CLIMATE CHANGE IMPACT, VULNERABILITY AND ADOPTION OF CLIMATE SMART AGRICULTURAL PRACTICES AMONG SMALL-SCALE FARMERS IN OROMIA REGION OF ETHIOPIA

By

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ABSTRACT

In Ethiopia, agricultural livelihoods are susceptible to environmental degradation and climate variability. Several interventions have been launched and implemented to promote utilization of environmentally sustainable farm practices. This thesis examined the weather variability and prevailing seasonal trends in the study communities; described farmers' responses to perceived climate change across some selected demographic characteristics; described the impacts of extreme weather events on farming households' livelihoods and farming practices; computed indicator of the households' vulnerability to climate change and analyze the factors influencing it; analyzed the factors influencing adoption of Climate Smart Agricultural (CSA) practices; analyzed the factors influencing adoption intensity of Climate Smart Agricultural (CSA) practices; analyzed the factors influencing farmers' perceptions on sustainability of Climate Smart Agricultural (CSA) practices; analyzed the institutional adaptive capacity to implement the adopted Climate Smart Agriculture (CSA) practices; and determined the effect of extreme weather exposure, coping and adaptation strategies on households' welfare using per capita income and food self-sufficiency indicators. Given the agro-ecological differences within each districts, the stratified random sampling method was employed to draw sample community from highland and lowland representing agro-ecology. More specifically, simple random sampling producer was used to select sample respondents from each selected community. Two districts were selected from each zone using random sampling methods. The Selected districts were sub-divided into three sub-categories emphasizing on farming practices and agro-ecologies. Accordingly, a total of twelve PAs (three PAs from each four Districts) were selected for structured interviews to generate primary data. Based on the sampling methods, Primary data were collected from 210 upland and 200 lowland farming households and 140 extension field staffs using scheduled interviews with structured questionnaires. The data were analyzed with descriptive statistics, binary logistic model, Ordinary Least Square (OLS) regression and Tobit regression models. The results showed that 88.5 percent and 70 percent of the highland and lowland farmers felt high and very high negative influences of changes in climate parameters, respectively. Moderate vulnerability to climate change was indicated by 63.5 percent of highland farmers, compared to 59 percent by lowland farmers. Among the CSA practices introduced to communities, crop rotation was most adopted by 82 percent and 89 percent of the highland and lowland farmers, respectively, where however overall aggregated adoption found to be about 35.6 percent for highlands and 34.8 percent for lowland community context. The perceived adoption sustainability of crops rotation was found highest (86 percent) which followed by planting time adjustment (64 percent) under lowland community situation, while crops rotation sustainability found 72.4 percent, followed by crops variety diversification (62.35 percent) in the context of highland community. The livelihoods' vulnerability of highland agro-ecology was observed 49 percent which is relatively lower as compared to highest 66.7 percent revealed by the lowland agro-ecology community which as a result only 37.5 percent and 22.9 percent of highland and lowland community respectively identified food sufficient covering the seasonal food demand from households' seasonal agricultural production, while the remaining majority are food insufficient for several months during each season. Notably, the impact of climate change coping mechanism on households' seasonal income was rated 39.3 percent in highland community, while was found 51.7 percent for lowland community, whereas the adaptation strategies impacts on households' income rated 59.3 percent in the highland community, while identified 44 percent in context of lowland community. On the other hand, Tobit regression model analysis were conducted where the results indicate that, a unit increase in mean rainfall tends to reduce the level of livelihoods vulnerability to climate change by a factor of 0.018 in the scale of livelihoods *vulnerability which is statistically significant at 10 percent significance level. In similar manner, the effect of drought frequency was found positive to livelihoods vulnerability, in which an increase in the frequency of drought, increase the level of livelihoods vulnerability by a factor of about 0.42 point indicating the significant impact of drought on community livelihoods vulnerability, where the effect is significant at 1 percent significance level. Consequently, all pitfall observed in survey results are majorly identified to be the result of policy limitation in the course of adaptation options promotion and publicity. Therefore, based on the study findings, it is suggested that the policy level leaders and functional managers ought to readdress the designed policies as well as strategies related to service provision and extension service delivery system need to be revised in the manner that will take into consideration the small-scale farming system situation to ensure environmentally sustainable rural development.*

Key Words: *Climate change, Impact, Vulnerability, Adoption, Sustainability, Coping, Strategy and Small-Scale Farmers*

DECLARATION

I, GERISHU BATI WARITU, do hereby declare that the thesis with the title ***"Climate Change Impact, Vulnerability and Adoption of Climate Smart Agricultural Practices Among Small-Scale Farmers in Oromia Region of Ethiopia"***, which I hereby submit for the Doctor of Philosophy Degree (PhD) in Agriculture at the University of South Africa is my own original work, and has not been previously submitted by me for a degree at this University or concurrently being submitted for a degree award at any other University.

I declare that the thesis does not contain any written work presented by other persons whether written, pictures, graphs, or data or any other information without acknowledging the source. I declare that where words from a written source have been used the words have been paraphrased and referenced and where exact words from a source have been used the words have been placed inside quotation marks and referenced. I declare that I have not copied and pasted any information from the internet, without specifically acknowledging the source and have inserted appropriate references to these sources in the reference section of the thesis.

I declare that during my study I adhered to the research policy of the South Africa, received ethics approval for the duration of my study prior to the commencement of data gathering and have not acted outside the approval conditions. I declare that the content of my thesis has been submitted through an electronic plagiarism detection program before the final submission for examination.

Signature:

Date: April, 2024

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LIST OF ABBREVIATIONS AND ACRONYMS

Abbreviation	Full meaning
AFOLU	Agriculture, Forestry and Other Land Use
ATA	Agricultural Transformation Agency
BSC	Balanced Score Card
BPR	Basic Process Re-engineering
CA	Conservation Agriculture
CCA	Climate Change Adaptation
CGE	Computable General Equilibrium
CRGE	Climate Resilient Green Economy
CRV	Central Rift Valley
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSA	Climate Smart Agriculture
CSAP	Climate Smart Agriculture Practices
CT	Conservation Tillage
CSI	Coping Strategy Index
DC	Development Centers
Das	Development Agents
DPPC	Disasters Protection and Preparedness Commission
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
FOLU	Forest and Other Land Use
FTCs	Farmers Training Centers
GCMs	Global Circulation Models
GDP	Gross Domestic Production
GHG	Green House Gases
GRV	Great Rift Valley
GWP	Global Warming Potential
HHs	House Holds

IPCC	Inter-governmental Panel for Climate Change
ITC	International Trade Center
KII	Key Informant Interview
LVI	Livelihood Vulnerability Index
MoANR	Ministry of Agriculture and Natural Resource
MoFED	Ministry of Finance and Economic Development
NAPA	National Adaptation Program for Action
NMA	National Meteorological Agency
ODPPC	Oromia Disasters Protection and Preparedness Commission
OLS	Ordinary Least Square
OBoANR	Oromia Bureau of Agriculture and Natural Resources
PA	Peasant Association
PADETES	Participatory Demonstration and Training Extension System
PCA	Proportional Component Analysis
PRA	Participatory Rural Appraisal
SOM	Soil Organic Matter
SNNPRs	South Nation and Nationality Peoples Regional state
SPSS	Statistical Package for Social Science
SWC	Soil and Water Conservation
SUA	Sokoine University of Agriculture
TLU	Tropical Livestock Unit
TOL	Tolerance Level
UNFCCC	Unite Nation Frame-Work Convention on Climate Change
UNISA	University of South Africa
US	United State
USAID	United State of America International Development
VA	Vulnerability Analysis
VIF	Variance Inflation Factor
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

In many developing countries, agricultural sector contributes significantly to economic growth and development. The immense share of the agricultural sector in the economy of developing nations is highly recognized, particularly for its functional share in nationwide economic development and improvement of rural communities' livelihoods. Correspondingly, in Ethiopia, the agricultural sector is a vital sector in the country for its practical supports to national economy, besides providing ample and needful support in the livelihoods of entire rural population. Agricultural sector is an economic system that provides employment opportunities for 80 percent of the labor force, in addition to generating about 90 percent of export revenues (Mulatu et al., 2016). Likewise, the sector supplies 70 percent of raw materials for domestic agro-industries, besides contributing 43 percent to the Gross Domestic Product (GDP) (Mulatu et al., 2016). In addition, in the context of Ethiopia, the Ministry of Agriculture and Natural Resource (MoANR) (2017) divulged that over 83 percent of the population in Ethiopia lives in the rural parts of the country and depends on subsistence agriculture to support their livelihoods.

Furthermore, there are evidences in support of the fact that a substantial proportion of the agricultural economic sectors is managed by rural small-scale farmers. Because of this, the effectiveness of small-scale farmers is dependent on environmental sustainability, including favorable climate, for sustainable agricultural production and development. More importantly, given that the climate associated variables are mostly direct inputs of agricultural production, whichever change in climatic condition of the locality is obvious to have a significant impact on the productivity of farmlands (Asha et al., 2012). It is equally apparent that sustainable agriculture is about climate resilient cropping system, coupled with water supply systems which decrease climate change linked hazards in the context of small-scale farm households and improve overall natural resource background of the farming systems and farm community (Getahun, 2017).

However, it is now well documented that changes in some climate parameters and weather variability are critical problems to the improvement of Ethiopia's agricultural farm productivity and they undermine the natural resource sustainability (Temesgen, 2014). Climate change affects the livelihood of the farming communities, particularly those living in the dry regions of the country (Temesgen, 2014). Likewise, on a global scale, climate change is currently identified as the most important challenge confronting the scientific communities as well as policy makers, while its impacts are primarily felt in the agricultural sector. The reason is that the agricultural production system is overly sensitive to climate change and its effects, even though the consequence on the other natural resources may vary across different agro-ecologies (Getahun, 2017). It has also been observed that rain fed agriculture experiences a greater climate related negative impact. Among the consequences of climate change are biophysical damages, ecological degradation, and economic constraints (Mendelssohn, 2009). In this regard, National Meteorology Agency (NMA) (2007) of Ethiopia, in its National Adaptation Program for Action (NAPA) document asserted that developing countries and specifically least developed nations like Ethiopia are more susceptible to unfavorable shocks resulting from changes in some climatic parameters. These countries are more vulnerable to variability and changes in climate because of the countries' inadequate adaptive capacity and sensitivity of the socio-economic systems to seasonal weather and climatic shocks.

The impact of climate change situation, coupled with associated hazards has been identified to be tremendous in many developing countries. This can be attributed to the fact that the development of their national economy, nationwide food security, as well as the livelihood of the traditional rural community is mainly dependent on agricultural development (MoANR, 2017). In this regard, households' exposure to climate change, sensitivity to climate related risk and capacity to adapt to the weather variability and changing climatic condition vary across agro-ecological zones, and these situations pose significant challenges to the development of the climate resilient strategy for the communities and country (Asrat and Simane, 2017). To this end, the economic improvement required in rural communities, in addition to many other factors is highly influenced by environmental sustainability, conducive weather and climate condition within the contexts of rural households in developing nations. Similarly, in Ethiopia, the livelihoods of several rural communities are dependent on agriculture, where more than 90 percent of food supply required to feed current population is practically obtained from rain-fed subsistence agriculture.

Consequently, under this situation, rainfall failure means loss of major livelihood and food insecurity in rural areas where the poorest communities are predominantly agrarian (Muluneh, 2015). Generally, Ethiopia is facing overwhelming challenges, from high level of persistent poverty, serious level of natural resources degradation, constant food insecurity situation and recurrent drought cycle due to inadequate adaptive capacity of the community to frequent weather variability and/or climate change (Kidanu et al., 2009). Ethiopia remains among the primary receivers of food aid in the global scale to survive some seasonal gaps in food supplies (Kidanu et al., 2009). It has been equally observed that nearly 10 percent of the country's population constantly need food related support per annum to make up for seasonal consumption shortfalls (Conway and Schipper, 2011). Significantly, inter-annual seasonal weather variability manifests through droughts, late onset of seasonal rain, and early termination of rainfall in the cropping season and overall lack of rainfall have been underscored as the most important causes of crop failure in Ethiopia (Araya and Stroosnijder, 2011 and Biazin et al., 2012). Accordingly, adequate adaptation and mitigation options to neutralize the impacts of climate change should be in place, to realize required sustainable and suitable development in agriculture and the nation. Based on this, van Scheltinga and van Geene (2011) affirmed that climate change adaptation practices require proper shift in existing livelihood strategies in the community. Moreover, it is significant to set adequate priority in respect of the most vulnerable community members and land management system; for both to complement other efforts that are in the system, and consequently help in the realization of sustainable economic development.

1.2. Problem Statement

In several parts of the world including Africa, recurring droughts are common features of climate change which always affect several sectors of the economy. The agricultural sector suffers most due to its dependence on sustainable weather condition to yield optimum production. In this regard, several findings evidenced that climate change related risks pose long-term threats for human beings in general, and rural households, where the negative influences are significant in vulnerable regions of the sub-Saharan African countries (Valdivia et al., 2012). The threats that are commonly induced by climate change in developing countries include harsh weather conditions like permanent desertification, recurrent drought, prolonged period of seasonal precipitation and flooding.

The frequent drought as well as the desertification is widespread in several parts of Africa, where flooding and unpredicted extended rainfall are predicted as the effects of climate change (Ajala, 2017). More importantly, IPCC (2007) noted that there is currently an alarming concern regarding the vulnerability of developing nations to frequent changes in climate patterns. The consequences of climate change are negative effects on agricultural farmland productivity and overall agricultural production. Likewise, climate change related impacts undermine agricultural land productivity in Ethiopia because majority of the farmers primarily depend on seasonal precipitation for crop cultivation.

In context of the African continent, above 80 percent of the farming practices in this region are rain-fed and farm productivity practically depends on adequate precipitation during the growing periods (FAO, 2003). It is vital to have sufficient precipitation to maintain adequate soil moistures. However, empirical evidences show that Sub-Saharan African region experiences either water related stress or water scarcity. Thus, food insecurity is mostly attributed to climate change resulting from rainfall unpredictability. For instance, in 2006, twenty-five African nations frequently needed food assistances, due to persistent drought and the prevailing chronic poverty ((FAO, 2003)

Arega (2013) and Fransen and Kuschminder (2009) submitted that, like many other developing counties, majority of the inhabitants of Ethiopia rely on rain-fed agricultural farming system as the major source of their households' livelihoods. However, the prediction stems from the result of biophysical instability modeling including some climate related parameters, such as agricultural production and productivity indexes that verified a declining trend from the 1960s onwards (Fransen and Kuschminder, 2009). Accordingly, there has been a remarkable decrease in the inter-seasonal precipitation, while increase in temperature is unfavorable for crop growth (Nesamvuni, 2011).

Consequently, the populace suffers from chronic poverty, where nearly 29 percent of Ethiopians below the poverty line, out of which 30percent and 26 percent constitute rural and urban residents respectively (MoFED, 2012). Moreover, about 78 percent of the currently estimated country's population survives on less than 2 USD daily, while about 44 percent of the national population is undernourished (Ramanaiah and Gowri, 2011). Aside the contrary impact of climate change, Ethiopians also experience natural disasters, causing loss of human lives. These disasters do affect the livelihoods of households by damaging a ranges of the crops, livestock, and other assets (Muluneh, 2015).

Accordingly, reputable disaster data summary recorded by UNISDR regarding Ethiopia indicates that during 1957 and 2012, amongst the natural catastrophes, recurrently occurring droughts accounted for about 42percent and 33 percent was because of floods, while 12 percent was attributed to conflicts (Gebrie, 2015). Additionally, 6 percent of the natural disasters were ascribed to fire hazards, and 2 percent to land slide, while the remaining disasters caused 2 percent deaths in the country. In Ethiopia, environmental degradation influences climate uncertainty. The largest proportion of the land in the country is environmentally degraded, resulting from inadequate natural resource management in the form of breakdown in the conventional system of proper crop rotation, inadequate soil fertility management, clearance of forest coverage, overgrazing of the natural grazing land, erosive cultural practices, and advance of annual cropping into steeply sloping land.

The Ethiopian Central Rift Valley (CRV) is under continuous threat due to frequent environmental degradation, leading to structural changes in climatic condition in the form of recurrent drought and seasonal weather variability. Similarly, Muluneh (2015) asserted that the CRV of Ethiopia is prone to frequent drought. Likewise, the level of households' food self-sufficiency and security in rural communities is significantly subjective to normal performance of the rainfall reliant farming systems which is naturally sensitive to climate and weather variability. In the meantime, although various programs and initiatives have been implemented to reduce environmental degradation, with the aim of improving the livelihoods performances and ultimately the food security situation of rural community, the potential negative impacts of natural disasters, coupled with climate change are significantly worsening from time to time affecting livelihood of rural households (NMA, 2007).

Similarly, in most parts of Oromia regional state, the major constraints to rural livelihoods are lack of awareness and inadequate knowledge to facilitate adoption of environmentally sustainable agricultural practices. Also, there is lack of needful innovations that will help farmers to manage environmental shocks. However, despite the rapidly growing endeavor to advance perception and awareness of farm households about the ultimate effects of environmental degradation on rural development and national economy, misleading perception and inadequate understanding concerning prevailing climate change associated hazards is widespread. Likewise, optimum adoption of introduced environmentally friendly strategic practices by rural community is limited. Subsequently, the unfavorable impacts of the changes in climate components remain a threat to general populace, particularly in rural communities. Even though various programs and initiatives have been introduced and implemented to manage environmental degradation, and in turn improve the livelihoods of the citizens, the magnitude of natural resource degradation has remained a formidable and challenging phenomenon in Ethiopia, especially in the rural community (NMA, 2007).

Even though government institutions, in collaboration with development stakeholders have instituted development programs and projects to alleviate an undesirable impact associated with climate fluctuations, availing a menu of adaptation strategies have some limitations in reaching the end users. This is because they lacked detailed implementation guideline and strategic approaches are not suitably mainstreamed into all working programs (FAO, 2016). This leaves a gap in the scholarship of agriculture, underscoring the significance of this research that analyses climate change impact vulnerability, and adoption decision of climate smart relevant practices in the Oromia region in Ethiopia.

1.3 Justification of the Study

Developing countries feel the impacts of climate change depending on their climate situation, geographical location, socio-cultural settings, economic and political condition (UNFCC, 2007). Consequently, each country has specific needs for climate change adaptation; even though they are all highly susceptible to the detrimental impacts of these changes (Mertz et al., 2009). Various documentations on climate change impact submit that the adoption of any adaptive strategy is dependent on the impact experienced. However, much is still to be learned on when, why, how and under what circumstance is adaptation required in some economic and social systems (Getahun, 2017). Specifically, the Ethiopian government introduced the Climate Change Resilient Green Economy (CRGE) strategic approach, that was purposely planned to promote environmentally suitable economic development while limiting Green House Gases (GHG) emissions by 2030 (Mulatu et al., 2016).

However, studies on estimating the overall impacts of introduced strategies on reducing climate change impacts are inadequate. Specifically, the studies that focus on the identification of the performances and effects of adopted strategic practices for reducing climate change negative impacts are limited and in line with the CRGE strategies, the concerns of this research is to identify the performance of climate management strategies that have been promoted and introduced into farming systems. This is a notable gap that is yet to be sufficiently researched in the country (Mulatu et al., 2016). Studies abound on the resultant effect of climate variability and changes in relation to the potential influence on national economic development, while there is inadequate research on its impacts on individual livelihoods and social vulnerability. This research is significant because it will identify the factors that are responsible for the very low adoption of CSA practices that can facilitate sustainable development of agricultural production among small-scale farmers in the East Shewa and Arsi zones of the Oromia regional state.

1.4 The Objectives of the Study

The general objective of the study was to analyze climate change impact, vulnerability and adaptation among smallholder farmers in highland and lowland agro-ecologies of the Oromia region, Ethiopia.

The specific objectives of the study were to:

1. Examine the weather variability and prevailing seasonal trends in the study communities.
2. Describe farmers' livelihood responses to perceived climate change across some selected demographic characteristics.
3. Describe the impacts of extreme weather events on farming households' livelihoods and farming practices.
4. Compute indicator of the households' vulnerability to climate change and analyze the factors influencing it.
5. Analyze the factors influencing adoption of Climate Smart Agricultural (CSA) practices.
6. Analyze the factors influencing adoption intensity of Climate Smart Agricultural (CSA) practices.
7. Analyze the factors influencing farmers' perceptions on sustainability of Climate Smart Agricultural (CSA) practices.
8. Analyze the institutional adaptive capacity to implement the adopted Climate Smart Agriculture (CSA) practices; and
9. Determine the effect of extreme weather exposure, coping and adaptation strategies on households' welfare using per capita income and food self-sufficiency indicators.

1.5 Research Questions

Based on the specific objectives, the research questions are identified and structured as follows:

1. What are the local weather trends and inter-seasonal variability in the selected region?
2. What are the farmers' livelihood responses to climate change across some selected demographic characteristics?
3. What are the impacts of climate change and extreme weather events on the livelihood of the farmers?
4. What are the underlying natural, socio-economic and institutional factors influencing households' vulnerability?
5. What are the factors influencing the adoption of CSA practices among the farmers?
6. What are the factors influencing sustainability perceptions of adopted CSA practices among the farmers?
7. What are the institutional adaptive capacities of the system to implement Climate Smart Agriculture (CSA) practices?
8. What are the effects of extreme weather exposure, coping and adaptation strategies on the welfare of the farmers?

1.6 Hypotheses of the Study

1. Households 'assets and financial resources do not significantly reduce vulnerability to climate change impacts and related risks.
2. Socio-economic characteristics of farming households do not significantly influence their rate of adoption of the CSA practices.
3. Socio-economic characteristics of households do not significantly influence their perception of climate adaptation sustainability.

4. Farming households' extreme weather exposure does not significantly influence farmers' welfare.

5. Farming households' coping and adaptation mechanisms do not significantly influence farmers' welfare.

1.7 Limitations and Delimitations of Study

This study was limited by financial resources which compelled selection of just two zones out of the 21 zones of the Oromia regional state. The study therefore focused on only four Districts and twelve Peasant Associations (PA). Again the data collection was conducted during the peak of COVID-19 outbreak under the condition of nationwide lockdowns. There were also transportation interruptions and restrictions on people's movement that influenced the number of participants. However, financial constraints encountered during study were partially resolved by research fund award from UNISA's bursary fund, whereas the remaining research costs were covered from researcher private fund. On the other hand, new data collection time table was re-planned and scheduled taking into consideration the improved condition in imposed people's movement restriction implemented during COVID-19 outbreak to ensure adequate movement in the study areas and beyond to manage data collection.

1.8 Structure of the Thesis

This thesis comprises of ten chapters. Chapter one presents the introduction of the study extensively, emphasizing on general background, problem statement, justification as well as objectives of the study. Chapter two deals with context review of pertinent literature and chapter three emphasizes the theoretical and empirical reviews of the literature. Chapter four articulates the methodology part of the study, with emphasis on the general description of biophysical condition of the study areas, research design, sampling procedures, and specification of analytical models. Chapter 5 discusses the result of weather variability and related impact in context of the trends of inter-seasonal precipitation and temperature parameters. In chapter 6, farmers' demographics characteristics and livelihood responses in context of climate variability and change management options are discussed. Chapter 7 provides the results on perceived climate change impact vulnerability and its determinants. In chapter 8, CSA practices adoption, sustainability, and institutional adaptive capacity in circumstance of climate change strategy management and implementation are assessed and presented. Chapter 9 presents the extensive result discussion related to climate change management and households' welfare, emphasizing on coping mechanisms and adaptation strategies. Chapter ten enunciates the general conclusions as well as recommendations focusing on major findings of the conducted study.

1.9 Ethical Considerations of the Study

The observed ethical issues for this study include the confidentiality of the data and information, and the rights of the participants to participate in the processes of the study willingly. The researcher obtained official letters from relevant government parastatals, which accounted for the willingness of the extension staffs to contribute to the success of the project. On the other hand, the researcher adequately considered and respected all issues and conditions stated in UNISA's ethical and code of research conducts in order to minimize risks to the participants and researchers involved in the study. Accordingly, the research ethical approval for the duration of first years of thesis phase was completed prior to data collection. Renewal of ethical approval was made at the beginning the remaining years of the study. The ethical clearance number of the study is 2019/CAES/050. On the other hand, based on UNISA's rules and regulations, the study adhered to the established ethics policy throughout the study period.

Subsequently, to gain and build the confidence of the study groups and respondents, all the required permission letters were sourced and communicated to the selected districts and PAs level communities. Likewise, the appropriateness of relevant questions in the enumerators administered questionnaires and the interview guide were considered by researcher to ensure that they adequately fit in with the study areas, taking into consideration the community's cultural values. Equally, the researcher ensured a strict compliance with regional and federal laws and regulations related to the field of study during the study by not conducting any research on anything restricted and prohibited by the Ethiopian government. Generally, the researcher also ensured that the respondents are conversant of the nature and purpose of the research study, whether any risk was involved in the process of the research and assured them that all interview questionnaires which have been used for data collection have been coded in a manner that would maintain confidentiality to protect identity and privacy of the respondents. Thus, the confidentiality of the data, information, data storage, disposal of research materials after use, following all ethical issues and procedures were maintained by the researcher and the assistant data collectors.

CHAPTER TWO

CLIMATE CONTEXTS AND CLIMATE CHANGE MANAGEMENT IN ETHIOPIA

2.1 Introduction

This chapter was designed to discuss the climatic conditions in Ethiopia under situation of climate change and its management. It provides the contextual literature review on climate change impacts, including its effects in each sub-sectors of the agricultural sector, in relation to the aggregate impacts on the national economy. Additionally, the chapter highlights the institutionalization of climate related risks mitigation strategies, through nationally focused climate change management support programs and projects that have been adopted to reduce climate related negative impacts on national food security and food self-sufficiency.

2.2 Climate Context and Climate Change Situation in Ethiopia

Ethiopian landscape is characterized by topographical diversity. This results in diverse climatic and weather conditions. The African Great Rift Valley (GRV) is the foremost topographic feature that represents Ethiopia. The diversity in topographical features had naturally established a variety of atmospheric systems that influence the climatic condition in Ethiopia, making it the home of various biodiversity and offering a conducive environment to grow potential crops in almost all parts of the country. In this dimension, Abate (2009) classified and described the climate conditions of Ethiopia into eleven zones. They were described under three major groups, which are the dry, tropical rainy and temperate rainy zones (ibid).

World Bank (2011) submitted that Ethiopia has a highly variable tropical climate and the country's climate is roughly alienated into three major categories: (a) alpine vegetation cool zones with over 2600 meters elevation and temperature ranges from nearly freezing to 16^0C, (b) temperate zones, those areas that the majority of country's population densely concentrating, with altitudes of 1500 to 2500 meters and temperature vary from 16^oC to 30^oC, and (c) hot climate zones, which encompass tropical regions as well as the arid areas that have temperatures ranging from 27^oC to 50^oC in the country which are conducive to farming practices. Given these situations, it becomes appropriate to comprehend the diversity of rainy seasons of a country. This will facilitate identification of crops growing seasons and associate the weather conditions to field yields of some crops (Gabrie, 2015).

The annual precipitation distribution of Oromia regional state shows two peaks which correspond to two main precipitation seasons that are usually separated by a comparatively short dry season. The central and most of the eastern half of the country in which this study is focusing have two major rainy seasons and one main dry period. These two main rainy seasons are short rainy season mainly from February to May and long rainy season which is from June to September. The dry season period commonly covers October to January. Most prominently, the varying topographic features found across a country as well as diversified atmospheric system identified are recognized in determining favorable precipitation pattern that is suitable for local farming activities and agricultural production (World Bank, 2010).

Additionally, despite the possibility of sufficient underground water resources in addition to commonly recognized surface water, the agricultural farming practices in Ethiopia is mainly rain fed. Seasonal precipitation is the most imperative weather variable that determines the performance of agricultural production in Ethiopian (NMA, 2007). However, current phenomenon of weather variability has resulted in unstable climatic structures, which consequently affects the performance of crop and livestock production. Consequently, frequent failure of adequate precipitation signifies drought, which will most probably diminish up to 90 percent of households' farm production. On the other hand, Ethiopia is among the lowest emitters of GHGs, ranking 182 out of 188 countries based on its per capita emission contribution of only 0.27 percent to global emissions (Ministry of Foreign Affairs, 2018).

However, Ethiopia is highly vulnerable to global climate change, currently ranking 163 out of 181 countries in perspective of climate variability and vulnerability (Ministry of Foreign Affairs, 2018). Ethiopia is the 22nd most vulnerable country and 31st among the least climate change prepared. These imply that the country is extremely vulnerable to climate related negative consequences, but so far mostly unready to manage climate oriented negative effects. Therefore, extreme events like droughts are common in Ethiopia. An analysis that was conducted in 2011 revealed that Ethiopia was ranked 5th out of 184 counties in terms of its risk of drought (Ministry of Foreign Affairs, 2018). On the other hand, flash floods and seasonal rivers floods with resultant impacts are common challenges (World Bank, 2011).

Despite the conducive weather condition and other environmental variables in the country, Ethiopia is among the most vulnerable countries to current environmental catastrophes, manifesting through climate change. World Bank (2011) described the recent climate trends of Ethiopia by asserting that the mean annual temperature increased by 1.3^{o}C between 1960 and 2006, with the average rate of 0.28^{o}C per decade. Increase in temperature was found to be most predominant during July-September at the rate of 0.3^{o}C per decade. On the other hand, hot days increases by 73 each year (with increment of 20 percent of days) between 1960 and 2003, whereas observed rate of increase was found strongest during the short dry spell between June and August.

The average number of hot nights increased by 9.9 days per months during similar period. Also, an average number of hot nights increased by 137 per year, with increment of 37 percent between 1960 and 2003.The rate of increase in hot nights is mostly found during the short dry season between June and August, where the average number of hot nights increased by 18 days per months over this period. On the other hand, frequency of cold days reduced considerably during every season apart from commonly known long dry seasons between December and February in which occurrence of cold nights declined more quickly and significantly in all remaining other seasons. Similarly, the normal number of cold days reduced by 21 days (5.8 percent) during the 1960-2003 period. The observed rate of decline is mainly rapid between the September and November, when an average number of cold days diminished by 2.2 days for every month during the period, while average number of cold nights for each year declined by 41 nights which constitutes the 11.2 percent (World Bank, 2011).

In generalized term, several studies reveal that Ethiopia is at the center of environmental catastrophe owing to mismanagement of the available natural resources, which has led to an entire environmental degradation, amplified water resource scarcity, deforestation, and extensive fracturing in the fragile biodiversity that is already susceptible to natural shocks (Temesgen and Wondie, 2014). A considerable increase was recorded in seasonal temperature, while an overall quantity of annual precipitation declined in the Gemechis district of Oromia region (ACCRA, 2011). All these are apt and adequate illustrations of the livelihood vulnerability to climate change in the study area.

In Ethiopia, the impacts of droughts include pastures shortage, over-grazing, environmental degradation, lack of adequate water and frequent outbreak of common and unusual livestock diseases (World Bank, 2011). Accordingly, there has decline in livestock and crop production efficiency with crops failures in the agro-pastoral farming system that often results into food insecurity and communal conflicts. Hagos et al. (2014) also noted that droughts do not only costs loss of human lives through chronic food shortages, but evidently affect overall economic growth and development in Ethiopia.

2.3 Climate Change Policies and Programs in Ethiopia

There has been consensus on the need to ensure that the agricultural sector becomes ‘climate smart’ (FAO, 2016). Therefore, initiatives to support Climate Smart Agriculture (CSA) should be established and supported by adequate policy framework (FAO, 2010). The Ethiopian government formulated its National Adaptation-Programs of Action (NAPA) which emphasizes the need for productive adaptation strategies. NAPA has been produced based on currently available information, community level swift assessments and technical dialogues. The trio helped to establish the national policy that categorized 37 adaptation measures in relation to climate change and variability in some weather parameters. Among globally recognized strategic practices, NAPA emphasized the development of small-scale irrigation schemes for dry lowlands. In addition, the institution as an integrated policy plan embraced a range of prioritized adaptations options. Accordingly, NAPA has been established to precisely focus on farm level practices like agricultural insurance, improved early warning mechanisms, natural range-land improvement, carbon sequestration, forest management and agroforestry related strategies. In accordance with selected priority options, the Ethiopian government has demonstrated adequate commitments to put in place the rewarding policies, strategies, and programs to ensure proper implementation of the policies. Therefore, the Climate Resilient Green Economy (CRGE) program officially commenced in 2012 to safeguard the national economy and natural resources from climate related degradation (Temesgen et al., 2014). Accordingly, the CRGE is an initiative that was established based on the mandates that are embedded in the NAPA and implemented by the Ministry of Water Resources and National Meteorology Agency of Ethiopia.

2.4 The Context of Climate Smart Agriculture in Ethiopia

The farming systems in Ethiopia can be classified into five major categories which are highland mixed farming, lowland mixed farming, agro-pastoralist, shifting cultivation farming and commercial farming (FAO, 2016). Fundamentally, the concept of climate smart agriculture is the proper integration of climate response options into agricultural development strategies with the aim of attaining national food security (Vermeulen et al., 2012). The integration is achievable through adequate planning and setting of the right priorities with the intention of addressing the trade-offs as well as the synergy among the three pillars of productivity, adaptation, and mitigation (Vermeulen et al., 2012). In the process of implementation, CSA harmonizes the priority areas to accomplish the most efficient, effectual, and reasonable food supply systems by addressing the environmental, social, and economic dimensions of the production systems. Majority of the practices embedded in CSA are already in existence worldwide, and currently farmers are widely applying them to manage some climate induced production hazards (Vermeulen et al., 2012).

The Ethiopian government has adopted CSA initiative and integrated them into the existing farming systems to moderate the vulnerability of the prevalent farming systems. CSA is the farming production system that maintains increased and sustainable productivity and production, improve livelihoods' resilience as well as environmental unit through reduction in Green House Gases (GHGs) concentration in the atmosphere (FAO, 2010). The primary focus of CSA program is effective promotion of some proven farming practices like mulching, inter-cropping, soil nutrient conservation farming system, crop rotation, integrated crop and livestock farming, agroforestry, improved range land management, and improved water management systems. Furthermore, CSA places some emphases on promotion of pioneering strategies-which include improved weather and/or climate variability forecast systems, proactive early warning system, index weather insurance and development of drought tolerant crop varieties (FAO, 2016). It is particularly worthy of note that Ethiopian government has adopted CSA initiative into the existing farming systems and its goal is to establish agricultural production systems which adequately increase the farm productivity, improve adaptability of agricultural livelihood as well as the ecosystem to natural disasters, especially those that are related to climate change (FAO, 2010).

The implementation process of the initiative is equally expected to reduce potential greenhouse gases emissions and/or remove already emitted GHGs from the earth's atmospheric components and ultimately supplement realization of food security and development at national and regional level (FAO, 2010). Regarding current trends, there is a promising emerging need to reconcile environmental security measures with small farmers' agricultural production practices through reduction in the levels of emission of GHGs, improved agricultural productions, and reduced systems susceptibility to expected impact of climate change and weather variability in the community (Vermeulen et al.,2012).

CSA practices implementation requires significant coordination and integration efforts to adequately reach grass-root levels. National policies could be harmonized with adequately designed attention and focus on implementation processes of CSA innovations to promote the productive partnership between government and non-governmental organization (Meinzen-Dicket al., 2012 and Williamset al., 2015). The Ministry of Agriculture and the Ministry of Environment and Climate are the key actors in the promotion of climate change management options, particularly in smallholders' farming systems of a country. The need to reduce the vulnerability of the systems substantially, with an intention established to increase the resilience call for considerable system level shifting in a manner that each of the key responsible institutions and players work together to reduce the negative impacts of climate change (Steinecker, 2012). Accordingly, legislations which emphasize the realization of the procedures and process of CSA's objectives are required to organize institutions and stakeholders to put into practice a cross-cutting as well as cross-sectoral coordination approach (Ngara, 2017).

Therefore, the design and implementation of climate change management strategies are anticipated to ultimately influence agricultural development, food security, poverty reduction and overall sustainable economic development. Thus, to be successful, CSA initiatives ought to be aligned with all government official structures and cross-sectoral development programs, which need the context understanding of structural functions of each level that is responsible for the execution of the developed policies. In addition to the established policies, comprehensive capacity building mechanisms need to be instituted to manage execution process. Consequently, to establish an enabling work environment for development partners and to mainstream CSA into nationally working frameworks, suitable institutions with effectual and clearly organized governance arrangements should be set up. To this end, once confirmatory commitment is established, there is the need for adequate unity, promising coordination, and sustainable amalgamation of CSA into each structural system to make it the priority, as well as the focus of each institution with the intention of minimizing the chance of drawback that can cause some detachment in the CSA implementation connectivity. In summary, adequately established institutions are sufficiently essential for the development of agricultural sector including the realization of climate change adaptable livelihoods (FAO, 2013).

2.5. Chapter Summary

The literatures related to climatic conditions, climate change and climate change management have been reviewed and discussed in the chapter in context of Ethiopia in general and in Oromia regional state in particular. Current climate change management policies, programs and strategies were discussed emphasizing on the climate resilient economy and climate smart agricultural strategies in viewpoint of design and implementation. In this aspect, the significant number of the reviewed literature revealed that climate change processes are fast at the global scale, and more compounded in developing nations. However, adaptation situation is worst in developing countries of Africa including the Ethiopia due to low adaptive capacity to regulate the climate change processes and their consequences. According to the literatures, the impacts of climate change have been growing and expanding exponentially in different dimensions of economic sectors particularly in Africa with worst scenario in Ethiopia. Accordingly, there is the need for adequate combination of efforts from all sectors of the economies for effective climate change management policies in sub-Saharan countries including Ethiopia. More importantly, sufficient research on bottlenecks related to adoption of climate change management strategies in Africa are essential to help stakeholders to emphasize on Policy and strategies development to manage climate change and resulting consequences.

CHAPTER THREE

THE NEXUS OF CLIMATE CHANGE AND AGRICULTURE

3.1 Introduction

This chapter presents the literature review that further situates the thesis within the academic conversation of agriculture, with special focus on climate change, its effects and adaptation strategies. It covers a wide range of climate change related problems that affect productivity of farmlands. Furthermore, previous studies and interventions on environmental conservation were particularly discussed. Specifically, the focus of the literature review under this chapter is to provide an overview of the theoretical and conceptual frameworks of the study, climate change and weather variability including its adverse effects on socioeconomic development and livelihood of small-scale farmers. Finally, the review of the empirical study of the technology adoption and sustainability with emphasis on climate change adaptation strategies and technologies are included in this chapter to compare and contrast the findings with extant findings.

3.2 Theoretical Frameworks of Major Variables

Climate change impact vulnerability and adoption of the mitigation strategies have natural and social dimensions which can be illustrated by people and environment interactions. Different academicians at different times viewed diversified set of theories in relation to climate change impacts vulnerability, and technology adoption, and review of concepts explanation related to these theories are adequately relevant for this study. In this regard, specifically the related and selected theories for this study are climate change impact vulnerability and adoption-diffusion of innovation. Considering the context of the climate change impact mitigation efforts, all these theories in one way or the other can explain a theoretical influence on household livelihoods and food security. Thus, the subsequent sub-topics draw attention to these theories by assessing potential arguments amongst academicians in relation to these theoretical frameworks.

3.2.1 Climate Change Impact Vulnerability

Climate change represents a long-term change in the normal patterns of some weather parameters, primarily temperature and precipitation over decades or longer period (Muhammad, 2012). UNFCCC (1994) described climate change as the persistent changes in the regular condition of the local climate and natural climate variability, which is influenced either directly or indirectly by the interference of the human practices. Furthermore, the IPCC also avers that climate change alters the situation of climate condition because of the natural variability in greenhouse gases that are released into the environment over a given period (UNFCC, 2011). Farmers are vulnerable to climatic changes. According to the definition that was adopted by Abate (2009) from Thornton et al. (2006) and Pulhin et al. (2006), vulnerability is the likelihood of households and communities to suffer some welfare losses from climate change and seasonal weather variability.

According to the IPCC (2013), vulnerability is the degree to which a particular society is at risk of exposure to climate change given that they lack the capability to manage the associated negative consequences. Climate change reduces the income generating potentials of a farming household or community (Abate, 2009). Remarkably, there is a huge range of technical knowledge that is appropriate for the assessment of climate and weather variability. Largely, the causes of climate change vulnerability include earthquakes, hurricanes, flooding, drought and increase in global warming (Elum et al., 2016). The central perception of vulnerability is interacting situation between human practices and natural environments and congruently, several researchers who conducted climate related studies suggested and generalized vulnerability as the resultant outcome of people-environment interactions in particular social system (Figure 3.1). Arega (2013) pointed out that vulnerability is the holistic function of exposure to stressors, sensitivity and adaptive capacity that frequently manifest within institutionalized interaction of societal experiences and natural environment.

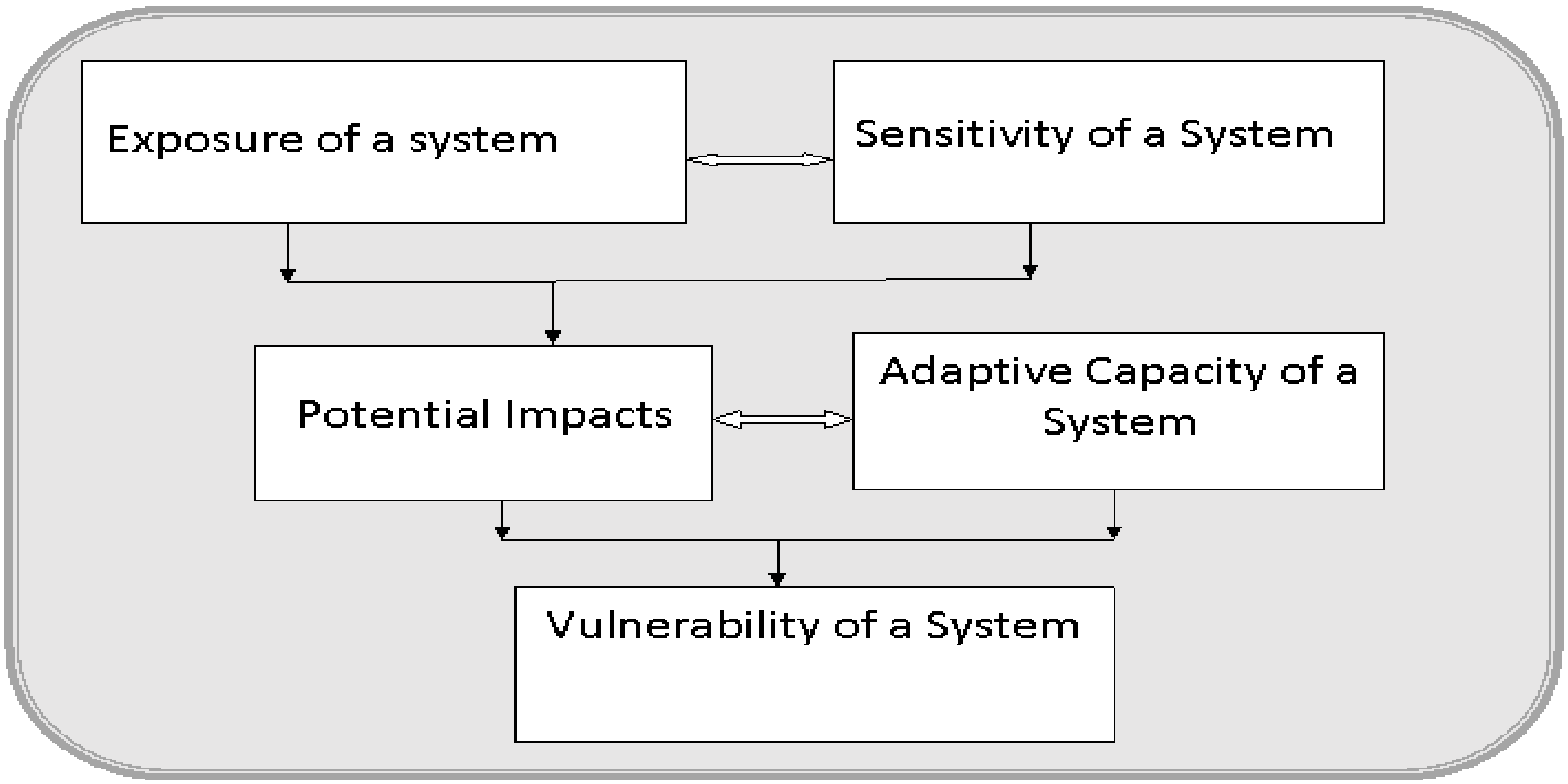


Figure 3.1: Vulnerability Component Framework (Adapted from Marshall, 2009)

Relatedly, Brikmann (2006) argued that vulnerability is a resultant effect of interactions among exposure and external stressors, which can be illustrated as the exposure to risks of climate variability shocks, and adaptive capability of the affected groups. Generally, the IPCC opined that vulnerability is a function of three interacting elements which are exposure to external environment, sensitivity to prevailing stressors, and the system's adaptive capability, which is commonly termed as the system's capacity. These elements can help in the evaluation of the nature and magnitude of climate change threat to detect the key sources of vulnerability and identify helpful actions that reduce the threat under each element of vulnerability.

Exposure corresponds to some key climate events and patterns that negatively influence the social and natural system. It also includes other changes that are associated with the systems that might be induced by abnormal climate effects recurrently happening in a particular socio-economic setting. In practical explanation, exposure is the extent to which a given region, resource or community experiences changes in climate related situation which is characterized by the magnitude, frequency, duration and/or spatial extent of a weather events including the seasonal pattern (IPCC, 2007). On the other hand, several authors described sensitivity as an extent to which existing systems are negatively influenced by changes in the climatic structures, or responsive to changing condition that helps to manage the risks. Thus, sensitivity of a system is commonly reliant on socio-economic status, prevailing politics in the system, the level of cultural traditions and institutional factors practiced in the community. For example, social system that widely depends on frequently vulnerable livelihood like farming is usually sensitive to changing conditions in some weather parameters (Marshall et al., 2007).

The adaptive capacity, when viewed from the perspective of climate related stressors illustrates the capacity of a particular system to respond to challenges which are induced by changing situations through learning, managing impact related risk, developing new knowledge, and devising effective adaptation approaches (Marshall, 2009). Adaptive capacity requires the flexibility of the target community to experiment and adopt innovative solutions among many other things which are recommended for climate change management (Marshall, 2009). In each society, adaptive capacity can either be an intentional or unintentional characteristic, enhanced by the existence of required institutions and set-up that learn and accumulate knowledge, including experience, craft capacity of flexibility in problem solving, without compromising the capability to manage and acclimatize to future changes in climatic condition (Marshall, 2009). On the other hand, according to Schipper (2010), adaptation refers to adjustment to a latest situation of climate structures. These attributes can be newly occurring situations and unusual changes as compared to what already exists in the community which takes place in response to impacts experienced in a particular system, as well as in anticipation of expected climate change impacts (Marshall, 2009). In this scenario, adaptation can be a spontaneous or autonomous process that commonly takes place depending on potential adaptive capacity of a system. These are actions that are taken to minimize the risk of welfare losses due to changes in climate (Füssel, 2007).

3.2.2 Adoption of Innovation and Technology

The process of adopting any new technology has been researched for several years (Ismail, 2006). Accordingly, researchers from different fields and disciplines have frequently adopted the Rogers' theory that is based on technology adoption model as a theoretical outline in technology adoption-diffusion research to explain the theoretical linkages of adoption processes. Thus, under practical condition, Rogers' diffusion theory is adequately suitable to examine the acceptance of an innovation, commonly termed as adoption. Much of the diffusion studies involve interactions of technological innovations with other systems, and the word technology and innovation have been used interchangeably (Ismail, 2006). Subsequently, this theory demonstrates the attributes of two components, which are hardware and software attributes. The hardware attribute is physical object which represents innovation in a material form, while the software component represents information in conceptual frameworks of the model. Additionally, an innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption (Rogers, 2003). The characteristics of an innovation depend on the context that engendered it. This is also associated with awareness, persuasion, and choice of a particular innovation during adoption (Rogers, 2003).

The adoption units are always uncertain about the new technology, while hesitation is an imperative setback in the course of adoption. For instance, the consequences of innovation might result in hesitation which usually includes changes that commonly take place at individual level or at societal level (Rogers, 2003). Adoption is a decision on the absolute acceptability of the introduced innovations. In contrast, an adoption unit may decide not to adopt an innovation due to perceived backgrounds of the innovations. Appositely, Rogers (2003) defined diffusion as the process of communicating an innovation to ultimate users via certain channels over a specified period within some established societal structures.

The course of adoption decision may start when an individual's adoption units move from a state of ignorance, usually called pre-contemplation to being aware of the innovation (Bothaand Atkins, 2005). Consequent upon awareness, the individual may out rightly reject the innovation immediately or the adoption decision-making process may continue leading to development and a subsequent demonstration of interest in the innovation (Bothaand Atkins, 2005). Likewise, the individual may reject the adoption, or proceed into the next stage of adoption decision which constitutes comparison of newly introduced innovation with similar existing ones. In adoption decision context, innovation is a reference to any attributes of adoption model that is new to a particular community or individuals. Correspondingly, a technology is a design for action which minimizes uncertainty that are involved in attaining a preferred outcome in a social system (Ismail, 2006).

During the comparison phase, individual community members generally compare the intended innovation with what is currently available in the community. After the evaluative comparison, they may decide to either adopt or reject the innovation based on the merit of the introduced innovation (Ismail, 2006). During comparison, once the result of the comparison assessment is favorable as compared to locally available practices, the next step is to experiment the innovation in which individuals usually assess the innovation on small-scale basis to evaluate whether it works or not within that farming system (ibid). Afterwards, they will compare the innovation's results with other locally available possible options, which may lead to rejection of innovation when it failed the test compared to other alternatives currently existing in the system (ibid). However, if the innovation passes the test as the better or best alternative, there is every possibility of adopting the innovation (Botha and Atkins, 2005). Nonetheless, after the innovation has been adopted, it can be discontinued (ibid).

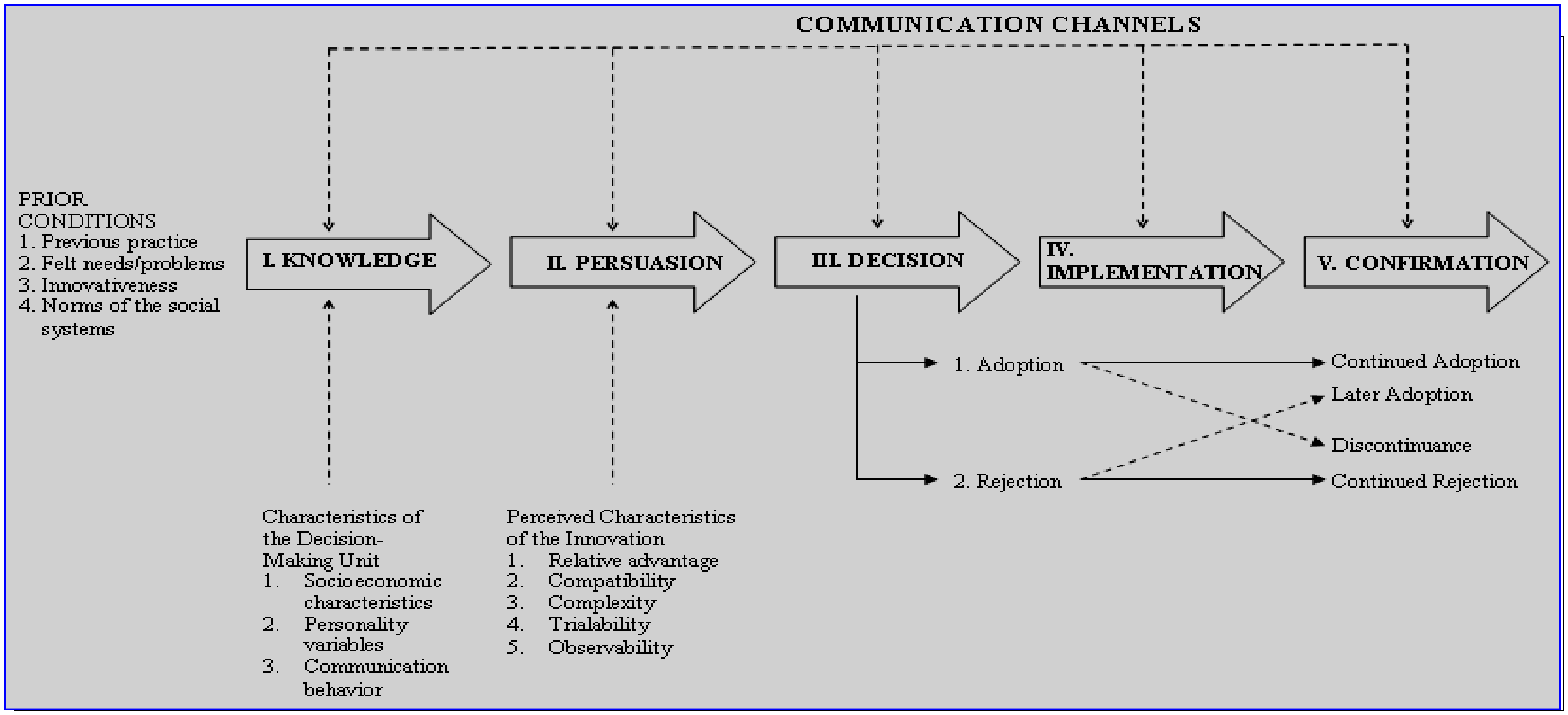


Figure 3.2: Stages of Adoption in Diffusion of Innovation (Rogers, 2003, 5th Edition)

In order to reduce uncertainty in the process of innovation adoption, individuals should be informed about its rewarding characteristic, as well as its drawbacks. The essence of the information is to know the consequences of adopting the innovation. Congruently, Rogers (2003) claimed and categorized the innovation consequences as useful or non-useful, direct versus indirect and predicted or unexpected (Ismail, 2006). Oppositely, communication channel is the second aspect of adoption components. Local and cosmopolitan channels will facilitate adequate communication among individuals within society. For instance, inter-personal channel could be classified as local or multinational (cosmopolite); virtually almost all mass-media are categorized as multinational channels (Ismail, 2006). However, the influence of the channels varies. For example, communication through the mass media is significantly important at knowledge phase, while local channel and inter-personal channel are significantly imperative at persuasion level (Rogers, 2003).

In this content, society level system is contextualized aspect explained in innovation diffusion, which is described as a set of inter-linked each unit established at community level that institutionalized generate combined effort to achieve a common goal and the diffusion of innovation usually takes place in a societal arrangement/setting that is practically influenced by social structures (Ismail, 2006). According to Rogers (2003), social structures are the orderly arrangements of units in a social organization. It is important to note that the arrangement can easily influence or affect the decision taken regarding innovations. Generally, several documents described the innovation-decision process as constitute of information seeking, where a particular members of a system is motivated to avoid doubt concerning merit and demerit, involves awareness, persuasion, decision, implementation and confirmation contents (Figure 3.2).

In summary, Rogers (2003) submitted that the adoption of innovations is more advantageous than the currently available practices. Several research findings have proved that all these factors have a potential capacity to influence the individual's likelihood of innovation adoption (Ismail, 2006). Accordingly, based on adoption behavior of individual, Rogers (2003) distinguished five categories of adopters which are innovators, early adopters, early majority, late majority, and laggards. In each category, individuals are closely similar in terms of innovativeness, which is the degree to which a unit of adoption is comparatively earlier in adopting new ideas than other members of a social system. In this regard, innovativeness is a socially constructed innovation seeking characteristics that indicate an individual's readiness to adjust traditional and locally familiar practices to potential and available innovation (Ismail, 2006).

3.2.3 Pro-Environmental Theory

The management of prevailing weather variability requires mitigation and adaptation. Mitigation is the effort organized to reduce the levels of GHGs emission while adaptation comprises of comprehensive measures to reduce the negative impacts of observed changes (Fussel, 2007). Nget et al. (2017) identified the theoretical framework which illustrates the inherent drivers of climate study. According to these authors, barriers in people's willingness to change lifestyles have some environmental implications which can be explained by theoretical framework established in the context of pro-environmental behavioral theory model. The environmental behavioral model adequately considers the economic incentives during weather variability and climate changes management to minimize the resultant disasters and related risks (Nget *et al*., 2017).

Economic incentives, like systematic subsidy, encourage pro-environmental behavior by settling required costs of adaptation or mitigation, while economic disincentive, like that of taxes usually discourages currently required behavior through adding cost of practices. Accordingly, consumption may increase because of subsidy accessibility, consequently resulting into lesser environmental damaging behavior (Nget *et al*., 2017). Profoundly, subsidies and taxes can be identified as separate constructs as both are monetary instruments that are broadly considered as independent economic tools that either encourage or discourage pro-environmental behavior. Taxes impose some financial burdens on producers to carry out the introduced practices, degrading behavior by making the cost of the behaviors extremely high (Nget *et al*., 2017). Availability of economic leverage could play a significant role to encourage, and shape required behavior, where the effectiveness of behaviors also could be affected by social, infrastructural, and psychological variables (Kollmuss and Agyeman, 2002).

On the other hand, climate model concept is a supplementary component of pro-environmental theory, where the module has feedback on economic model through the so-called damage function that affects several parameters (Roson, 2010). Climate change impacts are exogenous parameters', affecting the general equilibrium in all time steps of the recursive dynamics and the impacts normally affect exogenous variables, like stocks of land, capital and infrastructure or multi-factor productivity explained in crop yields (Roson, 2010). The total economic burden of climate change is associated with three cost segments: cost of mitigation, adaptation, and residual impact which are neither mitigation nor adaption (Traerup, 2010). Estimating the costs and benefits of adaptation is important to determine the levels and choice of investments for adaptation, where costs of adaptation refer to the costs that a social system spends to adapt to changing situation in climate parameters (Nget *et al*., 2017). According to Roson (2010), adaptation costs are the costs of adaptation measures' planning and implementation, including the transaction costs.

On the other hand, adaptation benefits can be referred to as the climate damages avoided by specific adaptation options (Callaway 2004). For instance, it had been widely recognized that the longer it takes to limit GHGs emission, the higher the damages (Roson, 2010). Furthermore, the negative influences of climate variability can be marked by economic shocks, where unpredictable events induce some considerable modifications within a society (Batten *et al*., 2020). For instance, supply-side shock commonly affects efficiency capacity of a particular economy. This can arise from physical climate risks along with price volatility caused by shortages of commodities (Batten *et al*., 2020). The cost of transition to a low-carbon economy is represented by trade-off between the need to limit future damage emanated from global temperature increases and present cost of emission reduction that shrinks the resources available for current development (Coeure, 2018).

On other hand, losses derived from extreme events such as flood and storm are termed as demand-side shock. For instance, climate unpredictability may lead to damage of households' assets and reduce private consumption. Furthermore, demand-side shocks can be caused by transition to a low carbon economy and tighter climate policy could cause dislocations in high carbon sectors leading to a large as well as sudden reduction in investment (Batten *et al*., 2020). More importantly, climate related changes can have an effect on monetary policies in diverse set of directions. First, climate change related physical and transaction risks may affect macro-economy leading to inflation. Second, climate change can affect monetary policy indirectly, through its impact on households' and firms' expectations (Lane, 2019). Generally, climate change is likely to affect monetary policies, whether it is addressed in the present, through economic cost of emissions reduction (transaction risk) or whether it is left unchecked, through impact of increased extreme events (Coeure, 2018).

3.3 Conceptual Frameworks

3.3.1 Climate Change Adaptation

Fundamentally, the predominant and major adverse impact of climate change on agricultural productivity comes through environmental degradation and climate instability which require proper adaptation for sustainable production system. As a matter of fact, scientists and social scientists have been studying climate change, and how it influences temperature and food production systems. Accordingly, Bette et al. (2011) asserted that there is a growing knowledge on climate change adaptation practices. Furthermore, the new evidence is brought into the climatic functional system and needs to be contextualized to comprehend each dynamic circumstance (Bette *et al*., 2011). The changes in climatic condition of a locality, including the exploration of resultant impact on diverse set of ecosystem and land uses have been discussed in literature. The significance of the continuous investigation is to precisely identify some scientific evidences on the impacts of climate change. In this aspect, currently it is generally agreed and recognized by majority that changing situation in the climate elements is happening in the natural ecosystem, and it has a negative influence on the normal process of the natural environments which requires adaptation measures (Bette *et al*., 2011). Hence, climate change adaptation entails the changes in current livelihoods strategic practices and setting of priority by focusing on the most susceptible social groups in the community and sensitive land use patterns that are functional in the existing farming systems. Furthermore, the global climate change adaptation options can be evaluated and presented based on the potential impacts on social sustainability, environmental stability, and economic development in perspective of sustainability (Bette *et al*., 2011).

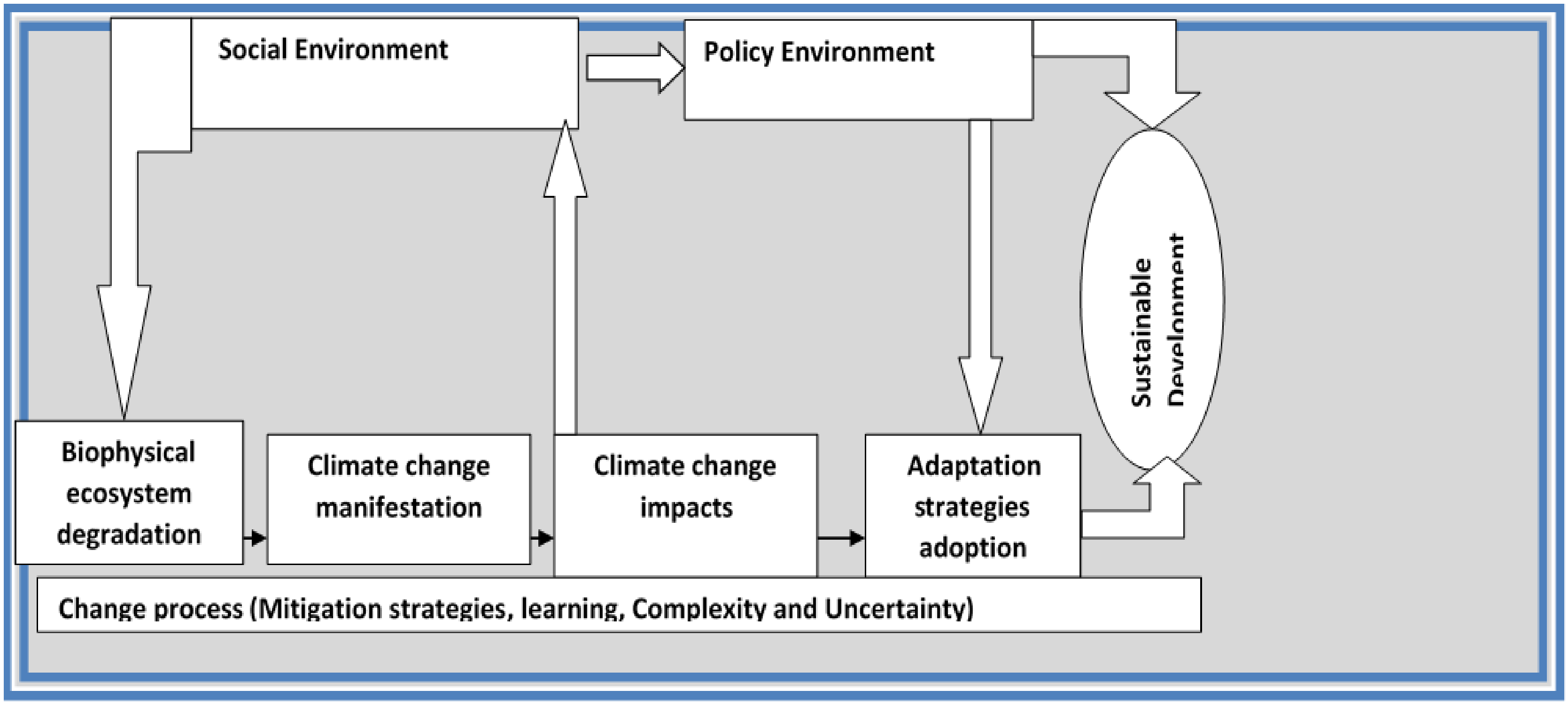


Figure 1.3: Climate Change Adaptation Strategies for Development (Adapted from Bette *et al*., 2011)

Climate change management is a change-oriented process which includes decision making groups, scientists, and private stakeholders from the community level to a higher national policy level. In this context, developing countries' decision makers require national and regional assessments that take a bottom-up intervention approaches and pro-poor perspective, to determine appropriate climate change management responses under intended socio-economic settings (Bette *et al*., 2011). In this study, the conceptual framework guiding the course of the study has been adapted with modification from the work of Bette et al. (2010). Accordingly, it functions as a strategic tool which helps in comprehending the conceptual relationship and interaction of climate change, impacts and responses (Figure 3.3). The structure of the framework is specifically framed by taking into consideration climate change related theory that links climate change situation to adverse effects, which ultimately influence the governments and communities to act against changing circumstances in the different socio-economic context.

Lemma (2016) posited that suitable mitigation and adaptation practices positively influence both climate change situation and the environment, thereby inducing some positive influences on agricultural farming practices. Some adaptation activities directly improve agriculture through changes that take place in land management, such as maintaining the traditional forest cover, grazing land management, proper wetland management, farmland handling, water bodies and soil conservation management. Moreover, sustainable development is a broad concept that encompasses a range of issues related to economic, ecological, and social dimensions. The definition of sustainable development implies that no generation in the future will be worse off than the present generation (Sara, 2010). Historically, the links between climate change and sustainable development have often been defined primarily as lying between mitigation and development. Nonetheless, climate change adaptation is often currently associated with sustainable development (Klein *et al.*, 2007). It is also increasingly acknowledged that development paths and adaptive capacity are intrinsically linked as economic development is regarded as an adaptation process of achieving sustainable development (Yohe *et al.*, 2007). Furthermore, an adaptation's conceptual framework describes the impacts of climate change on individuals and social wellbeing and highlights areas for policy action and responses (Boylan *et al*., 2014).

3.3.2 Systems Level Vulnerability to Climate Change

According to Adger (2006), vulnerability in respect of climate change is typically described to be a function of three overlapping factors which are exposure, sensitivity, and adaptive capacity that categorizes certain individuals as well as groups as "vulnerable" to climate change and related impacts. A wide range of factors emanating from natural hazards, entitlement failure, social, political, economic, culture and ecological can significantly expose an individual or group of people to being vulnerable to income shocks (Adger, 2006). Furthermore, according to Guillaumont (2017), there are three main areas of vulnerability which are economic, social, and environmental. Among these, economic vulnerability corresponds to structural vulnerability, which depends on longlasting or structural factors that are beyond the immediate control of a country, and general vulnerability, which depends both on the structural factors and a country's policies (Guillaumont, 2017).

Additionally, a system is vulnerable if it is exposed and sensitive to the effects of climate change and at the same time has only limited capacity to adapt. On the contrary, a system is less vulnerable if it is less exposed, less sensitive or has a strong adaptive capacity (Thomas, 2012). Vulnerability is applied as a key concept in assessing who experiences the greatest impacts of climate change (Kelly and Adger, 2000). The entitlement approach examines vulnerability in relation to people's access to different basic services that generate inequitable degrees of vulnerability which include access to health care, food, education, and land (Thomas, 2012). Accordingly, vulnerability of a society is influenced by its development path, physical exposures, distribution of resources and institutional setting (Smit and Wandel, 2006). It indicates that a system or simply people can be vulnerable to some varying degrees, pointing to the root causes of inequity and the entitlement approach (Guillaumont, 2017).

3.3.3 Institutional Adaptive Capacity in Service Delivery System

Adaptive capacity is the ability of a system to successfully adjust to climate change (IPCC, 2007). According to IPCC (2007), adaptive capacity comprises of adjustments in behavior, resources, and technologies. Socio-economic factors are important for the adaptive capacity of a system; integral role of institutions, governance, and management in determining the ability to adapt to climate change (Thomas, 2012). Additionally, Thomas (2012) noted that some socio-economic determinants of adaptive capacity are generic (education, income, and health), while others are specific to climate change impacts such as floods or droughts (institutions, knowledge and technology). The more adaptive capacity a system has, the greater is the likelihood that the system can adjust and thus is less vulnerable to climatic changes and shocks (IPCC, 2007).

In practical conceptual contexts, adaptive capacity and coping concepts are confusing, but both adaptive capacity and coping concepts are associated with different time scales and represent different processes (Boylan *et al*, 2014). The capacity of a system to accommodate deviations from "normal" climatic conditions describes the "coping range", which can vary among systems and regions (IPCC, 2007). Understanding the coping range and vulnerability thresholds of a system is a prerequisite for the assessment of likely climate change impacts and the potential role of adaptation (IPCC, 2007). On the other hand, adaptive capacity represents the potentials possessed by a system to adapt rather than the actual adaptation (Boylan *et al*., 2014).

The numbers of investigative studies conducted to assess the adaptive capacity of a particular system regarding natural environment related stressors including climate change have attempted to provide a conceptual framework and operational analytical approaches. For instance, Smit et al. (2001) identified six determinants of adaptive capacity in the context of climate change. Furthermore, Swanson et al. (2007) also noted that the underlying principle that is associated with each determinant provides guidance for the development of indicators for institutional adaptive capacity assessment based on resource types and availability in a service delivery system. Accordingly, the determinants of adaptive capacity of a system in rural communities for meeting climate change and weather variability related risks mitigation are identified as social resources, human resources, institutional, infrastructural, natural resources, technological, informational and skill resources (Swanson *et al*., 2007).

3.3.4 Technology Adoption Conceptual Framework

In developing the conceptual framework for technology adoption, a wide range of approaches which are illustrated in several studies have been reviewed to describe and understand the appropriate factors that can critically influence the technology users' adoption decision. In this regard, among the common approaches available in scientific literatures, the most preferred ones were selected and reviewed. Accordingly, the conceptual framework was reviewed, and the variables were clustered under eight categories. The view of the Unified Theory of Acceptance and Use Technology Model (UTAUT) which was formulated by Venkatesh et al. (2003) and described by Attuquayefio (2019) combined eight extant technology acceptance models as follows:

1. Performance of technology: Performance is defined as the degree to which an institution or individual believes that adopting the technology will lead to improved enterprise performance (Berg and Lingen, 2019). The six different constructs from previous research that pertain to performance are: perceived usefulness, relative advantage, technology context, viability, performance expectancy, and perceived benefits of the technology when introduced into the system (Berg and Lingen, 2019). According to a range of studies like Yua and Tao (2008) and Yang (2005), the positive perception of the benefits of a technology can act as an incentive for the adoption in a sustainable manner. Scornavacca and Barnes (2008) suggested that the need for enterprise to reduce latency, increase response, enhance efficiency, improve productivity, boost revenues, and increase competitive advantage would motivate the system to adopt adaptable technologies. Accordingly, the expected benefits of the technology will have a positive effect on the adoption of the technology (Scornavacca and Barnes, 2008). In addition, the Technology Acceptance Model (TAM) was established by Daniel (2015) to describe how the users come to accept and use any information technology such as CSA. According to this model, when a new technology is presented to users, several factors influence their decisions about how and when they will use the introduced technology. These factors are behavioural intentions, attitude, perceived usefulness of the technology, perceived ease to use of the technology, individual intention and institutional condition (Daniel, 2015). Technology Acceptance Model is the most influential theory in the literature, which hypothesized that the attitude of a user towards technologies is the major determinant on whether the user will use or reject it. The attitude of the user, in turn, is assumed to be influenced by two major factors which are perceived usefulness and simplicity to use (Daniel, 2015). Similarly, performance expectancy, which is also perceived usefulness, has been identified to have a positive relationship with Actual Technology Usage (Attuquayefio, 2019).

2. Technology usability: Technology usability is defined as the degree to which the system or individual believes that a technology is learnable, effective, and efficient (Berg and Lingen, 2019). These can be explained by perceived ease of the technology to practical use, complexity, and effort expectancy (Berg and Lingen, 2019). The report by Awa, Ukoha and Emecheta (2015) support the theory that the usability or ease of use of a particular technology commonly will have positive effect on the adoption intention. On the other hand, perceived ease-of-use is the ability of users to accept and use the technology and improved practices, which commonly influences the usefulness of the innovation as the resources and learning become easier to them to integrate into a particular production system (Daniel, 2015).

3. External environment: External environment is defined as the degree to which an organization believes that environmental factors, in which the enterprise operates, encourage technology adoption and sustainability. The factors that can be relevant to the external environment are subjective norms, observability and external organizational/institutional structure characteristics, environmental context, external social influence, and external pressure (Berg and Lingen, 2019). These environmental factors include peer influence, rate of technology change, market volatility, consumer readiness, competitive pressure, partner readiness, and regulatory environment (Martín *et al*., 2012 and Awa, Ukoha and Emecheta, 2015). Martín et al. (2012) cited competitive pressure as a significant factor that influences the growth and spread of a particular technology, mentioning that institutional pressures can facilitate adoption for improved productivity.

4. Enterprise readiness: Enterprise readiness is the degree to which a system considers that it can adopt, diffuse, and incorporate technology into its production structures and systems (Berg and Lingen, 2019). This includes the enterprise characteristics such as the technology infrastructure, leadership knowledge and support, resource availability (human, financial, and technical), organizational support processes, decision-makers' knowledge and human resource readiness (Yua and Tao, 2008). In addition to these, according to these authors, the constructs that pertain to enterprise readiness include compatibility, trial-ability, internal institutional structure characteristics, individual leader's characteristics, organizational context, fitness and viability, facilitating conditions and system level readiness to harness the intended technology (Yua and Tao, 2008). Enterprise readiness will have a positive effect on adoption of the intended technology. In this regard, Lin and Lin (2008) confirmed the positive link between improved infrastructure and the increased probability of technology and practice implementation success. It was therefore hypothesized that availability and quality of infrastructure required for promoting the technology will influence enterprise's decision to adopt (Lin and Lin, 2008).

