FARMER'S PERCEPTION ON CLIMATE CHANGE AND THEIR ADAPTATION STRATEGIES IN KĀLU DISTRICT SOUTH WOLLO ZONE ETHIOPIA

M.Sc. THESIS

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WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES,

WONDO GENET, ETHIOPIA

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APPROVAL SHEET- I

This is to certify that the thesis entitled "**Farmers' Perception on Climate Change and Their Adaptation Strategies in Kalu District, South Wollo zone, Ethiopia**" is submitted in partial fulfillment of the requirement for the degree of Master of Sciences with specialization in Climate Smart Agricultural Landscape Assessment. It is a record of original research carried out by **Ali Jemal** Id. No **MSc/CSAL/R005/09**, under my supervision; and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the courses of this investigation have been duly acknowledged. Therefore, I recommended it to be accepted as fulfilling the thesis requirements.

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APPROVAL SHEET- II

We, the undersigned, members of the Board of Examiners of the final open defense by **Ali Jemal** have read and evaluated his thesis entitled "**Farmers' Perception on Climate Change and Their Adaptation Strategies in Kālu District South Wollo Zone, Ethiopia**" and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment of the requirements for the degree of Master of Science.

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STATEMENT OF AUTHOR

I hereby declare, that this thesis was prepared and completed by me and only with the use of cited sources. I further declare that this work has not been submitted for the purpose of academic examination, in its either originality or similar form nor has it been presented a degree in this or any other universities.

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TABLE OF CONTENT

LIST OF ACRONYMS AND ABBREVIATIONS

C	Carbon
CH_4	Methane
CO_2	Carbon dioxide
EPA	Environmental Protection Agency
FGD	Focus Group Discussion
GHGs	Greenhouse Gases
IFP	International Food Policy
IFPRI	International Food Institute
IPCC	Inter Governmental Panel on Climate Change
KII	Key Informants Interview
MSA	National Metrological Service Agency
N_2O	Nitrous Oxide
NMA	National Metrological Agency
PANE	Poverty Action Network of Civil Program
SPSS	Statistical Package for Social Sciences
UNDP	United Nations Development Program
UNEP	United Nations Environment
UNFCC	United Nations Framework Convention on Climate Change
WMO	World Metrological Organization

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Climate Change is causing the greatest environmental, social and economic threats to all of humankind and across borders of many countries. However, developing countries are the most adversely affected by the impacts of Climate induced events because of their low levels of adaptation. This study was intended to answer how farmers perceive climate change and to compare their perception with its climate change variability of historical data of the past 30 years (1987-2016). The study also assessed factors influencing farmer's perception and adaptation strategies to cope with potential impacts of climate change. The study was conducted in three kebeles of Kalu district in south Wollo Zone of Amahara Regional state. It relied on qualitative and quantitative methods of data collection. The primary data were collected using household survey, FGDs, and field observation. Mann-Kendall's test and Sen's Slope estimator were used to detect the trend and its magnitude. Standard rainfall anomaly precipitation concentration index and coefficient of variations were used to describe of rainfall variability. 152 households were interviewed, besides focus group discussion and key informants interview were utilized to triangulate and substantiate the findings from household survey. Data was analyzed using descriptive statistics and econometric models. The result showed age, gender education and distance to the local market, had positive and significant influence on farmer's perception on climate change. However, wealth, agro-ecology and land size had an inverse and significant influence on the perception of farmer is to climate change. Land holding size, education, wealth, distance to the local market climate information and gender had positive and significant influence on choice of adaptation strategies. The finding of the result showed that Bleg season total rainfall exhibited statistically significant declined trend 36.9 mm per decades. The annual maximum rainfall were 1362 mm in 2016 while the lowest annual records were 725 mm in 1987 with the range of 637 mm. the average mean annual rainfall of the last three decades were 1033.88mm with standard deviation of about 159.99 where these much amount rainfall deviated from the mean. The annual average maximum temperature were increased by 1.3^{o}c , durning Belg season before 30 years were 25.5^{o}c, after 30 years the maximum-minimum temperature recorded was 29.3^{o}c in 2016 it increases 3.8^{o}c for the last three decades indicated that there was high inter-seasonal temperature and rainfall variability.

***Key words**: **Gr**eenhouse Gas emission, Standardized Rainfall Anomaly, binary logistic regression*

1 INTRODUCTION

1.1 Background of the Study

An important global challenge for the 21st century is adaptation to climate change. It is very likely that human contribution to changes in climate is due to emission of greenhouse gasses (IPCC, 2007). This human induced climate change strongly reflected in the definition given by the United Nations Framework Convention on Climate Change (UNFCCC). It refers to a change of climates that attribute directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable periods (UNFCCC, 1992). A broader and more adopted definition formulated by the Intergovernmental Panel on Climate Change (IPCC) what refers to it as a change in state of the climate that can identified by changes in the mean and/or variability of its properties and that persists for an extended period, typically decades or longer (IPCC, 2007)

Climate change is a global environmental threat and development concern. Developing countries are the most adversely affected by the negative effects of climate-induced events because of their low level of adaptation (Abide et al., 2015). It is one of the most significant environmental issues facing the world today and the most complex challenges of our century. Climate change management need cooperation, as one or two countries alone cannot. Do countries on the interconnected challenges posed by climate change.

Global Climate climate has been changing in the past and will continues to change in the future implying the need to understand how farmers perceive such change in order to guide strategies for adaptation and mitigation. Some studies indicate that farmers do perceive climate change and adapt to reduce its adverse impacts (David *et al*, 2007). In addition, other studies show the perception on climate change and taking adaptive measures (Madison, 2006, Hassan and Nhemachena, 2008, Deressa *et al*, .2009, 2010) have been influenced by different socioeconomic and environmental factors. Thus, climate change must be urgently addressed to minimize further damages. This can be achieving by implementing sustainable adaptation and mitigation strategies (UNFCCC, 2007). Although developing countries have contributed the least to the global warming problem associated to human activity, they are the most vulnerable to changing climate patterns.

Many ecosystems are likely to be affected by an unprecedented impact of climate change such as floods, drought, wildfire and other natural calamities. Thus developing countries, adaptation and mitigation measures should be taken to prevent greenhouse gas emissions. Given the little contribution of GHG emissions by vulnerable countries calls the international community to contribute to their adaptation needs. Developing countries need international assistance to support adaptation in the context of national planning for sustainable development, more capacity building and transfer of technology and funds.

Systematic planning and capacity building also needed to reduce the risk of disasters and raise the resilience of communities to increasing extreme events such as droughts, floods and tropical cyclones.

Climate variability and change present complex challenges to people‘s livelihoods in Africa. Against an anticipated increase in the frequencies of extreme events such as floods and droughts under climate change, agriculture will suffer greatly (IPCC, 2007). Climate change will have far-reaching consequences for agriculture that will disproportionately affect poor and marginalized groups who depend on agriculture for their livelihoods and have a lower capacity to adapt (World Bank, 2007).

Unfortunately, Ethiopia‘s dependence on rain fed agriculture makes the country particularly vulnerable to the effects of impacts of climate. Thus, a deeper understanding of the complex interdependence between changing climatic conditions and Ethiopia‘s agricultural sector together with adaptation options is crucial (Alebachew and Weldeamlak 2011). Therefore, the adaptation options to be implemented in different parts of the country that have varying climate related problems could vary depending on the type and urgency of the problem, as well as the major economic activities performed in these particular parts of the country.

Adaptation to climate change requires that farmers using traditional techniques of agricultural production first notice that the climate has altered. Farmers need to identify potentially useful adaptation strategy/methods and implement them. The researcher evaluated the perception of farmers towards climate change and their adaptation strategies from the context of perceptions on climate change and adaptive capacity

1.2 Statement of the Problem

Increasing agricultural production at the national level leads to improve overall economic growth and development. However, currently climate change has become a serious threat to sustainable economic growth (Gebreegziabher *et al.,* 2012). Ethiopia is a poor country and its economy is highly dependent on rain fed agriculture, which had failed to meet the growing food demand. This is because of the negative effect of climate changes on agricultural production (World Bank, 2007. The Northeastern highlands of the country where historical affected by climate variability and other related hazards by the 1970s, 1980s and 1990s predominate where the issue of climate change did not get much concern.

Therefore, Kālu district is the one that frequently under the influence of Climate variability and/or change. Perception about climate change, cause, impacts and the necessary response mechanisms to cope with climate calamities are important for any population in a given community.

Level of awareness determines the scope of implementation that needs tackled the problem. Lower awareness will make intervention mechanisms to be very slow and undirected. Similarly, knowledge of the adaptation methods on the side of smallholder farmers may make it Better to tackle the challenge of climate change (Deressa *et al*. 2009).

Adaptation is an essential strategy to enable farmers to cope with the adverse effect of climate change and variability, which in turn increase the agricultural production of the poor farm households (Yusuf *et al*., 2008). The capacity to adapt to climate change is unequal across and within societies. This fact implies that the adaptation measures at micro level are important to get truth and appropriate policies. According to Maddison (2007), there is a difference in the propensity of farmers living in different locations to adapt Farmers in different area or agricultural zone have unequal propensity and capacity to climate change impact and adaptation. Since adaptation is a local effort, therefore the adaptation method differs within community and even within individuals. According to Fussel (2007), modifying adaptation practices to specific societies or communities may make it possible to offset the adverse impact of climate change. Some researchers have done on climate related issues in Ethiopia but most of them focused at macro-level. Nevertheless, similar adaptive strategies for all recommendation are in appropriate given difference in agro ecologies. Therefore, a better understanding of the local dimensions of the climate change is significant to develop appropriate adaptation measures and appropriate policies. To address the proposed study one specific site area at farm level is appropriate. Mostly the local communities have no trust on acclimatize Climate Change by adopting different adaptation strategies rather considering everything as business as usual scenario. Therefore, it indicates that there is some ambiguity and lack of knowledge about climate change and the essence of adaptation strategies. For instance, local peoples have a range of strategies to cope with drought. However, these traditional coping mechanisms based on local knowledge and not supported by research.

The existence of warming and rainfall variability results reduce the agricultural production and death of livestock of the smallholder farmers and it is food shortage area and under food aid. As to the knowledge of the researcher, no earlier study conducted on farmers' perception and adaptation strategies on climate change in the study area. Thus, this study initiated as a bridge to fill the knowledge gap in the study area by analyzing three-decade rainfall and temperature data and smallholder farmer's perception and their adaptation strategies on climate change and variability to tackle the influence of climate change in Kālu district.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of the study was to investigate farmer's perception on climate change and or variability and their adaptation mechanisms to overcome the potential impacts of climate change.

1.3.2 Specific Objectives

1. Comparing farmer's perception on Climate change and variability with historical data of the past 30 years.

2. Examining factors influencing farmer's perception on climate change in the study area.

3. Assessing barriers on agricultural adaptation practices to climate change.

1.4 Research Questions

2 Do farmers believe the occurrence of climate variability or change?

3 How do they realize the effects of Climate Change for the last 30 years?

4 What factors influence farmer's perception on climate change in the study area?

5 What are the barriers have faced on agricultural adaptation practices in the area?

Significance of the study

The finding from this study is believed to contribute to the understanding of the determinants factors of local peoples on perception and adopting and implementing climate change adaptation strategies or to extend the knowledge of rural communities' perception and attitudes on climate change and/or variability and adaptation mechanisms. In addition, the findings from this study can help to design at farm level adaptation strategies and can be used by local development agents to improve the knowledge and adaptive capacity of farmers of the study area by correcting their perception on climate change and adaptation strategies. Adaptation strategies are improbable to be effective without an understanding of the farmers' perception of climate change. Above all the study is the first of its kind in the area that, it can used to stimulate for further research to improve the conceptual and methodology of the present study.

Scope and Limitation of the Study

The study conducted in Kālu District, as the area is drought prone. The study focus on only three kebeles considering the prevalence of the problem and its scope is limited to the farmers' perception on climate change and their adaptation strategies on. The study may much more interesting have been possible to include more kebeles in Kālu and beyond. However, because of Kālu has three agro-climatic zone, high lands (dega), midland (woinadega) and low land (kola). On the other hand due to, time and financial limitations, the study relies on three-selected kebele.

2. LITERATURE REVIEW

2.1 Global implication of Climate Change

There is increasing evidence that the climate of the world is changing already. It is probable that it will continue to change, where humans contribute to these changes. What turns this into a problem is that these changes affect the functioning of ecosystems and societies. Climate change is expected to cause serious difficulties for agriculture, especially in developing countries. According to the Intergovernmental Panel on Climate Change's (IPCC, 2007d), climate change can reduce rain-fed agricultural yields by as much as 50 percent. Global losses in gross domestic product (GDP) range from 1 to 5 percent for a 4°C warming, and regional losses could be substantially higher.

It is predicted that Africa is highly vulnerable to climate change since its economy largely relies on agriculture and uses low capital and inputs. Moreover, semiarid and arid regions are expected to be particularly affected, according to Mendelson, Nardhaus, and Shaw (1994). Vulnerability depends on the type of change (e.g. temperature, rainfall, variability, occurrence of extremes), magnitude and rate of the change, exposure, and adaptive capacity. Future climatic changes will affect the level and extent of impacts. The main impact areas are public health, agriculture, food security, forests, water resources, coastal areas, biodiversity, human settlements, energy, industry and financial services (Mohan Munasinghe Rob Swart, 2005).

One may even think of a situation in which a country may consider itself fully able to cope with the climatic changes locally and thus may not be interested in participating in international negotiations on a co-ordinated climate-response strategy (Toth et al. 2001). Furthermore, many believe that there is no need specifically to study adaptation, because it would be likely to happen anyway, without any significant costs, e.g. through natural selection or market forces (Kates, 2000). There was a lot of initial optimism that mitigation would be quite possible, probably based on the positive experiences with the internationally co-ordinated abatement of ozone-depleting substances and acidification. However, climate change appeared to be a much harder problem to address. R.A. Pielke (1998) also notes that even if climate change could be mitigated successfully, adaptation would still be very relevant, since many current developments increase vulnerability to climatic events (development of marginal lands and lands at risk to extreme events, increased dependence on highly technical interdependent systems, increased water and food demands).

"Most analysts in the less-developed countries believe that the urgent need, in the face of both climate variation and prospective climate change, is to identify policies which reduce recurrent vulnerability and increase resilience. Prescriptions for reducing vulnerability span drought proofing the economy, stimulating economic diversification, adjusting land and water uses, providing social support for dependent populations, and providing financial instruments that spread the risk of adverse consequences for individual to society and over longer periods. For the near term, development strategies should ensure that livelihoods are resilient to a wide range of perturbations." (Rayner and Malone, 1998).

2.2 Greenhouse emission from agriculture sector

Global warming is steadily increasing. Developing countries are vulnerable to its impacts, because of their physical exposure and their high dependency on climate-sensitive natural resources for agriculture. They have low adaptive capacity because of poverty, weak institutions and limited access to improved adaptation technologies. Most (sub-) tropical areas expected to suffer from considerable yield decreases, while temperate areas are likely to benefit from yield increases as impacts of climate change. Three greenhouse gases (GHG) are relevant for agriculture and land use change: carbon dioxide caused by the burning or mineralization of biomass (e.g. deforestation) and by fossil fuel consumption (machinery), methane produced through enteric fermentation by ruminants, by manure management and in irrigated rice production and, finally, nitrous oxide from use of nitrogenous fertilizer.

