
6. Trends of maximum temperature	43
7.Trends of minimum temperature	44
8.Factors affecting crop production in the study area	47
9.Respondent's perception of trends of rain fall	48
10. Respondents' perception about the trends of temperature	49
11. The problem which causes livestock mortality	53
12.Challenges facing on livestock rearing	54
13. Livelihood diversification strategies in the study area	59
14. Reason for engaging on non/off-farming activities	60
15.Contribution of livelihood diversification activities to farm households	64

LIST OF TABLES IN THE APPENDICES

Appendix Table	Page
1. Conversion factors of livestock number to TLU	79
2. Variance inflation factor	80
3. Total rainfall (1985-2017)	81
4: Maximum Temperature (1989-2017)	82
5: Monthly Minimum Temperature (1989-2017)	83

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ABSTRACT

It is evident that climate change is real and rural farm households are focusing on several livelihood diversification options in response to climate change. In the study area, West Badewacho, the change in climate shifted households to carry out different livelihood strategies. The main aim of this study is to investigate livelihood diversification of farm households in response to climate change in the study area. Both primary and secondary data were collected to address the research objectives. Both Simple random sampling and systematic random sampling techniques were employed to collect the primary data from 147 household heads through interview; key informants interview, and focus group discussions. The secondary data were collected from Ethiopian National metrological agency. The collected data were analyzed through descriptive statistics like mean, maximum, minimum, percentage and multinomial logit model by using SPSS version 20 and STATA 13 software. Four livelihood diversification strategies were identified in the study area. Those are on-farm only, on-farm and non-farm, on-farm and off-farm, and the combination of on-farm, non-farm and off-farm livelihood diversification strategies. Generally, from the total households about 34% of them are participated in on-farm and non-farm livelihood diversification strategies response to climate change and to pursue livelihood income. The result shows that a livelihood diversification strategy is significantly influenced by sex, education level, family size, farm land size, extension contact, credit access and saving habit. The most important practice to adapt climate change and variability is livelihood diversification in the study area.

Key words: Climate Change, Livelihood, Diversification

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

The Earth's climate is changing mainly as a result of the increasing concentration of greenhouse gases in the atmosphere that are emitted from various human activities (IPCC, 2007a). According to the recent Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014), sea levels have risen faster than at any time during the previous two millennia at global level in many parts of the world.

Warming of the climate system is now unequivocal. It is now clear that global warming is due to manmade emissions of greenhouse gas (GHG), mostly CO₂. Over the last century atmospheric concentrations of carbon dioxide increased from pre-industrial value of 278 parts per million to 379 parts per million in 2005 and the average global temperature rose by 0.74 °C (UNFCCC, 2007). If emissions remain at current rates, by 2050 the concentrations of GHGs in the atmosphere will reach 550 parts per million and continue to increase thereafter (World Bank, 2010).

Climate change is anticipated to have far reaching effects on the sustainable development of developing countries. Many research findings indicated that climate change had significant impacts on many parts of the world (Kurukulasuriya and Rosenthal, 2003). There are spatio-temporal variation in the capacity of both the sensitivity and adaptability of the diverse community within a given country. However, Africa's total contribution to emissions of greenhouse gases is less than 7% of the world's greenhouse emissions (IPCC, 2007a).

According to FAO (2007), developing countries are particularly at risk as their economies are highly dependent on agriculture and have fewer resources and options to combat any damages from climate change and variability. Hundreds of millions of people in developing nations will face natural disasters, water shortage and hunger due to the effects of climate variability.

The negative effects of climate change are threatening to reverse development gains in many parts of the world especially in Sub-Saharan Africa. It is now an accepted scientific phenomenon that the global climate is changing. Precipitation and temperature patterns are changing.

Ethiopia is one of the developing countries, which is more vulnerable to climate change and variability (FAO, 2007). Low level of socio-economic development, inadequate infrastructure, lack of institutional capacity, a higher dependence on natural resources make the country more vulnerable to the impacts of climate change (Agrawala and Fankhauser, 2008).

It is obvious that agricultural production is directly affected by climate change. Abnormal changes in temperature and rainfall, and increasing frequency and intensity of droughts and floods have long term implications for the viability and productivity of world agro-ecosystems (FAO, 2007). Water resources, agriculture, natural resources and biodiversity, human and animal health especially climate sensitive vector-borne diseases are the most sensitive and highly at risk to climate variability in Ethiopia (Haakansson, 2009).

Agriculture-based livelihood systems that are already vulnerable to food insecurity face immediate risk of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material, and loss of livestock.

Climate variability and change through diverse stimuli and intervening factors affect economic, social, cultural, and natural conditions of individuals and communities, altering the value and usefulness of various livelihood assets. The current trends of climate change and climate variability and the resulting effect on agriculture have necessitated the adoption of alternative livelihoods opportunities among farmers in order to secure their livelihoods.

Therefore, this study was designed to identify trends of climate change and variability, impacts and livelihood diversification as result of climate change of smallholding farmers in selected kebeles of West Badawacho District.

1.2. Statement of the Problem

The threat of climate change is real, happening now and is expected to hit countries the hardest since the developing countries already face social, economic and environmental stresses and resource constraints that limit their ability to adapt to climate change (Kinyangi *et al.*, 2009).

The impacts of increased temperature reduced and variable precipitation resulting from global warming and/or climate change is expected to reduce agricultural production, depress crop yields and put further pressure on marginal land that is currently under crop production and livestock grazing (FAO, 2007; Kinyangi *et.al.*, 2009). The agricultural focus is essential, but not sufficient for sustainable rural development due to constraints such as scarcity and degradation of agricultural land, weak extension services, lack of skill and training, low input supply and high price, lack of road network and unreliable rain fall (World Bank, 2007). In addition to agricultural activities, the rural households should practice non-farm activities to improve their incomes (World Bank, 2008). Non-farm activities are very heterogeneous which

include hand crafts, self-employed enterprises as well as wage employment in public or private organizations.

According to Disaster Prevention and Preparedness work Unit head of West Badawacho District Agriculture Office; from the year 2007 to 2018 year 19048, in 2014 year 9814 and from 2015 up to 2018 November 12293 households were registered to be victims of food shortage and famine and food aid was provided to sustain their life. This obviously verifies that food shortage and famine is prevalent in the study area. However, studies on major trends of climate change and variability, its impact and diversified livelihood strategies have not yet been conducted in Hadiya zone in general and in study area in particular. And, the study conducted by Kebede Birhanu (2016) reveals only Impact of Climate Variability on Food Security at Rural Household Level without showing the trends of climate change and variability, its impact and diversified livelihood strategies. Taking this in to consideration, this study aimed at filling this gap by assessing trends of climate change and variability, its impact and diversified livelihood strategies in West Badawacho District.

1.3. General objective of the Study

The general objectives of this study is to investigate livelihood diversification of farm households as a result of climate change and variability as well as the major trends of climate change and its variability, and farmers' perception in West Badawacho District of Hadiya Zone, Southern Ethiopia.

The Specific objectives

- i. To assess the rainfall and temperature trends using meteorological data in the study area.

ii. To investigate farm households' perception towards climate changes in the study area.

iii. To analyze farm households' livelihood diversification strategies in response to climate change in the study area.

1.4. Research Questions

1. What looks like the trend of rainfall and temperature in the study area?
2. Are there significant variation in farmers' perception under the climate change and variability?
3. What impacts of climate change are prevalent in the study areas?
4. What are diversified livelihoods strategies do smallholding farmers designed as a result of climate change?

1.5. Significance of the Study

The study generated information on farm household livelihood diversification strategies as result of climate change and variability in the study area. Consequently it is tried to contribute to enhance and facilitate exchange of climate knowledge and information among field experts, policy makers and researchers. Thus, it can serve as an input in main streaming local knowledge and local situation in the climate change adaptation policies at region and national government.

1.6. Scope of the Study

The study was focused on assessing climate change and variability, its impact and diversified livelihood strategies as a result of climate change. Based on the available of time, costs and accessibility, the study was relied on four selected kebeles in West Badawacho District. The meteorological data (1985-2017) used in the analysis and interpretation of major trends of climate change and variability in the area.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Review of Related Literature

2.1.1 Concepts of Climate Change and definition of key Terms

According to IPCC (2007a), Climate change is “any change in climate over time whether due to natural variability or as a result of human activity. It is a trend in one or more climatic variables characterized by a fairly smooth continuous increase or decrease of the average value during the period of record, such as, increasing trend in air temperature and the frequency of flood. Climate variability can be thought as climate change departs from some average state, either above or below the average value. It often used to denote deviations of climate statistics over a given period of time from the long term climate statistics relating to the corresponding calendar period (IPCC, 2007a).

Since the onset of the Industrial Era (1750), human-induced emissions from fossil fuel combustion and land use change has increased Greenhouse Gases (GHGs) concentrations in the atmosphere, resulted in an enhanced greenhouse effect. Carbon Dioxide (CO₂) and Methane (CH₄) are the two main (GHGs) affected by human activities. The concentration of CO₂ in the atmosphere has increased by 30% since 1750, with present concentration level being the highest in more than 400,000 years (Erikssen and Otto, 2003).

IPCC (2007a) defined that climate variability as Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. Variability may result

from natural internal processes within the climate system (internal variability) or from variations in natural or anthropogenic external forcing (external variability).

According to Ellis (1998) Livelihood diversification defined as “the process by which rural families construct a diverse portfolio of activities and social support capabilities in order to survive and to improve their standards of living”. More than 50% of income in rural farming communities in developing countries comes from non-farm sources IFAD, (2010). According to Duvel, (1991) Perception is defined as the more complex process by which people understood; interpret sensory stimulation in meaningful and coherent picture of the world. IPCC (2014) defines adaptation as “an adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.

2.1.2 The Impacts of Climate Change

IPCC (2007) indicated that climate change is considered as the biggest environmental threat in human history and the defining human challenge for the twenty-first century. Consequences of climate change are already felt throughout the earth system. The effects of climate change are observed on every continent and in all sectors. According to Thornton & Lipper, (2014) climate change is already affecting rainfall amounts, distribution, and intensity in many places. This has direct effects on the timing and duration of crop growing seasons, with concomitant impacts on plant growth. Rainfall variability is expected to increase in the future, and floods and droughts will become more common. Changes in temperature and rainfall regime may have considerable impacts on agricultural productivity and on the ecosystem provisioning services provided by forests and agro forestry systems on which many people depend.

Hannah *et al* (2010) stated that climate change affects all countries, but those likely to be worst affected are the world's poorest countries, especially poor and marginalized communities within these countries. Ironically it is these poor countries and people who have contributed least to the problem of climate change, because of their very low greenhouse gas emissions, but who will suffer most from its consequences. The foregoing argument shows 16 that climate change can no longer be sidelined as a development issue. The effect that climate change has on the poor communities in sub-Saharan Africa is increasingly prominent (Dube, 2013).

According to IPCC (2007) report, climate change impacts on water demand are predicted to be highly significant in Africa. The number of people facing water scarcity due to unreliable rainfall and drying up of springs and rivers is expected to be between 75 to 250 million people by 2025. Furthermore, this is likely to have severe impacts on crop yields, as the majority of the African population (over 85 percent in the case of Ethiopia) depend on rain fed agriculture, (IPCC, 2007). IPCC (2007) referred that climate change will aggravate the water stress currently faced by some countries, while some countries that currently do not experience water stress will become at risk of water stress.

2.1.3. Climate Change in Ethiopia; Observed patterns & projections

Bishaw *et al*, (2013) indicated that Ethiopia's diverse agro ecological zones are characterized by a dazzling variety of microclimates and corresponding weather patterns. Over centuries, its people have developed agricultural systems adapted to Ethiopia's diverse environment. However, the rapid pace of climate change, along with increasing socioeconomic pressures, threatens to overwhelm their ability to cope.

The country faces considerable hurdles in coping with the adverse impacts of long-term climate change. According to IFPRI (2011) low economic development, inadequate infrastructure, and lack of institutional capacity all contribute to the country's vulnerability to the adverse impacts of climate change.

NMA (2007), described that baseline climate that was developed using historical data of temperature and precipitation from 1971- 2000 for selected stations in Ethiopia, showed a very high year-to-year variation in rainfall for the period 1951 to 2005 over the country expressed in terms of normalized rainfall . Over those periods (1951-2000), some of the years have been dry resulting in droughts and famine while others were characterized by wet conditions (NMA, 2007). Temesgen *et al.* (2010) indicated that during extreme drought conditions, it is common that many farmers in the country either die due to hunger or depend on foreign food aid to sustain their lives. According to NMA, (2007) the observed trend in annual rainfall, however, remained more or less constant when averaged over the whole country.

According to the National Meteorological Agency, long-term climate change in Ethiopia is associated with changes in precipitation patterns, rainfall variability, and temperature, which could increase the country's frequency of both droughts and floods. Although both developed and developing countries are affected by climate change, developing countries face greater challenges in overcoming its adverse consequences. Ethiopia is one of the least developed countries in the world; with a per capita income of less than US\$130 in 2006.

2.2. The Empirical Review of Related Literature

2.2.1 The Impacts of Climate Change & Variability in Ethiopia

Ethiopian climate is characterized by a history of climate extremes, such as: droughts and floods; and increase and decreasing in temperature and precipitation, respectively. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia. The most drought prone and affected areas of the country are in the northern, eastern and southern parts. According to Cesar and Ekbom, (2013) research result the impact of climate change in Ethiopia is already apparent in the increasing temperature and declining rainfall, particularly in northern parts which are exceptionally vulnerable to drought.

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

2.2.1.1. Impacts on Agriculture

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

Ethiopian agriculture is heavily dependent on natural rainfall, with irrigation agriculture accounting for less than 1% of the country's total cultivated land. According to CSA, (2008) the amount and temporal distribution of rainfall and other climatic factors during the growing

season are critical to crop yields and can induce food shortages and famine. Like many other developing countries, agriculture (with the largest number of livestock in Africa) is the single largest livelihood of an overwhelming majority in Ethiopia, 85% of the population.

Abate (2009) research result shows that during drought and delay in the onset of rain land becomes dry and difficult to plough, forage deficit leads to weakness and oxen mortality (engine of subsistent cultivation), and lack of precipitation hinders seed cultivation and germination of cultivated seeds. Even weeks delay in the onset of rain was found to have significant difference on the harvest and has deprivation of households' livelihood.

2.2.1.2 Impacts on Livestock Production

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

Climate change affects livestock both directly and indirectly. The direct effects from air temperature, humidity, wind speed and other climate factors influence animal performance: growth, milk production, wool production and reproduction. Climate change will have far-reaching consequences for dairy and meat production, especially in vulnerable parts of the world where it is vital for nutrition and livelihoods. The impact of climate change can heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as

drought (Abebe, 2013). According to UNDP (2010) the most vulnerable communities to the impacts of climate change inhabit the dry lands areas. Pastoralists inhabiting dry lands have been able to survive the harsh environments practicing various sustainable livelihood approaches including seasonal movements, keeping livestock, among others.

2.2.1.3 Socio-Economic Impacts

Agriculture is one of the most vulnerable sectors to climate change. Zhai and Zhuang (2009) research result is noted that whatever technological advancement have been reaching in the last century, agricultural production and productivity is highly dependent on the weather and climatic conditions in many areas of the world. Determining the effect of climate change on agriculture is complex as it affects varieties of factors such as change in temperature, change in rainfall pattern and change in CO₂ levels (Aydinalp and Cresses, 2008). There are both direct and indirect effects of climate change on agriculture production and productivity. It directly affects agriculture by affecting weather variables such as rainfall, temperature, solar radiation, wind speed and humidity and indirectly through diseases and pest outbreak as well as favoring the development of climate related disease like malaria that affects the work force (Ngigi, 2009). Newton *et al.* (2010) also indicated that climate change affects the complex interactions between crop and pathogens leading to increased outbreak of pests and diseases.

Large part of the country is arid and semiarid and highly prone to desertification and drought (World Bank, 2006). Tadege (2007) indicated that current climate variability is imposing a significant challenge to Ethiopia by affecting food security, water and energy supply, poverty reduction and sustainable development efforts. Most studies indicated, that global mean annual temperature increase of a few degrees or more would prompt food prices to increase

due to a slowing in the expansion of global food supply relative to growth in global food demand (IPCC, 2001a). Moreover, rainfall variability was reported to have significant effect on Ethiopia's economy and food production for the last three decades (Araya and Stroosnijder, 2010). Furthermore, extreme weather events, such as droughts, floods, or landslides, may cause death to domestic animals (Pettengell, 2010). Livestock suffering and death often means that the farmers' wealth is decreased and they lose much of their resources. Mideksa (2010) conducted research indicated that climate changes will most likely increase poverty in Ethiopia. According to USAID (2004) long-term trends towards reduced rainfall, and recurring droughts, have played a role in weakening of the Ethiopian economy. Climate changes might raise the global economic inequality since many developing countries have a current climate close to or slightly warmer than what is considered optimal for agriculture (Mideksa, 2010). According to IPCC (2001b) Studies reported that climate changes would lower incomes of the vulnerable populations and increase the absolute number of people at risk of hunger, though this is uncertain and need further research. Climate changes in Ethiopia will be, and have already been, affecting productivity and fertility of animals especially as result of heat stress and increased water requirements. Moreover, drier conditions, drought, or flood, might mean decreased grassland and rangeland for animals in arid and semi-arid regions of Ethiopia (Pettengell, 2010).