5. Social and economic variables: According to the unified Acceptance and Use Technology Theory, social influence is considered as an essential factor affecting users' adoption of technology (Venkatesh *et al*., 2003). In this view, social influence is a perceived social pressure, where important people motivate an individual to accomplish or reject an intended behaviour. According to several findings, individuals tend to adopt new technology if some important people advise and encourage them to do so (de Luis *et al*., 2015). In this regard, previous studies have reported the significance of social factors that influence adoption of technology (Dezdar, 2017 and Mishra *et al*., 2014). On the other hand, an individual's socio-economic characteristics has been identified by several findings as the factors dictating technology adoption decision. In the conceptual framework development, in respect of social and economic variables**,** several studies identified age, educational level of the household head, household income, landholding and livestock ownership as the major determinants of technology adoption and sustainability (Ayatullah and Waqar, 2016). In this regard, the factors elucidating the adoption of biogas technology in India were examined by Mottaleb and Rahut (2019), in which the result demonstrated that both physical capital, such as house ownership and landholding, as well as human capital, such as education, are the influencing factors to the technology adoption (Mottaleb and Rahut, 2019). According to the study conducted from a household's perspective in Uganda, to ascertain and analyze the factors influencing the technology adoption; the empirical results suggested that the probability of a household adopting a technology is dependent on the age of the household head, income, the number of cattle owned, household size and increasing cost of alternative technology (Walekhwa Mugisha and Drake, 2016). Furthermore, in Ethiopia, the factors influencing households' decisions on biogas technology adoption include sex of the households, educational level of the households' heads, herds of cattle, income level and access to credit facilities are among many more others (Mengistu, *et al*.; 2016).

6. Policy environment: The policy environment refers to the national and international policy developed and/or adopted to reverse the negative impact of harmful phenomena. In Ethiopia, a feasibility report from a national programme for domestic biogas adoption outlined the limiting barriers and challenges, indicating that the technical, operational, economic and policy issues were the stumbling block in the advancement of the technology (Eshete, Sonder, and Heegde, 2006). On the other hand, Patinvoh and Taherzadeh (2019) asserted that the challenges associated with policy and strategy was among the important factors in hindering the implementation of biogas technology adoption in developing countries. An economic analysis of biogas technology adoption by rural farmers in Pakistan revealed that the adoption of the technology is hindered by policy based effective strategies such as awareness through public service such as the advertising through print and electronic media (Abbas, *et al*., 2017).In this regard, studies had found that all service provision related variables are commonly dependent on appropriate policies and strategies, while proper policies and strategies will have positive influence on technology adoption and sustainability (Abbas, *et al.*, 2017).

7. Organizational characteristics: Awa et al. (2015) referred to several studies in which they found that enterprise size is a major factor that affects technology adoption. A bigger enterprise has a greater resilience in dealing with implementation failures in the process of technology adoption, and smaller enterprises are more susceptible to the effects of resistance to change, lack of education, lack of trust in the security of technology, lack of technological expertise and lack of economic resources.

8. Leadership characteristics: Leadership characteristic, from the perspective of the age of leaders has been identified by many studies to have impacts on the perceptions of performance utility and technology usability. Studies conducted by Czaja, and Sharit

(1998), and Venkatesh and Morris (2000) indicated that younger managers were much more inclined to chase business growth strategies, as they are predisposed to take riskier decisions than their older counterparts. Accordingly, based on the above conceptual reviews, Figure 3.4 presents the adopted conceptual framework with some modifications (Berg and Lingen, 2019).

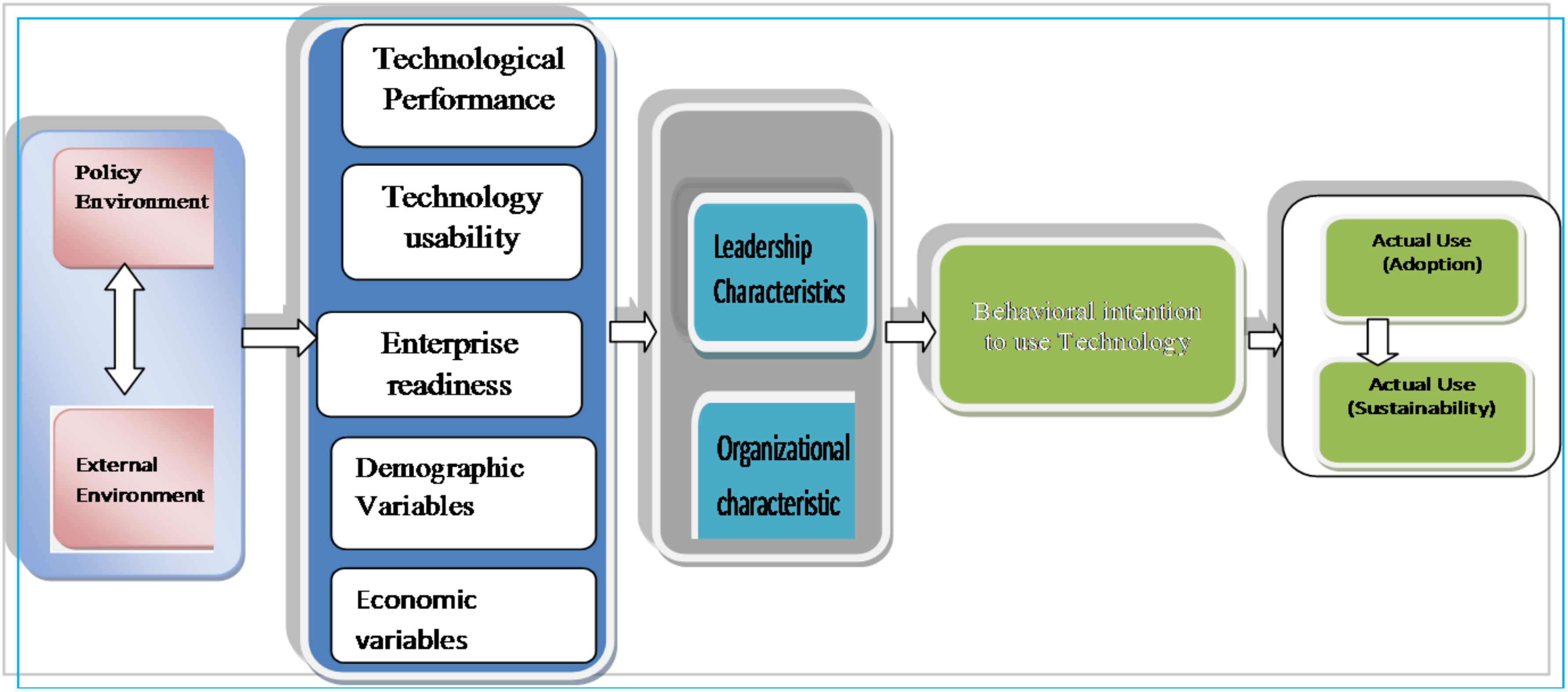


Figure 3.4: Conceptual Framework of CSA Technology Adoption (Adapted with Modification from Berg and Lingen, 2019)

3.4 Review of Climate Change Empirical Literatures

3.4.1 Econometric Empirical Review of Climate Change Adaptation

In recent times, climate change has gained great attention in global policy discussions with attractions from researchers and development strategists (Asanté and Amuakwa-Mensah, 2014). Accordingly, adoption of adaptation strategies has been researched by several researchers. Uddin et al. (2014) conducted research on adoption of different climate change adaptation strategies in Bangladesh. This author identified fourteen adaptation strategies among which irrigation was ranked first, while crop insurance was ranked as the least utilized. Additionally, regarding the climate change adaptation strategies that were integrated into farming system, Getahun (2016) found that 42 percent of the households used no adaptation measures to manage the negative impacts of the climate change in the community.

In contrary, according to Uddin et al. (2014), an overwhelming majority (84 percent) of the farmers indicated that they had employed at least one of the introduced adaptive strategies, with only 16 percent classified as non-adopters of any adaptation strategies. On the other hand, Uddin et al. (2014) analyzed the potential effect of different socio-economic variables on climate change adaptation strategies adoption using logit regression model. It was found that age, education, family size, farm size, family income, and involvement in community organization (cooperatives) were significantly related to adoption of adaptation strategies. Other studies have dealt with the impact of farmers' educational levels on technology adoption. Additionally, Getahun (2017) reported the statistical significance of households' heads' educational level in adoption of major adaptation strategies. It was indicated that at 1 percent level of significance, a unit increase in the number of years of formal schooling would result in a 1 percent and 1.7 percent increase in the probability of changing crop variety and intensifying irrigation, respectively.

Meanwhile, Weldlul (2016) revealed from Multinomial logit analysis results that sex of households' heads, education level, off farm employment opportunity, farm size, oxen ownership, farmer to farmer extension service, access to credit, and access to information related to climate change, were significant determinants of farmers' adaptation to climate change. In this regard, the findings of the regression model reported by Uddin et al. (2014) indicate that age is negatively and significantly (at 10 percent level) related to farmers' adoption of climate change adaptive strategies. This implies that the probability of adaptation to climate change significantly decreased as the age of the farmers increased, which is in line with several literatures. Family size was negatively significant (at 5 percent level) in relation to farmers' climate change adaptation strategies adoption. This is contradictory to initial hypothesis and assumption (Uddin, *et al*, 2014).

Regarding the age of the households' heads, Matlou (2016), asserted that, of farmers within age group of below 40 years, 8.3 percent adopted Biotechnology Maize (*Bt* maize), while among the farmers aged between 41 to 60 years, 50 percent adopted and among the farmers aged 61 years and above, 27.7 percent adopted between 2011 and 2014 cropping seasons. This indicates a very likely positive trend of Bt maize adoption for farmers that were aged 40 years and above during these seasons. Furthermore, the age of farmers has been discussed to influence adoption decision of new technologies both positively and negatively. Some studies in Ethiopia showed a positive relation between age of farmers and adoption of adaptation options (Getahun, 2017). Furthermore, Getahun (2017) identified the negative effect of household's head age with adoption of some major adaptation strategies. It was asserted that the average marginal effect computed shows that sample household's head with a one more year older would decline the probability of intensifying irrigation adoption by 1.26 percent ($p<0.01$).

Quayum and Ali (2012) found that family size had negative impact on adoption of technologies. Similarly, Matlou (2016) found that out of the households with 10 or less family members, 92.5 percent of households adopted *Bt* maize, while family with 11 or more family members only 7.5 percent adopted *Bt* maize in South Africa. This indicates a negative linkage between technology adoption and family size. There is a negative and significant relationship between farm size and climate change adaptation strategies adoption. Uddin et al. (2014) found that increase in farm size decreases the probability of farmers' adoption of climate change adaptation strategies. It was noted that large farmers deployed traditional technologies rather modern technologies as the large farms require greater levels of investment to implement adaptive strategies as compared to small ones. Moreover, large farms require large quantity of inputs at a rate that can put significant strains on farm budgets. However, other studies found positive linkage between farm size and technology adoption. For instance, Matlou (2016) asserted that large farms had higher level of technology adoption than small ones. Getahun (2017) found that farm size has positive impacts on changing crop variety and intensifying irrigation adoption to adaptive with the climate change scenario, where one unit of change in the farmland tends to change the probability of changing crop variety and intensifying irrigation by 2.9 percent and 6.7 percent, respectively.

On the other hand, households' incomes positively influence adoption of climate change adaptation practices (Kim *et al*, 2012). Gbetibouo (2012) explained that wealthier farmers were more interested in adapting to climate change by changing planting practices, using irrigation, and switching to those farming practices that are environmentally benign. Additionally, Uddin et al (2014) reported a positive and statistically significant relationship between family income and adoption of climate change adaptation strategies. It was found that farmers with high income were more likely to adopt adaptive strategies than farmers with low incomes. Furthermore, Nhemachena and Hassan (2013) indicated a positive association between households' income and farmers' decisions to take-up adaptation measures to manage climate change related effects and risks. According to Uddin et al. (2014), being a member of cooperatives positively and significantly influences adoption of climate change adaptation strategies at 10 percent significance level.

3.4.2 Determinants of Livelihoods and Vulnerability

In the study that was conducted in Tanzania, Mkonda and He (2018) asserted that the biophysical resources within a geographical area determine the livelihood systems. Therefore, people's lives are shaped based on the available resources and the level of entitlement. Therefore, when these resources are adversely affected, people's livelihoods become vulnerable to natural disasters and environmental shocks (Rowhani *et al*., 2011). Consequently, the type, quantity and quality of resources determine both resilience and vulnerability of the community.

Generally, climate change related livelihoods vulnerability determinants are socio-economic and environmental variables. These variables dictate the level of vulnerability to climate shocks given the system's vulnerability components of exposure, sensitivity, and adaptive capacity (Neset, *et al*., 2010 and Hoque, *et al*., 2019). Therefore, the correlated of vulnerability are socio-demographic variable, livelihoods strategies, health status, social networks, food security, water supply and exposure to natural disasters (Kabiret *et al*., 2018). In this regard, Hoque et al. (2019) conducted a study in Bangladesh that aggregated the weighted value of vulnerability indicators under the exposure dimension. Kabir et al. (2018) found the highest livelihoods vulnerability scores of0.406 and 0.386 for south west Bangladesh and Sarankhola study location, respectively, while Shyamnagar (0.380) and Dacope (0.372) were reported third and fourth highest livelihoods vulnerability ranking. Furthermore, the combined effect of livelihood vulnerability indicators under the sensitivity component revealed the highest sensitivity score of 0.655 (Hoque *et al*., 2019). In other studies, community level adaptive capacities were associated with districts' literacy rate (50.14 percent), structurally sound houses (12.60 percent), dependence on agriculture (55.94 percent), adoption of agricultural technologies such as improved crop variety (55.75 percent), irrigation pumps (27.38 percent) and harvesters (9.82 percent) (Wiréhn *et al* , 2015and Hoque, *et al*, 2019).In generalized term, economic scenario and limited relevant knowledge related to natural environment including the climate components have significant contribution to environmental degradation and consequently community vulnerability to climate change consequences (Paavola, 2008).

3.4.3 Climate Change and Weather Variability

Climate is the average pattern of weather condition in one vicinity averaged for at least 30-year period. Therefore, it can be best characterized based on extended period of measuring climate elements and proper records of meteorological weather data summarized overtime (Getahun, 2017). Weather variability captures short-term changes or fluctuations in climate, while climate change is a long-term variability in climate. Climate change can continue for decades, but weather variability can persist for months or few years (IPCC, 2007). To that effect, the occurrence of droughts, storms and floods are among the major manifestations of climate variability, which often cause serious welfare losses (Wilbank and Kates, 2010).

Appositely, Intergovernmental Panel on Climate Change (IPCC) affirmed that climate change is one of the fundamental challenges of the 21st century for human livelihoods. IPCC equally asserted that human beings are responsible for climatic change through their livelihoods practices which have resulted into increased concentration of greenhouse gasses (GHGs). Currently, the constant release of greenhouse gasses into the atmosphere is affecting some weather variables, and these emitted gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydro-fluoro-carbons (HFCs), per-fluorocarbons (PFCs) and carbon-hexafluoride (CF_6). Recently, instability in the monsoons system, evidenced by strong precipitation and unusually extended long dry seasons in West Africa, has been attributed to climate change (Barry *et al*., 2017). For instance, the disastrous droughts in African countries between 1970 and 1980 that severely affected many rural areas resulted from inconsistency in the monsoon system (Barry *et al*., 2017). Barry et al. (2017) further explained that precipitations remain mostly unstable in many West African countries, and extended dry seasons are commonly expected to affect many African nations and traditional communities located up to 15°N latitude in the continent.

Accordingly, many studies suggest that precipitation projections for the coastlines show decreased frequency in rainfall events as compared to long-term average with different intense storms surges resulting in subsequent higher surface runoffs, indicating somewhat the faster changing situation in the region than the global trend. Barry et al. (2017) also avowed that from the late 1970s, temperature has been increasing at the rates of 0.2°C to 0.8°C, whereas as of the end of the 1970s, temperature has been projected to further increase within range of 3°C and 4°C per decade. They argued further that regional changes in climate components, in addition to the frequency and magnitude of extreme weather events, have been recognized as damaging events. These detrimental events affect the traditionally adapted species, geographical distribution of species, natural diversity, and land productivity, negatively impacting the entire biodiversity in almost all agro-ecologies.

Comparatively, many scholars are of the view that the variability in precipitation has been recognized as the most indispensable parameter to characterize the climate situation in particular community. However, the characterization of regional climatic condition of an area is a healthier attempt when precipitation parameters are combined with other parameters such as seasonal river flows, trend of lakes surface levels, status of groundwater levels and especially temperature conditions related to intended locality. Assessing the chronological trends of climate strictures focusing on the deviations from mean and variance of these different meteorological parameters is therefore crucial to understanding the prevailing changes in local climate patterns, and subsequently helps to make future projections associated with climate conditions (Barry *et al*., 2017).

Likewise, climate change has been aggravated by human pressures on fragile natural environments. These human pressures are mainly from traditional farming system, progressive urbanization, industrialization, limited consideration on conservation of natural eco-systems, and over-exploitation of natural resources. The other factors are construction works without following some recommended standards, road construction and development of other physical infrastructures, which consequently lead to the decreased agricultural and forestland areas. All these practices eventually will lead to pronounced changes in some climatic parameters and components (Barry *et al*., 2017).

Correspondingly, many studies indicated that degradation of the natural vegetation covers ineludibly increases the ecosystem's vulnerability to natural hazards, thereby contributing considerably to global climate change. This is because land-cover changes because of human interferences modify the surface atmosphere and its energy exchanges hereby impacting on climatic parameters. According to the IPCC 4th assessment report, through the utilization of 21 Global Circulation Models, it established the likelihood of increased temperatures by 2-4 degrees in the Horns of Africa. Thus, some considerable changes in the volume of rainfall was forecasted with average an increase of about 10 percent by the end of the century (IPCC, 2007). In the meantime, potential evapo-transpiration will increase, and probably in addition to change in radiation, resulting into an increase in actual evaporation (IPCC, 2007). However, a change in radiation because of climate change is highly uncertain because this primarily depends on potential cloud cover change evaporation (IPCC, 2007). On a similar note, IPCC (2014) emphasized the evidence of human influence on the natural climatic system overtime. The report stated that it is very likely that more than half of the increase in worldwide average global surface temperature from 1951 to 2010originated from increase in anthropogenic Green House Gas (GHG) concentrations (IPCC, 2014). In addition, other human activities contribute to global warming.

According to the findings presented by IPCC (2014), developing countries are more vulnerable to climate change in the coming years than developed nations, because of inadequate capacity to adapt. Ethiopia is one of the developing nations experiencing the detrimental impacts of climate change. These impacts are not only affecting the national economy, but also the livelihood of many communities. Additionally, the negative effects of climate change have resulted to a high level of dependence on rain-fed agriculture, as well as extreme degradation level in fragile natural environment, including a persistent prevalence of food insecurity due to recurrent droughts (Temesgenetal. 2014). According to this study, the conducted vulnerability assessment indicated that the sectors that are most vulnerable to climate change are agricultural sector, water resource sector and human health, while smallholder rain-fed farmers, including the pastoralists are found to be the most vulnerable groups. The persistently arid areas, semi-arid and dry sub-humid segments of the country are usually affected most by recurrent droughts, in addition to inter seasonal weather variability in seasonal precipitations which consistently increase temperature and have been augmenting the occurrence of frequent and unpredictable drought (Temesgen *et al*., 2014).

3.4.4 Extreme Weather Events and Related Impacts

According to the report presented by IPCC (2014), the characteristics of extreme weather usually vary from place to place in an absolute sense, and when a pattern of extreme weather persists for some extended time, such that it can be categorized as seasons, it can be classified as an extreme climate event. It was noted that changes in many extreme weather and climate events have been observed since 1950 and some of these changes have been associated with human induced influences, including a decrease in cold temperature extremes, regular increase in warm temperature extremes and an increase in the number of heavy rainfall. Frequent variability in extreme temperature and precipitation patterns have been experienced for a long period of time in many parts of the world. In East Africa, several analytical methods have been proposed and used to assess possible changes in the magnitudes of temperature and precipitation to identify the prevailing situation. For instance, Oumaet al. (2018) and Rahmstorf and Coumou (2011) employed the Monte Carlo simulation approach to measure the effect of long-term extreme warming events and asserted that although promising results were obtained at global scale, the potential evidence of significant variability at local level was not fully captured and inadequate.

3.4.5 Climate Change Impacts and Related Risk

Khanal (2009) submitted that although climate change impact is expected to be severe on global economic development, developing nations are bound to suffer more. Those who are living in abject poverty often depend on agriculture, and they are typically among the most vulnerable people to climate change because of frequent crop failures. More recurring droughts with escalating water shortage will have some devastating effects on tropical farming systems (World Bank, 2009). Also, frequent floods and droughts have contributed more to the vulnerability of the agricultural sector, making it to be more vulnerable to climate change (World Bank, 2009). Smith et al. (2014) explained that climate change related impacts on agriculture will not only affect potential yield of crops, but also influence soil organic carbon (SOC) levels positively or negatively. However, because the impact is two-sided, it highlights uncertainty of the potential impacts of the climate change in a particular eco-system. Currently, there is a consensus that developing countries are more vulnerable to frequently occurring climate change impacts than nations that are economically better or stable. As stated by World Bank (2009), developing nations are more susceptible to climate change impact because of their predominant reliance on agriculture, lack of capital to adopt adaptation measures, mostly warmer climate conditions, and high possibility of exposure to extreme changing climatic events.

In Ethiopia, several reports suggest the significant impact of climate change on agricultural production, as the result of predictable increases in temperature composition, and decline of seasonal precipitation amount, including inter-seasonal variability of the rainfall distribution. For instance, FEWS NET (2011) affirmed that the aggregated rainfall amount in most parts of Ethiopia has steadily declined by about 15–20 percent starting from mid 1970s with substantial warming across the entire country. Furthermore, Keller (2009) affirmed that over the last decades, the temperature in Ethiopia has increased at the rate of about 0.2℃ with more pronounced 0.4℃ for minimum temperature per decades, whereas rainfall on the other hand, remained reasonably constant over the last 50 years. The author argued further that there is sufficient indication that temperature will keep increasing over the next decades, while projected increase in the inter-annual variability of seasonal precipitation in combination with periodic warming are likely to increase drought. Similarly, Abate (2009) confirmed that changes in weather will have some negative impacts on mid and lowlands areas of West-Arsi zone in Ethiopia. Nevertheless, positive influences have been observed in some areas where agriculture was potentially constrained by frequently observed low temperature, particularly in highland farming system.

Since agricultural development is an effective tool for poverty reduction and food security, climate change has a negative impact on every dimension of food production and the distribution systems. Climate change has a significant consequence on food production system directly through recurrent changes in agro-ecological conditions of areas, and indirectly affects the growth as well as the distribution of incomes, and ultimately potential and actual demand of agricultural products (IPCC, 2014). More importantly, from a long-term perspective, climate change equally affects food security through changes in the overall economic condition of a community, which determines the potential purchasing capacity of customers and consequent possibility of access to steady food supply system (Tubiello *et al*., 2009).

3.4.6 Agricultural Practices Impact on Climate Change

Generally, atmospheric structure contains majorly nitrogen, oxygen, argon, and other trace gases such as water vapor, sulphur dioxide, and nitrogen oxide, whose concentration can vary considerably over time (Smith, 2014). GHGs which play a key role in regulating earth's temperature comprise of water vapor (H_2O), Carbon dioxide (CO_2), Methane (CH_4), Ozone (O_3) and Nitrous Oxide (N_2O). The most abundant greenhouse gas and the prime contributor to greenhouse effect is water vapor, which constitutes about 4 percent of the volume of atmospheric air and 95 percent of the volume of the entire GHGs in the global scale. On average, about 60 percent of the greenhouse effect is attributed to water vapor, whereas about 26 percent of predictable warming effect is ascribed to carbon dioxide, which is naturally emitted every year from oceanic surface, animal farming practices, plant respiration, organic matter decomposition process, forest fires and during volcanic eruption process (Kiehl and Trenberth, 1997).

In addition to naturally emitted carbon dioxide, anthropogenic activities like fossil fuel burning, cement production processes and agricultural land farming practices, produce additional 34 billion metric tons of carbon dioxide annually, which is about 4 percent of natural carbon dioxide emission, whilst Ozone (O_3), also among the greenhouse gases, contributes about 8 percent of the total greenhouse warming in natural atmosphere (NASA, 2013). On the other hand, on the average, normal atmospheric composition contains about 5 billion metric tons of methane gas, whereby marshland methane emissions are estimated to comprise about 80 percent of the total natural methane emission sources. Consequently, the yearly total methane emissions from natural methane sources are estimated to be roughly 250 million metric tons, among which emissions resulting from the human linked practices are estimated to constitute nearly 60 percent of the whole annual methane emission which is evidently believed to exceed potential emissions from the natural emission sources (The Encyclopedia of Earth, 2013).

Globally, agriculture is one of the major sources of GHGs, because it contributes either directly or indirectly to the natural environment, and consequently changes situations in the natural climate components. Similarly, according to Pesticide Action Network (undated) and Intergovernmental Panel on Climate Change (IPCC), agricultural sector is regarded as the most important contributor to climate change phenomenon globally. In the case of agriculture linked practices, farm level application of synthetic nitrogen-oriented fertilizers is a major contributor to the effects of climate change in agricultural production process (Figure 3.6). This is the potent greenhouse gas nitrous oxide (N_2O) which is released into atmospheric air because of Enteric fermentation process, where cows and sheep digestive tracts produce CH_4 (methane) into atmosphere sphere. The processing of anaerobic fermentation and methane from cows and sheep is recognized as the second major source of this emission (IPCC, 2007). Nevertheless, a major agricultural practice associated with emission source is the land conversion.

Meantime, according to FAO (2010), when emissions that originated through land use process are considered, livestock production management practice is identified to account for about 9 percent of the total carbon dioxide emissions resulting from human associated practices. Equally, 37 percent of methane emission is primarily produced during digestion process in the digestive system of animals and other domestic ruminants, together with 65 percent of nitrous oxide emission, which is typically produced through manure management process (FAO, 2010).

From the foregoing, it is therefore fundamental to consider emission problems linked with livestock production system, together with socio-economic and environmental perspectives in the farming system. Similarly, IPCC (2007), which is consistent with FAO's (2010b) view, asserted that globally, out of agricultural sector emissions, livestock farm management practices have been identified to account directly for nearly 9 percent of all anthropogenic GHGs emissions. Subsequently, it is proved that throughout the livestock production lifecycle, the whole system's contribution has been estimated to be about 18 percent of global anthropogenic emissions (Gill *et al.*, 2010). Methane emissions accounted for 30 percent, which is almost like the N_2O's contribution, while land uses system, as well as land use change together with deforestation and grazing, accounted for 38 percent of estimated human induced emissions.

3.4.7 Climate Change Mitigation and Adaptation in Agriculture

Considering the current and predicted effects of climate change on human and natural environment, it is apropos to find plausible ways to mitigate the unavoidable adverse climate change impacts, stemming from human influence, especially in the agricultural farm management system. Contemporary mitigation is the synthesized measure widely taken to reduce Green House Gases (GHGs), which are accountable for changes occurring in climate conditions and climate related variability (Khanal, 2009). These GHGs are concentration of methane, nitrous oxide, and carbon dioxide, practically induced due to human interferences in general, and farm management system particularly in agriculture sector (Khanal, 2009).

More importantly, some of the strategic practices required to incorporate carbon (C) into soil include improved grazing land management, crop rotations, farmland fallowing systems, proper residue management approaches, minimum tillage practices, soil organic matter improvement, reclamation of degraded lands, and agro forestry-oriented farming systems (NASA,2013). If properly implemented, technically recommended suitable practices in production process and suitable system can remove and sequester CO_2 into the soil compounds. This production system improves agricultural productivity due to sustainably improved plant nutrient management, and enhances the plant nutrient uptake efficiency, whereas during management systems it reduces nitrous oxide (N_2O) emissions and contributes to Carbon sequestration.

Generally, agriculture offers major potential for mitigation and the most important mitigation options within Agriculture, Forestry, and Other Land Use (AFOLU) management systems involve at least one of three strategies. First, reduction or prevention of emissions to atmospheric air by conserving potentially prevailing carbon stock in soils components or vegetation biomass, which otherwise would be lost into atmospheric environments or reduce emissions of methane (CH_4) and nitrous oxides (N_2O). Second, is the sequestration-enhancing uptake of carbon in terrestrial pools, thereby removing the atmospheric CO_2 compound from the atmosphere. Third, there is a reduction of CO_2 emissions, which resulted from substitution of biological products for fossil fuels or energy intensive inputs for commodities production (Smith *et al.*, 2014). The Pesticide action network Europe presented climate change mitigation measures recommended in the Fourth Assessment report of the IPCC (2007) in the context of agricultural sector in the following manner including the details of sub-functions (Table 3.1).

Table 3.1: Climate Change Mitigation Options in Agriculture

I**. Crop Management** • Improving crop varieties • Use of cover Crops • Avoiding bare fallow land • Perennials in Rotation • Legume Crops in rotation	**II. Nutrient Management** • Reducing tillage or no tillage • Adjusting application to needs • Avoid leaching • Using slow releasing Fertilizers
III. Improve Livestock Farming • Preventing methane emission from manure • Introducing legume in grassland • Compositing Manure • Breeding Cattle for efficiency • Improved pasture management	**IV. Soil Fertility Management** • Applying substrates like compost • Reduced tillage or no tillage • Retaining crop residues as covers • Sequestering CO_2 into the soil • Initiating the re-vegetation

Source: Pesticide Action Network Europe (undated)

Niggli et al. (2009) asserted that a full shift from tradition farming system to organic agricultural production approaches, would eventually rebalance overall agriculture associated adverse effects which pose negative impacts on naturally established climate components in the ago-ecosystems. Regarding mitigation potential in agriculture, based on FAO (2009), pesticide action network Europe presented the proportional contribution of each farming practices in a manner summarized in Figure 3.5 shown below.

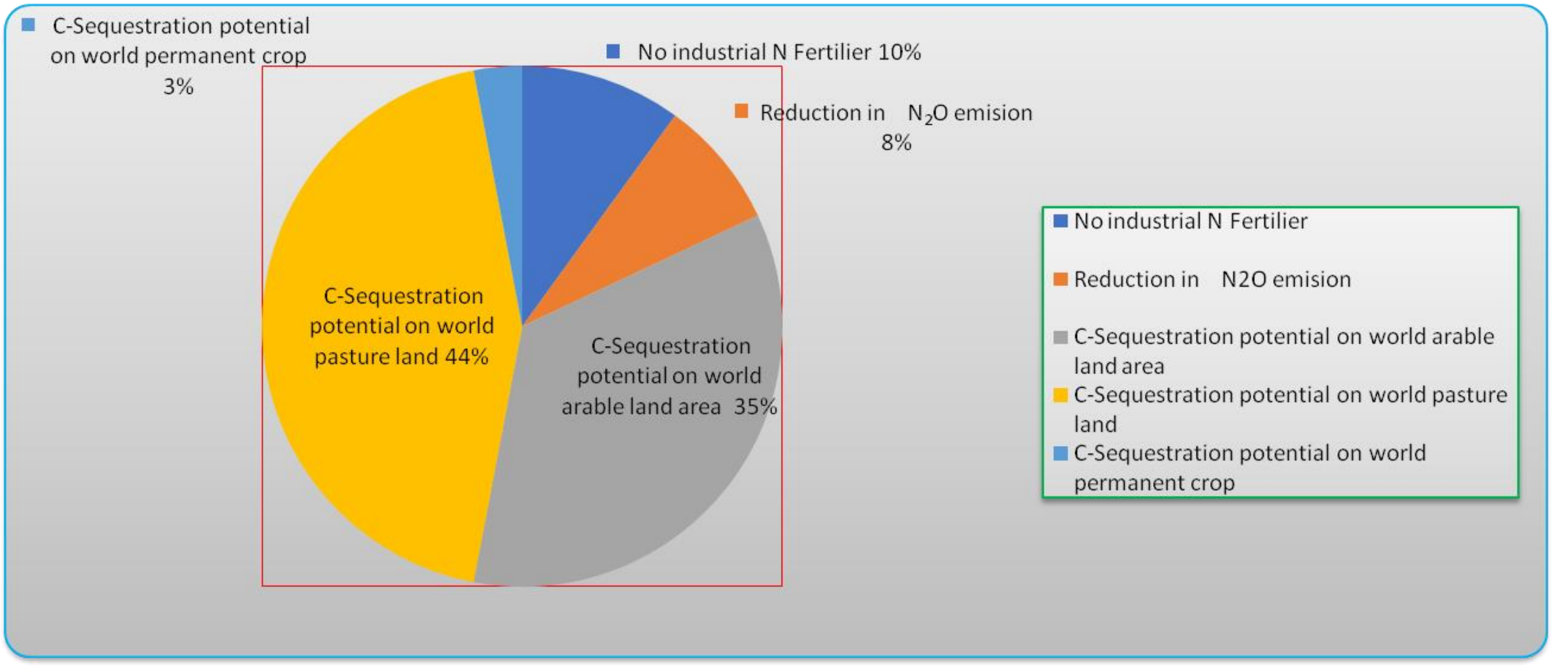


Figure 3.5: Mitigation Potential in Agriculture (Pesticide Action Network Europe -undated)

3.5 Knowledge Gaps in the Field of Study

There are many studies conducted on weather variability at regional level with limited focus on the inter- and intra-seasonal local level variability. The much-needed information on inter- and intra-seasonal variability of rainfall is still inadequately researched despite its critical implication on soil-water distribution, water use efficiency, nutrient use efficiency, and crop yields of the particular areas. To optimize agricultural productivity in any farming system, there is the need to quantify rainfall variability at a local and seasonal level. This study seeks to fill this gap in the context of Ethiopia by analyzing the impact of local climatic variability on smallholder farmers' level taking location specific weather data. Arguably, many of the current studies on climate change vulnerability do not relate vulnerability with development, which is leaving a significant knowledge gap in the scientific domain. The knowledge of structural vulnerability is limited and inadequate which will potentially influence identification of critical areas of interventions. This research is going to fill a major gap in Ethiopia by assessing the vulnerability of farming households in the highland and lowland areas to climate change. In addition, Gebrie (2015) ascertained that the technical feasibility and sustainability of soil and water conservation measures including the climate change management options undertaken on individual farms level in Ethiopia have not been studied and documented adequately. Thus, there is limited knowledge on local capacities in specifying key issues that affect natural resource management and eligible actors within the defined geographic area such as watershed level. Also, several studies are lacking on community level vulnerability to climate change based on social and cultural heterogeneity and set-up of community, which are commonly termed as location and livelihoods specific (ibid).

Accordingly, this study has focused and attempted to address this aspect of knowledge gap in the context of Ethiopia by analyzing the agro-ecologically disaggregated and community level cascaded assessment of climate change impact vulnerability at smallholder farmers' level. More importantly, the success of adopted climate change management strategies and technologies are the compounded impacts of institutional capacity to deliver the required services. This study seeks to explore the institutional capacity of extension service delivery system for climate change adaptation in Ethiopia.

3.6. Chapter Summary

This chapter reviewed literature on climate change and weather variability including its adverse effects on socioeconomic development and livelihood vulnerability. Some empirical studies of the technology adoption and sustainability with emphasis on climate change mitigation and adaptation strategies, and institutional adaptive capacity were widely reviewed and discussed. Generally, several findings revealed that climate change has altered local climate and seasonal weather conditions. These changes are partly influenced by the interference of some anthropogenic and human factors. According to several studies, a number of countries are significantly vulnerable to environmental shocks due to inadequate capacity to make investment on mitigation and adaptations options to manage climate change impacts. In particular, SSA countries are unable to fully manage the impacts of climate change. Specifically, Ethiopia is an agrarian country that is dominated by subsistence farming which is highly vulnerable to climate change and related consequences are significant under traditional farming systems. The literature review confirm that nations and communities differ in terms of asset endowments to manage the impacts of climate change. The overall review shows that despite the presence of awareness on climate change and its likely impacts on livelihoods of smallholder farmers, development of interventions that are systematically designed to address the problems is still inadequate. In this aspect, there is an urgent need to capitalize on existing adaptive capacity, awareness, technological, and technical packages to foster the institutionalized adaptive capacity in order to ensure effective adaptation.

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

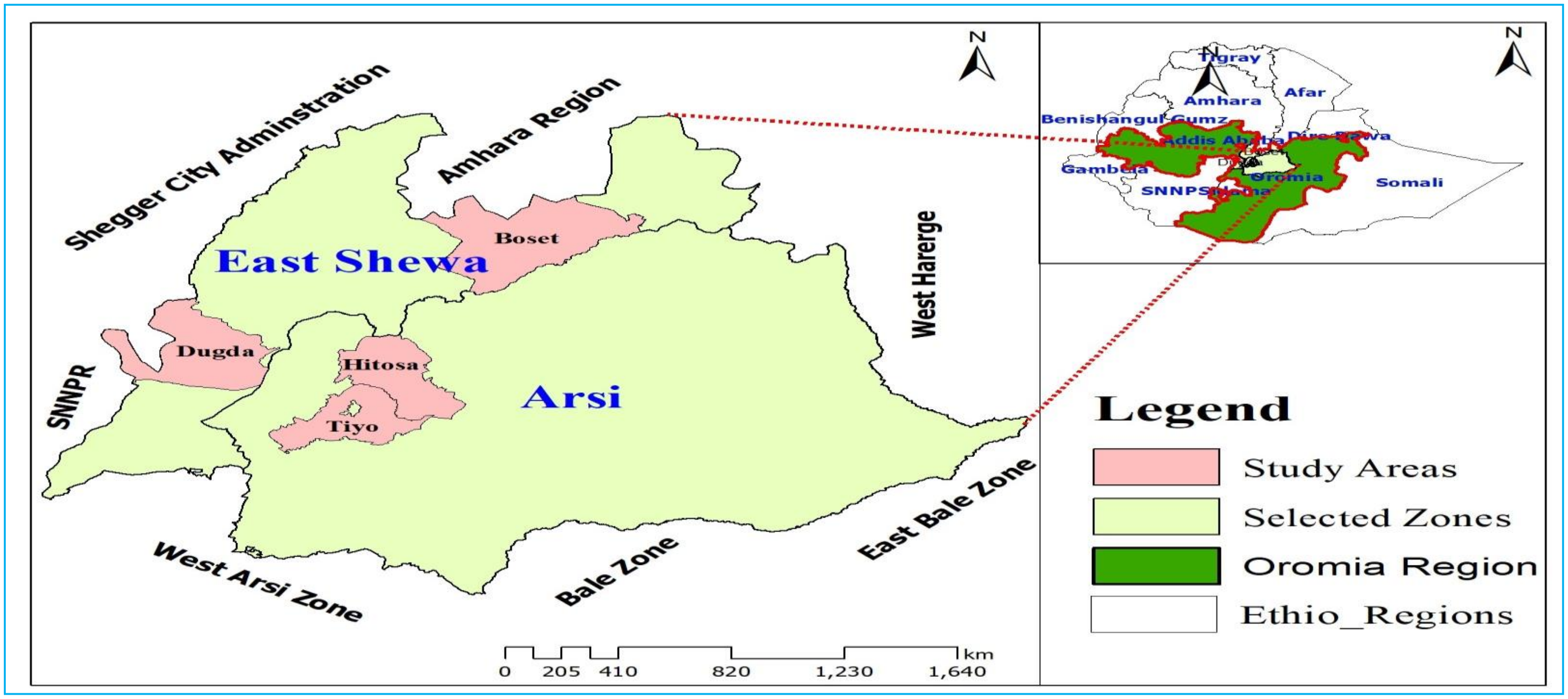
This chapter provides the description of the study areas, highlights a clear explanation of the sampling procedures, data collection tools and data analysis techniques to address the research objectives. Also, the selected analytical models employed to generate the inferential statistics for the interpretation of variables relationship were adequately presented.

4.2 Description of the Study Areas

4.2.1 Geophysical Context of the Study Areas

The study was conducted in the catchment of great African Central Rift Valley (CRV). This region crosses the central part of the Oromia regional state, where environmental degradation has manifested for many years. Climate change is affecting the livelihoods of the farming communities. Mixed farming and agro-pastoral farming system are commonly practiced in the highlands, mid and lowlands of the study areas. Regarding this study, Bosati and Dudga districts were selected from East Shewa, and Hetossa and Tiyo districts were selected from the Arsi Zone. These districts were selected because they are in the catchment of the great Awash River catchment, where the negative influence of climate change is very severe. Topographically, the altitude of these two zones ranges from 500-3500 meters above sea level (masl), but the study has been conducted in the low land part of the east Shewa and relatively midland districts of Arsi zones to see the variation along with agro-ecological variability (Figure 4.1).

The highland has temperate and cold climate ranging from 2300-3200 masl, the midland has warm climate ranging from 1500 to 2300 masl, and the lowland is hot with arid land areas ranges from 500 to 1500 masl. Despite continuous prevailing drought in these areas, like most part of Ethiopia, there are three distinct seasons with two rainy seasons and one dry season (World Bank Group, 2011). The main rainy season occurs from June to mid of September and early short rain season is a small rainy season that occurs from February to May in each season. On the other hand, the main dry season commences in October and ends in January of the following year. The short rain and main rainy seasons contribute nearly 31 percent and 56 percent of the annual rainfall. The main rainy season forms the main production season in Oromia region (ibid). Specifically, East shewa Zone is located in the lowland of central Oromia regional state extending from 703305000N to 900805600N and from 3802401000 to 4000503400E in sub-tropical and tropical climatic zones where the large portion of the zone is located along the Great Rift Valley at center of Oromia region (Gezai, *et al*, 2020). Dominantly, East shewa is characterized by dry and arid climatic conditions with an abundant water source to conduct farm practices, more widely vegetable production (Gezai, *et al*, 2020 and WIKIPEDIA, 2023).



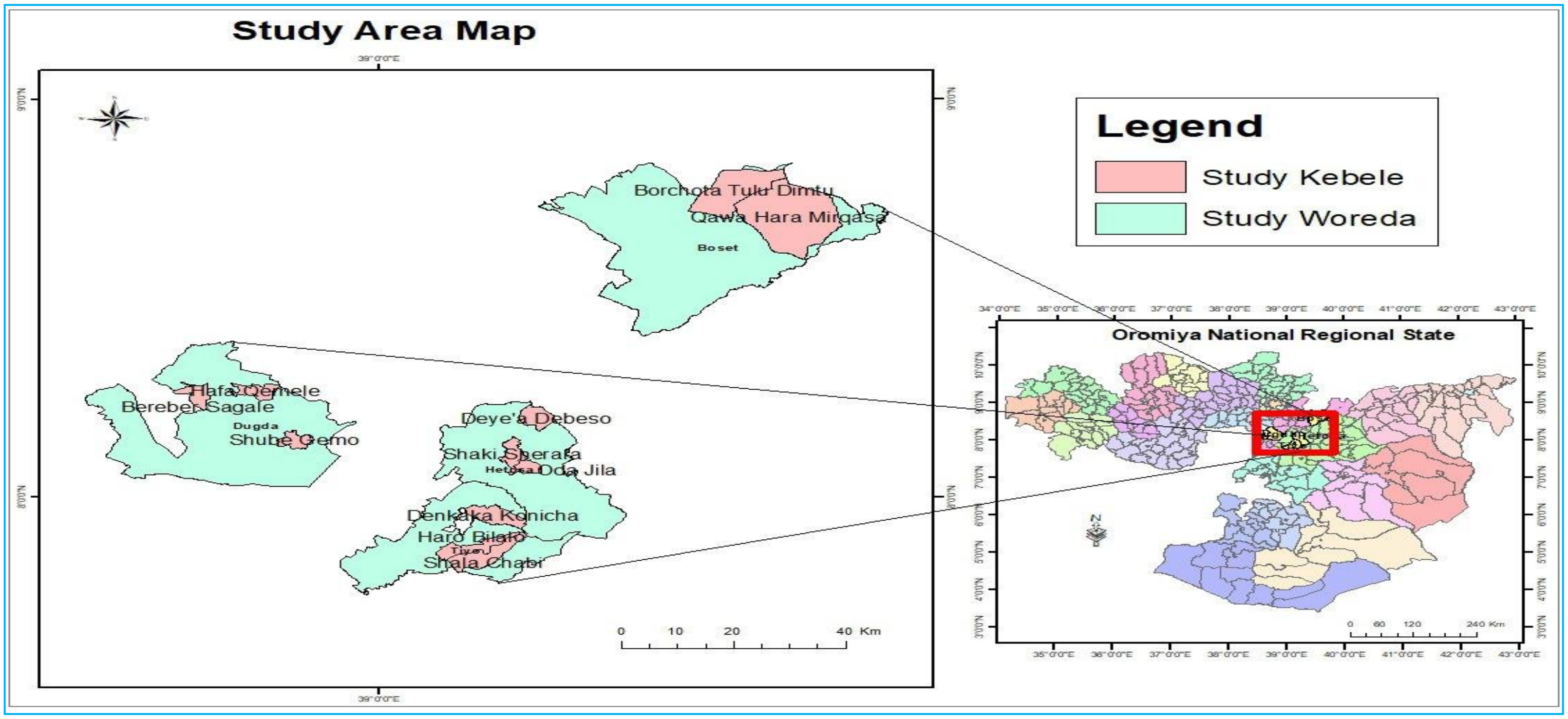


Figure 4.1. Study area map showing zones, Districts and PAs **(Source:** Developed based on google File)

East Shewa zone comprises of 8,370.90 square kilometers land area with twelve administrative districts (10 rural and 2 urban) in the central lowland of Oromia Region. Agroecologically, the zone constitutes 18.7 percent highland, a27.5 percent midland and 53.8 percent lowland with rainfall 1150mm (Asfaw, *et al*., 2020). An area of the East shewa zone covers a total of 971,159.21ha land, of which about 12.6 percent is arable land and of this total arable land 47.31 percent of the area is currently under cultivation practices for agricultural production (ibid).

Similarly, Arsi Zone is located in the central part of the Oromia National Regional State extending between 6045N to 8058N and 38032E to 40050E and it covers an area of 19,825.22 km^2. It comprises of 25 administrative districts including one special district (WIKIPEDIA, 2023). Based on the altitude, there are four major identified biophysical divisions in the Arsi zone (ibid). These includes the cool agro-climatic zone with highest altitude of above 3500 masl, which constitutes about 2.7 percent of the total area of the zone (Tamirat 2019). The second one is the cool temperate agro-climatic zone that includes the mountain ranges, massifs and high plateaus of Arsi (2500 to 3500 m) that lies in the central part of the zone covering about 22.7 percent of the total area of the zone. The third is the warm temperate agro-climatic zone (1500 to 2500 m), which comprises low plateaus of the zone constituting about 49.6 percent of zonal land surface. The fourth is lowlands (less than 1500 m) constituting about 24.9 percent of the total area of the zone (Tamirat, 2018 and Tamirat, 2019). Generally, due to diverse set of agro-ecological zonation, Arsi zone is dominantly characterized by moderately cool (40 percent) followed by cool (34 percent) annual temperature (Adisu, *et al.*, 2020).

4.2.2 The Major Farming Systems in the Study Area

The farming system of the study area is particularly based on regional and local weather conditions. Mixed farming system dominates the livelihood of the zones and land is an important asset of households for the production of crops and livestock. In this regard, many evidences reveal that due to the high complexity and strong inter-linkage between crop production and livestock farming, it is difficult to consider the two livelihoods separately and the inter-linkages are related to manure production, traction power, fodder production, and income generation. Though mixed farming is the dominant livelihood system in the study areas, there are some arid and semi-arid areas that are predominantly pastoralist in some of the mid and lowland areas. On the other hand, highland perennial crop livelihood systems are common in the region.

4.3 The Research Design

Research design is the systematically defined overall strategies and processes of carrying out a research or logical plan to tackle established research question(s) through the collection, interpretation, analysis, and discussion of data (MIKIPEDIA, 2023). Thus, a research design is viewed as the functional plan in which certain research methods and procedures are linked together to acquire a reliable and valid body of data for empirically grounded analyses, conclusions, and theory formulation (ibid). Research design thus provides the researcher with a clear research framework; it guides the methods, decisions and sets the basis for interpretation concerning the intended research problem (ibid). Accordingly, based on the objective of the research, this study involves a structured and semi-structured interview, focus group discussion and observation of the general situation related to research problem, which ultimately generates the qualitative and quantitative raw data. Thus, the appropriate research design for this study is non-experimental (survey research design) with mixed approach which consists of qualitative and quantitative data collection methods. This method allows for relevant and accurate collection of data, in addition to enabling informed decision making, consequently facilitating accurate conclusion and recommendation concerning the research problem. In Summary, in context of this study, the research design was non-experimental approach which constitutes the descriptive research design (mainly survey research) that complemented with literature review and field observation techniques to generate qualitative and quantitative data for generalization as well as conclusion.

4.4 Sample Sizes and Sampling Procedures for Quantitative Data

The target population of the study comprises of rural communities in the catchment of Central Rift valley (CRV) of the Oromia region. The households in the catchment of the CRV were selected to participate in the study. Two zones were selected purposively to represent highland and lowland agro-ecologies in the region. In this regard, respondents of Arsi were selected to represent highland agro-ecology, while respondents of East Shewa were to represent lowland agro-ecological zones of study areas. Within the zones, the districts were sub-categorized into two major categories based on prevailing altitudes which are mid-highland and extreme highland in the case of highland ecological zone and dry and semi dry in the case of lowland ecological zones. Given the differences in agro-ecology of the study areas within the districts, the stratified random sampling method was used for sampling. Two districts were selected from each ecological zone using random sampling. Selected districts were sub-divided into three sub-categories based on the similar criterion established for districts selection but emphasizing on farming practices. The sampling frame comprises of all households enlisted with the Peasant Associations. Therefore, the sample size was calculated with the formula presented in Equation 4.1 by following Singh and Masuku (2014).

$$n = \frac{N}{1+N(e)2} \tag{4.1}$$

where, N is the total population of the Peasant Association, which is 10,156 households, n is the desired sample size and e is level of precision required which was set as 5 percent. The required minimum sample size is estimated to be 385. Specifically, three Peasant Associations (PAs) were randomly selected from each of the study's districts. A sample size of between 420 was targeted to cater for expected non-response from some respondents. However, 410 households were successfully interviewed, and their distribution is in Table 4.1. The random sampling was selected to maintain an equal chance for each PA to be selected and included in the survey. The selected highland agro-ecology in the Arsi Zone areas were Tiyo and Hetossa districts, while those from lowland were Dugda and Bosat districts. Accordingly, a total of twelve PAs (three PAs from each four Districts) were selected for structured questionnaire interviews and Focus Group Discussion (FGD). On the other hand, to maintain the balance of the gender proportion in the study, the proportion of the gender composition was calculated and considered based on their proportion in the target community and distributed into selected agro-ecology accordingly. Finally, simple random sampling method was used to select the respondents. Based on the selected sampling frame, a total of 410 farmers (33-36 farmers from each PAs) were randomly selected for face-to-face interviews. The available and best alternative of all sampling frame was the list of farmers registered in registration sheets in each of the PAs offices, and farmers were selected randomly from the list of the community members' registers on the registration sheets.

Table 4.1: Summary of the Respondents Sampled from Districts and PAs

Agro-ecology	District	PAs (Kebele)	Households	Sample Size	Percent from sample
	Tiyo	Shala-Chabet	869	34	17.0
		Dhankaka-Konicha	841	34	17.0
Highland		Haro Bilalo	838	33	16.5
(Arsi Zone)	Hetossa	Dayea-Debeso	567	33	16.5
		Oda-Jila	682	33	16.5
		Shaki-Sharara	689	33	16.5
	S/Total	**6 PAs**	**4486**	**200**	**100.0**
Lowland	Bosati	Chale-Kiltu	639	34	16.2
(East Shewa zone)		Borchota	737	35	16.7
		Kawa	1573	36	17.1
	Dugda	Shubi-Gamo	1485	35	16.7
		Hafa-Kemele	680	35	16.7
		Birbirsa-Gale	556	35	16.7
	S/Total	**6 PAs**	**5670**	**210**	**100.0**
	G/total	**12 PAs**	**10156**	**410**	

Source: Survey Data (2020)

Currently in Oromia region, one PA is divided into three extension service delivery zones, while one extension Development Agent (DA) is assigned to deliver the extension service to community. Therefore, to maintain a uniform distribution of the samples, between 33 and 36 farmers have been allocated to each PA Zone (nearly 10 farmers from each PA Zone). Table 4.1 presents the summary of the selected sample frame and number of respondents. The quantitative data were collected from the farmers with structured questionnaires, while the data collected from extension field staffs were managed using self-administrated questionnaire.

4.5 Procedures for Collecting Qualitative Data

Qualitative data were collected through Focused Group Discussion (FGD) and Key Informant Interviews (KIIs). Participatory research approach was employed via mini workshops to facilitate the ranking of the problems, priorities, and indicators in addition to what have been done during interview schedules. A total of 140 extension field staffs, of which 16 (11.4 percent) were FTC level development agents (DAs) and 124 (88.6 percent) were extension experts, working in extension structure participated in the data collection processes. These respondents were selected using random sampling and included in self-administered individual interview. Policy level leaders have been included in the study as the key informants to explore the adaptive capacity of the extension service delivery system and institutional structures in context of Oromia Bureau of Agriculture to influence the adoption and sustainability of CSA practices.

4.6 Sources and Aggregation of Weather Variables

Secondary data on some weather variables were collected from the National Meteorology Agencies in the two agro-ecologies. These data were obtained from the Adama, Wolinchiti and Meki weather stations to represent lowland agro-ecology of East Shewa zone, while data from Assela and Etheya weather stations were used to represent highland agro-ecology of Arsi zone. The data covered 25 years (1993-2018) and were categorized into five categories, where the first category (1993-1997) was established as base year to compare the observed trends of other remaining years' categories. The data were summarized by computing their means and standard deviations over those years. The newly generated variables were part of the variables for regression analysis, with each matched with the primary data based on the location of respondents.

4.7 Methods of Data Analysis for Research Objectives

4.7.1 Examination of Weather Variability and Prevailing Seasonal Trends

Descriptive statistics were used to achieve the first research objective. Variability in the weather variables were analyzed with means and standard deviations. The data covered 26 years (1993-2018) and were categorized into five groups for the statistical analyses of their variability. The first five years (1993-1997) was taken as the baseline data for comparison with other periods. On the other hand, the season of the years was classified into three categories, which are represented as pre-season (January, February, March and April,), main season (May, June, July and August) and post main season (September, October, November and December) due to the fact that each has its own natural characteristics and effect on the seasonal farming practices and agricultural production. Based on the above approaches, the secondary data were summarized in tabular formats.

4.7.2 Farmers' Livelihood Responses to Perceived Climate Change

The second objective was analyzed with descriptive statistics such as frequency, percentage, mean, median and mode. Primary data on households' livelihoods and their perceived impacts of climate change were analyzed across the two agro-ecologies across some selected demographic characteristics.

4.7.3 Scaling Approach for the Analysis of the Impacts of Extreme Weather Events

The third objective was analyzed with descriptive statistics. The respondents were asked to rank the specified climate change impacts and the perceived climate change impacts. Scaling of the levels of extreme weather impacts on farmers' livelihoods had been conducted by the respondents under the guidance of the enumerators and analyzed for each variable to determine the level of impact of each impact indicator and the most influencing factors which helps to rank each indicator. For this purpose, during the interviews, the farmers and government staff were asked to evaluate the level of extreme weather impact or importance of the indicators by assigning a value on a four-point scale. The four-point scale established are very high, high, medium, and negligible, which takes numerical value of 3, 2, 1 and 0, respectively. Since 0 rank does not have any effects on the total score of the indicators, it was excluded from the Table during presentations to minimize the number of columns.

4.7.4 Computation of Farmers' Livelihoods' Vulnerability to Climate Change and Determinants

4.7.4.1 Computation of Farmers' Livelihoods' Vulnerability to Climate Change

Climate impact vulnerability is always an important aspect of climate change studies. Based on Adu (2013), IPCC Livelihood Vulnerability Index (IPCC-LVI) technique was used to achieve the fourth objective. The working equation is:

Vulnerability = *f*(*Exposure*, *Sensitivity*, *Adaptive Capacity*) (4.2)

A commonly used quantitative approach to assess vulnerability is the construction of a vulnerability index based on specific sets or combinations of indicators (Adu, 2013). Accordingly, each of the major components vulnerability (which contributes to exposure, sensitivity, and adaptive capacity) usually may have sub-components and these components must be standardized where average weight of the components will be used for the analysis of vulnerability. To analyze the index of each indicator to standardize the measurements (to make unit free), the following model has been employed to calculate the vulnerability of specific community.

$$Index_{shi} = \frac{S_h - S_{min}}{S_{max} - S_{min}} \quad (4.3)$$

Where s_h the observed sub-component of indicator is for *I* household and S_{min} and S_{max} are the minimum and maximum values, respectively for specific sub-component. After each indicator has been standardized, the sub-component indicators were averaged using below presented equation (equation 4.4).

$$M_h = \sum_{k=0}^{n} \frac{Index_{shi}}{n} \quad (4.4)$$

where M_h is one of the eight major components of vulnerability (Socio-Demographic Profile (SDP), Livelihood Strategies (LS), Social Network (SN), Health (H), Food (F), Water (W) and Natural Disaster, or Climate Variability (NDCV)] for household and $index_{shi}$ represents the sub-components, indexed by i, that makes up each major component, and n is the number of sub-components in each major component (Hahn, 2008). Working equation to estimate livelihoods vulnerability based on the IPCC framework is:

LVI= (Exposure-Adaptive Capacity) *Sensitivity (4.5)

Generally, livelihoods vulnerability components (major and sub-components) and indexing procedures for each component were adapted from IPCC and the vulnerability components (Variables) were defined and selected in the below presented manner.

Table 4.2: Livelihoods Vulnerability Index Components and Employed Indexing Approach

Major and Sub-components	Indexing Approaches
Exposure Index	
(1) Socio-Demographic	
Dependence ratio of family members in the households	Ratio of family below 15 and above 60 years age
Female headed households (%)	
Households' family members have any kind of skill (%)	Maximum 100 and minimum 0 percent, against actual (observed) percentage
Households whose heads did not attend school (%)	
(2) Livelihood Strategies	
Household depends solely on natural resources as sources of income (%)	
Households' family members working in a different community (%)	Maximum 100 and minimum 0 percent, against actual (observed) percentage
Households have alternative sources of food outside agriculture (%)	
Average natural/agricultural livelihood diversification index (%)	
(3) Social network	
Average amounts received: give ratio	Actual average ratio value for each sub-component
Average amounts borrowed: lend money ratio	
Households not gone to local government for assistance in 12 months (%)	Indexed based on the Maximum 100 and minimum 0 percent, using actual average
Membership in social organization (%)	
Adaptive Capacity Index	
(1) Health conditions and Facilities	
Accessibility to health facilities center (%)	
Households have family members with chronic illness (%)	Maximum 100 and minimum 0 percent, against actual (observed) percentage
Households spent more time to get Health center (>5hrs) (%)	
(2) Food source and availability	
Depend only on family farm for food source (%)	Maximum 100 and minimum 0 percent, against actual (observed) percentage
Covers yearly food demand (whole year sufficient) (%)	
Average crops diversification index	Inverse of crops grown (1/n+1)
Percent of households that do not stock crop produce (%)	Maximum 100 and minimum 0 percent, against actual (observed) percentage
Percent of households that do not save seed	
(3) Water source and availability	
Households utilize natural water source (%)	Maximum 100 and minimum 0 percent, against actual (observed) percentage
Households that reporting conflict over water (%)	
Households without sustainable water supply (%)	
Sensitivity Index	
(1) Natural disaster	
Average number of natural disaster events in the past 6 years	Max 6 and min 0 year, against actual average frequency
Households reported death family member due to climate related disaster (%)	
Reported injury of family member due to climate change (%)	Maximum 100 and minimum 0 percent, against actual (observed) percentage
Households reported their natural resource base reduced (%)	
Households reported property loss due to recent natural disasters (%)	
(2) Climate variability	Average Sub-Components Index
Frequency of drought events in the past 6 years	Max 6 and min 0 year, against actual frequency
Mean standard deviation of monthly average rainfall (6 years)	Computed standard deviation value

Source: Adapted with modification from Madhuri, Tewari and Bhowmick (2015) and Phu and Tran (2019).

Commonly, several researchers converge to common components and indexing approach adopted from IPCC, where eight major components with 35sub-components were identified for the study of livelihoods vulnerability. Specifically, Madhuri et al. (2015) and Phu and Tran (2019) approaches were adopted (Table 4.2). In Table 4.2, there are major components and sub-components in the first column, where the leading components are exposure, sensitivity, and adaptive capacity. According to this procedure, after each sub-component has been standardized, the values of sub-components were averaged using equation 4.4 and LVI was computed by averaging the values of major components.

4.7.4.2 Tobit Regression Model for the Determinants of Livelihood Vulnerability

The determinants of livelihood vulnerability to climate change were analyzed with Tobit regression model. Weather-related variables (mean, standard deviation, and coefficient of variation for rainfall and maximum temperature) were used directly in the Tobit regression analysis. Accordingly, the Tobit regression coefficients (beta) were assumed to estimate the linear relation of the latent variable for each unit increase of the predictor. Due to multicollinearity that was observed among the variables, minimum temperature variable was excluded from the model, but the indexed value was used for model estimation. The Tobit model was adopted from Bierens (2004) and the estimated model can be stated as:

$$LVI_i = \alpha + \sum_{j=1}^{3} \beta_j S_{ij} + \sum_{j=1}^{4} \gamma_j C_{ij} + \sum_{j=1}^{2} \delta_j I_{ij} + \sum_{j=1}^{9} \epsilon_j E_{ij} + v_i \qquad (4.6)$$

Where LVI_i is a latent variable denoting the vulnerability of i^{th} household to climate change. In addition, j is the number of variables in each major variable category. S_i, C_i, I_i and E_i are the independent variables for social, economic, institutional, and environmental variables, respectively, with β_j, γ_j, δ_j, and ϵ_j as the estimated parameters. The model's error term (v_i) is assumed to be independent $N(0; \sigma^2)$ distributed, conditional on the independent variables.

In summarized context, the livelihoods vulnerability indexes were used as dependent variable in the Tobit regression model analysis and estimation, where a number of selected socio-economic independent variables were regressed against indexed Livelihoods vulnerability. Accordingly, among socio-demographic characteristics, Age, Family size and Educational level of households' heads were included in the model, while, farm size, crops diversification, alternative income sources, and Livelihoods diversification were considered as sub-economic component. The selected Institutional sub-components were Extension service and credit Facilities, while Agro-ecology, Drought frequency, Rainfall standard deviation, Rainfall coefficient, average rainfall, Maximum Temperature mean with its coefficient, Minimum Temperature index were represented environmental variable sub-category. In detail manner, Table 4.3 shows the dependent and independent variables that were included in the Tobit model with adequate definitions and units of the measurements.

Table 4.3: Variables for Tobit Regression on the Determinants of Livelihoods Vulnerability

List of Variables	Definitions	Means of Measurement
Livelihoods Vulnerability	Livelihoods Vulnerability Index (Dependent variable)	Numerical scale
Social Variables **(S_{ij})**		
Age of the household head	Age of the house head at survey time	Number of years
Education level	Education level of the household's head	Years of schooling
Family size	Number of family size of households	Number of family members
Economic Variables **(C_{ij})**		
Farm size	Farmland holding of the households	Hectare
Crop diversification	Crop diversification on household farmland	Numerical scale
Alternative income source	Alternative income source for households	Dummy (1 if yes and 0 otherwise)
Livelihood diversification	Livelihood diversification for households	Dummy (1 if yes and 0 otherwise)
Institutional Variables **(I_{ij})**		
Extension support	Extension supports for the respondent	Dummy (1 if yes, and 0 otherwise)
Credit Support	Credit support to farm households	Dummy (1 if yes, and 0 otherwise)
Environmental Variables **(E_{ij})**		
Agro-ecology	Geographic location of the study community	Dummy (1 if highland and 0 otherwise
Drought frequency	Drought frequency in past six years	Number of drought years
Rainfall standard deviation	Ten years rainfall standard deviation	Millimeters
Rainfall coefficient of variation (CV)	Ten years rainfall coefficient of variation (CV)	Millimeters
Maximum Temperature Mean	Ten years maximum temperature mean	Degree- Celsius
Max Temp Coefficient of Variation (CV)	Ten years max temp coefficient of variation	Degree-Celsius
Minimum Temperature Index	Ten years minimum temperature index	Degree-Celsius
CSA Practices Adoption Index	CSA practices adoption index computed with PCA	Numerical scale
Average rainfall	Ten years average rainfall	Millimeters

4.7.5 Regression Models Specification and Definition for Selected Variables

(a) Determinants of CSA Practices' Adoption Using the Binary Logistic Regression

Based on Gujarati and Porter (2016), logistic regression model was employed to examine the determinants of adoption of CSA practices. This is the fifth objective of this study. The dependent variable (CSA) has only two categories, which were coded as 0 for nonusers and 1 for users. Thus, the general derivation of the working equation selected to compute proportional contribution of each predictor for the rate of adoption is presented as.

$$Ln\left[\frac{p}{1-p}\right] = \alpha + \sum_{j=1}^{5}\beta_j S_{ij} + \sum_{j=1}^{3}\gamma_j C_{ij} + \sum_{j=1}^{4}\delta_j I_{ij} + e_i \quad (4.7)$$

The estimated equation is stated as:

$$CSA_i = \alpha + \sum_{j=1}^{5}\beta_j S_{ij} + \sum_{j=1}^{3}\gamma_j C_{ij} + \sum_{j=1}^{4}\delta_j I_{ij} + e_i \quad (4.8)$$

Where p is the probability of adopting a CSA practice by *ith* household. In addition, *j* is the number of variables in each variable category. S_i, C_i, and I_i are the independent variables for social, economic, institutional, and environmental variables, respectively, with β_j, γ_j, andδ_j as the estimated parameters. The Logit model is a function (a transformation) of a parameter, and it is the logarithm of the odds in which the odd of an event is the probability of the event divided by the probability of the event not occurring. The Climate Smart Agriculture (CSA) practices that were included in this study, denoted as *k* are minimum tillage, crops rotation, inter-cropping, fallow farming, small-scale irrigation, improved pasture development, climate change adaptable variety adoption and change in crops planting time. On the other hand, the independent variables are presented in Table 4.4 along with dependent variable.

Table 4.4: Definition of Variables Included in the Binary Logistic Regression Selected for Adoption Analysis

List of Variables	Definition of Variables	Means of Measurement
Adoption Decision	Technology adoption (dependent variable)	Dummy (1 if adopted and 0 otherwise)
Social Variables **(S_{ij})**		
Respondent Age	Respondent age at survey time point	Number of years
Educational level	Education level of household head	Year of schooling
Family Size	Number of Family members in the households	Family Number
Respondent Gender	Gender of head of Household	Dummy (1 if male and 0 otherwise)
Farming Experience	Farm experience of the respondents	Farming Years
Economic Variables **(C_{ij})**		
Farm Size	Farmland holding of the households	Hectare
Livestock Holding	Livestock Holding by Household	Number in TLU
Non Agric Income	Income from Non agriculture source for Households	Eth Birr
Institutional Variables **(I_{ij})**		
Extension support	Extension supports for the respondent	Dummy (1 if yes, and 0 otherwise)
Credit Support	Credit support to farm households	Dummy (1 if yes, and 0 otherwise)
Farmers Training Centers (FTC) Distance	FTC distance from respondent's village	Kilometres
Project experience	Years of experience with extension projects	Years

(b) Tobit Regression to Analyze the Determinants of CSA Practices Adoption Intensity

Furthermore, to analyze the determinants of CSA practices adoption intensity in fulfillment of the sixth objective, Tobit regression model was employed. This was done by using the aggregated data collected from highland and lowland agro-ecologies. For this purpose, Principal Component Analysis (PCA) was used to generate composite indicator of CSA. The PCA was used to reduce the large size data dimension to one index. The model, which was adopted from Moffitt (2016) has some weather-related variables and can be stated as:

$$CSAI_i = \alpha + \sum_{j=1}^{3} \beta_j S_{ij} + \sum_{j=1}^{4} \gamma_j C_{ij} + \sum_{j=1}^{2} \delta_j I_{ij} + \sum_{j=1}^{9} \epsilon_j E_{ij} + v_i \quad (4.9)$$

$CSAI_i$ is the CSA adaptation index. S_i, C_i, I_i and E_i are the independent variables for social, economic, institutional, and environmental variables, respectively, with β_j, γ_j, δ_j, and ϵ_j as the estimated parameters. Thus, the model assumes that there is an underlying stochastic index equal to ($\alpha + \sum_{j=1}^{3} \beta_j S_{ij} + \sum_{j=1}^{4} \gamma_j C_{ij} + \sum_{j=1}^{2} \delta_j I_{ij} + \sum_{j=1}^{9} \epsilon_j E_{ij} + v_i$) which is observed only when it is positive, and hence qualifies as an unobserved latent variable, while independent variables presented in Table 4.5 are those that were included in the model estimation.

Table 4.5: Definition of Variables Included in Tobit Regression for CSA Adoption Intensity Analysis

List of Variables	Definitions	Means of Measurement
Climate Change Adaption Intensity	Composite Index of Adaptation	Numerical scale
Social Variables **(S_{ij})**		
Age of the household head	Age of the house head at survey time	Number of years
Education level	Education level of the household's head	Years of schooling
Family size	Number of family size of households	Number of family members
Economic Variables **(C_{ij})**		
Farm size	Farmland holding of the households	Hectare
Income	Seasonal Income of households	Eth-Birr
Institutional Variables **(I_{ij})**		
Extension support	Extension supports for the respondent	Dummy (1 if yes, and 0 otherwise)
Credit Support	Credit support to farm households	Dummy (1 if yes, and 0 otherwise)
Farmers Training Centers (FTC) Distance	FTC distance from respondent's village	Kilo-meters
Environmental Variables**(E_{ij})**		
Agro-ecology	Geographic location of the study community	Dummy (1 if highland and 0 otherwise
Drought frequency	Drought frequency in past six years	Number of drought years
Average rainfall mean	Average rainfall for the past ten years	Millimeters
Rainfall coefficient of variation (CV)	Ten years rainfall coefficient of variation (CV)	Millimeters
Maximum Temperature Mean	Ten years maximum temperature mean	Degree- Celsius
Max Temp Coefficient of Variation (CV)	Ten years max temp coefficient of variation	Degree-Celsius
Minimum Temperature Index	Ten years minimum temperature index	Degree-Celsius
Vulnerability Indicators Index	Vulnerability indicators Index	Numerical Scale
Adaptive Capacity Indicators Index	Adaptive Capacity indicators index	Numerical Scale

(c) Binary Logistic Regression Model for the Determinants of Perceived Sustainability of CSA Practices

To achieve the seventh objective, Binary logistic regression model was specified. This was used to analyze the perceived sustainability of CSA practices. The estimated regression model can be expressed as:

$$Z_i = \alpha + \sum_{j=1}^{5} \beta_j S_{ij} + \sum_{j=1}^{5} \gamma_j C_{ij} + \sum_{j=1}^{6} \delta_j I_{ij} + \sum_{j=1}^{3} \epsilon_j E_{ij} + v_i \quad (4.10)$$

Where, Z_i is the perceived sustainability which was estimated as dummy variable. This variable was coded as 1 for yes response, and 0 otherwise. Table 4.6 presents the included explanatory variables.

Table 4.6: Definition of Variables Included in the Binary Logistic Regression Selected for Perceived Sustainability Analysis

List of explanatory variables	Definition of Variables	Means of Measurement
Social Variables **(S_{ij})**		
Respondent Age	Respondent age at survey time point	Number of years
Educational level	Education level of household head	Year of schooling
Respondent Gender	Gender of head of Household	Dummy (1 if male and 0 otherwise)
Family Size	Number of Family members in the households	Family Number
Farming Experience	Farm experience of the respondents	Farming Years
Economic Variables **(C_{ij})**		
Family Farm Size	Farmland holding of the households	Hectare
Livestock Holding	Livestock Holding by Household	Number in TLU
Annual income	Total annual income for Households	Eth Birr
Non Agric Income	Income from Non-agriculture source for Households	Eth Birr
Agriculture income	Income from agricultural source	Eth Birr
Institutional Variables **(I_{ij})**		
Extension Support	Extension support for the respondents	Dummy (1 if yes and 0 otherwise)
Farmers Training Center (FTC) Distance	FTC distance from respondent home	Kilometres
Credit Facility	Credit for Climate adaptation	Dummy (1 if accessible and 0 otherwise)
Project Experience	Experience of the respondents in the project	Project Years
Market Distance	Market distance from the home of respondent	Kilometres
Media Accessibility	Mass media accessibility to respondents	Dummy (1 if accessible and 0 otherwise)
Environmental Variables **(E_{ij})**		
Agro-ecology	Residential Locality in which respondent	Dummy (highland or Lowland)
Rainfall	Rainfall parameters in the locality	Millimetre
Temperature	Temperature parameters in the locality	Degree centigrade

(d) Tobit Regression Model for the Determinants of Perceived CSA Practices Sustainability

The determinants of CSA strategic practices perceived sustainability were analyzed with the Tobit regression model in addition to the logistic regression that had been specified in equation 4.10. The model was specified based on aggregated data of the two agro-ecologies (highland and lowland. Following Jeffrey (2002), the estimated regression model is:

$$CSAPS_i = \alpha + \sum_{j=1}^{3} \beta_j S_{ij} + \sum_{j=1}^{4} \gamma_j C_{ij} + \sum_{j=1}^{2} \delta_j I_{ij} + \sum_{j=1}^{9} \epsilon_j E_{ij} + v_i \qquad (4.11)$$

Where CSAPS refers to CSA Practices Sustainability. Based on careful review of literature, the included independent variables are presented in the Table 4.7 below.