GHG originating from agriculture contribute at 14 per cent of the total GHG emission and that of land use change and forestry constitute 17 per cent to the global GHG emissions, adding to more than 30 per cent in total. Middle-income developing countries release the largest share of GHG related to agriculture and land use change, whereas low-income countries only release a small amount of GHG from these two sectors. The specific GHG sources vary according to the main geographic regions. Nitrous oxide is an important emission source in developing regions of East Asia (China and India). Methane from enteric fermentation of ruminants is especially high in Latin America, while methane from rice production is dominant in the South and East Asian countries. Nitrogen fertilization contributes substantially to agricultural productivity, but if applied in excess and during inappropriate periods, it releases considerable amounts of particularly harmful nitrous oxide. In Asia, the application of synthetic nitrogen fertilizer is still strongly increasing, partly because of national subsidy systems. Moreover, the energy-intensive production of nitrogen fertilizer releases high amounts of carbon dioxide registered in the industrial sectors.

Organic fertilizers (manure) also accounts for nitrous oxide and methane release if it is not stored, managed and applied appropriately. Irrigated rice production releases methane to the atmosphere. Water management, especially the shortening of the flooding periods, reduces the release of methane considerably. Livestock husbandry produces GHG from several sources. Due to increasing meat consumption, livestock husbandry is continuing to increase strongly, especially pigs and poultry production. Therefore, grazing and fodder production areas were increased, often to the expense of forest areas and wetlands in tropical countries such as Brazil and Indonesia. The conversion of forest and wetlands to grazing and fodder production releases huge quantities of carbon dioxide formerly stored in soils and vegetation. In addition, ruminants produce methane through enteric fermentation as further important GHG source originating from livestock.

The ratio of GHG per quantity of livestock product released during the lifecycle of animals is higher in arid and semi-arid zones with low productivity than in highly productive livestock systems. However, extensive livestock production is often the most important livelihood option in marginal production areas despite its relatively high methane emissions (Birgit Kunderman, Gießen, 2014).

2.2.1. Greenhouse gas mitigation in agriculture

Opportunities for mitigating GHGs in agriculture fall into three broad categories based on the underlying mechanisms;

1. Reducing emissions: The fluxes of GHGs can reduce by managing more efficiently the flows of carbon and nitrogen in agricultural ecosystems. For example, practices that deliver added N more efficiently to crops often suppress the emission of N_2O and managing livestock to make most efficient use of feeds often suppresses the amount of CH_4 produced.

2. Enhancing removals: Any practice that increases the photosynthetic input of C or slows the return of stored C via respiration or fire will increase stored C, thereby, building C sinks'.

3. Avoiding (or displacing) emissions: crops and residues from agricultural land can be used as a source of fuel, either directly or after conversion to fuels either ethanol or diesel. These bioenergy feed stocks still release CO_2 upon combustion, but now the C is of recent atmospheric origin via photosynthesis rather than fossil C. The net benefit of these bioenergy feed stocks to the atmosphere is equal to the fossil derived-emissions displaced less any emissions from their production transport any processing. Emissions of GHGs, notably CO_2, can avoid by agricultural management practices (P. Smith *et al*. 2007, and Birgit Kunderman, Gießen, 2014).

2.3. Climate change and the rural agricultural communities

The agricultural sector remains at the core of developing countries' economies. It plays a critical role in food security for all human being. In spite of their developmental significance, the rural communities characterized by poverty and marginalization, which are aggravated by the effects of climatic variations, seasonal changes and uncertainty caused by climate change. According to FAO (2011), farmers in some regions may benefit temporarily from the effects of CO2 emissions in the form of higher yields, the general consequences of climate change expected to be adverse, particularly for the poor and marginalized whom in turn, constitute the main inhabitants of rural agricultural communities.

The main reason is that, the rural agricultural communities are dependent on the fragile agricultural activities for their means of livelihoods and they are located in areas of high environmental risk and climatic exposure and easily affected. Moreover, the subsistence of these communities is largely resource-based. More intense and \ uncertain weather patterns and extreme events such as floods and droughts contribute to deforestation, desertification, land degradation, depletion of water sources, infrastructural and social damage, among others. This erodes not only local income but also ultimately the ability of rural agricultural communities to respond to the challenges posed by a changing climate. This makes rural agricultural communities a priority in the design of innovative climate change responses.

In addition climate-smart agriculture, contributes to the achievement of sustainable development goals. It integrates the sustainable development of economic, social and environmental by jointly addressing food security and climate challenges. It is composed of three main pillars:

1. Sustainably increasing agricultural productivity and incomes;

2. Adapting and building resilience to climate change;

3. Reducing and/or removing greenhouse gases emissions, where possible. Climate-smart agriculture and approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change. The effects of climate change on agricultural systems create a compelling need to ensure comprehensive integration of these effects into national agricultural planning, investments and programs. The Climate-smart agriculture approach is designed to identify and operational sustainable agricultural development within the unequivocal parameters of climate change FAO (2010).

2.4 Climate Systems in Ethiopia

Climate in Ethiopia is highly controlled by the seasonal migration of the Inter tropical Converging Zone (ITCZ), which follows the position of the sun relative to the earth and the associated atmospheric circulation. Moreover, it is also greatly influenced by the country‘s complex topography (NMSA, 2001). There are different ways of classifying the climatic systems of Ethiopia, including the traditional and the agro-climatic zone in classification systems (Yohannes 2003). The most commonly used classification systems are the traditional and the agro climatic zones. According to the traditional classification system, which mainly relies on altitude and temperature for classification, Ethiopia has five climatic zones.

Table 1: Traditional Climatic Zone and their characteristics

Zone	Altitude(meters)	Rainfall(mm)	Average-annual temperature
Wurch	3200 plus	900-2200	≥11.5
Dega(high lands)	2300-3200	900-1200	17.5-11.5
Woina dega(mid lands)	1500-2300	800-1200	20.5-16.5
Kola(low lands)	500-1500	200-800	27.5-20.0
Berha(deserts)	Below 500	Below 500	≥27.5

Source MOA 2000

The agro-ecological classification method based on combining growing periods with temperature and moisture regimes. According to the agro-ecological zone classification system, Ethiopia has 18 major agro ecological zones, which further subdivided into 49 sub agro-ecological zones. These agro-ecologies grouped under six major categories (MoA 2000), which include the following

1. Arid zone: This zone is less productive and pastoral, occupying 53.5 million hectares (31.5 percent of the country).

2. Semi-arid: This area is less harsh and occupies 4 million hectares (3.5 percent of the country).

3. Sub moist: This zone occupies 22.2 million hectares (19.7 percent of the country), highly threatened by erosion.

4. Moist: This agro ecology covers 28 million hectares (25 percent of the country) of the most important agricultural land of the country, and cereals are the dominant crops.

5. Sub humid and humid: These zones cover 17.5 million hectares (15.5 percent of the country) and 4.4 million hectares (4 percent of the country), respectively; they provide the most stable and Ideal conditions for annual and perennial crops and are home to the remaining forest and wildlife, having the most biological diversity.

6. Per-humid: This zone covers about 1 million hectares (close to 1 percent of the country) and is suited for perennial crops and forests. Over these diverse agro ecological settings, mean annual rainfall and temperature vary widely.

2.5 Impacts of Climate Change on agriculture

Climate change affects agriculture in a number of ways; including through changes in average temperatures; rainfall and climate extremes with an important impact on soil erosion (i.e. floods, drought, etc.): changes in pests and diseases, changes in atmospheric carbon dioxide, changes in the nutritional quality of some foods, changes in growing season, and changes in sea level. Crop yields show a strong correlation with temperature change and with the duration of heat or cold waves, and differ based on plant maturity stages during extreme weather events Yohannes H (2016).Agriculture is the backbone of the Ethiopian economy. In line with this climate is the key determinant factor for economic growth and development. This is due to the fact that most of population in Ethiopia is the dependence of rain fed agriculture sector. This sector is an important for the communities and also use as an engine for the country‘s economic growth. The sectors of agriculture can express in the form of crop production, livestock production, forestry, fishery etc. Each of them contributed to agriculture sector, for instance crop production estimated to contribute about 60 percent, livestock 27 percent, forest and other sub sector around 13 percent of the total agricultural value in the country (NMSA 2001).

According to Yusuf *et al*. (2008), Ethiopia is one of the most vulnerable countries to climate change with the least capacity to respond. Indeed, Ethiopia has experienced at least five major national droughts since 1980, along with literally dozens of local droughts. Cycles of drought create poverty traps for many households, constantly thwarting efforts to build up assets and increase income. Rainfall variability results reduce in crop production and Food shortage followed by famine associated cause a situation of high dependency on international food aid.

Farmers also reflect this in their claims that the weather is indeed different to what it was a few decades ago (Amsalu *et al.*, 2007). However, evidence does not bear out any significant change in rainfall; although it has, some changes in the pattern of rainfall observed. According to NMA (2007), there has been a warming trend in the annual minimum temperature over the past 55 years. It has been increasing by about 0.37 ℃ every ten years. The country has also experienced both dry and wet years over the same period. The trend analysis of annual rainfall shows that rainfall remained more or less constant when average over the whole county. Ethiopia is mostly vulnerable to climate variability and change due to lower adaptive capacity, low level of socio economic development, high population growth, inadequate infrastructure and lack of institutional capacity and heavy reliance on natural resource based socio economic activities, which are highly climate sensitive.

The country will experience an increasing level of temperature and precipitation in the coming decadence. The heavy rainfall and temperature patterns in the different regions of Ethiopia and the differences in the level of socio-economic development implies that the regions differ in their vulnerability and adaptive capacity to changing climate related hazards. According to Deressa T., Hassan M., Ringler C., (2008) found that Afar, Somali, Tigray and Oromiya regions more vulnerable to climate change than other regions of the country. The study revealed that Afar and Somali is attributed to their low level of rural service provision and infrastructure development and that of Tigray and Oromiya to the higher frequency of drought and flood, lower access to technology, fewer institutions and lack of institutions.

The frequently occurrence of droughts and floods have negatively affected agricultural production, demonstrating agriculture‘s sensitive to climate change. According to World Bank (2007), in Ethiopian context agriculture is the dominant sector of the economy. It contributes near half of the GDP and for the vast of majority of the employment, for generating income, foreign currency and supplying basic needs of f food security. Even though, Ethiopia is highly vulnerable to climate variability and change. Due to the fact that highly depends on rain fed agriculture and traditional practices in major parts of the Country.

2.5.1 Projected Climate Change in Ethiopia and its impacts on agriculture

Over the coming year all simulations come to terms that temperature will increase in Ethiopia but models predicting precipitation give controversial results of both increasing and decreasing precipitation. According to the World Bank (2007) climate change projected to reduce yields of the wheat staple crop by 33% in Ethiopia .This amounts to a serious threat to food security and to the achievement of major developmental goals.

The models predicting climate change scenario in Ethiopia put conclusion that temperature will increase in the coming decades. However, there is conflicting results concerning the predicted level of precipitation (Tadele *et al.* nd). There is constant, decreasing and increasing level of projected precipitation level are generated using different models. According to NMA (2007) indicate that temperature will increase in the range of 1.7 – $2.1C^0$ by the year 2050 and 2.7 3.4 ℃ by the year 2080 over Ethiopia. The country will experience an increasing level of temperature and precipitation in the coming decades. However, it stated that a small increase in rainfall can be expected. Studies indicate that Ethiopia in the coming year will face a decrease in agricultural production due to the adverse impact of climate change and variability‘s (Tadele *et al,* nd). This suggests that agricultural production as an engine of growth and development and it is vulnerable to climate change and climate variability. While the more marked effects on crops and livestock are probable to appear in later decades, efforts to *enhance* the resilience to climate shocks of crop yields and livestock production should be improve, this mechanism become increase in agricultural output and principal to achieve the overall objective of Ethiopian growth and transformation plan.

2.6 The concept of adaptation and climate change

There are different definitions of adaptation to climate change. These are as follows. **Adaptation** Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates, harm or exploit beneficial opportunities. Various types of adaptation distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC, 2001). Adaptation – Practical steps to protect countries and communities from the likely disturbance and damage that will result from adverse effects of climate change. For example, floodwalls should build and in numerous cases, it is probably advisable to move human settlements out of flood plains and other low-lying areas.

Adaptation - is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed, and implemented (UNDP, 2005). All these three definitions differ from one another in several ways. First, all are used different words to describe the definition of adaptation. The first key words in the definition that express adaptation as _adjustment‘; _ practical steps ‘ and process ‘ can be interpreted differently by various stakeholders. Process ‘seems to be a very broad and open ended term that does not include any specific time or subject references and can easily combined steps ‘and adjustments‘. Adjustment ‘seems to denote a process that leads toward some standard or goal. These seemingly small differences might create different expectations from different stakeholders, depending on the meaning of the term that they decide to practice.

The IPCC provides a broad definition by distinguishing various types of adaptation (e.g., anticipatory, reactive, public, planned adaptation, etc.) and focuses not only on technical adaptation measures but also on institutional responses. The IPCC definition also includes adaptation of natural systems not just human. One can already see that some stakeholders (e.g., community-based adaptation practitioners) use a more technical interpretation of the term (the one closer to the definition from the UNFCCC Secretariat website), while others (e.g., adaptation policymakers) use a broader definition and emphasize the institutional/policy side of adaptation. These diverse interpretations could have serious financial implications.

Adaptation and mitigation are two split strategies responses to climate change but both are interrelated. Mitigation is important to reduce the impacts and allow for adaptation to takes place, for ecosystems these boundaries are generally narrower than for human systems. Because mitigation measures will not be able to immediately avoid global warming (Parry et al, 2007), adaptive measurements needed to avert the negative consequences of climate change at the short term. On the longer-term mitigation, measures will be able to avoid further warming or even reduce the effect. Several studies have subsequently emphasized the need to pursue adaptation in addition to mitigation strategies.

The IPCC noted that adaptation through changes in processes, practices or structures is a crucial element in reducing potential adverse impacts or enhancing positive impacts of climate change (IPCC, 2001). Farmers use different adaptation strategies that fit with the types of the problems caused by climate change they faced.

This is because impact of the climate change is unevenly distributed over different geographic areas and hence the adaptation mechanisms vary with types and level of the impact of climate change. Therefore, adaptation strategies that the farmers used to reduce the impact of climate change in different way. for instance changing crop variety, changing planting dates, mix crop and livestock production, decrease livestock, moving animals/temporary migration, change livestock feeds, soil and water management, change from livestock to crop production, change animal breeds, seek off-farm employment, planting short season crop, and irrigation/water harvesting are among some of the several strategies available to enhance social resilience in the face of climate change (Bradshaw et al., 2004; Nhemachena and Hassan, 2007).

To sustain current levels of food production and to meet future challenges adaptation is underestimated by the international community. Climate-smart agriculture is the latest attempt to reconcile the dual competing scenarios i.e., achieving food security through increasing agricultural productivity, maintain environmental integrity through climate change adaptation, and mitigation strategies. The key elements include increasing productivity and resilience, reducing GHG emissions or enhancing sequestration, and managing interfaces with other land uses. Climate-smart agricultural options in many cases sustainable agriculture practices that take into account the need for climate change adaptation and mitigation.

Increasing productivity and the resilience of agricultural systems to climate change impacts, both from extreme events and slower-onset changes, as well as enhancing agricultural adaptation by altering exposure, reducing sensitivity, and increasing adaptive capacity, are considered fundamental to the continued viability of agriculture sector (FOA 2010). Information on climatic condition very important in order to response the impacts of these changes. Therefore understanding the linkage between climatic condition and socioeconomic activities are essential method to minimize impact of climate change. The understanding of adaptation to the impact of climate change can be decrease the adverse effect of climate change at the presence as well as for future climate. Adapting to present climate is not the same as adapting to future climate change.