2.2.2. Farmers' Perception on climate change and variability

Mongi *et al.* (2010) conducted research indicates that the degree of perception of farmers' on CCV depends on its impact on farmers' livelihood, as well as their social, institutional and economic background. Sometimes, farmers' perception about climate change is not evidenced from weather stations. In most parts of Ethiopia, people perceive declining in rainfall and

increased in frequency of drought but it was not informed from weather station (Maddison, 2006). Maddison (2006) also argued that this lack of congruence between farmers' perception and metrological records could emanate from the analysis of short term climate data and/or due to averaging of record from wide areas. The study conducted by Deressa *et al.* (2008) also indicated that majority of contacted farmers in Ethiopia are aware of climate change and perceives an increase temperature and decrease rainfall without assessing the fluctuation of rainfall pattern. Furthermore, the result indicated that age of the household head, wealth and information on CCV positively influence farmers' perceptions of changes in climatic attributes. In northern Ethiopia, farmers' mainly utilize traditional weather forecasting techniques. Strong wind during the month of July through October indicates that less rainfall in closer to the coming season.

2.2.3 Climate-change adaptation and livelihood diversification in Ethiopia

According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) indicates that the majority of countries in sub-Saharan Africa are likely to experience a higher increase in mean temperatures and greater variability in rainfall patterns than other regions this century (IPCC, 2007). The IPCC (2012) Similarly, Special Report on Extreme Weather Events indicates that the region is 'extremely vulnerable to climate extremes' such as droughts, heat waves and floods. The report specifies a likely increase in heavy precipitation in East Africa which arguably could cause more floods. There is less confidence about drought projections because of inconsistent results.

Ethiopia experiences diverse climatic conditions with considerable variation in altitude and location. The mean annual rainfall distribution in the country ranges from a maximum of over

2000 mm in the South-Western Highlands to a minimum of around 300 mm over the South-Eastern and North-Western Lowlands. According to FDRE (2007) similarly stated that, mean annual temperatures vary considerably: from below 15°C in the highlands to over 25°C over the lowlands. Such variability contributes to the classification of the three seasons in the country: the dry season (Bega) from October to January; the short rainy season from February to May; and the long rainy season from June to September. According to Conway and Schipper, (2011) the impact of climate change on Ethiopia can therefore be explained in terms of how temperature (which has been increasing gradually in recent decades) and precipitation (which has shown some signs of greater variability) are likely to unfold in coming decades.

Using a multi-model dataset, the National Meteorological Agency of Ethiopia indicates that the mean annual temperature is likely to rise significantly when compared with the 1961-90 level, by a maximum of 1.1°C by 2030, 2.1°C by 2050 and 3.4°C by 2080 (FDRE, 2007). Conway and Schipper (2011) conducted research concur with multi-model averages of 1.2°C in the 2020s, 2.2°C in the 2050s and 3.6°C in the 2080s. FEWS NET (2012b) also projects that most of Ethiopia will experience a greater than 1.0°C increase in temperature by 2039 if recent warming trends continue (with the south-central part of the country likely to warm most).

Turning to precipitation, the IPCC's projections indicate an aggregate 7% increase for East Africa in the last decade of this century compared to the same period in the twentieth century. According to FDRE (2007) the Ethiopian National Meteorological Agency reports that the average countrywide annual rainfall pattern remained constant between 1951 and 2006 and projections suggest little change in the future. Most importantly, the impact of climate change

on Ethiopia will largely be determined by the distribution of precipitation over the land surface. According to FEWS NET (2012b) based on three decades of short rainy season and long rainy season rainfall observations, highlights a 15-20% decrease across southern, southwestern and south-eastern areas. This observed decline in rainfall overlaps with densely populated locations. FEWS NET (2012b) particularly highlights the Rift Valley and Eastern Highlands, both of which have experienced a marked decline in rainfall. The rest of the country, and especially the Western Highland region, is likely to receive adequate amounts of rainfall which could potentially improve food security at the national level (if improved agricultural and water-management regimes are followed).

2.2.4 Income source diversification in Ethiopia

Although agriculture remains the main source of income and employment, rural non-farm income is gaining importance in most rural areas in developing countries. According to Haggblade *et al.* (2010) research result indicated that 35– 50% of rural incomes were attributed to the rural non-farm economy in developing countries at the start of the new millennium. A recent report by the World Bank (2009) estimates that 25% of rural households participate in the non-farm sector.

Carswell (2002) and LIU (2011) conducted research indicated that the importance of non-farm activities in Ethiopia varies by region and livelihood zone. The most important source of cash income for most rural households is crop sales in the cropping livelihood zone (broadly comprising Tigray, Amhara, Beneshangul Gumuz, Gambella, South Region and the western and northern parts of Oromiya) and livestock sales in the pastoral and agro-pastoral zones (roughly corresponding to Somali and Afar). Migrant labour is common in the parts of

Amhara and Tigray that were the epicenter of famines in the 1970s and 1980s. In these areas, income from migrant labour ranges between 31% and 54% of total household income. Income from non-farm and off-farm activities such as petty trading and self-employment constitutes up to 60% of households' income in some parts of the country. For instance, petty trading is significant in densely populated areas of the SNNPR. According to LIU, (2011) the collection of firewood and grass for fodder sales (defined as self-employment) is common in the lowlands and pastoral areas. According to LIU, (2011) income from firewood and charcoal sales contributes more than 9% of total cash income in Western Tigray, Southern Amhara, Southern Afar and the southern foothills of Hararge.

2.2.5 Diversification and adaptation

Diversification can have both positive and negative impacts: positive if livelihoods are more secure and if the adverse impacts of seasonality are reduced (through consumption smoothing, risk reduction, complete use of available household labour and skills, and cash generation for investment). According to Ellis (1998) diversification can result in negative effects if it increases households' vulnerability (World Bank, 2009). For instance, the positive role of non-farm activities and income is also suggested by Bryan *et al.*'s (2009) study on the determinants of adaptation to climate change in Ethiopia and South Africa. Next to basic household and demographic characteristics (mainly education and age), non-farm income is identified as having the most positive effect in encouraging adaptation options in agricultural livelihoods. According to Thomas and Twyman, (2005) a more extreme version of this argument is that 'diversification within natural-resource use may be regarded as reinforcing vulnerability to climate change'. But such a position does not take account of changing practices within natural-resource use, such as within farming.

According to Ellis, (1998) following a frequent distinction between diversification of necessity and diversification by choice), the relationship between diversification and climate adaptation defined in a tripartite manner. Regard to increased non-farm income as positive adaptation. Secondly, regard to increased farm income as a neutral form of adaptation (as greater income from farming tells us nothing about diversification or commercialization within farming). For example, greater income from farming can either increase or decrease exposure to climate variability. Finally, by applying a strict definition of off-farm activities as temporary farm-wage or in-kind employment, as well as collection of natural resources, an increase in off-farm income as an indicator of distress and therefore a negative form of adaptation. Such a categorization is intended to assess adaptive capacity only in the very short term. Betts *et al.*, (2011) conducted research clearly indicate that more severe medium- and long-term climatic changes easily render such a schema obsolete.

The conceptual frame work for this study was indicated that climate change and variability brought the changes in the amount of rainfall and temperature, unpredictability of rain fall, and pests and diseases, among others. This led for risk of crop failure, loss of livestock production, loss of crop production and household resource depletion and reduction of household income. However, the changes happening as a result of climate change and variability leads to vulnerability of the people especially in rural household. The vulnerable groups diverse different diversified livelihood strategies including the livelihood diversification like on-farm in come, on-farm and off-farm income, on-farm and non-farm and the combination of on-farm, off-farm and non-farm income activities in response to the impacts of climate change and variability. This led for income improvement and reduced Environmental risk. This is briefly sketched in (Figure 1).

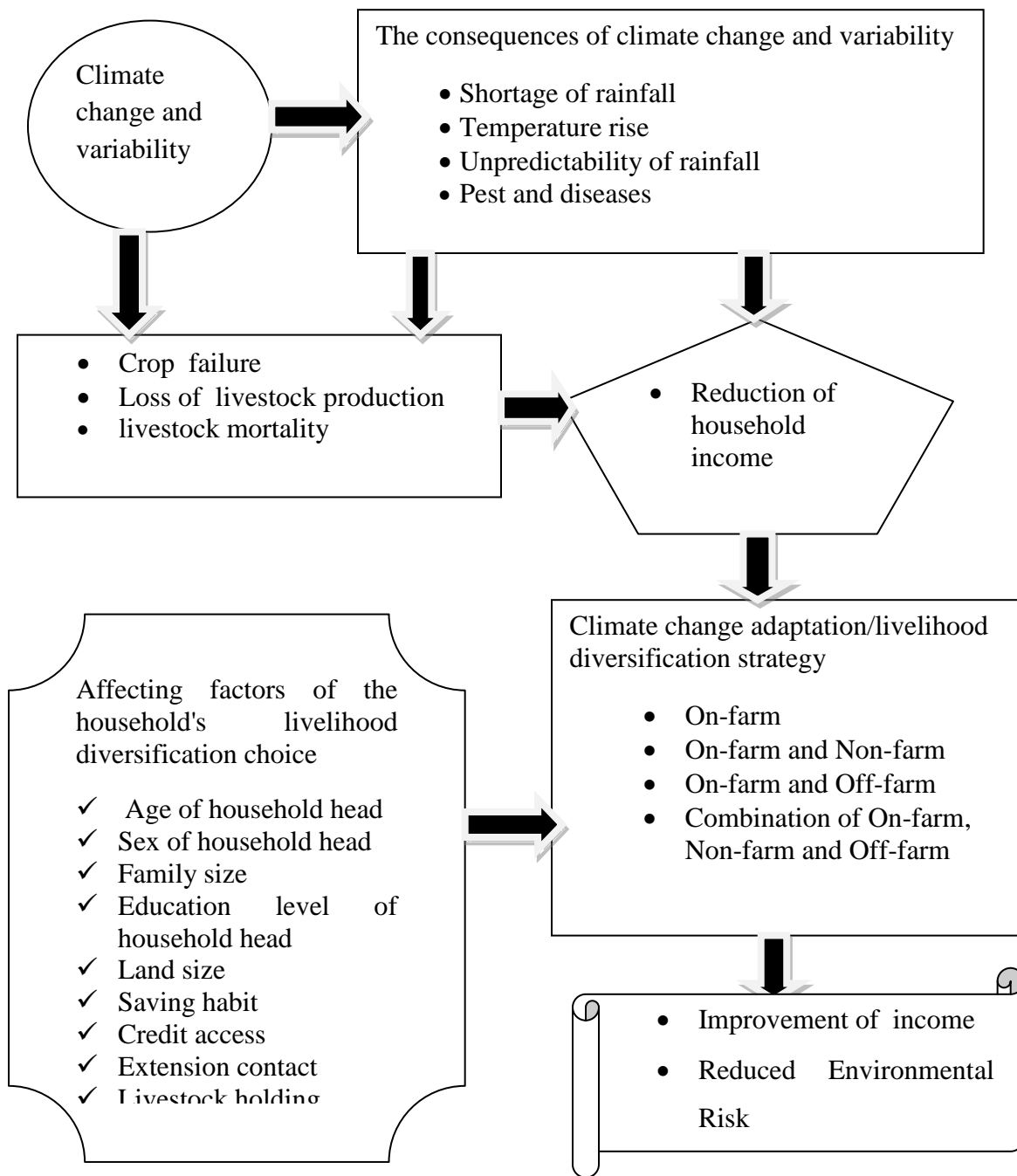


Figure 1. Conceptual frame work of Climate Change, Variability and Impacts and livelihood diversification

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Description of the Study Area

3.1.1. Location of the Study Area

The research was conducted in the West Badawacho District. This is one of the fifteen Districts of Hadiya Zone in southern Ethiopia. Geographically, it is located between $7^{\circ}30'0''$ and $7^{\circ}43'0''$ North and from $37^{\circ}35'0''$ to $38^{\circ}05'0''$ East. It is bordered by Kadida Gamella District to the North; Kachabira District to the West; Damot Gale District to South and East Badawacho District to the East. The administrative center of West Badawacho District is Danema; that is 320 km South of Addis Ababa and about 102 km west of Hawassa city, the capital of the SNNPR.

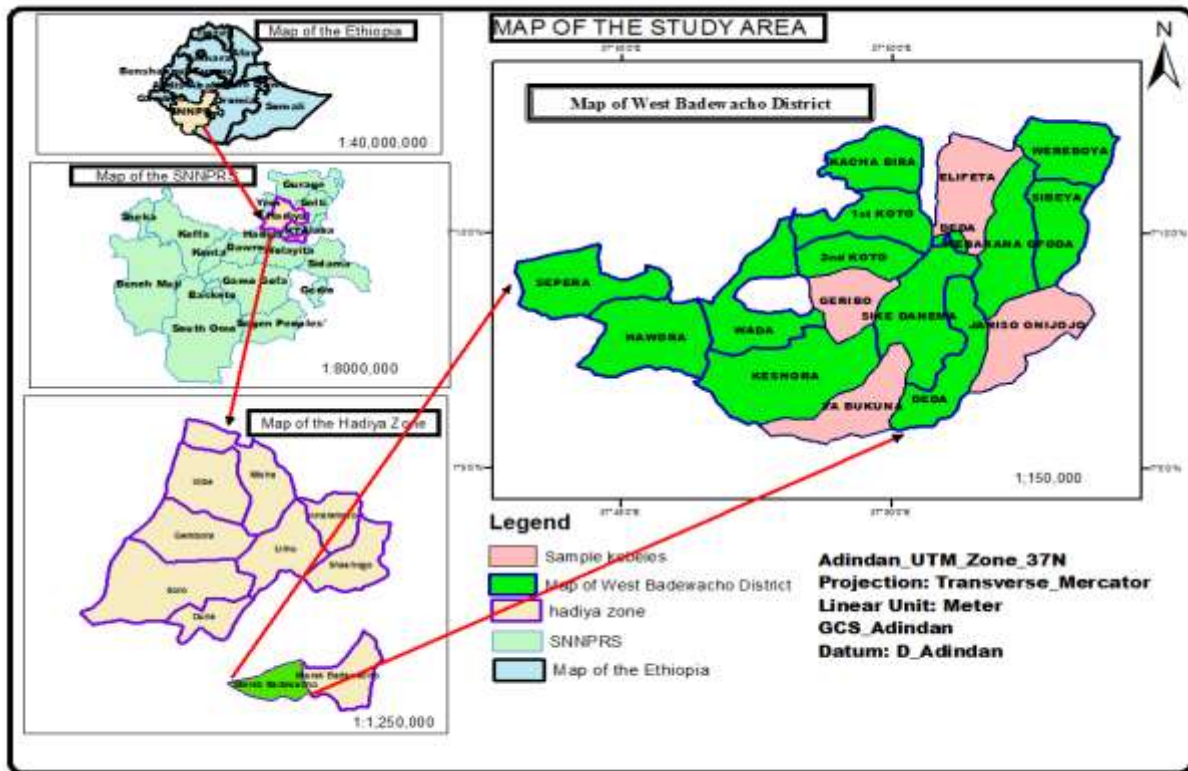


Figure 2. Map of the study area

3.1.2. Bio physical resources

The total area of the study area is about 19,500 hectares, of which flat and moderately steep slope land accounts for 65% and 35%, respectively. The altitude ranges from 1620m to 2680m above sea level MBWANRM (2014).

Agro ecologically, the District is hence categorized under the midland agro-ecological zone. The mean annual total rainfall is about 1260 mm and has average temperature of 19°C. The month January, February and the beginning of March are months that exhibit very high temperature which is also confirmed by Kibamo (2011). Accordingly, it has two rainy seasons, spring and summer. Spring represents the short rainy season and lasts between March and May. The summer season, which is the longest rainy season, lasts between June and September. More than 75% of the total rainfalls during this season and the highest rainfall occur in July and August. Rain that occurs during the kiremt season is very intensive.

According to the MBWANRM (2014), the common types of soils found in the District are black (vertisoil) and red brown basaltic (nit soil).