Table 4.7: Definition of Variables Included in the Tobit Regression Selected for Perceived CSA Sustainability

List of Variables	Definitions	Means of Measurement
Climate Change Adaption Intensity	Composite Index of Adaptation	Numerical scale
Social Variables **(S_{ij})**		
Age of the household head	Age of the house head at survey time	Number of years
Education level	Education level of the household's head	Years of schooling
Family size	Number of family size of households	Number of family members
Economic Variables **(C_{ij})**		
Farm size	Farmland holding of the households	Hectare
Income	Seasonal Income of households	Eth-Birr
Institutional Variables **(I_{ij})**		
Extension support	Extension supports for the respondent	Dummy (1 if yes, and 0 otherwise)
Credit Support	Credit support to farm households	Dummy (1 if yes, and 0 otherwise)
Farmers Training Centers (FTC) Distance	FTC distance from respondent's village	Kilometers
Environmental Variables **(E_{ij})**		
Agro-ecology	Geographic location of the study community	Dummy (1 if highland and 0 otherwise)
Drought frequency	Drought frequency in past six years	Number of drought years
Average rainfall mean	Average rainfall for the past ten years	Millimeters
Rainfall coefficient of variation (CV)	Ten years rainfall coefficient of variation (CV)	Millimeters
Maximum Temperature Mean	Ten years maximum temperature mean	Degree- Celsius
Max Temp Coefficient of Variation (CV)	Ten years max temp coefficient of variation	Degree-Celsius
Minimum Temperature Index	Ten years minimum temperature index	Degree-Celsius
CSA Adoption Index	Adoption indicators Index	Numerical Scale
Adaptive Capacity Indicators Index	Adaptive Capacity indicators index	Numerical Scale

(e) Analysis of Adaptive Capacity of Institutional System to Implement CSA Strategies

This section highlights the approaches that were adopted to achieve the eighth objective. According to several studies, determining or understanding the institutional adaptive capacity in context of adaptation and coping mechanism implementation within the system is important component before characterizing the climate change impacts on the livelihoods which ultimately influence the income of the households in the community (Nasir *et al.*, 2014). Obviously, system level adaptive capacity analysis further provides the insight into how priorities are being set and what shifts in approach may be possible to implement the climate change mitigation strategies in the context of CSA practices. The Adaptive Capacity Index (ACI) approach was used in this study. This is designed to measure and interpret the adaptability of introduced practices and adaptive capacity of institutional architecture including the flexibility of structural system that shapes adaptive capacity. The ACI model has a mixture of subcomponents that form an underlying conceptual framework for survey instrument: levels of capital (social and human, technological and economic); institutional structural design, institutional role as well as responsibility, system level ability to execute responsibilities and learn from process, command over system level accessible resources and capability to plan for future critical self-reflection.

For this purpose, randomly selected farmers, sample extension staff drawn from extension field staff working at different levels, and decision-makers including policy level leaders working in agriculture sector at different structure levels were interviewed and discussed with to evaluate the adaptive capacity of the extension service delivery system in Oromia regional Bureau of Agriculture. With regard to this study, the data generated through comparative scaling of adaptive capacity level of service delivery system to manage climate change have been analyzed robustly based on the index formula suggested and presented below by Nasir et al. (2014), which was employed to determine the adaptation of introduced strategies and innovations (Equation 4.12). The model specification is a composite of the summarized components and variables:

$$ASI = ASn \times 0 + Asl \times 1 + Asm \times 2 + Ash \times 3 \tag{4.12}$$

Where, ASI = Aggregated Adaptation Strategies Index

As*n* = Frequency of farmers rating adaptation strategy as having none………………. (0)

Asl = Frequency of farmers rating adaptation strategy as having low level…………… (1)

As*m* = Frequency of farmers rating adaptation strategy as having medium level……... (2)

As*h* = Frequency of farmers rating adaptation strategy as having high level….……...... (3)

More importantly, to enhance the potential insight into adaptation practices, respondents were asked to comment on present-day organizational capacities, along with capacities of previous times and current situation, to generate information over time and they were expected to assign a value for performance on a four-point scale for each indicator. The four-point scale are high (3), Moderate (2), low (1) and negligible (0) value for adaptation strategy adoption and highly adequate, moderately adequate, less adequate, and inadequate in the case of adaptive capacity scaling which assigned by respondents, while the results have been evaluated in both quantitative and qualitative data analysis approaches.

The key respondents that were selected to involve in adaptive capacity assessment were government's extension officers and farmers. The respondents assigned some rankings to institutional performance on a four-point scale for each index indicator mentioned above. They were asked to provide ranking value for each indicator to help justify their assessment of performance capacity of extension structures delivery system as an institution, which was assigned by the respondents based on their golden perception. The respondents were instructed to assign scores based on their perceived performance of the extension service delivery system. The acquired data were assessed in quantitative data analysis techniques, to produce a description of adaptive capacity from the viewpoint of the respondents which can be presented for each respondent and in aggregate form. The collected data were properly coded and analyzed quantitatively to analyze and interpret the results for drawing relevant conclusion related to institutional adaptive capacity of the extension service delivery system which helps to identify the gaps and opportunities that assist for improvement and enable the investigator to generate the reliable evidence to encompass the policy recommendations. Furthermore, this approach specified above regarding ASI, have been adequately extended for the utilization of proper ranking of the different CSA practices, priority ranking, problem ranking, effect ranking and impact ranking, particularly in this study.

In this aspect, the score of each rating level were summarized and finally aggregated from which the percentage was calculated considering the assumed highest score if all respondents (farmers) rate a particular indicators three (3 point) which is simply 600 for highland and 630 points for lowland agro-ecology, respectively in the case of strategies ranking and related variables, whereas, percentage of indicators' assessment were computed from 420 point, which is the highest score when all respondents (extension field staffs) rate highest three (3 score) for a particular indicator.

In addition to rating institutional adequacy in respective of each variable, perception of respondents' (Farmers and extension field staffs) were assessed, where cross-tabulation sub-program used to compute the results which preferably presented by percentage in order to supplement the results of indexing model. Additionally, to determine the determinants of Adaptive Capacity Index of extension service delivery system, Tobit regression model was selected and employed. For this purpose, the score of each adaptive capacity indicators were indexed using PCA technique and generated index values were inserted for each respondent along with other none indexed variables in respective of their districts and agro-ecology to determine the effect of each indicator on dependent variable which is indexed adaptive capacity of extension service delivery system in context of this study, where PCA was selected and used for dimension reduction of large size income related data and to reduce the number of variables to a single variable of interest in the model estimation.

(f) Institutional Adaptive Capacity Analysis Using Tobit Model

In addition to indexing based adaptive capacity analysis mentioned above, Tobit regression model was used to further analyze the determinants of institutional adaptive capacity in context of extension service delivery system. Having described concepts and procedures of Amore and Murtinu (2019), the Tobit model can be defined and specified as follows:

$$ICSA_i = \alpha + \sum_{j=1}^{3} \beta_j S_{ij} + \sum_{j=1}^{11} \delta_j I_{ij} + e_i \quad (4.13)$$

$ICSA$ is the institutional CSA adaptive capacity in the context of Agricultural extension service delivery system. Furthermore, the explanatory variables for the model are presented in Table 4.8 including the units means of measurements.

Table 4.8: Definition of Variables Included in Tobit Model for Determinants of Institutional Adaptive Capacity

Explanatory variables	Definition	Means of Measurement
Adaptive Capacity	Institutional capacity to deliver services (dependent variable)	Indexed Ordinal scale
Social Variables **(S_{ij})**		
Age of HH heads	Age of the households' heads at survey time	Years in number
Sex of HH heads	Sex of the households' heads	Dummy (1 for male and 0 female)
Education level	Education level of households' heads at survey time	Years of Schooling
Institutional Variables **(I_{ij})**		
Road facility	Road facility accessibility to farmland	Dummy (1 accessible and 0 otherwise
Farmers Training Center Distance	Farmers Training Center (FTC) Distance from farmland	Distance in kilometers
Structural set up adequacy	Institutional Structural set up adequacy	Ordinal scale
Institutional Technical Capacity	Technical capacity of extension structure	Ordinal scale
Resource Facility and capacity	Institutional resource facility and capacity	Ordinal scale
Institutional Climate Focuses	Institutional focus on climate change management	Ordinal scale
Climate strategy focuses	Institutional climate strategy focuses	Ordinal scale
Field staff contact capacity	Field staff contact capacity	Ordinal scale
Staff commitment	Staff commitment to deliver climate change services	Ordinal scale
Service accessibility and convenience	Extension service accessibility and convenience	Ordinal scale
Service content and quality adequacy	Extension service content and quality adequacy	Ordinal scale

(g) Two Stage Least Square Regression Model of the Determinants of Households' Incomes

To achieve the ninth objective, the study utilized the two stage least square regression model to examine the effect of some variables on the income of the farm households under climate change and weather variability. The estimated model can be stated and presented as shown below:

$$Y_i = \alpha + \sum_{j=1}^{3} \beta_j S_{ij} + \sum_{j=1}^{4} \gamma_j C_{ij} + \sum_{j=1}^{6} \delta_j I_{ij} + e_i \quad (4.14)$$

For this purpose, socio-economic and climate change coping strategies related variables were included as explanatory variables. The universal problem in empirical work is the possibility of inconsistent parameter estimation due to endogenous regressors, where regression model estimates only magnitude of association, without including the direction and however, instrumental variables estimators provide the way to obtain consistent parameters estimates (Baum, Schaaffer and Stillman, 2003). Accordingly, for this study, Two Stage Least Square (2SLS) were preferred and employed due to endogenous characteristics of some independent variables, rather than using Ordinary Least Square (OLS) estimation technique. In this aspect, the Hausman test procedure were selected among many more others, where the first step is to determine whether the independent variable(s) is (are) uncorrelated with the model error or not. In this regard, if not, least square is inconsistent which require the use of less efficient, but consistent instrumental variables (IV) estimator. Which means, in the first step least squares is used to estimate the first stage of two stage Least square (TSLS) model and then add the residual to original model. Then Estimate final equation using least squares, where t-ratio used on the coefficient of original model error term to test the null hypothesis. According to this test procedure, if model estimation is significantly different from zero, then the regressors X_i is not exogenous and use of the instrumental variables (IV) estimator (TSLS) is required to estimate coefficient of included variables; but if it is not significant, then the use of the most efficient estimators, OLS is adequate.

Accordingly, testing the relevance of Instruments (IV) is important aspect in regression modeling, where instrumental variable must satisfy two requirements, that it must be correlated with the included endogenous variable(s) and Orthogonal to the model error Terms. The former readily tested by examining the fit of first stage regression, where the first stage regression are reduced form of regression of endogenous variables x on the full set of instruments (Zs) (Baum, Schaffer and Stillman, 2003). In this regard, the statistics commonly used is the R^2 of the first stage regression with the included instruments "partial-out" (squared partial correlation) and alternatively, this may be expressed as the F test of the joint significance of the Z_1 instruments in the first stage regression and model estimations.

Regarding to endogenous and instrumental variables, many more authors extensively discussed and presented concepts and technical estimation procedures including estimators. In view of these authors, like Angrist and Knrueger (2001), good instruments often come from detailed knowledge of the economic mechanism and institutions to determine the regressor of interest, where specifically, in Angrist and Knrueger (2001), years of schooling (educational level) suggested as endogenous variables in context of earning model (Income modeling), while time variation in schooling, proximity to college and date of birth are identified as source of instrumental variable. Hence, based on preceding discussion, Hausman test of endogeneity procedure was employed to conduct diagnostics tests of the independent variables, to identify whether the variables in the model are endogenous or not in context of income outcome variable.

The selected endogenous variables undergo Two Stage Least square (TSLS) procedure, where at the first stage endogenous variables were regressed against each exogenous variables to generate instrumental variables (Zs) which are assumed none correlated with error term (u),but strongly correlated, rather than weakly correlated with the regressor victors (χ) have been selected and used at 2nd stage with other exogenous variables to estimate the unbiased constant terms which under current level of technology can be analyzed by computers' sub-program programs. Accordingly, for this purpose, among available SPSS programs, 2SLS sub program was selected and directly employed in running the regression analysis, where below presented variables are selected and included in the model (Table 4.9).

Table 4.9: Definition of Variables Included in the 2SLS Regression Selected for Income Determinant Analysis

Explanatory Variables	Definition	Unit of Measurement
Income	Households' incomes (Dependent)	Ordinal scale
Social Variables **(S_{ij})**		
Sex	Sex of household's head	Dummy (1 for male and 0 otherwise)
Family size	Family size of households	Ordinal number
Educational Level	Educational level of household's head	Years of schooling
Economic Variables **(C_{ij})**		
Rural off-Farm Employment	Employed outside household business	Dummy (1 if employed and 0 otherwise)
Rural on farm Employment	Family employment in rural on farm business	Dummy (1 if employed and 0 otherwise)
Urban non-farm Employment	Family member employment in urban non-farm	Dummy (1 if employed and 0 otherwise)
Farm Size	Farmland owned by households	Farmland in hectare
Institutional Variables **(I_{ij})**		
Internal mobility	Mobility from place to place for resources	Dummy (1 if employed and 0 otherwise)
Interconnectedness	Social networks for support	Dummy (1 if employed and 0 otherwise)
Emergence aid for households	Emergence support given by government	Dummy (1 if yes and 0 otherwise)
Extension Service accessibility	Technical service provided by extension staff	Dummy (1 if accessible and 0 otherwise)
Informal credit access	Non-formal credit accessibility to households	Dummy (1 if employed and 0 otherwise)
Formal credit accessibility	Formal credit available to households	Dummy (1 if employed and 0 otherwise)

(h) Food Self-sufficiency Related Determinants Analysis using Poisson Regression

Poisson regression was selected and employed on agro-ecologically aggregated data to determine the correlates of households' seasonal food self-sufficiency. In the context of this study, food self-sufficiency level was estimated by the number of households covers yearly food demand for household members from household's own agriculture food sources out of twelve months of the year. Accordingly, the number of households covered household's yearly food demand for specified months (2-4 months, 5-7 months, 8-10 months and 11-12 months) from households' agriculture related alternative food sources has been taken as a dependent variable, while socio-economic and weather-related parameters are defined as independent variables in Poisson Regression model analysis. For this Poisson regression analysis purpose, households' agriculture related food sources were considered and identified in the survey process and the data were indexed using PCA technique, where the indexed value assumed as dependent variable were inserted for each respondent in respective of their agro-ecology. The Poisson regression model described by Yang and Berdine (2015) was selected among a range of models that are available. Poisson regression was selected and used to analyze this food self-sufficiency data (the number of months food sufficient per year) for a particular household considering past six years into account. According to this author and many more documents, count data follow a Poisson distribution which is positively skewed and Logarithmic transformation can linearize the distribution; thus, the link function is log.

The log outcome rate is then expressed as a linear function of a set of predictors (ibid). Thus, based on this author, the estimated Poisson regression model selected for this study mathematically can be expressed as:

$$log_e(\mu_i) = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 + \cdots + \beta_k\chi_k \quad (4.15)$$

Whereβ_0 reflects the amount of change in the logarithm of the predicted number of events for a unit change in each X_k variable. Although generalized linear models are very flexible, they are limited to only one regression equation for a single outcome variable, which is also true for general linear models (ibid). Moreover, the independent socio-economic variables required in the model estimation are selected and identified, where weather related parameters such as rainfall and temperature are also included as the part of independent variables (Table 4.10).

Table 4.10: Definition of Variables Included in Poisson Regression Selected for Food Self-sufficiency Determinants Analysis

List of variables	Variables definition	Means of Measurement
Food Self-sufficiency	Households' seasonal food sufficiency (dependent)	Ordinal scale
Agro-ecology	Geographic location of the study community	Dummy (1 if highland and 0 otherwise)
Age	Age of the household's heads at survey time	Years in number
Educational level	Education level of households' heads	Schooling years
Family size	Number of family size in the household	Family in number
Crop diversification	Crop diversification	Numerical value
Alternative income	Alternative income for the households	Dummy (1 if yes and 0 otherwise)
Livelihood diversification	Livelihood diversification on households' farmland	Numerical scale
Drought frequency	Drought frequency in the past six years	Number of drought years
Farm size of the Households	Farm size owned by the households	Farmland in hectare
Extension Support	Extension support to the households	Dummy (1 if yes and 0 otherwise)
FTC Distance from home	FTC distance from households' farmlands	Distance in kilometers
Credit Support	Credit Support to households	Dummy (1 if yes and 0 otherwise)
Rainfall mean	Ten years average rainfall	Millimeters
Rainfall standard deviation	Ten years rainfall standard deviation	Millimeters
Rainfall Coefficient of variation (CV)	Ten years rainfall coefficient of variation (CV)	Millimeters
Vulnerability Index	Indexed value of vulnerability indicators	Indexed numerical scale
Max Temperature Mean	Ten years maximum temperature mean	Millimeters
Max Temp Coefficient of variation (CV)	Ten years max temp coefficient of variation (CV)	Degree-centigrade
Minimum Temperature Index	Indexed value of ten years Minimum Temperature	Degree-centigrade
CSA practices adoption Index	Indexed value of CSA practices adoption	Numerical scale

(i)Test Statistics Employed

(a) Independent t-Test and Chi Square

Independent t-test and Chi-square test were performed to identify the mean differences for continuous variables and the tendency of association for categorical variables respectively. The former test was performed to identify the typical level and significance of continuous independent variables impact on CSA practices adoption and direction of the impacts (positive or negative) on adoption decision, whereas the second technique was used to infer some association between categorical variables and dependent variables. Furthermore, the statistical significance level benchmarks which are usually and widely accepted as well as used in the scientific community and research practices that are commonly 1 percent, 5 percent and 10 percent were certainly employed consistently throughout the data presentation and interpretation in context of these mentioned tests statistics and summary works in order to infer the significance of observed variability and the effects of each variable.

(b) Diagnostic Tests for Multicollinearity

Multicollinearity was tested using the Tolerance (TOL) and Variance Inflation Factor (VIF). The nonexistence of multicollinearity was checked based on the Menard (1995, who documented the established threshold of more than 0.1 for Tolerance (TOL) and less than 10 test results for variance inflation factor (VIF) as benchmark for each independent variable. Additionally, Alemu (2007), suggested that, as a rule of thumb, the VIF rate greater than 10 shows high multicollinearity and tolerance close to zero also indicates high multicollinearity between independent variables. Furthermore, the research experiences already long time in extensively exploring and identifying the heteroskedasticity characteristics of the variables in the income variables modeling, where according to the literatures, the possibility of being heteroskedasticity is significant in the OLS model for this study. Thus, considering the highest possibility of heteroskedasticity in the OLS model, test of heteroskedasticity was skipped, where 2SLS computer program was directly selected and employed to analyze relevant data.

4.8 Chapter summary

The geophysical context of the study areas, sampling methods, data collection tools, data analysis techniques, inferential models, and research design were determined and explained in this section. Accordingly, the research design selected for this study and presented in this chapter was mixed research method which entails qualitative and quantitative methods. Based sample frame, a total of 410 farmers were randomly selected from four districts and twelve Peasant Associations. The descriptive analytical procedures were employed to generate some required statistics, such as means, standard deviation, frequency, and percentages, to make the raw data meaningful for presentation and elucidation, along with several inferential models. In this regard, binary logistic regression, was employed to analyze adoption and adoption sustainability of CSA strategic practices in the study community, while two stage least square regression model was used to analyze climate change management impacts on welfare of the study community. Furthermore, Tobit regression models was employed to generate the inferential statistics for the interpretation of variables relationship in perspective of CSA strategic practices adoption, adoption sustainability and Truncated regression model were employed to analyze adoption intensity, while institutional adaptive capacity also analyzed and estimated by Tobit model in addition to adaptive capacity indexing model. Furthermore, livelihoods vulnerability Analysis were conducted using Tobit regression model, while on the other hand, Poisson regression model was selected and employed to analyze the data collected to generalize the food security and food self-sufficiency situation of the study community.

CHAPTER FIVE

WEATHER VARIABILITY AND RELATED IMPACTS

5.1 Introduction

This chapter was designed to present the analyzed secondary data results related to inter-seasonal weather variability and trends which are the first implication of climate change adverse effects and related biophysical impacts. These secondary data were collected from the Department of Agricultural Bureaus and Disaster Risk management and National Meteorology Agency of the Ethiopia. The chapter also explains and presents natural disasters effects which are regarded as the climate change impact reflected on the livelihoods of the community and national economy. The secondary data collected in the perspective of highland and lowland study areas were analyzed and presented in the content of below sub-headings.

5.2 Seasonal Weather Variability and Inter-seasonal Trends

Rainfall and temperature variability are the most important variables in climate change studies. These two variables were examined in this study to determine their relative variability and impacts on households' livelihoods. Meteorological data were collected from five weather stations- Meki, Wolichiti and Adama from the lowland agro-ecology, whereas Assela and Etheya from the highland agro-ecology. The data covered 26 years (1993-2018) and were categorized into five groups for the statistical analyses of their variability. The first five years (1993-1997) was taken as the baseline data for comparison with other periods. On the other hand, the season of the years is classified into three categories, which are represented as pre-season (January, February, March and April,), main season (May, June, July and August) and post main season (September, October, November and December) due to the fact that each has its own natural characteristics and effect on the seasonal farming practices and agricultural production. Based on the above-mentioned approaches, the analyzed secondary data results are summarized and presented as shown below.

5.2.1 Precipitation Perspective of Climate Change and Impacts

To determine the prevailing impact of climate change along agricultural value chains, analyses of the precipitation amounts and their distribution were carried out in this study. The assessments were based on seasonal and aggregated weather data. The results in Tables 5.1a and 5.1b showed inconsistency in the rainfall pattern both in the mid-highland and lowland agro-ecology zones. According to NMA (2019), rainfall figures in 2018 were higher than that in 2017 both in volume and spatial distribution and lower in 2016 cropping year. Additionally, in lowland areas, except data from Meki weather station, which represent the Dugda Districts and surrounding environments, there was a reduction in the mean annual rainfall at Adama and Wolinchiti with a decline of 31 and 48 percent, respectively, during the 1998-2002 period. However, there were some increases in recorded rainfalls with 42 percent at Meki, 43 percent at Adama and 37.3 percent at Wolinchiti weather stations during the pre-main season (January-April) performance of the 3rd years category (2003-2007) compared with base years performance at the same stations. However, there are declining trends in annual mean rainfall with an average of 1 percent, 26 percent and 38 percent at Meki, Adama and Wolinchiti, respectively, during last 5th category of the years (2013-2018) as compared to base years (1993-1997) rainfall recorded at the same locality and weather data stations (Table 5.1a). Nevertheless, the average rainfall recorded during the last five years category (2013-2018) showed a significant decline only at Wolinchiti station with 17.3 percent when compared with average rainfall recorded during base years category (1993-1997) and others (Meki and Adama) showed an increase contrarily to Wolinchiti, during main season of the 2nd category (1998-2002) of the period. However, there are consistent decline in the trends of annual mean average rainfall amount during 2013-2018 in the main season (May-August) and post-main seasons (September-December) indicating the damaging situations at lowland areas known to produce the major cereals and lowland pulses (Table 5.1a).Thus, the results demonstrate that reduction in the amount of rainfall is a common phenomenon in the lowland agro-ecologies, which negatively influences the performance of the farmlands through moisture stress, extreme weather events and agricultural pest incidences.

Table 5.1a: Annual Rainfall Distribution and Trend in Each Weather Station

Years category	Meki		Adama		Assela		Wolinchit		Etheya	
	Mean	Change	Mean	Change	Mean	Change	Mean	Change	Mean	Change
Pre-main season (January-April)										
1993-1997	28.7		43.0		73.2		51.8		42.2	
1998-2002	32.8	14.3	29.7	-30.9	55.7	-23.9	26.8	-48.3	46.9	11.1
2003-2007	40.7	41.8	61.3	42.6	60.6	-17.2	71.1	37.3	51.8	22.7
2008-2012	27.9	-2.8	49.7	15.6	51.6	-29.5	27.2	-47.5	26.9	-36.3
2013-2018	28.4	-1.0	31.8	-26.0	45.9	-37.3	32.0	-38.2	23.3	-44.8
Main season (May-August)										
1993-1997	97.1		141.2		149.2		137.7		125.3	
1998-2002	102.6	5.7	141.3	0.1	146.5	-1.8	112.2	-17.3	158.4	26.4
2003-2007	86.3	-11.1	130.7	-7.4	140.9	-5.6	141.3	4.1	148.3	18.4
2008-2012	133.5	37.5	158.8	12.5	144.5	-3.2	131.9	-2.8	151.6	21.0
2013-2018	88.5	-8.9	134.7	-4.6	141.8	-4.9	110.9	-18.3	112.3	-10.4
Post Main season (September-December)										
1993-1997	28.3		14.2		58.0		46.7		43.7	
1998-2002	36.9	30.4	50.9	26.6	61.7	6.4	49.3	5.6	57.8	32.3
2003-2007	29.0	2.5	37.3	-7.2	55.0	-5.2	27.1	-42.0	51.8	18.5
2008-2012	31.0	9.5	46.2	14.9	57.8	-0.3	42.2	-9.6	55.0	25.9
2013-2018	27.5	-2.8	37.9	-5.7	63.3	9.1	35.2	-24.6	33.6	-23.1

Source: Compiled from NMA Secondary Data (2020)

In dissimilar manner with lowland agro-ecology, significant and consistent decline was identified from in the results on rainfall amount at Assela weather station. However, there were some increases at Etheya station by 11.1 and 22.7 percent during 2nd category (1998-2002 and 3rd (2003-2007) of cropping seasons, while it declined during the 4th (2008-2012) and 5th (2013-2018) category of the years, indicating fluctuating situations at highland areas of the Tiyo and Hetossa districts, when annual mean rainfall of pre-main season categories average compared with respective base years average. Also, there was a decline with relatively similar percentage when compared with 3rd (2003-2007) and 4th (2008-2012) categories of the years. However, closely similar and pronounced decline of 33.3 percent at Assela and 44.8 percent at Etheya were identified during last 5th (20013-2018) category of the years. These all variability situation in rainfall amount and distribution are significant and alarming situation related to climate change impacts which majorly affecting agricultural livelihoods and biodiversity at highland ecosystems. Commonly, inter-seasonal variability majorly affects the livestock's pastures production, crops farm land preparation practices and traditionally early planted crops husbandry.

Comparatively, the mean rainfall reduction was found smaller (4.9 percent in Assela and 10.4 percent in Etheya) for main season (May-August) during similar category of years last cropping years (2013-2018) as compared to pre-season (January-April) which is still significant in context of negative impact on agricultural production and livelihoods. This finding is relatively encouraging because of the major impact of main season rainfall on crops production and livestock farming. Likewise, there was a similar decline in rainfall amount at Etheya weather stations (23.1 percent) and an increase was observed for Assela (9.1 percent) during post main season situation of the last 5th category of the years (2013-2018) compared with baseline years (1993-1997) in respective of the corresponding period (Table 5.1a). Thus, the above summarized data (Table 4.1a), declaring that overall declining situation in rainfall amount is common phenomenon at all five locations but the worst at Assela areas where is the home of County's potential biodiversity and farm practices, when compared with twenty-six years back situation.

On the other hand, data were categorized under two agro-ecologies (highland and lowland). The data from Assela and Etheya weather stations represented the highland agro-ecology and data from Adama, Wolinchiti and Meki weather stations represented the lowland agro-ecology. The aggregated data of the weather station within the highland and lowland are combined in respective of the agro-ecology and used to describe the merged climatic parameter trends of areas and are discussed based on the results presented in Table 5.1b below. With respect to rainfall situation, there had been significant decline over the years in the highland agro-ecology. In the results for lowland, compared to the base line years, rainfalls in the pre-main season increased by 40 percent during the 2003-2007 period while it declined in other periods (Table 5.1b). Table 5.1b further shows the summarized rainfall data of highland agro-ecology (Etheya and Assela weather stations) of Arsi zone.

Table 5.1b: Aggregated Seasonal Rainfall Trend for Two Agro-ecologies

Agro-ecology and Years categories	Mean Seasonality trend						Aggregated trend	
	Pre main season (January-April)		Main season (May-August)		Post main season (September-December)		Mean (mm)	Change (%)
	Mean (mm)	Change (%)	Mean (mm)	Change (%)	Mean (mm)	Change (%)		
Highland								
1993-1997	57.7		137.3		50.8		81.9	
1998-2002	51.3	-11.1	152.5	11.1	59.8	17.7	87.9	7.3
2003-2007	56.2	-2.6	144.6	5.3	53.4	-12.6	84.7	3.5
2008-2012	39.2	-32.1	148.2	7.9	56.2	5.5	81.2	-0.9
20013-2018	34.6	-40.0	127.0	-7.5	48.5	-15.2	70.0	-14.5
Lowland								
1993-1997	41.2		124.2		38.4		68	
1998-2002	29.8	-27.7	118.7	-4.4	45.7	19.0	65	-4.8
2003-2007	57.7	40.0	119.4	-3.9	31.1	-19.0	69	2.1
2008-2012	34.9	-15.3	141.4	13.8	35.5	-7.6	71	3.8
20013-2018	30.7	-25.5	114.8	-7.6	33.5	-12.8	60	-12.3

Source: Compiled from NMA Secondary Data of Weather Stations (2020)

The results indicate a significantly decreasing trend in the mean annual rainfall for the whole category of the years, which are specifically considerably high by 32.1 percent and 40 percent during 4th (2008-2012) and 5th (2013-2018) categories, respectively in the pre-season mean rainfall, when compared with baseline year (1993-1997) average value. Obviously, the decreasing situation in precipitation during pre-main season is momentous indication of climate change. Also, adequate rainfall is critically necessary for cropping during main seasons and most of the farming practices such as farmland clearing, and land preparation are commonly conducted during this season, since the clearing and farmland preparation require adequate soil moisture, which is fundamentally determined by the amount of rainfall received during the pre-seasons.

In the same manner, main-season rainfall in the highland agro-ecology shows stable increase by 11.1 percent, 5.3 percent and 7.9 percent in the 2nd (1998-2002), 3rd (2003-2007) and 5th (2013-2018) category of cropping years, respectively, which are relatively positive for agricultural livelihoods makings. In the meanwhile, the summarized and presented highland representing weather stations Post main season rainfall data shows similar decreasing trend of 12.6 percent and 15.2 percent during 3rd (2003-2007) and 5th (20013-2018) categories of the years, respectively, while there are rising trends during 2nd (1998-2002) by 17.7 percent and 4th (2008-2012) by 5.5 percent as compared to corresponding post main season baseline years in the same highland agro-ecology.

However, these findings are slightly inconsistent with results from some other studies that suggest more variability in the trends of rainfall in Africa in general and in Ethiopia in particular (IPCC 2007). For instance, according to Sivakumar et al. (2005), changes in total volume of rainfall in Africa that were projected by most GCMs are relatively modest. Contrarily, a great uncertainty identified in relation to regional-scale rainfall changes simulated by GCMs but which failed in determining the character of the climate change signal on African rainfall against a background of large natural variability compounded by the use of imperfect climate models (Sivakumar et al., 2005), while, Thornton et al. (2006), in Mario et al. (2010) asserted likely decrease in rainfall amount in some very few places in East Africa, which is consistent with findings of this study. Under Ethiopia context, seasonal rainfall distribution is extremely unpredictable and typically takes place in the form of heavy rainstorm as the result of the country's wide-ranging landscape (World Bank, 2011). As a matter of fact, over the past three decades, Ethiopia had largely experienced seven major drought events, coupled with countless localized droughts aggravated by seasonal weather variability, out of which five had resulted into chronic famines in the entire country (World Bank, 2010).

Additionally, the variability in both climate and weather parameters is expected to greatly intensify the already widespread soil erosion, significantly exacerbate deforestation events, considerably speed up process of biodiversity distraction, enhance desertification process, recurrent flooding events, water as well as air pollution (ibid). World Bank (2011) also averred that the frequent droughts and floods will obviously cause the most bitter hazards to farming community, where agriculture, water resource and human health sectors are among the most negatively impacted ones by climate change. Habitually, seasonal rain onset as well as rainfall intensity and annual amount considerably fluctuate inter-annually in the country, due to movements of Inter-Tropical Convergence Zone (ITCZ), which usually lead to destructive drought events in different parts of the country (ibid). Differently, according to IPCC (2007) Projections established based on the results of diverse models' analysis are consistent in indicating considerable increases in annual rainfall amount for Ethiopia as a whole, where all estimated increases are mainly a result of increasing rainfall amounts which occurred during short rainy season (October-December), that has been projected to increase on average approximately around 10 and 70 percent across the country. Additionally, as to this author, climate change projection models adequately demonstrate a high level of agreement in suggesting predominant augmentation in rainfall amounts across the East African countries, where an increment of more than 20 percent in a very extreme rainfall events, that happen once in 100 years, is expected in southern Ethiopia by the year 21st century, which is slightly in contrary to the findings of this study.

More importantly, another aspect of weather condition which significantly affects the performance of the agricultural livelihood is inter-seasonal variability which shows the distribution of the precipitation in particular area over a given time. In this regard, to determine the standardized inter-seasonal variability of the rainfall distribution in the study areas, in addition to percentage change in mean annual rainfall, descriptive statistics was applied separately on averaged rainfall data of each category of the respective years and analyzed data results were presented accordingly based on the computed standard mean deviations.

According to analyzed and presented data in Table 5.1c, there is significant variability which is indicated by standard mean deviations ranging from 142.24 to 221.29 indicating the highest variability at almost all the weather stations, where the highest mean standard deviation of 221.29 was identified for Wonlichiti weather station and followed by Meki weather station, which both are located in lowland agro-ecology. Whereas the smallest (142.24) mean standard deviation was observed at Assela weather station indicating relatively stable variability in the context of highland agro-ecology in contrary to lowland area.

Table 5.1c: Rainfall Variability Statistics Computed from 10 Years (2009-2018) Data

Weather stations	Minimum	Maximum	Mean	Standard. Deviation	Coefficient of Variation
Adama station	558.80	1214.80	809.85	206.29	0.25
Meki station	389.70	966.80	645.05	216.51	0.34
Wolinchiti station	239.10	987.50	700.66	221.29	0.32
Assela station	796.80	1196.60	1002.38	142.24	0.14
Etheya station	498.40	1202.60	749.07	210.75	0.28

Source: Compiled from NMA Secondary Data (2020)

Similarly, slightly the highest coefficient of variation (CV) has identified from results of the data collected and analyzed from Meki weather station (34 percent) and Wolinchiti weather station data result comes second by 32 percent indicating the pioneering variability in respective of rainfall distribution, which agrees with most reports and prior assumption. Furthermore, the results of these data analysis reveal consistency with report of monthly bulletin of NMA (2019), which asserted that the monthly total amount of rainfall recorded was below normal in most parts of the country and total amount of rainfall recorded in January 2019 was below the rainfall recorded in January 2018 cropping seasons in the country, indicating declining tendency of rainfall amount. As to this monthly Bulletin report, the normal rainfall amount is decreasing in some areas of North-eastern Ethio-somali areas of lowlands, small areas of Eastern Oromia and Northern Gambella, which is relatively consistent with the findings of this study.

According to several findings, over the last few decades, the temperature in Ethiopia increased, whereby the increase in minimum temperatures is more pronounced, while rainfall amount, on the other hand, remained somewhat constant during the past 50 years when averaged across 22 countries including Ethiopia (Keller, 2009). In contrary to this finding, Ministry of Foreign Affairs of the Netherlands (2018), indicated increasing tendency in precipitation with considerable significant rates, resulting in decreased predictability in Oromia and Tigray regions of Ethiopia, while overall average yearly precipitation is declining in the same regions. Furthermore, it was affirmed that there are declining trends in precipitation in some southern, south-western and south-eastern regions of the country, where *Belg* season (February-May) and *Kiremt* (June-September) seasons rainfall have decreased by 15-20 percent during 1975 and 2010 cropping years. Thus, the decrease in rainfall amount demonstrates significant negative impacts on agricultural production potential and the impact becomes more apparent when there is a significant change in areas that normally receive sufficient rain (500 mm per season) to support crop production (ibid).

Accordingly, areas receiving sufficient rainfall during *Belg* season (February-May) seasons have shrunk by 16 percent from the year 1990 and onward; compounded by decrease in the *Kiremt* season (June-September) rainfall significantly affecting the most lowland parts of the country, primarily in densely populated Rift Valley areas located in regions of SNNPR and south-east Oromia (World Bank, 2011). There are also factual evidences indicating deteriorating situation in pastoral and semi-pastoral areas in the eastern parts of the country. Under normal condition, these areas are required to receive sufficient rainfalls amount of 250 mm per season to support pastoralists, but now it is considerably declining. However, despite current declining tendency of precipitation in the country, the long-term rainfall is projected to increase by about 9 percent for Ethiopia over 50 years, when relatively evaluated against 1975 rainfall situation (Ministry of Foreign Affairs of the Netherlands, 2018).

On the other hand, both increases and decreases in precipitation in different parts of the country demonstrate great differences more at the local level (World Bank, 2011). For instance, a study conducted in some districts of the Central Rift Valley predicted a considerable decrease in rainfall, with a decline of over 11 percent for some areas, and an increase of approximately 9 percent for other nearby districts. Obviously, there is a forecast that a larger proportion of the overall annual rainfall will occur during heavy precipitation seasons in the year, especially between July and December which customarily leads to escalating incidence of extreme weather events, with severe droughts in one year, and heavy flooding compounded with erosion and landslides in the following other year (ibid). Hence, the mixed trend of inter seasonal and spatial weather variability observed in this study is consistent with the findings of several other studies.

5.2.2 Temperatures Perspective Climate Change Impacts

Over the last decades, temperature readings in Ethiopia have increased by about 0.2^{o}C per decade, where the increase in minimum temperatures is more pronounced with roughly 0.4^{o}C per decade, impacting agricultural livelihoods and biodiversity (Keller, 2009). This finding indicated the importance of temperature variability and trends in local farming systems which insisted the researcher to look into the temperature parameters in context of the study community in this academic research. Regarding to data, adequate temperature data were not found at most of the weather stations (Wolinchit, Meki and Etheya stations). The available data were insufficient to represent the whole situations of the areas except data temperature obtained from Assela and Adama weather station. Based on this data shortage in other remaining weather stations, secondary data from Assela and Adama weather stations were considered to represent the highland and lowland agro-ecology, respectively. Accordingly, the secondary data sourced from the Adama weather station represents the lowland agro-ecology, while the one obtained from Assela weather station operates for the highland areas of the study. Subsequently, the temperature, functioning as the secondary data, from the respective stations was subjected to descriptive statistics analysis and presented in this section to describe temperature trends and related effects forecasted based on the observed trends (Table 5.2a and b).

According to the result of data analysis, maximum temperature mean has increased by 1^{o}C (3.6 percent) and the largest 1.8^{o}C (6.5 percent) changes was observed during 2008-2012 and 2013-2018 categories of the years for pre-main season when compared with base years (1998-2002) category average in the lowland agro-ecology (Table 5.2a). Whereas there are stable variabilities when other remaining categories of the years are compared with baseline category in the lowland study community. For instance, there are small maximum temperature increase during 1998-2002 and 2008-2012, where the temperature increased by 0.9^{o}C (3.2 percent) and 0.8^{o}C (2.9 percent), respectively, as compared to base years (1993-1997) average. Furthermore, insignificant increases were observed when 2008-2012 category of the year are compared with 2013-2018 years categories, in which an increase from 28.6^{o}Cto 29.6^{o}C was identified for the corresponding pre-season of the years indicating decimal level declining trend in monthly maximum temperature mean. However, the average maximum temperature variability identified for each season are quite significant (more than 1^{o}C) when estimated from baseline years category (1993-1997) in lowland agro-ecology, which is relatively high in the context of Temperature and temperature linked consequences (Table 5.2a).

Table 5.2a: Summary of Temperature Trend in lowland Agro-ecology Represented Station

Years	Pre-main season			Main season			Post main season		
	Monthly Average (ºC)	Change (ºC) from base years average	Change (%) from base years average	Monthly Average (ºC)	Change (ºC) from base year average	Change (%) from base years average	Monthly Average (ºC)	Change (ºC) from base years average	Change (%) from base years average
Maximum T									
1993-1997	27.8			26.8			26.2		
1998-2002	28.8	1.0	3.6	27.8	1.0	3.7	26.6	0.4	1.5
2003-2007	28.7	0.9	3.2	27.7	0.9	3.4	26.8	0.6	2.3
2008-2012	28.6	0.8	2.9	28.2	1.4	5.2	26.9	0.7	2.7
2013-2018	29.6	1.8	6.5	28.6	1.8	6.7	27.6	1.4	5.3
Average		1.1	3.9		1.3	4.9		0.8	3.1
Minimum T									
1993-1997	14.0			15.5			13.2		
1998-2002	11.2	-2.8	-20.0	13.4	-2.1	-13.5	10.5	-2.7	-20.5
2003-2007	14.9	0.9	6.4	16.6	1.1	7.1	14.2	1.0	7.6
2008-2012	15.1	1.1	7.9	16.8	1.3	8.4	14.3	1.1	8.3
2013-2018	16.0	2.0	14.3	17.1	1.6	10.3	14.8	1.6	12.1
Average		0.5			0.5			0.3	

Source: Compiled from NMA Data of Adama Weather Station (2020)

In this regard, local maximum temperature changed from 2.9 percent to 6.5 percent when estimated based on baseline years mean temperature and the change is approached 1.8^{o}C during last 5th category (2013-2018) of the years, which looks slightly high and unsuitable for agricultural livelihoods practices. In similar manner, maximum mean temperatures were changing during consecutive three category of years with on average by about 1^{o}C, but escalated during last 5th category (2013-2018) of the years to 1.8^{o}C (6.7

percent) when estimated based on baselines years' category (1993-1997) during main season which is similar in magnitude with temperature variability identified in the case of pre-main season annual maximum temperature (Table 5.2a).

On the other hand, the result shows closely similar increasing and decreasing tendency as observed in pre-main season, where only small variability identified between intermediate categories for main season and post main season, respectively, but relatively with significant change of 3.4 to 6.7 percent for main season from baseline years category in the local lowland agro-ecology compared with reference years in the maximum local temperature (Table 5.2a).Undoubtedly, moderately significant changes of smallest 1.5 to largest 5.3 percent were identified in maximum temperature at lowland agro-ecology during post main season.

On the other hand, as shown in table 5.2a above, change in mean annual minimum temperature found significantly high as compared to changes identified in maximum temperatures in all seasons, where the change from base years reached maximum 2^{o}C (14.3 percent) during pre-main season, but there declining trend in minimum temperatures during 1998-2002 category of the years, indicating devastating situation to already fragile agricultural livelihoods practices and biodiversity of the lowland farming environment in context of the study community.

In contrast to the situation in the lowland agro-ecology, the result of the analyzed temperature data from Assela weather station (representing highland agro-ecology) shows unclear tendency compared with actual expectation which is based on the rainfall trend and climate change condition. The secondary data analysis results indicate almost all significant declining trends in maximum and minimum local temperature as compared to baseline category of the years, showing different situation from traditional anticipation and several study findings (Table 5.2b). As shown in Table 5.2b, almost all the results of this weather station show a slight decline of about 2.9 to 5.8 percent during 2003-2007, 2008-2012 and 2013-2018 category of the years, with only increase by 4.6 percent observed during 2^{nd} category (1998-2002) in maximum local temperature during pre-main season when compared with summarized base years temperature of the same situation.

On the other hand, similar declining trends identified with 0.3 percent (during 1998-2002), 8.6 percent (2008-2012) and 1.7 percent (for 2013-2018) category of the years in minimum local temperature, with only 8.8 percent increase realized during 2003-2007 category, as compared to baseline situation during pre-main season. In summarized scenario, no significant increasing change is found in pre-main season, main season and post main season in maximum and minimum local temperature; but relatively significant increasing tendency of 5.6 percent, 1.1 Percent and 5.6 percent were observed during post main season for consecutive categories of 2003-2007, 2008-2012 and 2013-2018, respectively, is special situation in minimum temperature when compared with the situation in the last 26 years in the highland areas of the study (Table 5.2b).

Table 5.2b: Summary of Temperature Trend in Highland Agro-ecology

Years	Pre-main season			Main season			Post main season		
	Monthly Average	Change (ºC) from base years average	Change (%) from base years average	Monthly Average	Change (ºC) from base years average	Change (%) from base years average	Monthly Average	Change (ºC) from base years average	Change (%) from base years average
Maximum T									
1993-1997(1st)	24.0			22.3			22.5		
1998-2002(2nd)	25.1	1.1	4.6	22.8	0.5	2.2	22.0	-0.5	-2.2
2003-2007(3rd)	22.7	-1.3	-5.4	20.8	-1.5	-6.7	20.3	-2.2	-9.8
2008-2012(4th)	22.6	-1.4	-5.8	21.2	-1.1	-4.9	20.9	-1.6	-7.1
2013-2018(5th)	23.3	-0.7	-2.9	22.2	-0.1	-0.4	21.5	-1.0	-4.4
Average		-0.6	-2.5		-0.6	-2.7		-1.3	5.8
Minimum T									
1993-1997(1st)	9.6			11.1			9.0		
1998-2002(2nd)	9.6	-0.1	-0.3	11.2	0.1	0.9	8.5	-0.5	-5.7
2003-2007(3rd)	10.5	0.9	8.8	10.3	-0.8	-7.2	9.5	0.5	5.6
2008-2012(4th)	8.8	-0.8	-8.6	10.9	-0.2	-1.8	9.1	0.1	1.1
2013-2018(5th)	9.5	-0.16	-1.7	11.2	0.1	0.9	9.5	0.5	5.6
Average		-0.04	-0.4		-0.2	-1.8		0.16	1.7

Source: Compiled from NMA Data of Assela Weather Station (2020)

As shown in the above Table 5.2b, a steady increase of 2.2 percent during 2nd category of the year (1998-2008) has identified in the maximum temperature during main season, which is dissimilar with a declined trend by 2.2 percent of rainfall situation during post main season in respective of highland agro-ecology. Similarly, minimum temperature of the areas depicts similar increasing trend of 0.9 percent for both 2nd (1998-2002) and 5th (2013-2018) category of the years, for main season compared with baseline years summarized weather data which emphasized rainfall and Temperature.

According to the result presented in the above Table, in the highland agro-ecology, significant decrease in maximum temperature is observed throughout the whole seasons, except two situations (during 1998-2002 categories of pre-main season and main season) compared with respective seasons of the reference years. Meanwhile, post main season maximum temperature shows straight decreasing tendency, but with fluctuating magnitude of -0.5℃ (2.2 percent), -2.2℃ (9.8 percent), -1.6℃ (7.1 percent) and -1℃ (4.4 percent) during consecutive categorized years, when judged against reference years category for highland agro-ecology, while only a decline of -0.5℃ (5.7 percent) was identified in the case of minimum local temperature during the same season and 2nd (1998-2002) category of the cropping years. Accordingly, the highland agro-ecology may result in cooling effects that equally affect the performance of the crops and productivity of the farm animals. It should be noted that the three rainfall distribution seasons (pre-main season, main season and post main season) are not exclusively independent of one another; rather any weather related change from normal condition in one particular season automatically affects the performance of agricultural livelihoods conducted during next cropping seasons. For instance, any extreme weather change during pre-main season would affect the success and effectiveness of farm practices of main season and in a similar manner abnormal weather condition of the main season will assuredly affect the performance of agricultural practices performed during post main season. In addition to the above-mentioned temperature parameter estimates, seasonal variability is crucial for crops and livestock productivity and production.

Specifically, to seasonal weather variability, 10 years' temperature data collected from respective weather stations that are located within geographical location of the two agro-ecologies (highland and lowland) were managed and analyzed to find the tendency of temperature variability. In this research and presentation context, temperature variability has explained by mean standard deviation of the analyzed data, where the result shows about 0.33 mean standard deviation for Adama weather station and 0.78 for Wolinchiti weather station in maximum temperature, while mean standard deviation of 0.34 and 0.71 was identified, respectively, in the case of minimum temperature at these two stations, which both of them are located in the lowland agro-ecology. On the other hand, relatively high mean standard deviation of 0.72 for maximum temperature and 0.60 for minimum temperature were found in the highland agro-ecology (Assela weather station), which is slightly escalated temperature variability as compared to results from Adama weather station which represents lowland agro-ecology, but closely similar with result from Wolinchiti weather station which located in the same agro-ecology (Table 5.2c).

Table 5.2c: Temperature Statistics Computed from 10 Years (2009-2018) Weather Data

Location	Weather stations	Minimum	Maximum	Mean	Standard Deviation	Coefficient of Variation
Lowland	Adama Maximum Temperature	27.70	28.90	28.39	0.33	0.01
	Adama minimum Temperature	15.20	16.30	15.77	0.34	0.02
	Wolnchiti Maximum Temperature	29.43	31.49	30.26	0.78	0.03
	Wolnchiti Minimum Temperature	14.28	16.38	15.45	0.71	0.05
Highland	Assela maximum Temperature	21.20	23.50	22.08	0.72	0.03
	Assela Minimum Temperature	9.30	11.30	9.90	0.60	0.06

Source: Compiled from NMA Weather Station Data (2020)

On the other hand, when coefficient of variation (CV) considered as the measure of variability, the highest variability coefficient observed for Assela weather (6 percent) as compared to smallest variability coefficient of 2 percent for Adama weather station in minimum annual temperature. According to the result presented in Table 5.2c above, Wolinchiti comes second to Assela in minimum temperature by 5 percent coefficient of variation. The maximum temperature coefficient of variation for Adama, Wolnchiti and Assela weather station are 1 percent, 3 percent, and 3 percent, respectively. Furthermore, several study results indicate significant variability in weather condition in the country: for instance, mean annual temperature shows increasing trends by 1.3°C during the period of 1960 and 2006, with average rate of 0.28°C per decade, where an increase in temperature parameters has been observed to be significantly fast during the months of July-September, with a rate of 0.32°C that has been documented per decade (World Bank group, 2011). Intergovernmental Panel on Climate Change (IPCC) also employed GCMs to make specific projections through 2050 based on emissions scenario and has predicted mean yearly temperature increase of 1.1^{0}C to 3.1°C, and 1.5 to 5.1°C by 2060s and 2090s, respectively, in the coming years in Ethiopia.

Additionally, Marius Keller (2009) asserted that, it is very likely for annual temperature to continuously increase during the next decades with a rate of change as experienced for the duration of current years and seasons. Similarly, over the last decades in Ethiopia, almost all economic sectors have experienced frequent climate changes impacts which are expressed in temperature rise, where the country temperature has augmented markedly with an average rate of between 0.2◦C and 0.28◦C per decade during the past 40 to 50 years, whereas the rate of increase in annual temperature is dissimilar in each region as well as the season, and it is commonly extreme in areas that are already dry with hot temperature in the country (Ministry of Foreign Affairs of the Netherlands, 20181). The notably areas are in the north and eastern parts of the country, where the hot temperature occurs usually during July-September season in cropping years (ibid).According to this report, temperature parameters are expected to elevate considerably in the entire cropping seasons with an average of 1°C, 2◦C and 3◦C in the year 2030, 2050, and 2080, respectively, comparatively to 1975 situations, while in contrast, some models predict that the maximum temperature will increase as high as 5.1◦C in the year 2090s, thus inducing irreversible environmental and social impacts (world Bank Group, 2011). Arguably, the findings of this study indicates the fluctuating situations within the years, between the years and seasons in temperature parameters in contrast to what revealed by most of findings and reports reviewed above in relation to temperature, while relatively increasing trends in the case of lowland data results found consistent with projected increasing trends explained by majority of the study results summarized from secondary data.

5.3 Chapter Summary

This chapter presented the seasonal weather variability in context of annual precipitation and temperature trends for the studied agroecological zones. The secondary data were from five weather stations of the National Meteorology Agency offices in Meki, Wolinichit, Adama, Ethaya and Assela. The data were analyzed for the highland and lowland agro ecologies. The results indicated a significantly decreasing trend in the mean annual rainfall for the last two decades, which was considerably higher by 40 percent during 2013-2018 in the pre-season mean rainfall, when compared with the average value for baseline years. There were 7.5 percent and 15.5 percent declines in the annual precipitation in main-season and post main-season, respectively. Aggregately, 14.5

percent and 12.3 percent decline in annual precipitation at highland and lowland agro-ecologies are the alarming implication in context of agricultural production. Generally, in context of the results presented in this chapter, it is very likely for annual temperatures to continuously increase while rainfalls decline over the next few years. These changes will induce some disastrous impacts on agricultural production in the region.

CHAPTER SIX

FARMERS' DEMOGRAPHICS AND LIVELIHOOD RESPONSES

6.1 Introduction

This chapter articulates the demographic characteristics of smallholder farmers selected from the highland and lowlands agro-ecology of the study areas in respective of CSA strategic practices and innovations adoption. Consequently, it explains the profile of sampled respondents with regard to their age, sex, family size, farm experience and level of education. Congruously, based on the survey data results, the socio-economic characteristics of the respondents are summarized and presented across their utilization of CSA technology and practices in context of agro-ecologies selected for this research.

6.2 Demographics of the Farmers in Context of Adoption Decision

In this study, a total of 410 farmers from the highland and lowland areas of the study were sampled and included in survey study conducted in 202. There demographic characteristics are described in this chapter across their CSA practices adoption decisions in the manner present under subsequent sub-headings.

(i) Age of Households' Heads and CSA Practices Adoption

Table 6.1a and b show that the age of the respondents in the two agro-ecologies varied between 20 and 71 years. The average age of the respondents is 46 and 40 years for the highland and lowland agro-ecologies, respectively. Almost all the respondents (90.5 percent for highland and 99 percent for lowland) were within the age range of 20 - 60 years. Similarly, out of the 410 respondents, only few farmers were above 60 years old, while most of the older farmers were found in the highland areas, precisely about 9.5 percent, while it is only 1 percent in the case of lowland community respondent (Table 6.1a). As clearly presented in below Table, in totality, the aged (above 60) respondents group constitutes less than 10 percent in both highland and lowland, which indicated that majority were within the productive age group of 15-60 years and in the age category which is positively responsive to technology adoption. As shown in Table 6.1a, out of the total respondents represented in each agro-ecology, the age of the respondents varying between the ranges of 20 and 40 years constitutes 33.0 percent and 55.2 percent for highland and lowland represented study areas, respectively.

Likewise, out of the total sampled farmers, the age of the respondents between 41 and 50 years constitutes 37.5 percent and 34.8 percent in highland and lowland, respectively, while those between ages 51 and 60 accounts for 20.0 percent in the context of highland and 9 percent of lowland represented respondents, whereas the remaining are above 60 years age in context of the study community. Thus, the distinction between the ages also clearly underscored the fact that farmers below 20 years of age are not represented in this research survey sample. Regarding the head of the households, Bayard et al. (2007), confirmed that age has positive correlation with climate smart agricultural technology and practice adoption for climate change adaptations and mitigation.

The study claimed further that older farmers are believed to be more experienced, thus impacting positively on farmland productivity by adopting improved practices.

Table 6.1a: Age Category of the Survey Respondents (N=410)

Age category	Highland Agro-ecology			Lowland Agro-ecology		
	Total	Percent		Total	Percent	
		Valid%	Cumulative		Valid%	Cumulative %
20-30 years	13	6.5	6.5	25	11.9	11.9
31-40 years	53	26.5	33.0	91	43.3	55.2
41-50 years	75	37.5	70.5	73	34.8	90.0
51-60 years	40	20	90.5	19	9.0	99.0
Above 60	19	9.5	100.0	2	1.0	100.0
Total	**200**	**100**	**100.0**	**210**	**100.0**	**100.0**

Source: Compiled from Survey Data (2020)

Table 6.1b: Respondents' Age in Relation to CSA Practices Adoption (N= 410)

Age category	Highland Agro-ecology					Lowland Agro-ecology				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
20-30 years	13	1	7.7	12	92.3	25	9	36.0	16	64.0
31-40 years	53	16	30.2	37	69.8	91	36	39.6	55	60.4
41-50 years	75	29	38.7	46	61.3	73	17	23.3	56	76.7
51-60 years	40	17	42.5	23	57.5	19	10	52.6	9	47.4
Above 60	19	8	42.1	11	57.9	2	1	50.0	1	50.0
Total	**200**	**71**	**35.5**	**129**	**64.5**	**210**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

To determine the influence of the age characteristics of the sample households on the adoption of CSA practices, a comparison was made between different age categories of the respondents and tested using the frequency of each category. Accordingly, the age of sampled farmers was categorized into five categories, and Table 6.1b presents the age characteristics of the surveyed farmers in relation to CSA practices and technology adoption decision, where the subsequent discussion of this section is supported by the information presented in this Table. Based on this categorical approach, about the majority of the respondents are between 41 and 50 years of age, of which the majority of 61.3 percent were non-adopters of the CSA practices, while 38.7 percent of this category are adopters in respective of highland community and likewise, 76.7 percent of the lowland respondents of the same age category were found non-adopters of CSA practices. Also, about 40 farmers (20 percent) of the respondents are between 50-60 years of age, out of which 42.5percent are adopters, while 57.5 percent are non-adopters in the context of highland agro-ecology (Table 6.1a and b). In a similar manner, the second majority for highland and first majority for lowland of the respondents are within the age category of between 31-40 years in both highland and lowland community represented respondents; as well from this category, 30.2 and 69.8 percent are adopters and non-adopters, respectively in the case of highland, while 39.6 percent adopters and 60.4 percent are none-adopters in the context of lowland community. The remaining, about 19 farmers (9.5 percent) fall under the category of above 60 years; of which 42.4 percent represents adopters and 57.6 percent captures none adopters in the context of highland agro-ecology while only very few farmers are within a similar age category in lowland farming community representing respondents. In generalized term, the significant majority of the respondents are identified to be non-adopters of climate smart Agriculture strategic practices under both highland and lowland agro-ecology in each age category established particularly for this study.

Furthermore, the survey results show that the largest group amongst the represented respondents of the highland (about 84 percent), that is, within the age category of 31 to 60 years, which is the effective age group to produce food, of which 37 percent are adopters, while the percentage of non-adopters is 63 in same agro-ecology. Additionally, 6.5 percent are below 30, while a proportion of 9.5 percent is above 60 years. These findings are consistent with other findings in Arsi zone. An instance is Haji (2002); the research indicated that the proportion of young and older farmers were lower compared with other age categories, adding that the low proportion of this age group is due to lack of access to land resources as they were young when the land reallocation was conducted during revolutionary "Derg" regime in the country. Furthermore, the survey results show that proportionally the largest group of the respondents who are the adopter of the CSA practices (about 42.5 percent) for highland and (52.4 percent) for lowland agro-ecology found in the age category of 51 to 60 years which may indicates that the experienced farmers are likely to adopt the introduced technology and innovation.

On the other hand, the data related to family members are analyzed based on the usually accepted age categorization procedure which is important for determining the productive groups and dependent groups. Hence, the summary of the families in the two agro-ecologies are represented in Table 6.2 below. Accordingly, the processed data shows closely similar proportion for age categories within less than 15 years and above 64 years of age (traditionally considered as dependent groups) for highland and lowland agro-ecologies, respectively. The overall dependence ratio of the highland farming community is about 72 percent showing slightly high (73.8 percent) dependence ratio at lowland areas as compared to highland agro-ecology, which means, in addition to other factors the high dependence ratio is adequate indication for community vulnerability to natural disasters including the climate change related impacts. Similarly, the family related characteristics of the households were assessed against CSA practice adoption decision of the households. In this regard, about 6.1 represents the average family members of the Households for highland and about 5.9 for lowland agro-ecologies, and aggregated average family size for both agro-ecology is 6.0 which is relatively higher than the national average family size of 4.9 family sizes per household (CSA,2011b). According to the survey data, the family sizes of the surveyed households vary between 1 and 17 for highland community, whereas 2 and 16 for lowland areas (Table 6.2).

The larger family size in the survey community indicates that the population in the study area is quite high and this could affect the natural environment, particularly vegetation negatively as people attempt to meet their food, wood, fuel, and cash requirements for local consumption. This is similar with what revealed by several research findings, like Ntsabane and Moteele, (2008) who carried out a study, focusing specifically on Botswana and affirmed that human population in Africa and globally posed the greatest threat to the environment than ever before, threatening the sustainability of natural and social environment. Thus, the high population and population density in the study areas are areas of concern, for both aggravate the natural resource degradation and worsening the climate change process in the rural community. In relation to this concern, Bradshaw (2014), avowed that in order to realize a sustainable development in social and economic context, efforts should be directed towards reducing the impact of population growth on the environment through technological and social innovation in an environmentally friendly manner.

Table 6.2: Family Size of Respondents in Relation to CSA Practices Adoption (N= 410)

Family size category	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Less 5 Family	47	18	38.3	29	61.7	34	13	38.2	21	61.8
5-10 Family	149	50	33.6	99	66.4	167	52	31.1	115	68.9
11-15 Family	2	2	100.0	0	0.0	8	7	87.5	1	12.5
Above 15 Family	1	0	0.0	1	100.0	1	1	100.0	0	0.0
Total	**199**	**71**	**35.2**	**129**	**64.8**	**210**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

As depicted, about 34 percent of the Households family size falls under the range of 1-5 persons, while about 63 percent of the Households has a family size ranging from 6-10, while household size range of 11-15 amounts to 2.4 percent, and 1 percent represents a family size of more than 15 members per household. According to Mugula and Mkuna (2016), household with large family had the likelihood to put in a better work force in agricultural production, consequently resulting in high production, coupled with a better capability to adapt to prevailing climate change and related consequences. Overall, the analysis of the socio-economic and demographic characteristics of the family members of the households, evinces that majority of the respondents are within productive age group and are largely males. Generally, higher family size indicates fast population growth that could impact the environment negatively. More importantly, the average family size of respondents is high as compared to national average showing that population pressure as an important factor in managing and reducing environmental degradation in the context of the survey households and community.

(ii) Gender and Marital Status in Perspective of Adoption

The data related to Gender and marital status were analyzed and summarized in Table 6.3 to facilitate the result presentation and interpretation. According to the results presented in Table 6.3, of the total farmers, 88 percent of the respondents in highland area are males, while the proportion of the female respondents constitutes only 24 percent. On a similar note, the percentage of the male respondents in the lowland area is 91, which is slightly higher than the ratio discovered in the highland. Appositely, several studies reported similar results which are consistent with these findings. Accordingly, the study conducted by Ajala (2017) confirmed similar results and argued that the reason for having higher number of male farmers may be due to the drudgery nature of agricultural farm practices, which require muscularity with extended time to perform. The author explained further that male dominance in agriculture, referencing Oduniyi (2013), and Coster and Adeoti (2015), asserted that female farmers cannot be as active as men in agriculture, besides women unlike men, have limited access to critical agricultural inputs, and as such they are at a disadvantage in their participation in farming.

Table 6.3: Gender and Marital Status of Respondents in Relation to CSA Practices Adoption (N= 410)

Details of Category	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Gender of respondent	**200**	**71**	**35.5**	**129**	**64.5**	**210**	**73**	**34.8**	**137**	**65.2**
Female	24	11	45.8	13	54.2	19	10	52.6	9	47.4
Male	176	60	34.1	116	65.9	191	63	33.0	128	67.0
Marital status	**200**	**71**	**35.5**	**129**	**64.5**	**210**	**73**	**34.8**	**137**	**65.2**
Married	179	65	36.3	114	63.7	205	70	34.1	135	65.9
Single	21	6	28.6	15	71.4	5	3	60.0	2	40.0

Source: Compiled from Survey Data (2020)

In terms of head of households' sex composition, out of the total number (410 respondents), about 89.5 percent of the respondents are males, while females account for only 10.5 percent (Table 6.3). Correspondingly, of the highland respondents, 88 percent are male headed households; while the proportion of female headed household is about 12 percent during survey period. Comparatively, the proportion of female headed household presented above in the context of highland agro-ecology is slightly higher as compared to 9 percent of the lowland areas including the aggregate proportion of female in the two agro-ecology of the study areas. This aggregated result (10.5 percent of female-headed households) is by far lower than the nationally reported data of women headed families, which indicates that in rural Ethiopia 18 percent of households are headed by women (CSA, 2011), but closely similar with the proportion of female headed households observed in highland agro-ecology. Likewise, from the household survey conducted in Ethiopia, Arega (2013), revealed that out of the total sample households selected to generate survey data, about 14 percent is a female-headed household which is comparatively within the closer distance with proportion identified in the context of highland community of the current study.

Specifically, the submissions of these two studies maintained a slight conformity with the results obtained in the highland of this current research, while on the other hand, their findings are much higher than that of the lowland results. On the other hand, different study reported higher proportion of women headed Households as compared to these above mentioned findings and current research results. For instance, Codjoe, (2010) who divulged that female head is estimated to be 22 percent in Sub-Saharan Africa, and in a similar manner, USAID (2006) further asserted male-headed household dominance in the study it conducted. Thus, it can be deduced from these extant works and this current study that it is a normal characteristic in majority of African nations to have male-headed households, including Ethiopia. Regarding CSA practice adoption, the investigation shows that majority of the male headed household respondents (65.9 percent) are non-adopters, while moderate majority of the female headed household respondents (54.2 percent) are non-adopters in the context of lowland study community. Thus, this signifies the responsiveness of the female regarding the adoption of CSA practices and technology as compared to their male counterparts in the highland farming community and farming system.

Likewise, an overwhelming proportion of 67 percent in households headed by male are none adopters, whereas a ratio of 47.4 percent of households headed by females are none adopters of the CSA practices in the lowland agro-ecology of the study area, which is slightly lower in proportion as compared to highland situation performance of female head households. According to Arega (2013), female-headed households are usually differentiated by having small farmland holdings, severe labor force shortage, inadequate cash, as well as financial sources, insufficient assets to operate farm business, usually sell household's plots or exercise sharecropping practices with a better-off household due to labor force shortage and/or farm animals for farming practices. Besides, females shoulder greater responsibility to take care of family members; for instance, it is their responsibility to collect fuel wood and water for domestic consumption; hence, all these situations limit their chance of access to new technologies and information to adopt improved farm practices for household farm business (ibid).

The marital status of the respondents represented in the survey communities were summarized in Table 6.3 to be discussed accordingly. According to the result presented in this Table, out of the total respondents (410), 10.5 percent of them are single, while 89.5 percent are married in the highland agro-ecology. Likewise, about 97.6 percent are married, while only 2.4 percent are single in the lowland agro-ecology; thus, the analysis clearly indicates a lower proportion of the single as compared to the highland areas. In general, the result implies that majority of the respondents are married, and are living together with their spouses, evidencing the stability of marriage in the study area. Regarding to CSA practices adoption, the study result indicates that the majority (63.7 percent) of respondents in marriage status are non-adopters of the introduced practices, while only 36.3 percent found adopters in the highland community. Frustratingly, only 28.6 percent of the single status respondents found adopters against overwhelming majority (71.4 percent) who found non-adopters in similar highland agro-ecology. Similarly, significant majority (65.9 percent) of respondents in marriage are non-adopters of the introduced CSA practices, while only 34.1 percent found adopters in the lowland community. Whereas, of total single (without mirage) respondents, the highest proportion (60 percent) identified as adopters of CSA practices, while 40 percent of the single mirage status respondents found non-adopters in similar lowland agro-ecology of the study areas and communities.

(iii) Educational Level and Farm Experience in the Context of CSA Practices Adoption

According to several source documents, knowledge, innovation, and education are essential in building a culture of safety and resilience to climate change at all levels (Gebrie, 2015). Additionally, Harris (2012) stated that as individual's knowledge on environment increases, the community will be more aware of the potential consequences of the negative impacts and risks. Consequently, an educated farmer can have a realistic perception of natural disasters, its causes and impacts which consequently facilitate the adoption of the climate change adaptation measures in the community (ibid). All these necessitate the need of relevant assessment related to the impact of education on Technology adoption and thus, emphasized in this study.

Accordingly, examination of the educational background of the respondents reveals that only 6 percent and 29.5 percent of them have not attended any kind of formal education in the highland and lowland agro-ecology respectively (Table 6.4), While 6.5 percent of the respondents attended the least adult education schooling in highland, 25.7 percent are found in lowland farming community in the study locations.

Thus, this result indicates, better schooling profile of the study community than what is reported at the national level, which confirms that in Ethiopia 58 percent of women and 44 percent of men are illiterate (Gebrie, 2015). Generally, out of the overall total of the surveyed respondents located in the highland and lowland areas of the study, about 65.6 percent of them attended and completed primary school education, and above during the survey period.

As indicated in Table 6.4, most of the farmers who participated in this study are semi-literate, having attained high school education. Specifically, 17.8 percent attended junior secondary, while 14.6 had secondary level education, respectively when the aggregate of highland and lowland is considered. However, the proportion of the respondent with junior secondary and secondary level education is significantly lower at lowland agro-ecology compared with the ratio of participants from highland areas of the study households in the community.

Table 6.4: Educational Background of Respondents in Relation to CSA Practices Adoption (N= 410)

Education Level	**Highland Agro-ecology**					**Highland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
No-formal education	12	5	41.7	7	58.3	62	12	19.4	50	80.6
Adult education	13	6	46.2	7	53.8	54	21	38.9	33	61.1
Primary level	79	28	35.4	51	64.6	57	23	40.4	34	59.6
Junior-secondary	48	20	41.7	28	58.3	25	9	36.0	16	64.0
Secondary level	48	12	25.0	36	75.0	12	8	66.7	4	33.3
Total	**200**	**71**	**35.5**	**129**	**64.5**	**210**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

Several studies significantly supported the role of education and knowledge in enhancing technology adoption decision. In line with this, Ajala, (2017) suggested the role of education based on relevant sources, like Asfaw and Admassie (2004) and Bamire *et al.* (2002), that education facilitates agricultural production by enhancing farmer's expertise to produce more output from given farmland resources, in addition to strengthening farmer's ability to acquire and analyze relevant information in accordance with the community's situation. Furthermore, this author asserted that experienced and educated farmers have more skills and knowledge regarding climate change and coping measures which ultimately can positively influence the adoption decision of the farmers. Furthermore, Ibrahim *et al.* (2015) and Maddison (2007) affirmed that farmers' literacy level impact on adaptation, as it affects producers' awareness, as well as perception regarding climate change and importance of adaptation options, as educated farmers could be proactive or reactive to climate change risks by making appropriate options toward adaptation. On the other hand, although there is limitation to verify direct association between lack of formal education and household food insecurity, lack of education might limit household heads' capacity to read and understand written information related to regulation, markets systems, technology, technical training, financial management and infrastructures that could improve their awareness and perception to adopt the recommended innovations required to attain food security (Bunana, 2014).

In the case of this survey research, the respondents' educational profile is on average, and better than the national average of the country, which further indicates enhanced awareness of farmers about natural resource degradation, contributing knowledge regarding climate change, which particularly requires building adaptation skills and resilience at community level. This finding is in conformity with several other study results, like Gebrie (2015), who confirmed educated communities' responsiveness to adapt to climate changes and manage disaster better than uneducated community members. However, the survey result presented in Table 6.4, shows no significant difference among the educational level of the respondent in respective to adoption decision makings. In the study area, a ratio of 66.7 are adopters, with secondary educational level, all the remaining educational level including the non-formal education was found less than average (below 50 percent) rate of CSA practices adoption decision in both highland and lowland farming community. Therefore, the impact of education on CSA adoption decision is less, it seems that the education strategies need to be designed in a way that accommodate the environmental aspect of knowledge which require further revisiting of strategies including education policy.

The farming experience of the respondent is presented in Table 6.5, and it shows that the majority of the farmers (53.2 percent) had farming experience of 21 years and above, while 46.8 percent had farming experience of less than 20 years. Meanwhile, the proportion of farmers who have farm experience of more than 30 years is high (32.5 percent) at highland agro-ecology compared with lowland (5.7 percent) during survey period. Similarly, farmers with less farming experience (within the range of 10 years) account for 6.0 percent and 18.6 percent for highland and lowland, respectively, and almost the same proportion is observed with those who have between 11- and 15-years farming experience amongst the respondents. The farmers with less than two years of farming experience constitute only 7.1 percent. Thus, the distinction made is a pointer that there are more experienced farmers who had adequate knowledge about the farming sector in the study community. According to Ajala (2017), who explained referring to Ibrahim et al. (2015) and Madisson (2007, the farming experience of respondents would impact positively on farmers' productivity as the result of fact it helps to identify the climate change situation earlier and respond earlier to related impacts compared with less experienced farmers in the study community.

Table 6.5: Crop Farming Experience of Respondents in Context of CSA Practices Adoption (N= 410)

Years of farming experience	**Highland Agro-ecology**					**lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Less than 10 years	12	0	0.0	12	100.0	39	13	33.3	26	66.7
11-20 years	50	12	24.0	38	76.0	91	25	27.5	66	72.5
21-30 years	73	33	45.2	40	54.8	68	29	42.6	39	57.4
31-40 years	47	16	34.0	31	66.0	12	6	50.0	6	50.0
Above 40 years	18	10	55.6	8	44.4					
Total	**200**	**71**	**35.5**	**129**	**64.5**	**210**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

With regard to farming experience of the household heads, the results of the survey (Table 6.5), illustrate that a high proportion of farmers in each farming experience category are non-adopters of CSA practice, while just a few are adopters (below 50 percent). This is significantly low as compared to information garnered from literature, which indicates high impact of farming experience on technology adoption including climate change adaption and mitigation practices. In the meantime, inter agro-ecological variation concerning the rate of adoption decision of CSA practices is minimal, contrary to prior expectation. For instance, it was expected that there would be a better rate of adoption in the lowland farming community considering the significant impact of climate change on the national economy in general and livelihoods of the farming community in particular. Debatably, these findings adequately indicate that farming experience of individual farmers without integrating the CSA practices in Technology packaging and ultimately in the farming system has nothing to do with climate change management aspect in the farming system which clearly indicates limitation of Technology and innovation packaging in extension service delivery system. Furthermore, Table 6.6 enounces livestock farming experience in the context of CSA practices adoption decision of the respondents. Regarding livestock farming experience, two extreme situations were observed from the survey data. Majority (27 percent) of the respondents had more than 30 years of experience in the highland farming community, as compared to about 2 percent of the lowland, while majority of the lowland respondents (33.3 percent) had less than 10 years (including 10) experience in the field of livestock husbandry, which was relatively higher as compared to highland (9.5 percent) situation. In summary, the result shows that there is a high variability between the two agro-ecology, indicating a significantly pronounced experience in the lowland farming community when compared with its counterpart, the highlanders of the study community.