The responsible bodies can learn the past to the future about adaptation options and the process of their adoption. Studies of adaptation to current climate also make it clear that human activities are not now always as well adapted to climate as they might be. In the development context, therefore, a prudent adaptive response to the threat of climate change may be to improve adaptation to existing climate and its variability, including extreme events. Improving adaptation to current climate variability is not an alternative to preparing for adaptation to longer-term changes in climate. It is an adjunct a useful first and preparatory step that strengthens capacity now to deal with future circumstances (UNEP, 1998 cited in Muleta, (2011). Adaptation is an initiatives and measures to reduce the vulnerability of nature and human systems against or expected climate change effect. There is various type of adaptation, for example anticipatory and reactive, private and public, autonomous and planned. Adaptive capacity closely connected to social and economic development but it is uneven distributed to the societies. Many limitations hinder the effectiveness of adaptation measures.

The adaptive capacity is depend on the community productive bases, capital asset, social network, human capital and institutions, government, national income, health and technology. However, societies with high adaptive capacity may be vulnerable to climate change but may not be exposed (IPCC, 2007). Agricultural sector adversely affected by climate change and variability.

This can minimize the negative impact by using adaptation strategies like adjustment of planting and crop variety, crop relocation, improved land management erosion control and soil protection through soil and water conservation and tree planting. Similarly, adaptation strategies that the smallholder farmer has used to reduce the impact of climate change. These adaptation strategies are like changing crop variety. Changing planting date, mixed crop, livestock production, planting trees, soil and water management, off-farm employment and irrigation/water harvesting (Deressa el al., 2009, Nhemachena and Hassan, 2007).

Farm-level adaptation strategies is important to provide information that can be used to formulate policies that enhance adaptation as a tool for managing a variety of risks associated with climate change in farm household (Nhemachena & Hassan, 2007). Adaptation strategies are also necessary to tackle adverse impacts from higher temperature and changing precipitation patterns (Kurukulasuriya & Mendelsohn, 2007). Therefore, a key component of climate adaptation includes building resilience, where resilience is the capacity of a system to tolerate disturbance without collapsing into a qualitatively different state that controlled by a different set of processes (FAO, 2009).

2.7 Famers' Perception on and Adaptation to climate change

Perception is a process of receiving information and stimuli from our surroundings and converting them into psychological responsiveness. Perception of climate change, as a tremendously difficult idea for the farmers, has limited boundaries as the individual's perception differs with the past and present situation (M.N.Uddin *et al*. 2017).

Adaptation to climate change requires that farmers first notice the climate has been changing and then identify useful adaptations and implement them. Generally, studies on farmers' perception of an adaptation to climate change have provoked significant research interest in Africa.

According to Maddison (2006), perception of climate change appears to hinge on farmer experience and the availability of free extension advice specially related to climate change. In another study, Gbetibouo (2009) argues that farmers with access to extension services are likely to perceive changes in the climate because extension services provide information about climate and weather. Consequently, awareness and perceptions of a problem shapes action or inaction on the problem of climate change. Adaptation at farm-level involves two stages: perceiving the change in climate, and deciding whether to adapt or not, or which adaptation strategy to choose (Maddison, 2007).

There are still important questions on perception that need to be addressed, such as: Are farmers able to perceive the change in climate in the long run, which changes are they able to perceive, what economic, social and institutional factors influence their level and speed of perception (Deressa *et al*., 2009). Farmers who have perceived the change in climate may not adapt or the nature of their adaptation response may vary because of a complex interplay between social, economic and institutional factors (Maharjan *et al.,* 2011). Adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in the climate system and Adaptability refers to the degree to which adjustments are possible in practices, processes or structures of systems to projected or actual changes of climate. Adaptation can be spontaneous or planned, and be can carried out in response or in anticipation of change in conditions (Smith *et al.,* 2009). Adaptation options to climate change can group into autonomous or private and planned or public sector adaptation strategies. Private adaptation strategies involve action taken by non-state agencies such as farmers, communities or organizations and or firms in response to climate change. According to Bruin (2011), adaptation strategies include switching crops, shifting crop calendar, engaging new management practices for a specific climate regime, changing irrigation system and selecting different cropping technologies. Public adaptation involves actions taken by local, regional and or national government to provide infrastructure and institutions to reduce the negative impact of climate change.

Public adaptation strategies include development of new irrigation infrastructure, transport or storage infrastructure, land use arrangements and property rights, watershed management institutions (World Bank, 2010). According to Sathaye and Christensen (1998), Bruin (2011) adaptation options can be either proactive or anticipatory depending whether it takes place before or after climate change. Reactive adaptation options addresses effects of climate change after they have been experienced, while proactive adaptation options are engaged in anticipation of climate change. In crop production, reactive adaptation options include control of soil erosion, construction of irrigation dams, improving soil fertility, development of new varieties, shifting planting and harvesting time. Anticipatory adaptation options on the other hand involve the development of tolerant cultivars, research development, policy measures on taxation and incentives.

Gbetibouo (2009) suggested that smallholder farmers could adapt to climate change by changing planting dates and diversifying crops. This can be possible if government provides them with the necessary support. Smallholder farmers can also adapt to climate change by practicing soil and water conservation measures and planting trees (Yusuf *et al.*, 2008).

2.7.1 Adaptation strategies and its determinants

Several factors put forward to explain the presence or absence of adaptation to climate change. Downing et al., (1997) explore standard variables to explain adaptation in Africa. Hassan and Nhemachena (2007) analyze the determinant of farm level climate change adaptation measures in Africa using multinomial choice model fitted to data from a cross-sectional survey from 11 countries. The results indicate that specialized crop cultivation (mono cropping) is the agricultural practice most vulnerable to climate change in Africa. In this study better access to markets, extensions and credit services, technology and farm, assets (labor, land and capital) are critical for helping African farmers adapt to climate change.

Similarly, Gbetibouo (2009) studied understanding farmer's perceptions and adaptation to climate change and variability in the Limpopo Basin of South Africa for the farming season 2004-2005. The study applies both the Heckman probit and the multinomial logit models to the data collected using a farm survey. Its major finding indicates that household size, farming experience, wealth, and access to credit, access to water, tenure rights, off farm activities and access to extension services are the main factors that enhance adaptive capacity of farmers to climate change. Ishaya and Abaje (2008) found that lack of awareness and knowledge about climate change and adaptation strategies, lack of capital and improved seeds, and lack of water for irrigation played an important role in hindering adaptation to climate change in Jema‘a Nigeria. Furthermore, the result of factors affecting farmer's perception decision using ordered logit regression analysis showed that gender, age and level of education were statistically significant in making decisions on the level of perception made by the farmers. Finally they are used a multinomial logit regression model to analyze the factor that is influencing farmers choice of adaptation on climate change and variability. The result revealed gender, age, farming experience land tenure, farm size, access to extension services, access to loan, engage in non-farming activities, temperature and rainfall as the major factors influencing farmers‘ choice of adaptation to mitigate effect of climate change.

A better understanding of farmer's perceptions of climate change, ongoing adaptation measures and the decision-making process is important to inform policies aimed at promoting successful adaptation strategies for the agricultural sector. They were used data from a survey of 1800 farm households in South Africa and Ethiopia. The study presented the adaptation strategies used by farmers in both countries and analyzes the factors influencing the decision to adapt. They find out that the most common adaptation strategies include use of different crops or crop varieties, planting trees, soil conservation, changing planting dates and irrigation. However, despite having perceived changes in temperature and rainfall, a large percentage of farmers did not adjust their farming practices. The main barriers to adaptation cited by farmers were lack of access to credit in South Africa and lack of access to land, information and credit in Ethiopia. They are also used a probit model to examine the factors influencing farmers decision to adapt and perceived climate changes. Factors influencing farmer's decision to adapt include wealth, and access to extension, credit, and climate information in Ethiopia; and wealth, government farm support, and access to fertile land and credit in South Africa. They are used a pooled dataset to analysis the factors affecting the decision to adapt to perceived climate change across both countries reveals that farmers were more likely to adapt if they had access to extension, credit, and land. Food aid, extension services and information on climate change found to facilitate adaptation among the poorest farmers.

They conclude that policy-makers must create an enabling environment to support adaptation by increasing access to information, credit and markets, and make a particular effort to reach small-scale subsistence farmers, with limited resources to confront climate change. Deressa et al. (2008) studies analyzing the determinants of farmer's choice of adaptation methods to climate change in the Nile Basin of Ethiopia. The study was used a multinomial logit model to determine the smallholder farmers adaptation measures to climate change.

Their result revealed that the methods identified included use of different crop varieties, tree planting, soil conservation, early and late planting and irrigation. The results from the discrete choice model employed indicate that the level of education, gender, age, wealth of the head of household, access to extension and credit, information on climate, social capital, agro-ecological setting, and temperature all influence farmers‘ to choice adaptation method. The main barriers include lack of information on adaptation methods and financial constraints. Moreover, whose analysis reveals that age of the household head, wealth, information on climate change, social capital, and agro- ecological settings have significant effect on farmer's perceptions of climate change. Deressa *et al.* (2009) analyses the determinants of farmer's choice of adaptation methods in the Nile Basin of Ethiopia using cross sectional data from a survey of farmers. They are used a multinomial logit model to analyze the determinant of farmers choice of adaptation strategies.

In this study found that the adaptation methods are changing planting dates, using different crop varieties, planting tree crops, irrigation and soil conservation and not adapting. According to the finding, the most common adaptation method was use of different crop varieties while irrigation was the least common method. The result indicated that the reasons for not to adapting are lack of information on climate change impacts and adaptation technology, lack of financial resources, labor constraints and land shortages. The levels of education, age, sex, household size of farmers were to be significant determinants of adaptation to climate change in the study area. In addition, Deressa et al. (2010) was used the Heckman model to the same data where a Multinomial model referred to above was used to assess farmers' adaptation to climate change. This model initially assesses farmers perceptions that climate is changing followed by examination of the response to this perception in the form of adaption. Thus, the Heckman model has two equations; the selection equation and the outcome equation.

The study reveals that education of the household head, household size, whether household was male, livestock ownership, use of extension services on crop and livestock production, availability of credit and temperature all positively and significantly affected adaptation to climate change. However, large farm size and high annual average precipitation were negatively related to adaptation. Tessema *et al.* (2013) study examined smallholder farmers about climate change, types of adaptation strategies, factors influencing adaptation choices and barriers to adaptation Eastern Hararghe Zone, Ethiopia. The data collects from smallholder farmers' in the study area and employed a multinomial logit model. The result revealed that planting tree, early planting, terracing, irrigation and water harvesting, planting tree is the major adaptation method. Results of multinomial logit model showed that non-farm income, farm-to-farm extension, access to credit, distance to selling markets, distance to purchasing markets, income affect the choice of adaptation strategies. Finally, the study identified that lack of information as the most important barrier to climate change adaptation, the other barrier include; lack of farm input, shortage of land, lack of money, lack of water and shortage of labor.

The study conducted by Tagel (2013) in three districts of Tigrai, northern Ethiopia was focused on the farmers' perception of change in climatic attributes and the factors that influence the farmers 'decision to choice adaptation measures to climate change and variability. He used multinomial logit model to determine the factors that influence farmer's choice of adaptation measures to climate change. The results agricultural services; information on climate, and temperature all influences farmers choice of adaptation. Moreover, lack of information on adaptation measures and lack of finance are the main factors inhibiting adaptation to climate change. Generally, in Ethiopia most the study have been done by authors such as Deressa *et al*, Di Falco et al, Ringler et al. Yusuf *et al* and others focused the Nile Basin as a case study repeatedly by changing its methodology. Given the need for agro-ecologically based policy measures for climate change, there is no strong evidence for aggregating their findings across country. Therefore, this study conducted at farm level farmers' perception and adaptation strategies on climate change by taking Kālu district as a case study.

3. MATERIALS AND METHODS

3.1 Selection and description of the study area

This study was conducted in Kālu district (fig 1).The rationale behind the selection of the study area is its recurrent experience to erratic rainfall hailstorm and frequent drought causing the people to be food insecure and vulnerable climate related hazards repeatedly there are only limited studies undertaken in the area related to climate change.

3.1.1 Geographical location

Kālu district is located 11° 058`44” N latitude and 37° 041’4 8 ” E longitudes. It is found in South Wollo Zone of Amahara regional state, North East of Addis Ababa at 377 kms.

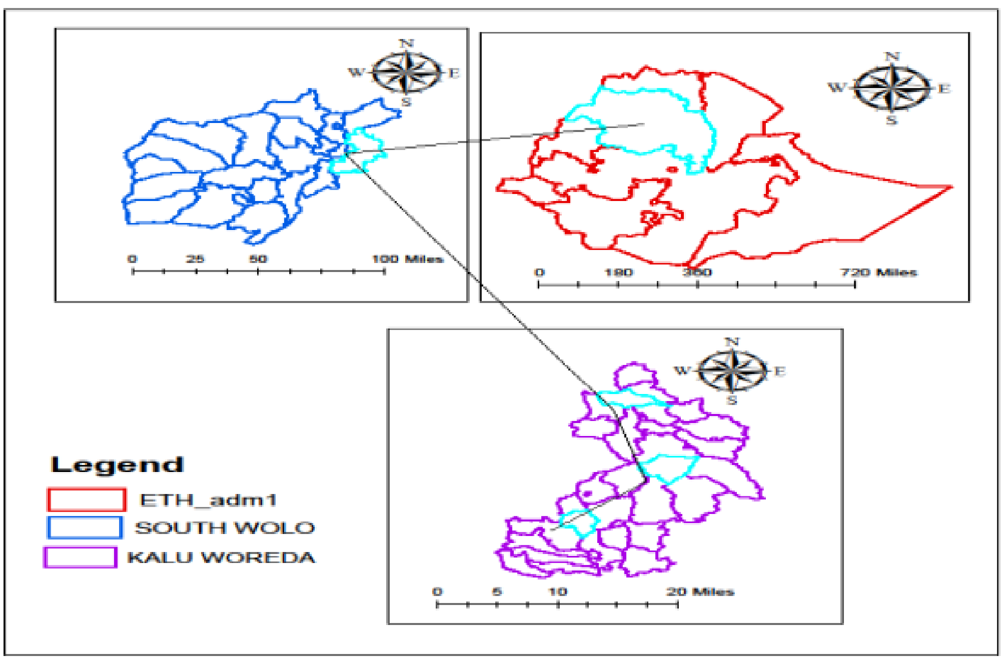


Figure 1. Map of study area

Topography

Kālu is one of the Woreda in the South Wollo Zone of Amahara regional state of Ethiopia. Dessie Zuria borders it on the west on the north by Wore Babo on the south and east by Bati, on the southeast by Argoba Special Woreda and on the southwest by Albeko. The center for this woreda is Kombolca. A highway linking Kombolcha and Afar bisects Kālu to two parts. The altitude of this woreda ranges from 1175 meters above sea level in the lowlands to 2849 meters above sea level in the highlands.

Climate

The climate of Kālu varies from dry sub-humid to semi-arid. Important rivers include the Chelelka and Borkena, Forested area includes Yegof forest, which is 180 square kilometers of native trees and plantations of exotic species covering the steep slopes of Mount Yegouf northeast of Kombolcha. The mean annual rainfall generally ranges between 800 mm to 1000 mm and the mean annual temperature is around 21 C^0. Based on the agro-ecological zone 9.22% of the woreda is low land (kola), 83.27% is Midland (Woina dega) and 7.62% is highlands.