Dominantly growing crops in the study area includes teff (*teff eragrostis*), haricot bean (*phaseolus vulgaries L.*), maize (*Zaye maze*), wheat (*triticum aestivum L.*), sorghum (*sorghum bicolor*), potato (*solanum tuberosum L.*), and enset (*Enset ventricosum*). Based on the National Population and Housing Census reports of 2007, projection of the total population of the District in 2014 was about 115,689. The four largest ethnic groups reported in West Badawacho District with their population proportion were Hadiya (95.57%), Kembata (2.03%), and the Amhara (1.23%); and others (1.17%). Hadyissa is spoken as a first language

by (93.13%), followed by Kembata (2.17%), and Amharic (0.75%). In terms of religion, about 89.15% of the population was Christians (Protestants), 3.04% were followers of Ethiopian Orthodox Christianity, 5.3% were Catholic, 2.15% practiced traditional religions, and 0.36% were Muslim (MBWANRM, 2014).

3.1.3. Socio-economic resources

Agriculture serves as the means of livelihood to the majority of the people. It is characterized by traditional and mixed farming as it includes both crop and livestock production.

Dominantly growing crops in the study area includes teff (*teff eragrostis*), haricot bean (*phaseolus vulgariesL.*), maize (*Zaye maze*), wheat (*triticum aestivumL.*), sorghum (*sorghum bicolor*), potato (*solanum tuberosumL.*), and *enset* (*Enset ventricosum*). *Enset* is the staple food in the area and almost always grown for both consumption and sale. Major crops such as *teff* (*teff eragrostis*), wheat (*triticum aestivumL.*) and haricot bean (*phaseolus vulgaries L.*) are grown once in a year during the summer growing season. Some other crops like maize (*Zaye maze*) and potato (*solanum tuberosum L.*) are also grown during the spring growing season. However, crop productivity is declining from year to year. As the remnants of tree species depict the area has once been covered by dense forest in the past. However, the vegetation cover has been removed, and replaced by cultivation fields and plantation of exotic species such as eucalyptus species (*Eucalyptus globules*) (MBWANRM, 2014).

3.2. Research Design

In order to achieve the intended objectives, the investigator used cross sectional survey research design. Cross-sectional survey research is the collection of data mainly using

questionnaires or structured interviews to capture quantitative and qualitative data at a single point in time.

3.3. Sampling Techniques and Size

In order to collect well-built data needed to achieve the objectives of the study, two stages sampling procedure was employed. In the first stage, West Badawacho District was selected purposively because of the researcher previous and current experience about the site, ease of access to get data. In the second stage from total 22 kebeles 4 sample kebeles, namely Ya'abukuna, Garbo, Elfeta and Jarso Onjojo were randomly selected for the study. From the total households of 2545 residing in the 4 sampled kebeles, a total 147 sample households was selected using systematic random sampling method. By using a sample size determination formula developed by (Yamane, 1967) to obtain the required sample size at 95% confidence level and level of precision 8% (0.08)

$$n = \frac{N}{1 + N(e)^2}$$

Where; n is sample size

N is the total household head (the population size)

e is level of Precision

The number of sample households in each of the four sample kebeles is allocated using probability proportional to the size of population in each *Kebeles*.

Using formula $n_i = \frac{nN_i}{N}$ (Bowley, 1926)

Where; n_i is sample size in each kebele

n is sample size

Ni is the size of population in each kebele

N is the total household head (the population size)

Table 1. Summary of sample size distribution along the sample kebeles

No	Name of kebeles	Agro-ecology	Household size			Sample size		
			Male HH	Female HH	Total	Male HH	Female HH	Total
1	Garbo	Midland	563	77	640	32	5	37
2	Elifeta	Midland	576	70	646	33	4	37
3	Ya'a Bukuna	Midland	545	68	613	31	4	36
4	Jarso Onjojo	Midland	581	65	646	35	3	37
		Total	2265	280	2545	131	16	147

3.4. Data types and Sources

The study used both primary and secondary data both of which comprise qualitative and quantitative data. Primary data were collected from sampled households, with a focus on socio-economic & demographic characteristics of households in the study area and other essential information related to objectives like livelihood diversification, adaptation strategies. Secondary data like long term trends of livelihood, long term agricultural and land use system, crop yield data were collected from GO office reports and documents while rainfall and temperature data were obtained from the National Meteorological Agency.

3.5. Methods of Data Collection

3.5.1. Rainfall and temperature data

Rainfall 1985-2017 and temperature 1989-2017 data was collected from Regional meteorological records to analyze the trends of climate variable (rainfall and temperature) in the study area.

3.5.2 Socio economic and demographic profile

Household survey is the commonly used approach in various data collection activities. In this study, it was the major primary data source. Structured questions were prepared to collect data on major issues such as climate change and diversification response to climate change, and key challenges they faced to adapt and also socio economic and demographic characteristic of respondents. Before the collection of actual data, the questionnaire was pretested to avoid some inconsistency in the questions. In order to ensure quality data collection, special attention was given to selection and training of enumerators. Four enumerators selected based on their education level and awareness about the localities as well as language, and provided with one day training about the questionnaire and objectives of the study. Following this, interview schedule was set to collect data from selected respondents.

3.5.3. Data collection instruments

3.5.3.1. Questionnaire

Before conducting the main survey, the questionnaire was tested on household heads that was not be in the sample in respective sample kebeles in order to check the validity and reliability of the questions. After necessary amendments following the feedback from pilot survey, final version of questions were prepared in English and translated in to vernacular language,

Hadiyissa. Then, similar questionnaire was used for all the respondents of the sample household heads through the use of open-ended and close-ended questionnaire. The actual data was collected by conducting sample household respondents. The investigator hired and trained enumerators with frequent monitoring and supervision for the better progress of data collection.

3.5.3.2. Focus group discussions

Focus group discussions was conducted using six groups of farmers who are not included in the main sample survey pre group from each sample kebele is conducted to make the process of data collection more effective. The discussions were focused on the research issues carried out among groups classified by sex, age and economic status of people. The FGDs was held with male, female and elder household heads that likely represent the opinion of the community and out of questioner respondents. Care was been taken to avoid idea dominancy of specific group and to capture disaggregated data as much as possible.

3.5.3.3 Key Informant Interview:

In order to understand in depth of historical trend of rainfall and temperature variability, climate change and variability induce change crop production and livestock production and to remember extreme climate events in the study area, in depth interview was conducted with 4 elders, and 8 DAs and 1 District disaster prevention and preparedness officer.

3.5.3.4. Field observation

The investigator conducted frequent field observation in sample selected kebeles. Thus helped to understand the local condition of the community in terms of the climate change and variability related problems impacts as well as diversified livelihood strategies developed in

the area. Through conducting transects walking across the study area. The investigator used checklist and visual photograph. In general, it helped the investigator to reduce complexity and even to make the research work more fruitful.

3.6. Method of Data Analysis and Presentation

The data collected through different methods analyzed by using descriptive and inferential statistical analysis. Before analyzing the data, raw data was processed (coded, edited, ordered and organized) to generate relevant information. To accomplish the analysis of the data for better understanding of the issues covered in the study, the investigator analyzed by using descriptive statistics and like, (frequency distribution, mean, and percentages). Moreover, inferential statistics such as trend analyses regression was employed with the help of Statistical Package for Social Sciences (SPSS) version 20 and Microsoft Excel software. Figures, pictures and tables, used to represent the collected and analyzed data.

3.6.1. Inferential Statistical analysis

In order to achieve the third objective of the study which identifies livelihood diversification of the household head, multinomial logistic (MNL) model was applied.

A multinomial logit (MNL) model used to estimate the polytomous response variable (i.e. clusters) to a set of regressor variables determining the household choice of diverse livelihood strategies (Mutenje *et al.*, 2010; Soltani *et al.*, 2012). The explanatory variables were the livelihood assets and socio-economic factors (e.g. number of household members and income). The goal is then to predict the livelihood of a household, with given characteristics, choosing a cluster representing an identifiable combination of livelihood activities.

The probability associated with choice of a livelihood strategy of a rural household is denoted

by P_{nj} ($j = 1-4$), where n represents the household; $j = 1$ represents the rural household in choosing livelihood strategy in cluster 1; $j = 2$ represents the rural household in choosing livelihood strategy in cluster 2. The multinomial logistic model is specified as follows, assuming that the unobserved portion of the utility (ε_n) is identically and independently distributed (iid) across alternatives according to Train (2003), cited by Babulo *et al.* (2008)

$$P_{nj} = \frac{e^{\beta x_n + H_n}}{\sum_{j=1}^4 e^{\beta x_n + H_n}}$$

If the β s and the γ s are set to zero for one of the activities (for instance cluster 1), the MNL model for each activity ($j \neq$ cluster 1) can be expressed as:

$$P_{jjn=1} = \frac{e^{\beta x_{nj} + H_{nj}}}{1 + \sum_{j=1}^4 e^{\beta x_{nj} + H_{nj}}} \quad (j=2, 3, \text{ and } 4) \text{ and}$$

$$P_{n1} = \frac{1}{1 + \sum_{j=2}^4 e^{\beta x_{nj} + H_{nj}}}$$

Where H_n is a random disturbance and, x_n are the explanatory variables.

3.7. Variable definitions and hypothesis

This study focused on the rural households in the study area. Thus, variables employed here are the characteristics of household heads. First, the outcome variables (variables used as dependent variable) are defined and described below.

In this study livelihood diversification is polychromous dependent variable which takes the value 1 if the household livelihood strategy is on farm only; 2 if the household livelihood strategy is on-farm and non-farm; and 3 if the household livelihood strategy is on-farm and off farm and 4 if the household's livelihood strategy is the combination of on-farm, non-farm and off-farm activities.

The independent variables that expected to affect diversification of livelihood strategies of rural households in the study area are discussed below.

Household size (HHSZ): This variable was measured as a continuous variable. This variable was anticipated to positively be associated with the household choice of livelihood diversification activity. Khatun and Roy (2012) established that household size impacts the ability of a household to supply labour. In a large household some members could stay engaged in traditional farming while others could choose non-farm/off-farm activities. Therefore, a positive relationship was expected between livelihood diversification activities and household size.

AGE (AG): This variable was measured continuous according to the years of the household head. This variable was hypothesized to have a negative influence on household choice of livelihood diversification activities. This is because the older the household heads get, the more reluctant they become to diversify. According to Mariotti *et al.*, (2014) as age increases and the household heads cross the turning point of approximately 60 years, it is less likely that the households would choose to have diversified livelihoods.

SEX: This variable was coded as a dummy variable with one if male and zero if

female. Dirribsa & Tassew (2015), gender is an important factor in influencing the choice of physically challenging work and therefore the household livelihood diversification activities. In this study, male headed households were expected to be positively related to diversification compared to their counterparts; this is because females are often restricted by time given their greater envelopment in household chores. Furthermore, male-headed households have more access to opportunities than female-headed households, the probability of diversifying is expected to be positive for the former (Beyene, 2008). Therefore, the choice of households to livelihood diversification activities was expected to be positively associated with the gender of the household head.

Education (EDU): This was measured as a continuous variable representing the number of formal and non-formal education years of the household head. This variable was expected to be positively associated with household choice of livelihood diversification activities. This is expected because the more educated household heads are, the more diversified activities they would have (Yizengaw *et al.*, 2015). Formal education increases the knowledge that one needs to become competent to choose activities that generates more income and up to date with all the modern technologies that make entrepreneurship much easier (Asfaw *et al.*, 2016). Therefore, enhancement in the educational level will escalate the probability engagement in livelihood diversification (Khatun & Roy, 2012).

Extension services (EXTNs): This was coded as categorical dummy variable one if the household had access to extension services and zero if not. Access to extension services was expected have a positive impact on choice of livelihood diversification of

activities; this is because extension services provide information and acts as a pull factor enabling households to take advantage of diversification opportunities (Asfaw *et al.*, 2015).

Credit access (GTCD): credit access refers to the household's opportunity to get credit service from formal/or informal institutions. It is dummy variable and takes 1 if there is credit use by rural farm households and 0 otherwise. Both the availability of access to formal credit had a positive and significant effect on the level of livelihood diversification. Because, without access to institutional credit rural farm households are not able to undertake any non-farm income-generating activities which requires some initial investment.

Livestock holding (LVON): livestock is a continuous variable which refers to the total number of household's livestock holding. Larger livestock holding generates household's income through sale of animals and animal products (milk, butter etc.) and enables them to accumulate more capital and thereby investing in different non/off farm activities.

Saving: This is a dummy variable given one if the household have saving that is generated between the two waves otherwise zero. It would have positive and significant effect on the level of livelihood diversification.

Land size (FMSZ): This was measured in hectares as a continuous variable indicating the total land size households owned. Increases in farm size explained by the assurance of households to invest in varying source of income and develop the land. Culas and Mahendrarajah (2005) found that in Norwegian farm size has a positive effect on household diversification. In addition, Anderson (2012) found out that bigger land sizes have largely been associated to increased involvement in agricultural activities.

Table 2. Variable description

Independent variables' name	Definitions	Nature
HHSZ	The size of the household size represented by the number of household members	Continuous
GND	Sex of the household head	A dummy variable with 1= male and 0=if female
AG	Age of the household head in years	Continuous according to the years of the household head.
EDU	Years of formal and non-formal education of the household head	A continuous
FMSZ	The total land size households Owned	A continuous variable
EXTNs	extension workers as information sources for farming activities	Dummy variable one if the Household had access to extension services and zero if not
GTCD	Credit access to the households	Dummy variable and takes 1 if there is credit use by rural farm households and 0 otherwise.
LVON	This refers to the total number of household's livestock holding.	A continuous variable
Saving	Saving from returns	A dummy variable given one if the household have saving that is generated between the two waves otherwise zero.

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents and discusses findings in the study area, climate change by recorded meteorological data of the past 30 years and identifying livelihood diversification response to climate change through household survey, focus group discussion and key informants.

4.1 Socio-demographic characteristics of the Respondents

Regarding to the sex, 89.1% were male and 10.9% were female. With regard to the age, the majority of the households were in the working age group. The mean age of the respondents was 37 years of old, with maximum 67 years and the minimum 28 years and 35.3% of the respondents were in the age group 36 to 45 years, 39.4% of the respondents were in the age group of 46 to 64 years, 24.4% of the respondents were in age group of 25 to 35 years and the oldest age group (>65) was only 0.68%. Indicating that those young age households relatively have active labour force which enables them to participate on off/non-farm activities.

Regarding to the educational back ground 17.6% of the respondents could not read and write whereas 23.8% of the respondents could read and write, nearly half of respondents (49.6%) were primary school complete while 7.4% of the respondents were secondary school complete and the rest 2% of the respondents were diploma and above. The result shows that majority of respondents were ready for capturing new information and technologies.

Regarding to family size of the respondents 43.5% had 6 to 9 family sizes whereas 49% had 3 to 5 family size, 3.4% had 1-2 family size and 4.8 had greater than 10 family sizes (Table 3). The survey result indicated that more than half of respondents had larger households to divert their labour to different activities to generate more income and provide for their households.

Table 3. Socio-demographic characteristics of respondents (n=147)

Variables	Frequency	Percentage
Sex		
Female	16	10.88
Male	131	89.12
Age		
From 25 to 35 years	36	24.49
From 36 to 45 years	52	35.37
From 46 to 64 years	58	39.46
Above 65 years	1	0.68
Educational level		
Cannot read and write	26	17.69
Can read write	35	23.81
Primary school (grade1-8)	73	49.66
Secondary school (grade 9-10)	11	7.48
Diploma or above	2	1.36
Family size		
1-2	5	3.40
3-5	72	48.98
6-9	64	43.54
Above 10	6	4.08

4.2 Institutional Information of the Respondents

From the total respondents, 62.5% had extension contact with kebele development agents but 37.4% did not have extension contact. Among those who had extension contact with the development agent 9.5%, 20.4% and 70.1% had contact always, frequently and sometimes, respectively. When the respondents were asked whether they had got training, 68% replied yes

but 32% had not got training. Concerning the type of training, respondents have got from development agent, 58.5% of respondents were about adoption of new technology in farm activities 21.1% of respondents were giving information about rain fall distribution in order to give early warning, 5.4% of respondents were climate change and how it can be cope up, 7.5% of .respondents were about livelihood diversification,7.5% of respondents were other training like soil and water conservation structures construction(soil bund construction).

The study results in the table 4 shows that, 52.3% of respondents have an access to credit services and 47.6% have no access to the services. The result showed that credit is one of the basic means of financial solution for poor rural household for the time of adverse condition and helps to undertake various activities but approximately half of respondents have no access.