Table 6.6: Livestock Farming Experience in Context of CSA Practices Adoption (N= 410)

Years of livestock farming experience	**Highland Agro-ecology**					**lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Less than 10 years	61	9	14.8	52	85.2	70	26	37.1	44	62.9
11-20 years	85	43	50.6	42	49.4	96	35	36.5	61	63.5
21-30 years	38	12	31.6	26	68.4	40	11	27.5	29	72.5
31-40 years	5	2	40.0	3	60.0	4	1	25.0	3	75.0
41-50 years	4	2	50.0	2	50.0					
Above 50 years	6	2	33.3	4	66.7					
Total	**199**	**71**	35.2	**129**	64.8	**210**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

In relation to CSA strategic practice adoption, the highlanders in almost all the categories concerning livestock farming experience are better adopters in comparison to the lowland respondents. However, with exception of those with less than 10 years' experience, the lowland farmers are better adopters (about 37 percent), contrasting the highlanders' rate of adoption (about 15 percent) in the same range of livestock farming experiences. It is however surprising, as depicted in Table 6.6, that no farmer had above 40 years of livestock farming experience among the survey sample selected from the lowland agro-ecology, unlike the highland respondents where there are farmers with more than 40 years of experience, and better adopters of the CSA practices. The study observed that majority of the respondents (50.6 percent) with 11-20 years of livestock farming experience are notable better adopter of the CSA practices in the highland agro-ecology, followed by 41-50, then 31-40 years of experiences as 2nd (50 percent) and 3rd (40 percent) respectively in the same farming system, indicating about an average rate of adoption. On the other hand, the rate of CSA practice adoption in respective to livestock farming experience were found below average in all the range of years of experiences, showing comparatively that the farmers within the livestock farming experience of less than 10 are (about 37 percent) better adopters, whereas 11-20 and 21-30 years of experiences are ranked 2nd (36.5 percent) and 3rd (27.5 percent) respectively. In general, the low rate of CSA practices adoption observed in this study indicates that the extension service delivery system and traditional farming systems are not integrating the environmentally friendly practices like that of climate smart agricultural practices. This is a threat to environmental sustainability and requires special managerial and technical attention to put maximum effort that will enable the integration of CSA practices into farming systems.

6.3 Resource Holding in Context of CSA Practices Adoption

The land holding of the survey households is among the resources emphasized in this study to ascertain whether there are potential impacts on CSA practices adoption as the result of the resources owned by households. The survey result is summarized in Table 6.7 in relation to CSA practices adoption. According to the survey data result, majority of the respondents (43.5 percent) for highlands and (37.2 percent) for lowlanders conduct the farming practices on the farm size that ranged between less than 1 and 1.5 hectares of plots. The farmers conducting farming practices on a farm size that is lesser than 1 hectare constitute is 33 percent of the respondents for highlands and 24.8 percent of the respondents for lowland agro-ecology. Similarly, of the total respondents, 10.5 percent of highlanders and 23.8 percent of the lowlanders cultivate their crops on farm sizes of above 3ha hectares of farmlands.

Generally, about 59.8 percent of the total respondents from highland and lowland carry out their crops farming on a plot size that is above national and regional land holding of 1.5ha farmland. Largely, the data generated from this study (Table 6.7) shows that farming practices in the study area is on a small-scale level which is practiced by smallholder farmers and susceptible to climate change related risks, because many study reveals that small-scale farmers are always among the community constrained with limited resources to purchase and use promising innovation in the community contexts as compared to resourceful farmers.

Table 6.7: Respondents' Farmland Holdings in Relation to CSA Practices Adoption (N= 410)

Farm size categories	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Less than 1ha	41	10	24.4	31	75.6	22	10	45.5	12	54.5
1.1-2ha	89	24	27.0	65	73.0	94	35	37.2	59	62.8
2.1-3ha	49	22	44.9	27	55.1	44	12	27.3	32	72.7
3.1-4ha	11	6	54.5	5	45.5	23	8	34.8	15	65.2
4.1-5ha	7	7	100.0	0	0.0	13	6	46.2	7	53.8
Above 5ha	2	2	100.0	0	0.0	14	2	14.3	12	85.7
Total	**199**	**71**	**35.7**	**128**	**64.3**	**210**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

As to CSA practice adoption, when the respondents within land holding range of less than 1ha category is considered, lowlanders (45.5 percent) are better adopters as compared to the represented respondents in highland (24.4 percent) although both are below the average rate of adoption. In similar manner, in the case of respondents who have land holding of between 1ha and 2ha, again the lowland respondents are ranked better adopters (37.2 percent) of CSA practices when compared with 27 percent of highlanders' rate of adoption. In contrast to that, the highlanders within the land holding category of 2.1-3ha are better adopters (about 45 percent), while less proportion (about 27 percent) of the lowland respondents are identified as adopters in the same land resources holding category of the farmers.

Likewise, among the 3.1-4ha farmland holders of the highland respondents, comparatively majority (54.5 percent) adopted the CSA practices, while out of total respondents represented in lowland community, less proportion (34.8 percent) is identified as the CSA practices adopters which can be considered lower when compare with highland adoption situation. According to the data summarized in Table 6.8, overall, the majority of the respondents represented in highlands (66 percent) and lowlanders (71.5 percent) are found within the livestock holding category of 11-50 heads of animals, while the second majority is respondents within the livestock holding category of less than 10 animal heads, thus attracting 30.5 percent for highlands and 21.5 percent for lowland.

Table 6.8: Respondents' Livestock Holdings in Relation to CSA Practices Adoption (N= 410)

Livestock holding categories	**Highland Agro-ecology**					**lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Less than 10 heads	61	9	14.8	52	85.2	27	7	25.9	20	74.1
11-20 heads	85	43	50.6	42	49.4	45	14	31.1	31	68.9
21-30 heads	38	12	31.6	26	68.4	54	20	37.0	34	63.0
31-40 heads	5	2	40.0	3	60.0	40	17	42.5	23	57.5
41-50 heads	4	2	50.0	2	50.0	22	10	45.5	12	54.5
Above 50 heads	6	2	33.3	4	66.7	21	5	23.8	16	76.2
Total	**199**	**71**	**35.2**	**128**	**64.8**	**209**	**73**	**34.9**	**136**	**65.1**

Source: Compiled from Survey Data (2020)

Generally, these findings indicate that there is higher livestock population in the lowland agro-ecology than the highland. Thus, this shows a threatening situation since livestock is the source of methane which can aggravate climate change impacts in the lowland community, underpinning a distinct contrast with highland agro-ecology. In the meantime, as illustrated in Table 6.8, there exists a similarity regarding the overall rate of CSA practices adoption within lowland agro-ecology (about 34.9 percent) and highland community adoption rate (35.2 percent) in the survey community.

Thus, the survey shows that both the highland and lowland farmers expend less effort and commitment to integrate climate change adaptation and mitigation strategies into farming system in order to compensate the negative environmental consequence which can be compounded because of high livestock population in the community. More importantly, the identified rate of CSA practices adoption in both agro-ecology (lowland and highland farming community) is by far below average (below 50 percent) and below expectation. This noted fact signifies the policy and strategic level to focus on, and where attention should be direct to make the CSA practices an integral part of the farming system.

More specifically, the livestock holders who fell within the group of those with 11-20 animal heads, were more adopters of CSA practices (50.6 percent) in the highland farming community, while the lowest (31.1 percent) rate of CSA practices adoption identified in the case of lowland community. On the contrary, in the livestock holding category of 21-30 heads, it was discovered that lowlanders were better adopters as compared to the highland farming community (Table 6.8).

In summary, the variation in respective of CSA practices adoption in relation to livestock holding was found insignificant between the two study community (highland and lowland farming community), indicating less influence of livestock stock holding variation on CSA practices adoption. Pertaining to household income, the conducted household survey results reveal that the average household income across all households is 93,775.7 Eth birr per annum, while the minimum income is noticeably found to be 2600 birr and the maximum reported income for high income households is 744,000 birr showing a large difference between low and high income family in the survey households for highland agro-ecology (Appendix 5).

According to the survey data, out of the total average income, the larger proportion (89.3 percent) is the income from the agricultural sources, while the remaining which is about 11 percent is from non-agricultural sources. Similarly, the average income for lowland households is 92,689 birr with a minimum income of 2200 birr showing a close similarity with highland agro-ecology. The maximum income of lowland community is 950,000 birr for high income household, and is significantly higher than the highland area households' high income family, showing about 28 percent above highland area high income family (Appendix 5). On the other hand, the lowest standard deviation of 93660 birr is identified in highland areas, compared with 143,287-birr standard deviation of lowland family, proving high income variability among the smallholder farmers of the lowland agro-ecology.

As indicated above, there are significantly larger income differences between high income and low income family in two study community and this larger difference is also confirmed by the standard deviation for highland and lowland, which is almost closer to average for highland and above average income of the households' income per year for lowland farming community. According to many studies, climate change vulnerability is the negative effect resulting from the combination of different factors and can be influenced by many more variables. One of these variables is the source of income, and it is one and the most important determinant to investigate the level of climate change impacts on the community livelihoods. Households' source of income diversification is significantly important, for it helps to cope with natural disaster including the climate change impact adaptation.

Table 6.9: Respondents' Average Total Income in Relation to CSA Practices Adoption (N= 410)

Total income categories	**Highland Agro-ecology**					**lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Less than 50,000birra	78	12	15.4	66	84.6	109	25	22.9	84	77.1
50,001-100,000birr	59	23	39.0	36	61.0	52	17	32.7	35	67.3
1000001-150000birr	28	13	46.4	15	53.6	15	11	73.3	4	26.7
150,001-200,000birr	14	8	57.1	6	42.9	12	9	75.0	3	25.0
200,001-250,000birr	4	3	75.0	1	25.0	8	2	25.0	6	75.0
250,001-300,000birr	9	8	88.9	1	11.1	5	3	75.0	1	25.0
Above 300,000birr	8	4	50.0	4	50.0	9	4	50.0	4	50.0
Total	**200**	**71**	**35.5**	**129**	**64.5**	**210**	**71**	**34.1**	**137**	**65.9**

Source: Compiled from Survey Data (2020)

Based on the empirical evidences concerning the susceptibility of natural resource related source of income (including agriculture which is heavily dependent on natural environment) and positive impact of the nonagricultural income source on the livelihoods of the households, aggregated family income has been broken down into two major sources of income; they are agriculture related income and non-agriculture source of income for survey households. The survey data shows that an average income of household that is from non-agriculture source is 7,053 birr for highland area households and 10,556 birr for lowland: 7.5 percent and 11.4 percent of total income, respectively, shows the dominance of agriculture impact in the family income. Thus, this result shows that the probability of the survey community to be vulnerable to natural shock including climate change is high regardless of a better situation at lowland agro-ecology compared with highland area households. As indicated in the above Table 6.9 above, the analyzed survey data shows that the majority of the respondents (68.5 percent) earn 100,000 and less per annum at highland areas, while reasonably, majority (76.7 percent) of lowland area farmers are earning within the same range of household incomes per annum. On the basis of the seasonal income of the survey households, the proportion of the family with better earnings, who are earning more than 300,000 birr, is 4 percent and 4.8 percent for highland and lowland agro-ecology, respectively. Consequently, the great majority of the households mentioned above that are earning below average per annum are among the low earning community member, and as such highly vulnerable to climate change.

Regarding to CSA practices adoption, the majority (84.6 percent) of low income family (those earning less than 50,000 birr) found non-adopters, while only 16 percent are adopters in context of highland agro-ecology. Contrarily, in almost all majorities of high earning categories of the respondents (above 150,000birr earners), the proportion of CSA practices and technology adopters significantly high in similar highland agro-ecology as compared to low earning categories of the respondents. Likewise, as one can realize from the Table 6.9, similar trend of CSA practices adoption has identified in context of lowland community and farming system; where for instance, the majority (77.1 percent) of low earning respondents found non-adopters.

On the other hand, households' source of income diversification which is significantly important because it facilitates the capacity to cope with natural disaster which includes the climate changes impacts and related shocks. Moreover, climate change impact adaptation is predominantly determined by livelihoods diversification, which are the agricultural and non-agriculture related livelihoods diversification; consequently, households' income sources. Based on the empirical evidences concerning the susceptibility of natural resource related income (agricultural income which is heavily dependent on natural environment) and significant positive aspect of the non-agricultural income source on the livelihoods of the households, aggregated family income source of the survey community bifurcated into two major sources of income that are agriculture related income and nonagricultural source of income: of which with especial emphasize the non-agriculture income source is summarize in Table 6.10 below and presented in subsequent section.

Table 6.10: Respondents' Non-Agriculture Source of Income in Relation to CSA Practices Adoption (N= 410)

Total non-agriculture income size categories	**Highland Agro-ecology**					**lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
No non agric income	137	48	35.0	89	65.0	137	31	22.6	106	77.4
Less than 10,000birra	24	9	37.5	15	62.5	30	17	56.7	13	43.3
10,001-20,000birr	13	4	30.8	9	69.2	11	1	9.1	10	90.9
20,0001-30,000birr	8	1	12.5	7	87.5	7	7	100	0	0.0
30,001-40,000birr	10	5	50.0	5	50.0	6	6	100	0	0.0
40,001-50,000birr	3	1	33.3	2	66.7	1	1	100	0	0.0
Above 50,000birr	5	3	60.0	2	40.0	16	8	50.0	8	50.0
Total	**200**	**71**	**35.0**	**129**	**64.5**	**208**	**71**	**34.1**	**137**	**65.9**

Source: Compiled from Survey Data (2020)

According to the result summarized above, the respondents are within the income category of food insecurity group in the context of non-agriculture income source as the result of low income to cover food demand for households' seasonal consumption to maintain required energy to survive and produces. In the case of non-agriculture income, Table 6.10 above illustrates this, where the majority (68.5 percent) of the respondents in the highland farming community reported that they had no non-agriculture source of income. Concerning lowland agro-ecology, a similar number of respondents (about 65.2 percent) were found without non-agriculture source of income for the households' seasonal consumption. Subsequently, this evidence shows that in both cases (Highland and lowland) the probability of the community to be vulnerable to climate change is significant and demands the need to revisit income diversification aspect of the strategies to address the gaps and limitations in the farming community related to households' income. In contrast, the high income earners in non-agriculture groups (above 40,000birr) in both areas are minimal, that is 9 percent in highland and about 11 percent for lowlanders, which indirectly shows inadequate non-agricultural income diversification in the farming community.

Predominantly, the proportion of non-adopters is high in low non-agriculture earning community in two agro-ecologies of the study, which for instance demonstrated by 65 percent and 77 percent for highland and lowland agro-ecology, respectively, while in the case of high earners (who earn above 50,000birr non-agriculture income), the majority found adopters of the CSA practices. Similarly, in context of the second majority of low earners (earn less than 10,000birr), the majority (56.7 percent) of the respondents found adopters of the CSA practices in lowland farming community, while in contrary, low proportion (37.5 percent) of highland respondents found adopters of CSA practices. In summary, in the context of medium earners (who earns between 10,001-50,000birr), the majority of highland respondents found non-adopters, while the majority of the lowland respondents who are the earners of medium income category found adopters (Table 6.10). Regarding livelihood diversification, predominantly, agriculture related livelihoods are taking leading role in both highland and lowland agro-ecology of the study. Its practicality vividly exposes the vulnerability of these two farming communities to climate change impacts and risks. Simultaneously, the identified inadequate livelihood diversification beyond agriculture authenticates the urgent need for adequate policy or strategy that helps to focus on non-agriculture in come diversification as a viable source of complementing farming to ensure livelihoods sustainability and food security.

Table 6.11: Respondents' Wealth Status in Relation to CSA Practices Adoption (N= 410)

Wealth category of the respondents	**Highland Agro-ecology**					**lowland Agro-ecology**				
	Total	Adopters		Non-adopters		Total	Adopters		Non-adopters	
		Frequency	%	Frequency	%		Frequency	%	Frequency	%
Wealthy group	58	34	58.6	24	41.4	24	12	50.0	12	50.0
Medium group	53	19	35.8	34	64.2	87	39	44.8	48	55.2
Resource limited	89	18	20.2	71	79.8	99	22	22.2	77	77.8
Total	**200**	**71**	**35.5**	**129**	**64.5**	**210**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

According to data presented in Table 6.11, wealth category classification shows that 44.5 percent are in low-income wealth category, while 26 percent individualized those in medium, and wealthy category attracted 29 percent, for highland agro-ecology respondents. Oppositely, whereas 47.2 percent singularized low income earners, 41.4 percent marked out the medium group, and 11.4 percent singled out the wealthy category for lowland farming community. Furthermore, the impression of most focus group discussion (FGD) and key informant interview (KII) which includes the extension field staffs shows that the majority of the communities participating in the development programs are amongst the very low- and low-income categories of the community members. The meager income explains the reason they do not have sufficient food and their food security is at risk; their socioeconomic situation is further worsened because of the natural hazards among which climate change is a major catastrophe affecting the community in general and households' livelihoods. In addition, the survey data shows that about half of the survey Households in the PAs fall within the poor wealth category which is logical proof of the community vulnerability to natural disasters, particularly, climate change and linked consequences.

With regard to adoption of CSA practices, in general term, the majority of the farmers within the low-income category and resource limited wealth category are notable non-adopters in both communities (highland and lowland) in context of study community. The identified neglecting situation explains a significant impact of households' seasonal income on the adoption rate of CSA practices by farmers under study community contexts. This in turn discloses the necessity for additional financial sources for the farmers to supplement the households' effort by resolving the financial constraints which limits the communities' capacity to purchase and use the technologies. Obviously, as shown in the Tables above, the majority who are identified within the wealth status of medium and resource limited categories found to be below average (less than 50 percent) CSA practices adopters as compared to non-adopters. Thus, from the examination conducted, it was shown that income constituted a major constraint of the communities' inability to adopt the introduced technologies and innovations in the community, hence livelihood diversification is paramount.

6.4 Institutional Facilities and Support in Context of CSA Practices Adoption

(i) Extension Infrastructure Facilities and accessibility

In the context of Ethiopian extension service delivery system, before launching the Participatory Demonstration and Training Extension System (PADETES) approach in the country, through national extension package program, the extension service in the study area and elsewhere in the country was limited to some pocket areas focusing on potentially productive crops using the very limited number of development agents (Gerishu and Mvena, 2007). However, this approach changed dramatically, and currently, there are minimum three (3) development Agents (DAs), stationed in development centers which established in each Peasant Associations in the country in general and in Oromia region in particular, including the study communities. In the circumstance of extension service framework, the integration of technology adoption, adoption sustainability, adaptation, and mitigation strategies into the farming system of the community is all about the behavioural change of the farm households which is fundamentally based on the quality of services, accessibility of infrastructures, availability of the appropriate Technologies and comparatively better performance of the introduced innovations in the context of ground level problems.

Based on this conceptual argument, structured interview questions were arranged for respondents and their views were analyzed in order to evaluate the level of adequacy and adaptive capacity of the extension service delivery system in Oromia region in general and in the study community in particular. Regarding system level services, agricultural extension service is one of the services provided by public institutions in the local area to promote agricultural and environmental technologies amongst the farmers (Haji, 2002). In this regard, in the study's regional state, the concerned institution for agricultural extension, which during survey period Bureau of Agricultural and Natural Resource (BoANR), has established the extension structure up to grass root level, which is development centers (DC), where the development agents (DAs) are responsible for the provision of extension services to clients in that particular area. According to the result of secondary data review from BoANR, one DC is established in each PA with an attempt of reducing DAs to farmers' ratio to increase the frequency of DAs to farmers contact per month, which ultimately enhances institutional support performance. Accordingly, in this study, appropriate survey tools were designed and employed to collect related data to assess the institutional support availed to study community including its efficiency. The main statistical analyses applied in this study for this section were descriptive statistics in perspective of CSA practices adoption decision. The results of the conducted survey to determine the nature of institutional adequacy and support of service delivery system were summarized in different forms to illustrate the existing condition in relation to climate change adaptation service provision, where the results related to these aspects are summarized and presented in different tables shown below.

Details of the respondent's farmland distance from different public support giving service, specifically road facility and FTC were summarized and presented in Tables 6.12a and b below, respectively. It was realized from different adoption studies that farmland distance from the residence of the respondents and its distance from different public services like development centers (DC) and primary road (s) significantly affect the rate of technology adoption. This study also confirms the same relationship between adoption and distance of farmland from the mentioned public service centers and residence of the households. According to household survey findings, overwhelming majority, which is about 82 percent of the farmland, is found within the distance of 5km from major road in the lowland agro-ecology, while it is 25 percent in the case of highland sample households (Table 6.12a). Accordingly, the majority (75 percent) of the highland household farmland distance from the major road was notably above 5km, indicating comparatively better road access for lowland community as compared to highland farm households.

As shown in Table 6.12a below, out of the total respondents of the lowland community, 56.8 percent whose location of farmland is less than 1km from major roads were found to constitute CSA practices adopters, against 43.2 percent non-adopters, while in the remaining more distances above 5km favored the non-adopters indicating better adoption rate in more road accessed households in the context of study community. Arguably, the situation found reverse in highland farming system and community, where the minority (16.7 percent) of the same farmland distance category respondents found adopters against dominant non-adopters in the study community of highland. Specifically, farmers constitute 50 percent in lowland, 83.3 percent in highland; of the total respondents having farmland in 1-2km distance category from road facility were adopted introduced CSA practices, against 50 percent and 16.7 percent of non-adopters, in lowland and highland agro-ecology, respectively. Similarly, about 16 percent in lowland and 58.8 percent in highland from the category with farmland located more than 2.1-3km distance from primary road were adopters, against about 84 percent and 41.2 percent non-adopters in the lowland and highland farming community, respectively.

Table 6.12a: Major Road accessibility to Farmland in Respective to Adoption (N =410)

No	Distance categories	Lowland agro-ecology				Highland agro-ecology			
		Adopters		Non-adopters		Adopters		Non-adopters	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	Less than 1km	21	56.8	16	43.2	2	16.7	10	83.3
2	1-2km	26	50.0	26	50.0	10	83.3	2	16.7
3	2.1-3.0km	7	15.9	37	84.1	10	58.8	7	41.2
4	3.1-4.0km	7	77.8	2	22.2	4	66.7	2	33.3
5	4.1-5.0km	2	6.7	28	93.3	1	33.3	2	66.7
6	Above 5.0km	12	31.6	26	68.4	42	28.0	108	72.0
	Total	**75**	**35.7**	**135**	**64.3**	**69**	**34.5**	**131**	**65.5**

Source: Compiled from Survey Data (2020)

On the other hand, of the respondents having farmland within the distance of above 5km from primary major road, the majority (68.4 percent) of lowland represented farmers found non-adopters, whereas in similar minor the majority (72 percent) of highland respondents are non-adopters, against 31.6 percent and 28 percent adopters in lowland and highland agro-ecology, respectively. In generalized term, better accessibility to major road facility found in favor of CSA practices adoption as compared to those in accessible to primary roads in context of this study finding.

Equally, the distance of Farmers Training Centers (FTCs) was analyzed against CSA practices adoption and the results has presented in Table 6.12b below. Accordingly, it has realized that almost all the households (90.7 percent) of highland and (82.3 percent) of lowland sample households found having the farmland within the distance of 5km appropriate from Farmers Training Centers (FCTs) in the study community (Table 6.12b), indicating only few farmers are actively involved in the farm activities on the farms that are far away for more than 5km from Farmers Training centers. In the context of sample households whose their farmland distance from FCTs is less than 1km, the majority of about 69.4 percent were identified CSA practices non-adopters, while only as few 30.4 percent found adopters in the lowland agro-ecology of the study. Whereas, 52.6 percent were found adopters of CSA practices in the highland agro-ecology, despite having less than 1kms distance between their farmlands and FTCs, while the remaining 47.4 percent are non-adopters. Similarly, 46.2 percent of the total lowland samples households having farmland within 1-2km walking distance from FCTs were aware of CSA practices and adopters of the practices; 53.8 percent were non adopters as indicated in Table 6.12b below. In the same FTCs distance from farmland, the majority of 74 percent of highland respondents identified non-adopters of CSA practices, while only as few 26 percent found adopters.

Table 6.12b: Distance of Farmland from FTCs in Km in Respective to Adoption (N= 410)

No	Distance categories	Lowland agro-ecology				highland agro-ecology			
		Adopters		Non-adopters		Adopters		Non-adopters	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	Less than 1km	7	30.4	16	69.6	10	52.6	9	47.4
2	1-2km	30	46.2	35	53.8	25	26.0	71	74.0
3	2.1-3.0km	16	43.2	21	56.8	14	43.8	18	56.2
4	3.1-4.0km	0	0.0	9	100.0	7	41.2	10	58.8
5	4.1-5.0km	14	37.8	23	62.2	3	15.0	17	85.0
6	Above 5.0km	7	18.9	30	81.1	8	42.1	11	57.9
	Total	**75**	**35.7**	**135**	**64.3**	**67**	**33.5**	**133**	**66.5**

Source: Compiled from Survey Data (2020)

In the distance category of 2.1-3km between Farmers Training Centers (FTCs) and farmlands, the highest proportion (56.8 percent) of respondents are identified as non-adopters of CSA practices in respective of lowland farming community, while 43.2 percent are adopters. Similarly, 56.2 percent of highland households having 2.1-3km found adopters of CSA practices in highland agro-ecology, where 43.8 percent adopters of the same practices. In the case of farmers doing farm practices on the farmland located within the distance of 4.1-5km from FTCs, the significant majority of 62.2 percent of lowland and 85 percent of highland respondents recognized non-adopters, against 37.8 percent and 15 percent adopters, respectively in the study community. In summarized manner, according to the findings of this study, the majority of the farmers having farmland within the distance of above 5km are notably identified as non-adopters of CSA practices, indicating negative relationship of FTCs distance and CSA practices adoption. Regarding to adoption, EEA (2006) argued that one of the reasons for the low rate of adopters can be attributed to inadequate or in accessibility of infrastructure, which is in line with the findings of this current research.

(ii) Credit Facility and Farmers Access to Financial Support

The review of different literature confirms that financial accessibility to farming community would influence agricultural technology transfers which will ultimately have impact on the productivity of the farmlands and particular crop. Based on this reality the accessibility of farmers to financial sources in the form of credit was investigated in this study and the results of the survey are compiled in Table 6.13a and b below showing credit accessibility and source of credit for farmers with emphasis on the climate change coping and adaptation strategies adoption, respectively. The results of the survey data concerning financial accessibility to farming community shows that about 62.5 percent of all respondents have had accessibility to credit facility in the past cropping seasons to support regular livelihood practices, out of which 46.4 percent and 53.6 percent are adopters and non-adopters, respectively in the highland agro-ecology. Likewise, out of the total respondents represented from the lowland agro-ecology, about 52.9 percent have had access to credit facilities for similar purposes, from this percentage, 47.7 percent are adopters of the CSA practices, while 52.3 percent are not, showing a slight decrease as compared to the situation highlighted in the context of the highland community and households.

Whereas, of total respondents not accessible to livelihoods practices supporting credit, only as few 17.3 percent are identified adopters of CSA practices, against the majority of 82.7 percent non-adopters in the highland farming community, while 20.2 percent and 79.8 percent found adopters and non-adopters, respectively in the context of lowland community. Regarding to climate change adaptation related credit support, of total respondents in these study agro-ecology 75.5 percent and 49 percent are among the farmers with adequate access to credit facilities in highland and lowland, respectively, while the rest which constitutes the 25.5 percent and 51 percent said they had no access to credit sources for the climate change adaption strategies supports and management (Table 6.13a).

According to the survey results, out of total farmers who had access to credit for the support of climate change adaptation strategies in highland agro-ecology, only 46.4 percent were adopters of CSA practices, introduced in the study area in the past extension package and/or SWC related project implementation years, while 53.6 percent non-adopters. Moreover, of total 49 farmers who had no access to climate change adaptation strategy support credit, 26.5 percent are adopters, while the remaining majority of 73.5 percent of the farmers were non-adopters in the highland farming community. On the other hand, of total 71 adopters in highland agro-ecology, 81.7 percent identified to have access to credit support for climate change management, while 18.3 percent have no similar financial access. In summary, in the highland agro-ecology, in all criterion based categorization, the proportion of the non-adopters was found to be significantly higher as compared to the adopters' proportion in the same agro-ecology of the study community and the households.

Similarly, of total farmers who had access to credit for the support of the climate change adaptation strategies implementation, only 38.4 adopted CSA practices, while the remaining majority of 61.6 percent are non-adopters, although had similar access to credit in the lowland farming community. In the lowland agro-ecology, the proportion of the non-adopters was significantly higher (65.2 percent) when compared with adopters' proportion (34.8 percent) in the same agro-ecology when evaluated in perspective of credit support for climate change management. However, of total lowland adopter only 75.3 percent had sufficient access to credit support for climate change management, while the rest 24.7 percent stated that they had no access to credit. In context of lowland non-adopters, 65 percent of the respondents reported no credit related financial access, while only 35 percent explained positive access to climate change adaptation support credit, thus, indicating a grave shortage of the credit support for CSA practices non-adopters farmers in the study community (Table 6.13a).

Table 6.13a: Accessibility of Credit in Respective to CSA Practices Adoption (N=410)

List of accessibility indicators	Highland agro-ecology				Lowland agro-ecology			
	Adopters		Non-adopters		Adopters		Non-adopters	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Livelihoods support								
Accessible	58	46.4	67	53.6	53	47.7	58	52.3
Not Accessible	13	17.3	62	82.7	20	20.2	79	79.8
Total	**71**	**35.5**	**129**	**64.5**	**73**	**34.8**	**137**	**65.2**
Climate change adaptation support								
Accessible	58	38.4	93	61.6	55	53.4	48	46.6
Not Accessible	13	26.5	36	73.5	18	16.8	89	83.2
Total	**71**	35.5	**129**	64.5	**73**	34.8	**137**	65.2

Source: Compiled from Survey Data (2020)

In addition to the accessibility of credit facilities and supports, the importance of the roles of different sources of credits are assessed and presented in Table 6.13b shown below. In Ethiopia in general, and Oromia region in particular, there are four major sources of credit when traditional source of credit is included. Accordingly, this research focuses on these four sources of credits currently available in the country and the investigation is conducted based on the below stated categories of the credit sources. The first is private formal source of credit, commonly known as the micro-finance, and it ranked highest (303 score) with an equivalent 50.5 percent in respective of highland and 380, equaling 60.3 percent in context of lowland farming community of the study. The second one is traditional non-formal source of credit, accorded the 2nd position in the ranking of the sources of credit facilities. However, the examination of the overall rating of the importance and roles of the credits regarding CSA practices adoption is below average and expectation. In this regard, the highlanders scored overall average of 197 score (32.8 percent), while the lowlanders had scored 289 (45.8 percent), which comparatively lower in highland context as compared to lowland. Thus, this signifies a significant limitation of credit availability and accessibility for CSA strategies promotions and supports. In this regard, the below presented Table 6.13b is a synopsis of the analytical evaluation in respective of source of credit.

Table 6.13b: Source of Credit and Rating in Relation to Current Role in CSA Practices Adoption (N=410)

Category of the Source of credit	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
Private Formal (Micro-finance)	117	162	24	303	50.5	234	124	22	380	60.3
Non-formal credit source	45	78	82	205	34.2	117	112	74	303	48.1
Formal credit source (Banks)	78	52	40	170	28.3	96	112	60	268	42.5
NGOs credit services	24	46	39	109	18.2	72	68	64	204	32.4
Average				**197**	**32.8**				**289**	**45.8**

Note: High (3), Medium (2), Low (1) and Negligible (0), where 0 exclude from the Table (**Source:** Survey Data, 2020)

In generalized statement concerning lowlanders' situation, as indicated above in Table 6.13b, the current role and influence of different credit sources on CSA practices adoption were assessed, where private formal credit scored 380 (60.3 percent), non-formal credit scored 303 (48.1 percent) and formal credits from formal Banks scored 268 (42.5 percent), which are first, second and third, respectively. Just as this current study examines the influence of credit on the adoption of CSA practices and technology, various studies have also presented their findings. For instance, Jugal (1992) cited in Gerishu B. and Mvena Z. A. (2007), posited that availability of credit facilities facilitates the adoption process of improved technologies due to the fact that credit enables smallholder farmers to meet their needs regarding the use of improved technologies.

Similarly, Sebsibe (1999) who conducted research on maize technology adoption in Awassa District (Ethiopia), asserted that the provision of credit functioned as the highest predictor of adoption of improved maize varieties, which significantly support the results of this study (ibid). In this aspect, the finding of this study is relatively closer, but slightly higher when compared to 33 percent rate of adoption reported by Haji (2002) who observed in context of farmers' groups with adequate accessibility to credit related financial sources.

(iii) Communication Media Accessibility in Respective of CSA Practices Adoption

This segment deals with the communication of information in context of extension information delivery system. Mass media are the most common extension channel that can quickly and easily reach out even to the extremely remote areas of the country, and helpful in divulging information to majority of rural population within short time. The importance and influence of the media cannot be downplayed. This work evaluated the significance of mass media in the study area, and it was confirmed that the radio and television played significant roles in technology promotion. Nonetheless, the impact is not as high as expected in order to cope with the fasting moving climate change impacts scenario. According to the survey results, majority of the respondents which are 90 percent from the highland and 66.2 percent from the lowland are residing within a walking distance of about two hours from the nearest communication stations. Likewise, some of the respondents said it will take a walking distance of about four hours or more to get to the communication stations; nevertheless, the proportion of these respondents is negligible in both cases (highland and lowland) in context of study community. Thus, the eventual result shows that the communities represented by the respondents have better opportunity to access the required information. Subsequently, the survey results reveal that a significant number of farmers (93 percent) represented highland community had access to mass media, a helpful channel that can help in the adoption of climate change mitigation and adaptation strategies. Although the majority of respondents have access to locally available mass media in the past cropping years, of total respondents have adequate accessibility to mass media, only 34.4 percent of highland community represented respondents found adopters of CSA practices, while 65.6 percent are non-adopters, indicating below expected influence of mass media on CSA strategic practices adoption in the framework of the study community.

Table 6.14a: Accessibility of Mass Media in Respective to CSA Practices Adoption ((N=410)

Mass media Service indicators	**Highland agro-ecology**				**Lowland agro-ecology**			
	Adopters		None adopters		Adopters		None adopters	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Accessible	64	34.4	122	65.6	70	39.5	107	60.5
Not Accessible	7	50.0	7	50.0	3	9.1	30	90.9
Total	**71**	**35.5**	**129**	**64.5**	**73**	**34.8**	**137**	**65.2**

Source: Compiled from Survey Data (2020)

Regarding to lowland agro-ecology, 60.5 percent of the respondents did not adopt the CSA strategic practices, even though they had adequate access to mass media. Furthermore, out of the total farmers who had access to mass media (which commonly is radio and TV, only 70 respondents (39.5 percent) in the lowland area were asserted to be adopters of CSA strategic practices to sustain agricultural land productivity in order to support households' livelihoods. In addition, out of the total farmers who did stated no access to any kind of mass media, 7 farmers (50 percent) in the highland agro-ecology and 30 farmers (90 percent) in lowland agro-ecology, were found to be non-adopters of CSA strategic practices, which imply significant drawback of mass media inaccessibility in context of lowland community (Table 6.14a).On the other hand, the mass media's effort was assessed to ascertain the level of adequacy in order to rate the effort of the mass media service delivery as institutions and systems. Equally, this study evaluated the strategic focus of the mass media regarding the integration of Climate change mitigation and adaptation strategies promotion and publicity in order to influence its adoption and sustainability in the farming community. Accordingly, the summary of assessment presented in Table 6.14b, where the survey results indicate a better attention and focus of the mass media in promoting climate change mitigation and adaptation strategies, by making it a regular program. However, as indicated in Table 6.14b below, only a few respondents (10.5 percent) of highlanders and lowlanders separately evaluated mass media effort adequacy as very high level, while 36 percent and 51.4 percent of highland and lowland represented respondents, respectively perceived mass media effort only as adequate in the course of CSA practices promotion.

Table 6.14b: Perceived Overall Mass Media Effort Adequacy in CSA Practices Promotion to Influence Adoption (N=410)

No	**Rating level categories**	**Highland agro-ecology**		**Lowland agro-ecology**	
		Frequency	%	Frequency	%
1	Very adequate	21	10.5	22	10.5
2	Adequate	72	36.0	108	51.4
3	Moderate	97	48.5	77	36.7
4	Negligible	10	5.0	3	1.4
	Total	**200**	**100.0**	**210**	**100.0**

Source: Compiled from Survey Data (2020)

Furthermore, in summary manner, about 46.5 percent from the highland and 61.5 percent from the lowland community rated the service of the mass media adequate and above (adequate and very adequate) in the context of respondents perception. As highlighted in extant studies, mass media efforts required outsmarting the traditional level (regular approaches) of integration, considering the fact that the impacts of climate change are speedily than the implementation speed of the strategies. However, as perceived from the results presented in the tables above and from the explanation related to the findings, all aspects of the mass media evaluated are found to be about average and below average in most aspects and indicators. Following these, this signifies that it is needful to redesign and review the approaches and procedures in order to adequately address the challenges related to CSA practices adoption and adaptation of strategies that can check the impacts of Climate change in the study areas, Oromia region in general and highland of Arsi and lowland of East Shewa Zones, in particular.

6.5 Perceived Effectiveness of Extension System in CSA Practice Promotion and Adoption

In addition to household level farmers' interviews managed by interviewers, self-administered questionnaire was developed and distributed to more than 200 government extension field staff members working in government institutions that have stake and responsibility in the process of CSA strategic practices promotion and implementation. However, among the total questionnaire distributed only 140 copies were properly managed and retrieved for analysis and presentation. The main reasons were COVID-19 outbreaks which led to nationwide lockdown of government offices and regular office works and the second was because of the individual's negligence to address the questions in the questionnaire properly and adequately with full responsibility. Based on the data collected from government staffs who are working at different structural (Regional level to FTCs level), out of which regional level staff accounts for 10 percent, zonal level staff, 32.2 percent, district level staff, 46.4 percent and TFCs level staff accounts for about 11.4 percent of the respondents.

The result was summarized and presented in the Tables 6.15a, b and c in respective of selected indicators for assessment of CSA practices effectiveness and efficiency in the farming system. Additionally, under this sub-heading system level weakness related to extension service in the context of climate change management as well institutional level adoption and sustainability success rating, including the major constraints that contributed to the setback of the expected success were managed and explained. The professional composition of the staffs who participated in the survey is dominated by the agriculturalist with 57 percent, followed by natural resource, 23.6 percent and environmentalist accounts for only about 3 percent. The professionals who are not agricultural structures staffs are about 16.4 percent of the sampled staff and are included in the interview of self-administered questionnaire. Basically, all CSA practices and strategies included in the farmers' questionnaire were included in the staff's self-administered questionnaire, but only six CSA practices were found atop the others, adopted by farmers.

According to the data shown in Table 6.15a, crop rotation was effective and efficient, with a score of 325 (77.4 percent), affording it the first position, while inter-cropping and minimum tillage practices were rated 2nd and 3rd respectively, among the selected six CSA practices. However, the result of the score evinced that almost all CSA practices were effective and efficient, for all were not far above the average; despite that, these are not encouraging when compared with the strategic goal of the institution. The objective of the Agricultural Bureau establishment is to attain more than 90 percent effectiveness and efficiency in all agriculture related strategic objective, among which technology adoption and sustainability is first and top priority for agricultural productivity improvement and sustainable production.

Table 6.15a: The Effectiveness and Efficiency of CSA Practices as Suggested by Staff Members (N=140)

No	List of CSA practices	Total Score for each CSA practices					Rank
		Good (3)	Medium (2)	Poor (1)	Total	%	
1	Minimum Tillage	72	156	64	292	69.5	3rd
2	Crop Rotation	198	106	21	325	77.4	1st
3	Inter cropping	156	104	36	296	70.5	2nd
4	Crops residue management	135	98	46	279	64.4	5th
5	Climate change adaptable crops varieties	117	134	34	285	67.9	4th
6	Crops and livestock insurance	63	80	79	222	52.9	6th
	Average				**283**	**67.4**	

Note: Percentage has calculated from total highest (420) score. (**Source:** Survey Data, 2020)

On the other hand, a similar approach was employed to assess the institution's success in influencing the CSA practices adoption and sustainability regarding these practices evaluated above to identify their effectiveness and efficiency in the extension service delivery system by extension field staffs. To that effect, Table 6.15b presents the summary of the success score of extension service delivery system. Accordingly, the summary of the institution's success indicates that extension service delivery system has been successful in crop residue management with success score of 287 (68.3 percent), whereas crop rotation and climate change adaptable crop variety adoption come 2nd and 3rd respectively as shown in Table 6.15b below. In a similar manner, the argument is how significant is the effect rather than the ranking, and what is the magnitude of the influence. To that end, the examination showed that the institution's success was below expectation; this performance contradicts the postulated benchmarks indicated in the extension strategic plans and objectives, which is to attain the highest level of achievement in all components of the extension services and its outcomes. Subsequently, this study submits that the success score of CSA practices adoption indicated by the government structures staffs is completely below the required level when compared with the aggressive situation of climate change impacts and related consequences in the study community and beyond.

Table 6.15b: Institutional Success Rating in CSA Practice Adoption as Suggested by Extension Staffs (N=140)

No	List of CSA practices	Perceived success Score for CSA practices adoption					Rank
		High (3)	Moderate (2)	Low (1)	Total	%	
1	Minimum Tillage	48	56	81	185	44.1	5th
2	Crop Rotation	75	176	24	275	65.5	2nd
3	Inter cropping	36	148	47	231	55.0	4th
4	Crops residue management	48	189	50	287	68.3	1st
5	Climate change adaptable crops varieties	78	164	29	271	64.5	3rd
6	Crops and livestock insurance	36	78	64	178	42.4	6th
	Average				**238**	**56.7**	

Note: Percentage has calculated from total highest (420) score. (***Source:*** Survey Data (2020)

It is pertinent to note that the reason the institution failed to meet the stipulated mandate is because the organizational structure compounded its limitation and constraints, inherently prevailing in the service delivery system of the organization. Accordingly, the failure to attain the required level of delivery in extension system as identified under this subsection is reasonably due to functional level constraints which must be identified to address them through proper recommendation. Based on this assumption some of the constraints selected as indicators to assess their negative effects in the extension service delivery system and the result are summarized in the Table 6.15c in respective of indicators and aggregate level.

The data presented in Table 6.15c shows that inadequate attention and focus on all structural level is first level in constraining the required positive influence of extension services. This underpinned the system's failure, in performance and outcome. Furthermore, the institution lacked adequate technical capacity to implement the CSA strategies, in addition to having inadequate workable climate change adaptation and mitigation related strategies; both were ranked 2nd and 3rd level, as constraining factors in the extension service delivery system.

Apparently, climate change adaptation and mitigation policy, resources, and facilities to mobilize adaptation and mitigation strategies and adequate projects availability are irrefutably among the important components that should be considered to positively influence CSA practices adoption and sustainability in the farming community of the study and beyond. Relatively, several research findings and conventional reports indicate that Ethiopia's environmental policy, including the CSA practices is smart, but the effort and the commitments in the process of implementation appeared to be inadequate as compared to the targets stated in the strategic documents, which is consistent with the staffs' perceived suggestion demonstrated and presented in context of this study.

Table 6.15c: Major Constraints Contributing to Inadequate Effectiveness and Adoption Success (N=140)

No	List of constraints	Score for each major constraints					Rank
		3	2	1	Total	%	
1	Inadequate attention at all level	117	130	30	277	66.0	1st
2	Inadequate appropriate policy	63	118	53	234	55.7	6th
3	Inadequate workable strategies	69	132	42	243	57.9	3rd
4	Inadequate innovation and Technology	93	88	54	235	56.0	4th
5	Inadequate Technical capacity	111	92	43	246	58.6	2nd
6	Inadequate Resources and Facilities	81	106	48	235	56.0	4th
7	Inadequate appropriate guidelines	87	92	50	229	54.5	7th
8	Inadequate CC project/program	66	106	52	224	53.3	8th
	Average				**240**	**57.2**	

Note: High (3), Moderate (2), Low (1) and Negligible (0). (**Source:** Survey Data, 2020)

The System's level integration of climate change management was evaluated in the survey process regarding pre-service education (College level) and in service training in order to identify the level of integration, to improve knowledge and awareness of the professional staffs and community concerning climate change consequence and management. Majority of the staffs (82.9 percent) agreed to moderate and below moderate integration of the Climate changes management in the higher learning education during their schooling years, while 6.4 percent amongst them said the integration was completely neglected, and 13.6 percent stated that integration into college or university level teaching and learning process was inadequate. Furthermore, majority of the staffs (75.7 percent) found climate management integration service a rare event or a seasonal event, and practices including seasonal trainings or awareness creation efforts, 19.3 percent rated the integration service as a very rare event, and about 6 percent considered it as something completely neglected in the service delivery system (Table 6.15c). Evaluation of climate change management system integration into functional system was extended to the level of operational level planning and implementation level in the service delivery system and the result reveals that the level of integration is about average (50 percent) and the majority of the staffs (51. 9 percent) perceived medium; 9.3 percent of the staff members considered the integration as a neglected aspect of development agenda. Similar trends were observed in relation to most of the seasonal events like seasonal training, workshop, and extension field visits. In this regard, only 34.3 percent of the staff members considered climate change management practices integration into seasonal events as very adequate (10 percent) and adequate (24.3 percent), whereas majority of the respondents, viz. 69 percent posited that it was below adequate performance level.

Additionally, the trend of CSA implementation progress was assessed from the past 10 years to the present time. Only very few staff members (4.3 percent) indicated adequate improvement in climate change management strategies including the CSA practices, while about 61.4 percent perceived moderate improvement and 34.3 percent suggested inadequate level in climate change management implementation progress in the sense of magnitude and proportionality in the functional segments. Specifically, further assessment was conducted concerning availability and appropriateness of the climate change management related available policies and strategies and nearly about average of the respondents disagreed with the availability and appropriateness of the available policies and strategies, and whether they were productive in climate change adaptation and mitigation efforts which include the CSA practices adoption. In this regard, out of the total respondent of government staff, 55 percent are not feeling comfortable with available polices and its adequacy to support climate change management, while 51 percent also do not agree on availability and appropriateness of the climate change strategies in the extension service delivery system of the extension structure.

6.6. Climate Change Impact Explained in Context of Seasonal Revenue and Livelihoods Diversification

Several findings recognize the significant impact of seasonal income on climate change-oriented households' vulnerability. Accordingly, this study further focused to interpret the climate change impact situation in respect to households' seasonal income, where the data collected from household survey were analyzed and presented in the Table 6.16a and b, and c, for total seasonal income, Agriculture related source income and non-agriculture source of income, respectively and the presentation of this sub-heading is managed in this perspective.

Table 6.16a: Total Income Situation of the Survey Households (N=410)

No	Income categories (Eth-Birr)	Highland areas		Lowland areas		Total	
		Frequency	%	Frequency	%	Frequency	%
1	Within less 10,000	9	4.5	9	4.3	18	4.4
2	10,000-100,000	128	64.0	152	72.4	280	68.3
3	100,001-200,000	42	21.0	27	12.9	69	16.8
4	200,001-300,000	13	6.5	12	5.7	25	6.1
5	300,001-400,000	7	3.5	4	1.9	11	2.7
6	Above 400,000	1	0.5	6	2.9	7	1.7
	Total	**200**	**100.0**	**210**	**100.0**	**410**	**100.0**

Source: Compiled from Survey Data (2020)

As indicated in the above Table 6.16a, the analyzed survey data shows that the majority of the respondents (68.5 percent) earn 100,000 and less per year at highland areas, while reasonably, majority (about 76 percent) of lowland area farmers were earning within the same range of household incomes per year. Meanwhile, on the base of seasonal income of the survey households, the proportion of the family with better earnings, who are earning more than 300,000birr, is 4 percent and 4.8 percent for highland and lowland agro-ecology, respectively. Consequently, the great majority of the households mentioned above that are earning below average per year are among the low earning community member and highly vulnerable to climate change. Per se, they are within the category of food insecurity group, as a result of low income to cover food demand for households' seasonal consumption.

Table 6.16b: Agriculture Related Income for the Survey Households (N=410)

No	Income categories (Eth-Birr)	Highland areas		Lowland areas		Total	
		Frequency	%	Frequency	%	Frequency	%
1	Within 10,000	10	5.0	13	6.2	23	5.6
2	10,000-100,000	131	65.5	157	74.8	288	70.2
3	100,001-200,000	39	19.5	29	13.8	68	16.6
4	200,001-300,000	16	8.0	4	1.9	20	4.9
5	300,001-400,000	4	2.0	3	1.4	7	1.7
6	Above 400,000	0	0.0	4	1.9	4	1.0
	Total	**200**	**100.0**	**210**	**100.0**	**410**	**100.0**

Source: Compiled from Survey Data (2020)

According to this study findings, all respondents are agrarians whose the main source of income is majorly dependents on agriculture and thus, apparently vulnerable to climate change and seasonal weather variability. The majority (about 70.2 percent of total respondents) of all respondents are generating within the range of 10,000-100,000 Eth-Birr for households' income, while the proportion of households making better income (more 200,000 Eth-Birr earner per annum) are less than 10 percent of the selected eligible respondents from study community (Table 6.16b).

Table 6.16c: Non-agriculture Source of Income for Households (N=410)

No	Income categorization (Eth-Birr)	Highland areas		Lowland areas		Total	
		Frequency	%	Frequency	%	Frequency	%
1	No non-agriculture income	137	68.5	137	65.2	274	66.8
2	Within 10,000	24	12.0	29	13.8	53	12.9
3	10,000-20,000	12	6.0	11	5.2	23	5.6
4	20,001-30,000	8	4.0	7	3.3	15	3.7
4	30,001-40,000	10	5.0	6	2.9	16	3.9
6	40,001-50,000	4	2.0	4	1.9	8	2.0
6	Above 50,000	5	2.5	16	7.6	21	5.1
	Total	**200**	**100.0**	**210**	**100.0**	**410**	**100.0**

Source: Compiled from Survey Data (2020)

More importantly, the majorly (about 67 percent) of the total respondents highland and lowland community have no access to none-agriculture sources of income to supplement agriculture related income and solely dependents on agriculture source of income which clearly indicate the vulnerability of this study community to natural disasters including the climate change and associated impacts (Table 6.16c). According to several study findings, a community solely dependent on agriculture related income is more boldly vulnerable to natural shocks and linked risks. Thus, on the base of seasonal income scenario, without any doubt these study communities are among severely vulnerable community to climate change and seasonal weather uncertainty considering the context of local farming system susceptibility to prevailing climate change and weather variability.

Similarly, households' wealth level also determines the probability of households' vulnerability to natural disasters and climate change impact related risks. Correspondingly, in Table 6.17, wealth category classification shows that 44.5 percent of the respondents are in low-income wealth category and those in medium and wealthy category accounted for 26 percent and 29 percent, respectively for highland agro-ecology. Likewise, 47.2 percent are low-income earners, 41.4 percent fall under medium, while just 11.4 percent are within the wealthy category for lowland farming community. It is pertinent to note that the impression observed from most focus group discussion (FGD) and key informant interview (KII) which includes the extension field staffs, shows that majority of the communities participating in the development programs are within the very low-, and low-income categories whom economic limitation is threatening their food self-sufficiency and food security most of the years and cropping seasons. Given this economic situation, their capacity to manage natural disasters like climate change and weather variability is ultimately limited. In addition, the survey data shows that a proportion closer to half of the respondents in households in the PAs fall within the poor wealth category which is a reasonable evidence validating the community's vulnerability to natural disasters, particularly, climate change related consequences (Table 6.17).

Table 6.17: Wealth Status of the Sample Households in the Community (N=410)

No	**Wealth categories**	**Highland areas**		**Lowland areas**		**Total**	
		Frequency	%	Frequency	%	Frequency	%
1	Wealthy group	58	29.0	24	11.4	82	20.0
2	Medium group	53	26.5	87	41.4	140	34.1
3	Low-income group	89	44.5	99	47.2	188	45.9
	Total	**200**	**100.0**	**210**	**100.0**	**410**	**100.0**

Source: Compiled from Survey Data (2020)

On the other hand, households' source of income diversification which is significantly important to cope with natural disaster which includes the climate change impact is predominantly determined by livelihoods diversification. Thus, the empirical evidence explicitly suggests that the coping and adaptation capacity of individuals and community largely depend on the livelihood diversification which ultimately leads to income diversification for the households in the community. Hence, the source of income that is derived from natural resources, which includes agriculture is susceptible to climate change impact because it is heavily dependent on natural environment. Differently, non-agricultural income source has a positive impact on the food self-sufficiency of the households and food security of the community as depicted in the investigation.

Furthermore, the investigation extended further to quartiles estimation in context of households' annual income. In this regard, Figure 6.1 presents the quartiles estimation results which help to compare the income gap of different income levels at household level. Accordingly, the households are classified into four categories based on income level, and the interpretation of estimate was made based on the 25th, 50th, 75th and 95th percentile of the survey households' income related data, respectively. The percentiles results indicate that the income gap of the high-income households (95 percentile) of the lowland community appeared to be the highest (more than double) as compared to the same categories of the highland community. Subsequently, depicting that the highland farmers whose livelihood is dependent on the farming system had less income than those in lowland agro-ecology, because of the income obtained from non-agricultural source. Conversely, the income of 75 percentiles in the highland community appeared to be higher, even more than double as compared to lowland community of the same income category.

On the other hand, the income of the remaining percentile (25th and 50th percentiles), conventionally assumed to be low and medium income households are negligible. Hence, this outcome aptly portrays the poor diversification of non-agriculture source of income, which is considered as the core strategy in climate change coping mechanisms. According to the findings presented in Figure 6.1; non-agriculture income diversification appeared successful only in the high income household of the community. This finding is a complete indication of low- and medium-income households' absolute vulnerability to natural disasters, including the climate change hazards and related consequences. As evidenced from the survey conducted, agriculture appeared to be the major and primary source of income that enables the respondents to cope with contrary effects of climate change, while income diversification is a secondary one, functioning as one of the adaptation strategies, particularly in the low-income households. Consequent upon this divulgence, the income gap and variation which practically exist in the lower percentiles categories are adequately focused on in the current study.

Following this, Figure 6.1 below shows that the income of the two communities (highland and lowland) maintains a similarity, and as such the gaps are very minimal and insignificant in the 25th percentiles category of total and agriculture related source of income, whereas the income gap in the medium percentiles (50th percentiles) appears to be wide (significantly higher in the highland households) as compared to the 25th percentiles of the income category. Thus, indicating absolute vulnerability of the medium income households to natural disasters when household income is taken as the single scenario. A similar result with 50th percentiles, but with a higher magnitude, is observed in the 75th and 95th percentiles of total and agricultural income (Figure 6.1).

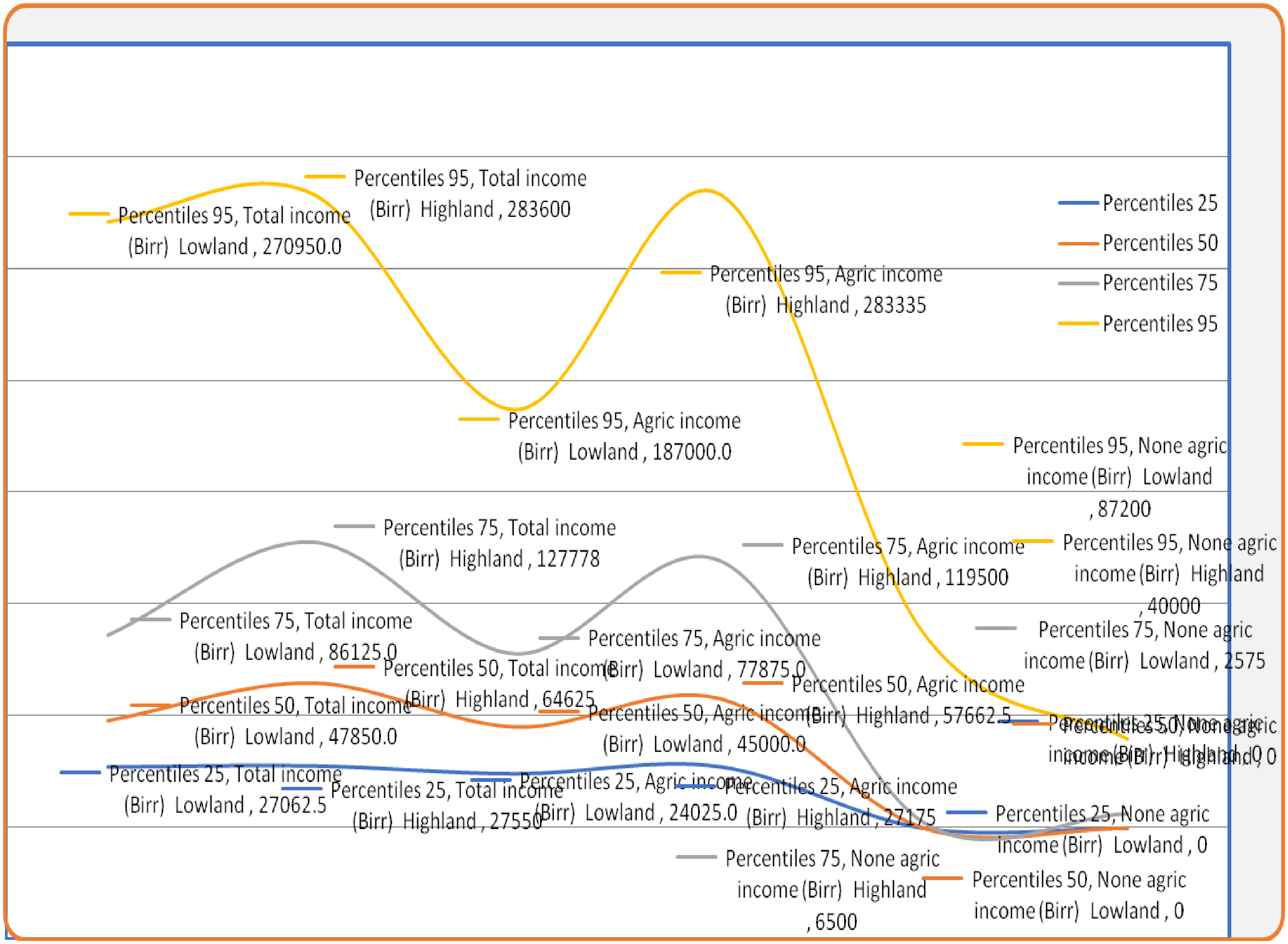


Figure 6.1: Income gap and Variability in Context of the Study Areas (**Source:** Compiled from Survey Data, 2020)

More importantly, the extreme wide gap (higher in the highland community) observed in the 95th percentiles of the agricultural source of income constitutes an absolute damage to the livelihood of the household in the lowland farming community considering the other scenarios are constant in the context of climate change adaptation and coping strategies. Although this finding may appear contrary to expectation, but there are plausible reasons for it. The cardinal reasons, amongst others can be attributed to weather variability and drought consequences. These have devastating effects on the households' income in lowland area, particularly those who are dependent on proceeds from agricultural production for survival; hence, the highland incomes topped the incomes of the lowland community. For instance, farmers who enjoy habitual conducive weather conditions to conduct agricultural livelihoods in a

regular/sustainable manner like the inhabitants of highland agro-ecology, traditionally diversify the crops they grow in given cropping years. On the contrary, farmers dwelling in places recognized for poor weather conditions and high frequent drought like lowlanders necessarily plant only limited crops and crops varieties throughout the year. This style inevitably influences the susceptibility of agricultural livelihoods to climate change and variability, commonly manifested through frequent crop failure.
As earlier stated and explicated above, Figure 6.1 above articulates a synopsis of the difference in income levels at 25th, 50th 75th and 95th percentiles of this income data, between high income earners of the highlanders and low income earners of the lowlanders, thus signifying a total vulnerability of the lowland community to natural disasters and the attendant consequences. As to findings of this survey data analysis, the median income levels (in all sources of incomes) were consistently found to be lower than the mean values, suggesting that the inclusion of a few households with very high incomes increased the mean income values in the households. Conversely, the large size of the low income households which may likely make the community vulnerable to natural shock and its impacts in the highland community and lowland community has different magnitudes. An instance is the case of the lowland households where a wide gap was observed, which further underpinned the destructive situation in the context of the lowland agro-ecology and community.

Equally, based on the survey results, Table 6.18 classifies and presents the households in relation to the main source of income for particular household. To that end, it was discovered that majority, exactly 47 percent depend on the seasonal crop production as their major source of income, followed by livestock, precisely 29.5 percent, in highland agro-ecology. Oppositely, relatively the majority of the lowlanders, 36.2 percent engage in livestock production as the source of income, while seasonal crops come second with a percentage of 34.7still in the lowland farming community. According to the survey results, the sale of livestock functions as the 3rd source of income in both highland and lowland agro-ecologies, constituting 17.5 percent and 13.8 percent, respectively. Thus, it is apparent from the examination that agriculture is the primary source of income (crops and livestock farming) for the highlanders and lowlanders, for it constitutes a ratio of 94 for the former, and 84.7 for the latter.

This is particularly underlined because only 6 percent (highland community) and 15.3 percent (lowland community) of the households recognize non-agriculture source of income as shown in Table 6.18, which includes the non-farm employment, on-farm employment, and remittance from the family members. Hence, both communities are really vulnerable to climate change impacts and related risks. Specifically, the majority generate income from marketing of seasonal crops, livestock, and livestock products both in the highland and lowland farming system relying predominantly on agricultural sources for sustenance. In actuality, extant studies consistently agree that the community which largely depends on natural resources for existence is commonly affected by immediate climate change effects and are necessarily and always on the front line risks of the vulnerability to climate change impacts and the tailgating consequences.

Table 6.18: Major Livelihoods in the Context of Survey Households

No	Major sources	Highland areas		Lowland areas		Total	
		Frequency	%	Frequency	%	Frequency	%
1	Seasonal crops husbandry	94	47.0	73	34.7	167	40.8
2	Livestock husbandry	59	29.5	76	36.2	135	32.9
3	Livestock product sale	35	17.5	29	13.8	64	15.6
4	On-farm employment	3	1.5	22	10.5	25	6.1
5	Non-farm employment	5	2.5	6	2.9	11	2.7
6	Family remittance	4	2.0	4	1.9	8	2.0
	Total	**200**	**100.0**	**210**	**100.0**	**410**	**100.0**

Source: Compiled from Survey Data (2020)

As presented in Table 6.18 and discussed above, the livelihoods of majority of the households come from agriculture, either directly or indirectly. This further emphasizes the insignificance of non-agriculture livelihood diversification, which would have probably been a promising strategy to coping with natural disasters in comparison to livelihood diversification within the agricultural sectors and sources. Thus, the livelihoods of those who are solely reliant on agricultural production are greatly dependent on conducive environment, particularly weather condition cannot be gainsaid; it is a global fact. In the meantime, the livelihoods of farming households are always vulnerable to weather variability and the contrary effect of climate change; which irrefutably affect economic and social structures of the community.

6.7 Mean Differences of Farmers' Demographic Variables across CSA Practices Adoption Decisions

The differences in mean were tested using the independent T-test and Chi-square test for the continuous and categorical data, respectively. The results of these two test statistics are presented in Table 6.19 for continuous variables, and Table 6.20 for categorical variables. As shown in Table 6.19, except for some variables (age, family farm size, family size, livestock farming experiences and holdings), all selected variables were found to be statistically significant. In Table 6.19, mean differences of households farming experiences, irrigation farm holdings, total yearly income of the households and agriculture related income of the respondents showed statistical significance at one percent level. These results indicate that the CSA practices and technology adoption are strongly associated with the irrigation farmland holdings, yearly income of the households and agricultural income of the sample households. Moreover, the remaining variables such as households farming experiences, yearly nonagricultural income, and distance of FTCs from households were also statistically significant at five percent. According to the results in Table 6.19, the mean difference of the market distances is with negative sign indicating a less average distance for adopters as compared to the average FTC distance of the non-adopters.

On the other hand, the relationship between CSA practices adoption and some other variables, like age of head of households, family size, family farm size, irrigation farm holdings, livestock holding, livestock farming experience and yearly income of the household (total income, agricultural income, and nonagricultural income) were found to have positive association. However, the positive mean difference between the mean age of adopters and non-adopters is unexpected, because many findings of previous investigations reveal negative association of age with technology adoption. In summary, these findings indicate that CSA practices and technology adoption are significant for households farming experiences, irrigation farm holdings, distance of Farmers Training Centers (FTCs) from farmland, and income characteristics of the households. In addition, the adoption is significantly dependent on other variables like, age of household heads, family size, farm size, livestock farming experience, livestock holdings, indicating the existence of a weak association with these factors of adoption.

Table 6.19: The Summary of Means Difference Test for Continuous Demographic Variables of the Farmers

Continuous explanatory variables	Mean for each variable			Variance Test		T-Test	
	Adopter	Non-adopter	Mean difference	F-Value	P-Value	T-Value	P-Value
Age of Respondent	44.2	42.6	1.6	0.60	0.44(NS)	1.62	0.106(NS)
Household Family Size	6.6	6.5	0.1	5.97	0.015**	0.54	0.595(NS)
Farming experience	24.9	22.3	2.6	0.19	0.661(NS)	2.52	0.012**
Household Farm size	2.4	2.2	0.2	0.06	0.807(NS)	1.09	0.276(NS)
Irrigation farm holding	0.22	0.10	0.12	26.49	0.000***	3.37	0.001***
Livestock Farm experience	20.8	19.2	1.6	2.13	0.146(NS)	1.46	0.1447(NS)
Household yearly income	124197.0	76686.2	47510.7	4.70	0.031**	3.83	0.000***
None agric yearly income	12314.1	6983.4	5330.7	11.19	0.001***	2.35	0.019**
Agric yearly income	108089.9	61796.1	46293.8	22.77	0.000***	4.98	0.000***
Livestock holding (TLU)	24.0	23.2	0.9	1.86	0.173(NS)	0.38	0.706(NS)
Distance of market place	6.2	6.5	-0.3	0.18	0.894(NS)	-0.37	0.713(NS)
Distance of FTC	3.4	2.8	0.6	3.45	0.064*	1.98	0.048**

Note: ***** -** Significant at 1% level, **** -** Significant at 5% level, *** -** Significant at 10% level and NS – not statistically significant

According to Wegayehu (2006), age of household heads can influence availability of labor, and that is one of the most important factors of production this factor also determines the decision of households regarding the type of farming practices to adopt on their farmland. However, this result is inconsistent with his findings, in which age of household head was found to be insignificant in influencing adoption of CSA practices. Furthermore, the finding in this study is similar to that of Haji (2002) who reported a non-significant t-test, which leads to the conclusion that there is no significant difference in age between adopters and non-adopters of Cross Bred Dairy Cows (CBDCs) in Arsi zone, Ethiopia. As mentioned in several research literatures, the gender of the households' heads and social participation in farming have shown to be significantly different among the technology adopters and non-adopters, but the significance levels differ from one study to another. In this study, only the social organization membership indicates high significance level at 1 percent, while others are significant at 5 percent. According to Wegayehu (2006), sex of households' heads determines access to Soil and Water Conservation (SWC) technological information provided by extension agents. Apparently, the marital status and social participation (membership in social organization) also would influence adoption of any particular technology and thus, these results indicate a strong influence of these variables on CSA practices adoption decision.

As shown in Table 6.20, there are strong associations between the listed social characteristics of the households and adoption of CSA practices. The gender of the respondents with Chi-square (X^2) of 5.421 and the wealth status of the household with Chi-square (X^2) value of 34.093 were both found statistically significant at 10 percent and 1percent significance level, respectively, while being a members of social organization with Chi-square (X^2) of 70.933 is significant at one percent level. However, among the social characteristics of the households listed here, the marital status of the head of the households remains non-significant.

Table 6.20: Test of Association between Categorical Variable and CSA Practices Adoption (Aggregated)

Categorical explanatory variables	**Response category**	**Adoption (%)**		**Chi-square**	
		Adopter	Non-Adopter	X^2-Value	P-Value
Gender of respondents	Male	33.2	66.8	5.421[a]	0.067*
	Female	49.0	51.0		
Marital status of respondents	Married	35.2	64.8	0.003[a]	0. 995(NS)
	Single	34.6	65.4		
Social-organization membership	Yes, member	40.8	59.2	70.933[a]	0.000***
	No, not member	21.5	78.5		
Accessibility of credit	Yes, available	38.6	61.4	6.586[a]	0.086*
	Not available	29.8	70.2		
Mass media Accessibility	Yes, accessible	43.1	56.9	16.900[a]	0.001***
	Not accessible	27.7	72.3		
Sustainable water supply	Yes, sustainable	29.1	70.9	7.658[a]	0.006***
	Not sustainable	42.2	57.8		
Participation in CSA project/program	Yes, participant	59.5	40.5	50.381[a]	0.000***
	Not participant	23.7	76.3		
Development Center (DC) in the community	There is DC	35	65	1.320[a]	0.251(NS)
	There is no DC	67	33		
Wealth status of the household in the community	Wealthy group	56.1	43.9	34.093[a]	0.000***
	Medium group	41.4	58.6		
	Resource limited	21.3	78.7		

Source: Compiled from Survey Data (2020)

Similarly, non-social variables were selected and analysed to identify whether there is a difference between two category and association with adoption decision makings. In this regard, the accessibility of the respondent to infrastructures and facilities was found to be statistically significant. This indicates an association between CSA practices adoption and access to infrastructure. Generally, among many institutional variables as shown in Table 6.20, availability of credit facility, access to mass media and electronic appliance as the means to access extension information were examined to determine whether there is meaningful mean difference among the adopters and non-adopters with respect to their association with CSA technology adoption. Subsequently, it was realized that credit facility with Chi-square (X^2) value of 6.586 and participation of farmers in CSA related regular extension program and/or projects with Chi-square (X^2) value of 50.381 and mass media accessibility with Chi-square (X^2) value of 16.07 are statistically significant at one percent significance level. However, marital status of the head of household, accessibility of electronic appliance as the means to get access to extension information and development Centre (DC) availability in the community was statistically insignificant regarding the mean differences and influence on CSA practice adoption decision. Finally, detailed discussions of these two continuous and categorical variables are presented in the subsequent section of this chapter with respective to the rate of CSA practice adoption in the study community.

6.8 Chapter Summary

This chapter summarized the demographic features of selected farm households from the highland and lowlands agro-ecology of the study areas. The significant number of socio-economic characteristics of the households in context of CSA strategic practice adoption were summarized and presented. Based on farmland holdings, those farmers with large farmland had higher adoption of CSA practices in the highland agro-ecology. Also, there is no significant variation in CSA adoption among large farmland and small farmland holders. More specifically to livestock farming, the livestock holders of those within the category of 11-20 animal heads, were found better adopters of CSA strategic practices (50.6 percent) in the highland farming community, while the lowest which is 31.1 percent rate of adoption identified in the case of lowland community within the similar number of Animal heads holders. On the contrary, in the livestock holding category of 21-30 heads, it was discovered that lowlanders were better adopters as compared to the highland farming community. In generalized content, the result presented in this chapter illustrated that, there exists a similarity regarding the overall rate of CSA practices adoption within the lowland agro-ecology (about 34.9 percent) and highland community adoption rate (35.2 percent) in the survey community. On the other hand, the results indicated that more experienced farmers were more likely to adopt CSA practices.

CHAPTER SEVEN

CLIMATE CHANGE LIVELIHOOD IMPACT AND VULNERABILITY

7.1 Introduction

This chapter presents the results on climate change impact vulnerability based on the biophysical, social, and economic conditions of the smallholder farmers. The chapter also elucidates on the perceptions of the respondents regarding climate change impact on the livelihoods of the community. Similar to other chapters, the study areas were categorized into highland and lowland with the intention of comparing and contrasting the effects of climate change in these agro-ecological zones.

7.2 Perceived Level of Climate Change and Resultant Impacts

The data summarized in Table 7.1 show that the majority of the respondents (88.5 percent of highland and 70 percent of the lowland households) agreed to have high and very high perceptions of climate change, while only a few respondents (15.5 percent from highland and 30 percent of the lowlanders) indicated moderate negative change perception. In an aggregated context, among the total sample respondents, 79 percent of the respondents perceived high and very high negative changes in the local climate and weather conditions, while 21 percent indicated moderate negative change.

Table 7.1: Perceived level of Climate Change and Resultant Negative Impacts (N=410)

No	Description	Highland areas		Lowland areas		Total	
		Frequency	%	Frequency	%	Frequency	%
I	**Climate Change situation**	200	100	210	100	410	100
1	Very high negative change	36	18	56	26.7	92	22.4
2	High negative change	141	70.5	91	43.3	232	56.6
3	Moderate negative change	23	11.5	63	30.0	86	21.0
II	**Level of CC negative impact**	**200**	**100**	**210**	**100**	410	100
1	Significant negative impact	23	11.5	92	43.8	115	28.0
2	Moderate negative impact	140	70.0	116	55.2	256	62.4
3	No negative impact	37	18.5	2	1.0	39	9.6

Source: Compiled from Survey Data (2020)

On the other hand, Table 7.1 shows that out of the 410 respondents that were sampled from the highland and lowland agro-ecologies, 90.4 percent perceived significant to moderate negative impact of climate change on their livelihoods. However, a few respondents (9.6 percent) perceived no negative impact caused by climate change and related risks. Disaggregated data also implies the similar situation of the negative impact related to climate change. In this aspect, disaggregated findings show that among the total respondents of the highland respondents, 81.5 percent felt moderate to significant negative impacts of climate change on their livelihoods, while 99 percent of the lowland respondents expressed a similar feeling. These findings reveal comparatively discouraging situation in the lowland community and farming system as compared to highland community.