3.1.2 Socio economic Characteristics

The economic base of the community is agriculture (crop production and animal husbandry). The dominant crops grown in the woreda are sorghum, teff, vegetables, bean, haricot bean, chickpea and maize during the wet and belg seasons. Based on the 2007 national census conducted by the Central statistical agency of Ethiopia (CSA), this district has a total population of 186,181, an increase of 9.18% over the 1994 census, of whom 94,187 are men and 91,994 women; 19,810 or 10.64% are urban inhabitants. With an area of 851.54 square kilometers, Kālu has a population density of 218.64, which is greater than the Zone average of 147.58 persons per square kilometer.

41,648 households were counted in this district, resulting in an average of 5 persons to a household, and 40,115 housing units. The majority of the inhabitants were Muslims with 98.73% reporting that as their religion, while 1.17% of the population said they practiced Ethiopian Orthodox Christianity.

3.1.3 Area coverage and land use

Most Kālu district made up of naturally- occurring scattered belts of acacia with natural and artificially planted trees. Woody vegetation survives better for longer period‘s than-non woody vegetation at the critical dry times of the year. Natural vegetation includes different *acacia* species, *Dodonea viscosa*, and several species of *euphorbia*, *Olea Africana*, *Entada abyssinica* and others. In addition, plant species such as *Eucalyptus species*, *Acacia spp*, *Cordia Africana*, *Gravilia Robusta* and others have planted through afforestation program of MOA. In the woreda cultivated land accounts for 31% of total land area, forest and bush land for 59% grazing land 1%, 9% settlement, and other land use.

3.2 RESEARCH METHODOLOGIES

3.2.1 Research Approach

The study employed both qualitative and quantitative research approaches (mixed approaches). The choice of this method was bounded up with the purpose of this study, because the purpose of the researcher was to describe, collect, analyze and conclude about the existing conditions at a time. Therefore, by using mixed methods, the researcher could be able to gather and analyze considerably more and different kinds of data. By these approaches, the weaknesses of the quantitative method tackled by the qualitative method and the weaknesses of the qualitative method overcome by the quantitative method.

3.2.2 Sampling methods

The strategy to identify the study area and sampling methods are as follows; the combination of multi-stage proportionate stratified sampling, simple random sampling and purposive sampling techniques employed in the selection of study site and sample households. Dega (highland), Woinadega (midland) and Kola (Lowland) agro-ecology respectively according to the traditional agro-climatic zone classification system, characterizes first Kālu district. The study area was selected purposefully because; it is one of the drought prone areas and frequently influenced by climate extremes (World Bank 2010). Based on the agro- ecology climatic zones one representative kebele from each agro-ecology three kebeles were selected randomly using lottery system RAND formula of excel software application with the help of Woreda agriculture and environmental protection offices especially, early warning and food security departments.

3.2.3 Sample size determination

The appropriate sample size for the household survey with their aggregated population size was determined by using a simplified formula provided by Yamane (1967) cited in Israel (1992) to determine the required sample size at 95% confidence level, degree of variability=5% and level of precision=8%.

$$\mathbf{n = N/1+N\,(e)^2}\text{--equation (1)}$$

Where n is the sample size, N is the population size (total number of households in the three kebeles), and e is the level of precision. So from the 4633 households 152 sample households selected. Accordingly, the respective number of sampled households to found sample size in each kebele, this thesis employed proportional sampling technique by distributing the total samples (152) to the selected kebeles proportionally.

Table 2: Sampling distribution of the household heads in the sampled three kebeles

Agro-climatic zone	Name of sampled kebeles	Total households	Number of sampled households
Dega	Adame	2264	73
Woina dega	Chorisa	1297	43
Kola	Abahelme	1072	36
Total		4633	152

Source; from Woreda Land administration and use office, November, (2017)

3.2.4 Households Selection

Households for the structured and semi-structured questionnaire selected by using simple random Sampling technique as lottery methods by using excel application software. The reason behind using this sampling technique everyone has equal chance of being chosen. In the case of selecting the respondents of the questionnaire, the households, whether headed by women or men of any age group considered without any discrimination.

3.2.5 Selection of Key Informants (KIs)

Key informants are knowledgeable persons about local situations like the past and present climate trends as well as adaptation practices to cop up adverse effects of climate change. KIs selected by using snowball method. Six individual farmers asked to give the names of six KIs. Out of 36 KIs identified at each kebele, the frequently appeared six KIs were selected for interview. In this way, 18 KIs (six from each kebele) were selected from the three kebeles for this study. Then a checklist was prepared and used to undertake the discussion with the selected key informants

3.2.6 Selection of Participants for Focus Group Discussions (FGDs)

The participants for the discussion were drawn from different social groups by using purposive sampling method. Discussions using semi structured or open ended questions held with the men and women, youth, kebele leadership, religious persons Agriculture Development Agents, agronomist, natural resources and environmental science. Staffs of those institutions were assumed to have extensive experience and knowledge about the research issues. According to Gill and Chadwick (2008), a focus group discussion composed of between six and fourteen members is adequate.

3.3 Data Sources

For the purpose of this study, qualitative and quantitative data gathered from both primary and secondary data and used to achieve the objectives of the study.

3.3.1 Primary data sources and types

Primary data collected from sample households ‘survey using questionnaire, focus group discussion, and key informants interview and direct observation. Primary data mainly related to respondents‟ demographic and socio economic characteristics, perceptions on climate change and adaptation strategies to cope up the impacts of climate change.

3.3.2 Secondary data sources and types

Secondary data collected from agriculture, Disaster prevention and preparedness, Environmental Protection and land administration offices at Woreda and Zonal level, NMA records (National Metrological agency) Kombolcha station. In addition, other Published and unpublished documents, books, journals, materials, from Internet web pages, research reports, and Governmental and Non-Governmental Institutions reports. Secondary data provide information on the issues related to temperature, rainfall, farmer‘s attitude and adaptation practices on climate change.

3.4 DATA ANALYSIS

3.4.1 Descriptive Statistics

The data was processed and summarized using Microsoft Excel. Then the data coded and entered in to Statistical Package for Social Sciences version 16.0 (SPSS version 16.0) was employed. Descriptive statistics mean, frequency standard deviation, frequency percentage was used to display the socio economic status of sampled household, compare farmer's perception with its climate variability with metrological data comparison made by undertaking linear trend analysis of annual means of temperature and total annual seasonal rainfall of 30 years record (1987-2016) obtained from NAMAS.

3.4.2 Econometrics

Econometric model was used to identify the major factors determining adoption of adaptation options to climate change and also to examine factors influencing farmer's perception on climate change in the study area. Because the assumption behind the econometric model is that farmers decision on adoption of any adaptation option and perception may influenced by a number of socio-economic. Factors that include age, sex, educational status, wealth, family size, land-holding size, distance to local market, climate information local agro-ecology, farming experience and access to extension service of the farming household heads (Madison, 2006, Hassan and Nhemachena, 2008, Deressa *et al.*2009, 2010). Therefore, multiple binary logistic regressions analysis employed to identify those determinant factors.

Table 3. Variables hypothesized to affect perception and adaptation decision by farmers concerning climate change

Variables and variable measurement	Mean	Std. Dev.	Min	Max	Expected sign
Age of the farm household in years	52.34	15.98	24	95	±
Genders of the head of farm household the farm household- dummy (1=female 0=male)	0.22	0.41	0	1	±
Education- attained by the head of the household in years	1.35	2.55	0	10	+
Household size-numbers of the family members a household	5.2	1.99	1	11	±
Land size-the size of farmland in hectare	0.67	0.458	0.12	3.5	±
Wealth status of the farm household,(1=poor=medium=rich)			1	3	
Distance to local market of the farm household head in kilo- meters	5.92	3.36	0.00	15	+
Climate information of the household head (1= access, 0=otherwise	1.06	0.77	0	1	+
Farming experience of the household in years	31.26	14.22	4	55	
Local agro ecology (1=lowland,2=migland,3=highland	2.24	0.814	1	3	±
Access to extension service,(1= access 0=otherwise)	1.49	0.66	0	1	+
N= 152					

3.5 Definition of variables and working hypotheses:

After the analytical framework is established, it is important to define the measurements of the variables as well as the symbols representing them. Accordingly, the major variables expected to have influence on the adoption of adaptation measures explained below.

The dependent variable of the model: In the study the following common adaptation strategies which are all explained by similar explanatory variables were identified: early maturing crop varieties, implement soil and water conservation, increase use of fertilizer and pesticide, improve animal feed and production system afforestation, rainwater harvesting, And no adaptation (business as usual scenario). Every adaptation option was represented by Y =1 if it is adopted by a household and 0 if not.

The general logistic equation with multiple explanatory variables given as:

$P = 1/ (1 + exp-(a + b_1X_1 + b_2X_2 + \ldots + b_kX_k)$, where, b_1 to b_k correspond to the effects of the respective Xi on Log (Odds) controlling for the other Xi variables. The linearized form of this expression is given as

$Ln (P/1-P) = a + b_1X_1 + b_2X_2 + \ldots + b_kX_{k}$,, where;-

P = the probability of encountering an event

1-P = the probability of not encountering the event.

The ratio (P/1-P) is called Odds and it is defined as the probability (likelihood) of observing an event relative to the probability of not observing the particular event. Odds simply mean likelihood for the occurrence of an event.

Table 4. Data analysis Matrix for each specific Objectives

Specific objectives	Data sets	Source of data	Methods of data analysis
1. To compare farmer's perception on climate change variability with historical data of 30 years trend	Temperature, rainfall, demographic and socio-economic	Household survey, FGDs ,KIIs NAMAS	SPSS as a tool for analysis, descriptive statistics
2. To examine factors influencing farmer's on climate change	Factors to perceive climate change	Household survey,KIIs and FGDs	Econometrics; Multiple binary logistic regression model SPSS as analysis tool
3.To assess barriers on agricultural adaptation in the area	Barriers on agricultural adaptation	Household survey through FGDs and KIIS	Econometric ; multiple binary logistic regressions

3.6 Metrological Data analysis techniques

3.6.1 Trend analysis

A number of techniques have been developed for the analysis of rainfall and temperature trends. Variability analysis involves the use of Coefficient of Variation (CV), percentage departure from the mean (Anomalies), Precipitation Concentration Index (PCI) and moving average. Trend detection and analysis achieved through parametric and non-parametric tests only for consistent data. Normality and homogeneity of variance throughout the series may be adversely affected by outliers and missing data in parametric tests. The advantage of non-parametric statistical test over the parametric test is that the former is more suitable for no normally distributed, outlier, censored and missing data, which frequently encountered in climatologic and hydrological time series (Ayalew et al.2012; Hadgu et al., 2013; Muluneh et al., 2016). As a result, MannKendall (MK) test is widely used to detect trends of meteorological variables. MK test is a nonparametric test, which tests for a trend in a time series without specifying whether the trend is linear or non-linear Amogne *et al,* (2018).

Generally, most researchers encouraged the use of non-parametric trend detection methods over parametric (Ayalew et al., 2012: 2013: Muluneh et al., 2016).

Variability analysis

In this study rainfall, temperature and variability computed using CV, Standardized Precipitation Anomaly and PCI. Furthermore, MK used to detect the trend of rainfall and temperature.

CV calculated to evaluate the variability of rainfall. A higher value of CV is the indicator of large variability, and vice-versa, which computed as, given by Oliver (1980) and modified by De Luis et al. (2011), as:

$$CV= \delta / \mu \times 100 \text{-- equation (2)}$$

Where CV is the coefficient of variation; σ is standard deviation and μ is the mean precipitation. According to Hare (2003) cited in Amogne (2018), CV is used to classify the degree of variability of rainfall events as less (CV<20), moderate (20<CV<30), and high (CV>30).

In order to study heterogeneity of monthly distribution of rainfall within a year, precipitation concentration index (PCI) was used (Luis et al., 2000), which is a modified version of (Oliver, 1980). This index was described or the values computed as the follows:-

$$PCI_{annual} = \frac{\sum_{i=1}^{12} p^2 i}{(\sum_{i=1}^{12} Pi)2} x100 \text{--equation (3)}$$

$$PCI_{seasonal} = [\frac{\sum_{i=1}^{n} p^2 i}{\sum_{i=1}^{n} pi)2}] \times n/12 \times 100 \text{---equation (4)}$$

$$PCI_{Belg} = [\frac{\sum_{i=1}^{n} p^2 i}{\sum_{i=1}^{n} pi)2}] \times 33 \text{--equation 5}$$

PCI Kermit $= [\frac{\sum_{i=1}^{n} p^2 i}{\sum_{i=1}^{n} pi)2}] \times 33$---**equation (6)**

Where: pi- is the rainfall amount of the ith month; n is number of months considered in the season. I.e. n is 4, 4, and 4 for Belg, Kiremt and Belg season respectively. PCI values of less than 10 indicates uniform monthly distribution of rainfall in the year (low precipitation concentration), values between 11 and 15 denote moderate concentration, values from 16 to 20 indicates high concentration, and values of 21 and above indicate very high concentration.

Inter-annual variability was evaluated using Standardized Rainfall Anomalies (SRA) rainfall with respect to the long-term normal conditions for a specific time scale. The SRA (also called Standardized Anomaly Index) were calculated and graphically presented to examine the nature of rainfall trend and to determine dry and wet years in the study area over the period of observation (Agnew and Chappel, 1999). It is described as:

$Z = (Pt - Pm)/ \sigma$ -- Equation (7)

Where, Z = standardized rainfall anomaly.

Pt = annual rainfall in $year\ t$.

Pm = long-term mean annual rainfall, over a given period of observation.

σ = standard deviation of annual rainfall over the period of observation.

Table 5. Methodology – Trend & Variability

S/N	Climate Characteristics		Trend		Variability		Remark
			Method	Software	Method	Software	
1	Rainfall	Annual Total	MKT & Sen’s Slope	MAKESENS	CV, PCI, & SPA	Excel 2007	Parametric linear regression used to detect trend and to compare with the results of MK-test.
2		Kiremt (JJAS) total					
3		Belg (MAM)Total					
4		Belg (FMAM)Total					
5		Mar-Sept Total					
6	Tem_{max}	Mean annual	MKT & Sen’s Slope	MAKESENS			
7		Mean Kiremt (JJAS)					
8		Mean Belg (FMAM)					
9		Mean belg (MAM)					
10		Mean Long (Mar-Sept)					
11		Mean Bega					
12	Tem_{min}	Mean annual	MKT & Sen’s Slope	MAKESENS			
13		Mean Kiremt (JJAS)					
14		Mean Belg (FMAM)					
15		Mean belg (MAM)					
16		Mean Long (Mar-Sept)					
17		Mean Bega					

Table 6. Methodology-Data Diagnosis (Data Quality Control)

Data quality control	Method	Software	Remark
Missing data	Normal ratio method(DAS,2009: Birhanu *etal.*2015)		Markova First-Order Moc
Outlier	Graphical Method(Muluneh *et al*, 2016)		Tukey Fence Method
Homogeneity test	Cumulative Deviation(Sahin and Kerem.2010; Ngongondo *et al*, 2011,Kang and yusof,2012:Hadguet *et al*, 2014) Double mass-curve(Ayalew *et al*,2012;Kefyalew,1994)	Excel 2007	RclimDex(Muluneh *et al.* 2016)
Test of randomness (Serial correlation effect)	Autocorrelation(Von Storch and N avarra,1995; Partal and Kahya,2006; Hadgu *et al*, 2014)		

4 RESULT AND DISCUSSION

4.1 Rainfall variability

The annual rainfall of the study area ranged from 1361 mm to 725 mm with mean 1033.9 mm and with a standard deviation of 160 mm over the study period (Table 7). The calculated PCI value for annual rainfall was (20.10%) and showed that rainfall in Kālu was generally characterized by high monthly concentration (i.e. represents a strong irregularity of precipitation distribution). The rainfall of Kālu is bimodal the first rainy season Beleg extends from February to May while the second rainy season is Kirermt extends from June to September.