Regarding to the purpose of taking credit, 18.4% were to purchase oxen, 9.5% were to purchase seeds, 4.8% were to purchase fertilizer, 2.8% purchase of chemicals, 6.1% for consumption 23.8% were to social obligation and 34.7% were to new investment (like packing of animals, trades of small ruminants).The result shows that taking credit is more essential for the purpose of new investment.

Table 4. Institutional information of respondents (n=147)

Variables	Frequency	Percentage
Extension Contact with DAs	55	37.41
No		
Yes	92	62.59
How often do you contact DAs		
Always	14	9.5
Frequently	30	20.4
Sometimes	103	70.1
Have you got training from kebele development agent		
Yes	100	68.0
No	47	32.0
Saving habit		
No	55	37.41
Yes	92	62.59
Access of credit		
No	70	47.62
Yes	77	52.38
Purpose of taking credit		
purchase of oxen	27	18.4
purchase of seeds	14	9.5
purchase of fertilizer	7	4.8
purchase of chemicals	4	2.7
For consumption	9	6.1
For social obligation	35	23.8
To start new investments	51	34.7

Own land here refers to the land owned through Government land distribution, inheritance and/or family gift. Land renting and crop land sharing are the main means of accessing land for smallholders. About means of accessing land, 71.4% respondents were from owned land whereas 10.2% were from rented land and 18.4% were crop lands sharing. The result tells us land renting and Crop land sharing are the main means of accessing land for smallholder and landless households (Table 5).

Table 5. Ownership status of the land

Variable	Frequency	Percentage
Own land	105	71.4
Rented land	15	10.2
Land sharing	27	18.4

4.3 Trends of Rainfall and Temperature

4.3.1 Trends of rain fall variability in the study area

Climate change is expected to create a serious risk on environment, agricultural production and food security of most developing countries including Ethiopia. The Ethiopian climate is characterized by great variation in different parts the country and a history of climate extremes such as drought and flood, and increasing and decreasing trends in temperature and precipitation is common in the country.

The data obtained from Ethiopia metrological Agency revealed that the coefficients of variation of study area were 36.6%, 26.9% and 25.7% for spring season (belg season), summer

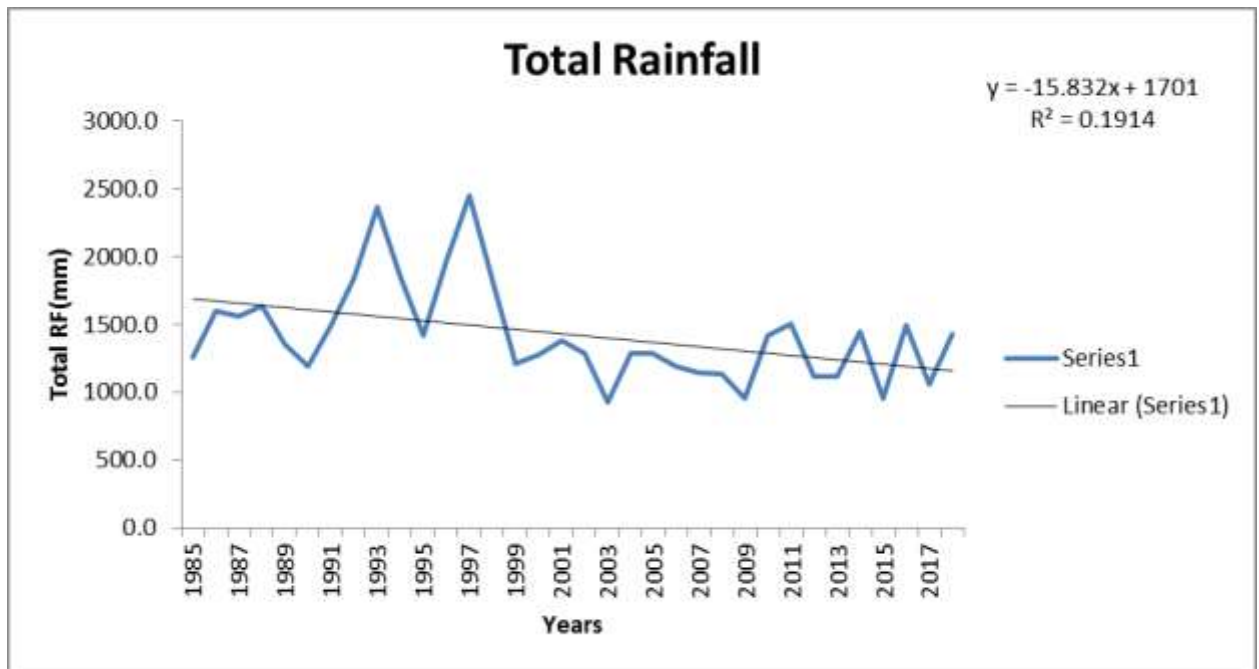
season (kiremt season) and annual rainfall, respectively which indicate that there was high inter annual variability of rainfall between 1985-2017. The degree of Variation in amount of rainfall was higher for spring season than summer season (Table 6).

Table 6. Coefficient of variance for annual, spring (belg) and summer (kiremt) rainfall (1985-2017)

Rainfall	Mean rainfall (mm)	CV (%)
Annual	1424	25.7
Spring	526.7	36.6
Summer	682.2	26.9

Source: National Metrology Agency of Ethiopia (2019)

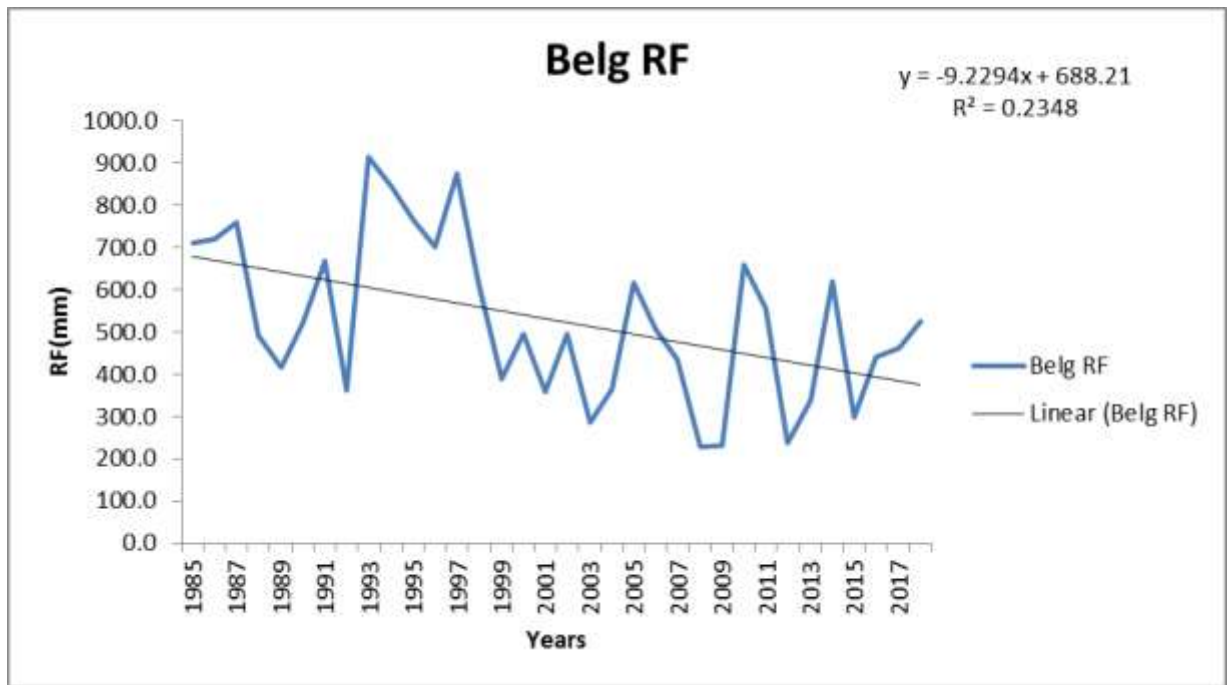
The annual rainfall in West Badawacho District over the 32 years decreased by about 15.83mm annually (Figure 3), this is also confirmed by the respondents, the trend of rainfall according to respondents' perception, 59.9%, 34.7%, and 5.4% said decreasing, fluctuating and increasing, respectively.



Source: National Metrological agency, Ethiopia (2019)

Figure 3. The trends of annual rainfall variability in the study area

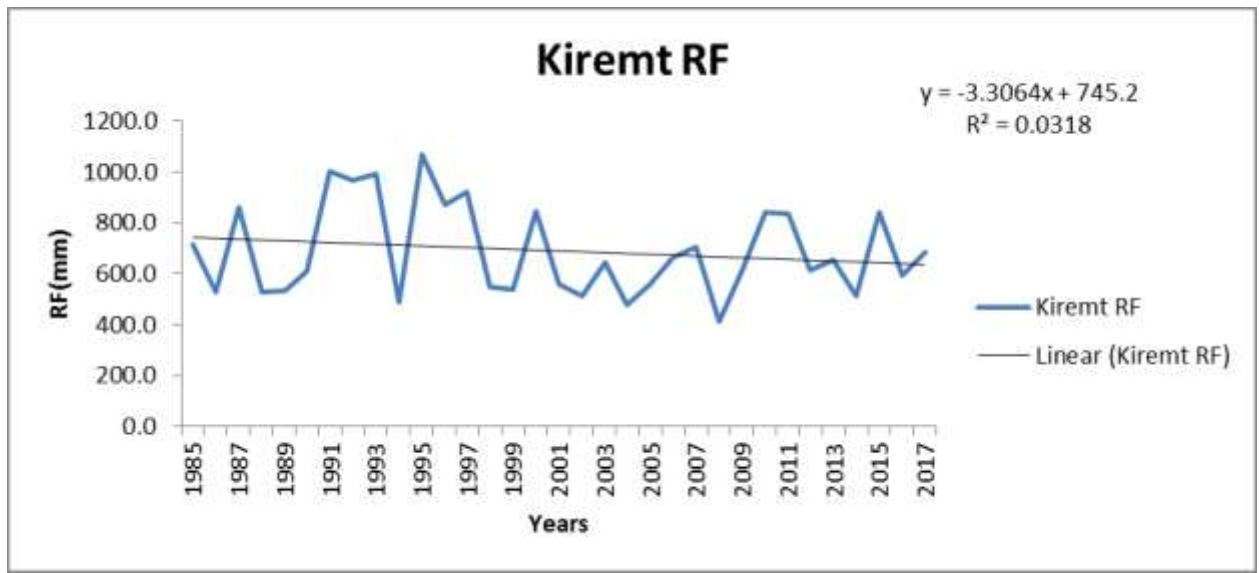
The spring season (belg) rainfall in West Badawacho District over the 32 years decreased by about 9.23mm (Figure 4), this is also confirmed by the respondents, the trend of rainfall according to respondents' perception, 59.9%, 34.7%, and 5.4% said decreasing, fluctuating and increasing, respectively.



Source: National Metrological agency, Ethiopia (2019)

Figure 4. The trends of spring season (Belg) rainfall in the study area

The summer season (Kiremt) rainfall in West Badawacho District over the 32 years decreased by about 3.306mm (Figure 5), this is also confirmed by the respondents, the trend of rainfall according to respondents' perception, 59.9%, 34.7%, and 5.4% said decreasing, fluctuating and increasing, respectively.

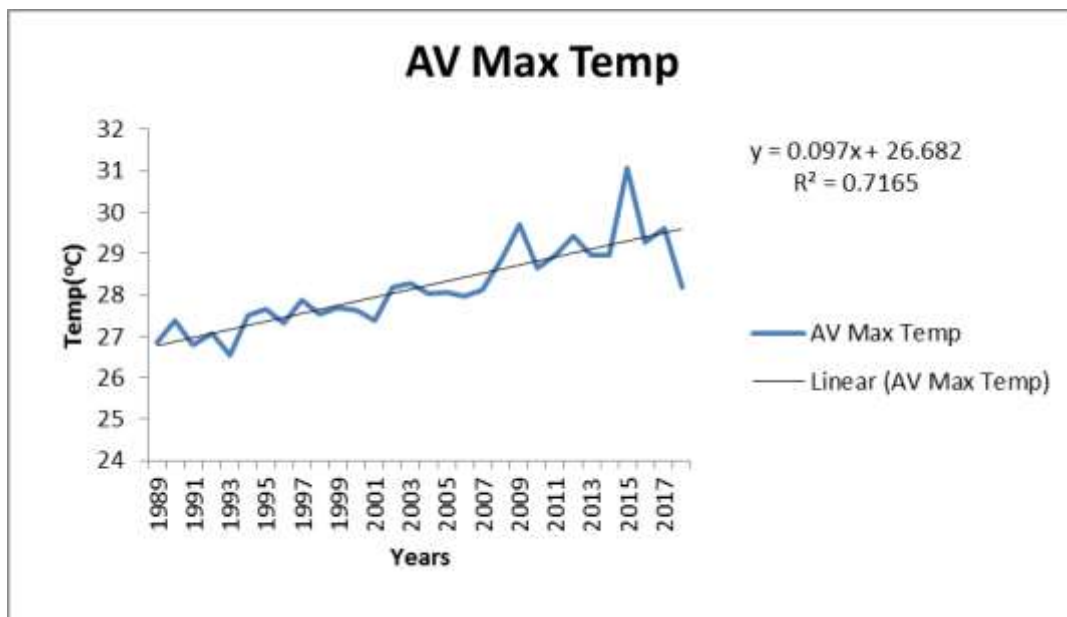


Source: National Metrological agency, Ethiopia (2019)

Figure 5. The trends of summer season (kiremt) rainfall in the study area

4.3.2 Trends of temperature in the study area (1989-2018)

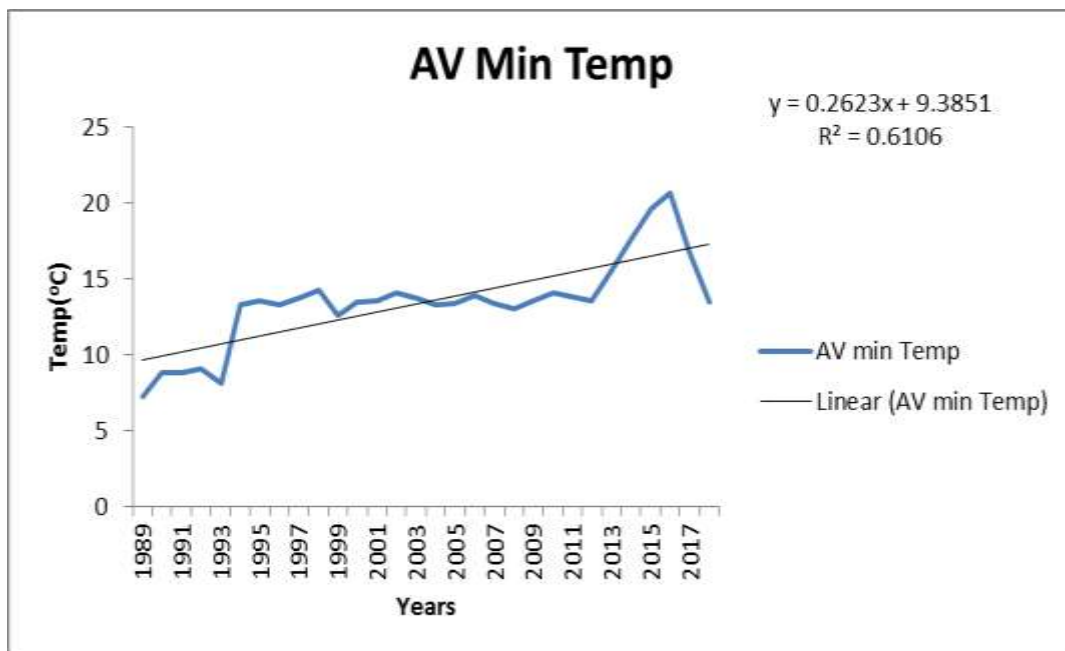
The average yearly maximum temperature of the study area was 28.18°C, while the average minimum temperature was 13.45°C. As indicated in Figure 6, the maximum temperature of the West Badawacho District over the past 28 years increased by about 0.097°C annually, while average minimum temperature is increased by 0.2623°C (Figure 6 and 7) . This result obtained from the Ethiopia Metrology Agency is in line with the survey result of respondents regarding the increment of temperature over the past thirty years in the study area.



Source: National Metrological Agency, Ethiopia (2019)

Figure 6. Trends of maximum temperature

The trend analysis of Metrological data record of temperature period (1989-2018) also showed that increasing trend in yearly maximum temperature over the past 28 years. Thus, farmers' perception appears to be in accordance with the statistical record of temperature from Metrological station.