Furthermore, as to results presented in Table 7.2 climate change and seasonal weather variability were perceived differently in the highland and lowland agro-ecologies. The results indicated that lowland farmers felt more negative impacts as compared to their counterparts on the highland. Table 7.2 shows that among the farmers from the highland agro-ecology, 52 percent perceived score was identified indicating reduction in the frequency of precipitations in the area. Increase in temperatures was perceived by about 51 percent score compared to the normal season within the highland. Contrarily, in the lowland agro-ecology, about 90 percent perceived score was observed reduction in the frequency of seasonal precipitation. On the other hand, of total respondents rated weather condition, 84 percent perceived score was computed in respective of an increase in temperature indicating by far different situation as compared to highland agro-ecology related perceived score.

Table 7.2: Farmers' Perceptions and Rating of Climate Change

Climate Change Indicators	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	3	2	1	Total	%	3	2	1	Total	%
Precipitation frequency reduced	72	198	42	312	52.0	462	100	4	566	89.8
Reduced seasonal rainfall amount	63	158	60	281	46.8	258	216	13	487	77.3
increased Temperature in the season	51	186	68	305	50.8	411	102	16	529	84.0
Frequency of drought increased	33	100	61	194	32.3	192	252	16	460	73.0
Irregularity in rainfall patterns increased	66	156	46	268	44.7	246	196	25	467	74.1
Late onset of rain to normal time frame	96	174	60	330	55.0	129	280	21	430	68.3
Early cessation of rainfall to normal	60	108	57	225	37.5	303	158	18	479	76.0
Reduced normal rainy season	72	128	71	271	45.2	177	248	21	446	70.8
Unpredictability of rainfall increased	57	160	76	293	48.8	276	178	23	477	75.7
Seasonal rainy days reduced	54	126	72	252	42.0	255	218	10	483	76.7
Average				**273**	**45.5**				**482**	**76.6**

Note: High (3), Moderate (2), Low (1) and negligible (0), which 0 has excluded from the Table **(**Compiled from Survey Data, 2020)

Overall, the indexed score of the weather variability indicators considered in this study and presented in Table 7.2 shows that an average score of 273 (45.5 percent) for highland agro-ecology and 482 score (76.6 percent) in the context of lowland agro-ecology indicating testing situation in the lowland farming system. On the other hand, several researchers researched context of weather variability in Ethiopia using different indicators; of which results of some are similar with this finding and different with some others. In this aspect, Deressa et al. (2011) observed noticeably increased number of hot days and nights which usually leads to increased local temperature over the last decades; while 20 percent and 38 percent increase have occurred during the 1960 and 2003 years, especially between June and August where the observed increase was as high as 32 percent and 59 percent, respectively. Simultaneously, the number of cold days and nights reduced by 6 percent and 11 percent, respectively, which consequently, has upped the country's minimum temperature with an average rate of 0.37°C to 0.4°C during each decade. However, according to this author, the increase in temperature is relatively stable across regions and over time, while the most frequently documented changes in precipitation are vague. Moreover, different sources documented significantly diverging information; for instance, according to Deressa, Hassan and Ringler (2011) posited that rainfall situation remained a little bit stable over the past 50 years when overall country level aggregate averaged for each season and initially observed decreases in the months of July-September rainfall in the year 1980s have adequately recovered during the 1990s and 2000s cropping years.

On the other hand, as to World Bank (2011), under Ethiopian conditions, coverage of sufficient precipitation amount during the main seasons have diminished over the last decades, affecting the seasonal crops production patterns in most parts of the country, mainly in densely populated areas of the central highlands which are the major source of food commodity. It is pertinent to note that these rainfall sensitive areas are inhabited by nearly 20 million community members, who are frequently exposed to chronic food shortage over the seasons as rainfall in the areas changes from sufficient to insufficient and subsequently, insufficient rainfall cannot support agricultural production, which commonly leads to failure in seasonal harvests. The same is true of pastoral communities inhabited in the eastern part of the country, where an area receiving sufficient rains of 250 mm per season to support livestock production is declining with alarming rate (Simane *et al*., 2017). In addition, the changes in temperature, reduced frequency of rainfall, severity of extreme weather events and increased warming have aggravated the frequency of droughts and desertification in the lowlands of the country (ibid). An increase in the severity of short and heavy rains in the highlands areas of the country commonly leads to escalated frequency of flooding in the lowlands locality, causing more environmental degradation in the already exposed areas, even though it may improve the fertility of lowland soils (ibid). At present, in Ethiopia, there is inadequate socio-economic development, insufficient infrastructural development and shortfall in institutional capability; all these are the factors contributing to the country's vulnerability to climate change impacts (World Bank, 2011). These widespread situations have already led to considerable environmental degradation, which further negatively influenced the communities' susceptibility to climate change associated risks, like occurrence of frequent floods and droughts (World Bank, 2011).

In this regard, the geography of the country includes mainly dry sub-humid, semi-arid and arid oriented agro-ecologies, all of which are extremely susceptible to frequent droughts; hence desertification and droughts have persistently strained Ethiopia since 1970s harming the national economy and household level livelihoods. For instance, areas where livestock husbandry is the main source of the community livelihoods is severely fraught with drought, thereby affecting animal feed as well as range land productivity, all of which are likely to exacerbated under predicted changes in climate conditions. The consequent effects of drought include pasture scarcity, natural pasture overgrazing, regular land degradation, reduced water availability and livestock diseases outbreak (Climate Resilient Green Economy (CRGE), 2011). To that effect, all of the drought related impacts usually lead to reduction in the number of livestock, and productivity, frequent crop failure in agro-pastoral farming system, chronic food shortage which commonly leads to food insecurity and escalated community conflicts over scarce natural resources, particularly water (ibid). In Ethiopia, agricultural sector, which is commonly, dominated by smallholder farmers, predominately subsistence in nature, and apparently dependent on rainfall patterns (World Bank, 2011). Thus, traditional technology is required to close-up the gapes in national food security, and these smallholder farmers plays distinct responsibility in the country's overall socio-economic development (World Bank, 2011). However, seasonal weather variability which frequently resulted from climate change has become a grave challenge to the furtherance of development in agricultural sector, frequent drought, which in many cases leads to famines, severely, reduces its productivity and overall agricultural production (ibid).

In this regard, inadequate water-storage capacity and substantial dependence on rain-fed production systems have significantly influenced the agriculture sector, making it more susceptible to climate change associated disasters (Hassan, 2010). In Ethiopia, population size and growing population impact on natural environment, which have resulted in persistent changes in climatic condition, while these changes are regularly followed by frequent droughts events (ibid).Ethiopia's National Meteorological Agency (NMA), (2001), has identified the most frequent spatial and temporal variability from a study carried out on temperature and rainfall data, spanning through 30 years (1961 to 1990) in seasonal weather structures (Simane et al., 2017). The research noted that average annual precipitation was constant at national level, but with significant declining tendency in the northern part of the country and increasing tendency in the central parts (Simane *et al*., 2017). Despite focusing on Ethiopia, documented changes and variability are roughly consistent with the trends experienced in a range of African and global environment, where the mean annual temperature has been elevated by 1.3°C during cropping season of the 1960 and 2006 with an average rate of 0.28°C for each decade (Climate Resilient Green Economy, 2011).

7.3 Social Context Perceived Impact of Climate Change

In the context of natural disasters and catastrophe, livelihood level impacts and related risks are the results of the social impacts. Likewise, the levels of livelihood and vulnerability are heavily dependent on the social effects of climate change. Based on this fact, the effects of climate change on the social level of the community were assessed against some selected criteria and dimensions in order to identify the impacts of the climate change in the study community. Accordingly, Tables 7.3 and 7.4 present the result of data analysis related to the social level effects of climate change. Subsequently, the examination shows that among the total respondents selected from the survey community, majority of them (70 percent) from highland and (77 percent) of the lowland respondents perceive the negative effect of climate change on the social aspect of the survey community, while very few group perceives positive effect of the climate change impacts in the community. As shown in Table 7.3, about 26 percent and 2.4 percent of the respondents perceive no social impact related to climate change and weather variability in the study community of highland and lowland agro-ecology, respectively.

Table 7.3: Perceived Climate Change Impact on Social Aspect of the Community

No	Perceived effect	Highland		Lowland		Total	
		Frequency	%	Frequency	%	Frequency	%
1	Negative effect	140	70	177	84.3	317	77.3
2	Positive effect	9	4.5	28	13.3	37	9.0
3	No effect	51	25.5	5	2.4	56	13.7
	Total	**200**	**100**	**210**	**100**	**410**	**100**

Source: Survey Data (2020)

On the other hand, a greater percentage of the respondents perceive negative impacts of the climate change; thus, about 82 percent and 90 percent of the survey respondents perceive the level of climate change impacts from moderate to high impact in the highland and lowland agro-ecology, respectively. Given this, the responses of the respondents substantively indicate the significance of climate change impact on the social aspects of the community. Furthermore, social level effect indicators are selected in order to identify the most impactful indicator regarding its impact on the social lives of the community. The findings are summarized and presented in Table 7.4 below. As shown in Table 7.4, internal migration as the result of climate change is the variables cored highest (42.3 percent) in the highland agro-ecology block of the study, while instability of the family and living style perceived score (66.2 percent) is underscored as the most impactful indicator of the effects of climate change on the social aspects of the lowland households in the community.

Table 7.4: Social Level Climate Change Impacts and Rating

Category of the effect indicators	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
External migration	45	122	37	204	34.0	6	148	83	237	37.6
Internal migration (within rural)	12	80	65	157	26.2	87	220	45	352	55.9
External migration (outside rural)	15	172	67	254	42.3	84	198	49	331	52.5
Instability of Family and living styles	6	80	74	160	26.7	240	136	41	417	66.2
Displacement from usual residential	21	72	78	171	28.5	138	156	58	352	55.9
School dropout increase	18	84	49	151	25.2	108	154	65	327	51.9

Note: High (3), Moderate (2), Low (1) and Negligible (0), where o excluded from the Table

It is apparent that the level of climate change impact is different for different categories of the community based on the characteristics and ability of the individuals to adapt and cope with prevailing climate change impacts and related risks. Concerning this, the rating scores were computed with some social impact indicators. The result shows that the impact on children for lowland agro-ecology is higher perceived score (58.9 percent) when compared with the highland agro-ecology (29.8 percent) perceived score. Thus, this implies the exposure of children to climate change impacts in lowland community as compared to highland community. Similarly, the impact score of climate change was higher (53.5 percent) for lowland community regarding its effect on youth (female and male) compared with highland rating score (36.3 percent), indicating the discouraging situation in the lowland farming system and traditional community.

According to survey results, an adult male is more impacted (32.2 percent) than female (26.7 percent) in the highland community, while in contrast, an adult female is found to be more impacted in the social group (59.4 percent) when compared with the male counterpart score (56.8 percent) in the lowland agro-ecology blocks with respect to climate change impacts and related risks. On the other hand, the survey data shows that the elders living in the lowland are badly impacted (61 percent) by climate change and weather variability when compared with highland groups (27.8 percent). It follows that the lowland elders are living in a worse situation, a pointer that their standard of living is very low, which is not good for their health, considering their ages.

A range of social features contributing to social susceptibility to climate changes related disasters include, consistent population growth, poverty level of the social groups, exposure to frequent hunger, poor health as a result of inadequate services facilities, low level of education, gender inequality, fragility nature of the location, hazardous tendency of the ecosystem, inadequate accessibility to public resources as well as services and limited access to technologies ((Fisher, Shah, and Van Velthuin, 2002).In this aspect, exposure to hunger and poverty levels of the community are directly inter-linked and both are the major causes of livelihoods' vulnerability to natural disasters and shocks. Also lack of adequate income to purchase food commodities is a most important factor causing food insecurity and frequent risks of hunger contribute to poverty via reduced labor productivity, reduced tolerance to prevalent disease and depressing educational achievements of a particular social group (ibid). Frequent changes in the Climate elements are negatively influencing human health and lives across the globe, and affecting both the social and natural environments, which are vital determinants for the health of mankind, such as the clean air, safe water resources, food security including its sustainability and shelter (Simane *et a*l., 2017).

In this aspect, Ethiopia is experiencing recurrent climate extremes, such as frequent drought events and different types of floods, elevated temperature and unpredictable precipitation related to climate change (NMA, 2007, and Aklilu and Alebachew, 2009), in which the frequent drought has a very negative influence on the social stability of the rural community. According to World Bank (2010), Ethiopia has frequently experienced excessive adverse social effects associated with drought events, as of early 1980s; five of the severe droughts have led to painful famines, as well as drying up of water resources leading to serious water shortage, in addition to a range of localized droughts. Furthermore, besides the escalating of the temperatures and frequent decline in the amount of seasonal precipitation, unrestricted population growth and potent environmental degradation are significantly impacting the social lives of the rural households, in addition to customarily recognized routine constraints (Simane *et al*., 2017).Likewise, in the Borena areas of the Oromia region and Somali communities in Somali regional state of Ethiopia, escalated human health related hazards and social instability are already affirmed due to elevated temperatures, frequently increasing of unproductive farmland and shortage of water resources (ibid).

Furthermore, decline in agricultural land productivity and decreased average farmland holding for each household, shockingly increased environmental degradation, accelerated deforestation and wide-ranged food insecurity are regularly reported to characterize Ethiopia, which commonly leading to considerably complicated social turbulences (Alex, 2012). Similarly, recent reports intended for countries vulnerability mapping absolutely confirmed Ethiopia's soaring social vulnerability to climate change related risks with least capacity to respond to environmental shocks, particularly climate change driven hazards (Simane *et al.*, 2017). Based on the current trends, about 33 percent reduction in wheat yield has been projected as the result of climate change connected consequence, further contributing to poverty as well as being a main constraint to strategic efforts to realize the national food security and environmental sustainability in Ethiopia (NMA, 2007).

Several empirical evidence suggest that persistent Climate change will put more strain on traditional women with already heavy workload, and it will negatively impact the women's capacity to exercise appropriate management for infants and children, which will noticeably magnify the likelihood of under-nutrition in the community (UNSCN, 2010). Simane et al. (2017), asserted that in Ethiopia and Kenya, two of the world's most droughts sensitive countries, 36 and 50 percent of children within the age of five or less, respectively, are further likely to be undernourished, if their birth happened during drought season. Frequently elevated temperature, augmented rainfall variability, combined with devastating environmental degradation, will contribute to uncontrolled mounting food insecurity and dietary shortfall (Simane *et al*., 2017 and Riche *et al*., 2009). Obviously, climate change and variability have a direct and significant link with poverty, as well as hunger. For instance, several findings confirmed that, not only climate change increase poverty and hunger through its undesirable impacts on food security and economic development, but poverty and hunger equally influence the desirable resilience and adaptive capacity of the community negatively in context of rural households (Ministry of foreign affairs of the Netherlands, 2018).

Correspondingly, the smallholder farmers represent the poor with inadequate resources, and as such, they are generally considered as the most vulnerable to climate change related disasters in the social ladder. Others are rural community members who have no land, the poor in urban cities, elders, and those who have health problems, including women and children who stay behind as male adults migrate to look for employment opportunity. In low-income community, a factor with specific significance in climate change vulnerability is gender. The issue of gender shows the dichotomy between male and female responsibilities; for instance, women often have more household responsibilities, and are identified to be more vulnerable to natural disasters (ibid). For instance, 25 percent of poor smallholder farm households are identified as female headed with chronic vulnerability in some districts of Ethiopian, while only 5-7 percent of resourceful households are female headed, and identified as less vulnerable to climate change associated disasters (ibid). In such kind of community, women are most frequently affected by climate change impacts in respective of their commonly assigned social responsibilities, which include fetching of water for home consumption, domestic activities, fuel wood gathering and small-scale farm practices in subsistence farming business (ibid). Moreover, further indirect negative impact of climate change hazards on women has already been recognized in a social context, that is, the likelihood of women and girls' exposure to sexual abuse, which is high as they are required to travel to far and remote place to look for water resources (ibid).

On the other hand, the capability of women as well as girls to manage climate change related impacts are frequently considerably low as compared to men's ability, as result of their reduced access to infrastructures, such as information delivery systems as well as marketing systems, low migration opportunity and inadequate access to alternative source of incomes. High and increasing population density increases climate change vulnerability because it decreases the number of resources (including water and food) available per person and may lead to resource conflicts.

Another social aspect of climate change impact is related to literacy, as it is very central in adaptive capacity development in certain systems. This is because facilitate people's ability to collect and access divulged, and relevant information conventionally related to climate change, like early warning systems. In addition, literary enables community to use adaptation as well as mitigation strategies according to technical standardized recommendation. However, in Ethiopia, there is a remarkable disparity between the literate and the illiterate, particularly in the lowland pastoralist areas of the country, where about 90 percent of the community members are stark illiterate, as compared to the literate elsewhere in other parts of the country (ibid). An apt illustration is the predominantly increased biophysical susceptibility of extremely dry and scorching lowland part of the country (ibid).

Regarding social interaction, conflict is the important aspect in the situation of climate change; customary conflicts are regularly aggravated due to climate change. Thus, these conflicts arise because of lack of, or insufficient natural resources, especially when water become significantly insufficient to be shared among drought affected community, and conflicts ultimately constrain potential capacities of individuals to survive climate change associated consequences (ibid) out-smartly. In the case of Ethiopia, grave competition is real amongst water resource users under projected dry climate scenarios which could be within the country when competition existed between traditional communities for home level demand, industrial consumption, and farm irrigation water requirement (ibid).

Also, conflict can spring up because of international resource, which commonly results from changing water availability in downstream countries (ibid). Regarding conflicts related to water resource, out of the total respondents represented in highland community, 41 percent suggested serious conflicts over water resources, while in the same agro-ecology about 59 percent did not recognize any kind of conflicts regarding water resource competition. This can however be attributed to availability of alternative source of water, and surplus water availability in the highland agricultural community as compared to lowland farm households. On the contrary, out of the total respondents selected from lowland community, about 56 percent of them agreed to the factual occurrence of serious conflicts over water resources. This indicates a slightly high competition as compared to highland, whereas about 44 percent stated that they did not experience conflicts regarding to water resource in the lowland households in the context of study community.

7.4 Climate Change Impacts on Livelihoods and Determinants of Vulnerability

7.4.1 Perceived Impact of Climate Change on Households' Livelihoods

Generally, Ethiopia is among the most vulnerable and least ready countries to handle natural disasters including climate change. Basically, v*ulnerability* measured by system exposure, sensitivity, and capacity to manage rampant negative impact of climate change, whereas r*eadiness* measured by a system's capability to influence investments in order to translate them into adaptation measures through enhanced economic, system governance and social readiness.

In the context of climate change impact vulnerability, this study assessed the vulnerability of rural livelihoods in two selected areas of Arsi and East Shewa zone, representing the highland and lowland agro-ecology, respectively. The two adopted approaches to assess the climate change impact related livelihoods vulnerability level of the community particularly are assessment of perceived vulnerability and application of livelihood vulnerability index based on the Inter-governmental panel for Climate change (IPCC) procedures and approaches.

In this study, to assess the perceived level of climate change impact vulnerability, the primary data collected from survey households were subjected to descriptive statistical analysis, in order to identify the perceived vulnerability level of the study community in the context of climate change. As shown in Table 7.5, the majority of the respondents perceived the level of climate change impact vulnerability as moderate level in both highland and lowland agro-ecology. However, comparatively the proportion of respondents that indicated moderate level of vulnerability for highland agro-ecology is higher (63.5 percent) as compared to lowland (59 percent) agro-ecology. In the case of lowland area, the second majority (33.8 percent) suggested highly vulnerable level in context of their community which is comparatively high as compared to negligible proportion (1 percent) of the respondent from highland agro-ecology and study community.

Table 7.5: Perceived level of Climate Change Impact Vulnerability of the Study Community

No	Perceived Vulnerability	Highland		Lowland		Total	
		Frequency	%	Frequency	%	Frequency	%
1	Highly Vulnerable	2	1.0	71	33.8	73	17.8
2	Moderately Vulnerable	127	63.5	124	59.0	251	61.2
3	Less Vulnerable	58	29.0	15	7.1	73	17.8
4	Negligibly vulnerable	13	6.5			13	3.2
	Total	**200**	**100.0**	**210**	**100**	**410**	**100.0**

Source: Compiled from Survey Data (2020)

According to the finding of this study presented in Table 7.5 above, overall moderate impacts were indicated as compared to some extra-ordinary highly significant impact reported by other researchers: for instance, like that of Udin (2016) who asserted that 88 percent of respondents experienced significant climatic change impacts; while all the respondents experienced increases in temperature, droughts and climate variability with high resultant impacts. According to this author, across all extreme weather events, the majority (80 percent) of the respondents reported the experience of climatic shifts which are likely to have a negative impact on agricultural practices and households' agricultural livelihoods.

7.4.2 Perceived Level of Households' Livelihoods Vulnerability

The perceived level of livelihoods vulnerability was also analyzed using the indexing approach. The livelihood vulnerability indexing (LVI) approach (specified under chapter 4 in equations 4.4 and 4.5) was adapted and used to analyze the livelihood vulnerability of the community. For this purpose, the collected data from two agro-ecologies were analyzed and presented separately to indicate the differences and similarities between the two farming systems. Based on the selected IPCC modality, all indicators were rated based on the rating scale of four levels, which means, high (3), moderate (2), low (1) and negligible (0), where rating values represented the perceived level of livelihoods vulnerability for a particular vulnerability indicator. The overall score of each indicator is the sum total of rating score assigned by each respondent after multiplied by number of farmers rated similar level for particular indicators. In this regard, the highest score assumed to be 600 for highland and 630 for lowland agro-ecology; which a particular indicator can maintain when all respondents rated high score (3) and the lowest score is zero which can be maintained when all respondents rated negligible (0) level.

Accordingly, the percentage score of each indicator are computed from the expected highest scores (600 and 630 for highland and lowland, respectively), which ultimately used for content interpretation and presentation. However, as the score of Zero does not have any difference on total score of the indicators, in the summary Tables, zero (0) was excluded for proper Table space management purpose only in order to save two columns from each Table. As a result, the vulnerability level assessment was conducted based on the three major vulnerability components which are sensitivity, exposure and adaptive capacity in the context of survey community, while finally the rating of livelihoods vulnerability considered and handled in respective of established indicators. Accordingly, the results are summarized and presented in below four Tables (Table 7.6, 7.7, 7.8 and 7.9) in respective of these major vulnerability components described above.

Table 7.6: Sensitivity of Households Livelihood to Climate Change Impact

Category of effect indicators	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	3	2	1	Total	%	3	2	1	Total	%
Productive crop land decrease	81	168	18	267	44.5	336	126	31	493	78.3
Crops production decreasing over time	51	144	41	236	39.3	207	196	39	442	70.2
Loss of crops varieties over time	90	174	31	293	48.8	222	224	19	465	73.8
Livestock Number decrease over years	66	170	60	296	49.3	234	210	24	468	74.3
Declining of Livestock productivity	78	92	59	229	38.2	312	156	26	496	78.7
Livestock production decrease	75	186	45	306	51.0	219	224	19	462	73.3
Declining of biodiversity	30	154	80	264	44.0	192	216	34	442	70.2
Average				**270**	**45.0**				**467**	**74.1**

Note: High (3), Moderate (2), Low (1) and Negligible (0), where 0 was excluded from the Table **(**Compiled from Survey Data, 2020)

Table 7.6above shows the IPCC-LVI sensitivity indicators which show the aggregated score below average (45 percent) for highland; 74.1 percent for lowland agro-ecology which clearly indicates highest degree of sensitivity at lowland area compared with highland farming system. Specifically, the declining trend of livestock productivity (78.7 percent) appear the highest in the lowland area followed by the declining situation of productive farmland used for seasonal crops which is the next top rated (78.3 percent) in the lowland block. Differently, the highest score which explains declining trend of livestock production in the context of highland area is about the average (51 percent), indicating the larger disparity between the highest score of the lowland and highland agro-ecology. Generally, the sensitivity indicators rating scores show that the lowland farming business is operating within a sensitive situation which is an alarming situation for policy makers and producers, and a signal that they need to look for better adaptation and mitigation strategies in order to alleviate the worst situation coming in the nearest future. Specifically, among sensitivity indicators, the highest score (70.2percent) identified in the case of decreasing crops production over time in lowland agro-ecology of the study area, is comparatively closer to the finding of Maponya (2012), who reported 91.3 percent, households' livelihoods disturbance and 89.3 percent of respondents who perceived crops yield reduction as the result of weather variability and climate change related consequences.

Table 7.7: Exposure rating in Respect to Climate Change Impact Vulnerability

Categories of effect indicator	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
Weather variability Frequency increased	21	262	52	335	55.8	357	162	10	529	84.0
Decline of Water availability and supply	171	158	54	383	63.8	234	226	19	479	76.0
Shortage of Irrigation water	261	64	49	374	62.3	237	158	42	437	69.4
Drought frequency increased in10 years	15	140	45	200	33.3	330	162	18	510	81.0
Increased Rain shortage frequency	27	124	83	234	39.0	324	164	19	507	80.5
Agricultural pest incidence increased	204	138	53	395	65.8	342	146	22	510	81.0
Family Natural resource base reduced	168	146	55	369	61.5	159	246	34	439	69.7
Average				**327**	**54.5**				**487**	**77.3**

Note: High (3), Moderate (2), Low (1) and Negligible (0), where 0 excluded from the Table **(Source: S**urvey Data, 2020).

Table 7.7 presented above is based on IPCC-LVI Exposure indicators with the intention to show the extent to which the community is exposed to bad climate condition and variability in the past ten years which ultimately leads to climate change related risks and impacts. According to collected and interpreted survey data, among the selected event indicators, frequent weather variability and change is found to be the highest (84 percent) in rating score in the lowland areas, while increased agricultural pest incidence is the indicator that scored highest (65.8 percent) within the highland agro-ecology. Nevertheless, overall, and aggregated score of exposure indicators for highland agro-ecology is about average level (54.5 percent) when compared with the highest (77.3 percent) of the lowland agro-ecology situation. This simple indicates that harmful situation needs new strategies and approaches to divert the negative impacts perfectly to come due to climate change related disasters and risks.

On the other hand, Adaptive capacity to climate change and weather variability has conceptualized as the ability to cope with new situations without losing future options, which IPCC noted as the dynamic capacity required to adapt to changing situation that commonly influenced by economic resources, natural resources, social networks, entitlements, institutional support, governance, human resources and technology accessibility (Trærup, 2010). The concept of adaptive capacity therefore seems inversely correlated with that of vulnerability, where the conceptual link between adaptation and vulnerability is constituted by adaptive capacity and thus, on these grounds, a system and community with high adaptive capacity could be adapting to new changes and possess low vulnerability to the impacts exerted from climate change (ibid). Remarkably, climate change and weather variability which affect the social, economic, and natural environments of the community is dependent upon the adaptive capacity of individuals and community as well as the broader institutional structural system (Adger, *et al*., 2011). The adaptive capacity of the community is the function of livelihoods, resources and technical dimensions of the community and service delivery system to influence the impact of climate change in a positive manner without affecting normal systems in the community. In this study, IPCC-LVI adaptive capacity indicators adopted and used to identify the most influencing factors in the study community and Table 6.8 shows the summary of the indicators based on the respondents' rating score which indicates the overall adaptive capacity of the community and most determinant factors.

Table 7.8: Community Level Climate Change Adaptive Capacity Indicators with Rating

Category of the indicators	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	3	2	1	Total	%	3	2	1	Total	%
Agricultural livelihood Diversification	102	172	77	351	58.5	99	260	44	403	64.0
Non-farm income diversification	15	76	84	175	29.2	39	190	60	289	45.9
Family Wealth (Assets)	63	134	95	292	48.7	30	142	71	243	38.6
Family level yearly income	54	200	69	323	53.8	30	216	75	321	51.0
Improved agricultural Technology	105	152	80	337	56.2	69	170	102	341	54.1
Technical capacity to manage strategy	99	194	59	352	58.7	54	178	84	316	50.2
Exposure to Technological support	108	126	91	325	54.2	60	194	85	339	53.8
Exposure to extension service support	129	202	50	381	63.5	63	242	59	364	57.8
Average				**317**	**52.8**				**327**	**51.9**

Note: Highly adequate (3), Moderately Adequate (2), Less Adequate (1) and in Adequate (0), where 0 is excluded from the Table

Regarding the adaptive capacity of the study community, the analyzed data presented in Table 7.8 shows that for highland agro-ecology exposure to extension service is the most important variable (63.5 percent) followed by technical capacity of the community to manage the adaptation and mitigation strategies and agricultural livelihood diversification with 58.7 percent and 58.5 percent, respectively. However, majority (62.5 percent) of the selected adaptive capacity components is rated within the range of the average level (around 50 percent score) by the respondents which is not encouraging level as compared to fast accelerating rate of climate change impacts and related consequences.

The signification is that there exists a moderate level adaptive capacity of the community to withstand the climate change related shocks and risks associated with community livelihoods. Similarly, the most important component for the lowland agro-ecology is agricultural livelihood diversification (64 percent), while the exposure to extension service (57.8 percent) and use of improved agricultural technology (54.1 percent) are rated ^{2nd} and 3rd levels respectively in the lowland blocks of the study community. Likewise, majority of the adaptive capacity components (62.5 percent) rated average level by survey respondents which shows similar trend with highland agro-ecology which is still an indication of the moderate level adaptive capacity of the community in the lowland study area. In these selected two agro-ecology, the overall and aggregated rating score is found to be in the average level with slight difference, that is, 53 percent and 52 percent for highland and lowland agro-ecology respectively showing moderate level adaptive capacity of the study community. Therefore, the ability of the study community to adjust to climate change, including variability and extreme, to moderate the potential damage, or to cope with the consequences seems to be about average. Consequentially, the community needs strategies to improve the adaptive capacity to higher level so that the system can remain sustainable in all aspects against climate change impacts. Finally, based on rigorous review of the related literatures, the livelihoods vulnerability indicators have been identified and established for this study, where the related data were analyzed and adequately presented in the Table 7.9 below accordingly.

Table 7.9: Livelihoods Vulnerability Indicators and Ratings in the Survey Community

Vulnerability Indicators	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	3	2	1	Total	%	3	2	1	Total	%
Agricultural production in danger	126	190	20	336	56.0	372	138	14	524	87.3
Lack of weather early warning	60	168	51	279	46.5	150	248	27	425	70.8
Frequent change of crops choice	144	166	51	361	60.2	96	284	30	410	68.3
Shortage of potable water	132	128	37	297	49.5	234	202	18	454	75.7
Shortage of Irrigation and facilities	261	86	53	400	66.7	270	138	40	448	74.7
Small farm landholding	39	132	73	244	40.7	153	150	49	352	58.7
Poor access to Extension services	45	116	119	280	46.7	213	168	36	417	69.5
Dependency on outsider	75	120	52	247	41.2	93	154	69	316	52.7
Inadequate access to credit service	48	102	106	256	42.7	84	200	52	336	56.0
Inadequate access to CC training	24	152	101	277	46.2	96	212	58	366	61.0
Lack of private land for family	90	122	73	285	47.5	93	190	69	352	58.7
Average				**297**	**49.0**				**400**	**66.7**

Note: High (3), Moderate (2), Low (1) and Negligible (0), where 0 excluded from the Table **(Source: S**urvey Data, 2020)

The result summarized in Table 7.9 above is handled based on IPCC-LVI vulnerability indicators with the intention of showing the degree at which the community is vulnerable to climate change and variability in past cropping seasons which eventually leads to social insecurity and disorder in the exposed community. As shown in Table 7.9 above, among the selected eleven vulnerability indicators, the danger related to agricultural production is the highest scored indicators (87.3 percent) in lowland block compared with shortage of irrigation water which is rated 66.7 percent for highland agro-ecology. The aggregated vulnerability score is found to be about average (49 percent) from bottom line for highland agro-ecology, while the lowland score (66.7 percent) is relatively higher and above average when compared with the count noted under highland.

7.5 Potential Impact of Determinants on Livelihood Vulnerability

(i) Vulnerability Determinant Assessment Using Livelihoods Vulnerability Indexing

The livelihood vulnerability analysis was conducted for two agro-ecologies separately and summarized accordingly in Table 7.10 below. For this purpose, a livelihood vulnerability index (LVI) was adapted to assess the overall vulnerability of the farming communities based on the sample households representing the highland and lowland agro-ecology of the study areas. The assessment was based on the measurement of eight major components and thirty-five subcomponents which ultimately contribute to the value of the three indicators. Each of the sub-components was measured according to appropriated scale for the particular component and thereafter, the sub-component values were indexed according to the model described in the methodology, in Chapter four (equation 4.2, 4.3 and 4.4 of the model specifications presented in the methodology chapter).

Table 7.10: Perceived Livelihood Vulnerability Situation in the Survey Community

Lead Indicators	**Number of Major components**	**Number of sub components**	**Major component index value**	
			Highland	Lowland
Adaptive capacity	3	12	0.444	0.525
Sensitivity	3	15	0.485	0.542
Exposure	2	8	0.448	0.601
Total	**8**	**35**	**1.377**	**1.668**
Livelihood Vulnerability Index (LVI)			**0.459**	**0.556**
LVI-IPCC vulnerability (e-a)*S			**0.002**	**0.041**

Source: Compiled from Survey Data (2020)

According to the result presented in Table above, the aggregated Livelihoods Vulnerability Index (LVI) values were found to be 0.459 and 0.556 for highland and lowland agro-ecology, respectively, indicating a bottom level moderate vulnerability to the impact of climate change for highland areas, and above moderate vulnerability level to the impact of climate change related risks in the context of lowland study community.

As shown in Table 7.10, the three contributing factors are adaptive capacity, sensitivity, and exposure to natural disasters. These factors contribute to the vulnerability of highland and lowland agro-ecology community, while the variation among the contributing factors is higher for lowland agro-ecology area compared to highland areas and community. Thus, the finding shows that lowland community livelihoods are highly vulnerable to climate change impacts as compared to highland community as a result of compounded effect of natural disasters and climate variability which are expressed as exposure to natural shock and weather variability in the study community (Table 7.10). The agriculture sector in the study communities is mainly dependent on rainfall amount and distribution that fit the requirement of crops to mature and livestock husbandry. With regard to this, the rainfall variability, especially deficit rainfall, as well as poor distribution increases the livelihoods vulnerability of the community, which subsequently result in poor productivity and low production from a unit of agricultural lands as compared to the crops varieties potential and attainable yields. On the other hand, the aggregated data analysis results are summarized in presented in Figure 7.1 below, which followed by its interpretation.

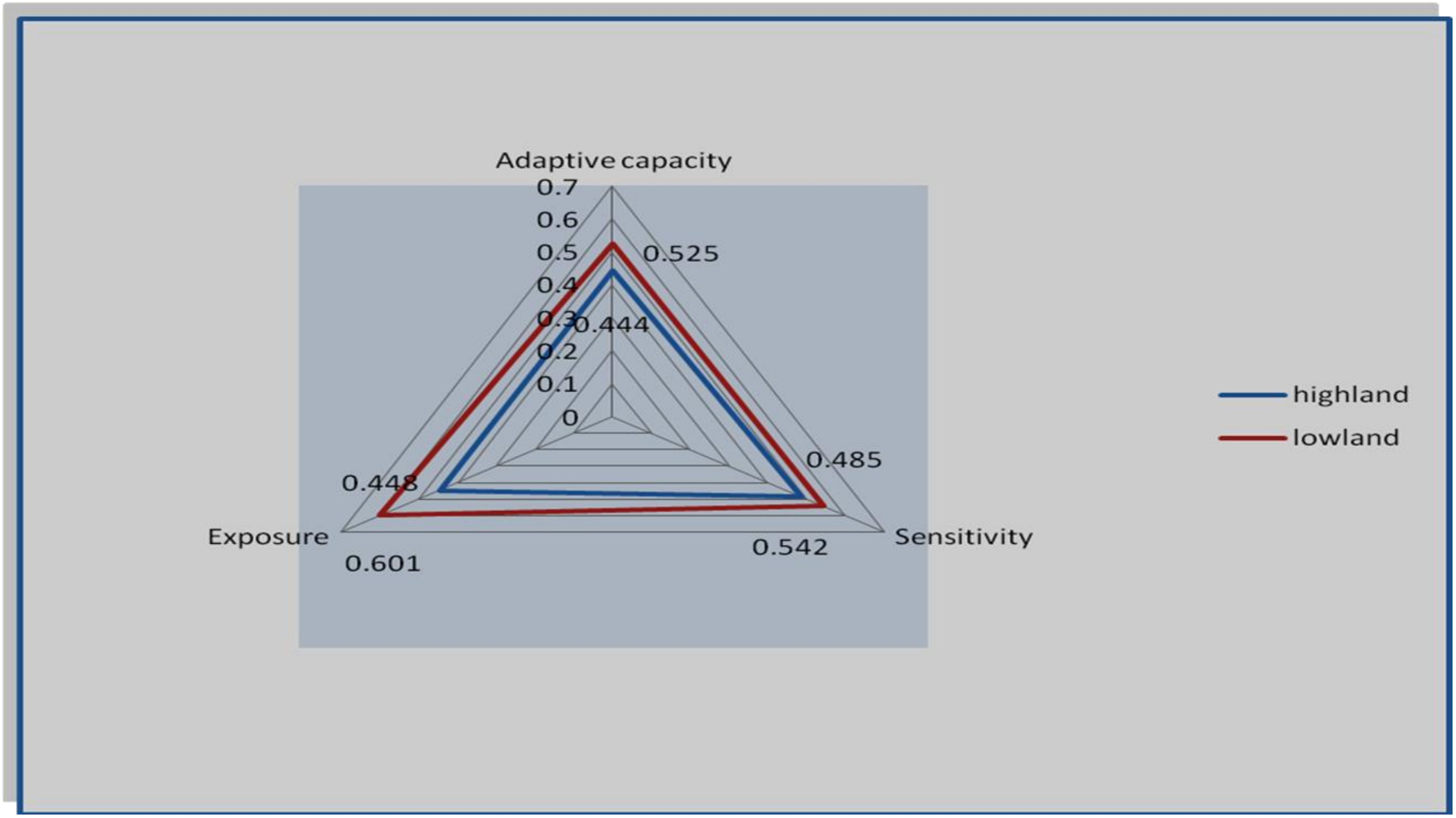


Figure 7.1: Aggregated Vulnerability Level for Highland and Lowland Agro-ecology (Compiled from Survey Data, 2020)

In accordance with the result, the highest value (0.601) of exposure and sensitivity (0.542) for lowland agro-ecology indicates the degree of burden or challenge that the local community is confronting in the process of sourcing for daily livelihoods, as compared to highland farming community. Likewise, the determinants of climate change impact vulnerability were assessed; where the results are presented in Figure 7.2 and 7.3 separately for highland and lowland agro-ecology, respectively. The intention behind the presentation of the two is to show the most contributing, moderate, and least contributing factors to the respective indicators and ultimately to overall livelihood vulnerability in respective of agrology with somewhat details of livelihoods vulnerability major components, while the values of sub-components are summarized separately for each sub-component (Appendix 4).

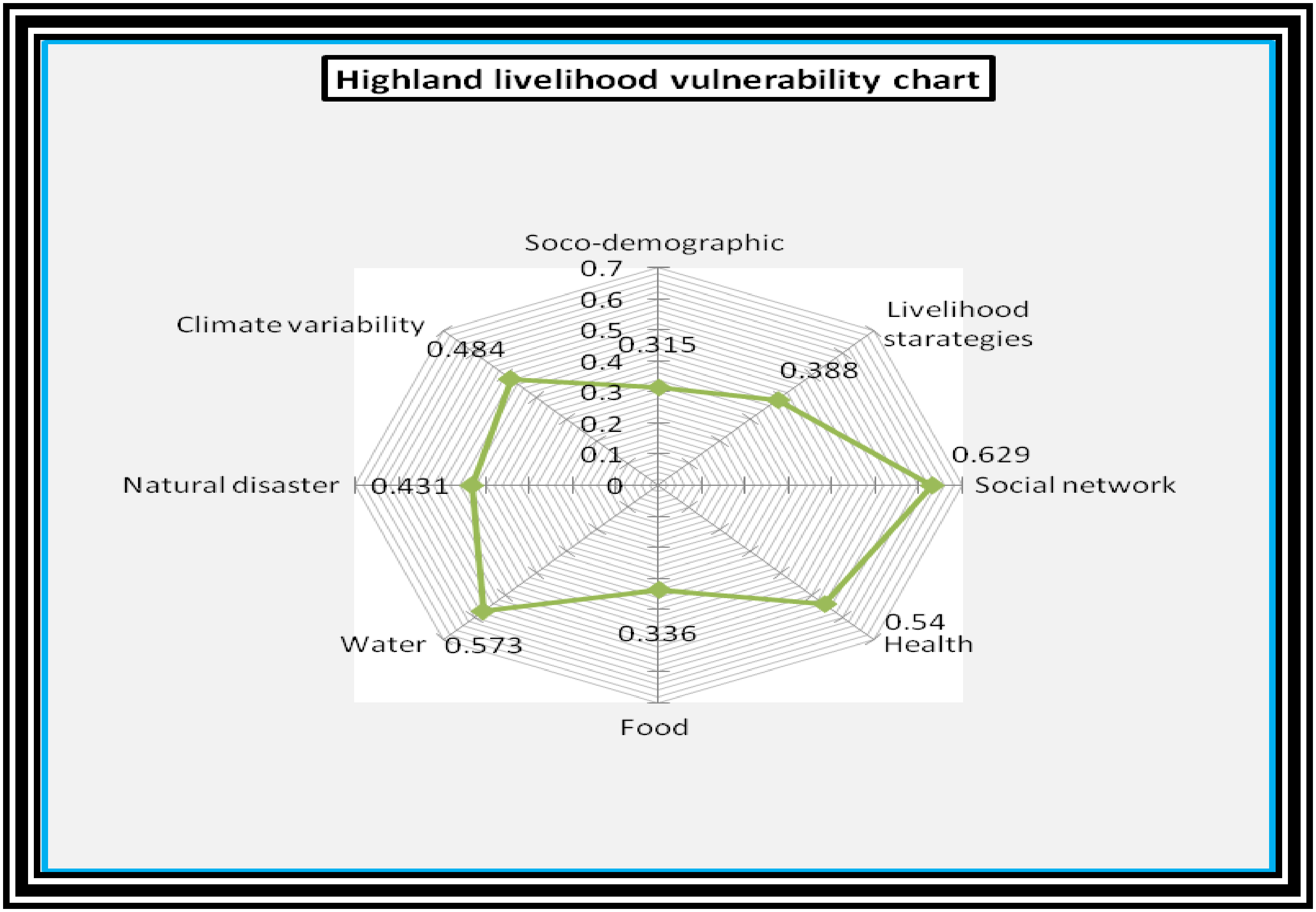


Figure 2.2: Arsi Highland Vulnerability Contributing Determinants (Source: Survey Data, 2020)

According to IPPC, there are eight major components that contribute to three vulnerability indicators: adaptive capacity, sensitivity, and exposure. They ultimately contribute to climate change impact vulnerability. With regard to this study, there are thirty-five sub-components, where each of them contributes to respective major component and ultimately to vulnerability contributing indicators, which are adaptive capacity, exposure and sensitivity of the social systems.

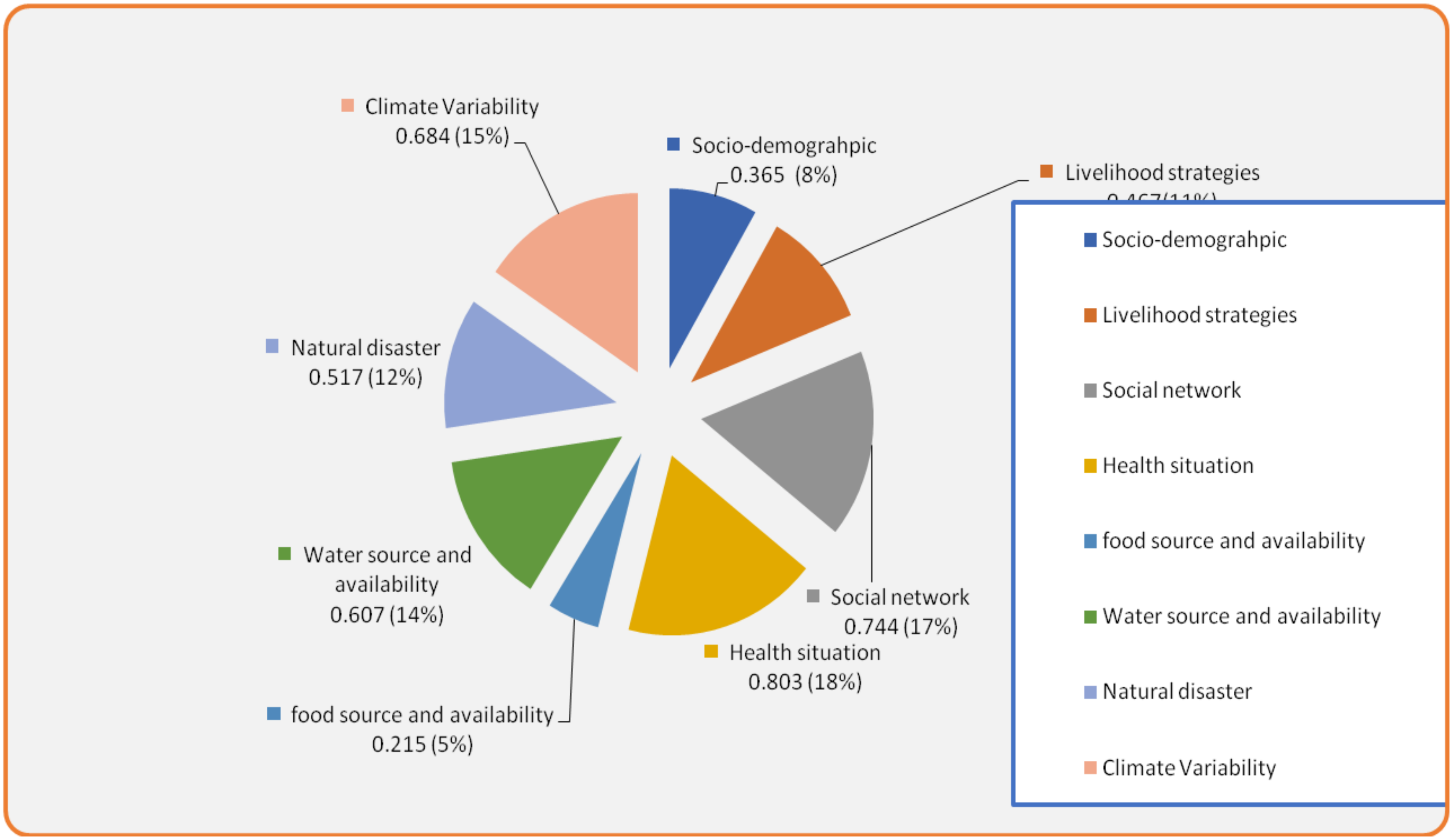


Figure 7.3: East shewa Lowland Vulnerability Contributing Determinants (**Source:** Survey Data, 2020)

As shown above in Figure 7.2 and 7.3, these major components include, demography, livelihoods strategies and social network, and they are the main contributors to adaptive capacity; in contrast, health, food and water are assumed to contribute to sensitivity; lastly, natural disaster and climate variability are the components identified that augment exposure in the specified vulnerability assessment approach. Likewise, according to this approach there are thirty-five sub-components which equally contribute to the respective major components. Generally, all the specified sub-components, including the summarized indexed values are presented in Appendix 4 of this thesis and accordingly, based on this Appendix in which the indexed value of all sub-components are summarized and presented; the result of each major component is presented and discussed in the below stated manners.

Socio-demographic component: According to IPCC, socio-demographic component is one of the major components that contribute to the adaptive capacity of the households and ultimately the community. In this aspect, the sub-components of this major component are dependence ratio, female headed households, head of household with no formal education, while each of them is indexed based on appropriate measurement and major component value summarized from these indices. Given this, the overall major component value for socio-demographic is within the values considered as lower for both highland and lowland agro-ecology, while there is no significant difference between the two agro-ecologies.

Livelihood strategies: It is a common approach; the major components of livelihood strategies include households' dependence only on natural resources, including agriculture, family member working in or out of the community and farming to generate additional income for the household, and average household livelihood diversification index. The findings of this study show that the livelihood strategies are functional and a major component moderating the vulnerability of farmers to climate change impact. Hence, the moderate level (0.467) for lowland area which is slightly higher than the highland value (0.388) showing a high magnitude of the climate change impact vulnerability at lowland area compared with highland farming system.

Social network: The social network is another aspect of adaptive capacity as the major component and this component is established to assess the effect of social interconnectedness with the climate change impact vulnerability through measuring the household social relationships and social supports. Accordingly, this major component consists of the assessment of the support given and received, borrowing and lending situation of the households and support from external structures and social responsibilities of the head of the household in social organization and these all sub-components are indexed to establish the contribution of this particular component. The indices and the summary of the result show extremely higher (0.744) for lowland farm households and also slightly higher (0.629) for highland agro-ecology. Justifiably, the contribution of this component observed from the studied findings for highland agro-ecology is the highest of all other remaining components within the same agro-ecology, and the second highest when compared with results of other components within the same agro-ecology for the lowland area and respective community.

Health: The three sub-components of the vulnerability due to health include, time taken to reach the nearest health facility centers, family having family members with chronic illness, family members experience of regularly missing works or school due to health problem which can affect the potential capacity of individual and households to generate the optimum income required to sustain the normal life of family members. In this aspect, the finding of this study reveals the highest contribution (0.803) at lowland while moderate effect (0.540) at highland agro-ecology contributing for the sensitivity indicator.

Food: Various studies have shown that food is one of the major components within the category of sensitivity indicator and it includes the sub-components like single dependence on family farm for household consumption, especially as the source of food for the family, grain storing experience of households, seed saving practices for seasonal consumption and proportion months that households cover yearly food demand from own sources especially from private farms. The indexed value of this major component looks generally lower at highland and lowland areas of the study and destructively lower (0.215) score for lowland agro-ecology. Thus, this, indicates the damaging situation that lowland farm households are confronting to survive and maintain their livelihood practices. However, better index score (0.336) observed at highland illustrates promising situation for highlanders compared with lowland situation. Overall, the lower score in both cases (highland and lowland) is the alarming condition which adversely affects the whole system of community, like change of lifestyle, migration within and outside the country. All these deepen the instability of social system and livelihoods, ultimately leading to chronic vulnerability of the community.

Water: Water is also an area of assessment utilized to rate the level of the community's vulnerability to climate change impacts and related risks. According to many findings, vulnerability in the context of water is directly related to rainfall variability, water resources availability and utilization. With regard to this, water constitutes a major component of sensitivity indicator, which also consists of five subcomponents, namely conflict over water resources, sustainability of water supply for household consumption, and time taken to access water sources in the community. The index summary of this major component indicates above average score situation in highland and lowland agro-ecology. However, the indexed score of highland (0.573) is closer to moderate when compared with lowland score (0.607) of vulnerability within the context of sensitivity which require immediate and adequate attention, and emphasis to maintain sustainable life and livelihoods of the community.

Natural disasters: Natural disasters include mainly natural hazards, excluding climate variability, and the prominent one is the damage related to flooding occurrence in the community. In most of the scholarly reports, natural disasters and climate variability are considered as the major components under exposure vulnerability function. Vulnerability score in situation of natural disasters was quantified based on the five sub-components; they are the average number of the flooding events in the past six years in the community, reported health related damage (Death and injury), implication of natural resources reduction at household level, reported property damage due to natural disasters, and accessibility to early warning about natural disasters. Accordingly, the overall vulnerability score of highland agro-ecology seems within the bottom range of moderate (0.431), showing relatively moderate vulnerability, while aggregated score of lowland area illustrates the upper level moderate (0.517) which is closer to unsafe range when considered frequent climate change and weather variability.

Climate Variability: As mentioned above, climate variability was treated separately with the intention of unwrapping the effect of this main component, in order to identify its direct contribution to community vulnerability in the context of climate change. Under exposure structure of the vulnerability assessment approach, climate variability was assessed based on two sub-components and the result of the analysis shows bottom range moderate (0.464) for highland agro-ecology, and as expected the highest score (0.684) is obtained for lowland agro-ecology. Thus, as traditionally assumed the rainfall variability and other climate related variables to variability contributed to a high level of climate variability components which ultimately increase the community level livelihoods vulnerability to climate change impacts.

(ii) Analysis of Livelihood Vulnerability Determinant Using Tobit Regression Model

Tobit regression model was selected and employed to analyze the determinants of livelihoods vulnerability to climate change and resultant impacts. In this aspect, wide range of livelihoods vulnerability documents were reviewed to establish commonly recognized livelihoods vulnerability indicators and included in Tobit regression analysis to determine the relationship of independent variable with dependent variables, which is livelihoods vulnerability in context of this study. The aggregated data (merged highland and lowland agro-ecology data) were used to analyze the determinants of livelihoods vulnerability in the context of these two locations and community. Accordingly, the indexed value of vulnerability component indicators scores was taken as a dependent variable, while socio-economic, technological variables and weather related parameters listed in the below Table 7.11, are considered as independent variables in Tobit Regression model. Deressa et al. (2011) submitted that rural households' vulnerability is explained by physical assets (livestock holding and housing units); financial assets such as access to credit, off-farm employment; social assets-savings and credit associations; human assets; like education, health, age, sex composition and family size, and natural assets such as mean rainfall, rainfall standard deviation and farm size.

The vulnerability indicator scores components (exposure, sensitivity and adaptive capacity) were indexed using the Principal Component Analysis (PCA) and indexed value of those variables has taken as dependent variables in Tobit regression model analysis. Similarly, CSA practices rates of adoption and minimum temperature parameters were indexed using the same technique (PCA) in order to reduce the dimension of variables score to single variables. In this regard, rainfall and maximum temperature parameters were used directly in Tobit regression analysis, while based on the multicollinearity effect observed in the process of data analysis and management, minimum temperature parameters were indexed using PCA technique. According to Tobit regression model estimate, among the effect of some socio-economic variables included in the model, only the effect of family size and age of households on livelihoods vulnerability was found positive influence indicating that as these particular variables increase in their measurement scale, the resultant effect tends to increase households' livelihood vulnerability in the context of climate change. In this regard, a unit increases in the scale of family size in the households, the vulnerability of the households tend to increase by a factor of 0.175 which is statistically significant at 1percent significance level, while a unit increase in the age of households heads tends to reduce the households vulnerability to climate change impacts by a factor of 0.067 which is statistically significant at 1percent significance level. This finding is somewhat consistent with other research findings, like Arega (2013), who asserted that an increases in family size of household heads tends to increase the odds of a household being vulnerable in the circumstance of climate change and weather variability.

Table 7.11 showed that among the two institutional supports (extension and credit) included in this analysis, dummy credit accessibility and supports were with positive association with climate change related livelihoods vulnerability, indicating that respondents with credit had a higher likelihood of increasing the vulnerability to climate change by about factor of 0.88 point, which is statistically significant at 1percent significance level, while the effect of extension support found statistically insignificant. This finding contradicts that of Arega (2013), who suggested that in the drought-prone areas of Ethiopia where crop production is highly affected by the amount and temporal distribution of rainfall, access to credit enhanced food gaps of households and helps households to diversify their livelihood options to cope with the resultant negative impacts of weather variability and climate change. Furthermore, almost all diversification approaches (crops, income sources and livelihoods diversification) found to reduce the livelihoods vulnerability related to prevailing climate change and linked impacts in the study community circumstances. Accordingly, income diversification and livelihoods diversification reduce the level of livelihoods vulnerability by a factor of 0.94 and 0.33, respectively, in the scale of livelihoods vulnerability measurement and the effect of both variables are statistically significant at 1 percent and 5 percent significance level, respectively.

Table 7.11: Tobit Regression Analysis of the Determinants of Livelihoods Vulnerability

Explanatory variables	**Inferential statistics**			
	Coefficient	**Std. Err**	**t-value**	**p>/t/**
Agro-ecology	-3.830	4.662	-0.820	0.412
Age of the HHs head	-0.067	0.015	-4.460	0.000***
Education level of Households head	0.164	0.120	1.360	0.175
Family size of Households	0.175	0.056	3.140	0.002**
Crop diversification	-0.003	0.102	0.030	0.979
Alternative income source	-0.935	0.297	3.150	0.002**
Livelihood diversification	-0.330	0.129	2.570	0.011**
Drought frequency	0.419	0.106	3.970	0.000***
Farm size of Households	-0.032	0.090	-0.360	0.720
Extension Support	-0.105	0.182	0.580	0.565
Credit Support	0.882	0.255	3.450	0.001***
Rainfall mean	-0.018	0.010	-1.830	0.068*
Rainfall standard deviation	0.173	0.166	1.040	0.300
Rainfall coefficient of variation (CV)	100.380	84.628	-1.190	0.236
Maximum Temperature Mean	0.449	0.640	0.700	0.483
Max Temp Coefficient of Variation (CV)	121.207	136.916	-0.890	0.377
Minimum Temperature Index	-0.027	0.299	-0.090	0.929
CSA Practices adoption Index	-0.057	0.124	-0.460	0.647
Constant	**0.725**	**18.067**	**0.040**	**0.968**

Log Likelihood -------------------------------- 910.078
LR chi-square (X^2) --------------------------- 133.030
Prob>chi-Square (X^2) ---------------------------0.000
Pseudo R^2 --0.068

Regarding to weather factors, the majority of selected weather related parameters, such as rainfall mean standard deviation, rainfall coefficient of Variation (CV), maximum temperature mean and maximum temperature coefficient of variation (CV) found positive association with livelihoods vulnerability to climate change, indicating that a unit increase in particular weather parameters mentioned above tends to increases the likelihoods of the livelihoods vulnerability with the proportional amount of coefficient mentioned in respective of variables indicated in the Table 7.11 above, but the effect of majority found statistically insignificant except mean rainfall which found statistically significant. In this regard, a unit increase in mean rainfall tends to reduce the level of livelihoods vulnerability to changing in climate parameters by a factor of 0.018 in the scale of livelihoods vulnerability and statistically significant at 1percent significance level. In similar manner, the effect of drought frequency was found positive to livelihoods vulnerability in perspective of climate change, in which an increase in the frequency of drought, increase the level of livelihoods vulnerability by a factor of about 0.42 point indicating the significant impact of drought on community livelihoods vulnerability and ultimately on the national economy, where the effect is significant at 1percent significance level.

7.6 Chapter Summary

Climate change impacts and vulnerability were investigated, emphasizing on the biophysical, social, and economic aspects. The results showed that the majority of the respondents from highland and lowland perceived high and very high level of negative change in climate components, while only a few proportion of the respondents perceived moderate negative change in climate parameters. More notably, about 55 percent and 68.3 percent of highland and lowland households, respectively, perceived late on-set of seasonal rainfall, Additionally, the significant majority of the respondents from lowland community perceived reduction in the number of rainy days. Additionally, social level impact of climate change and weather variability were analyzed based on resultant effects that manifested in the social systems. In this aspect, about 34 percent and 37.6 percent of highland and lowland respondents considered external migration (migration outside the country) as the consequences of climate change and weather variability, while 26.2 percent and 55.9 percent of highland and lowland respondents predicted internal migration (within the rural community) caused as the result of climate change. Again, 42.3 percent and 52.3 percent of highland and lowland respondents revealed outside rural community migration (to urban community within the country) to survive prevailing hard time condition caused as the result of the climate change and weather variability.

CHAPTER EIGHT

CLIMATE SMART AGRICULTURE PRACTICES ADOPTION AND SUSTAINABILITY

8.1 Introduction

This chapter presents the results of data analysis on adoption of climate smart agricultural practices and sustainability perceptions. The chapter presents the estimates of adoption sustainability of climate change management related agricultural practices and innovation introduced and adopted. Accordingly, the chapter explains the rate of adoption and perceived adoption sustainability across selected demographic, economic, and environmental variables.

8.2 Comparison of CSA Practices in the Context of Adoption

8.2.1 General Overview of CSA Practices Adoption

Adoption decision is a function of different, but interlinked factors among which extension services support extended to farmers are notable. Technology adoption is required to facilitate changes in farming systems for improved agricultural productivity. In this view, extension services are the most important factors that enhance and facilitate the decision-making intention of a farming community to adopt agricultural production practices which usually supported and influenced by extension projects and programs. Nevertheless, as shown in Table 8.1a and b, the participation level of the respondents in regular extension programs and/or projects is significantly below the strategic goal established in the national extension strategy which have been set to attain 90 percent or above participation and satisfaction. In this regard, the majorities of the respondents, that is 79 percent from the highland community and 58 percent from lowland agro-ecology had never participated in any kind of CSA related projects or program for the past cropping seasons. On the other hand, among the selected respondents, 39 percent from the highland community and 58 percent of the farmers from lowland community are unaware of CSA practices and innovation.

This ignorance adequately explains the reason behind the inadequate adoption of SCA practices in the study community. More importantly, as shown in Table 8.1a, a significant proportion (58 percent) in highland and (59 percent) of the lowland respondents perceived that they did not achieve the intended and expected benefit from the introduction of CSA practices into the community farming systems. Thus, this indicates that their failure to adopt the CSA practices is probably because of inadequate services provision, limitation related to strategy, policy related bottleneck, and/or inadequacy in appropriate (social and environmental perspective) innovation, programs and project selection in context of these communities. Equally important is the participation of the farmers in the CSA extension regular program and/or projects. It is important because it matters much to the level of innovation adoption and sustainability in the community. To that end, out of the total respondents, cumulatively 91 percent of those from highland and about 68.5 percent of those from lowland have been involved in regular extension program and/or project for not more than 3 years, while of this group 70 percent and 49.5 percent of highland and lowland community, respectively had no participation in any development initiatives for past ten cropping years.

Table 8.1a: Participation of the Respondents in CSA Related Project or Regular Program (N=410)

Category of Variables	**Highland agro-ecology**				**Lowland agro-ecology**			
	Yes, adequately		No, not at all		Yes, adequately		No, not at all	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Participation in CSA related project or regular program	42	21.0	158	79.0	89	42.4	121	57.6
Introduction of CSA practices and Innovation to respondents	120	60.0	78	39.0	88	41.9	122	58.1
Success in achieving intended benefits from introduced practices	85	42.5	115	57.5	86	41.0	124	59.0
Farmers decision to use introduced CSA practices (overall adoption)	71	35.5	129	64.5	73	34.8	137	65.2
Recognized coping mechanism availability in the community	163	81.5	37	18.5	174	82.9	36	17.1

Source: Compiled from Survey Data (2020)

Table 8.1b: Farmers' Project or Program Participation Experiences in Years (N=410)

No	**Participation Years**	**Highland**			**Lowland**		
		Frequency	Valid %	Cumulative %	Frequency	Valid %	Cumulative %
1	No participation	140	70	70.0	104	49.5	49.5
2	1-3 years	42	21	91.0	40	19.0	68.5
3	4-6 years	14	7	98.0	49	23.3	91.9
4	7-10 years	4	2	100.0	17	8.1	100.0
	Total	**200**	**100**	**100.0**	**210**	**100.0**	**100.0**

Source: Compiled from Survey Data (2020)

On the other hand, of total respondent only 7 percent of highland community respondents and 23.3 percent of lowlanders suggested 4-6 years of project/program experience, while the rest, only 2percent of the highland and 8.1 percent of lowland respondents are the category of the respondents that have had the attachment of more than 70 years and below 10 years with CSA related regular extension program or project in the study community (Table 8.1b), which is sufficient to conclude the inadequacy of development projects/programs to promote the development strategies related to climate change management. Furthermore, the overall statistical analyses for some selected CSA strategic practices were conducted and presented in Table 8.2 in order to make relative comparison between different practices in respect to farmers' adoption behavior in the two study agro-ecologies. As shown in Table 8.2, about

81.5 percent and 88.9 percent of the farmers in the highland and lowland respectively adopted crop rotation. Certainly, the adoption rates of crop rotation in these two agro-ecologies are encouraging when compared to other practices. However, on the contrary to crop rotation, the adoption rate of some practices observed under the highland agro-ecology, like small-scale irrigation (11 percent), improved rangeland management (17 percent) and water harvesting (30 percent) are very low when compared with other practices. Similarly, the lowest adoption rate of some practices, such as 12.6 percent for agricultural insurance, 15.9 percent for small-scale irrigation and 28.2 percent for fallow farming practices are also low in the lowland represented study households and community.

Table 8.2: Comparison of Different CSA Practice Adoption (N=410)

Selected practices	**Highland agro-ecology**				**Lowland agro-ecology**			
	Adopter		Non-Adopter		Adopters		Non-Adopter	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Minimum tillage	70	35.0	130	65.0	129	62.0	79	38.0
Crops rotation	163	81.5	37	18.5	185	88.9	23	11.1
Inter cropping	123	61.5	77	38.5	86	41.3	122	58.7
Fallow farming	89	44.5	111	55.5	58	28.2	148	71.8
Crop residue management	136	68.0	64	32.0	83	39.9	125	60.1
Small-scale irrigation	22	11.0	178	89.0	33	15.9	174	84.1
Improved range land management	34	17.0	166	83.0	53	25.6	154	74.4
Water conservation practices	89	44.5	111	55.5	90	43.3	118	56.7
Water harvesting practices	60	30.0	140	70.0	61	29.6	145	70.4
Adaptable crop varieties	116	58.0	84	42.0	122	58.7	86	41.3
Adjust planting time	121	60.5	79	39.5	142	68.6	65	31.4
Crop varieties diversification	129	64.5	71	35.5	60	28.8	148	70.5
Agricultural insurance	83	41.5	117	58.5	26	12.6	181	86.6

Source: Compiled from Survey Data (2020)

Unarguably, the low rate of adaptation (below 50 percent) for some majority of total assessed practices identified in most of the CSA practices is very low and certainly will lead to low production in crop and livestock farming practices in addition to ecosystem related impacts. On the other hand, adoption rate of within the range of 50-65 percent , were observed in the case of adaptable crop variety adoption(58 percent), planting time adjustment (60.5 percent), inter-cropping (61.5 percent) in perspective of highland agro-ecology and adaptable crop variety adoption (58.7 percent) and minimum tillage (62 percent) in the lowland area are found intermediate, which require the adequate attention to further intensify the effort in order to attain optimum adoption rate which ultimately contributes to farm productivity and production improvement. Amazingly, some of the CSA practices adopted by the government better adopted at lowland agro-ecology as compared to highland. For instance, minimum tillage, adaptable crop variety adoption and planting time adjustment are among better adopted practices in the lowland areas of the study, which is encouraging from the point of disastrous climate change effect in the lowland areas of the country that commonly manifested in the form of drought events and associated consequences.

A range of study conducted focusing on adoption adequately elaborated the impacts of contemporary project and program on technology adoption and sustainability in the context of small-scale farmers. For instance, Gerishu (2007) asserted based on the study conducted on soil and water conservation (SWC) practices adoption, where of total farmers who had more than five years' experience in conservation projects, the majority (about 83 percent) were found to adopt SWC practices and innovation. On the other hand, Jabbar, Ziauddin and Abedin (2011), asserted that for technologies which were more vigorously promoted through knowledge dissemination and input supply, both incidence of knowledge and adoption increased significantly in the project areas.

8.2.2. Regressions Analysis and Discussion in Context of CSA Practices Adoption

(i) Agro-ecologically Disaggregated Binary Logistic Estimates

In the process of carrying out logistic regression analysis to look for fitting model for particularly selected variables among the total independent variables, different techniques and tools were employed to establish relatively more fitting regression line to determine the relationship between dependent and independent variables included in the model. The dependent variable which is adoption of Climate Smart Agricultural (CSA) practices was taken as categorical (dichotomous) variable with binary representation; while independent variables included in the model were a mixture of continuous and categorical variables that were arranged in binary manner. Therefore, in this model building process, different continuous and dummy explanatory variables were included in the logistic distribution model. Based on the adoption rates that were identified under this chapter (section 8.2.1 and Table 8.2), CSA technologies and practices that were well adopted (ranked 1^{st} to 4^{th}level) have selected and included in the binary regression model analysis and the following subsection presents and discussed the model output of the estimation against each variable included in the models for the agro-ecologies. The usual procedure was to first test for multicollinearity among the variables. To this end, tolerance (TOL) and variance inflation factor (VIF) testing techniques were employed (Appendices 1 and 2), and the result of this diagnostic analyses indicated that there was no serious existence of multicollinearity among the included variables since the tolerance levels for variables were more than 0.1 and VIF were less than 10 (Menard, 1995). In addition, the analysis for correlation coefficient shows similar weak co-linearity among the variables. Due to this reason, marital status was excluded from the model based on the magnitude of their contribution to the logistic regression model to influence the change in odd ratio of technology adoption. In generalized term, there was no indication of serious and significant multicollinearity between explanatory predictors and after the mentioned variable was omitted from regression model, co-linearity effects were found insignificant among variables. Therefore, those variables tested for Multicollinearity and found statistically insignificant were included to predict fit model for this study and the model outputs have been adequately summarized and presented in the following below presented manner in the tables (Table 8.3a and b).

Table 8.3a: Parameter Estimate for Adoption of Two Top CSA Practices at Highland Agro-ecology

Explanatory variables	Crops Rotation (1st)				Crops residue management (2nd)			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondent Age	-0.078	2.869	0.925	0.090*	0.005	0.022	1.005	0.883
Education Level	-0.517	5.151	0.596	0.023**	0.114	0.433	1.121	0.510
Respondent Gender	-0.600	1.039	0.549	0.308	-0.628	1.733	0.534	0.188
Family Farm Size	-0.130	0.332	0.878	0.564	-0.146	0.655	0.864	0.418
Livestock holding	0.010	1.463	1.010	0.226	-0.021	1.366	0.979	0.242
Non Agric Income	0.000	1.667	1.000	0.197	0.000	2.047	1.000	0.153
Farming Experiences	0.042	0.871	1.043	0.351	-0.027	0.784	0.973	0.376
Family Size	-0.122	1.486	0.885	0.223	0.015	0.039	1.015	0.844
Extension Support	0.206	0.459	1.229	0.498	0.099	0.167	1.104	0.683
FTC Distance	-0.414	5.341	0.661	0.021**	-0.122	1.634	0.885	0.201
Credit Facility	0.573	1.646	1.774	0.199	0.107	0.091	1.113	0.763
Project Experience	0.827	3.099	2.287	0.078**	0.039	0.007	1.039	0.931
Constant	2.190	1.27	8.94	0.26	-0.05	0.01	0.95	0.97
-2 Log likelihood				154.379				228.327
Hosmer and Lemshew test (Chi-square(X^2))				18.615***				14.012*
Test of model coefficient (Chi-square (X^2))				35.939***				18.599*

Source: Compiled from Survey Data (2020)

The Wald Chi-Square Statistic was used to determine the goodness of fit of the models estimates. This tests the unique contribution of each predictor, in the context of the other predictors, which means by holding the other predictors constant for eliminating any overlap between predictors' effects. It can be realized from the -2Log Likelihood statistical results, adding those selected explanatory variables in the regression model have improved the model estimate accuracy and precision in almost all CSA practices selected to be test in highland farming community contexts (Table 8.3a and b). In addition, in all cases the model Chi-square (X^2) appeared statistically significant, indicating that including selected explanatory variables significantly reduced the log likelihood ratio of the model when compared with the model established using only intercept. Noticeably, according to these results, the -2Log Likelihood statistic has dropped (reduced), indicating that the new expanded model is better at predicting adoption decisions than it was with only intercept predictor in logistic regression model in the case of highland area of the study. As it can be realized from

Tables 8.3a presented above (concerning highland study community situations), there are varieties of model outputs, with some of them outlying from initial assumptions and traditional expectation.

Table 8.3b: Parameter Estimate for Adoption of Two Immediate Top CSA Practices at Highland Agro-ecology

Explanatory variables	Crops varieties diversification (3rd)				Intercropping (4th)			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondent Age	0.046	2.077	1.047	0.150	0.023	0.582	1.024	0.445
Education Level	0.030	0.033	1.031	0.857	0.022	0.019	1.023	0.890
Respondent Gender	0-.054	0.014	0.948	0.905	0.757	3.238	2.132	0.072*
Family Farm Size	-0.287	2.565	0.751	0.109	0.255	2.423	1.291	0.120
Livestock Holding	-0.026	1.826	0.975	0.177	-0.001	0.044	0.999	0.833
Non Agric Income	0.000	4.392	1.000	0.036**	0.000	1.002	1.000	0.317
Farming Experience	-0.030	0.941	0.971	0.332	-0.026	0.739	0.975	0.390
Family Size	0.041	0.327	1.042	0.567	-0.201	7.706	0.818	0.006***
Extension Support	-0.325	1.872	0.723	0.171	-0.203	0.817	0.817	0.366
FTC Distance	-0.133	2.108	0.876	0.147	0.034	0.168	1.035	0.682
Credit Facility	0.042	0.014	1.043	0.905	0.077	0.051	1.080	0.822
Project experience	-0.654	1.476	0.520	0.224	0.511	1.575	1.666	0.210
Constant	0.436	0.083	1.546	0.773	-0.595	0.173	0.552	0.677
-2 Log likelihood				231.957[a]				243.928 [a]
Hosmer and Lemshew test (Chi-square (X^2))				10.296**				13.249
Test of model coefficient (Chi-square (X^2))				24.413**				19.710*

Source: Compiled from Survey Data (2020)

Accordingly, the results show that the gender of the households' heads, distance of Farmers Training Centers (FTCs) from farmland, Family size, farm size and livestock holdings of the households have negative association with almost all CSA practices (Crops rotation, crops residue management, crops variety diversification and inter-cropping) adoption decision in this agro-ecology under discussion. Beside this, some of the households' characteristics, like age of households head, education level of the respondents, farming experiences, project experiences of the family and even the extension support have negative relationship with some CSA adoption decision (Table 8.3a and b), among which the observed negative association of educational level of the respondents' farming experience of the households, project experience of the households and extension support relationship were found to be out of expectation and rare in other research findings in which most of them reveal their positive linkage with technology and innovations adoption decision.