The study result also indicated that monthly average rainfall was least in the months of December (i.e.17mm), November (18 mm) and followed by January (24 mm) and February (25 mm) while maximum amount of rainfall recorded in the months of July, and August (Fig 2). Belg season rainfall varied from 541 mm to 48.2 mm with mean 241.1 mm and standard deviation 107.4 mm, while *Kiremt* rainy season rainfall ranges between 962.5 mm to 379 mm, and with standard deviation of 141.2 mm. The PCI value of total seasonal rainfall distribution was 12.86 and 12.60 mm in Belg, kirermt respectively, and Characterized by moderate concentration (Table 7).

The analysis result of Coefficient of variation revealed that rainfall in the district has shown from less to high inter-annual variability depending on the seasons (Table 7). Rainfall during Belg season (FMAM) was highly variable (CV=45%); while the annual and Kiremt rainfall coefficient of variation indicated that less and moderate rainfall variability (CV= 15% and 20%) respectively. This finding is similar to the previous findings, which indicated that Belg season rainfall has high inter- annual and inter-seasonal variation than Kirmet season in

Ethiopia (Ayalew *et al*, 2012, Amogne *et al*, 2018). The mean PCI value was used to examine the variability (heterogeneity pattern) of rainfall at different scales (i.e. annual or seasonal).

Table 7. Descriptive statistics of rainfall at Kombolcha station for the period 1987 to 2016

	Annual Rainfall	Total seasonal Rainfall	
		Belg (FMAM)	*Kiremt* (JJAS)
Mean (mm)	1033.9	241.1	692.1
Standard Deviation (mm)	160.0	107.4	141.2
Co-efficient of Variatio (%)	15%	45%	20%
Maximum (mm)	1361.6	541.0	962.5
Minimum (mm)	725.1	48.2	379.2
Mean PCI (%)	20.10%	12.86%	12.60%

Source: meteorological data obtained from NMSA of Ethiopia at Kombolcha station.

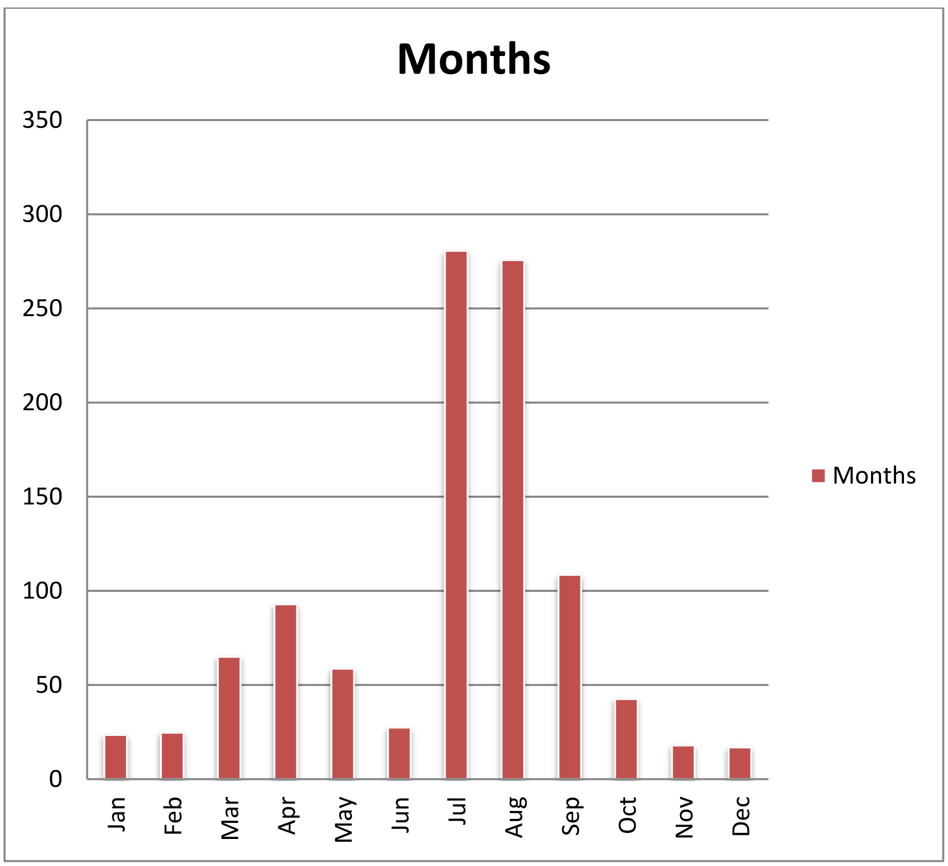


Figure 2. Monthly rainfall distribution with Standard deviation of Kombolcha station of 30 years (1687-2016)

The result of inter-annual variability (Fig 3) below showed that rainfall anomaly for the annual rainfall generally indicated that cyclic wet and dry conditions with negative anomalies for 56.66% of the years or 17 out of 30 years for annual rainfall anomalies was negative (fig 3). This denotes that in the study area there is high inter-annual variation during the study period. It is also obvious that most of the negative anomalies (13 out of 17) occurred between 2001 and 2016. Most of the positive anomalies (10 out of 13) occurred between 1988 and 2000. Between 2001 and 2016, the chance of occurrence of positive anomalies was only 3 years (fig 3). The result indicated rainfall in the study period showed inter-annual rainfall variability is a common phenomenon and this result was supported by all FGDs during the discussion period.

The result depicted that 1990s were the wettest period. Nevertheless, from the beginning of 21st century the wet period starts to decline and changed to drier period in the study area. The result similar with Bewket and Conway (2007) noted that 1990s was the wettest decade and the beginnings of 21st century indicate a slight decline in Amhara region of Ethiopia. The current result also similar with Funk et al. (2012) disclosed that since the beginning of 21st century, average rainfall conditions had been poor in most areas of the country. Moreover, during the last three decades, 1998 was the wettest year with SRA 2.05 while 2015, was the driest year recorded in the station with SRA-1.93. For *Belg* season 60%, the years showed negative anomaly relative to the long-term average rainfall (fig 3). Out of 30 years 18 years showed negative anomalies only 12 years ((40%) was above the mean. From 1999 until 2016 only 4 years recorded was positive anomaly the rest 14 years were recorded negative anomalies. For example from the year 1999 to 2016, the highest positive anomaly with SRA recorded 0.73, the highest negative anomaly recorded with SRA-1.77. Therefore, the season was extremely dry.

The *Kiremt* rainfall anomaly showed that 53.34% of the observed years were experienced an amount of rain lower than the long terms mean (Fig 3). The result of this study revealed that 16 years of the study period was below the mean or negative anomalies. However, 14 years (46. 66%) was above the long-term mean with SRA value minimum 0.00 in 1989 and 0.14 in 2014. The maximum SRA positive kiremt season anomaly was 1.92 in 2010 and 1.86 in 1994. The analysis result showed that from the study period 1987-2016, the maximum negative anomaly or below the mean SRA value was -2.22 in 1987 and -0.01 in 2013 (fig 3). Generally, the result showed that there was high inter-annual and inter-seasonal variation in the amount of rainfall and long dry period observed in the study area. So it implies that the perception of farmer's to climate change by considering rainfall variability, long dry period was observed and it resulted in decrease in agricultural production as indicators of Climate Change was similar to the analysis result.

II. **SPA**

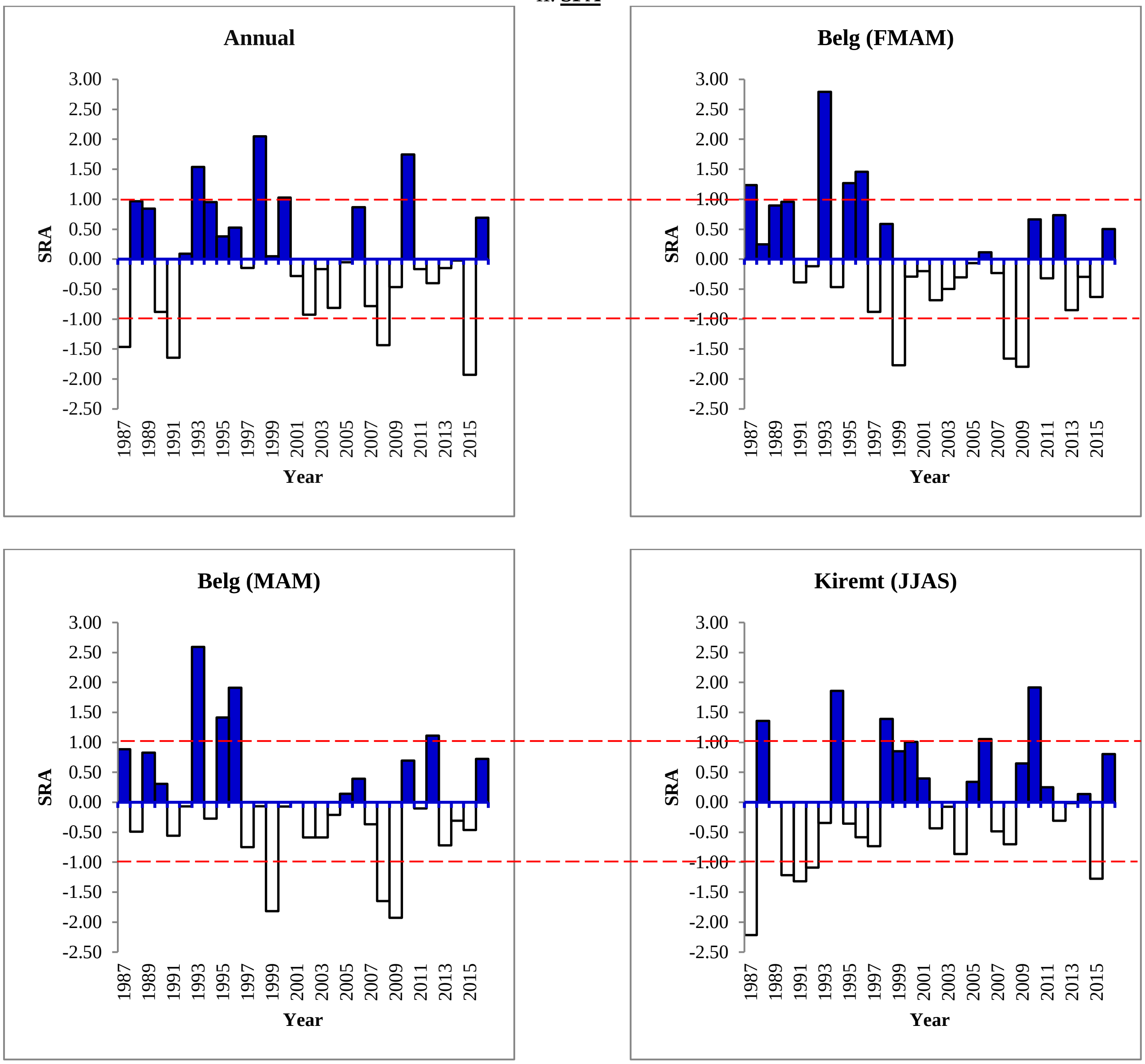


Figure 3. Seasonal rainfall deviation from the long-term mean (anomalies) at Kombolcha Station (1987-2016)

4.2 Rainfall trends

4.2.1 Annual rainfall trends

The result showed that annual maximum rainfall recorded for the past 30 years was 1362 mm in 2016 while the lowest rainfall recorded was 725 mm in 1987 with the range of 637 mm. It shows that there is high inter-annual variability of rainfall across the years. On the other hand, the average/mean annual rainfall of 30 years was 1033.88 mm, while standard deviation is about 159.99 mm where this much rainfall amount is deviated from the mean. In general, there was high variability in rainfall distribution across the past three decades.

Mann–Kendall's test on annual rainfall data showed a declining trend of annual rainfall (28.7mm per decade) over the study period of 1987 to 2016. However, the result obtained from the data analysis of annual rainfall trend statistically not significant there was high annual rainfall variability. For example at the end of 1990s to 2000 to there was an increased amount of annual rainfall and decline immediately in 2001 to 2008 (Fig: 4). the parametric linear regression test (student t-test), as a comparison, also detected a declining trend of annual rainfall in the study period with p-value 0.48 (Fig 4).

The data obtained from ENMA trend of rainfall decrease in amount supported by all FGDs and Key Informants. but, from 152 sampled household heads 120 (78.4%) of them were perceived that rainfall decreased for the last three decades and 32 (20.9%) did not agreed on decreased in amount of rainfall rather it was erratic but no change in amount these much.

4.2.2 Trends of Belg season rainfall

As it is indicated in Table 8, the Mann-Kendall trend test on the rainfall of Belg season showed a statistically significant declining trend (36.9 mm per decade) over the study period at 10% level of significance. The parametric student t-test also detects a significant declining trend of Belg season rainfall with p-value 0.03 within the study period (Fig 4). This result is in agreement with other studies in the country and across the region. For instance, Ayalew et al.

Moreover, focus group discussants and key informants substantiated these findings, and they revealed that the unreliability or unpredictability of Belg season rain has made farmers to focus on rainwater harvesting in high land of the study area plantation of Catha edulis (chat). However, not to fully invest their resources on the necessary packages or inputs like fertilizers in the lower agro-ecological zone.

4.2.3 Trend of Kiremt season rainfall

MK test on Kiremt season total rainfall showed a non-significant increasing trend (40.5 mm per decade) over the study period (Table 8).This result is different from other findings because in most parts of the country there is a declining trend of Kirermt rainfall. The study generally revealed that there was inter-annual and inter-seasonal rainfall variability in Kalu district during the study period.

Table 8. Trends of annual and seasonal rainfall total (1987-2016).

Rainfall Characteristics	Trend		
	Zs	Sen's Slope(mm/annum)	Intercept(mm)
Annual rainfall total	-0.89	-2.87	1,076.1
Belg season total rainfall	-1.86*	-3.69	283.25
Kiremt season total	1.03	4.05	613.1

Zs is MK trend, test * - statistically significant at 0.1 probability level.