Source: National Metrological Agency, Ethiopia (2019)

Figure 7. Trends of minimum temperature

4.4. Respondents perception of climate change and variability

When respondents were asked whether they have heard about climate change, about 97.3% of respondents replied yes, they were heard about climate change, but 2.7% of respondents replied no, they were not heard about climate change and variability in the study area. Regarding local indicators that evaluate rain fall pattern, 20.4% were loss of some plant and animal, 8.1% were increased drought and flood, 18.4% were growing period of plant has shortened, 23.1% were rain fall comes early or lately, 21.8% were decline agriculture yields, 5.4% were decreased available water (Table 7).

According to respondents were asked about changing condition of rain fall distribution pattern has effect on reduction of households income. From sample households 94.0% of respondents

were replied yes, for effect of changing of rain fall pattern has reduction effects of households income, 6% of respondents were replied no, for the effects of changing pattern of rain fall has no reduction effect of households income.

According to study result that show on perception of sampled respondents on the trends of temperature and rain fall show that 97.3% of the sampled households perceive that temperature has become warmer over the years and 89% of the sampled households were perceive that rain fall has declined with time. Deressa *et al.* (2008) also indicated that majority of contacted farmers in Ethiopia are aware of climate change and perceives an increase temperature and decrease rainfall.

Participants of focus group discussion stated that; we know well about climate change and variability in our area throughout many years, there is disordered rain fall patters. Most of the time rain fall starts lately and ends early, sometimes it onset lately and ends lately and this effect occur when the crop is already ready for harvest.

Table 7. Local indicators that evaluate rain fall patterns in the study area.

Variables	Frequency	Percentage (%)
Have you heard of the word climate change before		
Yes	143	97.3
No	4	2.7
Local indicators that evaluate RF pattern		
Loss of some plant and animal species	30	20.4
Increase drought and flood frequency	10	6.8
Growth period shortened	27	18.4
Rainfall comes early or lately	34	23.1
Decline of soil productivity/fertility	6	4.1
Decline of agricultural yields	32	21.8
Decreased available water	8	5.4

More than one response is possible for local indicators, and therefore the sum of the respondents may be more than the sampled household number.

Study results indicated that the major type of climate change and variability which are experienced in the area 90.0% were drought and 88.7% were too little rain fall and they occur frequently and always respectively. Off seasonal rain fall and high temperature were others indicators of climate change and variability the respondents always experienced in the study area. Flood and frost were also other indicators of climate change and variability those were the respondents rarely experienced in the study area. Studies show that over the past three decades, 17 Ethiopia has experienced countless localized drought events and seven major droughts, five of which resulted in famines (World Bank Group, 2010).

The study result indicated that the factors affecting crop production 40.8% were unpredicted rain fall, 8.8% were increased rain fall, 20.4% were increased pests and diseases, 10.2% were low soil fertility, 6.1% was shortage of labor, 7.5% were inadequate farm land, 6.1 % were high price of farm implements.

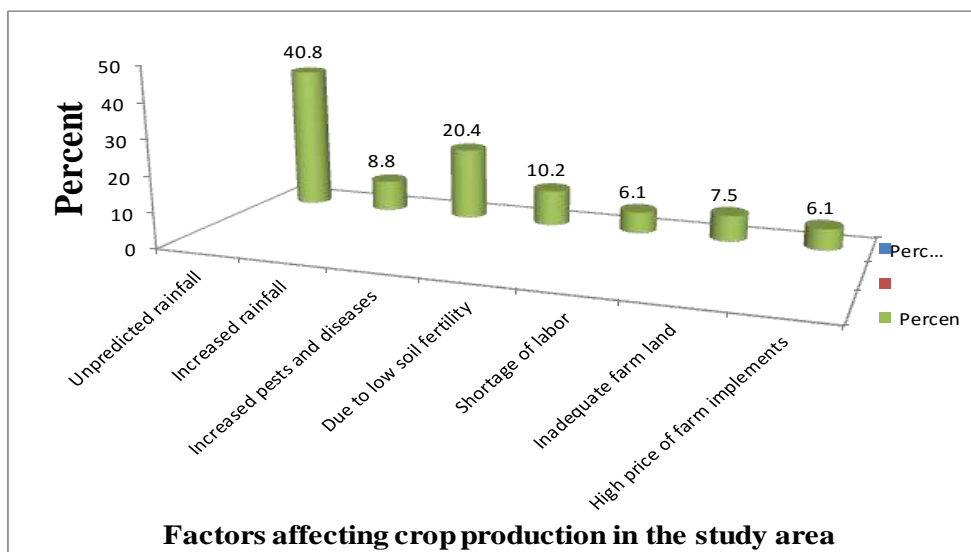


Figure 8. Factors affecting crop production in the study area

Regarding to trend of rain fall according to respondents perception, 59.9% were perceived decreasing, 34.7 % were perceived fluctuating and 5.4% were perceived as increasing. Most of the respondents were perceived that trends of rain fall was highly decreasing and fluctuating in amount and small numbers of respondents were perceived as increasing in the study area.

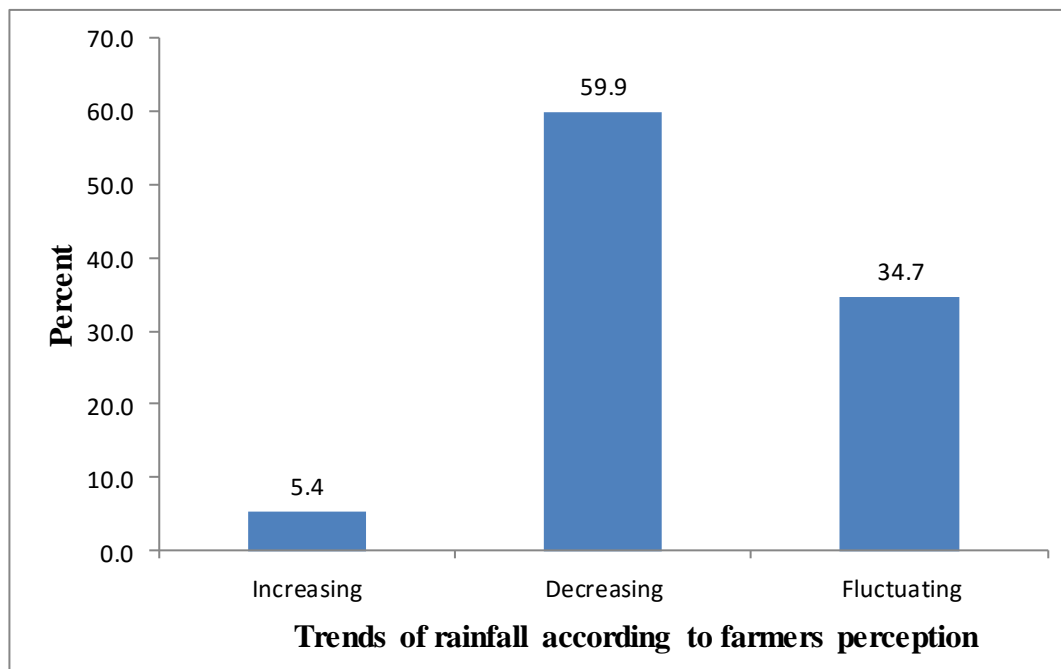


Figure 9. Respondent’s perception of trends of rain fall

The study result indicated that the trends of temperature according to respondents' perception, about 85.7% of respondents said increasing, 10.9% of respondents were said fluctuating and 3.4% of respondents were perceived as constant (Figure 10).

In general, smallholder farmers in the study area perceived well about the basic two elements of climate which are temperature and rain fall trend over the past thirty years.

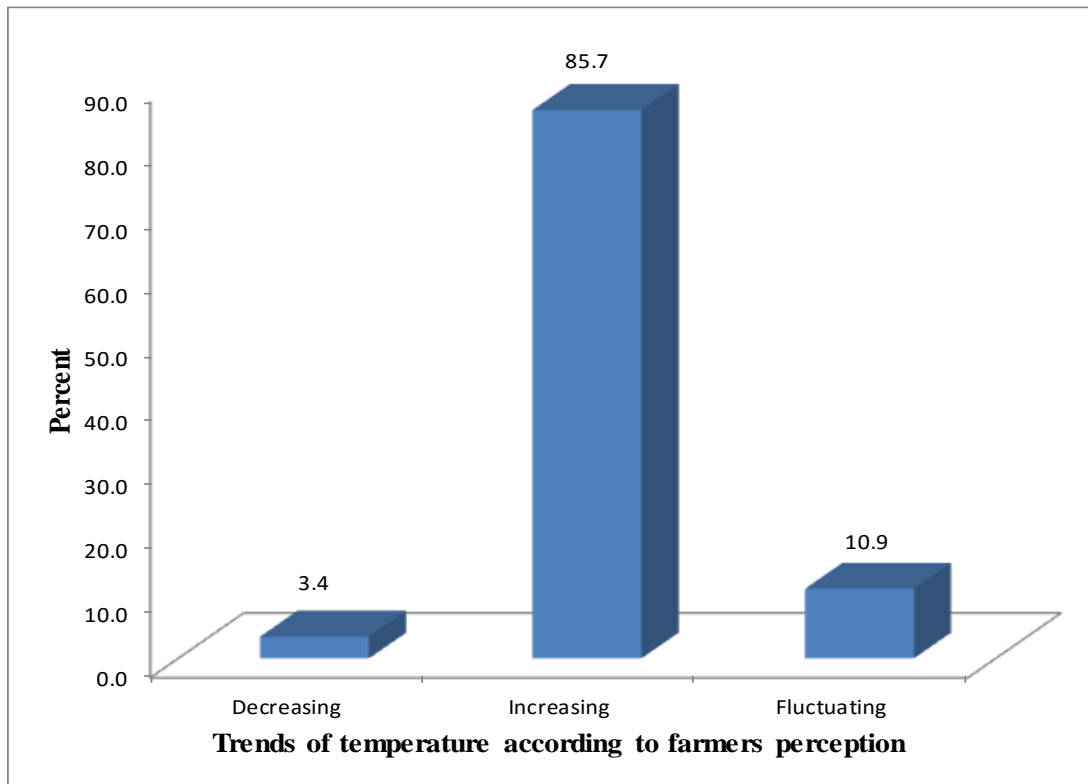


Figure 10. Respondents' perception about the trends of temperature

4.5 Livelihood strategies of the study Area

4.5.1 On-farm activities

4.5.1.1 Crop production

Depending on the extent of households' land size and crop production inputs like land, fertilizer, varieties and management skills the types and amount of crops grown differ from the household to household. Dominantly growing crops in the study area includes teff (*teff eragrostis*), haricot bean (*phaseolus vulgeriesL.*), maize (*zayemaze*), wheat (*triticum aestivumL.*), sorghum (*sorghum bicolor*), potato (*solanum tuberosumL.*), and enset (*Enset ventricosum*).

Table 8. The area coverage of crops in hectare

Crop grown	Mean	SD	Minimum	Maximum
Teff	0.4565	0.23075	0.25	1.25
Maize	0.4100	0.21029	0.13	1.00
Haricot bean	0.3480	0.19636	0.13	1.00
Sorghum	0.0629	0.03853	0.01	0.13
Potato	0.2267	0.18006	0.01	0.13
Wheat	0.0245	0.04982	0.00	0.25
Enset	0.0501	0.04212	0.00	0.13

4.5.1.1.1 Failure of crop production in the study area

The respondents were asked that they faced crop failure, the result indicated as 86.4% replied yes, they were faced crop failure in the production year of 2017/2018 and 13.6% were replied No, in the production year of 2017/2018. The result indicated that the main reason for crop production failure due to shortage of rainfall, early cessation of rainfall and late onset were 47%, 43% and 33% respectively. Crop failure resulted from extreme weather events were increasing in frequency. Farmers in the study area were forced diversify their livelihood activities and to have better adaptation strategies under the stress of climate change and variability. The key informants in the study area stated that failure of crop production is mainly due to lack of rainfall on time and variability of its distribution pattern. According to CSA the amount and temporal distribution of rainfall and other climatic factors during the growing season are critical to crop yields and can induce food shortages and famine (CSA, 2008).

Table 9. Failure of crop production

Variables	Frequency	Percentage
Have you faced failure of crop production		
Yes	127	86.4
No	20	13.6
Reason for crop failure		
Crop diseases	15	10.2
Shortage of rainfall	47	32.0
Flood	6	4.1
Problem of late onset rainfall	33	22.4
Reduction of crop production and productivity	3	2.0
Problem of early cessation of rainfall	43	29.3

4.5.1.2 Livestock ownership

The second most important agricultural activity in the study area is livestock production. Goats and sheep, cow, oxen and poultry are reared for both income and consumption purpose. Above 98.8% the households were engaged in rearing at least one of the livestock types.

Table 10. Livestock types owned by respondents

Livestock type	Mean	SD	Min	Max
Sheep	2.56	1.597	1	6
Goats	0.29	0.662	0	3
Cow	1.56	1.314	0	4
Oxen	1.35	0.985	0	4
Calf	2.01	1.057	1	6
Poultry	3.10	1.892	0	12
Donkey	0.48	0.715	0	2

4.5.1.2.1 Challenges faced in livestock production

Livestock are the major source of income in rural area where mixed farm is practiced. Particularly the ownership of farm oxen forms the cornerstone of farm economy in the rural households. It determines the household's food security status and the level of vulnerability to climate change impacts.

The major problem of livestock production in the study area 46.3% were drought, 8.2% were increase of disease outbreak, 2.7% were lack of veterinary services and 42.9% were shortage of forage according to their order of security of problem (Figure 11).

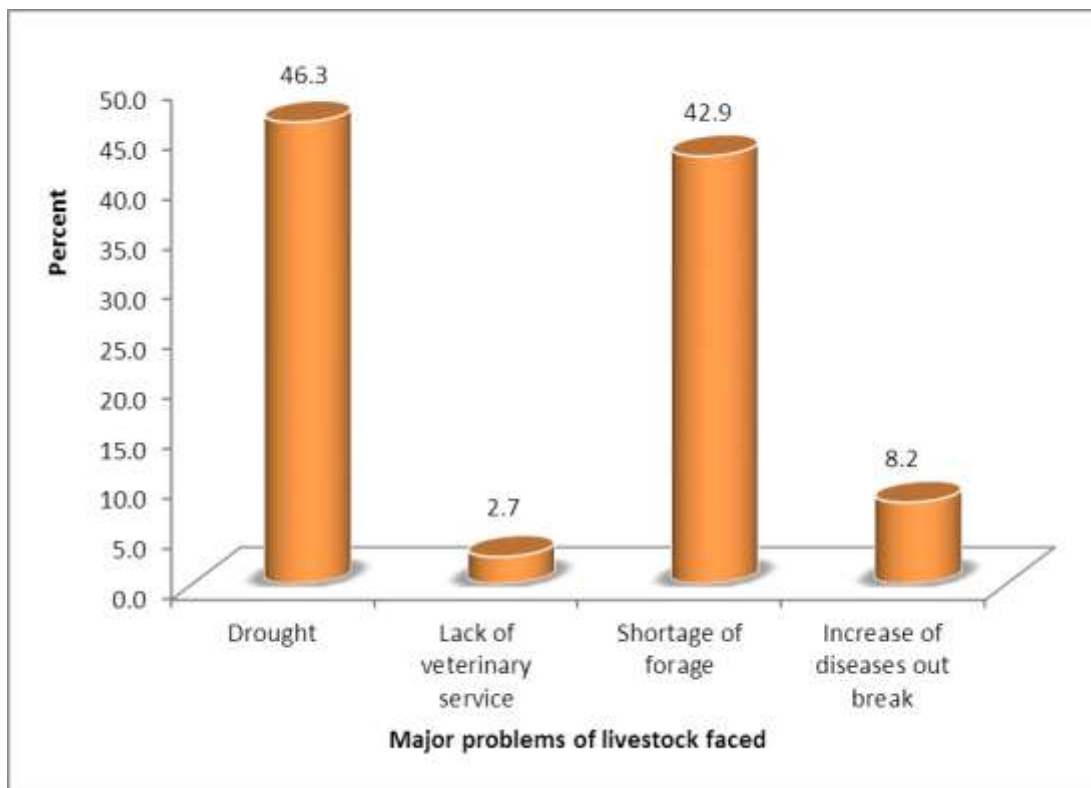


Figure 11. The problem which causes livestock mortality

The study result indicated that the problem of livestock rearing 36.7% were climate change, 27.9% were shortage of grassing land and 19.7% were the outbreak of diseases due to climate change and variability were the major problem that farmers faced in livestock rearing (figure 12). The projected increase in temperature and rainfall variability and recurrent drought would favorable condition for pests and disease outbreak as well as water stress in which this also aggravate loss of livestock production and deaths. The impact of climate change can heighten the vulnerability of livestock systems and exacerbate existing stresses upon them, such as drought (Abebe, 2013).