On the other hand, the impact of household age, educational level, distance of FTCs from the farmland and project year of the households on crop rotation adoption decision were statistically significant at 10 percent for age and 5 percent for the remaining other variables, while the effect of non-agriculture income on crop variety diversification is significant at 5 percent and the effect of gender and family on inter-cropping adoption found statistically significant at 5 percent level. According to survey findings summarized concerning the highland study community, the remaining socio-economic variables estimated in the model was statistically non-significant, without denying customarily recognized potential effects and influences on technology adoption decision of the survey households (Table 8.3a and b).

Table 8.4a: Parameter Estimate for Adoption of Two top CSA Practices at Lowland Agro-ecology

Explanatory variables	Crops Rotation (1st)				Adjust crop planting time (2nd)			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondent Age	0.050	0.633	1.051	0.426	-0.107	6.759	0.899	0.009***
Education Level	-0.065	0.082	0.937	0.775	-0.166	1.050	0.847	0.305
Gender of Households	0.527	0.394	1.694	0.530	-0.514	0.534	0.598	0.465
Family Size of households	0.184	1.431	1.202	0.232	0.024	0.059	1.024	0.808
Farm Experiences	-0.045	0.749	0.956	0.387	0.074	4.163	1.077	0.041**
Farm Size of households	-0.431	3.193	0.650	0.074*	-0.165	2.466	0.848	0.116
Livestock Holdings	-0.002	0.024	0.998	0.876	0.018	4.083	1.018	0.043**
Non-agriculture income	0.000	1.661	1.000	0.197	0.000	1.419	1.000	0.234
Project Experience in years	0.286	0.216	1.330	0.642	-0.610	2.039	0.543	0.153
Farmers Training Center distance	0.145	2.479	1.156	0.115	-0.026	0.143	0.974	0.706
Credit accessibility	1.045	2.928	2.842	0.087*	0.647	3.014	1.910	0.083*
Extension Support	0.778	3.961	2.177	0.047*	0.457	3.269	1.579	0.071*
Constant	**-7.837**	**6.133**	**0.000**	**0.013****	**1.828**	**0.824**	**6.219**	**0.364**
-2 Log likelihood				113.544[a]				220.078[a]
Hosmer and Lemshew test (Chi-square(X^2))				9.004				12.607
Test of model coefficient (Chi-square (X^2))				19.932*				23.795**
Overall correct prediction				79.6%				67.0%
Sensitivity prediction				98.9%				94.9%
Specificity prediction				13.6%				10.8%

Source: Compiled from Survey Data (2020)

As it can be realized from the model outputs of lowland agro-ecology (Table 8.4a and b), adding those selected explanatory variables in regression equation adjusted the -2Log Likelihood statistic for each CSA practice adoption decision of the original model. In addition, the model chi-square appeared statistically significant, indicating that including the selected explanatory variables, it significantly reduced the log likelihood ratio of the model when compared with the model established used without independent variables. Noticeably, the -2Log Likelihood statistic has dropped (reduced), indicating that new expanded model is better at predicting adoption decisions than it was with only intercept predictor in logistic regression model.

Table 8.4b: Parameter Estimate for Adoption of Two Immediate Top CSA Practices at Lowland Agro-ecology

Explanatory variables	**Minimum Tillage (3rd)**				**Climate change adaptable varieties (4th)**			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondents age	0.025	0.351	1.025	0.554	-0.037	1.012	0.964	0.314
Education Level	0.393	5.567	1.481	0.018	-0.080	0.277	0.923	0.599
Gender of households	-0.478	0.346	0.620	0.557	-0.058	0.009	0.944	0.924
Family size of Households	-0.128	1.349	0.880	0.246	-0.034	0.142	0.967	0.707
Farm experience of households	0.001	0.001	1.001	0.980	0.014	0.197	1.014	0.657
Farm size of households	0.520	17.683	1.681	0.000	0.089	1.103	1.093	0.294
Livestock holdings	-0.001	0.006	0.999	0.939	0.025	6.738	1.025	0.009***
Non-agriculture income	0.000	4.987	1.000	0.026	0.000	3.341	1.000	0.068*
Project experience in years	-0.247	0.333	0.781	0.564	0.396	1.094	1.486	0.296
Farmers Training center distance	0.022	0.094	1.023	0.760	-0.019	0.084	0.981	0.773
Credit accessibility	-0.161	0.181	0.851	0.671	0.628	3.320	1.874	0.068*
Extension Support	0.384	1.690	1.468	0.194	0.076	0.099	1.079	0.753
Constant	**-2.056**	**0.793**	**0.128**	**0.373**	**-0.594**	**0.106**	**0.552**	**0.744**
-2 Log likelihood				201.295[a]				245.751[a]
Hosmer and Lemshew test (Chi-square(X^2))				16.141**				22.523***
Test of model coefficient (Chi-square (X^2))				61.348***				20.715**
Overall correct prediction				89.6%				70.1%
Sensitivity prediction				88.6%				89.8%
Specificity prediction				65.4%				42.2%

Note: - ***, ** and * significant at p< 1%, p<5% and P<10%, respectively.

On the other hand, based on the default threshold of 50 percent classification rule, SPSS program was classified a subject into the adoption category if the estimated probability is 50 percent or more and classified a subject into the non-adopters' category if the estimated probability is less than 50 percent. Accordingly, the classification table shows that this rule allows to correctly classify between 70.1 to 98.9 percent (98.9 percent crop rotation, 94.1 percent planting time adjustment, 89.8 percent climate change adaptable crop variety adoption and 88.6 percent minimum tillage adoption) of the subjects where the predicted event (adoption) was observed, which is known as the sensitivity of prediction or correctly predicted event, that is, the percentage of occurrences correctly predicted (Table 8.4a and b). We also see that this rule allows to correctly classifying 50 percent of the subjects where the predicted event was not observed which is known as the specificity of prediction or correctly predicted event, that is, the percentage of non-occurrences correctly predicted ranging from 10.8 to 65.4 percent. This means, 65.4 percent minimum tillage, 42.2 percent adjusting crop planting time, 13.6 percent crop rotation and 10.8 percent climate change adaptable crop varieties adoption were correctly predicted by regression models. On the other hand, overall prediction of models was found correct more than 67 percent, which means for an overall success rate of between 67 to 89.6 percent (67 percent adjusting crop planting time, 70.1 percent climate change adaptable crop varieties adoption, 79.6 percent crop rotation and 89.6 percent minimum tillage adoption) which is relatively high when compared with that of original model that is established only with intercept (Table 8.4a and b). The Hosmer-Lemeshow technique is the tests of the null hypothesis that states there is a linear relationship between the predictor variables and the log odds of the criterion variable, which means expected frequencies are computed based on the assumption that there is a linear relationship between the weighted combination of the predictor variables and the log odds of the criterion variable. A chi-square statistic is computed comparing the observed frequencies with those expected under the linear model. A mixed chi-square (X^2) of the models (non-significant in 1st and significant in 2nd table two practices) which is the Hosmer-Lemeshow test, indicates that the available data fit the model well in this particular study in contrary to null hypothesis that suggested no significant difference between new model and original regression model which is established only with intercept and disproved the assumption of linear relationship between the log odds (probability) estimate and predictor variables.

From regression analysis credit for climate change adaptation was found to be the leading variable in contributing to change in odds ratio of the CSA practices adoption with odds ratio of 2.842 for crop rotation, 1.910 for adjusting the planting time and 1.874 for climate change adaptable crop varieties, while this first place was taken by farm size in the case of minimum tillage with 1.681 odds ratio as an adaptation strategy in the lowland agro-ecology. In this regard, the odds ratio found for accessibility of farmers to credit facilities for climate change adaptation indicates that the odds of approval (adoption) are higher for each one-point increase in respondent's accessibility to any kind of credit sources compared to other predictors. That is, for each one-point increase on the credit accessibility scale, there was a higher time increment in the odds that the respondent would adopt the CSA practices as compared to other predictors. Furthermore, extension support was found to be 2nd level in the context of odds ratio in the case of crops rotation and adjusting planting time of the crops and comes 3rd level in the case of minimum tillage and climate change adaptable crop varieties adoption, while educational level of the head of the households and project experiences are 2nd in respect of these two last CSA strategic practices.

On the other hand, the analysis demonstrated that the odds ratio of farm size, project years, gender of the households' heads and educational level of the respondents were the smallest of all against crops rotation, adjusting of crops planting time, minimum tillage, and climate change adaptable crop varieties adoption, respectively in this particular agro-ecology (Table 8.4a and b). Concerning the direction of influences, as enunciated in the results presented in the indicated Tables above, the coefficient of each variable indicates whether the variable has negative or positive effect on the dependent variables of interest and different effects identified among which some of the effects are different from the initial prediction and experiences. For instance, the odds ratio of farm size effect on crop rotation is the smallest of all, with the opposite direction, indicating that with a one-point increase on the farm size scale being associated with the odds of disapproving (non-adoption) of the crops rotation would increase by a multiplicative factor of 0.65 point, where the effect of this variable is found to be positive in some of the other study findings. For the gender of households (dummy variable), the 0.62 odds ratio means that the odds (probability) of disapproval of the minimum tillage adoption would increase by this point as binary dummy changed to one point.

Furthermore, as shown in Table 8.4a, among the rest of the explanatory variables included in the model, ten explanatory variables (education level, FTCs distance from the farm land, farm land size, farmers experience in farming, livestock holding, gender of the households, age of the respondents, project years, family size and credit accessibility) have different unique contribution of odds ratios to the expanded model that varies between less than one, indicating positive or negative association between predictors and adoption of the respective CSA practices, while the rest contribute one and more to the probability of approval or disapproval. In this aspect, some other explanatory variables such as credit accessibility, extension supports, project years, gender of the household heads, farm experiences, family size, educational level, livestock holdings and age of the respondent in general, or in some cases influence the odd ratio of technology adoption by more than one factor, indicating negative or positive association between explanatory variables and binary CSA practices adoption.

Largely, more than average explanatory variables, about 66.7 percent of crop rotation crops, 50 percent adjusting planting time, 58.3 percent for minimum tillage and climate change adaptable crops varieties adoption of explanatory variables, provided positive association with independent variables among these, extension support and non-agriculture income were found to be as predicted (hypothesized) in the model specification section of this research, while others were as predicted in some cases and different in other cases, showing inconsistency of relationship with independent variables of interest. For instance, the observed result of the distance of FTCs from farmland is in opposite direction in the case of crop rotation and minimum tillage to hypothetical proposal which suggested a negative association with technology adoption, but consistent in the case of planting time adjustment and climate change adaptable crop variety adoption. The proposed reason for this outcome is that in most cases in these study areas, CSA activities are largely carried out by soil and water conservation (SWC) related project rather than regular extension program or extension package program, and usually the implementation procedures depend on the nature and distribution of soil degradation rather than climate change impacts including the related social and economic penalties.

On the other hand, the significance of the included explanatory variables effect was determined using formal statistical procedures employed anywhere to determine the effect of variables. Consequent upon that, out of the selected twelve explanatory variables, almost all were found statistically insignificant at any probability levels. Specifically, the coefficient of the age of respondents had a positive effect on crop rotation and minimum tillage, while a negative influence was observed on the planting time and climate change adaptable crop variety adoption, but the effect was statistically insignificant at any percent significance level among the variables included. Similarly, the association of two explanatory predictors (gender and distance of FTCs) was found to be positive with crops rotation and minimum tillage. Oppositely, negative association was observed with respect to adjusting crops planting time and climate change adaptable crop variety adoption, which are statistically insignificant. Equally, among the remaining explanatory predictors, educational level of the respondents, mass media and land renting, were also found statistically insignificant with almost all negative association to these selected CSA practices adoption except minimum tillage practices where its effect was found to be positive to adoption decision.

In accordance with the model result, there was a confirmation that the educated farmers are more likely to disapprove (not adopt) CSA practices as compared to those who did not attain formal education. Nevertheless, this finding considerably differs from initial assumption and most of the previous findings which suggest a positive association with technology adoption since educated farmers would have more access to information. Thus, signifying that farmers with formal education are more likely to be aware of the severity of community problem, which should inspire them to seek for appropriate innovation in order to mitigate the effects and risks. However, concerning the effect of education, this result is not similar with some other findings; for example, Mulugeta (2000) and Haji (2002) conducted research in Ethiopia on soil conservation and cross breed dairy cows (CBDCs) adoption, individually. Both however submitted a total positive association of technology adoption with educational level of the respondents. Basically, as noted from Tables 5.18a and b above, the effect of all predictors included in the model remained non-significant in proposed regression model in the context of lowland agro-ecology. Nonetheless, it is obvious that there is an important association between those independent variables and the outcomes as indicated by parameter estimates which in actual sense was found statistically non-significant.

(ii) Agro-ecologically Aggregated Data Regression Analysis

(a) Adoption Decision Parameter Estimates Using Tobit Regression

The intention of this section is to determine the effect of selected explanatory variables on CSA practices adoption decision when two data collected from highland and lowland agro-ecologies are summarized and analyzed aggregately. Based on the early assumption presented in chapter four, both continuous and dummy/categorical variables were included into the model and analyzed using Tobit model, where the model constant was found statistically significant at 1 percent significance level indicating the goodness of fit of the model to estimate at least one of the explanatory variables (Table 8.5a). In this regard, the adoption rate of different CSA practices (minimum tillage, crop rotation, drought adaptable crops variety diversification, inter-cropping, small-scale irrigation, fallow farming, adjusting planting time, improved forage management, crops diversification, water harvesting and Agricultural insurance adoption) were indexed using one of dimension reduction technique known as Principal Component

Analysis (PCA) which is SPSS sub program and the indexed value has taken as dependent variables, while a range of socio-economic and environmental variables were considered as independent variables.

Accordingly, two data which were managed separately in respective of highland and lowland in the previous sections has been summarized on one data view sheet in order to run Tobit regression analysis, where the final results were interpreted and presented accordingly in the subsequent manner based on Table 8.5a below. For this particular section, a total of eighteen explanatory variables were selected and included into the Tobit regression model analysis, of which seven explanatory variables were found to significantly influence adoption decision of CSA strategic practices. These variables are yearly income index, farm size of the households, rainfall standard deviation, rainfall coefficient of variation, maximum temperature coefficient of variation (CV), minimum temperature index and adaptive capacity indicators index, while the remaining other explanatory variables were found statistically non-significant at any statistical significance level benchmarks. In this section, in addition to previously considered socio-economic variables to determine relationships (magnitude and direction of effects) of the explanatory variables on CSA practices adoption, agro-ecology was included in the model in order to determine the influence of this natural environment on CSA practices and technology adoption decision of the farmers, where in this case, agro-ecology denotes highland and lowland areas of the study which are regarded and coded as dummy variable for data analysis and presentation, but the result revealed non-significant impact of agro-ecology on CSA practices adoption decision. Accordingly, the effect of incomes and adaptive capacity indicators index were found to be statistically significant at 1 percent significance level indicating substantial influence in decision making to adopt CSA practices and strategies in perspective of the study community.

On the other hand, the effect of significant number of variables found statistically significant at 5 percent significance level and these variables includes Farm size, rainfall standard deviation, rainfall coefficient of variation, maximum temperature coefficient of variation (CV) and minimum temperature parameters indexes, which boldly specify the significant impact of weather variability on Climate change-oriented innovation adoption decision of the farmers. Evidently, these findings are similar with other study like that of Endale (2011), who revealed the dependence of technology adoption on the climatic condition of the particular area; describing how the variability in weather conditions affect the farmers' decision to adopt improved climate change management technology, innovations and strategic oriented practices.

Specifically, among the tested variables, the influence of indexed yearly income of the households and adaptive capacity indicators index found statically significant with similar significance level (at 1 percent significance level), but with different direction, in which only households' income index found negative, while in other remaining case (adaptive capacity indicators index) identified to have positive association with CSA practices adoption decision. In this regard, the negative association of the households' income index identified in this study is uncommon and unpredicted, because several study reveal that farmers with better income would develop interest to commercialize the farm business which only can be realized through innovation adoption and integration into the farming system and farm community.

Table 8.5a: Tobit Model for Adoption Parameter Estimates Using Aggregated Data

Explanatory variables	**Inferential statistics**			
	Coefficient	Std. Err	z-statistic	p>/t/
Agro-ecology	-0.490	1.725	-0.28	0.777
Age of Households head	-0.003	0.006	-0.44	0.659
Education level of Households head	-0.027	0.044	-0.60	0.546
Family size of the Households	0.002	0.020	0.09	0.925
Drought frequency	0.039	0.040	0.98	0.329
Farm size	0.067	0.032	2.07	0.039**
Income index	-0.241	0.048	-5.04	0.000***
Extension Support	0.033	0.065	-0.50	0.619
FTC accessibility	0.002	0.016	0.13	0.897
Credit Support	0.104	0.096	1.08	0.282
Rainfall mean	0.005	0.004	1.31	0.191
Rainfall standard deviation	-0.137	0.061	-2.25	0.025**
Rainfall Coeff. of variation (CV)	78.673	30.991	2.54	0.012**
Maximum Temperature Mean	-0.244	0.237	-1.03	0.304
Maximum Temp Coeff. of variation (CV)	122.411	50.235	2.44	0.015**
Minimum Temp Index	-0.268	0.110	-2.45	0.015**
Vulnerability Index	-0.006	0.019	-0.31	0.754
Adaptive Capacity indicators index	0.367	0.049	-7.51	0.000***
Constant	**6.049**	**6.619**	**0.91**	**0.361**

Log Likelihood --516.772
LR chi-square (X^2) ---------------------------------------134.690
Prob>chi-Square (X^2) --------------------------------------0.000
Pseudo R^2--0.115

Source: Compiled from Survey Data (2020)

To be more detailed, the effect of agro-ecology was analyzed using the Tobit model where the result shows negative association of agro-ecology with the factor of 0.49 (49 percent) as the agro-ecological variables changed from lowland to highland areas, but the effect was found statistically non-significant at all established benchmarks which is similar with several findings in many aspects. In this regard, asserted that the farmers in drier and hotter climates are more likely to respond to climate change adaptation options adoption (Deressa et al., 2011). As to this author, farmers doing farm business in the lowland (Kola) area are hypothesized to adapt more to climate change than the farmers of the midland (Woina-Dega) by using all types of adaptation strategies; but the results are not consistent for all types of adaptation options. As to findings reported by Getahun (2017), communities living in the Kola area use mulching and cover crop 26 percent more times than those living in the Woina-Dega and this is reliable at 1 percent level of significance. Commonly, the traditional assumption and most of the research findings concerning the effect of education was positive influence in perspective of technology adoption, but in this study negative association was identified indicating increased probability of technology rejection by factor of 0.03 as the level of education increased by one unit (years of schooling), but which is non-significant at any percent significance level. For instance, the study conducted by Shongwe (2014) was identified and suggested the positive association of years of formal education of the household head to climate change adaption options adoption. Again, according to Getahun (2017) finding, the highly significant coefficient of education of the household head to major adaptation strategies shows that the probability of adapting to climate change increases with the formal years of schooling. As to this author, a unit increase in number of years of formal schooling would result in a 1 percent and 1.7 percent increase in the probability of adoption of crop variety and irrigation intensification, respectively, at 1 percent significance level. Encouragingly, according to Udin et al. (2014), the regression model results explained positive effect of education with likelihood increasing by a factor of about 1.22 and significant at 5 percent significance level related to adaptation strategies to climate change effects, implying that the probability of adaptation to climate change is greater for those who have higher educational attainment compared to less-educated or illiterate farmers. As to this author, it is obvious that educated farmers have more knowledge, a greater ability to understand and respond to anticipated climate changes, are better able to forecast future scenarios and, overall, have greater access to information and opportunities than others, which might encourage adaptation to climate change

Arguably, inconsistency effect of determinants on technology adoption has identified and recognized by several studies, in which a particular variable exhibits different association (negative or positive), with agricultural technology adoption decision in particular community. As to the findings of several studies, the determinants of agricultural technology adoption do not always have the same effect on adoption decision rather the level and direction of effect varies depending on the technology being introduced; for instance, the effect of farm size on adoption of some technologies such as chemical fertilizer adoption can be positive, while the same variable may have negative impact on some other technologies such as zero grazing technology (Milkessa, 2020).

Land hold is known to represent household wealth in rural areas and significant to influence the Technology adoption decision (Tessema et al., 2013). According to Getahun (2017), the land holding has positive impacts on changing crop variety, intensifying irrigation and reducing livestock number. As to this author, an increase in a unit of measurement of the land holding, the probability of changing crop variety and intensifying irrigation changes by 2.9 percent and 6.7 percent, respectively, at 5 percent and 1 percent significance levels. The research conducted in Africa identified the shortage of land as a barrier in climate change adaptation option adoption (Bryan et al., 2009 cited in Getahun, 2017). Similarly, the effect of farm size was found positive in current study with factor of 0.067 (6.7 percent) and significant at 5 percent significance level, which is in agreement with above authors' findings, who reported positive impact of land holding in respective of innovation and best practices adoption under consideration as a climate change adaptation options. Furthermore, in current study finding, positive relationship was identified between farm size and climate change adaptation (CSA) strategies adoption; specifically, the result shows that a unit increase in a farmland size increases the probability of farmers' adoption of climate change adaptation strategies (Specifically CSA practices), which inconsistent with other findings, like Deressa et al. (2011) and many more, who reported negative influence of farmland size on climate change adaptation strategies adoption. Additionally, farm size was negatively (reduced likelihood by 10.11 factor) and significantly related to adoption of technologies (Udin; 2014). According to this author, there is a negative and significant (at 5 percent level) relationship between farm size and adaptation to climate change effects by adopting management strategies and specifically, results show that increasing size of a farm operation decreases the probability of farmers' adoption of adaptive strategies to climate change (ibid).

On the other hand, a household head who is younger with lower farming experience, higher education level, more extension agent contacts, larger farm size and closer to the source of commercial organic fertilizer is more likely to adopt organic fertilizer as compared to the households with opposite characteristics (Ajewole, 2010), which is almost similar with this study result, with only exception in the case of education in which negative influence was identified differently from this findings and theoretical assumption. For instance, the effect of family size on CSA practices adoption was found to be positive (by factor of 0.002) and statistically insignificant in this study finding, while differently Uddin et al. (2014) reported negative influence of Family size on climate change adaptation strategies adoption which is statistically significant at 5 percent significance level. On the other hand, according to the study results established by Endale (2011), having a large family size found to have positive impact on fertilizer adoption, which is consistent with the findings of the study result presented in this section (Table 8.5a) and initial assumptions. Again, as to Milkessa (2020) findings who made empirical study on technology consumption, a farmer with a large family is likely to adopt manure than chemical fertilizer, because such farmer can easily mobilize enough labour for both manure preparation and overall farm management, indicating adequate consistency with the result of this study. Additionally, family size of the household was found to have positive influence at the 5 percent significance level to intensifying irrigation; however, this variable was not found to determine the other adaptation strategies at 10 percent significance ((Ndambiri et al., 2012). Differently, even though it is less significant, the household family size was negatively related to the rest of the adaptation measures and this is in agreement with the argument that larger households are less likely to adapt to climate change than the smaller households (ibid). According to the current study result, a unit increase in the family size found to increase the likelihoods of adoption by positive factors, which is similar with several findings like that of Getahun (2017) who reported positive association of family size on technology adoption. However, as to Udin (2014), the family size effect was found negative indicating reduced likelihood by factor of 2.17 in the adoption and significantly (at 5 percent level) related to farmers' adaptation strategies to climate change effects which is contradictory to initial assumption.

Furthermore, as to Milkessa (2020), age of the household head negatively influenced adoption of organic fertilizer, indicating an increase in age by one year decreases the probability of adoption of organic fertilizer by 2.6 percent; perhaps this is because older farmers tend to invest several years in a particular practice hence may not want to risk themselves by trying out completely new other methods of farming, which is consistent with this study findings that revealed a decrease of CSA practices likely adoption by a factor of 0.003 (0.3 percent) in the study community. Furthermore, according to Getahun (2017), contrary to the expectations and findings in other research in Ethiopia, the age of the household head is negatively associated with major adaptation strategies prevailing in the area at the 5 percent level of significance and again this author affirmed that there are several findings in Ethiopia which asserted negative relation between age and adoption of some strategies introduced to adapt climate variability. The finding of this author revealed that the average marginal effect computed shows that sample households with a one more year older head there was decline in the probability of intensified irrigation at the 1 percent significance level by 1.26 percent and for other adaptation strategies the decrease in the probability at the 5 percent significance level is extremely low with effects varying from 0.11 percent to 1.1 percent in context of study community. The finding of these above mentioned researchers are in agreement with arguments of current findings which state that older farmers are less likely to be flexible than younger farmers and thus have a lesser likelihood of adopting CSA strategic practices. Similarly, as to Udin (2014), the effect of age in context of his study was negative and significantly (at 10 percent significance level) related to farmers' adoption of climate change effects adaptive strategies; implying that the probability of adaptation significantly decreases in context of the older respondent farmer as result of such farmers have less interest or less incentives in taking climate change adaptation measures.

Regarding to extension services, Milkessa (2020) revealed that one additional contact with extension workers increased the likelihood of organic fertilizer adoption by about 3.7 percent, confirming that better information dissemination through extension workers could enhance adoption of organic fertilizer by improving knowledge about the advantage of new technology, which in actual sense the positive influence reported is consistent with this study finding. Similarly, result of the current study asserted that an increase in extension contact increased likelihoods of CSA strategic practices adoption by 3.3 percent which closely similar with the finding mentioned above in this context. Certainly, the positive influence of extension supports and contact identified in the finding of this study is consistent with the theoretical assumption and other study findings, even though the impact was found statistically insignificant at any significance level. Widely, several study findings have been asserting that the effect of extension services on crop and livestock production are known to be an encouraging Factor to climate change adaptation adoption (Nhemachena and Hassan, 2007 cited in Getahun, 2014). According to Getahun (2017), the effect of extension service was identified positive for the majority of adaptation options discussed in the study except for mulching where it is negatively related, but the relation was not significant at all significance levels. Certainly, the regression analysis prediction presented in Table 8.5a show the positive estimate associated with frequency of extension officers' visits with CSA practices adoption, which is statistically significant at 5 percent significance level and in line with some other findings; like that of Maltou (2016), who reported positive correlation, but differently statistically significant at 1 percent significance level in context of Biotechnology Maize adoption. Regarding to extension services, Milkeessa (2020), discovered that one additional consultation with extension workers increased the likelihood of organic fertilizer adoption, indicating consistency with this study finding in context of positive likelihood of extension service frequency to adoption decision. More importantly, according to Getahun (2017), access to climate information mainly in the form of seasonal forecast has mixed direction of relation for the adaptation strategies adoption where it has a significant and positive impact on using cover plants and mulching as adaptation mechanisms, thus households with access to climate information use this method 21 percent more often than the households that are not using it at the 1 percent significance level in the context of the study community.

As to the Tobit regression model result, physical access to credit had non-significant positive influence on the likelihood of CSA practices adoption which has explained by a factor of about o.10 (10 percent) in the context of study households and the positive influence asserted by this study finding is consistent with the work of Ashenafi and Oliyad (2020), who conducted research on Malt Barley Technology adoption in Ethiopia. According to several studies findings, access to credit had a positive impact on climate change adaptation options adoption. For instance, as to Busisiwe (2011) having access to credit increased the likelihood of adaptation options adoption by a factor of about 0.48 in the community where the study conducted. In generalized term, the results like that of Deressa et al. (2009) implied that institutional support in terms of the provision of credit was an important factor in promoting adaptation options to reduce the negative effects of climate change. Significantly, several studies have shown similar results in which an access to credit by farmers is an important determinant of the adoption of various technologies where such farmers were assumed to have been able to make comparative decisions on climate change adaptation option (Busisiwe, 2011). Certainly, availability of financial resources would enable farmers to buy new breeds of livestock and other important inputs that might require for the adaptation choices (ibid).

In the Udin (2014) study, the coefficients of Credit which shows decreasing (by factor of about 1.69) were not statistically significant and in certain ways these results are surprising in light of the theory surrounding its use as development instruments in general and in climate change adaptation strategies in particular. On the other hand, according to several studies, extension service delivery infrastructure in which Famers' Training Centre (FCTs) is one are the critical to generate adequate services to farmers in order to positively influence the technology adoption decision of the customers which is farmers in this study context. Likewise, the study diagnostic procedure conducted show that the FTCs distance from the farmland was found positive in influencing CSA strategic practices adoption decision by a factor of 0.002 (0.2 percent) in the study community. According to Gerishu (2007), distance of development center which is always similar with FCTs were found to be statistically significant at five percent significance level where an increase in the distance of development center tend to increase the likelihoods Soil and Water Conservation (SWC) practices by factor of 0.47 (significant at 5 percent significance level) in context Adama districts which closer to current study areas. In this context, current study finding is similar with this finding, but boldly different from most of the prior study findings and initial assumption in which the distance of FTCs from the households was hypothesized to have negative association with CSA strategic practice and innovations adoption.

According to Milkessa (2020), family income positively and significantly affects the adoption decision of household head significantly at 5 percent level, indicating dissimilar result with the finding of the study presented under this section, which asserted negative association of households' annual income with CSA practices adoption. According to this author, an increase in farm households' income by one unit increased the likelihood of adoption by 2.5 percent, which found different from this study result that indicated negative association by factor of about 0.24 between households' income index and CSA practice adoption. The result of the regression model generated by Uddin et al. (2014), shows statistically significant at 5 percent significance level with positive relationship between family income and adoption of adaptation strategies to climate change effects, implying that farmers with high income are more likely to adopt adaption strategies than farmers with lower income households, which is inconsistent with this study finding.

However, regardless of the expectations, overall better income earner households were negatively related to a number of technologies like the use of a water harvesting scheme, cover crop/mulching and reducing the number of livestock in which the computed marginal effect for all strategies are almost zero, indicating its contradiction to prior researches which are explaining that wealthier farmers are advantageous in adaptation options adoption (Getahun, 2017). Differently, Udin (2014) presented the result of the logistic regression which indicated an increasing by 0.0002 factors which shows positive and significant (at 5 percent level) relationship between family income and adoption of adaptive strategies to climate change effects; implying that farmers with high income are more likely to adopt adaptive strategies than farmers with lower incomes (ibid). In several context and settings, drought have been common phenomenon in the tradition community and beyond affecting efficiency and effectiveness of community livelihoods and national economy.

Accordingly, this study emphasized to analyze the households level drought effect on community's livelihoods and beyond, where the result shows the positive association of drought to CSA strategic practices adoption in perspective of climate change management and adaptation where its effect shows an increase by 0.039 factors as drought frequency increase by one unit in intended measurement. However, the effect found statistically non-significant at any of the conventional statistical level.

(b) Adoption Intensity Estimates and Discussion in Context of CSA Practices

This section is designed to determine the effect of selected explanatory variables on CSA practices adoption situations using different model from binary and Tobit regression, which is truncated regression models, to determine the adoption intensity in the context of study community. This approach was adopted from Musba (2021), who determined adoption intensity assuming the farmers' adoption decision at two level, of which the first level is the single point decision to practice the introduced new innovation, while the second is the extent which is important to determine the level of innovation implementation. According to Cragg, (1997); Sanchez (2005) and Humphreys, (2010), cited by this author, the farmers faced with two hurdles in decision making process concerning the agricultural innovations, which is the decision to participate in an activity is made first and then the decision regarding the level of participation in the activity follows the first decision.

Accordingly, this author selected double-hurdle model and employed considering distinction between the determinants of adoption and the level of adoption in soybean production through two separate stages, which involves running a probit regression to identify factors affecting the decision to participate in the activity using sample households in the first stage, and a truncated regression model on the participated households to analyze the factors that affect the extent of adoption, in the second stage. Thus, based on this author, in this study, adoption decision was analyzed in the first stage using Tobit regression model which presented in the previous above section and the analysis of adoption intensity has performed in the second stage using truncated regression model, where the results inferred based on the inferential statistics. In this aspect, the adoption rate of different CSA practices (Minimum tillage, crop rotation, drought adaptable crops variety diversification, inter-cropping, small-scale irrigation, fallow farming, adjusting planting time, improved forage management, crops diversification, water harvesting and Agricultural insurance adoption sustainability) were indexed using proportional Component Analysis (PCA) and the indexed value considered as dependent variables, while the socio-economic and environmental variables were included in the truncated regression as independent variables in context of this study.

The data collected from two study agro-ecologies (highland and lowland) combined and analyzed using truncated regression aggregately to determine the comprehensive effect of explanatory variables on adoption intensity and the discussion were performed accordingly. Meaning, two data processed in respective of highland and lowland agro-ecology in the previous sections has been combined on one excel data sheet and transferred to STATA software in order to run truncated regression analysis, where the final results were interpreted and presented accordingly in the subsequent manner based on the results summarized in the Table 8.5b for Adoption intensity in the context of study community. For this particular sub-section, a total of eighteen explanatory variables were selected and included into the selected models (truncated regression), of which the effect of seven (about 39 percent of total) explanatory variables were found significant in influencing the use intensity of CSA strategic practices and innovations in study community situation.

Table 8.5b: Aggregated Data Analysis to Estimate Adoption Intensity Using Truncated Regression Model

Explanatory variables	Inferential statistics			
	Coefficient	**Std. Err**	**t-value**	**p>/t/**
Agro-ecology	-0.573	1.667	-0.34	0.731
Age of households heads	-0.002	0.005	-0.43	0.668
Education of households head	-0.022	0.043	-0.51	0.613
Family size of households	0.003	0.020	0.13	0.893
Drought frequency	0.039	0.038	1.02	0.309
Farm size of households	0.066	0.031	2.11	0.035**
Income index	-0.239	0.046	-5.17	0.000***
Extension support to farmers	0.032	0.063	-0.50	0.614
FTC accessibility to farm land	0.002	0.016	0.11	0.914
Credit support to farm households	0.107	0.093	1.15	0.250
Rainfall mean	0.005	0.004	1.36	0.174
Rainfall standard deviation	-0.135	0.059	-2.29	0.022**
Rainfall coefficient of variation (CV)	77.639	29.948	2.59	0.010**
Maximum temperature Mean	-0.228	0.228	-1.00	0.318
Maximum temp. coefficient of variation (CV)	119.873	48.531	2.47	0.014**
Minimum Temperature Index	-0.261	0.105	-2.48	0.013**
Vulnerability indicators Index	-0.007	0.018	-0.40	0.692
Adaptive Capacity indicators index	-0.369	0.047	-7.83	0.000***
Constant	5.638	6.394	0.88	0.378
Sigma	0.837	0.029	28.39	0.000

Log likelihood --500.455
Prob> Chi-Square (X^2) --0.000
Wald Chi-square (X^2) ---172.300

Source: Compiled from Survey Data (2020)

The result of the related data analysis revealed that the overall fitness of the model found to be statistically significant at 1 percent probability level, indicating that the selected model predicted at least the effect of some variables included in the employed model. Regarding to this finding, among socio-economic variables included in the regression model, the impact of households' income (indexed agriculture and non-agriculture sources) and the indexed adaptive capacity indicators found statistically significant at 1 percent significance level, while farm size found statistically significant at 5 percent significance level and the effect of other remaining variables found non-significant at any significance levels. On the other hand, among institutional support, negative relationship was identified in respective of FTC distance mentioned in the Table below when related to adoption intensity of CSA practices, but the effect is statistically non-significant at any significance level. According to this finding, the farmers who had reasonable access to Farmers Training Center (FTCs) are better CSA practices adopter and use intensity than those who are far from the nearest FCTs infrastructural facilities. Meaningfully, as indicated in the summary Table below, a unit increase in the accessibility of FCTs infrastructure and facility to the households' farmland increase the probability of use intensity of adopted CSA strategic practices by factor of about 0.002 in context of the study community. Furthermore, as to the result presented in Table 8.5b, the adequate accessibility to credit/credit support had positive and adequate influence on the likelihood of use intensity of adopted CSA strategic practices and technological package, although the impact is statistically none significant at any significance level established as statistical bench mark. According to this result, those farmers who have access to credit support are more likely to adopt CSA strategic practices and technological package, indicating an increases in the likelihood use intensity of adopted CSA practices by a factor of about 0.011 as compared to those who have no access to formal credit support.

Under Ethiopia condition in general and Oromia region in particular, access to input related credit is predominantly organized by farmers organization specifically cooperative where being the member of the cooperative would enhance the access to credit from cooperative in which fifty percent down payment required to be made during early input delivery and repayment usually made at the crops harvesting period up on sale of the produces. Majorly, the intention of credit support and access to farmers in Ethiopia is traditionally to enhance technology adoption and ultimately the use intensity in the farming system of the country by resolving farmers' financial constraints and limitation. The result of the truncated regression model presented in the above Table shows the negative influence of the age of the respondents which is statistically non-significant, implying that the adoption intensity of CSA practices and technologies had related none significantly to the age of the respondents. This contained that as the households heads advance in age by one year, could equivalently decrease in the probability of adoption intensity of CSA practices and technologies by factor of 0.002, but this declining trend identified in this finding is in contrary to findings of Ume, et al (2020), who reported 32 percent increase per unit increase in age of the Odourless fufu processors, arguing that aged processors have higher inclination of being endowed with experiences through series of observations and experimentation to enhance the adoption intensity of the technology. In context of this model results, the relationship of households' family size had found positive correlation with adoption intensity of CSA practices and technology and statistically insignificant.

This implies that an addition of one family member to household members tends to increase the likelihoods of adoption intensity of CSA strategic practices and technologies by factor of 0.003as compared to small number of family members. On the other hand, the processed data revealed indirect (negative) correlation of education level of household heads with CSA adoption intensity by a factor of 0.022, indicating declining adoption use intensity as the educational level increased by one unit in measurement scale, which validate inconsistency with most of the study findings which commonly asserted positive relationship between Technology adoption intensity and education level. Accessibility of extension support to farmers observed to have positive relation with CSA practices probability of adoption intensity, indicating an increase in the likelihood of adoption intensifies. This is consistent effect with several findings that found positive impact of the extension services on innovation adoption and use intensity. The implication is that an additional one-unit increase in extension support for the CSA practices implementers; increase the adoption intensity of introduced technologies and innovations by a factor of 0.032 in response to per unit increase in the scale of extension support. According to adoption-diffusion theory, the adoption of technology by farmers is primarily determined by information obtained from Development agents (DAs), in which farmers are more stimulated to adopt technology when considerable information is available to them as the result of frequent contact of the extension agents and this study finding is in agreement with this theory and much more others prior assumption.

Similarly, the finding of this study revealed an increase by factor of about 0.04 in the likelihood of CSA strategic practices adoption and its use intensity as the result of a unit increase in the drought frequency and occurrences for particular area and the impact was found statistically insignificant at any percent significance level in respective of selected model to estimate this parameter. Furthermore, per unit increase in the scale of vulnerability index had found negative correlation with CSA strategic practices adoption intensity, but with slightly lower coefficient (by factor of about 0.007) of influence, while its effect was found insignificant at any percent significance level in respective of CSA practices adoption intensity. The implication is that the more vulnerability catastrophe in the context of the farm community would decrease the probability of adoption intensity of CSA practices and technology by factor of 0.007 point, indicating that the per unit increase in vulnerability index tends to decrease the likelihood of adoption use intensity in the situation of study community.

Regarding to annual income, the truncated regression analysis result indicates a decrease by a factor of about 0.24 in the likelihoods of CSA practices adoption intensity, with a unit increase in the households' incomes index and this finding is in line with the positive finding of the Milkessaa (2020), who reported based on the analysis of Organic fertilizer adoption intensity. In relation to farm size, the results indicate that a unit increase in the households' farmland size measurement tends to increase use intensity of CSA practices adoption by factor of about 0.66, which is consistent with the work of Milkessa (2020), who reported positive relationship between farmland size and Organic fertilizers adoption intensity. Furthermore, this finding is consistent with earlier study finding of the Ashenafi and Oliyad (2020), who conducted study on Malt Barley adoption intensity and identified similar result. Furthermore, family size expressed in number of persons per household affects the adoption intensity of farmers of the study community positively with the factor of 0.003, while the effect is statistically non-significant, which this observed positive relationship is in line with Ashenafi and Oliyad (2020) finding concerning family size influence on Malt barley technology and innovation package adoption intensity.

8.3 Perceived Sustainability of CSA Practices Adoption

(i) An Overview of CSA Strategic Practices Sustainability

Under current situation, to achieve sustainable productivity of farmlands, climate change adaptation practices must fit into the existing farming system throughout the effective use period of land resources in a sustainable manner. Thus, this necessitates sustainability of CSA practices in the farming system beyond single point adoption decision, which impressed to include sustainability of CSA practices in this research study in addition to adoption. The sustainability aspect of this study is an assessment that examines the persistence of previously adopted recommended CSA practice in the small-scale farming system without external support or after the external support was terminated.

It is the continued application or use of some adopted relevant technologies and practices after the withdrawal of the projects or programs by farmers' own resources and efforts. Sustainability, as an aspect in CSA strategic practices is concerned with different financial and physical contribution of farmers to sustain the introduced practices in order to maintain sustainable farmland productivity using recommended climate change adaptation strategies and practices. According to the findings of this study, the aggregated rate of perceived sustainability is 75 percent for the highland respondents and 47.6 percent in the case of lowland area respondents, indicating larger variation between highland and lowland farming community. However, as articulated in Table 8.6, the sustainability of many introduced CSA technologies and practices are discouraging and only about 39 percent and 31 percent of the introduced practices maintain more than 50 percent rate of sustainability in the study community of the highland and lowland agro-ecologies, respectively, indicating that more negative situation concerning lowland area in respective of CSA practices and innovations sustainability in the study community.

Likewise, among thirteen different CSA strategic practices that were investigated, only crops rotation (72.4 percent), intercropping (58.8 percent), crops residue management (59.3 percent), adjusting planting time (58.3 percent) and climate change adaptable crops varieties diversifications (62.3 percent) appear to be sustainable in the farming system of the highland agro-ecology and the remaining practices are either poorly sustainable or not introduced into the farming system. Certainly, the remaining practices were below 50 percent sustainability. specifically, some of the CSA practices like conservation agriculture (minimum tillage), small-scale irrigation, improved range land management and water harvesting were found to be the least sustained practices (below 30 percent) in the highland farming system contexts. The result of the survey also indicates great variability between different CSA practices sustainability in lowland agro-ecology and community. The data summarized in Table 8.6 shows that among the introduced CSA practices, only very few (about 31 percent) are sustained by more than 50 percent of the sample households, and the remaining proportion of the farmers either rejected the CSA strategic practices after adoption or decided not to adopt the introduced CSA practices in lowland farming system.

Table 8.6: Perceived Sustainability of Introduced CSA Practices and Technologies (N=410)

Selected CSA practices	**Highland agro-ecology**				**Lowland agro-ecology**			
	Sustained		Not sustained		Sustained		Not sustained	
	Frequency	%	Frequency	%	Frequency	%	Frequency	%
Minimum tillage	56	28.1	143	71.9	122	58.9	85	41.1
Crops rotation	144	72.4	55	27.6	178	86.0	29	14.0
Inter cropping	117	58.8	82	41.2	87	42.0	120	58.0
Fallow farming	80	40.2	119	59.8	50	24.2	157	75.8
Crop residue management	118	59.3	81	40.7	46	22.2	161	77.8
Small-scale irrigation	14	7.0	185	93.0	29	14.1	176	85.9
Improved range land management	28	14.1	171	85.9	49	23.8	157	76.2
Water conservation practices	83	41.7	116	58.3	89	43.0	118	57.0
Water harvesting	50	25.1	149	74.9	55	26.7	151	73.3
Adaptable crop varieties	98	49.2	101	50.8	114	55.1	93	44.9
Adjust planting time	116	58.3	83	41.7	132	64.1	74	35.9
Crop varieties diversification	124	62.3	75	37.7	58	28.0	149	72.0
Crops and Livestock insurance	71	35.7	128	64.3	19	9.2	187	90.8

Source: Compiled from Survey Data (2020)

The presented data shows that, among CSA practices considered in this study, conservation agriculture (minimum tillage), crops rotation, adjusting crops planting time and adoption of climate change adaptable crop varieties are the CSA practices relatively sustained in the lowland farming community. As shown in summary Table 8.6 above, conservation agriculture (minimum tillage), crops rotation, adjusting crops planting time, and climate change adaptable crop varieties, with 58.9 percent, 86 percent, 64.1 percent, 55.1 percent, respectively, are better sustained in the lowland farming community. However, the sustainability of almost all of these practices found to be about average level, which is between 50 percent and 65 percent, except crop rotation, which 86 percent of the respondents are sustainably using after withdrawal of projects or programs from community level. On the other hand, of the total sample respondents of lowland, about 43 percent and 42percent reported that they are using water harvesting and intercropping, respectively, in a sustainable manner to support the effort to reverse the negative impact of climate change, while of total respondents, 49 percent, 41.7 percent and 40.2 percent of climate change adaptable crops variety, water conservation and fallow farming sustained, respectively in highland context. Discouragingly, the remaining practices were below 40 percent sustainability in context of community in both lowland and highland agro-ecology. With the national attempt to improve crop yield per unit of cultivated farmland, the Ethiopian government has adopted Participatory Demonstration and Training Extension System (PADATES) approach, which is usually based on high external input without optimum attention.

These inputs are mainly chemical fertilizers to compensate yield reduction due to soil degradation and climate variability impacts. Essentially, the approach is meant to promote environmentally sustainable practices, especially those technologies which are important to supplement climate change adaptation efforts. However, it ultimately contributed to the poor sustainability of these particular practices in the environmentally fragile farming system of the community. Differently, the challenge encountering the Ethiopian small-scale farmers is how to find mechanisms that help poor rural communities to improve the environment and their capacity to produce crops without becoming dependent on external inputs. Thus, the survey results indicate that this extension approach need to be reversed or shifted in a way that the system accommodates the environmentally friendly practices which integrates the climate change adaptation strategies and practices so that the small-scale farming community would maintain optimum productivity from a unity of agricultural lands without affecting environmental sustainability.

(ii) Agro-ecologically Disaggregated Binary Logistic Estimates of CSA Practices Sustainability

Regarding to this sub-topic, a blend of socio-economic explanatory variables has been identified to serve in the assessment of CSA practices perceived adoption sustainability in the study community. The statistics were computed based on multiple regression analytical techniques, to determine the association of dependent and independent variables, of which dependent variable is perceived sustainability (dummy) of CSA practices and independent variables are socio-economic factors (mixture of dummy and ordinal) that potentially can influence the CSA practices adoption-sustainability in the study farming system.

The dummy was determined by assigning a value of 1 for respondent who is using CSA practice for past some three years in response to negative effects of climate change and a value of 0 for other respondent. For instance, if a farmer uses at least one strategy for three and more years in order to manage the negative impact of climate change, then that farmer is considered to have “sustained” (1), where the question designed in the manner that manageable to present with a simple dichotomous “sustained/not sustained” response, about whether or not he had sustained any of CSA practices to manage climate change in the community.

Accordingly, data analysis was analyzed using the Statistical Package for Social Sciences (SPSS) software, particularly binary Logistic regression function, where multi factors regression analysis Technique were used to analyze quantitative data coded in perspective of perceived sustainability to determine the CSA practices perceived adoption sustainability and the results summarized in a tabular format to make ready for interpretation and presentation.

In particular, to this sub section, three types of multi-collinearity test analysis were conducted in the process of data management which can serve for all models (Binary logistic, Tobit and truncated model); where these are Variance Inflation Factors (VIF), test of Tolerance, person correlation which conventionally explained by contingency Table. The VIF, person correlation and test of tolerance were used to identify groups of inter-correlated variables in order to examine hidden interrelationships amongst them, which negatively affect the precision and accuracy level of model estimates where the results of these analyses are presented in Appendix 1, 2 and 3 in context of disaggregated and aggregated highland and lowland data. Based on collinearity test analysis, some explanatory variables which exhibited multiple collinearity tendency with other variables (those which found to have significant correction with more than two variables), such as irrigation land holding and non-agriculture income exclude from the most of regression model established to determine the adoption and sustainability of adopted Climate Smart Agricultural (CSA) strategic practices and innovations.

On the other hand, some important variables with slightly moderate collinearity (not more than two collinearity) which are also difficult to exclude from the binary regression analysis were tolerated and maintained in the course of data processing and management. The binary Logistic regression model was used to determine whether farmers' sustained or not the CSA practices. In this regard, the data were analyzed using the SPSS program version 20 and properly interpreted for presentation. In this aspect, the results were presented in descriptive and inferential statistics, such as frequency tables with percentages, means and standard deviation, as well as P-value, Hosmer and Lemshew and Chi-square to infer the processed data.

Thus, this sub section present and discusses the sustainability of CSA practices based on analyzed and interpreted data in respective of selected variables include in the binary logistic regression model (Table 8.7a and b) for lowland location. According to model results implication (presented in Table 8.7a and b), adding the selected explanatory variables in regression equation adjusted the -2Log Likelihood statistic of each CSA practices sustainability as compared to suggested original model by values indicated in the Tables regarding the CSA practices under lowland farming condition. Appositely, the model chi-square shows statistical significance, indicating that including selected explanatory variables significantly reduced the log likelihood ratio of the model when compared with the model used without independent variables.

Noticeably, the -2Log Likelihood statistic has dropped (reduced), indicating that the new expanded model was better at predicting the sustainability of the CSA practices than one with only intercept predictor in logistic regression model. On the other hand, the model test of fitness (Hosmer and Lemshew test Chi-square) was statistically significant at five percent significance level in the case of crop rotation, while it was insignificant in all other CSA practices sustainability. Based on the binary logistic regression analysis output, Tables 8.7a and b present and show observed association between explanatory variables and CSA practices adoption sustainability concerning lowland study community situations, and there are ranges of variability.

Table 8.7a: Parameter Estimate for Sustainability of Two Top CSA Practices at Lowland Agro-ecology

Explanatory variables	**Crops Rotation (1st)**				**Adjust crop planting time (2nd)**			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondent Age	-0.093	4.054	0.911	0.044**	-0.020	0.468	0.981	0.494
Respondent Sex	-2.254	3.390	0.105	0.066*	-0.328	0.235	0.720	0.628
Educational Level	-0.684	5.356	0.504	0.021**	-0.319	2.893	0.727	0.089*
Irrigation FARM Size	1.593	12.164	4.921	0.000***	-0.496	1.405	0.609	0.236
Livestock farm experience	0.081	3.834	1.085	0.050**	-0.015	0.353	0.985	0.552
Sustainable water supply	0.765	1.467	2.150	0.226	-0.143	0.154	0.866	0.695
Non-farm income	0.382	1.542	1.465	0.214	-0.126	0.442	0.881	0.506
Drought events	0.342	3.476	1.408	0.062*	-0.155	1.247	0.857	0.264
Extension Service accessibility	0.637	2.537	1.891	0.111	0.238	0.142	1.308	0.986
Market distance	-0.126	7.042	0.881	0.008***	0.008	0.102	1.008	0.750
Communication Center distance	-0.104	0.521	0.901	0.471	0.175	4.526	1.191	0.033**
Media accessibility	1.591	6.475	4.909	0.011**	0.833	3.372	2.300	0.066*
Constant	**-1.913**	**0.534**	**0.148**	**0.465**	**0.508**	**0.087**	**1.663**	**0.768**
-2 Log likelihood				112.527[a]				232.697[a]
Hosmer and Lemshew test (Chi-square(X^2))				14.484**				9.963
Test of model coefficient (Chi-square (X^2))				45.495***				26.618**

Source: Compiled from Survey Data (2020)

More importantly, while some of them are similar with initial assumptions, others are different from the original hypothesis. Accordingly, the results show that the age and sex of the households' heads have negative association with almost all CSA practices (Crops rotation, planting time adjustment, minimum tillage, and climate change adaptable crops variety diversification) adoption sustainability in the condition of lowland agro-ecology and farming system. In contrast, others are mixed, like distance of marketplace and communication center from farmland; the investigation discovered a negative association with crop rotation and climate change adaptable crop variety diversification, but positive association was identified in the case of minimum tillage and crops planting time adjustment. Likewise, livestock farming experience of the households, sustainable water supply for the households and none farm incomes amount have positive association with some of the CSA practices (Crops rotation, minimum tillage, and climate change adaptable crops variety diversification), while different in others. Differently from the above explained, crop planting time adjustment registered a positive association with adoption sustainability in the condition of lowland agro-ecology and farming system.

Table 8.7b: Parameter Estimate for Sustainability of 3rd and 4th CSA Practice at Lowland Agro-ecology

Explanatory variables	**Minimum Tillage (3rd)**				**Climate change adaptable varieties (4th)**			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondent age	0.009	0.076	1.009	0.782	-0.028	1.132	0.972	0.287
Respondent sex	0.191	0.071	1.210	0.789	-0.172	0.081	0.842	0.776
Educational Level	0.241	1.473	1.272	0.225	0.018	0.012	1.018	0.914
Irrigation Farm Size	-0.758	2.483	0.468	0.115	0.096	0.067	1.101	0.795
Livestock Farm Experience	0.019	0.482	1.019	0.487	0.012	0.244	1.012	0.621
Sustainable water Supply	1.087	6.967	2.964	0.008***	0.422	1.544	1.525	0.214
Non-Farm income	1.596	10.38	4.932	0.001***	0.192	0.216	1.212	0.642
Drought events	-0.505	10.66	0.604	0.001***	-0.157	1.537	0.854	0.215
Extension Service accessibility	0.058	0.036	1.059	0.849	-0.265	1.075	0.767	0.300
Market Distance	0.026	0.927	1.026	0.336	-0.001	0.001	0.999	0.976
Communication Center Distance	-0.029	0.366	0.971	0.545	0.195	3.895	1.216	0.048**
Media accessibility	1.916	9.620	6.794	0.002***	0.094	0.046	1.099	0.831
Constant	**-5.441**	**7.269**	**0.004**	**0.007**	**0.173**	**0.009**	**1.188**	**0.924**
-2 Log likelihood				202.098a				256.943a
Hosmer and Lemshew test (Chi-square(X^2))				12.877				8.479
Test of model coefficient (Chi-square (X^2))				68.277***				17.113

Source: Compiled from Survey Data (2020)

Among the households' specific variables, educational level of the respondents, underscored a negative relationship with some CSA practices (crops rotation and planting time adjustment) but positive association with others (minimum tillage and climate change adaptable crop variety adoption) adoption sustainability. Similarly, the impact of irrigation farmland size on some CSA practices, like crop rotation and climate change adaptable crop variety diversification was found positive, indicating that, as the irrigation farmland holding of the household increases the probability of adoption sustainability increases as well, while a negative association was observed in the case of planting time adjustment and minimum tillage sustainability.

In the same vein, it was observed that the impact of drought events was negative, signifying that as the drought frequency increases the probability of adoption sustainability for planting time adjustment, minimum tillage and climate change adaptable crops variety diversification declines with the proportion indicated in Table 8.7a and b above in respective of each CSA practices, while positive association was identified in the case of crop rotation sustainability. In the same manner, service and mass media accessibility registered a positive association with crop rotation, planting time adjustment and minimum tillage, but differently service accessibility attracted a negative association with climate change adaptable crop variety, while positive association was realized in the case of mass media accessibility.

On the other hand, in the situation of highland community, the log likelihood statistics shown in Table 8.8a and b, indicates adequate improvement in the original model as depicted in the result of those selected explanatory variables included in the regression equation of the CSA practices sustainability. Furthermore, the model chi-square appeared statistically significant; indicating that including selected explanatory variables significantly reduced the log likelihood ratio of the model when compared with model that established without independent variables.

Table 8.8a: Parameter Estimate for Sustainability of 1st and 2nd Top CSA Practices at Highland Agro-ecology

Explanatory variables	**Crops Rotation (1st)**				**Crop variety diversification (2nd)**			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondent age	-0.012	0.151	0.988	0.698	0.021	0.666	1.021	0.414
Respondent Sex	-0.726	1.001	0.484	0.317	-0.299	0.267	0.741	0.605
Educational Level	1.055	6.470	4.153	0.167	0.527	3.408	2.049	0.492
Livestock Farm Experience	E	9.405	0.916	0.002***	-0.029	1.500	0.971	0.221
Sustainable water supply	1.574	4.660	4.825	0.031**	0.249	0.279	1.283	0.597
Extension Service accessibility	1.625	12.075	6.798	0.007***	0.894	7.972	2.444	0.005***
Market Distance	-0.038	0.289	0.963	0.591	-0.260	16.005	0.771	0.000***
Communication Center Distance	0.198	2.960	1.220	0.085*	-0.125	0.362	0.882	0.547
Nonfarm income source	-0.129	0.152	0.879	0.697	0.201	0.465	1.222	0.495
Constant	**-3.334**	**4.681**	**0.036**	**0.031**	**-1.392**	**1.499**	**0.249**	**0.221**
-2 Log likelihood				136.066[a]				201.171[a]
Hosmer and Lemshew test (Chi-square(X^2))				13.447*				12.551
Test of model coefficient (Chi-square (X^2))				55.080***				58.144***

Source: Compiled from Survey Data (2020)

Patently, the model Ch-square (X^2) suggested significance of the explanatory variables effect at one percent statistical significance level for all CSA practices (crop rotation, crops variety diversification, crops residue management and inter-cropping) that were included in the sustainability assessment models in the context of highland farming community of the study (Table 8.8a and b). According to the survey data results generated by logistic regression model, there are array of results for interpretation, among which some of them require adequate analytical justification with arguments, while others are best explained directly in traditional manner. Hence, the results show that among the social characteristics of the households, sex of the households' heads had a negative association with almost all CSA practices, like crops rotation, planting time adjustment and minimum tillage. Contrastingly, it was positive for climate change adaptable crops variety diversification adoption sustainability in the condition of highland agro-ecology and farming system, while age of the households' association was positive in the case of Planting time adjustment, minimum tillage, and climate change adaptable crop variety adoption, but found negative for crop rotation adoption sustainability in the context of study communities.

Table 8.8b: Parameter estimate for Sustainability of 3rd and 4th CSA Practice at Highland Agro-ecology

Explanatory variables	**Crops Residue management (3rd)**				**Inter cropping (4th)**			
	Coefficient	Wald stat	Exp(B)	P-Value	Coefficient	Wald stat	Exp(B)	P-Value
Respondent age	.0013	0.304	1.013	0.581	0.028	1.522	1.028	0.217
Respondent Sex	-0.803	1.827	0.448	0.177	0.475	0.874	1.608	0.350
Educational Level	-0.013	0.005	0.987	0.944	0.142	0.683	1.153	0.409
Livestock Farm Experience	-0.086	12.53	0.917	0.000***	-0.021	0.885	0.980	0.347
Sustainable water supply	0.464	0.974	1.591	0.324	0.227	0.266	1.255	0.606
Extension Service accessibility	0.611	4.291	1.842	0.038**	-0.209	0.618	0.811	0.432
Market Distance	0.049	0.715	1.051	0.398	0.060	1.285	1.062	0.257
Communication Center Distance	-0.250	1.154	0.779	0.283	0.737	10.919	2.090	0.001***
Non-Farm income source	-0.484	2.326	0.616	0.127	-0.491	3.032	0.612	0.082*
Drought events	0.377	3.625	1.457	0.057*	0.188	1.062	1.207	0.303
Constant	**-1.035**	**0.516**	**0.355**	**0.473**	**-2.833**	**4.357**	**0.059**	**0.037**
-2 Log likelihood				202.433				235.331[a]
Hosmer and Lemshew test (Chi-square(X^2))				28.291***				19.153**
Test of model coefficient (Chi-square (X^2))				46.025***				30.277***

Source: Compiled from Survey Data (2020)

Surprisingly, the effect of livestock farming experience in years and non-agricultural source related income was negative in all CSA practices adoption sustainability, but differently from others where almost the majority indicated mixed association. This discovery signified half positive and negative for others in the highland community context. Equally, among the selected variables, some factors like distance of marketplace and drought events recorded a negative association with crops rotation and crop planting time adjustment, while they exhibited positive relations with minimum tillage and climate change hard time adaptable crop variety adoption sustainability in the study community.

The distance of communication centers from households' farmland also shows similar trend like in the case of market distance, but slightly different in CSA practices they influence, because it had negative with some variables and positive relationship with some others, which means, negative to climate change adaptable crops variety diversification and crops residue management while positive to crop rotation and inter-cropping adoption sustainability. Amazingly, under highland farming system condition, educational level of the heads of the household and service accessibility demonstrated a mixed association with almost all CSA practices in closely similar manner, but with slight differences. In this regard, their associations were found positive with crop rotation and adaptable crop variety diversification, while lnter-cropping found positive for education, but negative in the case of service accessibility. Furthermore, the effect of educational level found negative, while service accessibility is positive in the case of crop residue management adoption sustainability in the context of highland farming system under discussion. Beyond predictors effect direction discussed above, in respective of all CSA practices included in this analysis, explanatory variables effect coefficients have summarized and articulated in two Tables shown above (Table 8.8a and b).

(iii) Agro-ecologically Aggregated Adoption Sustainability Estimates Using Tobit Model

The overall inferential statistical analyses for many CSA practices were conducted and presented in the previous sub section in a agro-ecologically disaggregated manner in order to make relative comparison between the effect of different variables on adoption sustainability in respective of each agro-ecology which can help to generate relevant conclusion related to those particular practices and recommendations on agro-ecologically disaggregated bases. On the other hand, under this section the emphasis was made on the aggregated (merged highland and lowland) data to determine the effect of variables on CSA practices adoption sustainability. For this particular sub-topic, Tobit regression model was selected and employed to analyze the aggregated data of highland and lowland agro-ecology of the study areas. In this regard, the dependent variables has established from the indexed value of different CSA practices adoption sustainability (Minimum tillage, crop rotation, drought adaptable crops variety diversification, inter-cropping, small-scale irrigation, fallow farming, adjusting planting time, improved forage management, crops diversification, water harvesting and Agricultural insurance adoption sustainability) which has generated using principal component Analysis (PCA) and result has summarized in the Table 8.8c and interpreted in the below presented manners.

As shown in Table 8.8c, nearly the effect of majority variables (89.5 percent of 19 variables) are observed statistically non-significant, while only two variables (CSA practices adoption index and adaptive capacity indicators index) found statistically significant at 1 percent and at 5 percent significance level, with a positive 0.74 and 0.097 coefficient of association, respectively, to CSA practices adoption sustainability. According to the result summarized in the below Table 8.8c, the age of the households' heads, education level of the households, distance of FTCs from farmland and credit support for the households have negative association with indexed CSA practices adoption sustainability by a factors of about 0.001, 0.039,0.009 and 0.078, respectively, though the effect is statistically insignificant. However, of these above mentioned variables, the negative association of education level and credit support is in contrary to several findings and prior assumption, as the most of study findings identified positive effect of these two variables (education and credit) on technology adoption and consequently adoption sustainability. Furthermore, the family size (by a factor of 0.015) and farmland holding (by a factor of 0.009) of the household, found to have positive association with CSA practices adoption sustainability, which is consistent with several research findings, for instance, Milkeessa (2020) and Ashenafi and Oliyad (2020). On the other hand, some imperative environmental and weather variables were analyzed to determine their effect on CSA practices sustainability, of which the effect of agro-ecology, rainfall standard deviation, maximum temperature mean, drought frequency and minimum temperature index were found negative on CSA practices adoption sustainability, but the effect of all these variables are statistically insignificant at any significance level, while the effect of rainfall mean, rainfall coefficient of variation (CV) and maximum temperature coefficient of variation (CV) were found positive on CSA practices adoption sustainability.

Table 8.8c: Aggregated CSA Practices Sustainability Estimate Using Tobit Regression Model

Explanatory variables	**Inferential statistics**			
	Coefficient	**Std. Err**	**t-value**	**p>/t/**
Agro-ecology	-0.367	1.251	-0.29	0.770
Age of Households head	-0.001	0.004	-0.32	0.747
Education	-0.039	0.032	-1.22	0.225
Family size of the Households	0.015	0.015	1.03	0.303
Drought frequency	-0.015	0.029	0.51	0.608
Farm size of the Households	0.009	0.024	0.38	0.703
Extension support	0.020	0.047	0.41	0.681
FTC Distance from farmland	-0.009	0.012	0.71	0.476
Credit support	-0.078	0.070	-1.12	0.264
Rainfall mean	0.000	0.003	0.03	0.979
Rainfall standard deviation	-0.029	0.045	-0.65	0.519
Rainfall Coefficient of variation (CV)	14.414	22.659	0.64	0.525
Maximum Temperature Mean	-0.001	0.172	-0.01	0.995
Maximum Temp coefficient of variation (CV)	24.440	36.715	0.67	0.506
Minimum Temperature Index	-0.022	0.081	-0.28	0.782
Livelihoods Vulnerability Indicators Index	-0.017	0.014	-1.25	0.212
Income index	-0.031	0.036	-0.87	0.383
CSA practices adoption Index	0.740	0.038	19.29	0.000***
Adaptive Capacity indicators index	0.097	0.038	-2.52	0.012**
Constant	**1.769**	**4.805**	**0.37**	**0.713**

Log Likelihood ------------------------------- -375.182
LR chi-square (X^2) -------------------------- 394.150
Prob>chi-Square (X^2) ---------------------------0.000
Pseudo R^2 ---0.344

Source: Compiled from Survey Data (2020)

In the meantime, the effect of the indexed vulnerability indicators and incomes by its sources were found negative on CSA practices adoption sustainability, indicating that a unit increase in the livelihoods vulnerability and households' income index tend to reduce the probability of CSA practices adoption sustainability by a multiple of 0.017 and 0.031 points, respectively, of which the negative effect of income is rare in other research findings. Beside these, some of the variables, like CSA practices adoption and adaptive capacity indicators have positive relationship with CSA practices adoption sustainability, where the observed positive association of adoption and adaptive capacity index are relationship found to be normal in the context of expectation and common in other research findings in which most of them reveal their positive linkage with technology adoption decision and eventually sustainability. As to this study data analysis result, of environmental variable variables considered in this study, the effect of agro-ecology found to have negative association with CSA practices adoption sustainability, indicating reduced tendency by a factor 0f

0.367 point in the likelihoods of CSA practices adoption sustainability as the result of change from lowland to highland agro-ecology in the context of study community. On the other hand, as to the study result, the effect of extension service accessibility to farmers found to have positive influence on CSA practices adoption sustainability, which indicating a unit increase in the scale of extension service accessibility tends to increase the likelihood of adoption sustainability by a factor of 0.02 in context of study households and community.

8.4 Institutional Adaptive Capacity in Context of Climate Change Management

In the context of climate change, adaptive capacity represents the potential for the system to adapt, and a high level of adaptive capacity only reduces a system's vulnerability to future impacts from climate change (Adger et al., 2011). In the context of organizational culture and values, the ultimate goal of the resources development (particularly human resources, infrastructures and technology) is to attain the optimum institutional adaptive capacity which leads to overall customer satisfaction which in agricultural extension case, farmers' satisfaction that can be expressed through Technology adoption and sustainability in the farming community level. Based on this background, in this study institutional adaptive capacity and customer satisfaction assessment was considered to investigate the level of adaptive capacity and rate of farmers' satisfaction in order to highlight the situation for polices and strategies development, which emphasis the environmental sustainability. Consequently, the findings of the survey are summarized and presented below under below sub-headings.

(a) Perceived Institutional Adaptive Capacity of Extension Structure

Currently, with the national attempt to improve agricultural yield per unit of cultivated farmland, the Ethiopian government has adopted Participatory Demonstration and Training Extension System (PADATES) to facilitate and make efficient the service delivery system. For this purpose, adequate institutional adaptive capacity is critically required which includes approaches shifts, Technical and Technological capacity of the institutional structures of the extension service delivery systems. Based on these views and concepts, a review of previous studies were conducted which equally affirmed the survey indicators that are globally recognized to decipher the adaptive capacity of the service delivery system in the context of extension services provision system. Consequently, these indicators have been used to assess and infer the level of institutional adaptive capacity at higher structural level in general and lower level in particular.

Regarding the institutional adaptive capacity of the extension structures, around nine indicators were selected in order to assess the potential capacity of the structure to adjust itself according to the need of the climate change adaptation strategies implementations. In addition, almost all respondents from the highland and lowland community were involved in rating the indicators; and the majority of the highland and lowland agro-ecology represented respondents assented to the importance of the extension services with respect to climate change adaptation strategies promotions (Table 8.9).

Table 8.9: Institutional Adaptive Capacity of the Extension Service Delivery System Ratings

Category of adaptive capacity indicators	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	3	2	1	Total	%	3	2	1	Total	%
Climate change adaptation strategies Integration	225	144	50	419	69.8	102	190	77	369	58.6
Technical capacity of the staff (DAs)	165	250	19	434	72.3	126	284	23	433	68.7
Resource Facilities of structural levels	138	98	100	336	56.0	108	94	108	310	49.2
Focus for CC during seasonal events	153	214	40	407	67.8	132	140	88	360	57.1
Focus to promote climate change strategies	111	242	33	386	64.3	84	146	93	323	51.3
DAs contacts for Climate change	219	194	29	442	73.7	153	222	42	417	66.2
Commitment of extension staff (DAs)	153	226	35	414	69.0	129	174	74	377	59.8
Services accessibility and convenience	177	186	45	408	68.0	102	176	82	360	57.1
Service Contents and quality at FTC	129	222	39	390	65.0	87	240	57	384	61.0
Average				**404**	**67.3**				**370**	**58.8**

Note: Highly adequate (3), Moderately Adequate (2), Less Adequate (1) and in Adequate (0), where 0 excluded from the Table

Regarding the importance of extension services, only a few respondents neglected the significant role of extension services and strategies on the households and community livelihoods. More importantly, among the selected indicators, DAs contact for climate change adaptation strategies promotions (73.7 percent), the technical capacity of the staffs (72.3 percent) and Integration of Climate change mitigation strategies into the service delivery system at FTCs level (69.8 percent) are rated from 1st to 3rd ranking level by the respondents, in the highland farming systems. Also, resource Facilities of structural levels (56 percent), Focus to promote the climate change strategies at the community level (64.3 percent) and Service Contents and quality at FTC (65 percent) was rated and ranked from 1st to 3rd from the last in the same highland agro-ecology. Apparently, according to the survey results summarized in Table 8.9 above, the aggregated overall score of 404 (67 percent) out of the expected highest (that of 600 for the highland) is slightly above average by 17.3 percent, indicating relatively moderate capacity of the extension structure concerning climate change mitigation and adaptation strategies promotion, in order to influence adequate adoption and sustainability of the adopted practices in the farming community. Similarly, among the selected indicators, Climate change related technical capacity of the staff (DAs) (68.7 percent), the DAs contacts for Climate change (66.2 percent) and Service Contents and quality at FTC (61 percent) are rated from 1st to 3rd ranking level by the respondents, in the lowland farming systems. Additionally, resource Facilities of structural levels (49.2 percent), Focus to promote the climate change strategies at the community level (51.3 percent), and service Accessibility and Focus of climate change issues during seasonal events like Training, workshop (two indicators scored 57.1 percent each out) was rated and ranked from 1st to 3rd from the last in the same lowland agro-ecology and farm community (Table 8.9).

Accordingly, as shown in the survey results summarized in Table 8.9 above, the aggregated overall score of 370 (58.8 percent) out of the expected highest score (that of 630 for the lowland community) is slightly above average by 8.8 percent, indicating relatively moderate capacity of the extension structure in respective of climate change mitigation and adaptation strategies promotion. The function is to influence adequate adoption and sustainability of the adopted practices in the farming community, but the score is discouraging when compared with highland's score, especially when the level of climate change impact in the lowland is considered. Furthermore, among the included indicators, no one scored 70 percent, and above which is the best indication of the least adaptive capacity of the extension service delivery system as compared to highland, where two indicators scored above 70 percent and others two scored closer to 70 percent.

On the other hand, as shown in Table 8.9, almost all of the indicators scores for highland were ranked above average (between 50 and 60 percent), except resource Facilities of structural levels, when compared with lowland agro- ecology in which 66.7 percent of the adapted indicators were poorly rated, below the range of average contrary to highland situation. Nevertheless, the scores failed to attain the stipulated the strategic goal of the country which are established in different strategic documents (like Basic Process Re-engineering (BPR) and Balanced Score Card (BSC)), particularly when they are considered as reference points. According to these strategic documents, the institutional efficiency and effectiveness are expected to be about 90 percent and above in order to attain a maximum satisfaction, with respect to customers and citizens in all sectors established to provide regular services to citizens including the agricultural sector. This finding is consistent with some other researchers' report, like that of Brown, et al. (2000), who asserted based on the facts in context of Cameroun's institutional capacity. According to this author, the most institutional key challenges to adapt to climate change was a lack of appropriate infrastructure, financial and human capacity, which at the national level these constraints were particularly acute in government and research institutions where there is a serious lack of capacity on the technical aspects of climate change.

(b) Extension Structure Adaptive Capacity Determinant Analysis Using Tobit Model

As documented by several study findings, the process of adopting improved innovations is the result of compounded effect of institutional capacity which commonly influenced by institutional resources, technical capacity and system level commitment. For instance, referring to IPCC experiences, Engle (2011) suggested determinants of adaptive capacity as economic resources, technological capacity, information, technical skills, infrastructure facilities, institutional settings, governance, networks, management and equity, which play significant role in determining a system's ability to adapt to climate change. Once more, as to Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR) (2011), as well as Jones, et al. (2010), adaptive capacity is the ability or potential of a system to respond successfully to climate change and weather variability to moderate potential damage, take advantage of opportunities or cope with the consequences of shock or stress; which includes adjustments in behaviour as well as resources and technologies, where these resources could be natural, financial, institutional or human resources.

In this regard, in the traditional and contemporary service delivery system, institutional capacity to deliver required service to the level of responsibility and actual demand is the major factors for the success of particular institution and structural settings, which require the scientific assessment to determine system effectiveness and efficiency. Based on this reality and reviewing the research oriented facts, this sub-section has designed in this research study to determine the determinants of extension service delivery system efficiency to adapt to climate change in general and weather variability in particular. Accordingly, among a range of variables to influence adaptive capacity of service delivery system, a list of institutional adaptive capacity indicators were selected and included in the system level capacity analysis process, with maximum emphasis on institutional structural settings and capacity required to deliver compulsory responsibility and role of public domain in the context of climate change management and related practices implementation.