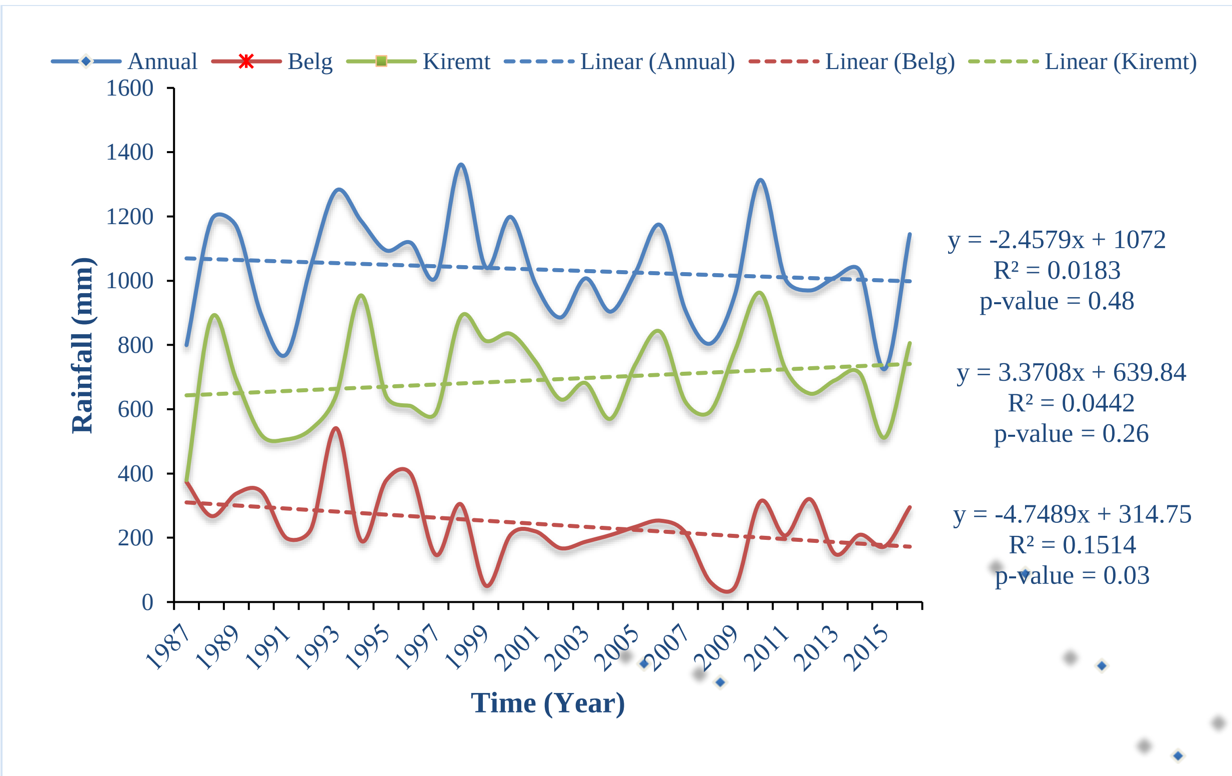


Figure 4. Long-term annual and seasonal rainfall trends at Kombolcha station.

4.3 Long term temperature

4.3.1 Descriptive statistics of temperature (1987-2016)

The average annual temperature recorded was 20.04 ^{O}C and the mean annual maximum temperature recoded during the study period was 28.05 ^{o}C while the annual mean minimum temperature recorded was 12.16 ^{o}C from this result it is possible to conclude that there was a great inter-annual variation of temperature for the past 3 decades. Furthermore, the average maximum Belg season temperature recorded was 29.45 ^{o}C while the mean minimum temperature recorded of Beg season was 12.75 ^{o}C. The average annual temperature recorded of Kiremt season temperature recorded was 19.18 ^{o}C. However, the average annual recorded of temperature was 20.04 and Belg season 21.06 and Kiremt 19.18 ^{o}C, therefore the average temperature of Belg season was exceeds by 1.05 ^{o}C from annual and 1.91 ^{o}C greater than Kiremt season temperature recorded. The Belg season mean maximum temperature record was 29.45 ^{o}C while the annual and Kiremt mean maximum temperature recoded was 28.05 and 25.58 ^{o}C by decreasing 1.4 ^{o}C 3.87 ^{o}C from the season of Belg respectively. The annual mean minimum temperature recorded 12.61 ^{o}C, the mean minimum temperature recorded of Belg season was 12.73 ^{o}C and mean minimum temperature of Kiremt season temperature recorded was 12.88 ^{o}C. Therefore, the result showed that Kiermt mean minimum temperature recorded was higher than annual temperature by 0.72 ^{o}C 0.15 ^{o}C from Belg season rainfall (Table 9).

Table 9. Descriptive statistics of temperature at Kombolcha station (1987- 2016)

Descriptive statistics	Annual	Seasonal	
		Belg	*Kiremt*
Average annual temperature (°C)	20.04	21.09	19.18
Mean Maximum temperature (°C)	28.05	29.45	25.58
Mean Minimum temperature (°C)	12.16	12.73	12.88

Source: Computed from ENMA data

4.3.2 Trend of annual and seasonal temperature

The mean annual maximum temperature recorded was 26.6°C in 1987 and the average annual maximum temperature recorded in 2016 was 27.9°C. Therefore, the analysis result showed that the mean annual maximum temperature increased by 1.3°C for the last three decades. However, the average annual minimum temperature in 1987 recorded was 13.2 °C and after 30 years, the mean annual minimum recorded was 13.2 °C in 2016 this shows that there was no change of mean annual minimum temperature for the last three decades (fig 5).

The mean maximum Belg season temperature recorded was 25.5 °C in 1987 and 29.3 °C in 2016 this result indicated mean maximum Belg season temperature was increased by 3.8 °C during the study period. Furthermore, the mean Belg minimum temperature recorded was 13.7 °C in 1987 and 14.3 °C in 2016 so the analysis result showed that mean Beg minimum temperature increased by 0.6 °C.

The mean Kiremt maximum temperature recorded was 28.8 °C in 1987 and after 30 years the mean Kiremt maximum temperature recorded was 28.5 °C in 2016 therefore the result revealed that mean Kiremt maximum temperature was decreased by -0.3 °C for the past three decades in Kalu district. The mean minimum Kiremt temperature recorded was 15.4 °C in 1987 and 15.1 °C in 2016 the study shows that mean minimum Kiremt temperature was decreased by -0.3 °C (fig 6). In general, there was inter-annual and inter-seasonal variation of temperature in the study area and the average annual maximum temperature increased, both Belg season mean maximum and mean minimum temperature showed an increased temperature trend. However, the maximum and mean Kiremt minimum temperature analysis result showed a declined trend. However, the mean annual maximum and mean annual minimum temperature have no change for the past 3 decades in the study area during the study period.

MK trend test result revealed that annual maximum temperature, Belg season Maximum and Kiremt Maximum temperature have been increasing through significantly at 0.01 probability level (table 10), the result revealed that for the last three decades and there was high seasonal and annual temperature variability in the study area. However, the minimum temperature of Belg season showed a declined temperature trend but it was not significant. According to the sampled household heads, 69.7% the respondents perceived that the temperature of the area increased for the past three decades however, 30.7% of the sampled households did not agreed rather they realized that there was no change of temperature. All key informants and FGDs agreed that there was an increased in temperature amount for the last thirty years and the climate was changed.

Table 10. Trend of annual and seasonal 0temperature (1987- 2016)

Season	Trend					
	Z_S		Sen's Slope (ºC/annum)		Intercept (ºC)	
	T_{max}	T_{min}	T_{max}	T_{min}	T_{max}	T_{min}
Annual	4.78^{***}	0.07^{ns}	0.061	0.001	25.99	12.72
Belg (FMAM)	4.46^{***}	-1.36^{ns}	0.102	-0.026	25.81	13.52
Kiremt (JAAS)	3.57^{***}	1.32^{ns}	0.044	0.011	27.38	14.83

Z_S is MK trend test; *** indicates statistically significant at 0.01 probability level; ^{ns} is "non-significant"; Tmax – maximum temperature; T_{min}

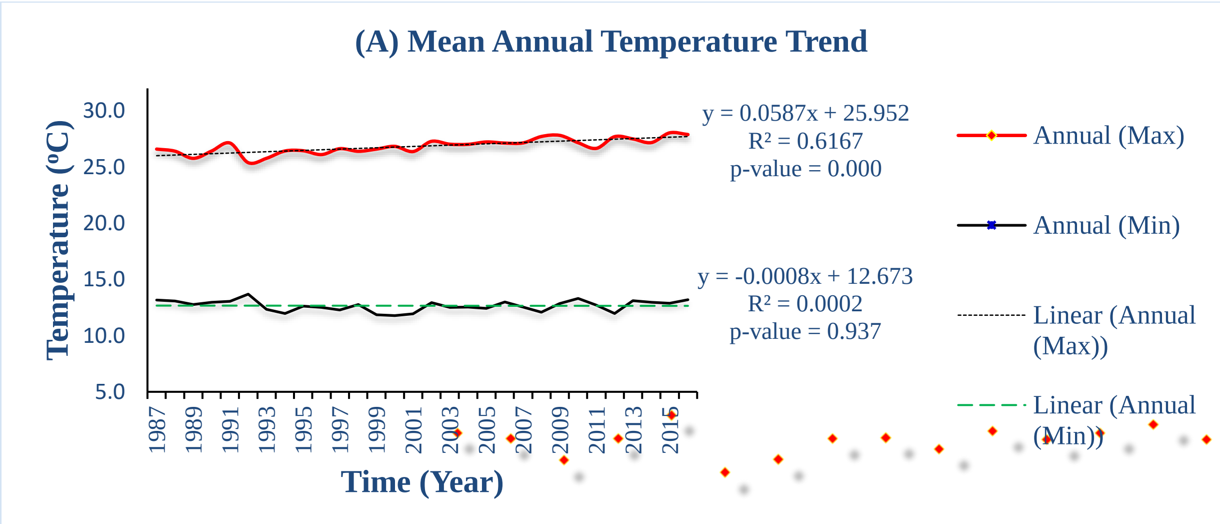
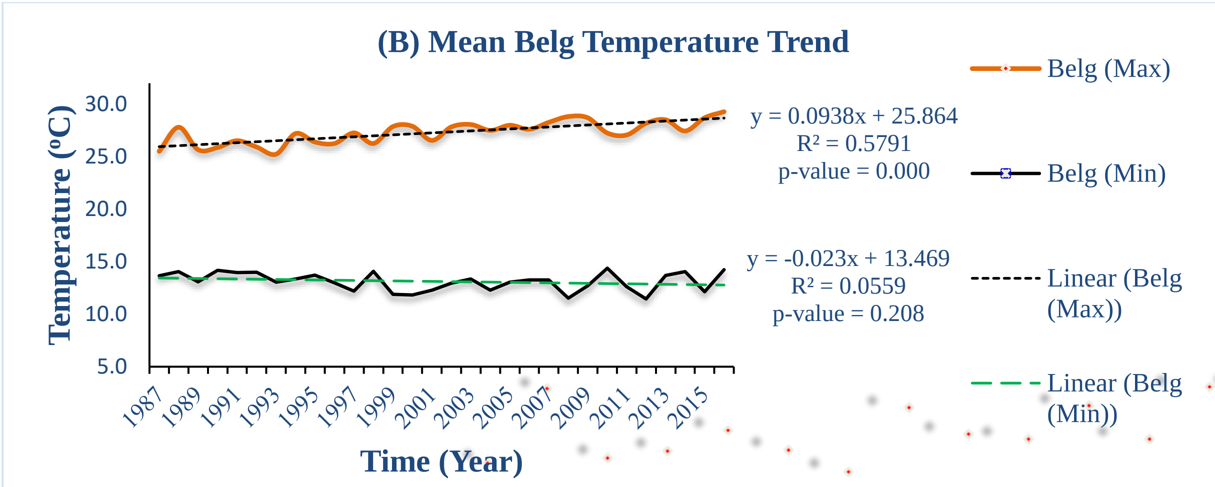


Figure 5. long term mean annual temperature trend



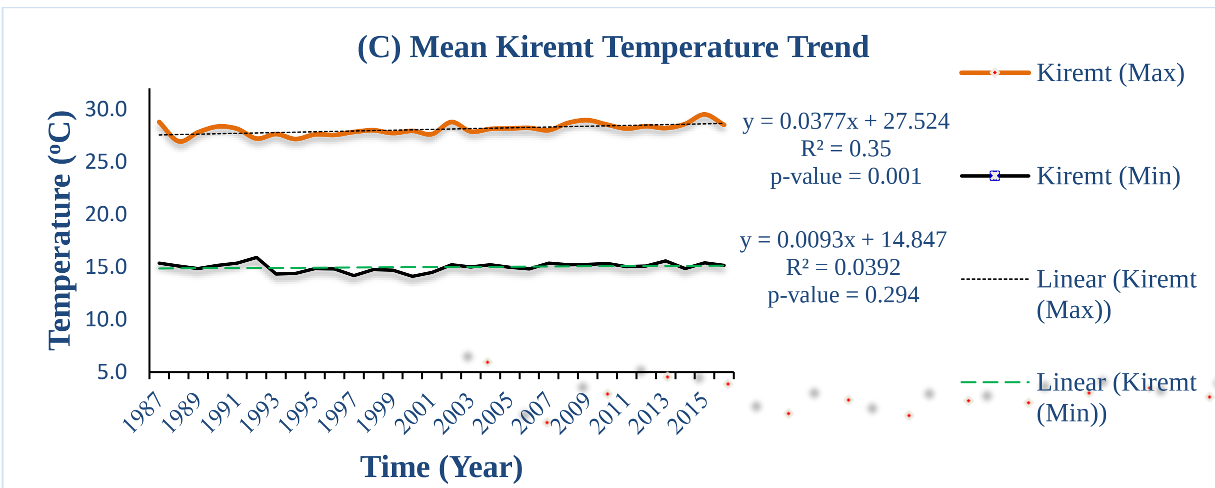


Figure 6. long-term mean-maximum and minimum temperature at Kombolcha station

4.4 Factors affecting farmer's perception on climate change

The result analysis revealed that factors influencing farmer's perception to climate Change have shown in (Table 11) below shows that the age of sampled household, sex, education wealth, land holding size, distance to market and agro-ecology has positively and significant impact on the perception of farmers in the study area. Decrease amount of rainfall, changing in cropping season, extreme weather events, increase crop pest and disease, increase in temperature and long dry period. For example, the result revealed that increasing the age of the household head by one unit increases the probability of perceiving decrease in rainfall amount by 7.498, increase temperature 1.055 and increase in crop pest and disease 0.299 and extreme weather events 0.55 times higher than other age category. For example, the perception of aged from the age category 25-54, 55-64 and over 65 years analyzed by the model.

All sampled household aged above 54 understand about the variability of rainfall, temperature, occurrence of long dry periods and an increase of temperature for the last three decades. Moreover, they feel extreme weather events (too cold too warm) and increase crop pest and disease even in human unprecedentedly as indicators of climate change. The possible reason is that that older farmers have more experience in farming and are therefore, better placed to assess their environment than young farmers did. The result was similar to Mddison 2006: Ishaya and Abeje 2008.

As expected male household heads, had better opportunity to take an adaptation and climate change perception than female household headed but in this study revealed that the probability of perceiving female household headed like decrease and drying of water, increase 3.676 times higher than male-headed households increase and significant at 5% level of significance. Perceiving increase in temperature and extreme weather events result shows positive and significant at 5% and 10% level. This is probably because female-headed households spent many times in search of water and their day today activities related with water so they have more chance to observe their surrounding than male household heads.

The logit model also established an inverse relationship between farmer's perception to climate change and their local wealth status. The result showed that the poor household heads were negative relationship with in increase temperature, changing cropping pattern than medium and rich household heads. For example, the poor household heads perception about increasing in temperature decreased by the value of -2.28 sig value of 0.012 and significant at 5% probability level. This observation is probably because of their perception on decrease rainfall amount undermine perception on temperature or probably due to their low economic status they were not involved in farming activities and they may their livelihoods depend of renting their farms to others. Likewise, the result of this study shows that negative and significant at 10% probability level relationship between farmer's wealth status and perception on changing cropping season.

Agro-ecology: The study also confirmed that both and positive relationship between local agro-ecological conditions and farmers perception's on climate change. Farmers living in the lower agro-ecological zones were more likely perceive drought frequency and erratic rainfall pattern than farmers living in higher agro-ecological zones did. The study shows that positive and significant at 10% probability level. The result is similar with Belay *et al. (*2005): Ndambiri H. K *et al.* (2012). However, the result of perception of farmers living in lower agro-ecological zone confirmed that they did not feel change in cropping season, increase in temperature and increase in crop pest and disease revealed a contradictory result to the former researchers but similar with Deressa *et a*l.(2010). The probable suggestion behind is farmers in lowland may applied more pesticide input or they were not mostly dependent on Belg rainfall relative to farmers living in highland agro-ecological zone. Because Belg rainfall become more variable, erratic and mostly absent so farmers forced to feel the change and forced to change their cropping season but not pronounced in lowland agro-ecological zone. Has its own set of conditions known to the farmers and have a small change in these conditions have a higher likelihood of influencing the farmers to perceive the changing of climate.