On the other hand participants of FGDs were stated that, due to challenges of climate change and variability rural people who are dependent on rain-fed agriculture are exposed to food insecurity. Participants said that, “we all are highly depend on agriculture for any means of expense, for example expense of schooling our children, expense of our household, social obligation expense, and rearing of livestock activities are affected by climate change and variability we faced a numbers in security of life”.

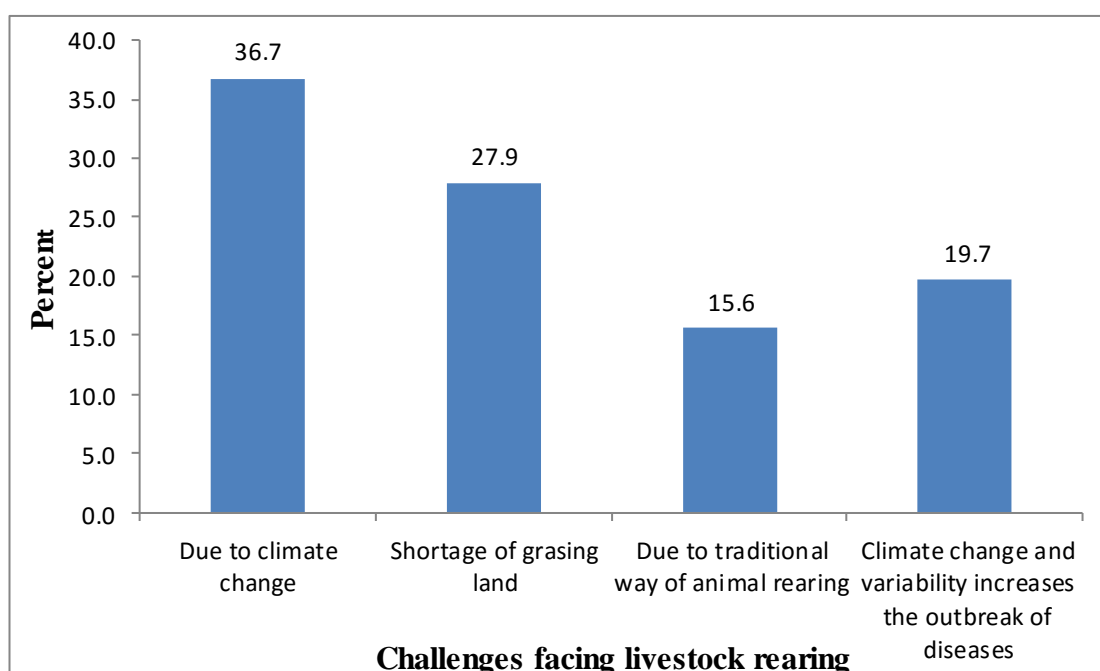


Figure 12. Challenges facing on livestock rearing

4.5.2 Off-farm and Non-farm Livelihood strategies in the study Area

4.5.2.1 Off-farm activities

An off-farm activity here refers to agricultural activities which take place outside the person's own farm. The activities includes local daily wage labour at village level or the neighboring

areas in return for cash payment or it is the agricultural work at another person's farm in return for part of the harvest in kind.

In this regards those who participated on off-farm activities, like rent of land were 15.0%, daily wage labour were 23.1%, 10.9% were sales of fire wood and 2.0 % were sale of charcoal (Table 11).Key informants also stated that daily wage labour is the most important means of generating income at times of food shortage. Most of the time for pushes reasons smallholder rural farm households are engaged in daily wage labours in others farm crop weeding and harvests.

Table 11. Respondents participated into off-farm activities (n=75)

Variables	Frequency	Percentage
Daily wage labor	34	23.1
Sales of fire wood	16	10.9
Sales of charcoal	3	2.0
Rent of land and packing animals	22	15.0
no any activities	72	49.0

4.5..2.2 Non-farm activities

Non-farm activities in this study refer to activities takes place outside the agricultural sectors. It includes handcraft activities, petty trading likes coffee, local beverages, trading of small ruminants and cattle. In these regards those who participated in petty trading like coffee

19.7%, 0.7% were handy craft, 2.7% were in selling local beverages, 22.4% were in trading of small ruminants and cattle and 17.7% were remittance (Table 12).

Table 12. Respondents participated in to non-farm activities

Variables	Frequency	Percentage
Petty trading like coffee	29	19.7
Hand crafts like making weaver and poet making	1	0.7
saling local beverages like Araqe (katikala)	4	2.7
Trading of small ruminants and cattle	33	22.4
Remittance like income from relatives	26	17.7
No any activities	54	36.7

As key informants stated, most of rural households in the study area were engaged in non-farm activities like petty trades when the time of coffee harvesting and time of availability of cash crop in the area.

Regarding the participation of income source from non-farming to the households, 54.5% were getting their income from trading small ruminants and cattle, 17.4% were from petty trading like coffee, 12.4% were from remittance, 10.3% were from handy craft and 5.4% were from selling local beverage (Table 13).

Table 13. The income source (in Birr) from non-farming to the households

Income sources from non-farm activities	Mean	Std. Deviation	Minimum	Maximum	Sum	Percentiles
Petty trading	132.6531	607.61867	0.00	3500.00	1 9500.00	17.4
Handy craft	80.2721	693.87136	0.00	6800.00	11800.00	10.3
Making local beverage	42.1769	365.07180	0.00	3600.00	6200.00	5.4
Trading of animals	422.7891	1564.53888	0.00	8450.00	62150.00	54.5
Remittance	67.3469	408.33160	0.00	3600.00	9900.00	12.4
Total income					114050.00	100%

Regarding of income source from off-farming to the households, 29.9% were getting their income from rent land and pack animals whereas 10.3% were from sales of fire wood,1.1% from sales of charcoal while more than half of (58.5%) were from daily wage labour (Table 14).

Table 14. Off-farming as the income source (in Birr) to the households

Income sources from off-farm activities	Mean	Std. Deviation	Minimum	Maximum	Sum	Percentiles
Daily wage labor	645.5782	712.79705	0.00	2200.00	94900.00	58.5
Sales of firewood	115.6463	369.92237	0.00	2000.00	17000.00	10.3
Sales of charcoal	12.9252	110.58506	0.00	1000.00	1900.00	1.1
Rent land, pack animal	325.5102	608.53989	0.00	3000.00	47850.00	29.9
Total income					162150.00	100%

There were four livelihood strategies were identified which include the on-farm only, on-farm and non-farm, on-farm and off-farm and the combination of on-farm, non-farm and off-farm activities.

As shown in the figure 13, about 20.4% of the households entirely depend on the on-farm only livelihood strategy. On-farm activities are focused on both crop production and animal husbandry activities, 21.8% households depend on the combination of on-farm, off-farm and non-farm. Non-farm activities concerned with the non-agricultural activities and off-farm activities agricultural activities but takes place outside one's own farm and natural resource based activities, 36.7% of the respondents depend on on-farm and non-farm, this focused on

both crop production and animal husbandry activities and concerned with the non-agricultural activities and the rest 21.1% of respondents depend on on-farm and off-farm, both crop production and animal husbandry and off-farm activities but takes place outside one's own farm and natural resource based activities. Rural farm households in the study area followed one, two or a combination of these livelihood activities to pursue their livelihood strategies for diversifying their livelihoods to prevent environmental risks like drought and shortage of rainfall. Only on-farm livelihood strategy is more vulnerable to climate change and variability.

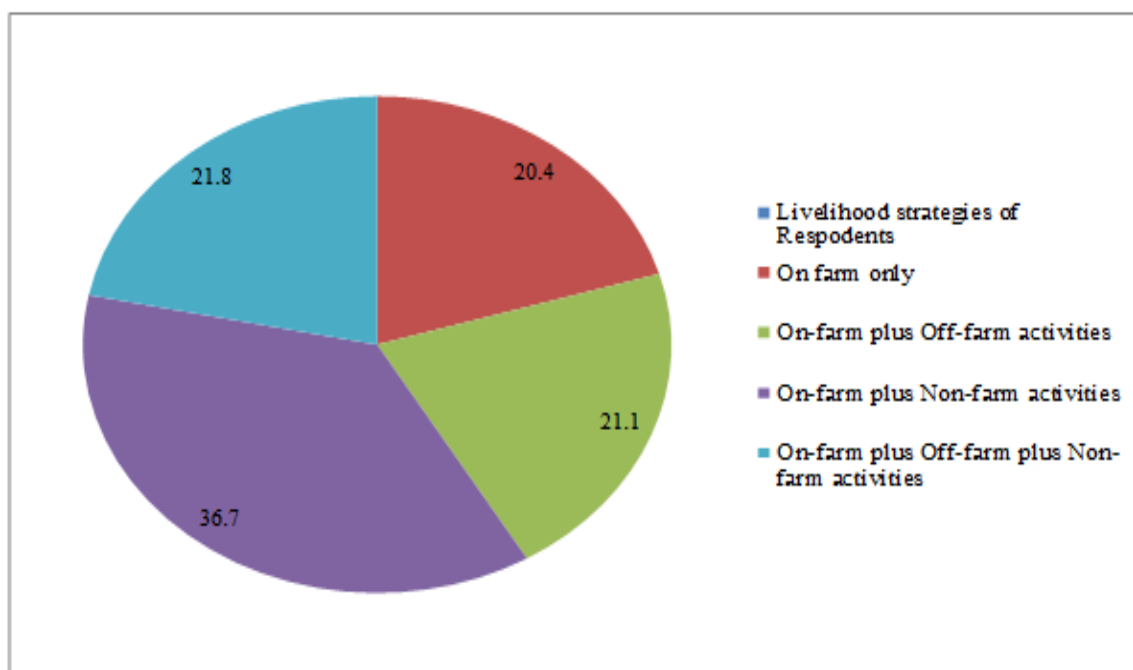


Figure 13. Livelihood diversification strategies in the study area.

The study result indicated that reason for engaged in non/off-farming activities 35.4% for survival under climate change impact, 21.1% were risk minimization, 25.2% were income

improvement, 21% were climate change adaptation and 1.2% were others (to get seasonal income especially harvesting time of coffee and time of food shortage).

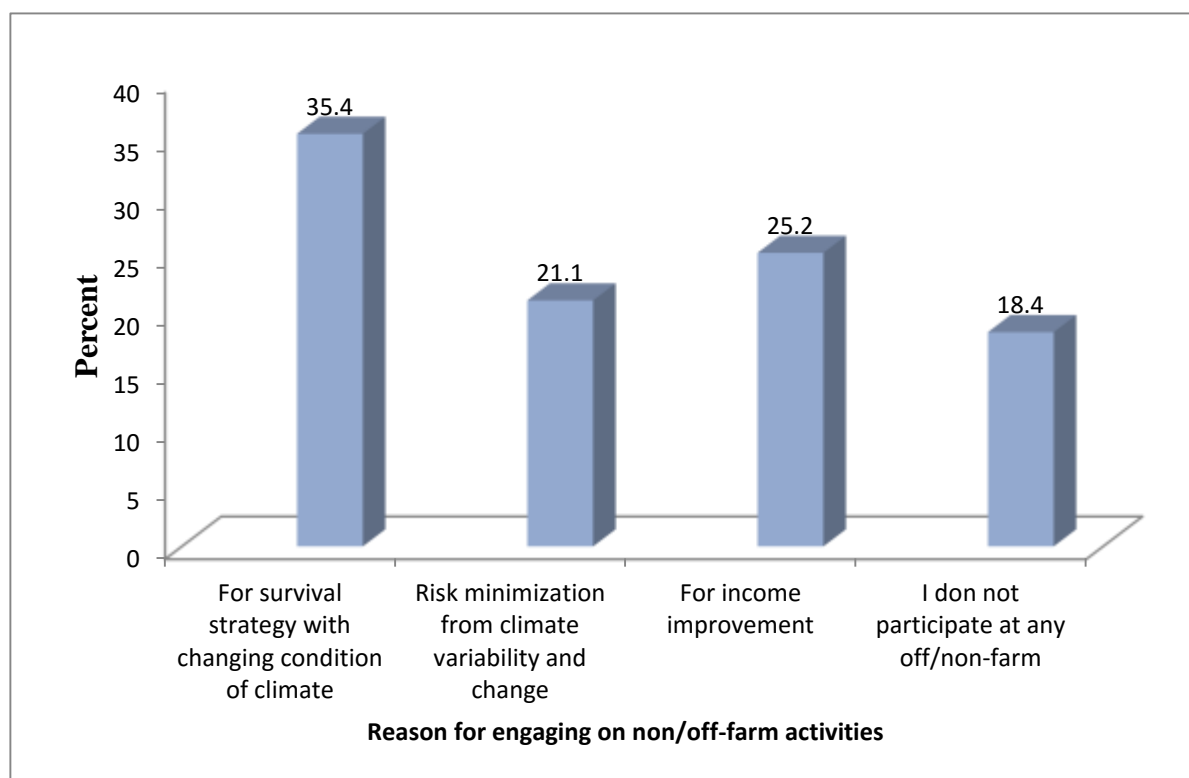


Figure 14. Reason for engaging on non/off-farming activities

4.5.3 The constraints of the households' choices of non/off-farm livelihood strategies

In the study area there are different constraints of non/off-farm livelihood strategies. From the total households who faced constraints, 31.3% of the households reported that were lack of capital is one constraint for the non/off-farm livelihood strategies. This indicates that the accessibility of credit in the study area is limited. And the other constraints that affecting households choice of non/off-farm livelihood strategies, 10.9% were lack of labour, 6.8% were lack of information about usage of non/off-farming activities, 36.1% were lack of credit, 11.6% were lack of support from NGO and governmental organization (Table 15)

Table 15. The constraints of non/off-farming activities

Constraints	Frequency	Percentage (%)
Lack of credit	53	36.1
Lack of different opportunities like poor infrastructure	5	3.4
Lack of support from NGOs and GO	17	11.6
Lack of working capital	71	41.5
Availability of different agricultural and non-agricultural risks lack of labor	16	10.9
Lack of information about the usage of non/off-farm activities	10	6.8

4.5.4 Contribution of livelihood diversification to climate change adaptation

The study result indicated that most of respondents 91.2% were agreed that the diversification of livelihood have role to climate change adaptation, and very small numbers of respondents 8.8% were not agreed that the diversification of livelihood have role to climate change adaptation.

Key informants stated that for adaptation of climate change and variability at local level is timing of growing of crop, early planting is one adaptation strategies to climate change and variability. Diversifying of crop with livestock and non/off-farm activities are other adaptation strategies to climate change variability at local level. But, it is not sufficient way to adapt

changing condition of rainfall through these practices in the area in order to secure life of farm households.

According to the respondents for those who have less risk were the households practicing the combination of on-farm, off-farm and non-farm activities. According to field survey the household who were less risky 86.4% were the combination of the on-farm and off-farm and non-farm practicing households, 5.1% were on-farm and off-farm practicing households who have high risk.

Table 16. Contribution of livelihood diversification to climate change adaptation

Diversification of livelihood have adaptation to climate change	Frequency	Percentage
Yes	134	91.2
No	13	8.8
Ways of climate change adaptation		
By growing crop and rearing livestock	15	10.2
By On-farm and Off-farm	49	33.3
By practicing non-farm activities	83	56.5
Who have less risky to climate change		
On-farm only	4	2.7
On-farm and off-farm	32	21.8
On-farm and non-farm	46	31.3
On-farm, off-farm and non-farm activities	65	44.2
How livelihood diversification helps to CC adaptation		
By enhancing income sources	51	34.7
Only farm activity is more vulnerable to climate change	16	10.9
More resilience to climate change	31	21.1
Used to minimize multiple sources of risk from climate change	49	33.3

Livelihood diversification implies that farming households are involved in more and different (non-agricultural) activities for instance, petty trades, shopping, or selling local drink like arake. Both agricultural and non-agricultural forms of diversification may be relevant for climate risk management. Climate related shocks, such as drought, too little rain, off-seasonal rain, frost, excessive rain or floods, high temperature have different and sometimes even opposite effects on different farming system components or economic activities. Diversification can potentially reduce the impact of weather events on income, and it can also provide farmers with a broader range of options to address future change and often helps as risk management strategy

The study result showed that the contribution of non/off-farm activities were 11.6% reduce environmental risks, 25.9% can give opportunity to cope up climate change, 25.9% diversify income source and 36.7% increase annual income of households (Figure 15). Diversification is an important element of climate change adaptation. However, little systematic information exists to guide farmers and farming communities on how to best manage diversification options in their specific context. Off-farm activities serve as a survival strategy for the rural poor. According to the study of World bank, (2006) importance of livelihood diversification in addition to agriculture, growth of non-farm rural income generating activities offers important opportunities to reduce rural poverty (World Bnk,2006).