With this regard, different adaptive capacity indicators ranked based on score assigned by farmers in this section (Table 8.9 above) have been indexed according to score level assigned and the indexed value has taken as dependent variables, while independent variables are demographic, resources and extension structure set up as well as capacity in context of this study (Table 8.10). According to data analysis result presented in Table 8.10 below, predominantly the effect of included variables are statistically significant at 1 percent significance level, with positive influence in almost all majorities, where the only effect of few variables (sex of households' heads, educational level and FTC distance) found statistically insignificant.

These findings are inconsistent with some researchers' findings and consistent with others, like that of Uddin et al. (2014), who indicated negative association of age with statistically significant at 10 percent significance level to adaptive capacity of a system, which is different from positive influence and statistically significant at 5 percent significance level in the case of this study finding. Again this author, explained the positive and 5 percent significant effect of education related to adaptation to climate change effects, implying greater probability of adaptation to climate change for those who have higher educational attainment compared to less-educated or illiterate farmers, which is relatively consistent with positive findings of this study, but in contrary statistically insignificant. Similarly, of total variables have taken as the part of the model analysis, only the effect of road facility identified significant at 5 percent significance level. Surprisingly, of total explanatory variables integrated in the model analysis, only the effect of FTC distance was found to have negative association with institutional adaptive capacity, while the effect of the entire remaining category of variables found positive relationship with institutional adaptive capacity of the extension service delivery system in context of study community.

Table 8.10: Extension System Adaptive Capacity Analysis Using Tobit Model

Explanatory variables	**Inferential statistics**			
	Coefficient	**Std. Err**	**t-value**	**p>/t/**
Age of the Households heads	0.00004	0.00002	2.55	0.011**
Sex of the Households heads	0.00023	0.00047	0.49	0.622
Education level of household heads	0.00011	0.00012	0.88	0.381
Road facility accessibility	0.00004	0.00002	1.90	0.059*
FTC facility Distance from farmland	-0.00006	0.00005	-1.22	0.224
Structural set up adequacy	0.24065	0.00025	970.76	0.000***
Institutional Technical Capacity	0.16981	0.00022	755.39	0.000***
Resource Facility and capacity	0.21016	0.00022	974.32	0.000***
Institutional Climate Focuses	0.23904	0.00023	1043.34	0.000***
Climate strategy focuses	0.17845	0.00021	866.41	0.000***
Field staff contact capacity	0.24202	0.00025	970.84	0.000***
Staff commitment	0.22909	0.00023	990.60	0.000***
Service accessibility and convenience	0.22651	0.00023	981.71	0.000***
Service content and quality adequacy	0.25500	0.00025	1001.99	0.000***
Constance	**-3.77206**	**0.00129**	**-2930.42**	**0.000**

Log Likelihood -------------------------------------1799.973
LR chi-square (X^2) --------------------------------4747.860
Prob>chi-Square (X^2) ------------------------------0.000
Pseudo R^2 --- 4.136

Source: Compiled from Survey Data (2020)

Accordingly, a unit increase in the measurement scale of structural set up, institutional technical capacity and resource facility/capacity found to increase the likelihoods of adaptive capacity of the extension service delivery system by a factor of about 0.241 point, 0.170 point and 0.210 point, respectively, in the context of currently working extension structure and system. In the meanwhile, a unit increase in the measurement scale of institutional climate change management and strategy focus found to increase the adaptive capacity of the extension service system by a factor of about 0.239 and 0.178, respectively, when other remaining variables are kept constant. Furthermore, according to study result, a unit increase in the measurement scale of field staffs contact, field staff commitment, service accessibility and convenience, and service content and quality adequacy, the adaptive capacity of extension institution increase by a factor of 0.242 point, 0.229 point, 0.227 point and 0.255 point, respectively, under current situation and contexts.

(c) Customer satisfaction in the Context of Institutional Adaptive Capacity

In the context of Customers services, both national and regional level organizational structures emphasize the institutionalized adoption of customer oriented strategies and approaches. The target is to attain the highest level of customer satisfaction in service delivery and ultimately the highest achievement of the institutional goals, which established to secure customer needs and interests. As to several study findings, the highest level of institutional achievement is the compounded effect of institutional capacity to satisfy the customers' needs, which indirectly customers' satisfaction employed as the indicator of institutional adaptive capacity measurement. Thus, this sub-section under this study, emphasized on customers' satisfaction analysis and interpretation to gauge extension service delivery system adaptive capacity to triangulate the results of adaptive capacity indicators presented and discussed above in the preceding sections. Subsequently, among several services delivered by agricultural extension some of the services selected as indictors to assess the customer satisfaction level in perspective of climate change adaptation and mitigation orientation, which are considered as the representatives of the remaining other extension services in order to infer and conclude the general situations (Table 8.11).Moreover, this survey research identified the tremendous variation among the different services and strategies in relation to their impacts on the community livelihoods and climate change adaptation strategies sustainability. Precisely, in the framework of agricultural sector which is the dominant service delivery is extension service, the situation is different from the stipulated target. In this regard, the existing reality on the ground shows that the adopted service delivery system strategies are not as functional as expected. This has consequently, affected the agricultural sector negatively, which is evidenced in its low rate of improved CSA practices adoption and sustainability in the study community.

On the other hand, in contemporary extension approach the success and effectiveness of the extension system is all about the farmers' satisfaction on the service provided, which ultimately leads to trust based on the impact of the services. This usually based on the accessibility of services, frequency of visits, quality of services in respective of contents and relevance and timelines of the services. Consequent upon that, this study assessed farmers' satisfaction taking these components as indicators. Accordingly, the study indicates that a large percentage of farmers (82.5 percent) in the study area was contacted by field extension agents, specially Development Agents (DAs) 1-5 times per month for technical supports and advice, while other few farmers (11.5 percent) visited 6-10 times and the remaining group (6 percent) had more than 10 times contact with extension agents per month in the context of highland farming community.

Likewise, in respect to lowland agro-ecology, the study further revealed that a significant proportion of respondents (88 percent) in the study area was contacted by field extension agents 1-5 times per month for technical visit, while other few farmers (12 percent) had 6-10 times contact with extension agents per month for advisory services. However, out of the total respondents represented the highland community, majority of them (about 50 percent) confirmed 3-5 times visit of extension field staffs (particularly DAs), where a larger proportion (about 54 percent) of lowland respondents mentioned 3-5 times contact per months for extension technical services, indicating slightly better situation as compared to highland agro-ecology. This may be due to the fact that, climate change and variability are usually significant and frequent, hence the focus and commitments rendered by high official in the extension service delivery system, which increased the frequency of extension contacts in respective of climate change adaptation and mitigation, in the lowland study community. Moreover, an existing extension strategy targeted to work adequately within the community frequently vulnerable to climate change impacts could have caused an increase in the number of extension field staff contact regularly for climate change related advice. However, according to the study findings, respondents from the study areas (highland and lowland) had a range of alternative sources of information through which they can access the advice on agricultural best practices and technologies. Among the various sources of information, majority of the respondents (87 percent), rated extension workers as the primary source of information and advice as compared to other sources, while the remaining few group (13 percent) underscored the significance of the extension workers as the source of extension information.

With regard to climate change related extension service, availability and accessibility which was explained in the context of advice received, majority of the respondents from highland (95.5 percent) and lowland (96.7 percent) communities recognized the availability of the practical service and they are adequately adopted to cope with the contrary impacts of climate change. Regarding with importance of the extension service strategies in increasing and improving the households' seasonal livelihoods, majority (92 percent) of the highland agro-ecology respondents indicated significant level for importance of the extension services and strategies in impacting the livelihoods of the community, while only a few respondents (8 percent) refuted this. Similarly, the large proportion (about 95 percent) of the lowland respondents appreciated the significant role and importance of available extension services and strategies, which ultimately can improve the living condition of the individuals and community.

In addition to points presented and discussed above in the preceding section, indicators scoring approach were employed; where the score of each indicator were indexed to identify the most influential indicator/indicators in context of study community. Generally, as shown in Table 8.11, almost all of the extension service considered as indicators (except Content of advice and technical support) in the highland agro-ecology were rated below, and within the range of average level (50 percent), when compared with lowland agro- ecology, whereby at least some (about 50 percent) of the selected strategies were rated above average. The reason for the contrast, as earlier stated can be attributed to the fact that the lowland area is noted for frequent severe impacts of climate change, which has consequently drawn more attention to them by the government. Similarly, the overall indexed values average score of 363 (57.6 percent) observed in the context of lowland farm households found to be slightly high as compared to 312 score (52 percent) observed in context of the highland households and farming community.

Table 8.11: Satisfaction with Climate Management Services Provision in Extension Delivery (N=410)

Satisfaction indicators	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
Content of advices and Technical support	123	206	52	381	63.5	102	298	22	422	67.0
Content and relevance of training	93	134	67	294	49.0	186	128	78	392	62.2
Practical demonstration	144	98	80	322	53.7	126	216	56	398	63.2
Frequency of Staff visit	60	164	61	285	47.5	87	118	114	319	50.6
Technical tour and experience sharing	84	118	80	282	47.0	57	154	90	301	47.8
Timeliness of the services	69	150	89	308	51.3	69	186	90	345	54.8
Average				**312**	**52.0**				**363**	**57.6**

Note: High Satisfaction (3), Moderate Satisfaction (2) Slight Satisfaction (1) and No Satisfaction (0)

With regard to disaggregated ratings, the findings of the study indicate that content of advice and technical support were rated best (63.5 percent) in the highland farming community situation, while others like Practical demonstration (53.1 percent) and timelines of the service provision comes 2nd and 3rd in service-related satisfaction scenario. Likewise, Content of advice and technical support (67 percent), attracted the best score in the lowland community, where practical demonstration (63.2 percent) and content quality and relevance of the Technical trainings (62.2 percent) were rated 2nd and 3rd, which however indicates the promising level of satisfaction as compared to highland agro-ecology where the highest score was 63.5 percent and its only single score above the average ranges. However, as mentioned under the adaptive capacity assessment section of this study, the aggregated ratio of all summarized satisfaction scores presented in Table 8.11 can only be described as low and painfully discouraging. This is because the extension service delivery has not been able to meet the postulation of the government established in its strategic documents like Basic Process Re-engineering (BPR) and Balanced Score Card (BSC), which set to attain more than 90 percent customer satisfaction and trust in service delivery system.

8.5 Chapter Summary

This part of the Thesis was emphasized to present the adoption and adoption sustainability of the CSA strategic practices. In this regard, among CSA strategic practices, only 46.2 percent attained more than 50 percent adoption rate in the highland areas, while the rest 53.8 percent scored below 50 percent rate of adoption in the same agro-ecology and community. In similar manner, only 30.8 percent of included CSA practices maintained above 5o percent rate of adoption, while 69.2 percent of the CSA practices scored below 50 percent rate of adoption in the lowland agro-ecology. On the other hand, about 38.5 percent of CSA strategic practices were adopted by more than 50 percent of the highland households, where 61.5 percent of selected practices were scored below 50 percent rate of sustainability in context of highland community. Furthermore, as similar with rate of adoption, 30.8 percent CSA strategic practices were adopted by more than 50 percent of respondents, while 69.2 percent of practices scored below 50 percent rate of adoption-sustainability in scenario of lowland households.

Additionally, a number of models were employed under this chapter to comprehensively identify the determinants of CSA adoption and sustainability, where only agro-ecology aggregated data results are presented in this summary presentation. In this regard, among 18 socio-economic and natural variables included in Tobit model analysis, only the effect of 7 variables (38.9 percent) found statistically significant, while about 11 percent and 27.8 percent statistically significant at 1 percent and 5 percent significance level, indicating that the effect of about 61 percent of socio-economic variables is statistically non-significant.

CHAPTER NINE

CLIMATE CHANGE MANAGEMENT AND HOUSEHOLDS' WELFARE

9.1 Introduction

Chapter eight focuses on the final part of the results and discussion, which is climate change management and adaptability. This chapter is specifically structured to present the findings that are related to climate change coping and adaptation mechanisms, and strategies used by the farmers. The chapter further presents the effects of the climate change coping and adaptations strategies on households' incomes. The chapter also discusses the institutional adaptive capacity in the context of resource facilities availability and accessibility to farming households in the context of study community.

9.2 Climate Change Coping Mechanisms and Adaptation Strategies

In Ethiopia condition, several documents have identified a range of natural and human made disasters, along with the mitigation, adaptation and coping strategies that were used by community members. Accordingly, this section is designed to deal with the identification of household level climate change impact coping mechanism, and to determine the level of influence exerted by specific adaptation and coping mechanisms adopted by community to sustain the livelihoods in the farming system. The study areas are located in the drought-prone areas of the central rift valley of the country which are characterized by irregularity in the onset of the first rains, inadequacy in the amount received, and failure in the middle of the crops' physiological maturity periods. These problems are especially severe in lowland agro-ecology of the study areas (*Woina-Dega* and *Kolla*), adversely affecting the livelihoods of the community.

Furthermore, households suggested that frequently there are livelihoods instability and food shortage in the areas because of unpredictable rainfall, variability and failures during crop growing periods. According to the conducted survey and climate data results, there are high rainfall and temperature variability in the study areas over the years; negatively impacting the crops and livestock productivity. These problems are more complicated among the lowland farmers because the frequency and severity of droughts have increased considerably through time, widening the coverage in the community as compared to their highland counterparts. The study further discovered that, unlike the previous experiences, the frequency of drought is increasing per ten years when compared to the last twenty years drought experiences in the community. Based on the increasing severity of the climate change related impacts, the community is compelled to look for coping strategies, which they adopt into their farming systems and livelihoods of their households. On the other hand, the government also designs and promotes the nationally and internationally recognized climate change coping mechanisms and adaptation strategies practiced by farming communities. Communities adopt various adaptation and coping mechanisms against climate change and weather variability. For instance, a community can decide to grow fast and early maturing crops varieties, livelihood diversification (crop production, livestock production, non-farm activities and off-farm activities) and crop diversifications. Other coping strategies are stocking seed reserves, soil conservation measures, early planting, and the use of water harvesting techniques with regard to agricultural livelihoods. In addition, there are several non-farm related coping mechanisms adopted by the farming community, while most of them are globally recognized means of coping with climate change impacts and risks. Thus, among the commonly recognized mechanisms are rural off farm employments, urban non-farm employments, credit sources, borrowing, selling of available assets, and natural resources like firewood, charcoal, and other natural resources related products. Accordingly, the results are adequately summarized and presented in the below concise manner (Table 9.1).

The study examined the importance each of the individual coping mechanisms using scoring and indexing approaches, where the scoring value for each coping strategies was assigned by the respondents, then analyzed for interpretation. As the short-term strategic responses of the poor and vulnerable households to climate change comprised of sale of tree products (charcoal and fuel wood), access to loans or credits, borrowing in kind or cash from friends, and/or relatives and sale of valuable assets. All these were the major ex-post coping strategies practiced in both the highland and lowland agro-ecology. Apparently, a significant majority, precisely about 82 percent of the represented respondents in highland appreciated the availability of the recognized coping strategies in the farming community through which they survive the hard season situation. However, only a few respondents (18 percent) disagree with the functional availability and the overall role of the coping strategies to survive climate change related risks and damage in the same agro-ecology. Similarly, a considerable size (83 percent) of the lowland respondents appreciated the availability of the recognized coping strategies in the farming community, while only a few farmers (17 percent), like the result noted in the highland, dissented to the availability and the overall importance of the coping strategies. Subsequently, in order to identify the most important coping mechanisms in the survey community, the Coping Strategy Index (CSI) is adapted to determine the level of importance and role score of coping strategies that the household may employ when there is a shortage of reliable resources as the result of climate change and weather variability.

For this study purpose, the Coping strategies index is used as a comparative tool, rather than an absolute measure of importance concerning coping mechanisms. The survey result presented in Table 9.1, shows that among the selected coping mechanisms, the sale of natural forest products (Firewood and charcoal) scored the highest (46.8 percent) within the highland agro-ecology, followed by sale of households' assets (46 percent), borrowing grain in kind (45.5 percent) and with overall score of below average (40.3 percent) indicating less importance of the selected coping mechanisms on the livelihoods risk management. However, based on the confirmed information of the respondents, the survey indicates that sampled households employed various coping strategies due to climate change and weather variability, especially drought related impacts. The most important coping strategies were the utilization of natural resources, commonly known as wood in the case of highland community with few practices of charcoal production, indicating compounded effect of climate change impacts on natural resources and environmental sustainability.

Table 9.1: Rating Importance of Coping Mechanisms of Climate Change as Livelihood Risks Management

Category of the coping mechanisms	**Highland Agro-ecology**					**Lowland Agro-ecology**				
	3	2	1	Total	%	3	2	1	Total	%
Rural off-farm employment	15	148	25	188	31.3	87	172	42	301	47.8
Urban non-farm employment	6	82	74	162	27.0	90	74	67	231	36.7
Informal credit source	87	56	112	255	42.5	81	136	64	281	44.6
Formal credit source	42	94	82	218	36.3	168	172	26	366	58.1
Borrowing grain in kind	72	114	87	273	45.5	54	158	64	276	43.8
Sale of wood for fuel	129	60	92	281	46.8	135	136	48	319	50.6
Use of available own savings	54	140	58	252	42.0	168	198	37	403	64.0
External emergence aids	63	98	74	235	39.2	63	170	88	321	51.0
Seasonal internal mobility	12	114	98	224	37.3	117	160	74	351	55.7
Social interconnectedness	51	140	79	270	45.0	117	164	76	357	56.7
sale of household assets	57	124	95	276	46.0	51	162	92	305	48.4
Household Land renting	51	124	89	264	44.0	51	154	75	280	44.4
Average				**242**	**40.3**				**316**	**50.1**

Note: High (3), Moderate (2), Low (1) and Negligible (0), where 0 not included in the Table **(Source:** Survey Data, 2020)

As shown in the Table 9.1 above, the survey result indicates better importance of the coping mechanisms in the lowland agro-ecology as compared to highland agro-ecology when the score of the strategies is considered. Regarding to this point, in the context of lowland farming community, use of available household level own saving topped the strategies (64 percent) as coping mechanisms, followed by formal credit sources, with 58.1 percent, then social interconnectedness (relative support) was ranked third by 56.7 percent. More importantly, the aggregated overall score 316 (50.1 percent) of the selected coping mechanisms is about the average, unlike the highland agro-ecology which is below average point when estimated from total highest indices points. Similarly, among the total coping mechanisms, half of the strategies scored average and above in the lowland farming system, while none of the strategies scored average and above in the case of highland agro-ecology farming community. According to traditional practices, household and personal assets are not generally likely to be used under normal conditions for household consumption, but 46 percent and 48.4 percent of highlanders and lowlanders, respectively, expressed sale of available assets to survive hard seasons, which in real sense is the indication of notorious situation in the study community. Because traditionally it is only in times of natural hazards like repeated drought frequency, when domestic food stock becomes exhausted or very low, there comes the need to sell assets to raise cash to buy food. In this aspect, this finding is consistent with some other findings. For instance, Paul (1998), identified sale of household assets to purchase food items to minimize the risk of vulnerability to prevailing climate change effects. This researcher specifically noted the sales of livestock as well as poultry, lands resources, mortgaging of family lands and housing structures, termed as "non-agriculture adjustments" practiced in North Bengal of India, during drought season in the traditional farming community.

9.3 Impact of Climate Change Management Strategies on Income and Food supply Systems

This sub-heading formulated to deal with different major sources of households' incomes and potential climate change management impact on seasonal households' income**.** Additionally, considering pressingly importance of food items production and supply**,** Perceived Impact of Climate Change on Seasonal Food Sufficiency and Security were included, where the results of two variables (income and food) are presented and discussed in the below shown manner under two major sub-headings.

9.3.1 Climate Change Management Strategies Impact on Households' Seasonal Income

(i) Source of households' Income and Implication on Climate Change Adaptation

To really comprehend household income portfolios and livelihood strategies during the cropping seasons, individual income sources (seasonal crops sale, Livestock and livestock product sale, on-farm employment, non-farm employment and family member's remittance) were examined and discussed in this study. In view of this, different illustrative tables are presented below, showing major livelihoods and the source of income for the households under the study community. Others present the total and average real per capita income in the surveyed households. By studying average income amongst all surveyed households, it helps to gain an understanding of the importance of various income sources at the community level within each agro-ecology, which indicates the level of livelihoods diversification as well as incomes that help the community to cop up natural disasters including climate change. According to many studies, climate change vulnerability is the negative effect resulting from a combination of different factors and can be influenced by many more variables among which source of income is one, and most important determinant that can be used to investigate level of impacts on the community livelihoods. As such, households' source of income diversification is significantly important because it helps in coping with natural disaster, including the climate change negative impacts. Based on the empirical evidence concerning the susceptibility of natural resource related source of income (including agriculture, which is heavily dependent on natural environment) and positive impact of the non-agricultural income source on the livelihoods of the households, family income has been assessed in context of two major sources of income that are agriculture related income and non-agriculture source of income for survey households (Appendix 5).The analysis related to income of surveyed households showed that across the two agro-ecology, the households in highland consistently earned on average better incomes than households in the lowland agro-ecology in almost all income categories, but the difference is minimum and insignificant, whereas the lowland community is earning better income from non-agricultural sources as compared to the highland represented farming households and community. Thus, the household survey of highland community reveals that the average household income across all households is 93,776 Eth birr per annum, while the minimum income is 2600birr and the maximum reported income for high income households is 744,000birr showing a large difference between low and high income in survey households for highland agro-ecology (Appendix 5).Similarly, the average income for lowland households is 92,689birr and minimum income 2200 birr, demonstrating closely a similar feature with highland agro-ecology. The maximum income is 950,000birr for high income household, and this is significantly higher than the highland area households' high income, showing about 28 percent above the high-income earners in highland community (Appendix 5).

On the other hand, the lowest standard deviation of 93660 birr is identified for highland areas, as compared to 143287birr standard deviation of lowland family, which proves significant income variability among the smallholder farmers when low-income earners in highland agro-ecology compared with lowland farming community low earners households. Congruous to that, the survey data shows that an average income of household that is from non-agriculture source is 7053birr for highland area households and 10556 birr for lowland represented households which are 7.5 percent and 11.4 percent of total income for both, respectively. This result evidenced the dominance of agriculture in the family income. Thus, this result shows that the probability of the survey community to be vulnerable to natural shock including the climate change is high regardless of better situation at lowland agro-ecology as compared to highland area households.

(ii) Impacts of Climate Variability and Management Strategies on Households' Income

Based on the data collected from the survey households, the impact of some of the introduced coping and adaptation strategies on households' income are analyzed and presented in Table 9.2 to identify the influence of overall coping and adaptation strategies in general and each strategy in particular. Several studies have postulated various definitions for adaption. Even though these definitions vary because of the specific focus of the researcher, yet there exists a central convergence in all the postulations. Subsequently, according to Akinnagbe and Ironies (2014), adapting to climate change involves taking appropriate actions to minimize an anticipated adverse consequences of climate change as well as exploiting useful aspect of changes through making suitable adjustments in given systems. Once more, as to IPCC (2007), adaptation is adjustments made in natural or human systems through actions taken by individuals, societies, and countries, in response to actual or expected climate change linked consequence, which restrain potential damage or exploits obtainable positive opportunities during climate changes with negative consequences.

Accordingly, it has been identified that, adaptation has three possible objectives: (i) to minimize the chances of exposure to hazard; (ii) to develop potential capacity to cope with inevitable damages, and (iii) to take advantage of new opportunities (Akinnagbe and Ironies 2014). Correspondingly, many previous studies have documented numerous coping mechanisms and experiences in relation to climate change management. Accordingly, while some are universal, others are indigenous, that is, geographically specific or within limited area local communities. Likewise, while some are traditional adaptation, others are intentionally introduced into the farming systems. With regard to indigenous mechanisms, within African farming community a large body of knowledge and experience on coping with climatic variability and extreme weather events is adequately available (ibid). In Africa, rural farm households have already acquired experiences to develop and use several agricultural practices, functioning as coping mechanisms along with externally promoted innovations in order to realize sustainable food items production and supply systems, which are usually described as structural and non-structural measures (ibid). In this research and presented result, the coping and adaptation strategies used for the last couple of years of cropping seasons in Ethiopia were assessed and discussed in the context of agriculture (crop and/or livestock) and non-agricultural related coping and adaptation strategies.

In the Ethiopian context, many studies validate the utilization of both national and regional promoted coping and adaptation strategies, as means of safeguarding the livelihoods of communities from the negative impact of climate change and related risks. However, the examination carried out on the practicality of these adopted adaptation and coping strategies evidenced just slight effectuality. Thus, farmers are unable to overcome the pace of the negative impact following climate changes, as such, farmers are disenabled from attaining sustainable livelihoods and income for their households, and the community at large. This research also identified a remarkable variation among the different adaption and coping strategies regarding their impacts and importance on the community's livelihoods and income sustainability, and lives of the households. In this context, majority of the respondents from highland, that is, 81.5 percent and 82.9 from the lowland community recognized the significance of adopting the available coping strategies to check the contrary impact of climate change.

Among a list of strategies internationally recognized and nationally adopted as adaptation and coping mechanisms commonly found in community daily experience are selected for this study to assess perceived impact of each strategy on the livelihoods of the community and income of the households. Regarding the importance of the coping strategies in increasing and improving the households' seasonal income, majority (92 percent) of the respondents from highland agro-ecology indicated the importance of the coping and adaptation strategies on their seasonal income, while only a few respondents (8 percent) refuted the functional roles of these strategies on the household's annual income. Similarly, most of the represented households from the lowland, (about 95 percent) acknowledged the significant roles played by availability of adaptation and coping strategies the positive influence on the households' seasonal income which ultimately can improve the living condition of the individuals and community at large.

On the other hand, the overall importance and role of the coping mechanisms on the households' income were rated by the respondents during survey interview using the rating scale from low to very high. Afterwards, majority (85 percent) of the lowland respondents rated the importance and roles of the mechanisms as very high, high and moderate level, while only few (15 percent) respondents rated them as low in context of importance in lowland community. In the meantime, about 13 percent, 39 percent and 33 percent of the respondents agreed on very high, high, and moderate importance of the climate change coping strategies, respectively in lowland households' livelihoods. Likewise, in the highland, a larger proportion (87 percent) of respondents rated the strategies importance as very high, high, and moderate level, while only few (13 percent) respondents rated the available coping mechanisms in the community as having low importance, while 9 percent, about 38 percent and 41 percent rated the overall importance of coping strategies as very high, high, and moderately important, respectively in the highland situation. Meantime, as shown in Table 9.2, almost all the coping mechanisms introduced (except rural on farm employment) in the highland agro-ecology were ranked below average level (below 50 percent) with respect to the impacts of each strategy on the income of households.

Table 9.2: Perceived Impacts of Climate Change Coping and Adaptation Strategies on Family Income

Climate Change management strategies	Highland Agro-ecology					Lowland Agro-ecology				
	3	2	1	Total	%	3	2	1	Total	%
a) Coping strategies										
Rural off-farm employment	36	144	33	213	35.5	150	164	69	383	60.8
Rural on farm employment	144	116	54	314	52.3	126	196	45	367	58.3
Urban non-farm employment	0	146	67	213	35.5	129	112	62	303	48.1
Informal credit source	12	78	95	185	30.8	105	132	71	308	48.9
Formal credit source	45	158	54	257	42.8	156	162	52	370	58.7
External emergence aid	30	88	83	201	33.5	81	172	41	294	46.7
Internal mobility	30	158	55	243	40.5	102	121	60	283	44.9
Social interconnectedness	99	96	78	273	45.5	66	174	59	299	47.5
Aggregated				**237**	**39.6**				**326**	**51.7**
b) Adaptation strategies										
Crops diversification	177	124	64	365	60.8	156	100	48	304	48.3
Conservation Agricultures	78	186	48	312	52.0	69	150	42	261	41.4
Integrated soil fertility Management	162	166	49	377	62.8	135	108	47	290	46.0
Access to early warning information	78	238	39	355	59.2	87	146	46	279	44.3
Introduced Improved Crops Varieties	183	158	42	383	63.8	162	104	43	309	49.0
Introduced crops/livestock insurance	81	214	49	344	57.3	36	146	38	220	34.9
Aggregated				**356**	**59.3**				**277**	**44.0**

Note: High (3), Moderate (2), Low (1) and Negligible (0), where 0 exclude from the Table (**Source:** Survey Data, 2020)

In contrast, in the lowland agro- ecology, about 38 percent of the respondents ranked that the introduced coping strategies as above average, a marked contrast with the situation in highland community. According to the survey data content, respondents perceived that most of the introduced coping mechanisms are better, working adequately, and influential for the lowland farming community. Thus, the functional roles of the strategies can be attributed to the frequent occurrence of climate change impacts, and vulnerability to its effects in the lowland areas, which contrasts the situation in highland agro-ecologies of the country in the Oromia region in general and study community. More specifically, the highest score of 383 (60.8 percent) for rural off-farm employment was identified in the context of lowland community, while rural on farm employment ranked highest score 314 (52.3 percent) in highland study community regarding to coping strategies. Similarly, overall average score of 326 (51.7 percent) found the highest score in lowland community, as compared to 237 score (39.6 percent) of highland community.

In contrast to coping mechanisms, the impact of adaptation strategies on household's income is better rated by respondents from highland, as opposed to the ranking of the respondents from lowland. Lowlanders scored almost all the introduced and selected strategies below average, indicating a discouraging situation in that community. In this regard, with score of almost all adaptation strategies above average when each individual score considered, the highlanders' adaptation strategies topped with overall score of 356 (59.3 percent), while low level 277 score (44 percent) found in the case of lowland community.

Considering the regularity of climate change and weather variability with the accompanying negative impacts resulted from droughts, one would have expected that the farmers support the adaptive strategies. Nevertheless, while the highlanders rated the strategies above average (above 50 percent), on the contrary the strategies were ranked below average by the lowlanders. Thus, the ranking of the lowlanders indicates that they prefer the coping mechanism, which is a short-term strategy than the long-term ones.

More importantly, the results above show that in high climate variability situation, the impact of adaptation on household income is lower, which could be attributed to either incompatibility of introduced strategies or inadequate accessibility for the community. On the other hand, in the lowland farming community, focusing on switching system is common rather than using the strategies mentioned in the Table 9.2a above. Besides examining the rating of some of the adaptation strategies by the respondents from both communities in this section, the study simultaneously inspected the importance of adaptation that entails switching from rain fed to irrigate farming, which involves the use of an open-access resource such as the ground water, natural rivers, and natural lakes (like Hara-Dambale) for agricultural livelihood practices and agricultural production.

Subsequent to the aforesaid, the investigation aligns with the common characteristic of agriculture that irrigated farming is better able to fill income gap which commonly affects households' seasonal income, owing to weather variability shocks than the rain fed farming. This is partly because irrigation can smooth out water input across times and it allows plants to mitigate the negative effects of heat shocks as the results of climate change. In other words, according to the respondents' suggestion, the adoption of irrigation using local water resources is a possible adaptation measure to check or acclimatize to climate change in the context of lowland agro-ecology of the study.

(iii) Linear Regression Parametric estimates and Discussion Related to Households Income

This section has designed primarily to analyze data collected on individual level concerning incomes (total income, agriculture and non-agriculture incomes) in respective of the respondents. The survey has included questions relevant to generate household income and a variety of variables that are generally used to estimate determinants of income or revenue of households (Table 9.3a and b). Thus, interviewees are included in the survey samples only if they report being the primary income earner of the household. Regression analysis were conducted exclusively at two stage: firstly, agro-ecologically separate (disaggregate) estimations are conducted for each agro-ecology; while secondly: estimation of parameters using aggregate data (merged data of two agro-ecology) driven from respondents' responses generated in the context of each agro-ecology the respondent is representing to take part in the survey study conducted in the rural community.

Table 9.3a: Linear Regression Analysis of Households' Income Determinants at Lowland Agro-ecology

Explanatory Variables	**Un-standardized Coefficients (B)**	**Standardized Coefficients (Beta)**	**T-Value**	**P-Value**
Constant	6475.073		0.078	0.938
Respondent Sex	-75124.902	-0.148	-2.035	0.043**
Family size of Households	18859.092	0.291	4.066	0.000***
Educational Level	-2210.462	-0.018	-0.231	0.818
Rural Farm Employment	26000.572	0.153	1.920	0.056*
Rural on farm Employment	-568.612	-0.004	-0.046	0.963
Urban non-farm Employment	5379.037	0.040	0.426	0.670
Internal mobility	-2697.684	-0.020	-0.218	0.827
Interconnectedness	21038.056	0.136	1.628	0.105
Farm Size of Households	7898.381	0.104	1.361	0.175
Emergence aid for households	-13803.111	-0.097	-1.098	0.273
Extension Service accessibility	34087.158	0.177	2.193	0.030**
Informal credit accessibility	389.145	0.003	0.030	0.976
Formal credit accessibility	-19766.615	-0.131	-1.401	0.163
Model summary		Value		
R Square		0.188		
Adjusted R Square		0.133		
Variance (F-Value)		3.124***		

Dependent variable: Aggregated Yearly Income of the Survey Households (**Source:** Survey Data, 2020)

Despite the high financial cost and time utilized to collect primary data, the approach offers an excellent opportunity to examine determinants of income over a geographically diverse area of highland and lowland agro-ecology of the study community. Furthermore, since data were collected based on the agro-ecology, the data offer excellent opportunities for inter agro-ecological comparisons. Household income equations are estimated for a pooled sample in each Agro-ecology and each of the individual agro-ecology result is summarized and presented. The data provides a specific household income figure which has been used for parameter estimation. To facilitate comparison between lowland and highland agro-ecology, the data from households in each group are placed in four income groups - low to high income. Table 9.3a shows the results for 2-stage least square (LS) estimation for these two selected areas rural sample groups respectively assuming average income of over the period of six years.

Pertaining to regression analysis result, based on the model specification in the methodology section of this thesis, 2-stage least square Regression Analysis was conducted for selected demographic variables and coping strategies in respective to variables impact on household incomes in the two study agro-ecologies and community. In this aspect, the sex of the respondents, family size, and educational level of the respondents are among demographic characteristics of the households included in the model, in addition to coping strategies in order to determine their effects on and relations to household income and the results presented in Table 9.3a and b below which show lowland and highland agro-ecology related results separately. According to lowland area data presented in Table 9.3a, sex of the respondent and the income of the household indicate a negative relationship and the impact is significant (at 5 percent significance level), pointing to the detrimental impact on the household income. Similarly, although the influence is not statistically significant, educational level of the respondents, rural on farm employments, internal mobility to look for better situation, emergence aid and formal credit show negative relationship with the income of the households in lowland agro-ecology. Among the selected social characteristics of the households, family size of the households indicates positive association with households and statistically significant (at 1 percent significance level) which is consistent with most of the findings. On the other hand, the coping strategies having positive relationship with the income of the household are urban off-farm employment and service accessibility and are found to be statistically significant at 10 percent and 5 percent significance level, respectively, in context of lowland farming system and community.

On the other hand, more specifically to highland, the results of the regression model are presented below in order to show the detailed impact of the independent variables on the dependent variable which is income in context of this study. As shown in the below Table 9.3b which presents the highland area data results, the relationship between the rural farm employment and the source of household income, exploited by the members of the households as an opportunity to support the livelihoods of the household, emergence aid received from outside the community, interconnectedness or relatives support and urban non-farm employments is found to be negative among which only one (urban non-farm employment) is statistically significant at 1 percent significance level and the impact of the rest are not statistically significant in respective to household income in the context of the highland agro-ecology represented households and community. On the contrary, informal credit, formal credit sources, internal mobility to look for better situation in the community, crops rotation adoption and crops diversification adaptation have a positive relationship with household seasonal income. Furthermore, among the selected coping mechanisms with positive relationship to household income (Table 9.3b), only the relationship of the two strategies (Crop rotation adoption and Crop diversification adaptation) are statistically significant at 5 percent and 1 percent significance level, respectively in the context of highland rural farming community.

Table 9.3b: Copping Strategies Impact on Income of Households at Highland Agro-ecology

Explanatory Variables	**Un-standardized Coefficients (B)**	**Standardized Coefficients (Beta)**	**T-Value**	**P-Value**
Constant	3943.074		0.085	0.932
Respondent Sex	26529.868	0.092	1.394	0.165
Family Size	3171.576	0.082	1.166	0.245
Rural off-farm Employment	-2170.365	-0.027	-0.318	0.751
Rural on farm employment	-5830.563	-0.066	-0.726	0.469
Informal credit accessibility	1166.908	0.010	0.127	0.899
Formal credit accessibility	3000.328	0.030	0.381	0.704
Emergence aid	-4224.944	-0.039	-0.476	0.634
Internal mobility	6860.927	0.067	0.789	0.431
Interconnectedness	-14650.248	-0.155	-1.648	0.101
Crops rotation adoption	35179.563	0.146	2.020	0.045**
Crops diversification	25776.351	0.259	3.224	0.001***
Urban nonfarm employment	-42564.310	-0.371	-3.679	0.000***
Model summary	Value			
R Square	0.471			
Adjusted R Square	0.222			
Std. Error of the Estimate	0.172			
Variance (F-value)	4.43***			

Dependent variable: Aggregated Yearly Income of the Households (**Source:** survey Data, 2020)

Generally, the overall variation, due to the included variables is significant in both case (lowland and highland agro-ecologies) with variance of 3.124 and 4.43 which are statistically significant at 1 percent significance level. According to the model outputs, the results reveal that the sex of farmers has a negative impact on the (decreased by 14.8 percent per change in sex of the household head) total income of households in the lowland community which is statistically significant at 5 percent significance level. Conversely, the impact is positive in the case of highland where the change increases the family income by 9.2 percent, although the influence is statistically non-significant.

The value of coefficient of family members involved in agricultural activities has a positive sign in both cases (highland and lowlands), which shows that the more the family members are, the more likelihoods increases will be in the households' income. The model shows that one percent increase in members causes a positive increase in income, keeping all other factors constant, indicating that this factor directly affects the income of the households in the community. Accordingly, the coefficient for family size is positive and significant at 1% significance level for lowland farming community which reveals that increase in family size of the households has positively contributed to the income of farmers by 29 percent per unit increase. In a similar manner, a unit increase in family size positively influences the income of the households by 8.2 percent in the case of the highland farming community, as opposed to lowland area, the impact is statistically non-significant. The model explains that unit increase in the scale of rural off-farm employment opportunity causes 15.3 percent likelihoods increase in the income of the households, which is significant at 10 percent level, in lowland agro-ecology, while a unit increase in rural off-farm reduces the likelihoods of family income by 2.7 percent in highland farming community, keeping all other factors constant. Again, in the case of urban level, non-farm employment opportunity, the impact is negative for highland, contrasting the result discovered in lowland agro-ecology, where a unit increase in the scale of urban non-farm employment, reduces the income of the highland community by 37.1 percent, while increasing the households' income by 4 percent (but non-significant) in lowland community situation. On the other hand, adaptation strategies, like crops rotation and crops diversification are observed as important components in the household income in highland community when compared to other strategies included in the model, where a unit change in crop rotation and crops diversification measurement positively increase the household income by 14.6 percent and 25.9 percent, respectively in the highland agro-ecology of the study community.

Besides, it is a generalized fact that the level of the land size owned by a family, as well as ownership is commonly an important factor of production in farm business. The implication of this reality is that the more the land size owned by a household, then the more will be the likelihood for a farmer to cultivate diversified types of different crops on a large quantity of land. The ultimate result is its contribution to large production. Thus, where more amount is produced as a result of more land under farming means more marketable surplus production leading to more income for farm households. The value of the model coefficient for land holding discovered is 0.104 for lowland agro-ecology, showing that a unit increase in the landholding scale enhances the household income by 10.4 percent in the community, although the impact is statistically non-significant. Likewise, many variables having non-significant impact presented and among those, emergence aid and rural on-farm employment relationship to income are negative in both cases (highland and lowland agro-ecologies), which indicates negative impact of the external aids. Internal mobility has a positive influence in the highland, but a negative one in the lowland; interconnectedness has a negative impact in the case of highland, contrasting the positive influence in the lowland community. Likewise, informal credits positively impact the highlanders' and the lowlanders' incomes, and finally, formal credit sources depicted a positive impact on the family seasonal income in highland, as opposed to the negative influence observed in lowland, but the impact is statistically non-significant.

Furthermore, based on the literatures the coefficient of determination was employed to indicate the fitness of the model in context of this study. According to Ghafoor, Hussain, Naseer Ishaque and Baloch (2010), the coefficient of determination (R^2) is interpreted as the proportion of total variability in the dependent variable that can be accounted for by the set of independent variables. As indicated in Table 9.3b, in the estimated income model for smallholder farmers, R^2 denotes 0.471, showing about half proportion (50 percent) variation in the dependent variable and are explained by the selected independent variables in the model, while adjusted R^2 is 0.222 for the highland agro-ecology, while the R^2 and adjusted R^2 for lowland agro-ecology found to be 0.188 and 0.133, respectively. According to the study results shown in Tables 9.3a and b, the adjusted R-squares are suggesting that our regressions explain only around 22.2 percent and 13.3 percent variation of the annual income as the result of the independent variables included in the model in highland and lowland agro-ecology, respectively. In this study, the R-square value tends to be low in explaining the model as it has been shown in many other previous studies (Blinder, 1973; Hughes and Maurer-Fazio, 2002; Secular et al., 2007) cited in Biwei Su and Almas Heshmati (2013). According to this author, this may be because (i) the individual's income has a large dispersion so that makes regressions difficult to capture the marginal effects of each variable; (ii) there might be some unobserved effects that we fail to capture using the selected variables such as ability.

(iv) Linear Regression Parametric Estimates and Discussion in Context of Households' Income

In the preceding section, the linear regression statistical analyses were conducted separately for each agro-ecology emphasizing on socio-economic and climate change management strategies effect on the households' income. However, under this section income related highland and lowland data were aggregated to determine the aggregated effect of variables on aggregated households' income and for this analysis, Tobit regression model was selected and employed to analyze the income related data considering as dependent variable in respective of relevant independent variables. In this regard, the dependent variables have established as the indexed value of different income obtained from two sources (agriculture and none agriculture sources) which was generated using principal component Analysis (PCA), where the result has summarized in the below Table 9.4 and interpreted accordingly.

Accordingly, the selected demographic variables, adaptation strategies and coping strategies were included in the Tobit regression analysis to determine specific impacts of these independent variables on household incomes in the context of aggregated two study agro-ecologies related data. In this regard, among climate change management practices, adaption strategies were included directly in the selected Tobit model analysis, while coping strategies were indexed to reduce the number of variables to manageable size for the data summary and interpretation. In this case, the score of all coping strategies selected in this study, such as rural-off farm employment, rural on-farm employment, urban non-farm employment, informal credit, formal credit, external emergence aid, internal mobility, external mobility, and social interconnectedness were indexed to a single value in respective of each agro-ecology and inserted for each respondent in respective of their agro-ecology. Similarly, adoption rate of different CSA practices, vulnerability indicators and adaptive capacity indicators were indexed using principal components analysis (PCA) and the indexed value was used in Tobit regression analysis to determine the determinants of households ‘annual income.

Importantly, age of the respondents, family size and educational level of the respondents are among demographic characteristics of the households included in the model, in addition to coping and adaptation strategies in order to determine their relations to household income and the results presented in Table 9.4below which show list of included variable and different inferential statistics in separate column. According to data presented in Table 9.4 below, among demographic variables, family size of the household indicates a negative relationship with households indexed annual income, though the impact is statistically non-significant, pointing the detrimental impact it has on the household annual income. Differently, although the influence is again not statistically significant, educational level and the age of the respondents show positive relationship with the indexed annual income of the households in study community.

Furthermore, the effect of households’ farmland holding was analyzed based on aggregated data, where the result revealed positive influence (by a factor of 0.042) of farmland holding on households’ annual income, indicating an increase in households’ annual income as the result of a unit increase in the farmland holding measurement scale. Among the selected and included adaptation strategies, the influence of livelihoods diversification, crops variety diversification, soil fertility management and climate change early warning are identified to have positive association with indexed households annual income, while only crops diversification and coping strategies index found negative to households income, but only the effect of crops variety diversification and climate change related early warning variables are statistically significant at 5 percent significance level, which is consistent with most of the research findings.

On the other hand, among the climate change adaptation strategies having positive influence on the annual income of the households, only the CSA practices adoption index found to be statistically significant at 1 percent significance level, while other remaining majority variables found statistically non-significant. Additionally, a list of environmental and weathers variables were selected and included in Tobit regression analysis, of which the effect of agro-ecology, rainfall mean, rainfall standard deviation, maximum temperature mean and minimum temperature index were found positive direction on households annual income, while the effect of drought frequency, rainfall coefficient of variation and maximum temperature coefficient variation were indicated the negative association with the indexed households annual income, though the effects of all these variables are statistically non-significant at any significance level.

Table 9.4: Agro-ecologically Aggregated Income Determinant Analysis Using Tobit Model

Explanatory variables	**Inferential statistics**			
	Coefficient	Std. Err	t-value	p>/t/
Agro-ecology	0.499	1.723	0.29	0.772
Age of the Households head	0.003	0.006	0.50	0.614
Education level of Households head	0.022	0.042	0.51	0.612
Family size of Households	-0.029	0.021	-1.39	0.165
Crop diversification	-0.009	0.038	-0.23	0.820
Livelihood diversification	0.030	0.045	0.68	0.499
Drought frequency	-0.008	0.040	-0.21	0.833
Farm size of the Households	0.042	0.033	1.30	0.196
Rainfall mean	0.003	0.004	0.77	0.442
Rainfall standard deviation	0.024	0.060	0.39	0.694
Rainfall Coefficient of variation (CV)	-13.074	30.728	-0.43	0.671
Maximum temperature Mean	0.046	0.235	0.19	0.846
Maximum Temp Coefficient of variation (CV)	-9.138	49.949	-0.18	0.855
Minimum Temperature Index	0.037	0.110	0.33	0.739
Vulnerability Index	0.015	0.018	0.81	0.417
CSA Practices adoption Index	0.242	0.050	-4.85	0.000***
Adaptive Capacity indicators index	0.045	0.058	0.77	0.441
Coping strategy Index	-0.081	0.055	-1.48	0.139
Crops Variety diversification	0.199	0.080	2.47	0.014**
Soil fertility management	0.021	0.087	0.24	0.813
Climate change Early warning	0.158	0.067	2.36	0.019**
Constant	**-5.681**	**6.546**	**-0.870**	**0.386**

Log Likelihood --------------------------------- -503.296
LR chi-square (X^2) ---------------------------- 118.55
Prob>chi-Square (X^2) ---------------------------0.000
Pseudo R^2 ---0.105

Dependent variable: Aggregated Yearly Income of the Survey Households (**Source:** Survey Data, 2020)

With regard to effect magnitude, a unit increases in the scale of average rainfall, rainfall standard deviation, maximum temperature mean and minimum temperature index trend to increase the likelihoods of households' annual income by a factor of 0.003, 0.024, 0.046 and 0.037, respectively, in the study community (Table 9.4). According to the result presented in Table 9.4 above, vulnerability index and adaptive capacity indicators index found positive association with households' income, meaning, a unit increase in vulnerability and adaptive capacity indicators index would increase the annual income of the households by a factor of

0.015and 0.045 point, respectively, in the scale of households' annual income. Similarly, according to the result presented above, a unit increase in the crops variety diversification, soil fertility management and climate change early warning, found to increase the households' income by 0.199, 0.021 and 0.158 coefficient of change, respectively, in households' annual income scale of measurement when all other variables are constant.

Arguably, the coping strategies index were identified to have negative correlation with households' income, indicating that an increase in coping strategies index (which include, non-farm/off-farm employment and others) to result in decrease of 0.081 likelihood in annual income of households in context of study community, which is statistically found insignificant. This finding is inconsistent with Arega (2013), who observed positive and highly significant correlated effect of non-farm/off-farm employment related income with annual total income of households (at 1 percent level), when other variables held constant. Though the influence is statistically non-significant according to this research finding, family size of the study households were showed negative correlation with household annual incomes with a factor of 0.029 decreasing in the likelihood of households annual income in the study community situation and this result is inconsistent with the finding of Arega (2013), which has revealed positive impact of households' family size on annual households' income with 10 percent significance level.

9.3.2 Impacts of Climate Change and CSA Strategies on Food Supply System

(i) Perceived Impact of Climate Change on Seasonal Food Sufficiency and Security

In general term, an immediate impact of climate change is usually recognized on food items production and distribution by breaking supply system and value chain which affects national food security and family level food self-sufficiency. With regard to these views, community perception was assessed, where the findings of the survey households' summarized in Tables (Table 9.5a and b). In this regard, Table 9.5a presents the perceived negative impacts of climate change on food security and food self-sufficiency situation in the study communities, while Table 9.5b shows food sufficiency and sustainability within the cropping seasons in the context of study community.

As indicated in Table 9.5a below, relatively the majority of respondents, which is 59 percent for highland and 60.5 percent for lowland study community observed moderate negative impact of climate change and weather variability on households' food self-sufficiency, while relatively nearly similar number of respondents which constitutes 58.5 percent of highland and 55.2 percent of lowland farming community perceived similar moderate negative impacts of climate change and weather variability on households' food security in context of the study community.

The second majority of 31.5 percent and 32 percent of respondents indicated low negative impacts of climate change on households' food self-sufficiency and food security, respectively in highland farm households. Whereas, in the context of lowlander, the second majority of 35.2 percent and 42.9 percent of respondents suggested high negative impacts of climate change on households' food self-sufficiency and food security, respectively, in contrary to highland community.

Table 9.5a: Perceived Negative Climate Change Impact on Food System

No	perceived level of negative Impact	Highland areas				Lowland areas			
		Food self-sufficiency		Food security		Food self-sufficiency		Food security	
		Frequency	%	Frequency	%	Frequency	%	Frequency	%
1	High	6	3.0	2	1.0	74	35.2	90	42.9
2	Moderate	118	59.0	117	58.5	127	60.5	116	55.2
3	Low	63	31.5	64	32.0	9	4.3	4	1.9
4	Negligible	13	6.5	17	8.5	0	0	0	0
	Total	**200**	**100**	**200**	**100**	**210**	**100.0**	**210**	**100.0**

Source: Survey Data (2020)

Climate change and seasonal weather variability traditionally affects food availability and accessibility constraining seasonal food supply systems, leading to seasonal food shortage in the social system. In this regard, traditional farming community usually covers seasonal food demand for households from household's farmlands produces and Table 9.5b attempted to assess the potential capacity of community to cover seasonal household's food demand from own farms sources. The survey data indicates that 37.5 percent of households in the highland agro-ecology feeds family members for 11-12 months, where only 9 percent in the case of lowlanders from households' farm sources. On the other hand, relatively the majority (about 40 percent) of respondents are be able to cover seasonal food demand for 8-10 months per annum in the lowland agro-ecology, which is better as compared to 25.5 percent of highland community seasonal coverage (Table 9.5b).

Table 9.5b: Months of Food self-Sufficiency from Own Source for Households (N=410)

No	Number of Months food demand covered	Highland areas		Lowland areas		Total	
		Frequency	%	Frequency	%	Frequency	%
1	2-4 Months	43	21.5	37	17.6	80	19.5
2	5-7 Months	31	15.5	71	33.8	102	24.9
3	8-10 Months	51	25.5	83	39.5	134	32.7
4	11-12 months	75	37.5	19	9.0	94	22.9
	Total	**200**	**100**	**210**	**100.0**	**410**	**100.0**

Source: Survey Data (2020)

Arguably, this data result indicates that the proportion of lowland respondents covering households' seasonal food demand from own farm sources for more than 11 months identified to be insignificant (9 percent) indicating the devastating situation related to food shortage catastrophe in the community. Whereas, according to this finding the second majority of the lowland respondents, are capable to cover seasonal households' food demand for 5-7 months (33.8 percent), while 15.5 percent of the highland respondents are covering households' food requirement for similar number of months in the seasons. Differently, the highest proportions (21.5 percent) of the highland respondents are capable to cover households' seasonal food demand for 2-4months as compared to small proportion (17.6 percent) of lowland respondents. However, some study reported more significant proportion of households exposed to food shortage falling to fulfill from own agricultural sources. For instance, the result of survey conducted by Arega (2013), revealed that about 86 percent of the households in Amhara region of Ethiopia were a net purchaser of households' food demand for about six months during survey period. The same author asserted 74 percent food insecurity in similar region based on the recommended per capita daily calorie intake of 2100, while of total sample households only 26 percent were food secure in the study households and the community.

In congruent to food crops production, substantial crop model simulation results and integrated evaluation performed during the last 15–20 years identify impacts of climate change on food systems and observed that there was a consistent overall small impact at global level in the first half of 21st century but turn progressively more negative after the second half of the century, as average temperatures elevate beyond 2.5–3°C continentally and globally during the respective cropping seasons (CRGE, 2011). In this aspect, crop yield change estimation conducted based on aggregated crops models' results has projected significant impact of climate change on some cereal crops' yield in 2080 for selected countries, while 21 percent reduction in yield was predicted based on baseline year for Ethiopia (Tubiello, 2008). As such, the calculated reduction estimation assigned Ethiopia the 5th position in the world, coming after India with a 29 percent, grading it the 1st position, while Mexico ranked 2nd with 26 percent, southwest was placed 3rd, having 25 percent and south Africa, 23 percent, affording it the 4th place, whereas the remaining 10 other countries were found below 20 percent reduction or positive oriented climate change impact at the global scale (ibid).

(ii) Determinants of Seasonal Food Self-sufficiency in the Context of Study Community

In addition to descriptive statistics analysis conducted to determine the households' seasonal food self-sufficiency level in the preceding sub-topic, Poisson regression model selected and employed to analyze and interpret the determinants of family level food self-sufficiency from own food source emphasizing on agricultural food sources. In this regard, food self-sufficiency level was estimated by the number of households particularly covers yearly food demand for household members with in specified number of months out of twelve months of the year. Accordingly, the number of households covered household's yearly food demand for specified months (2-4months, 5-7months, 8-10months and 11-12months) from households' agriculture related alternative food sources has been taken as a dependent variable, while socio-economic and weather related parameters listed in the Table 9.6 below, are defined as independent variables in Poisson Regression model analysis. As indicated in the below Table 9.6, the coefficients of most variables indicate similar association reported by several study findings and in agreement with conventional assumption. For instance, the generated negative association of the drought frequency, rainfall coefficient of variation (CV), maximum temperature mean, maximum temperature coefficient of variation (CV), minimum temperature parameters index and vulnerability indicators index are consistent with most of the findings and prior assumption. For instance, Arega (2013) reported that the seasonal food availability could be negatively and extensively constrained by unpredictable rainfall variability in addition to inappropriate agricultural technologies application and farm management. On the other hand, the negative relationship identified in the case of other variables, like education level and livelihood diversification are unexpected and in consistent with previous findings. For example, this finding is inconsistent with the Arega (2013), assessment made to distinguish the influence of education on households' vulnerability to food insecurity resulted from climate change effects, where the result revealed 60 percent of the illiterate households found vulnerable to food insecurity indicating in favor of positive influence of education level on food security resulted from prevailing climate change and seasonal weather variability.

Table 9.6: Food Self-Sufficiency Determinant Analysis Using Poisson Regression

Explanatory variables	**Inferential statistics**			
	Coefficient	Std. Err	t-value	p>/t/
Agro-ecology	0.967	0.839	1.15	0.249
Age of the Households heads	-0.001	0.002	-0.38	0.702
Education level of Households heads	-0.023	0.019	-1.22	0.221
Family size of Households	-0.011	0.009	-1.30	0.194
Crop diversification	0.004	0.015	0.23	0.816
Alternative income	0.062	0.046	1.34	0.182
Livelihood diversification	-0.036	0.020	-1.81	0.070*
Drought frequency	-0.036	0.016	-2.20	0.028**
Farm size of the Households	0.028	0.013	2.13	0.033**
Extension Support	0.006	0.028	0.22	0.826
FTC Distance from home	0.013	0.006	2.27	0.023**
Credit Support	0.046	0.039	1.17	0.242
Rainfall mean	0.000	0.002	0.26	0.795
Rainfall standard deviation	0.010	0.021	0.50	0.618
Rainfall Coeff. of variation (CV)	-3.169	10.966	-0.29	0.773
Vulnerability Index	-0.031	-3.740	0.23	0.000***
Max Temperature Mean	-0.117	0.118	-0.99	0.323
Max Temp Coeff, of variation (CV)	-10.538	19.019	0.55	0.580
Minimum Temperature Index	-0.096	0.045	-2.12	0.034**
CSA practices adoption Index	0.092	0.019	-4.84	0.000***
Constant	**1.859**	**2.946**	**0.63**	**0.528**

Log Likelihood --------------------------------- 994.084
LR chi-square (X^2) ------------------------------ 86.430
Prob>chi-Square (X^2) ---------------------------0.000
Pseudo R^2 --0.042

Source: Survey Data (2020)

Similarly, positive relationship observed in the case of FTC distance from respondents' home is not common findings and by far different from conventional assumption, because traditionally, when the distance of households home from service center like that of FTCs increased, technical and technological supports provided by extension service delivery system will be decreased which practically have negative impacts on agricultural production and ultimately on food self-sufficiency. The negative association in the case of family size most probably possible when number of family members increased on limited resources (limited land size, livestock holdings, and productive assets, etc) without diversifying the livelihoods and income sources, which logically increase the dependence ratio in the households and ultimately decrease the number of months of food self-sufficiency per annum for a particular household. However, the predicted result in Table 9.6, point out that other variables remain contestant, as the number of family size in the households increases by one unit, the probability of a household being food sufficient decreases by a factor of 0.011, while the effect is statistically none significant. This negative coefficient of family size effect is consistent with the works of Arega (2013), who reported similar relationship, but statistically significant at 5 percent significance level as contrary to the significance level identified in this finding.

On the other hand, as shown in Table 9.6 above, among independent variables included in this regression analysis, only few variables' effect are found statistically significant, while the effects of remaining majority were found statistically insignificant. In this context, only the effect of vulnerability indicators index and CSA practices adoption index found highly significant at 1 percent significance level, while the effect of Minimum temperature parameters index, family farm size, FTC distance and drought frequency found statistically significant at 5 percent significance level and only the effect of livelihoods diversification found statistically significant at 10 percent significance level. Differently, the effect of other remaining variables found statistically insignificant at any statistical significance levels in context of this result. Accordingly, the result indicated that as livelihoods vulnerability indicators index increased by a unit of its scale, the food self-sufficiency level of this particular study community reduced by a factor of 0.031 point when other all variables assumed constant, while increased by a factor of 0.092 point with a unit increases in CSA practices adoption index. Whereas, with a unit increase in a rainfall coefficient of variation (CV), maximum temperature mean and minimum temperature indexed value, the likelihoods of households' annual food self-sufficiency level reduced by a factor of 3.169, 0.117 and 0.096, respectively, in its measurement scale. Likewise, a unit increase in drought frequency and maximum temperature coefficient of variation (CV) in the study community, found to reduce the likelihoods of food self-sufficiency by a factor of 0.036 and 10.538 point which are statistically insignificant at any acceptable statistical significance level and this finding is consistent with prior assumption and hypothesis.

Similarly, the effect of Agro-ecology found positive on seasonal food self-sufficiency of the households, verifying that a change from low land to highland agro-ecology indicate the tendency to increase the chance of being food self-sufficient by a factor of 0.967, but statistically insignificant; which is consistent with the finding of Arega (2013), who reported similar effect of agro-ecology on households' food security. In the model output, the effect of household age has predicted to have negative (by a factor of 0.001) influence on annual income of the households, but the effect is statistically insignificant at any acceptable significance level, which is in line with the finding of Arega (2013), who reported negative and insignificant influence of households heads' age on food security. Regarding to credit, a unit increase in the credit availability to farmers, tend to increase the seasonal food self-sufficiency of households by a factor of 0.046 and this positive influence of credit is in line with the finding of several study documented by relevant researchers. Furthermore, the effect of alternative income source was identified to have positive influence, but insignificant correlation with annual income of households, which means, other variables held constant, having alternative income sources increases households‟ food self-sufficiency by a factor of 0.062 in the context of study community. In several research studies, educational attainment of household heads commonly found to be an important factor in households' food security, which in this study found to have negative correlation to seasonal food sufficiency and security, indicating that as educational level of households' head increases by a unit of measurement scale, the chance of a household being food self-sufficient decrease by a factor of 0.023, while the effect is statistically non-significant. This model prediction is contradictory to Arega (2013), who argued an increase in food security as the result of a unit increase in educational attainment of household heads, which is statistically significant at 5 percent significance level.

9.4 Chapter Summary

The chapter encompassed of the final results and discussion the Thesis with emphasis on the climate change management options impacts on households' livelihoods and welfare which explained in perspective of households' income scenario. In this regard, among climate change coping strategies, almost all strategies (87.5 percent) were rated below average score (50 percent) in the highland situation, where only rural on-farm employment was rated 52.3 percent in perspective of its impact on highlanders households' income. The three strategies like rural off-farm, rural on-farm and formal credit access were rated 60.8 percent, 58.3 percent and 58.7 percent, respectively, in viewpoints of importance to positively impact rural households' income of lowland community. In contrary to coping strategies rating, among climate change adaptation strategies, almost all strategies (100 percent) were rated above average score (50 percent) in the highland agro-ecology with highest scores of 63.8 percent for access of improved crops varieties, 62.8 percent for integrated soil fertility management and 60.8 percent for crops diversification in context of their impacts on climate change adaptation scenario.

However, the situation is absolutely different in the case of lowland community in which almost all climate change adaptation strategies were rated below average indicating discouraging situation in context of lowland communities, where climate change impacts are already significantly evident affecting rural households' livelihoods systems. On the other hand, of total variables included in the Tobit regression model analysis, only CSA practices adoption index were found statistically significant at 1 percent significance level, while crops variety diversification and climate change early warning were found statistically significant at 5 percent significance level. In similar manner, the perceived impact of climate on food self-sufficiency were found to be 59 percent in context of highland households, while 60.5 percent in the case of lowland households and impact of climate change on households' food security observed 58.5 percent in highland and 55.2 percent in lowland scenario which are closely similar. Additionally, relatively the majority (37.5 percent) of highland households were found food self-sufficient for some 11-12 months, while only 22.9 percent in the case of lowland. The findings indicate that the majority of the adaption and coping strategies didn't have adequate impact on households' welfare (income and food system) and socially and economically fitted strategies are ideal to address the awareness of the community in the study areas and beyond.

CHAPTER TEN
CONCLUSION AND RECOMMENDATION

10.1 Introduction

The study examined climate change impact vulnerability and adoption of climate smart agricultural practices among small-scale farmers, using Oromia region of Ethiopia as a case study. Subsequently, the thesis focused on the vulnerability of the households' livelihoods' to the impact of climate change, adoption, and sustainability of climate smart agricultural practices (CSA) with emphasis on the level of livelihoods vulnerability of the two (highland and lowland) farming system of the study. Consequently, during investigation, the study engendered a rational interpretation of both primary and secondary data, and a consequent suggestion of relevant technical, institutional and policy related conclusion and recommendations. Thus, based on the survey results, conclusions and recommendations are made with the intention of contributing to the progressing effort of sustainable socio-economic development of the rural community through adequate climate change adaptation and mitigation strategies integration into the farming system of the community of the Oromia region in general and in the study communities in particular.

10.2 Summary and Conclusion

Natural resource degradation is the foundation of environmental change, compromising livelihoods' sustainability of the community and national economy of the developing countries including Ethiopia. Thus, given the critical condition of natural resources degradation this ultimately leads to climate change related risks, this study set out to investigate climate change impact vulnerability, and adoption sustainability of climate change management practices in the small-scale farming system of the Oromia region in general and in the study community. Accordingly, the results of the survey reveal that household's vulnerability and technology adoption decision of the individual farmers greatly is affected by ranges of factors which adequately helped to suggest the following conclusions based on the result of the study.

1.Climate change impacts vulnerability: According to the responses of the respondents, the impacts of climate change on the livelihood of the community are significant, and apparently manifest as economic burden, social instability, and food insufficiency. These three are more pronounced in lowland drought prone areas of the study. Livelihood's vulnerability diagnosis indicates that the inhabitants of lowland area are highly vulnerable to climate change impacts and related risks. Specifically, the survey result indicated that about 95 percent of the respondent perceived climate change and its consequent problems as the major threat to their livelihoods. In fact, majority of them reported that their natural resource, which is mainly their farmlands are in a poor state because of climate change, leading to low productivity. More importantly, out of the total respondents, majority equally perceived the negative impact of climate change on the communities' livelihoods; they revealed that the most practiced livelihoods are vulnerable to climate change related risks. Likewise, majority confirmed that the problem is very serious on cropping land than other land use systems. Additionally, the respondents asserted that in most of the study community, the most frequent natural disasters (drought and over flooding) are already identified as the major source of crisis of the area, which was equally affirmed from the secondary data. Consequently, the vulnerability of the livelihoods of the households to the contrary impacts of climate change and weather variability has affected their lives and the lifestyle of the community. Specifically, majority of the respondents in the lowland community, (about 53 percent) mentioned that they have experienced the occurrence of drought more than 3 times in the past six cropping years. Still about 94.5 percent Households reported serious crop related livelihood damage as the result of this natural disaster. Meanwhile, the examination revealed that 52 percent of the respondents from highland solely depend on natural resource as a means of livelihood, and admitted that its exploitation during food shortage can result in natural resource degradation leading to environmental calamity and catastrophe in the farming system.

2.***Adoption and Sustainability:*** Generally, the rate of adoption and adoption sustainability observed in the study areas were very low in almost all CSA practices introduced and selected in this study. Surprisingly, some of the practices which are very important for climate change adaptation and mitigation were not exploited by the respondents, the percentage of adopters was discouragingly low and below expectation and the required level. For instance, in the case of small-scale irrigation the majority (88 percent) of the aggregated total were non-adopters; likewise, overwhelming majority (80 percent) failed to adopt improved range land management. Similarly, about 73.2 percent did not adopt water harvesting as CSA practices which could supplement household consumption and livelihoods practices. The study revealed that almost all predicted socio-economic factors appeared to have influence on adoption decision of farmers' utilization or rejection of the nationally adopted climate smart Agricultural practices and technologies. In this regard, the households with high age, long farming experiences, large family size, and better educational level were found to be better adopters of the CSA practices and Technology. On the other hand, adoption of introduced technologies were predominantly influenced by a range of variables which included participation of farmers in natural resource conservation program and/or project, economic variables such as farmland holdings, livestock holdings and yearly income of the households, and institutional factors mostly concerned with credit, extension service provision and mass media accessibility. As confirmed from the findings of the study, farmers with more resources are more likely to participate in the CSA program and then adopt the introduced technologies than resources poor farmers. According to the findings of this study, most of the households within the low income categories were non-adopters, as compared to high income categories, where the majority were adopters of the introduced CSA practices. Similarly, majority of the households in the wealthy group adopted the CSA practices, while majority of the medium and low in wealth categories households did not adopt the introduced CSA practices. Additionally, in this study, a comparison was made between rates of adoption of CSA practices with other agricultural technologies. The results showed that adoption rate of other disciplines (crops and livestock) technologies was by far better than adoption rate of natural resource conservation strategies including climate change management practices, indicating a poor attention and promotion of natural resource conservation related technologies, which ultimately influence the climate change impact related risk management.

Similarly, the sustainability of the introduced and adopted strategies shows similar trends observed in the adoption of CSA practices. The examination evinced that majority of the practices were not sustainable in the farming system for no more than three cropping years and a significant number of practices were rejected after two years of adoption. On the other hand, the applied Tobit regression model output indicate significant likelihoods in the case of some independent variables while overwhelming majority found statistically no-significant. In this aspect, among 18variables included in Tobit model parameter estimates, the effect of only 7 variables found statistically significant implying that high level of influences on CSA practices adoption. Aggregately, according to this study finding, an increase in households' farm size by a unit of measurement increase the likelihoods of CSA practices adoption by a factor of 0.067 (about 7 percent), while an increase in rainfall standard deviation decrease the probabilities of CSA practice adoption by 0.137 factor (about 14 percent) and an increase in minimum temperature index indicated the decrease in the likelihoods of adoption by 0.006 factors (0.6 percent) in which the effects of all these variables found statistically moderately significant at 5 percent significance level. Again, the study result shows that an increase in the income index indicated the decrease in the CSA practices likely adoption by 0.241 factors (about 24 percent), while institutional adaptive capacity indicators index indicates positive relationship by 0.367 factor (36.7 percent) in which in both case the effects of variables are highly significant at 1 percent significance level in the context of study community. In contrary to likelihoods of CSA practices adoption, in the case of adoption sustainability, only two variables found statistically significant among 18 variables included in the Tobit model parameter estimation**.** In this aspect, among these variables, CSA practices adoption index indicated an increase of 0.74 (74 percent) which is statistically significant at 1 percent significance level, while adaptive capacity indicators index shows increasing likelihoods by 0.097 factor (9.7 percent) at 5 percent significance level.

3.***Coping and Adaptation Strategies:*** Largely, the study revealed that income diversification, especially nonagricultural income was the most important strategy that should be adopted to cope with the catastrophic impact of climate change, and significantly required to sustain the livelihoods of the farm community. However, the finding of this study noted the inadequacy of nonagricultural related income source diversification in the study community, indicating the predominant dependence on the agricultural livelihoods, which naturally vulnerable to climate change effects. The most dangerous coping mechanism identified were the sale of firewood and charcoal; 53.8 percent of lowland households depended on this mechanism to survive during food shortage, particularly when seasonal crop failure occurred in the community. With regard to livelihood diversification, about 84.3 percent of the respondents were found within the categories of below average (moderate, low, and negligible), while only 15.7 percent of the households adopted adequate livelihood diversification practices in the lowland farm households. In this aspect, majority of the households asserted that there was no alternative source of food outside agriculture during food shortage, resulting from crops failure, a consequence of climate change in the community. The investigation also showed an inadequate alternative source of non-agricultural coping mechanisms diversification. For instance, about half of the households from the lowlands (50.5

percent) were dependents on external aid for food to survive hard season, like food shortage, which was due to the occurrence of drought or over flooding. The availability of some other most important alternative coping mechanisms like credits (formal and informal), rural and urban non-farm employment were found inadequate in the two study communities which is a clear indication of being vulnerable to climate change impact related risks.

4.***Technical Support:*** Basically, the study showed that technical support and advice were moderate in terms of DAs contact with communities regarding climate change management practices promotion. Meanwhile, the study further revealed the poor participation of farmers in development project process, thereby contrasting the stated principles of PADETES strategies. In reality, most of the approaches were lacking the elements of participation and it was not encouraging the farmer's active participation in development project process from planning to implementation, and evaluation. Thus, out of the total aggregate of two agro-ecology represented communities (highland and lowland), only about 32 percent of the respondents appreciated farmers' participation in development project process while the remaining 68 percent reported their participation as poor in the past implementation years. According to these findings, though the number of farmers involving in the extension program has been growing over the last few years, the real number of farmers included in projects and participation in project planning, implementation process and evaluation was found to be very limited. Furthermore, it is realized from the study findings, that the technical support related to climate change was lacking in some important aspects like, content of technical advice, relevant technical support, quality of technical training and timeliness of the climate change related services were rated low as compared to the required standards. On the other hand, poor attention and focus for natural resource conservation technology including the climate change management promotion at different level was confirmed by majority of the farmers (86.5 percent) and extension field staff (scored 66 percent out of the total point) and was rated 1st among other included constraints. In this regard, due to poor attention in extension service delivery system in the past extension package program and soil conservation related projects implementation, almost all natural resource conservation practices were neglected and marginalized throughout the past many years leading to unsustainable agricultural land productivity. Equally, the content of technical advice and support were found to be more production oriented with limited attention for natural resource conservation which ultimately contributes to climate change management.

5.***Technological and Technical packaging:*** In Ethiopia, as the tradition of approach, extension package program was adopted for the past three decades of cropping years, with intention to focus on effective and efficient practices. Following this, the formulation of appropriate technological and technical package with optimum assembling of potential resources was crucial to attaining the intended development objectives under any circumstances. However, this study indicated that the past extension program and project approaches were lacking inputs of appropriate packaging of the technologies which adequately integrates the adopted climate change adaptation strategies. More importantly, the problem of technology packaging appeared worst especially in the field of natural resources management and conservation which have direct potential effect on the climate change adaptation and mitigation. Basically, the practices of Conservation agriculture (CA) such as crops rotation, intercropping, fallowing, and conservation tillage and crop residue management are essential components of natural resource conservation package to enhance restoration of soil fertility of farmlands. However, adoption rate and sustainability of those practices were found to be minimal compared with the adoption rate of other production technologies which was a clear indication of poor packaging system. Furthermore, there were no clear evidence to suggest that the packages were being refined to fit into the various agro-ecological zones of the country and biodiversity, it means that the Technologies and Technical packaging approach in the extension system seems territorial without considering agro-ecological diversity and environmental variability which ultimately affect the adaptability (fitting into the local situation) of the introduced strategies. With regard to extension Technology packaging, only 18.6 percent of the extension field staves' respondent claimed that Climate change management practices were adequately integrated as major components of the extension full package system, while the remaining majority indicated that the practices were minor or inadequate integration into extension package program for the past cropping years.

6.***System level CSA Integration:*** According to several findings, the effectiveness of the introduced Technologies and improved practices are significantly influenced by the level of integration into the service delivery system. Following this, the findings of this study also show that participation of the farmers in extension package programs has improved the use of agricultural technologies among the farming community. However, integration of agricultural technologies with environmentally sound technologies and managements is far less than the theoretical recommendations, leading to natural resources degradation and becoming threats to environmental sustainability. According to the perception of the respondents, the crucial limitation of natural resources management innovations was found to be the main constraints of extension service delivery system, and this has disenabled the needful influence that could enable the integration and adoption of climate smart agricultural practices and strategies into farming system context. In relation to this point, majority of the respondents (nearly 56 percent) were found unsatisfied with benefits obtained from existing CSA practices as most of them were not integrated with local practices and promotion of indigenous knowledge and developing of new innovation for the past years were very limited. Regarding to this scenario, most of the projects and programs are dependent on external inputs and external driven negatively influencing locally adapted practices, while it is not right to influence the farmers to use and depend on introduced external innovation that may not be well-suited to local conditions. According to several research and development documents, there are tremendous local practices and knowledge which have been experimented and approved by traditional community, but these locally effective best practices were less focused on, in addition to limited integration of adopted modern research based Technologies and practices in the extension service delivery system.