Distance to market: the current study shows that there was a positive relationship between distance to local market and perception of climate change, the study result indicated in (Table 11). Farmers residing to closer to local market were also more likely perceive climate change than farmers residing further away from the nearest market do. For example, the study result indicated that farmers located to closer to market by one-unit increases the probability of perceiving the occurrence of drought, frequency and encountered crop failure by 11.941 and significance at probability level. increase in crop pest and disease probability of perception increased by 2.641 and significant at 10% probability level than farmers located further away to the local market.. These is probable because of Proximity to market may serve as means of sharing and exchange information with farmers and experience.

Education: the result of the logistic model shows that education has positive and significant relation with climate change indicators of independent variables like change in cropping season, decrease in rainfall amount, erratic rainfall, drought frequencies and increase pest and disease. For example as the level of the household increases by one unit significantly increases the probability of perceiving the probability of changing cropping season by 2.034 times than non-educated household heads and significant at 10% probability level. Similarly increasing the level of education also has significant and positive relationship with the perception of variables decrease in rainfall amount, erratic rainfall, increases a probability of perceiving by 2.689 times, 2.034 and 1.008 times respectively and significant at 10% probability level.

Landholding size: - is also a statistically significant explanatory variable in this model. That means farmers' perception to climate change is also significantly affected by the amount of farm size that the households owned. For instance, a one hectare increases in the farm size, the probability of the farmers perception on, increase crop pest and disease and extreme weather events by 2.535 and 4.859 with 10% level of significance, holding other variables constant. Farm size may also associate with grater wealth and it is hypothesized to increase adaptation to climate change. However, farmers with small land holding size has negative and significant impact on the perception of changing in cropping season, decrease rainfall amount and erratic rainfall at 10% probability level.

Table 11. Analysis of variables that affect farmer's perception on climate change

Variables	Change in cropping season		Decrease in rainfall amount		Decrease and drying of water		Erratic rainfall	
	B(s)	Exp(B)	B(s)	Exp(B)	B(s)	Exp(B)	B(s)	Exp (B)
Age	-1.5 (0.323)	0.271	2.015 (0.028)**	7.498	0.813 (.417)	2.254	0.782 (.443)	2.186
Sex	- 0.896 (0.469)	0.408	- 0.243 (0.712)	0.784	1.302 (0.013)**	3.676	0.542 (.422)	0.582
Education	21.433 (0.998)	2.034	.317 (.593)	1.374	23.240 (.999)*	1.239	0.325 (1.000)	5.663
Wealth	-19.52 (0.999) *	0.000	0.989 (.237)	2.689	0.737 (0.391)	0.469	0.08 (0.995)	1.008
Size of Farmland	-18.396 (0.999)*	0.000	-2.824 (.999)*	8.170	.283 (1.000)	1.327	-18.920 (.995)	1.008
Climate information	-16.823 (.699)	0.000	-40.255 (.799)	0.000	-.194 (1.000)	1.297	0.565 (1.000)	1.759
Agro ecology	-3.702 (0.003)**	0.025	-1.502 (0.999)*	0.223	0.260 (0.597)	1.297	0.689 (.999)*	9.659
Farming Experience	16.565 (.998)	1.56	0.759 (2.19)	2.137	0.400 (0.589)	1.492	-0.225 (0.882)	0.799

N.B ***, **,* indicates significant at 1%, 5% and 10% level significance.

S---------- = significance (p-value) &

B--------------- = intercept

EXP (B) ------- = Odds ratio

Variables	temperature increases		Drought Frequency increases		Increase crop pest&diseas		Extreme weather events
Age	0.54 (0.967)	1.055	0.327 (0.658)	1.387	1.208 (0.045)**	0.299	2.899 (0.000)**
Sex	1.425 (0.016)**	0.241	-0.275 (0.661)	0.759	0.194 (0.774)	1.214	0.063 (.907)
Education	-2.019 (0.159)	0.133	1.687 (1.000)	5.405	19.276 (0.999)*	2.353	-21.074 (.999)
Wealth	-2.28 (0.012) **	0.102	-1.124 (0.213)	0.325	- 1.118 (0.129)	0.327	-0.738 (.319)
Farm size	18.206 (0.199)	8.064	0.620 (0.361)	1.858	21.653 (0.999)*	2.535	20.001 (0.999)*
Distance to Market	21.270 (0.999)*	0.000	2.480 (0.031) **	11.941	19.392 (0.999)*	2.641	0.59 (0.959)
Climate Informatio n	-21.434 (1.00)	0.000	-17.520 (1.000)	0.000	-20.573 (0.799)	0.000	2.207 (0.207)
Agro ecology	-0.830 (0.177)	0.436	1.396 (0.014)**	5.916	-3.524 (0.000)**	0.29	0.117 (0.817)

N.B ***, **,* indicates significant at 1%, 5% and 10% level significance.

S---------- = significance (p-value) &

B--------------- = intercept

EXP (B) ------- = Odds ratio

4.5 Determinants of adaptation

The present study binary logistic regression analysis was employed to identify the determinants of adaptation strategies. The findings are discussed as follows;-

Wealth status of the household head; - is one of the significant explanatory variable in which negatively affect both drought tolerant crops and increase use of fertilizer and pesticide. In this study, the result indicated (Table 12) decreasing one-step in wealth status there is a probability of decrease the use of drought tolerant crops and increasing use of fertilizer and pesticide by 0.106 and 0.386 respectively at 5% probability level putting the other variables constant.

Landholding Size;- is the total holding of the farm household that uses the farming activities, the farming household with large land size has more to use different adaptation strategies. It indicated a positive sign for the farmers were used adaptation method to Climate Change. However, the farming households with small land holding size in this study showed negative sign (Table 12). For example farming households with less than 0.5 and 0.5 to 0.9 hectare of land indicated negative result to use of increased use of fertilizer and pesticide, decreasing one unit in landholding size, decreased the probability of adopting increase use of fertilizer and pesticide by 1.432 times and significance 10% probability level.

Education: - according to the study of the result this explanatory variables (education) has been observed positively and significant impact on and using of drought tolerant and early maturing crop varieties, rainwater harvesting and early maturing crop varieties. For example as the educational status of the farmers increase by one unit, the use of drought tolerant crop varieties increased by 8.463 times than non-educated farmers. Likewise, educational status of the sampled households' head increased by one unit, the use of adaptation technologies of rain water harvesting and early maturing crop varieties increased by 1.685 and 37.2 times significance at 10% and % probability level.

Similarly, better access to Climate information has positive and significant outcome on applying increase use of fertilizer and pesticide, drought tolerant crop varieties, soil and water conservation, early maturing crop varieties and improving animal feed and production system. This means as the farmers have better accessed to climate information the changing of climate have more probability of increases, the uses of those two technologies by farmers increased by 5.866 and 1.176 times than farmers have no access to climate information and significant at 10% probability level respectively.

As depicted in the model result, better accessed to climate information was found to have positive and significant relation with adaptation measures of soil and water conservation, early maturing crop varieties and improving animal feed and production system increase by the probability 7.083,9.244, and 2.226 times than those farmers not accessed to climate information to implement such adaptation strategies.

Agro-ecology; - the study was established a negative relationship between local agro ecological conditions and farmers perception and different adaptation strategies to climate change. The study result showed that there is a negative relationship between lowland agro-ecological conditions with rainwater harvesting, increase use of fertilizer and pesticide, soil and water conservation. The logistic regression result discovered that, farmers living in lower agro-ecological zones believed that, rainwater harvesting, increase use of fertilizer and pesticide, soil and water conservation have a significant negative relationships. However the analysis result was not significant, farmers living in midland and highland agro ecological zones believed those adaptation strategies have a positive relationships. The results came out as expected or this study established an inverse relationship because, many researchers like Maddison (2006) and Nhemachena and Hassan (2007), H.k. Ndambiri et al, (2010) disclosed that farmers living in lower agro-ecological zones were more likely to perceive climate changes than farmers living in higher agro-ecological zone. The possible reason for this negative relationship is that Climate information service is not properly addressed about the better benefits adopting of those adaptation strategies, probably in lowland agro-ecological zone is mostly influenced by moisture stress so farmers may have an assumption increase use of organic fertilizer may affected to their crop production. Water harvesting technology is not attractive type of adaptation technology in lowland than the highland, probably the rate of evaporation is high in lowland so if the harvested water evaporates easily May the farmers not benefited, or the cost of the material may discourage the farmers.

Access extension service:-using the logit binary logistic regression model, investigation revealed that access to extension service showed a positive sign for female household heads for afforestation and it is significant as depicted table 12, farmers with better accessed to climate information have a better chance to implement climate change adaptation strategies. For example increasing a one unit or rate of better access to extension service increases the probability of implementing tree plantation or afforestation by female-headed households by 4.594 times higher than male farmers while keeping the other variables constant and significance 0.01-probability level. Therefore, it plays a great role that affects farmers to adopt strategies in response to climate change.

4.6 Descriptive analysis of adaptation practices

The agrological setting of farmers' influences their perception and, adoption of different adaptation strategies to cope the existing change of climate. The study by Belay *et al. (*2005):

Ndambiri H. K *et al.* (2012), farmers living in lowland are with more frequent droughts are more likely to describe the climate change to be warmer and drier with higher drought frequency than other areas. Therefore, it is hypothesize that farmers living in lowland areas are more likely to perceive climate change as compared to midland and highlands. Likewise, the scientific community argues that adaptation to climate change is also a two-step process that involves perceiving that climate is changing, and then responding to changes through adaptation. This study argue with the majority of the populations have already perceived climate change (Maddison 2006, Ishaya & Abaje 2008; Gbetibouo 2009; Deressa, 2010). However, the result of this study indicated that people who perceived climate change but not ready to adopt adaptation strategies. For example in (Appendix-4) indicated that from the total 152 sampled households 25.6% (39) of them believed that the exiting change of climate is impossible to adapt but 113(74.34%) considered that there is a chance to adapt by adopting different adaptation options.

Based on agro-ecological zones from the lowland sampled households 15 (36) or 41.67% believed that the existing change of climate is impossible to adapt, 21(36) or only 58.33% realized it is possible to adapt. Farmers living in highland agro-ecological zone only 15 (20.55%) out of 73 believed that the existing climate change is impossible to adapt whereas, 58(73) 79.45% believed possible to adapt the changing of climate. Farmers living in midland agro-ecological zone from 43 sampled house holds 34 (70.07%) have the perception of possible to adapt but nine out of (43) or 20.93% believed that it is impossible to adapt the changing of climate. According the result of the study from different adaptation options like soil and water conservation, afforestation, rainwater harvesting, early maturing crop varieties, drought tolerant crops, increase use of fertilizer and pesticide, climate change adaptation strategies have adopted in the study area. From those adaptation strategies, the study raveled that farmers living in highland 71.23% adopted rainwater harvesting of the sampled households, however farmers living in the midland and lowland from the sampled households only 9.30% and 11.11% adopted the technology.

Increase use of fertilizer and pesticide: farmers living in low-agro-ecological zone only 38.88% considered as adaptation option but, farmers living in midland and highland agro-ecological zone adopted 79.1% and 68.49% considered as coping mechanisms.

Soil and water conservation: - the study depicted that farmers living in lowland agro-ecological zone adopted these strategy 38.88% of but farmers living in midland and highland agro-ecological zone adopted 79.1 and 68.49% respectively.

Early maturing crop varieties;-farmers living in lower agro-ecological zone considered these adaptation practices as adaptation strategies were 19.44% however, 69.76% and 2.74% in midland and highland agro-ecological zone respectively from the sampled households

Afforestation;-According to the result of the study farmers living in highland agro-ecological zone adopted 68.49%

As indicated in (Appendix) farmers living in lowland agro-ecological zone adopted afforestation as adaptation strategy were only 38.88% and 79.1% farmers living in the midland agro-ecological zone from the sampled 43 households, the study in general revealed that farmers living in highland and midland agro-ecological zone have adopted different adaptation options rather farmers living in lowland agro-ecological zone. This is probably because of the farmers living in the study area May influenced by the adaptation determinant factors in a pronounced manner than farmer living in highland and lowlands. As indicated (9) the majority of farmers living in high agro-ecological zone of the study area have adopted rainwater harvesting technology and cash crop plantation is common because, FGDs and KIIs confirmed during interview and discussion. The area before 30 years were barley and other highland crops were the dominantly grown in the area but now due to change in climate even coffee lowland crop and fruits cultivate to in the same plot of land. They consider as indicators of climate change.

Figure 7. Soil and water conservation in the study district, 2018

Table 12. Analysis of Variables That Affect Farmers Adaptation to Climate Change

	Drought tolerant crop varieties		Rain water harvesting		Increase use of fertilizer & pesticide		Soil and water conservation	
Variables	B(S)	Exp(B)	B(S)	Exp(B)	B(S)	Exp(B)	B(S)	Exp(B)
Age	-.812 (0.612)	0.444	0.495 (0.540)	1.640	-1.306 (0.080)	0.271	-.414 (0.571)	0.661
Sex	-.613 (0.622)	0.542	1.044 (0.069)	1.685	0.743 (0.192)	2.102	0.674 (.228)	1.962
Education	20.556 (0.999)*	8.463	18.942 (.999) *	1.685	0.726 (0.626)	2.067	2.522 (.149)	12.448
Family size	0.878 (0.351)	2.407	.625 (0.373)	1.868	0.350 (0.590)	1.420	-.447 (0.447)	0.640
Wealth	-2.241 (0.096)	0.106	-.527 (0.488)	0.591	-0.590 (0.047)**	0.386	0.422 (.595)	1.525
Land holding size	0.056 (1.000)	1.057	-1.679 (0.433)	0.187	-41.163 (0.999)*	1.432	-40.616 (.999)*	1.431
Distance to market	0.323 (0.752)	1.381	19.914 (.999)*	4.452	2.099 (0.070)	8.154	2.137 (.054)	8.470
Climate information	16.280 (0.999)*	1.176	-4.020 (0.016)	0.018 .	20.190 (0.999)*	5.866	20.378 (.999)*	7.083
Agro-ecology	-2.270 (0.000)***	0.103	-3.702 (0.000)***	0.21	-2.287 (0.000)**	 0.102	-2.124 (0.001)	0.120
Access to extension service	0.908 (0.230)	2.479	0.277 (0.706)	1.319	-.087 (0.897)	0.917	-.162 (0.821)	0.851

Variables	No-adaptation		Afforestation		Improving animal feed & production system		Early maturing crop varieties	
	B(S)	Exp (B)	B(S)	Exp (B)	B(S)	Exp (B)	B(S)	Exp (B)
Age	-.750 (0.304)	0.472	-.704 (0.384)	0.495	1.759 (0.086)	5.804	-.116 (0.875)	0.890
Sex	0.944 (0.76)	2.570	1.525 (0.004) **	4.594	18.702 (0.998)*	1.332	-.027 (0.970)	0.974
Education	2.104 (0.232)	8.201	2.313 (0.181)	10.110	0.18 (1.000)	1.203	5.920 (0.004)***	37.25
Family Size	-.133 (0.838)	0.876	0.933 (0.200)	2.543	-.886 (.284)	0.412	-1.212 (0.78)	0.289
Wealth	0.492 (0.465)	1.636	-1.490 (0.087)	0.225	-1.861 (.073	0.155	0.272 (0.763)	1.313
Land holding size	-40.277 (0.999)*	0.000	1.512 (1.000)	4.537	18.628 (1.000)	1.231	-37.319 (.999)*	0.000
Distance to market	2.219 (0.073)	9.202	1.604 (0.281)	4.975	-.426 (0.720)	0.653	1.114 (0.024)**	12.278
Climate information	0.423 (0.788)	1.526	0.121 (1.000)	1.129	19.221 (0.999)*	2.226	18.342 (.999)*	9.244
Agro-ecology	-2.270 (0.000)***	0.103	-22.584 (0.997)	0.000	1.352 (0.399)	3.866	3.235 (0.000)***	25.394
Access to extension service	-.263 (0.711)	0.769	-1.519 (0.011)**	0.219	0.432 (0.570)	1.540	-.005 (0.995)	0.995

N.B ***, **,* indicates significant at 1%, 5% and 10% level significance.
B(S) ---------- = significance
EXP (B) ------- = Odds ratio

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The finding from this study shows that rainfall in the district was high inter-annual and inters seasonal variability. It also indicated that Belg season rainfall was more than *Kiremt* variable. Farmer's perception was also in line with these findings and the rainfall anomaly witnessed for the presence of inter-annual and seasonal rainfall variability. Moreover, the analysis for observed historical data climate data revealed that annual rainfall has shown a declined trend, which was not statistically significant and Belg season rainfall has shown declined trend statically significant. However, Kiremt rainfall shows a non-significant increased trend and it was concentrated in the months of July and august, the rainy season was short and long dry period was the feature of Kālu district.