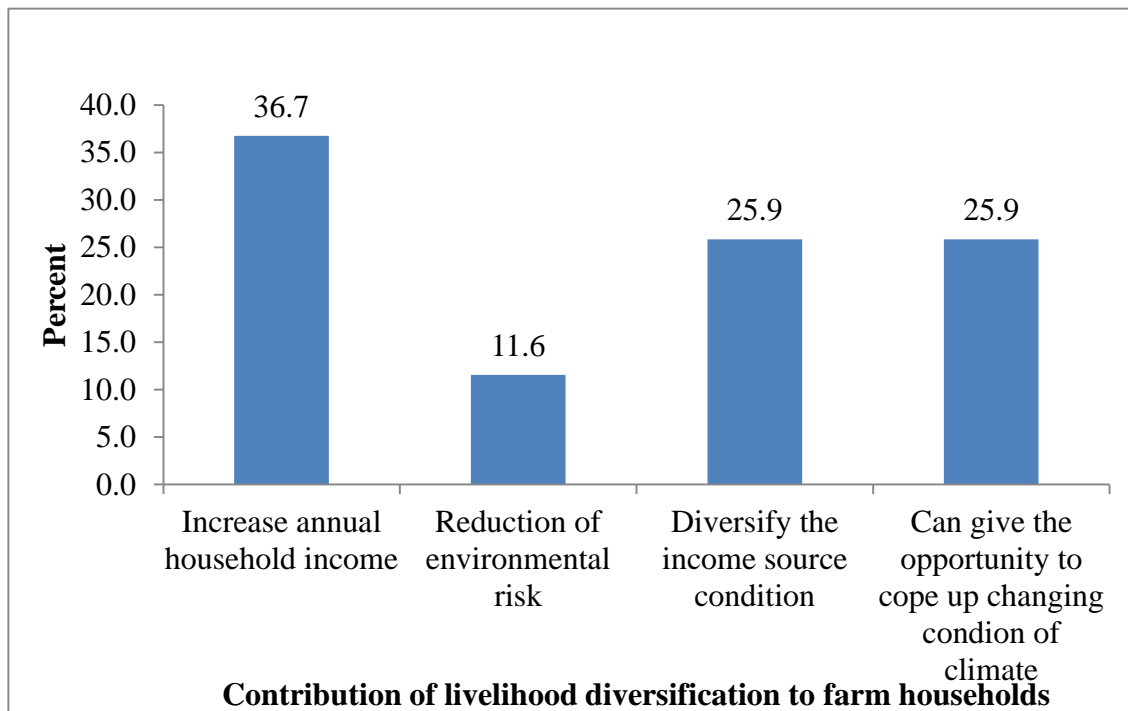


Figure 15. Contribution of livelihood diversification activities to farm households

Results of Multinomial logit Model

Multinomial logit model regression shows the determinant variables for each category versus the base category. Accordingly, the base category is the household who choose on-farm and non-farm as a livelihood strategy. This strategy is used as a reference category.

The maximum likelihood method was employed to estimate the relative importance of predictor variables on the farmers' decision to choose livelihood strategies. The parameter estimates of the multinomial logit model give only the direction of the effect of explanatory variables on the dependent variable, but the estimates neither stand for the actual size of change nor the probabilities.

The multinomial logit model analysis shows that out of the nine explanatory variables entered into the model seven variables including sex of the household head, education level, family size and farm land size, extension contact, credit access and saving habit of the households were the significant determinants of the livelihood diversification strategies up to 10% level of significance.

Table 17. Multinomial logit analysis of determinants of livelihood diversification

Explanatory variables	Coefficient & p-value	on farm only	On farm and off- farm	Combination of On farm, non-farm and off farm
Sex	Coefficient	0.0004	-0.142	0.219
	P-value	(0.997)	(0.217)	(0.046)**
Age	Coefficient	-0.019	0.080	-0.017
	P-value	(0.704)	(0.113)	(0.738)
Education level	Coefficient	-0.057	-0.088	0.100
	P-value	0.082	0.005	(0.012)**
Family size	Coefficient	0.018	-0.073	0.136
	P-value	(0.743)	(0.142)	(0.033)**
Farm land size	Coefficient	0.064	-0.091	0.048
	P-value	(0.219)	(0.026)**	(0.428)
TTLU	Coefficient	-0.002	-0.013	-0.007
	P-value	(0.919)	(0.440)	(0.772)
Extension contact	Coefficient	0.107	-0.166	0.102
	P-value	(0.046)**	0.000	(0.158)
Credit access	Coefficient	-0.063	-0.197	0.126
	P-value	(0.369)	0.007	(0.056)*
Saving habit	Coefficient	-0.111	-0.065	0.151
	P-value	0.034	(0.194)	(0.096)*

***, **, * indicate significant at 1%, 5% & 10% probability level, respectively

Number of observation = 147

Base category: On-farm plus non-farm livelihood strategy

SEX: As it was hypothesized the sex of the household head was one of explanatory variable. In which its coefficient has positive sign and the probability of farmers using the combination of on-farm and non-farm and off-farm could increase by 21.9% at 5% significance level versus or relative to on-farm and non-farm. In this study, male headed households were positively related to diversification compared to their counterparts. In line with this, furthermore, male-headed households have more access to opportunities than female-headed households, the probability of diversifying is expected to be positive for the former (Beyene, 2008).

Education level: As it was hypothesized education level of household head was one of the significant expletory variable in which its coefficient has positive sign a unit increase in number of years in education, the probability of farmers using combination of on-farm, non-farm and off-farm could increase by 10 % at 5% significance level versus or relative to on-farm and non-farm. In line with this, formal education increases the knowledge that one needs to become competent to choose activities that generates more income and up to date with all the modern technologies that make entrepreneurship much easier (Asfaw et al., 2016).

Family size: - As it was hypothesized family size was one of the significant expletory variable in which its coefficient has positive sign a unit increase in household size, the probability of farmers using the combination of on-farm, non-farm and off-farm could increase by 13.6% at 5% significance level versus or relative to on-farm and non-farm. In line to this, Tizale (2007) found that larger households divert their labour to different activities to generate more income and provide for their households.

Farm land size: As it was hypothesized farm land size of household size one of the significant explanatory variable in which its coefficient has negative sign a unit increases in farm size, the probability of farmers using on-farm and off-farm could decrease by 9.1% at 5% significance level relative to on-farm and non-farm. In contrast with this, Culas and Mahendrarajah (2005) found that in Norwegian farm size has a positive effect on household diversification.

Extension contact: As it was hypothesized extension contact one of the significant explanatory variable in which its coefficient has positive sign, the probability of farmers using on-farm only could increase by 10.7% at 5% significance level relative to on-farm and non-farm. Contradict with this, extension services provide information and acts as a pull factor enabling households to take advantage of diversification opportunities (Asfaw et al., 2015).

Access to credit: In opposite to the hypothesized idea, access to credit one of the significant explanatory variable in which its coefficient has negative sign, the probability of farmers using on-farm and off-farm could decrease by 19.7% at 5% significance level relative to on-farm and non-farm.

Access to credit: As it was hypothesized access to credit was one of the significant explanatory variable in which its coefficient has positive sign, the probability of farmers using the combination of on-farm, non-farm and off-farm could increase by 12.6% at 10% significance level versus or relative to on-farm and non-farm.

Saving habit: AS it was hypothesized, saving habit of the household one of the significant explanatory variable in which its coefficient has positive sign, the probability of farmers using the combination of on-farm, non-farm and off-farm could increase by 15.1% at 10% significance level relative to on-farm and non-farm.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The identified rural livelihood diversifications that used in response to climate change in the study area are four. Those are on-farm only, on-farm and non-farm, on-farm and off-farm and the combination of on-farm, non-farm and off-farm diversification of livelihood strategies. The majority of households (79.6%) of the sample households are participated in on-farm and non/off-farm diversified livelihood strategies to adapt climate change and increase household income. Generally, this shows that in the study area farm households practice not only crop production and livestock rearing alone without non/off-farm livelihood diversification to provide income and in response to climate change.

Farmers' perception showed that trends of rainfall and temperature decreasing and increasing, respectively. According to respondents' perception trends of rainfall, 59.9%, 34.7%, and 5.4% said decreasing, fluctuating and increasing, respectively. According to farmers' perception trends of temperature showed that 85.7% of respondents have perceived that trends of temperature is increasing, 10.9% of respondents were perceived fluctuating and 3.4% of respondents were perceived as constant.

The Metrology data analysis also shows the same as perceived by the respondents, this indicates that in the study area the two basic elements of climate well perceived by the farm households.

The livelihood diversification showed in the result, significantly influenced by the seven variables. Sex of household, family size, education level, farm size, extension contact, credit

access and saving habit of the households are significantly affecting the participation of livelihood diversification in the study area.

Generally, in the study area engaging in non/off-farm livelihood activities were done as adaptation mechanisms in response to climate change. 80.1% of respondents were implementing through practicing of diversification of crop varieties and livestock with non/off-farm activities for the climate change adaptation.

5.2 Recommendations

Based on the finding of this study, the following recommendations were provided to the concerned parties:

- The decreasing of the trends of rainfall distribution has negative effect on the rain fed agriculture in the study area. So, the Federal and Regional Government should give due attention to additional livelihood source and plus to that creating awareness on the necessities of participating on non/off-farm activities at the study area for the farm households.
- From the climate factors drought is the most frequently occurring factor, that puts the farm households' livelihood at crisis, then the Government should make the access to get drought resistant crop varieties with an appropriate cost and time.
- The concerned bodies specially DAs and local Governments should support the farm households by giving information on engaging of diversifying livelihoods are necessary to adapt climate change in the study area.
- The role of non/off-farm activities for the climate change adaptation was acceptable for that matter the appreciations for the participants should be given by the concerning bodies (Local Governments).

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APPENDICES

Appendix Table 1. Conversion factors of livestock number to TLU

Livestock species	TLU
Local oxen/bulls	1
Local cows	0.7
Local heifers	0.5
Local calves	0.2
Sheep	0.1
Goat	0.1
Horses	0.8
Donkeys	0.5
Mules	0.7
Poultry	0.01

Source: Jahnke (1982) TLU=Total Livestock Unit

Appendix Table 2. Variance inflation factor

Explanatory Variable	VIF	1/VIF
Age	1.93	0.518171
Family size	1.70	0.587268
Education level	1.61	0.621078
Access of credit	1.43	0.700269
Saving habit	1.33	0.750754
Extension contact	1.16	0.861081
TTLU	1.13	0.881496

Appendix Table 3. Total rainfall (1985-2017)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1985	0.0	0.0	153.7	353.4	204.8	60.8	158.0	131.6	106.4	45.4	21.4	22.5
1986	0.0	130.7	86.4	292.1	209.2	181.6	220.7	208.7	105.9	126.9	16.3	17.9
1987	30.0	29.8	204.0	112.4	411.6	73.2	1.3	246.1	206.3	143.5	44.8	56.6
1988	42.0	130.5	55.4	202.7	103.2	190.0	206.8	118.1	345.1	236.4	0.0	1.1
1989	0.0	162.4	57.3	129.3	68.2	118.3	151.7	79.2	179.1	146.1	16.9	247.1
1990	36.8	121.6	119.4	162.0	121.1	107.6	147.0	104.4	172.5	48.1	44.8	9.1
1991	42.2	87.2	263.8	51.7	265.5	75.2	160.9	193.4	180.6	95.5	44.8	37.1
1992	38.8	51.3	111.9	132.7	66.6	184.8	286.8	267.5	262.9	88.9	157.4	197.8
1993	249.7	187.0	113.8	350.7	261.8	165.4	141.2	371.6	290.3	229.7	4.0	0.0
1994	0.0	0.0	171.6	398.8	275.3	250.7	253.7	336.4	153.1	0.0	8.9	0.0
1995	0.0	58.2	199.2	368.5	138.0	54.6	102.5	75.2	256.4	96.3	0.0	70.2
1996	123.7	51.0	155.0	287.5	207.2	300.7	242.8	284.1	239.0	32.9	33.9	7.5
1997	38.8	0.0	154.2	404.6	315.1	193.4	131.9	325.2	218.1	297.8	325.3	42.7
1998	103.0	96.4	109.8	193.5	213.6	249.6	343.1	217.3	112.9	167.9	17.5	0.0
1999	20.2	0.0	133.2	75.7	179.7	102.1	174.7	139.7	132.5	229.1	18.5	1.4
2000	0.0	0.3	41.2	242.3	210.8	105.6	153.7	174.2	104.7	122.3	106.7	19.2
2001	1.4	32.9	116.2	46.7	163.8	159.4	291.4	273.1	123.6	156.0	10.3	1.0
2002	69.8	54.8	226.3	115.0	100.4	41.4	143.4	201.4	174.1	35.2	0.0	121.3
2003	27.7	26.4	98.2	105.7	54.6	128.9	123.1	163.6	95.1	45.3	37.8	24.8
2004	121.3	56.6	71.8	194.1	42.1	84.8	198.1	221.1	138.0	84.1	27.9	42.6
2005	51.9	34.3	114.7	167.0	300.2	73.9	74.0	110.4	220.3	68.2	65.2	5.3
2006	10.1	54.3	148.2	201.7	104.5	67.3	150.3	228.4	112.6	81.8	6.5	26.1
2007	34.0	35.8	109.5	169.7	119.9	210.8	148.3	161.7	142.5	14.7	1.3	0.0
2008	20.4	0.0	11.9	139.5	76.7	133.4	273.0	162.4	137.0	87.0	95.1	2.1
2009	72.6	14.3	40.1	81.6	95.4	85.6	65.5	103.5	155.8	90.5	17.1	136.6
2010	36.7	157.1	94.6	234.2	174.3	103.3	179.4	135.7	194.2	24.1	61.8	24.3
2011	19.9	20.0	68.7	193.6	272.6	203.1	155.9	235.3	246.6	38.6	44.8	0.0
2012	0.0	0.0	37.5	139.2	61.2	187.6	235.4	164.5	245.9	19.0	6.8	15.3
2013	21.5	6.3	88.1	103.6	140.8	110.4	173.3	190.9	139.2	95.5	48.3	0.0
2014	0.0	36.5	126.8	251.0	204.2	54.8	215.3	131.5	252.8	95.5	44.8	37.1
2015	0.0	1.7	24.2	100.2	171.2	131.5	87.7	138.8	155.7	14.4	105.9	20.3
2016	30.5	32.5	73.4	193.6	141.5	166.4	198.1	295.2	180.6	95.5	44.8	37.1
2017	0.0	21.4	111.9	193.6	134.7	47.5	174.4	193.4	180.6	0.0	0.0	0.0

Source: National Metrological Agency, Ethiopia (2019)

Appendix Table 4: Maximum Temperature (1989-2017)

Monthly Maximum Temperature (1989-2017)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	28.4	28.3	28.3	26.2	27.3	25.4	23.5	25.9	25.7	27.2	28.6	27.3
1990	29.6	28.2	27.8	27.8	27.5	25.7	24.5	24.4	26.9	28.2	29.2	28.8
1991	26.7	8.8	28.2	28.6	27.8	25.6	22.1	24.6	27.2	28.1	28.5	27
1992	28.1	27.4	29.5	29.1	28.1	25.3	23.4	26.0	26.1	26.7	27.0	27.8
1993	27.6	29.9	27.0	26.9	25.8	24.7	23.2	24.1	25.7	26.5	28.1	28.6
1994	30.0	31.5	30.5	28.9	26.9	24.3	23.0	23.6	25.7	28.1	28.7	28.5
1995	29.9	29.1	28.8	27.0	27.7	27.0	24.4	24.3	26.6	27.9	29.3	29.2
1996	27.7	30.8	29.7	27.9	26.5	23.7	23.3	24.7	26.5	28.1	28.9	29.4
1997	29.4	30.1	31.1	27.2	28.0	27.0	24.5	24.6	28.2	27.4	27.4	29.2
1998	28	29.8	29.0	29.8	28.5	25.6	23.6	23.9	25.9	26.3	28.6	30.9
1999	30.9	31.0	28.5	30.2	28.0	26.4	23.5	25.0	26.4	24.9	27.9	29.1
2000	29.9	30.7	31.6	30.2	26.9	25.3	24.3	24.6	25.9	26.1	27.8	28.7
2001	29.0	31.0	27.4	28.6	27.0	25.3	24.1	24.7	25.6	27.2	28.7	29.6
2002	28.4	30.4	28.8	29.2	28.1	26.1	26.3	25.2	27.1	29.2	30.4	28.6
2003	28.6	30.4	30.1	28.3	29.5	26.4	24.3	28.3	28.3	28.2	28.2	28.3
2004	28.0	30.2	31.1	27.8	28.7	26.4	24.7	24.7	26.6	28.0	29.9	30.0
2005	29.5	32.0	30.2	29.4	26.3	25.9	24.3	25.3	25.9	28.6	29.2	29.6
2006	30.7	31.4	29.1	27.3	27.8	26.3	23.7	24.9	26.7	28.7	30.0	29.4
2007	30.2	28.9	31.4	29.2	28.5	24.6	24.8	24.8	26.2	28.4	29.9	29.8
2008	31.7	31.4	33.1	31.0	28.3	25.9	24.1	25.4	27.3	29.0	28.4	30.3
2009	30.6	31.6	33.3	30.4	30.4	29.1	25.7	26.7	28.9	29.1	31.0	29.3
2010	30.0	29.2	29.7	29.2	27.9	27.1	25.0	25.6	26.9	30.5	31.5	30.7
2011	31.0	30.8	31.3	32.0	28.4	25.9	25.5	25.4	27.2	30.3	29.6	29.7
2012	31.4	32.3	32.8	28.4	30.8	27.1	24.6	25.3	27.0	30.2	31.7	31.0
2013	31.6	32.9	31.6	29.9	28.0	26.0	24.6	24.9	28.2	29.0	30	30.3
2014	31.7	30.3	32.1	30.7	28.5	27.9	25.7	26.2	27.1	28.9	28.9	31.0
2015	31.4	33.6	34.1	33.4	30.2	28.0	28.1	28.6	29.6	32.5	31.8	31.1
2016	31.0	33.2	34.5	29.6	28.1	26.6	25.5	25.7	27.5	29.6	29.9	29.4
2017	31.0	31.6	31.9	16.7	28.8	29.0	25.1	16.7	16.7	16.7	16.7	16.7