7.***Policy and Strategy: -*** Under any circumstances, the fortune of adopted best practices is predominantly determined by the policy based strategies support, established to influence the promotion and publicity of the practices. With regard to policy based strategy, it has been realized from the study findings, that an existing environmental management policy of the country was found to be far from satisfying the interest of the farmers. It is a positive direction to encourage natural resource conservation practice which ultimately influences the CSA practices and technology adoption including the sustainability. In addition, the study discovered that lack of clear extension and land use policy including institutional instability in the government and farmers' structures were negatively affecting the efforts to mitigate the natural resource degradation processes in general and farmland degradation in particular. Accordingly, the existing agricultural policies and strategies were approved in perspective of production technology orientation without due attention to adequately emphasize the environmentally sound strategies, and the situation is worsened as a result of climate change management policy limitation. More disastrously, the effort put in place to implement the existing policy has a wide range of limitation and are practically limited and lacking the attention and focus of policy level leaders and managers.

8.***Institutional Adaptive Capacity: -***The capacity of a system to influence the adoption and sustainability of the adopted best practices is a holistic effect contributed by each unit of the system and resources devoted for service in the service delivery system. According to current many more research findings, adequate technical, technological and resource capacity of the system positively influence the effectiveness and efficiency of the services. However, this study and other many more research literatures revealed that the overall inadequacy of institutional adaptive capacity of the extension service delivery system, handicapped the integration of climate change adaptation strategies. Institutional level technical capacity and resource availability for extension services were found to be the major limiting factors in the adaptive capacity of the system. Rather than function as promotion process of the climate change adaptation and mitigation strategies at the farming community level, they served as limitation components. With regard to system level capacity, farmers, and extension field staff respondents, rated them below average level, indicating inadequate capacity of the extension service delivery system in extension service in general and in climate change management services in particular. According to the findings of the study, implementation capacity of the system declined drastically, so much that it could barely meet the needs of the farm communities. The service lacked adequate resources, which was a marked limitation, and a significant challenge as compared to technical limitation in the service delivery system.

10.3 Recommendation

The empirical evidence of research findings, suggest that global warming resulting from climate change is already affecting and will continue to affect the agro-ecological suitability negatively affecting the development of agricultural sectors which requires the adoption and sustainability of the adaptation and mitigation strategies in the farming community. Accordingly, as revealed in a range of literatures and findings, the responses to climate change situation can be of two broad types. The first response is concerned with the employment of adaptive measures to reduce the impacts and maximize the benefits and opportunities of climate change, while the second involves mitigation measures to reduce human contributions to climate change. Thus, both adaptation and mitigation measures are essential elements and rational aspect of response to climate change in order to maintain sustainable livelihoods and reduce socio-economic vulnerability. According to widely accepted reality, in the absence of mitigation and adaptation capacities, losses from damage to the infrastructure, the economy, as well as social chaos, and loss of life, will escalate and be substantial, which need adequate response within critical time frame for full adoption of the appropriated climate change management best practices. However, the results from this study indicated that Ethiopian farmers are doubtful, hence, the reluctance to adopt natural resource conservation related to CSA practices resulting from inadequate appropriate technical, technological, and institutional support to the farmers including inadequacy of the right policy direction. Consequently, in order to support development actors' efforts, the recommendations are required based on the findings of the study focusing on the policy, strategic, Research and Technical approaches of service delivery system which related to climate change adaptation and mitigation in the country broadly and in the study community specifically. Hence, based on the survey findings, the following policy, technical and institutional related recommendations are made which suggested for influencing the technology adoption and sustainability, ultimately improves the benefits from the livelihoods of the community.

(i) Institutional and Policy Context Recommendation

Under this sub-heading, it is intended to indicate policy and extension service-related areas requiring improvement and adjustment in context of climate change management scenario, to be effective and efficient in adaptation and mitigation options implementation in perspective of set of objectives and priorities in the national and regional development goals.

1. The evidence from this study suggests that much policy related aspects need to be considered to promote economically and environmentally sustainable development approaches, with particular emphasis on climate change managements. Specifically, according to this study findings and other empirical study results, extension policy of the country in general and study region in particular need redesigning to attain intended environmentally sustainable development goals without compromising the climate change negative impacts as the results of policy level limitation. In this regard, there should be well designed locally fitted rural extension policy and strategies using integrated grass-root opinion to foster sustainable rural development approaches with adequate integration of climate change management policy and strategies.

2. Intrinsically, this study and others many more empirical evidence suggested that among many factors, natural resource degradation is the immediate consequence of mismanagement and utilization of land resources, especially, agricultural land resource. In this regard, environmentally sound and effective natural resources use, and management policy can influence the attitude of society to conserve the natural resources which ultimately can positively influence the climate change negative impacts and risks. Therefore, it is recommended that farmland use and management policy with appropriate strategies should be in place which adequately emphasizes the climate change scenario to supplement technical and local efforts that will address the natural resources degradation problem, including the negative impacts of climate change and consequences.

3. As to several study findings and investigated literatures, the process of land degradation is the results of erosive agricultural practices and in adequate natural resource management which resulted from high population pressure. Therefore, appropriate

population policy should be established and promoted with immediate effect to regulate fast growing population which is the major threat to natural resources sustainability

4. The effectiveness and efficiency of rural development strategies in general and agricultural extension strategies in particular is a function of appropriate technical and technologies recommendations. However, this study reveals many technical limitations, such as inadequate technologies availability, poor packaging system of the technologies, especially in the perspective of natural resource managements and practices related components, lack of proper integrations and insufficiency in promoting indigenous knowledge are major areas of concern for farmers to attain sustainable rural transformation. Therefore, redesigning of research and extension strategies in the way that the system can accommodate the interest and the indigenous knowledge of farming community have paramount importance to attaining optimum sustainability of strategies and technologies in the farming system which will eventually positively influence the livelihoods of farmers in the two study communities.

5. The evidence from this study showed that the poor linkage among potential stakeholders is a crucial setback during program implementation and technology promotion. Hence, to improve the linkage between stakeholders, there should be technical forum and established system which can sustain the efficient relationship and communication among the potential stakeholders in order to facilitate resolution of conflicting development interests and can put collaborated effort together in the process of development in general, and climate change management strategy implementation in particular.

6. Institutional stability and implementation capacity are critical components of service delivery systems to attain optimum efficiency and effectiveness in extension service, and to be successful in development management. In this aspect, the result of the study suggested that there were low institutional capacity and frequent restructuring of the respective farmers and government institutions. Thus, the system should not be subjected to frequent change and due attention should be given prior to implementation during design and proposal of institutional structures to avoid frequent change of the institutional service delivery systems and technological packages promotion approaches.

7. Extension service-oriented farmers' organization is a common experience in Ethiopia and extension organization such as, Farmers extension group which comprise about 25-30 and extension unit which contained 5 farmers under the farmers extension groups were used to deliver extension service through this farmers structures which along with service provision helps to exploit the indigenous knowledge. However, according to the study results, the role of farmer's organization and indigenous institutions were neglected. Currently, these farmers' organization structures have been dismantled and socially discriminated against as a result of blended service (blending extension service with political responsibility) operating through these structures. Therefore, policy makers and technical staff should pay particular attention in integrating indigenous institutions in development process, which can harmonize indigenous location specific knowledge and improved technical recommendations which ultimately enhance technology adoption and sustainability in the farming system. With regard to farmers' extension organization, new design with

distinct approach is required with proper care to avoid negative attitude of the community to ward extension organization to maintain optimum trust of the potential customers.

8. Along with resource availability and work environment suitability, the technical capacity of human resource is the critical factors of success in service delivery level in extension system. However, it was realized from the findings of the study that the technical capacity of extension field staff (especially DAs) in relation to climate change management is adversely affecting the effectiveness and efficiency of the extension workers working in rural community. Therefore, it is needful to recommend that the field extension agents should be well trained and technical back stopping must be in place to fulfil potential technical capacity gap in the Climate change strategies and innovations implementation.

9. According to a range of literatures and findings, global environmental change which includes climate change is expected to have a significant impact on food systems worldwide including the non-agricultural sectors and the design of adaptive policies to cope with environmental changes is critical to attain sustainable livelihoods at community level and food security at national level. Therefore, climate change policy should put across national policy which should be integrated into all sectoral policies with adequate implementation strategies to reduce the impact of climate change.

10. Nationally adopted and Community level coping strategies are critical to safeguard the community during natural calamity and food shortage. However, the result of this research suggested several limitations in respective of coping strategies' availability, promotion, and community awareness. Hence, it is necessitous that a menu of the required coping strategies and with adequate amount should be made available to farmers according to their level of awareness and technical capacity. Specifically, non-agricultural based coping strategies such as credits, non-agricultural employment opportunities and petty business must be strategically emphasized in order to help the community during natural disasters which directly improves households' own food supply system, rather than running after food aids during catastrophes.

11. The extensive reviews of the extant literatures and selves administered survey result (extension field staffs and managerial leaders) revealed that there is limited attention for climate and climate change domain in higher learning institutions policies, while it is significantly important to integrate climate perspectives into learning and research programs. Thus, considering the significance to focus climate scenario, higher learning institutions of Ethiopia are required to rework with adequate attention to redesign currently existing learning and research policies and/or strategies in the manner that the future strategies are adequately accommodate the climate contexts in learning and research agenda.

12. Generally, current findings, several literatures and many more past practical experiences indicate that the Technical, Technological and managerial efforts invested in the course of project/programs implementation are futile without community lead for sustainability of programs/projects efforts and experiences in the traditional community. Findings show that as long as communities rely on only government efforts through projects and programs, progress might not be realized soon and the success

might not be sustainable. Conventionally, community lead is all about the community empowerment through capacity building (Technical, Technological, material and managerial capacity) of the farming community to empower the community to take the lead in the community and national development agendas. Therefore, specifically it is logical to focus on the strategies and tactical practices that have potential capacity to positively influence the community empowerment so that community take a lead during policies and strategies development as well as programs and project designing for the community development including the climate change management programs. However, to be effective in this regard, local, regional and international partnerships for funding and expertise are critically important and must be focused during potential strategy development for CSA programs.

13. Profoundly, a number of studies and current findings suggest that there are multiple experiences at local, regional and at global scale related to climate change management which are not yet scaled-out at local, regional and global level. These includes research result oriented innovations and local endogenous knowledge which are critical for climate change management and adaptation. Accordingly, local and international level experience sharing and knowledge exchange oriented approaches must specifically be focused during strategy development for the study community and beyond to scale-out the available climate change management related best practices and innovations particularly those which are locally verified in the practical field level.

(ii) Research and Knowledge Context recommendation

This sub-heading specifically identifies some areas require focused research to provide foundational knowledge in context of climate change management scenario, which many of these recommendations needed for advancing of scientific understanding related climate and its impacts as well as generate sufficient information for decisions making institutions in respective of climate change management for adaption and mitigation.

1. The review of available literatures is revealing that there are many studies conducted and in progress on weather variability at global and regional scale with little emphasis on the location specific and thus under current situation it is important to channel local research focus on local and inter-seasonal specific climatic parameters which ultimately the result will directly support adaptation and mitigation efforts currently in progress at national and local level.
2. The research information on structural vulnerability is limited and inadequate which will potentially influence identification of critical areas of interventions which as a result requiring latest research to generate broader knowledge that potentially can positively influence the climate change adaptation policies and strategies implementation efforts at national and community level under Ethiopia context in general and Oromia region in particular.
3. Extensively, it is realized that the information and knowledge on adaptation options and technologies suitable to address context-specific climate extremes impacts and risks for agriculture as well as the net effect of climate change at the local level are found inadequate which requiring detailed context specific research study to provide comprehensive understanding and information related to locally fitting of available options to manage consequences of climate variability and change for local setting, including

best practices for adaptation planning, implementation, and management. These may include research on adaptation processes, adaptive capacity, adaptation option identification, implementation, effective evaluation pattern and adaptive management of risks and opportunities with more emphasize on the context of users which are rural community.

4. In the practical context, critical time for adaptation options application is important aspect to be effective in climate change management strategies implementation at community level. However, the appropriate time scale of specific climate change management strategy implementation seems within the knowledge gap where it remains unclear as to which time is right to be effective in the mitigation and adaptation strategies implementation which still waiting for further and specific research study.

5. In view of current literatures in context of Ethiopia, the knowledge on the effectiveness of climate change management strategies and technologies is incomplete evidence in relation to biodiversity, social and economic scenario. For instance, knowledge of the climate change impacts on biodiversity and its linkages to ecosystem services including the effectiveness of adaptation strategies in farm household level is limited which under currently situation require disaggregated research information and knowledge to influence users' behavior toward climate change adaption options.

6. Precisely, several studies have focused to generate global level and regional level information and knowledge, while down scaling of these generated research information to a local level are severely limited or most of the times missing in the context of small-scale farming community and thus, properly planned strategy is necessary to cascade globally and regionally generated research knowledge and information to grass root users level by employing the effective and efficient information packaging and dissemination systems in context of study community in particular.

7. The findings of subsequent review of literatures and the selves administered survey result (extension field staffs and managerial leaders) pointed out that there is an inadequate integration of climate and climate change domain into higher education learning and research agenda, while it is critically important to contribute for scientific knowledge and for community level adaptation efforts. Considering the knowledge gap prevailing currently at location specific perspective, Ethiopian higher learning institutions are required to adequately emphasize and integrate the climate contexts into the institutions learning and research priority agendas.

8. In the course of study in general and literature review in particular, it was realized that local level research findings and related technical resources are inadequate and there is significant limitation related to emission research in the country. Honestly, almost all literatures used in this study were either regional or international where local level emission research results are painfully limited. Thus, research on emission level and related consequences in the country is critically required to make informed decision making in the course of program designing and implementation.

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APPENDIXES

Appendix1: Aggregated Multicolinearity Diagnostic Test statistics

List of Continuous variables	Standardized Coefficients	T-value	Sig.	Co-linearity Statistics	
	Beta			Tolerance	VIF
Age of the respondent	0.016	0.159	0.874	0.237	4.227
Educational level of the respondent	-0.100	-1.550	0.122	0.564	1.773
Total Family size of the Households	0.075	1.340	0.181	0.743	1.345
Head of Households farming experience	-0.195	-1.708	0.088	0.179	5.582
Farm land size owned by Households	-0.097	-1.356	0.176	0.457	2.186
Farm land under irrigation for Households	-0.128	-2.208	0.028	0.692	1.445
Head of Households livestock farming experience	0.122	1.415	0.158	0.314	3.186
Livestock holding of Households	0.027	0.496	0.620	0.785	1.274
Annual total income for HOUSEHOLDS	-0.023	-0.306	0.760	0.412	2.425
Agriculture income for Households	-0.145	-1.796	0.073	0.357	2.799
Distance of market from home	0.088	0.933	0.352	0.260	3.845
Distance of level FTC from home	-0.001	-.014	9.989	0.385	2.599
Distance of major road from home	0.072	0.922	0.357	0.380	2.634

***Dependent variable*:** Aggregated CSA practices Adoption decision (Total Highland and Lowland Area Sample)

Appendix 2: Agro-ecologically disaggregated Multicollinearity Statistics

Independent variables	Highland agro-ecology		Lowland agro-ecology	
	Tolerance	VIF	Tolerance	VIF
Age of the respondent	0.221	4.529	0.322	3.107
Family size of the household	0.823	1.215	0.565	1.770
Farm land size owned by household	0.460	2.175	0.616	1.623
Irrigable farm land size	0.643	1.556	0.485	2.063
Livestock farming experience	0.279	3.591	0.502	1.992
Livestock holding of the household	0.853	1.172	0.738	1.355
Household farming experience	0.250	5.549	0.271	3.691
Yearly income of the household	0.665	1.503	0.462	2.165
Agricultural related income	0.735	1.361	0.405	2.472
Educational level of the respondent	0.785	1.274	0.708	1.413
Participation in project or/program	0.869	1.151	0.528	1.895
Distance of FTC from farmland	0.338	2.955	0.803	1.245
Distance of market from farmland	0.575	1.738	0.493	2.029
Distance of major road from farmland	0.361	2.769	0.629	1.589

Dependent Variable: Farmers decision to use the introduced CSA practice

Appendix 3: Contingency Table (Person correlation) to detect Multicollearity

Variables	Age	Marital status	Education level	Gender	Family size	Livestock holding	Yearly income	Extension support	Project support	FTC Distance	Market Distance	Credit access
Age	1											
Marital status	-0.003	1										
Education	-0.18**	-0.051	1									
Gender	-0.085	-0.276**	0.019	1					.*			
Family size	0.421**	-0.020	-0.231**	0.004	1							
Livestock holding	0.277**	-0.009	-0.018	0.002	0.257**	1						
Income	0.060	-0.003	-0.027	-0.095	0.275**	0.293**	1					
Extension support	-0.090	-0.030	0.038	-0.062	-0.063	-0.104	-0.038	1				
Project support	-0.110	-0.119	0.124	0.258**	-0.179**	-0.001	-0.240**	-0.316**	1			
FTC Distance	-0.029	0.054	-0.186**	-0.215**	0.103	0.007	0.238**	0.042	-0.120	1		
Market Distance	-0.192**	-0.032	-0.371**	0.103	-0.141*	0.009	0.083	0.052	-0.120	0.242**	1	
Credit access	0.013	0.040	0.007	0.146*	-0.137*	0.051	-0.150*	-0.297**	0.366**	-0.177*	0.064	1

NB: Excluded variables and predicted correlation (exclusion made when the variables are correlated with more than 3varibales)

1. Irrigation Farm: - Extension support and gender**, Family size * and FTC distance *
2. Non agric income: - Irrigation farm**, Extension support*, Project support**, FTC Distance**, Market** and Credit**

Appendix 4: Vulnerability index summary including sub-components

Major and Sub components	Sub-components Index		Major components Index	
	High land	Low land	Highland	Lowland
(i) Socio-demographic	**1.258**	**1.461**	**0.315**	**0.365**
Dependence ratio	0.700	0.740		
Percentage female headed Households	0.180	0.076		
Family size of the Household	0.318	0.350		
Percentage of Households head not attended school	0.060	0.295		
(ii) Livelihood strategies	**1.550**	**1.867**	**0.388**	**0.467**
Households depended solely on natural resource as source of income (%)	0.780	0.638		
Households Family members working in a different community (%)	0.385	0.648		
Households have alternative source of food outside agriculture (%)	0.185	0.381		
Average Natural/agricultural livelihood diversification index (%)	0.200	0.200		
(iii) Social network	**2.514**	**2.975**	**0.629**	**0.744**
Average receive: give ratio	0.484	0.795		
Average borrow: Lend money ratio	0.625	0.740		
Households have not gone to local government for assistance in 12 months (%)	0.685	0.750		
Membership in social organization	0.720	0.69		
Aggregated Adaptive capacity index			**0.444**	**0.525**
(i) Health conditions and Facilities for Households	**2.181**	**3.213**	**0.545**	**0.803**
Accessibility to health facilities center	0.820	0.652		
Percent of Household with chronic illness	0.165	0.524		
Percent of Household family had to miss work or school in past two weeks due to illness	0.165	0.533		
Average time to get Health center	1.031	1.504		
(ii) Food source and availability	**1.680**	**1.077**	**0.336**	**0.215**
Household depend only on family farm for food source (%)	0.815	0.619		
Households struggling to cover yearly food demand (Whole year sufficient food) (%)	0.375	0.067		
Average Crops diversification index	0.200	0.200		
Percent of Household that do not stock crop produce	0.15	0.171		
Percent of Household that do not save seed	0.14	0.02		
(iii) Water source and availability	**3.435**	**3.639**	**0.573**	**0.607**
Households utilize natural water source (%)	0.700	0.490		
Average time spent to get water source	0.755	1.409		
Households without sustainable water supply (%)	0.605	0.314		
Inverse of the average no of Liters of stored water	0.110	0.016		
Aggregated sensitivity index			**0.485**	**0.542**
(i) Natural disaster (Flooding)	**2.588**	**3.100**	**0.431**	**0.517**
Average number of natural disaster events in the past 6 years	0.583	0.764		
Households reported death Family member due to climate related disaster	0.075	0.02		
Household reported injury of Family member due to climate change (%)	0.025	0.335		
Households reported their natural resource including agriculture base reduced (%)	0.645	0.838		
Households property loss due to recent natural disasters (%)	0.615	0.767		
Households that didn't receive early warning about natural disaster (%)	0.645	0.376		
(ii) Climate variability	**0.928**	**1.368**	**0.464**	**0.684**
Average number of drought events in the past 6 years	0.445	0.583		
Mean standard deviation of monthly average rainfall (5 years)	0.483	0.785		
Natural disaster and climate variability index (Exposure)			**0.448**	**0.601**
Livelihood Vulnerability Index (LVI)			**0.459**	**0.556**
LVI-IPCC(Exposure-Adaptive capacity)*Sensitivity((e-a)*s)			**0.002**	**0.041**

Appendix 5: Summary of Income based on source of Households Seasonal income (Eth Birr)

No	Income categorization	Highland areas		Lowland areas		Differences (b)	
		Amount	% (a)	Amount	% (a)	Amount	%
I	**Total income (Birr)**						
	Maximum income	744000		950000		206000	27.7
	Average income	93776		92689		1087	1.2
	Minimum income	2600		2200		400	15.4
II	**Agricultural income (Birr)**						
	Maximum income	354200	47.6	759000	79.9	404800	53.3
	Average income	83750	89.3	72290	78.0	11460	13.7
	Minimum income	2600	**100**	0.0	**0.0**	**2600**	**100**
III	**None Agricultural income**						
	Maximum income	125000	16.8	13300	14.o	**800**	**6.0**
	Average income	7053	7.5	10556	14.6	**3503**	**33.2**

Note: Column "a" is % estimated from total income and column b is difference of the highest in either of the two agro-ecology

Appendix 6: Conversion factors applied to Estimate Tropical Livestock Unit (TLU)

Categories of livestock	Types of livestock	Livestock's TLU estimation factor	
		Live weight(Kg)	Equivalent TLU
Cattle	Cows and oxen	250	1.00
	Heifer	125	0.50
	Calves	50	0.20
Small ruminant	sheep and goat	25	0.10
Equines	Donkey	90	0.50
	Horses/Mule	200	0.80
	Camel	175	1.00

Source: ILCA (1990) in Gerishu B (2007)

Appendix 7a: Turnitin Originality Report Summary

No	List of summary based on Sources	Turnitin Summary Report	
		1st report	2nd report
1	Similarity index Summary	23 %	19%
2	Similarity by Source		
2.1	Internet Sources	19%	17%
2.2	Publications	12%	7%
2.3	Student Papers	5%	6%

Appendix 7b: Originality Assessment Digital Receipt


turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Gb Waritu
Assignment title:	AAH Submissions 2021
Submission title:	PhD Agriculture thesis
File name:	GB_Theses_1572211263.doc
File size:	3.97M
Page count:	251
Word count:	96,441
Character count:	556,788
Submission date:	09-Jul-2021 11:43AM (UTC+0200)
Submission ID:	1617488374

Appendix 8. Last awarded Ethical Clearance Certificate

UNISA university of south africa

UNISA-CAES HEALTH RESEARCH ETHICS COMMITTEE

Date: 15/03/2021

NHREC Registration # : REC-170616-051
REC Reference # : 2019/CAES/050
Name : Mr GB Waritu
Student #: 61495263

Dear Mr Waritu

Decision: Ethics Approval Renewal after Second Review from 01/04/2021 to 31/03/2022

Researcher(s): Mr GB Waritu
61495263@mylife.unisa.ac.za

Supervisor (s): Prof AS Oyekale
Abayomi.oyekale@nwu.ac.za; 018-389-2751

Working title of research:

Climate change impact, vulnerability and adoption of climate smart agricultural practices among small scale farmers in Oromia Region of Ethiopia

Qualification: PhD Agriculture

Thank you for the submission of your progress report to the UNISA-CAES Health Research Ethics Committee for the above mentioned research. Ethics approval is renewed for a one-year period. After one year the researcher is required to submit a progress report, upon which the ethics clearance may be renewed for another year.

Due date for progress report: 31 March 2022

*The **low risk application** was originally **reviewed** by the UNISA-CAES Health Research Ethics Committee on 14 March 2019 in compliance with the Unisa Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

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Appendix 9: Farmers Interview Schedule (Sheet-1)

Title: *Climate Change Impacts, Vulnerability and Adoption of Climate Smart Agricultural Practices among Small Scale Farmers in Oromia Region of Ethiopia*

I. Introduction and Instruction

a) Introduction:-Dear respondents, you have been selected among the farmers participating in Climate Change programs/project, extension package programs and/or any other related conservation projects to provide us with the information related to the Climate change management practices in your village. The information generated will be used only for research and academic purposes and all information will be confidential, no information will be related to any particular personality of any body and institution. The researcher is responsibility to avoid any negative impacts and related risks in the process of the study.

b) General Guideline for enumerators

1. Make sure that respondent understand question before attempt to give any information and answers related to the questions and consider all ethical procedures in the interview process
2. Complete this questionnaire with maximum care and responsibility to generate relevant data
3. For the provided boxes or space for single answer, put 'X' in the correct box or space
4. For the question summarized in the table, use the respective information provided
5. In case of additional comments, please use separate paper and attach to this questionnaire
6. Make sure to introduce the purpose of the data collection adequately and correctly to respondents

II. Basic Information related to Demographic characteristics of the respondent

1 Respondent's residential location

(1) Zone: ________________ (2) District: ____________________

(3) Kebele: -______________ (4) Extension group: ____________

2. Head of household in the respondent's family

(a) Female (__________) (b) Male (_________)

3. Agro-ecological category and location of the Kebele (Peasant association)

(a) Mid-high land (_______) (b) Low land (_________)

4. Social characteristics of the respondent's

(a) The age of the respondent at the survey period (in year).___________years

(b) The sex of the respondent (put X): (1) Female (____) (2) Male (____)

(c) Marital status of the respondent at the survey time point (1). Married: _____ (3). Divorced: _______

(2). Single (Unmarried) ______ (4). Widowed: _______

5. Educational level of the respondent at the survey time (consider formal classification)

(1) No formal education: (__________)
(2) Adult education (reading and writing) (__________)
(3). Primary school (Grade1-6) (________Grade)
(4). junior secondary (Grade 7- 8) (_________Grade)
(5). Secondary school (Grade 9_12) (_________Grade)
(6) Above secondary school (>12) (________Diploma/Degree)

6.What is the family size of the households at the survey time? (Please consider the head of household head and dependent family members and use the classification indicated in the table 1)

Table 1. Age category of the Household

No	Age Category	Unit	Family members		
			Male	Female	Total
1	4 and below (<5)	No			
2	5-10	>>			
3	11-15	>>			
4	15-17	>>			
5	18 -64	>>			
6	65 and above (>64)				
	Total	>>			

III. Farming experience and Resource ownership

(a) Crop Farming experience and Farm land holding

1. What is the major livelihoods of the head of household which helps to generate the Family income at the survey time point?

(1) Crop farming (____) (2) Livestock farming :(____) (3) Mixed farming :(____)

2. What is the farming experience of the respondent in specified livelihood mentioned above in Qn 1?

a) <10Years (____) (b) 11-20 (____) (c) 21-30 (____) (d) 31-30 (___) (e) >30 years

3. What is the Improved Natural resources conservation experience of the respondent in years during specified experience of livelihood and farming experiences mentioned above in Qn 2?

a) Years of experience (_______) b) Year started in EC (_________)

4. How many hectare of land do the family owing currently for household livelihood activities and use to generate seasonal family level farm revenue to sustain the life of the family members?

a) Family owned farm land (______ha) b) Rental farm Land (_______ha)

5. Based on the response in number '9' indicate the utilization (commonly implemented land use plan) of land owned by the house hold (write in hectare in the provided space). (A) Seasonal crops: ________ha (c) Grazing land: __________ha
(b) Perennial crops: ________ha (d) Tree planting __________ha

(b) Livestock Farming experience and holdings

6. How long the family (as household) engaged in Livestock farming to compliment the family's seasonal income? (______years)

7. How many livestock are owned by the household to generate seasonal family income at the survey period (please indicate in the below provided table 2).

Table 2. Livestock ownership of the Respondents

No	Livestock category	Types of Breeds			Estimated monitory value (Eth-Birr)
		Local	Improved	Total	
1	Cattle				
2	Small ruminants				
3	Equines				
4	poultry				
	Total				

(c) Source of income and amount of income for the Respondents' households' economy

8. What is the major and dominant source of the households' income?

(a) Crop Farming (_______) (b) Livestock husbandry (_____)

(C) Both (a & b) (_______) (d) Non-farming (______)

9. If the main source of income is farming, do the family have other non-farm (outside the farming) occupation to supplement family yearly income in the past two years of experiences?

(1) Yes: (_____) (2) No: (____)

10. Based on the Qn.9, Please, indicate the sources and estimated the households' amount of income in the following table using minimum, maximum and average yearly income of past five years of cropping years based on the below stated sources of incomes

Table 3. Source and amount of Income for respondents' household

No	Income Source Category	Estimated income (Birr)		
		Minimum	Maximum	Average
1	Crops products sale			
2	Livestock Sale			
3	Livestock product sale			
4	On Farm employment			
5	Non-farm employment			
6	Family member remittances			

11. Based on the yearly income of your family indicated in the table 3, in which category of the community is your family included?

(a) Wealthy group (_______) (b) Non wealthy (________)

12. In your opinion are you implementing the crop diversification to mitigate the climate change impacts and risks on the livelihood of the family? (Please show against list of crops in Table 4 below)

Table 4. Crop diversification

No	Income Source Category	Estimated rate of diversification			
		Mostly (3)	Some times (2)	slightly (1)	Negligible (0)
1	Maize				
2	Wheat				
3	Teff				
4	Barely				
5	Pulse				
6	Horticultural Crops				

IV. Data related to each Objectives of the Study

4.1 Impact of climate change on the Livelihoods and social aspect of households (sp. Objective1)

a) Impacts of extreme weather events on farm households' livelihoods and practices

13. How do you perceive the current climate system in your community compared with normal situations of the one used before ten years in your Area and community? (1) Very high negative Change: (____) (2) High negative change: (____) (3) Moderate negative change: (____) (4) No negative change (_____)

14. If there is a unusual negative change in the climate system (In Qn13), please give your opinion in respect of the Climate parameters stated in the below table by putting 'X' in the appropriate Colum.

Table 5. Farmer perception and ranking of the climate change in the study community

No	Climate change Indicators category	Rank of perceived change				
		Very High (4)	High (3)	moderate (2)	Low (1)	No change
1	Rain fall or precipitation frequency reduced					
2	Rain fall amount in the main seasons reduced					
3	Temperature in the season increased					
4	Frequency of recurrent drought increased					
5	Irregularity in rain fall patterns and distribution					
6	Frequent fluctuation in weather system					
7	Late on set of rain to normal time frame					
8	Early cessation of rain fall to normal time line					
9	Long Summer in the seasons					
10	Frequency of unpredicted rain fall					

15. In your opinion, what are the major cause for manifested climate change in the farming system?

(a) Natural process (_____) (b) Human interferences (____) (c) Others factors (_____)

16. How do you perceive the farm practice effects on aggravating the Climate change process and related risks in the community? (Indicate considering the negative aspects of the practices using the table 6)

Table 6. Perceived negative impact of Farm practices on the climate change

No	Categories of Farm practices	Perceived Degree of negative impacts on climate change			
		High (3)	Moderate (2)	Low (1)	No effect (0)
1	Farm land expansion				
2	Current practices of open Grazing system				
3	Over cultivation (repeated cultivation)				
4	Removal of Crops residue from the field				
4	Lack of proper Crops rotation				
5	lack of Minimum tillage practices				
6	Removal of natural vegetation				

17. To your opinion, is there significant climate change impact on the major households' livelihoods during past ten years of cropping season at family and community level? (1) Yes, Negative (___) (2) yes, positive (_____) (3) No impact (___)

18. If the influence of the climate change is negative on your livelihoods and its components, is there adequate adaptation strategies introduced to mitigate the negative impacts on the community livelihoods? (a) Yes (_____) (b) not at all (_______)

19. If you perceive the climate change influence is negative to the livelihood of the households (referring Qn 18), please indicate the level of the climate change impact on that particular livelihood by putting "x" in appropriate Colum in the table7 against each livelihood components

Table 7. The climate change impact on the Livelihood of the community

No	Category of the effect indicators	Considering Yes (Level of the effect)			
		High (3)	Moderate (2)	Low (1)	Negligible (0)
IPCC-LVI Sensitivity indicators					
1	Seasonal productive crop Land decrease (abandoned land)				
2	Crops productivity decrease over time				
3	Crops production decreasing over time				
4	Significant Loss of crops varieties over time				
5	Livestock Number decrease over years				
6	Declining of Livestock productivity				
7	Livestock production decrease				
8	Food sufficiency reduced (below yearly 1.8 Qt/person)				
9	Increased change associated Risks and impacts				

b) Climate change Social level impacts and vulnerability indicators at the household level

20. What is the social level influence and effect of the climate change on your household during past ten years of the farm experience?

(1) Negative (___) (2) positive (_____) (3) No impact (____)

21. If you perceive the climate change impact is negative on your household stability (in Qn.20), please indicate family instability observed in your family and community, considering the scale of instability against social crises indicated in table 8, putting "***x***" in appropriate Colum in the table and show the rate of related adaptive components.

Table 8. Social level climate change impact indicators

No	**Category of effect indicator (Social instability components)**	**Yes (Level and scale of crises)**			
		Very high (3)	High (2)	Low (1)	Negligible (0)
1	External migration (outside the country)				
2	Internal migration (within rural areas)				
3	Internal migration (outside the rural or to urban)				
4	Instability of Family and living styles				
5	Displacement from usual residential areas				
6	Shift of traditional (normal) way of social affairs and relationship styles				
7	School dropout increase				
8	Linear increase of affected people in the community				

22. Considering the influence of the climate change is negative on social aspect of the community, is there adequate adaptation strategies introduced to mitigate the negative impacts on the community social structures? (a) Yes (_____) (b) No, not at all (____)

4.2. The households' vulnerability to climate change and the factors influencing Vulnerability (Obj.2)

23. In your opinion, generally, how do you evaluate the household and community vulnerability to climate change impact in your working areas and environment? (1) Extremely high (_____) (2) very high (____) (3) Moderate (___)

(4) Low (____) (5) very low (_____) (6) Negligible (____)

24. If the changing climate parameters are adversely affecting the community's Livelihoods and social structures, indicate the degree of change impact based on the climate parameters listed in the table 9 (put "X' under corresponding level stated in the column)

Table 9. The ranking of the climate change impact vulnerability indicators

No	Category of the effect indicators (Based on IPCC-LVI Indicators)	Considering Yes (Level of the effect)			
		High (3)	Moderate (2)	Low (1)	Negligible (0)
a) Exposure indicators					
1	Frequency of climate variability (time of variability)				
2	Water resource availability and supply declining				
3	shortage of Irrigation water source				
4	Drought frequency increased (in10 years)				
5	Major Agricultural diseases and pest occurrence increased				
***b)* Adaptive capacity components improved**					
1	Agricultural livelihood Diversification				
2	Non-farm income diversification				
3	Sufficient Wealth and yearly income				
4	Use of improved agricultural Technology				
5	Advancement of Technical capacity related to climate change management and mitigation				
6	Exposure to Technical and Technological support				
c) Infrastructure components					
1	Accessibility to service facilities health post veterinary post and FTCs				
2	Accessibility to service facilities (veterinary health post)				
3	Accessibility to extension services centers (FTCs Facilities)				
4	Accessibility to market places and Facilities				
d) Demographic components					
1	Adult equivalent in the family				
2	Dependency ratio in the household				
3	Farm experience which helps for Adjustment of planting dates, varieties and management				
4	Land ratio to Family				
5	Access to trainings				
6	Borrowing to Lending ratios				
7	Receiving and giving ratios (assistance to support)				

25. How many family members are totally pendent in your household level? _______persons

26. Based on your family current situation, are you able to save adequate seed for seasonal crop farming in each cropping years in past five years? (a) Yes (______) (b) Not at all (_____)

27. Based on your current crop farm land productivity and production, are you able to produces adequate grain for seasonal consumption in each cropping years in past five years? (a) Yes (______) (b) Not at all (_____)

28. On average for how many months annual consumption you can cover from your own sources to fulfill the family demand per year in past five years? (a) _______ Months/year sufficient (Enough)

(b)________ Months/year deficit (shortage)

29. Are there family members working out side community to generate additional income for your household? (Please indicate the numbers in the following categories) (a) Within rural community _______ (b) In urban community ________

30. In your family life situation, what do you think about the household expense compared with annual income in past five years of cropping seasons? (a) More annual income than annual expense (______)

(b) More annual expense than annual income (______)

(c) Almost the same level annually (______)

31. Considering farm investment for seasonal agricultural production and other issues, have you ever taken loan (borrow) from different source during past five cropping years? (a) Yes, I was (______) (b) No, I wasn't (____)

32. Have ever have experience of lending money to somebody during past five years?

(a) Yes, I was (______) (b) No, I wasn't (____)

33. Do you remember your experience of giving help to other people in the past five years?

(a) Yes, I was (______) (b) No, I wasn't (____)

34. Do you remember your experience of receiving help from other people in the past five years?

(a) Yes, I was (______) (b) No, I wasn't (____)

35. In your family, is there family members with chronic health problem?

(a) Yes, there is (______) (b) No, there isn’t (____)

36. Do you have any health problem which is leading to frequent medication and treatments during past five years?

(a) Yes, I have (______) (b) No, I haven’t (____)

37. Please, suggest your respected opinion and judgment concerning the vulnerability indicators mentioned in the Table 10 below (Put the "**x**" in the right column).

Table 10. Climate change impact vulnerability indicators

No	Details of indicators	Response	
		Yes	No
1	Less rain fall amount (Below optimum) during last five years		
2	More and frequent drought during five year		
3	Unusual rain fall situation events (occurrence)		
4	Unusual temperature increase in five years		
5	Agricultural production in terrible (problem) due to climate change		
6	Early warning regarding sever bad weather during last five years		
7	Change of crop choice and calendar due to climate change during last cropping season		
8	shortage of potable water (far distance to water source and point)		
9	Shortage of irrigation water and facilities		
10	The source of family food is only Agriculture		
11	Small farm land holding (<1ha)		
12	poor access to Agricultural extension services		
13	Grain crop saving over yearly consumption		
14	Assistance from outside (Government, NGOs etc) during five years		
15	severe injury or death as result of drought in past five years		
16	Adequate access to credit services during last five years		
17	Accessed climate change related training during past five years		
18	Source of income is only Agriculture livelihood		
19	Private land less (Lack of private land) for family livelihood		
20	Dependence on natural resource exploitation during food shortage		
21	Membership to social organization during past years		
22	No any source of income during drought and food shortage years		

38. What is the average number of drought/rain shortage events in the community during last five years? ________years

39. Currently and during past five years are you engaging in Agricultural and nonfarm livelihood diversification to adapt to climate change related adverse impacts and risks? (a) Yes (_______) (b) Not at all (________)

40. If your answer is yes in Qn 39 and you are engaging in livelihood diversification, please indicate your engagement in different livelihood presented in the table 11.

Table 11. Engagement in different livelihoods

Livelihoods Categories	List of livelihoods	Engagement response as livelihoods	
		Yes	No
Agriculture related	Crop farming		
	Livestock farming		
	Natural resource management and related practices		
Non-agriculture source	Daily labor employment		
	Rural petty business		
	part-time employment		
	Other		

4.3 Adoption and sustainability of CSA strategic Practices

a) Adoption of Climate Change Mitigation Strategic practices (Objective 3)

41. Do you remember any modern Climate Change mitigation practices and innovations introduced to you and your community in the past 10 years of farm experiences? (1) Yes, introduced (___) 2). No, not introduced: (____) (3) I don't know

42. If you and your community have introduced some of the climate mitigation strategies, have you ever decided in the past years to use it at large farm level these Technologies and practices to tackle environmental degradation and to mitigate the Climate change impacts on your household livelihoods? (1) Yes: (___) (2). No :(____)

43. If your response to Qn.42 is yes, please, show which of the practices you decided to use them and time of your decision toward technology utilization. (Use the "x" in corresponding Colum to indicate its appropriateness).

Table 12. Adoption of the climate Smart Agricultural practices

No	Major Climate smart Agricultural practices	Adoption decision of respondents		
		Adopted	Not adopted	Year of adoption
1	Conservation Agriculture			
2	Small-scale irrigation			
3	Agro-forestatry			
4	Improved Range land resource management			
5	Water conservation and Harvesting			
6	Crops and Livestock drought Insurance			
7	Moisture stress/Drought tolerant crops varieties			
8	Adapting proper crops rotation			
9	Inter cropping			
10	Introduce the improved and Climate change adaptable crops varieties			
11	Integrated soil Fertility Management			
12	Livelihood Diversification			
13	Adjusting planting time of the crops			
14	Introducing the fallow System			
15	Crop diversification			

44. If you did not decide to use some of the CSA practices mentioned above (Table 6), what are the main reasons help you to reach decision to reject those practices?(refer to number table 7).

(1) No enough information: (____) (2). Costly to use it: (___)

(3). Not efficient to solve problems: (____) (4). Not suitable to our condition :(___)

b) Perceived Sustainability of the climate change Mitigation practices (Objective 4)

45. In the past ten years, have you ever been the beneficiary of the any (participated in any) CSA or Soil and water conservation (SWC) project or regular program? (a) Yes, I did (______) (b) No, I didn't (_______)

46. If you were/are beneficiary of CSA or SWC project/program, for how long were you engaged in the program /projects that supporting you and your community, in respective of the Climate change strategies implementation?

(a) <3 years (__) (b) 4-6years (____) (c) 7-10 years (___) (d) >10 years (___)

47. Currently, are you graduated (terminate involvement) from the mentioned project/program?

(a) Yes, graduated (___) (b) No, not graduated (_____)

48. Currently, after graduated and the withdrawal of external support, are you still using (continue using) introduced (by project/program) CSA or SWC Technologies and practices by your own technical capacity and investment costs?

(1) Yes: (____) (2) No: (_____)

49. In your opinion, did you achieve the intended benefits from the practices you decided to use it and continued to implement at large farm level? (1) Yes: (____) (2) No: (_____)

50. If yes in No.49, are those benefits similar or equal to what you expected from the practices at the beginning of the program/project?

(1) Yes: **(____)** (2) No**: (____)**

51. If you adopted some of the technologies mentioned above (Table 12), please indicate its present situation and your future plan whether to continue using or to reject it for some reasons. Please, use "X" under corresponding column where appropriate and leave free space where not.

Table 13. Sustainability of the Adopted Climate change mitigation Strategies

No	**Climate smart Strategies**	**Perceived Sustainability**		
		Year of adoption	Current sustainably of prances	Future plan to sustain practices
1	Conservation Agriculture			
2	Small-scale irrigation			
3	Agro forestry and a forestation			
4	Improved Range Land resource management			
5	Water conservation and Harvesting			
6	Moisture stress/Drought tolerant crops varieties			
7	Crops and Livestock Insurance			
8	Adapting proper Crops rotation			

52. If you have rejected some of the practices mentioned in table 13 (stopped using after adoption), would you outline some major reasons for rejecting those practices after your decision to adopt the practices?

(1) No enough information: (____) (2). Not efficient to solve problems: (___)

(3). Not suitable to our condition (___) (4). Costly to implement: (____)

53. If you will not continue using some of conservation practices (referring table 7), what would be the main reason (what are the constraints) for such decision not to sustain the technology(s) and practices to use in the future time on farm land?

(1) No enough information:(___) (2) Costly to implement:(____)

(3) Not efficient to solve problems: (___)   (3) Not suitable to our condition (____)

54. What are the major problems facing the respondent to adopt and sustain the introduced climate change mitigation strategies and practices? (Indicate using the table 14 below)

Table 14. Major community problems and rating

No	**List of Major constraints**	**Degree of problem**			
		High (3)	Moderate (2)	Low (1)	Not at all (0)
1	Lack of Irrigation water				
2	Lack of water for livestock				
3	Shortage of farm land				
4	Lack of money and credit				
5	Lack of market access				
6	Lack of farm animals				
7	Lack of agricultural inputs				
8	Lack of Information				
9	Inadequate soil fertility management technologies				
10	Lack of Improved agricultural Technology				

4.4 Coping mechanisms and Adaptive Capacity of Climate Change (Objective 5)

(a) Community level Climate change coping Mechanisms (Objective 5a)

55. Do you recognize and adopt any kind of climate change coping Mechanisms in your Community?

a) Yes, there are mechanisms (_____)   b) No, there no mechanisms (____)

56. If your response to Qn.55 is yes, please, show which of the practices you decided to use them and time of your decision toward utilization of the mechanisms. (Use the corresponding numbers to indicate its appropriateness in the table 15 below).

Table 15. Coping mechanisms of Climate change impacts and risks in the community

No	**Categories of coping mechanisms**	**Yes (Rating in respect of importance)**				No importance (0)
		Very high (4)	High (3)	Moderate (2)	Low (1)	
1	Rural off-farm employment					
2	Urban non-farm employment					
3	Informal credit source					
4	Formal credit source					
5	Borrowing grain in kind					
6	Sell of the fire wood and charcoal					
7	Use of available savings					
8	External emergence aids					
9	Seasonal internal mobility for pastures/water					
10	Social interconnectedness (relatives support)					
11	Sell of household assets					
12	House hold Land renting					

57. If you are adapting and using some of the coping mechanisms and adaptation strategies how do you evaluate (estimate) the overall importance on the families seasonal income?

(a) Very high (______) (b) High (______) (c) Moderate (______) (d) low (_____)

(b) Impact of Coping and adaptation strategies on the Family income

58. Do you think the adaptation of the some coping mechanism and climate change adaptation strategies are important to increase the household level annual income (a) Yes, important (_______) (b) Not important (______)

59. If you assumes using some of the coping mechanisms and adaptation strategies are important, please indicate the adaptation of strategies which is important to estimate its contribution and impact on the family's seasonal income?

Table 16. The Climate Change Coping and Adaptation strategies

No	**Major Categories of the strategies**	**Adaptation of the Strategies**	
		Adapted (1)	Not adapted (0)
	a) Coping strategies		
1	Rural off-farm employment		
2	Rural farm employment		
3	Urban non-farm employment		
4	Informal credit source		
5	Formal credit source		
	b) Adaptation strategies		
1	Crops diversification		
2	Conservation Agricultures		
3	Integrated soil fertility Management		
4	Access to early warning information		
5	Introduce Improved Crops Varieties		

(c) Institutional adaptive capacity of climate change (Objective 5b)

(1) Extension services provision and related Supports

60. Is there development center (DC) in your farm community. (1). Yes (___) (2). No (___)

61. If there is a development center located in your village, is there development agent that responsible to provide extension services? (1) Yes: (__) (2) No: (___)

62. If yes in question 61, currently, on average how many time you made extension agent contact or visited by development agent per month. ______days/Month.

63. When you compare last three (and before) years, how do you evaluate the trend of current extension contact? (1) Increasing: (___) (2) Decreasing: (____) (3) Remain the same: (____)

64. Have you ever received any advice related to climate change mitigation practices from DAs during the last five years of farming? (1) Yes (______) (2) No (___________)

65. How do you evaluate the DA's attention for CSA practices during visiting your home or farmland?

(1) Good (_____) (2) Satisfactory (____) (3) Poor (______)

66. How do you evaluate the overall extension service delivery system and structure adaptive capacity to support you in mitigating the climate change impact related risks at household and community level? (a) Significantly adequate (___) (b) Adequate (______) (c) Moderate (____) (d) inadequate (______)

67. In your opinion, how do you evaluate the detailed extension services delivery system in respect of climate change adaptation capacity and indicate your opinions which correspond to the statement in the table 17 below.

Table 17. Institutional Adaptive Capacity of the Service Delivery System

No	Category of adaptive capacity indicators (concerning climate change)	Rating of the adaptive capacity				
		Very good (4)	Good (3)	Moderate (2)	Low (1)	Poor (0)
1	Integration of Climate change mitigation strategies in the system at FTCs level					
2	Human resource (Staff) allocation and composition at kebele (FTC) level					
3	Climate change related Technical capacity (competence) of the staff (DAs)					
4	Transport Facilities in extension structural level of the FTC					
5	Focus of climate change issues during seasonal events (Training, workshop... etc)					
6	Facility, Resource capacity and allocation at the FTC level					
7	Focus to promote the climate change strategies at the community level					
8	DAs contacts for Climate change					
9	Commitment of extension staff (DAs)					
10	Service timeliness at FTC level					
11	Accessibility and convenience of services					
12	Service Contents and quality at FTC level					

68. When you compare current Climate change extension service with last years situation (in term of attention), what is your opinion concerning its trend in extension service delivery system?

(1) Increasing (___) (2) Decreased: (____) (3). Remain the same: (_____)

69. Have you ever attended any extension training during last three years (1-3 years)?

(1) Yes: (_____) (2) No**: (______)**

70. If yes in No. 69, how was the contribution of training in assisting you in adoption of Climate change practices?

(1) Good (_____) (2) Satisfactory (____) (3) poor (______)

71. What is your satisfaction with the current Climate change services provision adopted to assist you to reduce climate change impact on your household livelihood? Rate and show your filling in the table 18 presented below. (Please, focus on the climate change management aspects and parameters)

Table 18. Satisfaction with Climate management services provision

No	services category	Rate of satisfaction				
		extremely (4)	very high (3)	Moderately (2)	Slightly (1)	Not at all (0)
1	Content of advices and Technical support					
2	Content of Technical training					
3	Practical demonstration					
4	Frequency of Staff visit					
5	Technical tour and experience sharing					
6	Timeliness					

72. Which are the most important sources of information for you to become aware of CSA innovations and practices?

(1). Extension field staff: (_____) (2). NGOs staff: (____)

(3). Neighbor or fellow farmers :(_____) (4) Others (specify) (_____)

73. In your understanding, which program/project is most important to help you become aware of the available SCA and SWC practices/strategies in your community?

(1). Regular extension program: (_____) (2). NGO: (_______)

(3). Extension package program: (_____) (4). Gov't CSA projects: (_______)

(5). Gov't SWC projects: (______) (6) others (specify): (________)

(2) Access to Public infrastructures and facilities

(i) Community Level Infrastructure

74. Is there tarmac (asphalt) road facility in your village (locality). (1) Yes (____) (2) No (_____)

75. On average, how far is your home and farm land from the below mentioned facilities in the table?

Table 19. Major Infrastructures in the community

No	Major Facilities	Estimated Distance (Km)		Estimated time to reach	
		Farm land	Home	Farm land	Home
1	Major (National) Road				
2	Village level gravel Road				
3	Village office				
4	Development Centre (FTC)				
5	Health center (Human)				
6	Veterinary health centers				
7	Market facility and place				

(ii) Credit facility and availability for the respondent's household

76. In your opinion, is credit important to support the climate change mitigation practices implementation in your village and for your household? (1) Yes; (____) (2) No: (____)

77. In the past 2-3 years, is there credit facility that assists your financial capacity to carry out farm and other related activities on your household land? (1) Yes :(____) (2) No: (____)

78. If yes in No.77, do this credit facility available or include to support the Climate change mitigation practices and innovation promotion in your community? (1) Yes (____) (2) No: (_____)

79. Would you indicate your trustful judgment in respective of the rates provided in the below table concerning the importance of credit source to community livelihoods.

Table 20. Source of credit for the households

No	Category of the Source of credit for the respondent	yes (Rating of the credit source contribution)				
		Very good (4)	Good (3)	Medium (2)	Poor (1)	No contribution (0)
1	Informal credit source					
2	Private (Micro-finance) formal credit sectors					
3	Government formal credit source (public Bank)					
4	NGOs related credit services					
5	Non-formal credit source					

80. If you are customer of one of the credit institutions mentioned in Table 20, what is major problems related to credit services? Indicate in the below table 21 against rating scale in the column.

Table21. Problems related to credit facilities and services

No	Description of the problems	Rate of the problem related to credit services				
		Very high (4)	High (3)	Moderate (2)	Low (1)	Negligible (0)
1	Inadequate in amount					
2	High interest rate					
3	Lack of timeliness					
4	Lack of access					
5	High down payment					
6	Shortage of repayment time					

(iii) Communication media facility and services

81. Do you think that the mass media is important in Climate smart agricultural Technology and innovation promotion in your particular area? (a) Yes, important (______) (b) No, not important (______)

82 In the past 3-5 years of your experiences, do you have access to any kind of mass media?

(1) Yes: (_____) (2) No: (______)

83. In your opinion, did these mass media help you in learning about climate change impacts and mitigation practices and available adaptation technology and innovations (s)?, indicate its importance in table 22.

Table 22. Role of the Mass media in Climate change mitigation Technology Promotion

No	Mass media	Rating of the Mass media influence in CSA practices promotion				
		Very high (4)	High (3)	Moderate (2)	Poor (1)	Very poor (0)
1	Oromia TV (OBN)					
2	Ethiopia TV (ETV)					
3	News papers					
4	Private TV					
5	Social media					
6	Public Radio					
7	Private Radio					

84. In your opinion, how do you evaluate the overall focus and attention of currently available mass media in promoting the CSA practices and innovations in your community? (a) Very good (____) (b) Good (____) (c) Moderate (_____) (d) poor (____)

Thank you for your contributions!

Appendix 10: Extension Field Staff Questionnaire (Sheet-2)

Title: *Climate change Impacts, Vulnerability and Adoption of Climate Smart Agricultural Practices among Small Scale Farmers in Oromia Region of Ethiopia*

a) Introduction:-Dear respondents, you have been chosen among the extension field staff participating in regular and extension package programs and/or any other related projects to provide us with the information related to the soil conservation practices (SWC) and Climate change mitigation Strategies in your working environment. The information obtained will be used only for research and academic purposes. All information will be confidential and no information will be related to any particular personality of some body. Hence, feel free to provide us your original ideas and views openly and transparently.

b) Instruction for respondent and enumerators: - The purpose of this survey is to generate accurate data for academic empirical conclusion and the following are the general guiding principles for the respondent completing the questionnaire.

1. Make sure that you understand the question before attempting to give any information or answer to the questions and consult the facilitator (researcher or enumerator) for any problem that you come across when you are completing the questionnaire
2. Please, complete this format with maximum care and responsibility
3. For the provided boxes, for a single concept put 'X' in the given correct box or space
4. For provided blanks, please write the required information in the provided spaces

1. Respondent's level and positions in the extension structural arrangement

(i) Zone: (a) Arsi Zone (_____) (b) East shewa Zone (____)

(ii) Level and Place of work (a) Regional Level (_____) (b) Zonal level (____)
(c) District Level (______) (d) DC (FTC) level (____)

(iii) Positions: (a) Managerial level (___) (b) Expert level (SMS) (____)
(c) Development Agent (DA) (___) (d) DAs' supervisors (____)

II. Demographic Characteristics of the Respondent

(a). What is your age at the survey time in Years? (____Years)

(b) What is your gender (Sex)? (1). Male: (____) (2). female: (____)

(c) What is your highest and last level of education? (Put "X" in correct space).

(1) Secondary school (Grade 9-12): (___) (2) College certificate: (___)
(3) College diploma: (____) (4) University/college 1st Degree (___)
(5) University 2nd Degree (____) (6) University 3rd degree (___)

(d) When did you complete your last field of study: _______________

(e) What is your last field of study? (1) Agriculture (_____) (2) Natural Resource (_____) (3) Others (____)

III. General information Related to the study

1. How do you evaluate pre-service study programs and fields of study at college/university level in respective of climate change?

(1) Climate change oriented: (____) (2) Not Climate Change Oriented (____)

2. When were you employed as extension field staff? (Ethiopian calendar): _______year.

3. Have you ever attended any in-service training since you have been employed as extension field staff?

(1) Yes :(____) (2) No: (____)

4. If yes in Qn.3, on the average how many times do you attend in-service training per year in the context of the current extension service delivery system?__________ times/year

5. Please, evaluate the in service training arrangement and contents in relation to climate change management?

(1) Highly Climate change oriented (______) (2) Moderately climate change oriented (___)

(3) Low climate change oriented (_______) (4) Not climate change oriented (____)

IV. Extension service delivery system and focus for conservation strategic practices

6**.** In your opinion, how are the situation of the climate change problems in your work environment?

(1) Very serious (____) (2) serious: (____) (3) Moderate (____) (4) Minor: (_____)

7. What is the current trend of climate change related risks in your work environment?

(1) Increasing (______) (2) Decreasing (______) (3) Remain the same (constant) (____)

8. Currently, how many kebeles (PAs) are functioning in your work areas/community? (___ Kebeles)

9. What proportion of the kebeles are susceptible (high exposure) to Climate change and variability in your working areas and community? (1) All (100%): (__) (3) Three fourth (75%): (__)

(2) Half (50%) (___) (4) Below half (<50%): (___)

10. What is the current population of your work area or development center? (1) Male: _____ (2) Female: ____ (3) Total: _____

11. Among total population, what is total number of farmers in your working area? (1) Male: _____ (2) Female: ______ (3) Total: ____

12. Among farmer population, what proportion are you covering in extension service delivery?

(1) All (100%): (__) (3) Three fourth (75%): (__)

(2) Half (50%) (___) (4) Below half (<50%): (___)

13. Among farmers population found in your work area, what proportion of them are on average involving in extension package program (full package) in the past program implementation years. (1) All (100%): (__) (3) Three fourth (75%): (__)

(2) Half (50%): (___) (4) Below half (<50%): (___)

14. Among the farmers participating in package program, on average what proportion of them were involving in climate change mitigation strategic program and practices? (1) All (100%): (__) (3) Three fourth (75%): (__)

(2) Half (50%) (___) (4) Below half (<50%): (___)

15. In your opinion, during past ten years of experience, how do you evaluate extension package program in respect of climate change management inclusiveness? (1) Good (____) (2) Medium (_____)

(3) Poor (_____) (4) negligible (_____)

16. If extension package program is not focusing the climate change management, what would be the major reason that dictate the program to neglect the Climate change management strategies and practices? (Evaluate and rate against stated reasons in Table 1)

Table 1. Major problems to promote the CSA strategic practices and Innovations

No	Major categories of reasons	Rating the level of problems				
		Very high (4)	High (3)	Moderate (2)	Low (1)	Negligible (0)
1	Poor attention at national and regional level to promote CSA					
2	Lack of proper CSA policy/strategy					
3	Lack of appropriate/adequate Climate change innovations and Technology:					
4	Lack of Technical capacity related Climate change management					
5	Lack of adequate resources and facilities					
6	Farmers are not concerned to climate change management					

17. What is your opinion concerning statements in the table 2, in extension service delivery system (indicate your agreement against statements, putting 'X').

Table 2. Scaling some of the CSA practices and implementation

No	Category of indicators	Scale of the agreement				
		Strongly agree (4)	Moderately agree (3)	Medium (2)	Moderately disagree (1)	Strongly disagree (0)
1	The Farmer's awareness of CSA strategic practices is satisfactory					
2	The Farmer's attention/concern to mitigate the Climate change effect is adequate					
3	Attention for CSA is satisfactory in extension service delivery system					
4	Overall effort to implement CSA is sufficient to avoid climate change risks					
5	Availability of CSA technologies are satisfactory					
6	Research attention to CSA practices is satisfactory					

Note: - In this study, CSA represent the Climate Smart Agriculture

18. To your opinion, what is the trend of implementation of CSA practices by the farmers?

(1) Improving (____) (2) Decreasing (_____) (3) No change (___)

19. Which kind of conservation practices mentioned below is more efficient in solving the soil degradation problems and climate change indicates their acceptability?

Table 3. Efficiency and effectiveness of conservation interventions related to CSA strategic practices

No	**List of practices**	**Efficiency**			**Effectiveness**		
		Good (2)	Medium (2)	Poor (0)	Good (2)	Medium (1)	Poor (0)
1	Reforestation						
2	SWC practices						
3	Crop rotation						
4	Reforestation						
5	Inter cropping						
6	Crops residue Management						
7	Fallowing farming						

20. In your extension service delivery system, on average, how many times you visit individual farmer per month (DAs only)

(1). Once (_____) (3). Three times (___)

(2) Twice (_____) (4) More than three (___)

21. Do you think, CSA innovations promoted by projects/ programs were spread (copied) to non-project farmers?

(1) Yes (_____) (2) No (____)

22. What is the magnitude (estimates) of non-participant farmers have got (have copied) the innovations within 3-5 years (DAs only)?

(1) Less than 25% (____) (2) Half (50%) (____)

(3) About 75% (____) (4) More than 75% (___)

V. Adoption and sustainability of SWC innovations related to CSA strategic practices

23. Are there any SWC related projects which complement CSA practice promotion in your development center or work area in the past Experiences of 5-6 years? 1. Yes (___) 2. No (____)

24. If there were SWC related projects, please indicate their assistance to farmers in the project area.

(1) Technical assistance only (____) (2) Material assistance only (____)

(3) Both (technical & material) assistance (__) (4) information (____)

25. What proportion of farmer's population is included in the project (Qn.24) in the past project implementation years? _____________%

26. How many of them graduated (Completed two years) from the program in the past implementation years? (______%)

27**.** How many of them (graduated farmers) were decided (adopted) to implement the SWC practices to implement without external support and funding? **(**____%)

28. How many of them (graduated farmers) were reject to use SWC practices to implement without the project support? (____%)

29. Among adopted farmers, how many of them were discontinue using the introduced SWC practices? (____%)

30. In your working area, did CSA strategic practices promoted to mitigate the climate change related impacts and risks? (1) Yes, there are (_____) (2) No, not at all (_____)

31**.** If yes in Qn 30, how long it is, since CSA introduced to your development center or work environment?

(1) Less than 5 years (____) (2) 5-10 years (____) (c) More than 10 years (____)

32. In your opinion, do you think overall farmers are adopting CSA strategic practices and innovation disseminated through extension package program in past implementation years? (1) Yes (____) (2) No (____)

33 If yes in question.32, estimate rate of adoption of CSA technology and practices compared with required level of achievement

(a) Good (____) (b) satisfactory (____) (c) poor (___)

34. When you compare different SWC which contribute for CSA practices, which are more adopted by the farmers? (Please, indicate in the below table against provided practices)

Table 4. Estimated rate of adoption (considering farmers number adopted)

No	List of practices	Perceived Adoption Rate		
		Good (2)	Medium (1)	Poor (0)
1	Reforestation			
2	Conservation Agriculture			
3	SWC practices			
4	Crop rotation			
5	Reforestation			
6	Inter cropping			
7	Crops residue application for soil improvement			
8	Fallowing farming			

35. If rate of adoption for CSA package is poor in your judgment and climate change is serious problem, what would be major reason for less adoption?

Table 5. Some expected reasons for poor adoption

No	Major problem	Perceived level of problems			
		Very serious (3)	Serious (2)	Moderate (1)	Less serious (0)
1	Technologies are not efficient				
2	Technologies are not compatible to local conditions				
3	Poor attention in the extension service delivery system				
4	Lack of promotion and publicity				
5	Not efficient and effective				
6	High cost of implementation				

36. In the SWC project area, do farmers carryout conservation works on their own land without external support?

(1) Yes (_____) (2) No (_____)

37. Do you think farmers are implementing required Soil and water conservation practices to protect land degradation after the external supports are terminated? (1) Yes (____) (2) No (____)

VI. Institutional Adaptive capacity of extension services delivery system

38. Do you think the adaptive capacity of the extension structure is adequate to mitigate the climate change impact related risks in your working environment? (a) Yes adequate (____) (b) No, not adequate (____)

39. In your judgment, is there overall adequate climate change management/adaptation strategic practices available to mitigate the climate change related adverse impacts on the community regular livelihoods? (1) Yes (_____) (2) No (_____)

40. In your opinion what is the adaptive capacity of extension system? (Please rate the level of extension structure adaptive capacity to influence the farmers' SCA adoption and sustainability, using indicators presented in the below table).

Table. 6. Institutional Adaptive capacity of the Agricultural extension system

No	**Category of climate change adaptive capacity indicators**	**Rating of the adaptive capacity**				
		Very good (4)	Good (3)	Moderate (2)	Low (1)	Poor (0)
1	Guideline and strategic documents					
2	Adequate climate change policy and strategies					
3	Institutionalization (integration) of Climate change mitigation strategies					
4	Inter sectoral partnership					
5	Human resource (Staff) allocation at different level					
6	Climate change related Technical capacity of the staff					
7	Climate change knowledge management system					
8	Material capacity of extension structures					
9	Transport Facilities in extension structural level					
10	Focus of climate change during seasonal events (Training, workshop. Etc)					
11	Facility and Resource capacity and allocation of the extension structure					
12	Focus to promote the climate change strategies					
13	DAs contacts for Climate change					
14	Commitment of extension staff					
15	Climate change programs/projects					
16	Monitoring and Evaluation capacity					

41. In your opinion, do you think recent soil and water conservation approaches will be sustainable after the withdrawal of external support? (1) Yes (_____) (2) No (____)

42. What institutional support or collaborations is needed for small-scale farmers to promote sustainable soil and water conservation practices in the farming system to complement the CSA strategic practices? (1) Technical (Training) (__) (2) Materials (_____) (3) Financial (material) (___) (4) Organizational (___)

***Thank you for your contribution*!**

Appendix 11: Agricultural Secondary Data Collection format at Each Level (Sheet-3)

Title: *Climate change Impacts, Vulnerability and Adoption of Climate Smart Agricultural Practices among Small Scale Farmers in Oromia Region of Ethiopia*

a) **Introduction:-**Dear customer, your Zone and Some the Districts in your zone have been chosen among others participating in regular and extension package programs and/or any other projects to provide us secondary data related to Agriculture in perspective of Climate change impacts and mitigation Strategies in your working environment. The information obtained will be used only for research and academic purposes.

b) **Instruction: -** The purpose of this survey is to generate accurate data for academic empirical conclusion and the following are the general guiding instruction for the organization expected to provide these data and information:

1. Make sure that the intention and request is clear before attempting to give any information or answer to the questions and consult the enumerators for any problem that you come across when providing the information
2. Please, complete this format with maximum care and responsibility
3. For the provided boxes, for a single concept put 'X' in the given correct box
4. For provided blanks, please write the required information in the provided spaces

I. Basic Data related to study Zones

1. Name of Zone: (1) Arsi (__________) (2) East Shewa (_______)
2. Total Areas of the Land under Zonal Administrative boundary in ha: _________ha
3. Based on the Qn.2, identify the Land use categories in the Administrative boundary
   (1) Seasonal Crop Farm Land _________ha (_________ %)
   (2) Perennial Crops Farm land ________ ha (_________ %)
   (3) Livestock Grazing Land __________ha (_________ %)
   (4) Forest covered Land __________ha (__________ %)
4. Description of the Agro-ecological condition of the Zoe
   (1) High Land (*baddaa*) _______________%
   (2) Mid high Land (*badda-daree*) ________%
   (3) Low Land (*Gamoojjii*) ____________ __%
5. Description of the major soil types in the study Zone
   (1) Sandy soil_________% (2) Clay Soil ______________%
   (3) Loam soil _________% (4) Clay loam soil______%
   (5) Sandy Loam soil___% (6) Other type___________%

II. Farm and conservation practices in the study Zone

6. Major Farming system in the Administrative boundary of the Zone

(1) Crop Farming ______________%

(2) Livestock Farming__________%

(3) Mixed farming _____________%

7. What is Land under soil and water conservation practices for the past years?

(1) Under physical conservation ____________ha (______ %)

(2) Under Biological Conservation __________ha (______ %)

(3) Under area closure ____________________ ha (_______ %)

III. Demographic characteristics in the Zones

8. Population characteristics in administrative boundary of the Zone

(a) Number of Farmers (1) male _________ (2) female _____ (3) Total________

(b) Total population (1) Male __________ (2) Female _____ (3) Total________

Table 1. Please indicate the detailed population characteristics in this table

No	Age Category	Unit	Family members		
			Male	Female	Total
1	4 and below (<5)	No			
2	5-10	>>			
3	11-15	>>			
4	15-17	>>			
5	18 -64	>>			
6	65 and above (>64)	>>			
	Total	>>			

9. Summarized major Crops productivity and production data for past cropping years

Table 2. Major Crops productivity (Quintal) for a minimum of ten years (200-2019 years)

No	Cropping years	Actual productivity			Potential productivity			Model farmers productivity		
		Maize	Wheat	Teff	Maize	Wheat	Teff	Maize	Wheat	Teff
	2000 (Base year)									
	2019 (Last year)									

Table 3. Major Crops production (Quintal) for minimum of ten years (2000-2019 years)

No	Cropping years	Actual production			Potential production		
		Maize	Wheat	Teff	Maize	Wheat	Teff
	2000 (Base year)						
	2019 (Last year)						

10. What is the potential of the irrigable land in your zone ___________ha

111. What is the current performance of the irrigation development in your Zonal Boundary?

Table 4. Production of irrigated land during past cropping years (2000-2019 years)

No	**Cropping years**	**Land (ha)**	**Productivity (Qt/ha)**			**production (Qt)**		
			Maize	Wheat	Teff	Maize	Wheat	Teff
	2000 (Base year)							
	2019 (Last year)							

Table 5. Input consumption and utilization (2000-2019 years)

No	**Cropping years**	**Fresh Improved seed (Qt/ha)**			**Farmers seeds (Qt)**		
		Maize	Wheat	Teff	Maize	Wheat	Teff
	2000 (Base year)						
	2019 (Last year)						

Table 6. Estimated Farm land under Climate Smart Agricultural strategic practices

No	**cropping years**	**CSA practices in hectare or percent**			
		Conservation agriculture	Crops rotation	Fallow cropping	Composite application
1	2015				
2	2016				
3	2017				
4	2018				
5	2019				

12. According to the perceived standard of drought, how many time droughts occurred during past ten cropping years in your zone?

Table 7. Drought frequency and Effect on Community

No	Drought Years (Rain shortage)	**Population**			**Degree of drought impact**		
		Male	Female	Total	High (3)	Moderate (2)	Low (1)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

13. If there are drought years, what your data shows concerning the interval at which the drought is prevailing (occurring) in your working zone? (1) 5 and less years (______) (2) 10 years (______) (3) Above 10 years (_______)

14. What is the climate change impact in your zone? (Complete according to Tables shown below)

Table 8. Estimated abandoned land due to the climate change effect in the Zone (2010-2019)

No	**Cropping years**	**Abandoned land (ha)**	
		Crop Farm land	**Grazing land**
	2010 (Base year)		
	2019 (Last year)		

Table 9. Production loss due to recurrent drought in the past Ten years (2010-2019)

No	**Cropping years**	**Estimated Production loss of major crops (Qt)**		
		Maize	Wheat	Teff
	2010 (Base year)			
	2019 (Last year)			

Table 10. Estimated migration and displacement due to the climate change (2010-2019)

No	Years	**Migrations**			**Displacement**		
		Male	Female	Total	Male	Female	Total
	2010 (Base year)						
	2019 (Last year)						

Thank you for your effort invested and contribution!

Appendix 12: Agro-meteorological Secondary Data Collection Format (Sheet 4)

Title:-*Climate change Impacts, Vulnerability and Adoption of Climate Smart Agricultural Practices among Small Scale Farmers in Oromia Region of Ethiopia*

a) Introduction:-Dear client, your weather station have been chosen among other Weather stations to provide us secondary data related to Agro-meteorology in perspective of Climate change impacts and mitigation Strategies in your working circumstances. The information obtained will be used only for research and academic purposes.

b) Instruction: The purpose of this survey is to generate accurate data for academic empirical conclusion and the following are the general guiding instruction for the organization expected to provide these data and information. Make sure that the intention and request is clear before attempting to give any information or answer to the questions. Please, complete this format with maximum care and responsibility.

I. General Information

1. Name of meteorological station: ______________________

2. Altitude at which the station located (Masl) ____________

3. Number of sub-stations (No) ________________________

4. Coverage of the meteorological station (number)

   (a) Zone covered: ______________________________

   (b) No of Districts: ______________________________

   (c) No of Kebele_________________________________

II. **Required climatic parameters and Related Secondary Data**

1. The Summary of climatic data from the station which represent the study zone; indicating Major (Use Table 1 below)

Table 1. Climate parameters and indicators summarized in this table (2000-2019 years)

No	list of years	Rain fall (ml)			Temperature (C°)			Humidity		
		Max	Min	Average	Max	Min	Average	Max	Min	Average
	2000 (Base year)									
	2019 (Last year)									

2. Provide the Summary of days in which the seasonal Rain fall recorded in each years

Table 2. Summary of rainy days in the seasons (2000-2019 years)

No	**List of years**	**Summary of rain recorded days in each years**		
		Minor season	Main season	Total
	2000 (Base year)			
	2019 (Last year)			

3. According to meteorological standard, how many time droughts occurred during past cropping years in your service coverage areas? (Consider past twenty years) (at most six drought years, please use Table 3 below)

Table 3. Drought Frequency and effect coverage with its impacts

No	**Drought Years**	**Coverage of drought effect (No)**			**Degree of drought impact**		
		Zones	Districts	Kebeles	High	Moderate	Low
1							
2							
3							
4							
5							
6							

4. When you consider the long term trend of the drought information in your working area, what your data shows concerning the interval at which the drought is prevailing (occurring) in your work area?

(1) 5 and less years (______) (2) 10 years (______) (3) Above 10 years (_______)

5. When you consider the long term trend of the rain shortage information in your working area, what your data shows concerning the interval at which the rain shortage is prevailing (occurring) in your work area?

(1) Less than 4 years (______) (2) 4-6 years (______) (3) Above 6 years (_______)

***Thank you for your golden time and commitment to provide us this information*!**