The current study revealed the mean annual maximum temperature was increased however; the mean annual temperature was similar for the last 3 decades. Belg season mean maximum and mean minimum temperature was increased by 3.8 and 0.6℃ respectively MK trend test result revealed that annual maximum temperature, Belg season Maximum and Kiremt Maximum temperature have been increasing significantly in Kālu district during the study periods.

The findings of the study also confirmed that from various socio-economic factors that affect farmer's perception on climate change was age; wealth, agro-ecology, distance to market; education and land size were the most significant factors.

Similarly, the aforementioned socio-economic factors were also determinant to choice of climate change adaptation options. Based on Climate Change adaptation strategies; the study revealed that wealth statuses of the farm family influence negatively and significantly the adaptations of drought tolerant crop and increase use of fertilizer and pesticide.

Land holding size education, climate information, gender of the household head had positive and significant impact on the adaptation options of drought tolerant crop, increase use of fertilizer and pesticide, rainwater harvesting and early maturing crop varieties. Soil and water conservation and improving animal production systems.

Agro-ecology; had a negative influence for the adoption of adaptation practices of rainwater harvesting, increase use of fertilizer and pesticide, and soil and water conservation practices. In general, farmers living in mid and highland agro-ecological zone perception and adaptation strategies were better than farmers living in lowland area did.

5.2 Recommendations

Based on the findings of this study the following recommendations promoted to better perception and adaptation strategies to avert the existing impacts of climate change in the study area.

- ✓ Since adaptation to Climate change is a two-step process that involves perceiving that climate is Changing and responding to change through adaptation. Therefore, most of the local community in the study area perceives most of the Climate Change indicators, however, there are still peoples' that believe in Climate change comes from God to punish the people and it is impossible to adapt. Therefore environmental education should be addressed in an integrated, mainstreaming manner and should include in national educational policy.
- ✓ Empowering local people with information and education: Creating and expanding awareness among the population ,policy makers and implementers about climate change , its causes and consequences by providing reliable and up to-to-date information to take appropriate adaptive measures.
- ✓ Build indigenous knowledge and coping strategies by stimulating traditional practices like enhancing drought tolerant and early maturing crop varieties, agroforestry, rainwater harvesting, livelihood diversification, soil and water conservation integrated pest management, organic fertilizer and other best practices.

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APPENDIX I.

Household questionnaire

The purpose of this questionnaire is to collect relevant information for academic purpose for the fulfillment of MSc degree in Climate Smart Agricultural Landscape Assessment. I Ali Jemal student in Hawassa University Wondo Genet College of Forestry and Natural resource.

Objective of this research is to critically analyze the perception of farmers on Climate Change and their adaptation mechanisms to cope up from the adverse impacts of Climate change in Kālu woreda and then to recommend possible solution. Your response is very important to the study, hence you are kindly requested to give your answer for the questions provide below. I would like to thank you in advance for your invaluable time devoted to the following questions

I. General Information

Enumerator

□

Name of Enumerator-------------------------------------signature------------------

Date ---------Ensuring completeness of the questionnaire and correctness.

II. Identification of respondent or household characteristics and Hypothetical independent variables that affect farmers' adaptation strategies

1. Woreda------------------Locality (kebele) --------------------------------

2. Name of the household head or respondent---------------------------------Age------

3. Sex of the respondent (circle) 1.male 2.female

4. Education level 1.no formal education 2. First cycle (1-4 grade) 3. Second cycle (5 to 8 grade) 4. High school (9-10 grade) 5.completd (grade preparatory), 6.Others (specify)

5. Current marital status 1.married 2. Unmarried 3.divorce 4.widowed

6. Religion of the respondents 1. Muslim orthodox protestant catholic 5. Others (specify)

7. What is your major occupation? 1. Crop production 2.animalhusbandry mixed farming If others specify-------------------------------------

8. Family size of the household by age and gender

Age	Male	Female	Total
Less than 18 years			
18-64 years old			
Greater than 64 years old			

9. For how many years you have engaged in agricultural activities? 1,5-10years 2, 10-15years 3, 15-20 4. ≥ 20 years

10. At present time do you have your own land? 1. Yes 2.No

11. If yes the size of your land in hectares---cultivated land----------grassland-----woodland---?

12. Have you get land certification for your land? 1. Yes 2.No.

13. If the answer is yes what do you feel and how are you managing? 1. I feel good and sense of ownership and manage properly 2.No change from earlier 3. I do not know

14. Number of farming oxen-------------------------cows-----------

15. Number of cattle---

16. Number of ruminant animals (goats---------sheep------------------others-------------

17. What type of grazing do you use? 1. Communal grazing land. 2. Individual grazing land

3. If others specify------- ---

18. Are you accessed to market? 1. Yes 2.No, how far it is-------km approximately

19. Do you have access to use improved production inputs and technologies? 1. Yes 2. No

20. If your answer is yes what are those inputs and technologies that you are using?

21. What is the source of information regarding weather condition? 1. Media 2.devlopmentagents 3. Others please specify

22. Are you accessed to veterinary services to your cattle? 1. Yes 2.No**23. Have** you acess to extension service? 1, yes 2, No

III. To assess perception of Climate change, causes and effect

1. Have you heard of the word climate change before? 1. Yes 2.No

2. If yes from which source you heard. 1. Radio Television newspaper 4. Family/friends

5. Extension workers 6. Others please specify

3. In your opinion, do you think that there is climate change in your local area? 1. Yes 2 . No

4. Is the weather of today is the same as the weather conditions over the last 30 years? 1. Yes 2.No

5. What are the local indicators do you use to evaluate the temperature trend?

6. What is your local indicators do you use to evaluate todays _rainfall pattern? 1. Too little rain fall 2.Too much rainfall 3.increased drought 4.erratic rainfall 5.decrease availability of water 6.decline of agricultural production 8. Loss of plant species. 9. Flood and erosion 10.If others (specify) multiple answer is Possible

7. What is the cause of climate change in your assumption? 1. Natural phenomena 2. Due to human activities 3.Both human and natural causes 4. God punishment

8. Is there change in amount of rainfall during main rain season? 1. Yes 2. No

9. Is the amount of rainfall increased or decreased? 1/ Increased 2/ Decreased 3/ No change

10 Has the timing of the onset of rain in the main season changed? 1. Yes 2. No 3.No change

11. Has rain started lately than normal? 1. Yes 2. No 3.No change

12. Is main rainy season early outset than normal? 1. Yes 2. No change

13. Is there occurrences of drought? 1. Yes 2. No

14. If your answer is yes, how is the occurrence of drought? 1. Increased 2.decreased

15. If your answer is yes within how many years it occurs? 1. Every five years 2.every ten years 3.every fifteen years 4. I do not know the exact time 5. If others (specify)

16. Is your sowing/ planting date changing due to change in the onset of rain? 1. Yes 2. No 3. I do not know

17. Does the sowing/ planting date change apply to most crops? 1. Yes 2. No 3. I do not know

18. How is the amount of precipitation from year to year? 1. Increases 2.decreases 3. No change

19. Is the amount of precipitation is sufficient for full cropping during drought Period? 1. Yes 2.No

20. Is your harvesting date is changing due to early outset of rain? 1. Yes 2.No 3/No change

21. Do you feel temperature of the area is changing? 1. Yes 2/No

22. Do you feel temperature is increasing? 1. Yes 2/No 3) No change

23. If your answer is yes for question number 22 is there any negative impact on your agricultural activities? 1. Yes, 2.No

24. Is diversity of crops changing? 1. Yes 2. No

25. Has crop diversity increased because of climate variability? 1. Yes 2/No

26. Did you encounter complete crop failure? 1. Yes 2. No

27 I s there occurrence of frost? 1. Yes 2. No

28. Does the problem is frequently occurred? 1. Yes 2.No

29. Is there an Increase problem of heavy rain, flood and hail? 1. Yes 2. No 3. I do not know

30. Is there an increase of human health problem because of climate change? 1. Yes 2.No 3.I do not know

31. If the answer is yes what kinds of human health problem did you encountered?

32. Is there an increase of livestock health problem due to climate change? 1. Yes 2/ No

33. is there weed and pest pressure due to climate change? 1. Yes 2/ No

34. Is there any alien and Invasive species of plants that affect crop and livestock production? 1. Yes 2. No

35. If yes, what kind of Animal diseases more frequently affect your animal?

36. How many livestock died in your house because of drought or climate change caused problem?

37. If you have any other about the effects ofd Climate Change please specify-------------
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iv. Farmers' adaptation strategies

1. Have you ever heard adaptation strategies to climate variability and change? 1. Yes 2.No

2. Do you think that it is possible to adapt the impacts of climate change induced- hazards? 1. Yes 2.No

3. What is your adjustment mechanism in your farming for long shifts in temperature?

4. What adjustments in your farming have you made to the long term shifts in rainfall? List below

5. Have you ever been involved adaptation strategies for the last two years? 1. Yes 2.No

6. Do you use different crops cultivation? 1. Yes 2/No

7. Do you use different varieties of crops? 1. Yes 2. No

8. If yes please explain crop varieties that you are using.

9. Did you apply short season growing crops? 1. Yes 2. No

10. If yes what are they?

11. Have you applied Drought tolerance varieties? 1. Yes 2.No 3.I do not know

12. If yes, what are they?

13. What is your copping mechanism when you encountered long period drought? 1. Selling of cattle

2. Migration to another place 3.eating seeds 4. Government support (safety net program 5/Borrowing money from relative or credit association 6. No copping mechanism

14. What are your diversity adaptation mechanisms? 1. Crop diversification 2. Growing early maturing varities 3. Improving planting date 4. Being selective in crop variety 5. Shift in cropping pattern 6/using small irrigation

15. Have you rain water harvesting structure and using it? 1. Yes 2.No

16. If your answer is yes for question number sixteen for what crop or vegetable used?

17. Do you apply improved animal production systems? 1. Yes 2.No

18. If your answer is yes for question number 17 what are the methods? 1. Decrease the number of animal stocks 2.using exotic breeds' 3.improving feeding systems. 4. Shifting from livestock rearing to small ruminants 5. If others please specify?

19. Did you planting trees by considering their role to climate change? 1. Yes 2.No

20. Are you familiar to soil and water conservation practices in your farm? 1. Yes 2.No

21. If you have any other mechanisms specify please?

22. From the whole adaptation practices that employed in your locality what are the best adaptation strategies to climate change.

List____

____

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APPENDX II

Questions for key informant interview

1. Do you feel that the temperature and rainfall of Kālu has changed in the past 30 years? Why do you think this might be?

2. Have you heard of the word climate change before? What do you know about it?

3. What do you think is the cause of climate change?

4. What local indicator can identify to evaluate the changing climate?

5. Do you think climate change affected the lives of the community? If yes how?

6. What are the major impacts of climate change up on the community, the livestock and the environment? List them.

7. Who is more affected by climate change? Why?

8. Who is responsible to give response to the changing climate?

9. What has been the responsibility of the community?

10. What were the response of government and nongovernment organization?

11. What were the limitations to give response to the changing climate on the part of the community and organization?

12. Which adaptation practices is better/best from the different adaptation practices that you have employed in the area

13. What are the factors influencing the adoption of adaptation strategies in order to adapting to the effect of climate change?

APPENDX III.

Guiding questions used to discussion of Focus Group (FGD)

1. Have you heard of Climate Change? From which sources

2. Do you agree the trend of weather is changing?

3. What is the dynamism of climatic condition in the area especially temperature and rain fall?

4. What is the cause of climate change?

5. What are your traditional/local indicators to understand if there are changes in climate? Is the occurrence of drought and/or flood if yes explain its frequency of these climate extremes?

6. How can you express the intensity of climate extremes (flood and drought)? By comparing to the scenarios 20-30 years ago?

7. Do you think that there are differences in adaptive capacity across resources groups? Explain

8. What are the major challenges to cope the potential impacts of climate change?

9. What are the major problems to perceive climate change?

10. What are the major adaptation strategies to avert the risks of livestock and crop loss?

11. Do you have access to credit? From which institutions

12. Do you have access to receive early warning information either in short term variations or long term climate change from any source?

13. Do you have sufficient knowledge about adaptation options?

14. Do you have easy access for agricultural technologies and inputs?

15. If you perceive climate change but not adapt what other barriers do you have faced?

16. Explain the major adaptation strategies that you employed?

17. Among the major adaptation strategies what are the best adaptation practices? What is the reason to be best?

18. What are the factors influencing the adoption of adaptation strategies in order to adapting to the effect of climate change?

IV: APPEENDX: Major adaptation strategies by agro-ecological zone(descriptive statistics)

Agro ecological zone	**No adaptation (impossib**			**Rain water harvesting**			**Increase use of fertilizer & pesticide**			**Soil and water conservation**		
	Yes	No	**Total**	Yes	No	**Total**	Yes	No	**Total**	Yes	No	**Total**
Lowland	15	21	36	4	32	36	14	22	36	14	22	36
Midland	9	34	43	4	39	43	34	9	43	34	9	43
Highland	15	58	73	52	21	73	56	17	73	50	23	73
Total	39	113	152	60	92	152	104	48	152	98	54	152

Agro-ecology	**Afforestation**		**Total**	**Improve animal feed & production system**		**Total**	**Early maturing crop varieties**		**Total**
	Yes	No		Yes	No		Yes	No	
Lowland	14	22	36	0	36	36	7	29	36
Midland	34	9	43	7	36	43	30	13	43
Highland	50	23	73	0	73	73	2	71	73
Total	98	54	152	7	145	152	39	113	152

Appendix-v

Results - Data Control

Missing Data

No missing data were found in the dataset. If there were any, normal ration method would have used.

Outlier detection

Graphical method was used and no outlier data was observed.

Homogeneity test

Cumulative deviation method was used.

Rainfall	R/√n
	Rainfall
January	0.67
February	0.56
March	0.64
April	0.70
May	0.68
June	0.83
July	0.84
August	0.97
September	0.67
October	0.67
November	0.61
December	0.74
Annual	0.73
Kiremt (JJAS)	0.75
Belg (FMAM)	0.84
Rejection zone R/√n is > 1.5 at 5% probability	

Double mass curve

This method requires at least five stations (assumed to be homogeneous and correlated with the test station) to test homogeneity.