Source: National Metrological Agency, Ethiopia (2019)

Appendix Table 5: Monthly Minimum Temperature (1989-2017)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1989	7.6	6.2	6.5	7.0	5.5	8.4	8.9	7.2	6.4	6.7	6.6	9.8
1990	9.6	10.5	9.4	9.6	9.3	8.7	8.9	8.8	8.7	7.0	7.3	7.7
1991	8.8	8.8	10.2	8.9	9.9	10.5	9.8	8.3	7.8	6.4	6.4	8.0
1992	9.2	10.4	10.0	9.7	9.4	9.4	8.0	9.2	8.9	8.0	7.6	8.6
1993	8.6	7.9	8.0	9.5	9.1	9.1	8.6	8.7	8.5	7.0	5.0	7.1
1994	11.1	12.3	14.9	14.5	14.9	14.3	14.4	14.2	13.9	10.1	11.7	12.0
1995	12.6	14.1	14.5	15.2	14.1	13.2	14.6	14.2	13.4	11.8	11.0	13.6
1996	14.0	13.5	14.1	14.5	14.8	14.8	14.3	14.0	13.8	10.4	10.0	11.0
1997	13.1	12.7	14.8	14.7	13.6	13.2	13.8	14.5	13.6	14.2	14.0	12.4
1998	15.3	15.8	15.2	15.0	15.3	14.6	15.0	15.0	14.5	14.6	10.2	9.9
1999	11.7	11.5	13.6	12.9	13.0	13.2	13.6	12.9	12.2	13.9	10.2	11.7
2000	12.2	12.8	13.5	15	13.8	13.5	13.9	13.8	13.5	14.0	12.9	12.0
2001	12.5	13.1	14.5	14.3	14.1	14.3	14.3	14.6	13.1	13.1	11.7	12.3
2002	14.3	13.3	14.8	14.3	15.0	14.8	14.5	14.4	13.8	11.9	12.8	14.9
2003	13.0	13.1	14.8	15.0	15.4	14.7	14.5	14.6	13.9	11.4	12.3	11.8
2004	13.5	13.0	14.0	14.9	13.3	13.6	13.5	14.2	13.6	11.8	11.3	12.6
2005	12.6	13.5	15.1	14.7	15.1	14.6	14.0	14.6	13.8	12.0	10.4	10.1
2006	13.0	13.9	14.6	14.4	13.8	13.9	14.7	14.5	14.0	14.0	11.8	14.2
2007	14.3	14.2	12.9	13.6	14.4	14.6	14.1	14.4	14.0	10.9	11.4	10.8
2008	12.6	13.1	12.1	13.8	14.4	13.9	14.1	14.1	13.9	12.1	11.3	10.9
2009	12.2	12.9	13.9	14.2	13.8	13.7	14.2	14.2	14.0	12.6	11.1	14.9
2010	13.2	15.6	14.2	15.3	16.1	14.7	15.0	14.7	14.4	12.0	11.1	12.1
2011	12.9	12.9	14.8	14.6	15.2	14.9	14.2	14.5	14.3	12.3	13.4	11.3
2012	12.2	12.2	14.0	15.2	14.7	14.6	14.7	14.4	14.0	11.8	12.0	12.4
2013	13.1	13.7	15.4	15.0	14.6	15.4	16.5	17.5	17.4	16.6	16.2	14.6
2014	16.6	18.2	17.3	17.0	18.3	18.0	19.2	19.2	19.5	17.5	17.5	17.5
2015	17.8	18.3	18.2	18.1	19.4	20.1	20.1	20.8	21.0	20.4	19.7	20.6
2016	21.2	21.1	21.8	23.1	22.9	22.8	20.6	20.6	20.6	20.6	20.6	12.1
2017	10.9	14.1	15.0	16.7	15.4	14.1	14.0	16.7	16.7	16.7	16.7	16.7

Source: National Metrological Agency (2019)

Questionnaire for the survey on climate change and livelihood diversification in rural West Badawacho District, Southern Ethiopia

Dear Respondent

My name is **Kebede Bekele**, a graduate student in climate change and sustainable agriculture program at **Hawassa University**. I am conducting to collect a research data on, Climate Change and livelihood diversification in rural West Badawacho District. Therefore, I kindly request the response to fill this questionnaires and I will assure that all the information are confidential and will be used only for purpose of the research alone. I thank you in advance for your concern and time.

Kebele: -----

Name of interviewer: -----signature-----

A. General information

1. Address: Name-----

Demographic and socio-economic characteristics

1. Sex of the respondent. A. Male Female

2. Age of the respondent

A.18-24years B.25-35 C.36-45 D.46-64 E.>65

3. Educational level

A. Cannot read and write B. Can read and write C. Primary School (grade 1-8)

D. Secondary school (grade 9-10) E. Preparatory F. Diploma or above

4. Family size A.1-2 B.3-5 C.6-9 D.>10

C. Institutional information

5. Do you have had extension contact with kebele development agent?

A. Yes B. No

6. If your answer for question 5 is "yes", how many contacts did you have during the production season? -----

7. Have you got training from kebele development agent?

A. Yes B. No

8. If your answer for 7 is "yes", what about you have taken the training?

A. About adoption of new technology in farm activities

B. Give information about rainfall distribution in order to give early warning

C. About climate change impact and how it can be cope up

D. Give awareness about diversified livelihood

E. Others (specify)

9. Did you get credit during the last one production year (2017/18?)

A. Yes B. No

10. Purpose of taking credit?

- A. purchase of oxen B. purchase of seeds C. purchase of fertilizer D. purchase of chemicals E. purchase of farm implements F. for consumption G. for social obligations
- H. to start new investment I. others-----

11. If answer for question 9 is "yes", fill the following table

Source of credit	Purpose(s) of taking credit	Amount in kind or birr borrowed
1. Formal service		
Commercial bank		
Cooperatives		
Omomicro finance institution		
2. Informal local institutions like Idir or Ekub		
Local money lenders		
Friends or relatives		
Others		

12. If answer for Q9 is "no", why? (Multiple answers are possible)

- A. Fear of ability to pay B. Lack of collateral C. High interest rate D. Others (specify) ---

13. Do you have farm land? A Yes B. No

14. If answer for Q13 is "yes", please fill the table below in credit.

Source of land	Total plot size in ha	Cultivated land in ha	Grazing land in ha	Home stead in ha
Own land				
Rented land				
Land sharing				
Others				

15. How did you get your own land?

A. Inheritance B. Government distribution C. Family gift D. Others

16. Do you have saving habit?

A. Yes B. No

17. If answer for Q16 is "yes", how much is the current amount of saving-----birr
or in kind-----Qt. which is extra of consumption

D. Livelihood activities and their contribution to total household income

I. Agricultural activities contribution to household income

18. Do you grow crops? A. Yes B. No

19. If answer Q18 is "yes", please fill the information you have in the production year
(2017/18) in the table below

No.	Crops grown	Area covered in ha in production year	Total amount in birr at local price
1	Maize		
2	Teff		
3	Wheat		
4	Enset		
5	Vegetables		
6	Fruits		
7	Cash crop(coffee and chat)		

20. Did you face failure of crop production? A. Yes B. No

21. If your answer for Q20 is "yes", what are the problems you mostly face?

A. Crop diseases B. shortage of rainfall C. Flood D. Frosts and ice E. Reduction of crop production and productivity F. Problem of late onset rainfall G. Problem of early cessation of rainfall

22. Do you rearing livestock? A. Yes B. No

23. If your answer for Q22 is "yes", please tell us in detail about livestock types

Livestock type	Total number of livestock owned	Total sales in birr
Sheep		
Goats		
Bull		
Cow		
Calf		
Donkey		
Poultry		

24. Did you face mortality of livestock? A. Yes B. No

25. If the answer for Q24 is "yes", what is/are major problems of livestock production you faced?

A. Lack of veterinary service B. Drought C. Shortage of forage D. Shortage of water

E. Increase of diseases out break

26. What is the reason for the problems that livestock faced?

A. Due to climate change B. Shortage of grassing land C. Due to traditional way of animal rearing (e.g. large number of animals with low care of their health)

D. Low attention is given to rearing of livestock

E. Climate change and variability

increases the outbreak of diseases

II. Contribution of Non/off-farm activities to household income

27. Did you ever get income from non/off-farm activities during 2017/18?

A. Yes B. No

28. If your answer for Q27 is "yes", please tell us in detail the information during 2017/18?

No	Off-farm/Non-farm activities	Total income during the last 12 months(in birr)	Raw materials cost in birr
1	Income from off-farm activities		
	Daily wage labor		
	Sales of fire wood		
	Sales of charcoal		
	Rent of land, pack animals, and oxen		
	Others		
2	Income from Non-farm activities		
	Petty trading like trading of banana, spices etc.		
	Handy crafts (weaver and poet making)		
	Selling local beverages like Tella and katikela		
	Trading of small ruminants and cattle		
	Remittances (income from relatives/friends)		

29. If you were not employed in any of non-farm/off farm activities what are the constraints that you faced?

A. Lack of credit B. Lack of different opportunities like poor infrastructure

C. Lack of support from GOs and NGOs D. Lack of working capital

E. Availability of different agricultural and non-agricultural risks lack of labour

F. Lack of information about the usage of non/off-farm activities G. Others specify

30. If you were engaged in any of off/non-farm activities why you were engaged in such type of activities?

A. For survival strategy with changing condition of climate C. For income improvement

B. Risk minimization from climate variability and change D. Other

E. Perception about climate change and variability

31. Have you heard of the word "climate change" before?

A. Yes B. No

32. Which local indicator do you use to evaluate today's rainfall pattern?

A. Loss of some plant and animal species B. Increase drought and flood frequency

C. Growth period shortened D. Rainfall comes early or lately?

E. Decline of soil productivity/fertility F. Decline of agricultural yields

G. Decreased available water H. Other (specify)

33. Do you face the problems of household income reduction due to changing of rainfall pattern?

A. Yes B. No

34. If your answer for Q33 is "yes", how do you think your coping system and rearing livestock will be affected by climate change?

No	Have you experienced with the following types climate change and variability indicators?	Response		How often? (in past decade)
		Yes	No	
1	Drought			
2	Floods			
3	Off-seasonal rain fall			
4.	Too much rainfall			
5	Too little rainfall			
6	Higher temperature			
7	Frost (coolness)			

35. Do you think that production per unit area has been declining since the last 30 years?

A. Yes B. No

36. What do you think the major factors affecting crop production in this area?

A. Unpredictable rainfall B. Increased temperature C. Increased pest and diseases

D. Low soil fertility

37. What has been the trend of rainfall for the past 30 years to date according to your perception?

A. Increasing B. Decreasing C. Fluctuating

38. Do you feel that the timing of rainfall is a problem?

A. Yes, it onsets late and ends up late D. Yes, it onsets on time but ends up early

B. Yes, it onsets early and ends up late early E. Yes, it onsets late ends up early

C. No, there is no problem on timing of rainfall but on its amount

39. What has been the trend of temperature for the past 30 years to date according to your perception? (Please tick the appropriate answer)

A. Increasing B. Decreasing C. Fluctuating D. Constant E. Don't know

F. Livelihood diversification to climate change adaptation in farm households

40. What are contributions of non/off-farm activities to farm households?

A. Increase annual household income B. Reduction of environmental risk

C. To diversify the income source D. Can give the opportunity to cope up changing condition of climate

41. Which option of livelihood diversification activities you engaged?

A. On-farm B. On-farm and off-farm C. On-farm and Non-farm

D. On-farm and Off-farm and Non-farm

42. Do you think that diversification of income source activities are possible to adapt to the impact of climate change by your locality?

A. Yes B. No

43. If yes how they adapt climate change in you locality?

A. By growing crop and rearing livestock B. By on-farm and off-farm

C. By practicing non-farm activities D. By on-farm and off-farm and non-farm activities

44. Who have more income? A. On-farm only B. On-farm and off-farm

C. On-farm and Non-farm D. On-farm and off-farm and Non-farm

45. Do you think that diversified of livelihood helps to climate change adaptation?

A. Yes B. No

46. If your answer for Q45 is yes, how diversified livelihood helps to climate change adaptation?

A. By enhancing income sources B. Only farm activity is more vulnerable to climate change than farm and non-farm C. More resilience to climate change

D. Used to minimize multiple sources of risk from climate change

1. Checklist for Focus Group Discussion/FGD

A. Diversification of livelihood systems

1. Do you think there are livelihood diversification systems in the study area?
2. Do you know if there are plans or initiatives to diversify livelihood systems in the region?
3. Do you think contribution of livelihood diversification systems to climate change adaptation in the study area?
4. What kind of support do you think is necessary for the farmers when they decide to diversify their livelihood systems?

B. climate change assessment

1. Do you know the meaning of climate variability?
2. Is the pattern of weather is changing?
3. How do you explain the change?
4. What would be the cause?
5. In the past 30 years how would you describe the rainfall pattern in terms of
 - A. Rainfall on-set and Cessation
 - B. Rainfall amount
 - C. Rainfall seasonal distribution
 - D. Temperature
6. Do ho have any event that you remember causing life and property damage?
7. What are the manifestation of climate change and variability? Are flood, drought, high temperature, too little rainfall, and frost frequently occurring?

8. Has it impact on agricultural practice? Could you tell us the major impacts that you perceived?
9. Have you faced food insecurity? How you explain it in relation with climate change?
10. What are the local coping mechanisms used to reduce the impacts of climate change and food insecurity? Please list community based, governmental and/or NGOs assistance?
11. Which crop and livestock types is more resistance to climate variability?

2. Checklist for Key Informant Interview/KII

Which include key informant interviews with government experts in the District and Kebele, Agricultural and natural resources Development Offices.

Dear Respondents

My name Kebede Bekele. I am a postgraduate student at Hawassa University College of Agriculture, Department of Climate change and Sustainable Agriculture. Currently, I am writing my thesis proposal on climate change and livelihood diversification in rural West Badewacho District. You have been selected purposely from different experts in West Badewacho District. The response give are valuable and will be held in almost confidentiality and will be used only for analysis of this research. You are honestly requested to respond to any following questions.

Thank you in advance for your cooperation!!

1. Name-----

2. Position/profession-----

3. Have you noticed any form of climate change in your zone or District? If your answer is yes, please can you explain?

4. If the answer to Q3 is yes please would you like to explain the extent of climate change and variability? And then, its impact on crop production in your District/peasant association?

5. What are the local coping mechanisms used to reduce the impacts at household level?

6. What are the institutional level coping strategies to reduce future impacts?

BIOGRAPHY OF THE AUTHOR

The author, Kebede Bekele Woilebo, was born on March 1, 1988 from his father Bekele woilebo and his mother Shewa huro in Shone town, Hadiya Zon, Ethiopia. He attended his elementary school in Shone primary school and attended his secondary school in Shone secondary school. Soon after completing his secondary school, the author was joined Woilita Sodo University, College of Agriculture, and Department of Rural Development and Agricultural Extension since October 2008, graduated with B.Sc degree in June 2010.

Following his graduation he was employed in Mirab Badewacho woreda agricultural office. After seven years work experience he joined Hawassa University, school of graduate studies in Climate change and sustainable agriculture in 2018 academic year. He is married.