FARMERS' PERCEPTIONS OF CLIMATE CHANGE AND DETERMINANTS OF CHOICE OF ADAPTATION STRATEGIES IN CENTRAL ETHIOPIA.

MSc THESIS

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A THESIS SUBMITTED TO THE

DEPARTMENT OF AGROFORESTRY, WONDO GENET COLLEGE OF FORESTRY AND NATURAL RESOURCES,SCHOOL OF GRADUATE STUDIES, HAWASSA UNIVERSTY,

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APPROVAL SHEET I

This is to certify that the thesis entitled with ‘‘FARMERS’ PERCEPTIONS OF CLIMATE CHANGE AND DETERMINANTS OF CHOICE OF ADAPTATION STRATEGIES IN LUME DISTRICT IN CENTRAL ETHIOPIA’’ is submitted in partial fulfilment of the requirements forthe degree of Master of Science with specialization in Climate Smart Agricultural Landscape Assessment, Wondo Genet College of Forestry and Natural Resource is a record of original research carried out by Sisay Girma , under my supervision, and no part of the thesis has been submitted for any other degree or diploma. The assistances and help received during the course of this investigation have been duly acknowledged. Therefore, I recommend that it be accepted as fulfilling the thesis requirements.

Professor Tsegaye Bekele	______________________	____________________
Name of Major advisor	Signature	Date

APPROVAL SHEET II

We, the undersigned members of the board of examiners of the final open defence by Sisay Girma have read and evaluated his thesis entitled "FARMERS' PERCEPTIONS OF CLIMATE CHANGE AND DETERMINANTS OF CHOICE OF ADAPTATION STRATEGIES IN LUME DISTRICT IN CENTRAL ETHIOPIA" and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfilment of the requirements for the degree of masters of Science in Climate Smart Agricultural Landscape Assessment.

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Name of major advisor	signature	date
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Name of internal examiner	signature	date
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Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the CGS through the DGC of the candidate's department

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DECLARATION

I, Sisay Girma , hereby declare that this thesis is my original work and has not been presented and submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Name: --- Signature: ------------------

DEDICATION

This thesis work is dedicated to my beloved family.

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ACRONYMS

0C	Degree Censuses
CRGE	Climate Resilient Green Economy
DA	Development Agent
ENMA	Ethiopian National Meteorology Agency
EPACC	Ethiopian Program Of Adaptation To Climate Change
FAO	The Food And Agriculture Organization Of The United Nations
FGC	Focus Group Discussion
GHG	Greenhouse Gas
GTP	Growth And Transformation Plan
HH	Household
IPCC	Intergovernmental Panel On Climate Change
IPFPRI	International Food Policy Research Institute
KI	Key Informant
MFECC	Ministry Of Environment, Forest And Climate Change
MLN	Multinomial Logit
MNP	Multinomial Probity
NAP	National Adaptation Programme
PBCM	Process-Based Crop Models
SSA	Sub-Saharan Africa
TLU	Tropical Livestock Unit
UNFCCC	United Nations Framework Convention On Climate Change
USAID	United States Agency For International Development
WMO	World Meteorological Organization

Farmers' Perceptions of Climate Change and Determinants of Choice of Adaptation Strategies In Lume East Show Zone of Oromia Nation Regional State in Central Ethiopia

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ABSTRACT

*Agriculture is a sector that dominates Ethiopia's economy which suffers from increasing frequency and intensity of climate-related disasters. In the past few years, reducing vulnerability and adapting to climate change through implementing sound adaptation strategies has become an urgent issue for the world's developing countries like Ethiopia. This study also demonstrates how farmers perceived and adapt climate change including the factor affect their choice of adaptation strategies. Data were collected from 128 Households using questionnaire and multi-stage sampling techniques using stratified random sampling in the purposively selected kebeles of the Lume district of East Shewa of Oromia region, central Ethiopia. The survey results showed that 90% of the respondent was perceived climate change and variability which is aligned with real metrological data. Changing planting calendar, Using early maturing crop variety, irrigation, using more input, using more input and engaging beyond farm activities were dominantly used adaptation strategies in the area. Parameter coefficients estimated by the multinomial logit model illustrate as most of the independent variables exhibit positive and statistically significant (P=0.05) effect on the choice of farmers adaptation. The model result showed the age of household has a significant and positive effect only on use more inputs and land management (0.158** & 0.11**). Distance from Awash River, education level and number livestock affected all adaptation strategies positively and significantly. Sex of household affected positively and significantly the probability of farmers choosing Changing planting calendar (3.49***) and Using early maturing crop variety (2.565**). In general farmers almost perceived climate change and implement different adaptation strategies based on their socioeconomically and institutional factors. For effective and efficient implementation of adaptation strategies, at farm level support could be critical. Policymakers should plan adaptation at local contexts base on farmers' socioeconomically characteristics and available institutions rather than adopting from another area at local and international levels.*

Keywords; Multinomial logit, Awash River, climate change, perception, adaptation strategies

1. Introduction

1.1.Background

Many studies have reported as climate change is real. Climate change impacts can affect all sectors and levels of society (IPCC, 2007). Impacts on natural and human systems from global warming have already been observed many land and ocean ecosystems including some of the services they provide have already changed due to global warming (IPCC, 2018). Adverse climate change impacts are considered to be particularly strong in countries located in tropical Africa that depend on agriculture as their main source of livelihood (Boko *et al*., 2007 and Tazeze and Haji, 2012).Agriculture is an important sector of sub-Saharan Africa (SSA) countries' economies, providing an incentive to accelerate poverty reduction and improve food security(Ojo and Baiyegunhi, 2019). The evidence that climate change will adversely affect agriculture in sub-Sahara Africa has become a crucial challenge for sustainable development on the continent. This challenge is composed of the likely impacts on ecosystem services, agricultural production, and livelihoods (Juana *et al*., 2013). A range of climate models suggests average temperature increases between 3 ^{0}C and 4 ^{0}C in Africa by the end of the 21st Century. This will 1.5 times the global mean which will be its impact far greater than expected (Bryan *et al.*, 2013 and IPCC 2018).

Climate change affects agriculture and agriculture also affects climate change. Many African countries have economies largely based on weather-sensitive agricultural production and are particularly vulnerable to climate change (FAO, 2016). Borona et al., (2019) agreed that as rain-fed agriculture is a sector that is highly vulnerable to climate variability and change. Africa is highly dependent on seasonal rainfall agricultural production, including access to food, in many African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020(Burton et al., 2005 and IPCC 2007). The high intra-seasonal rainfall variability and the lack of adaptive capacities are the major limiting factors for rain-fed agricultural production in smallholder farming systems across Sub-Saharan Africa (Boko et al., 2007).

Agriculture is the mainstay of the Ethiopian population and a key sector of the country's economy. Agriculture completely dominates Ethiopia's economy and any climate-change impacts on agriculture will be considered in the coming decades (Alemu and Mengistu, 2019). However, on account of climatic, social and institutional factors contributing to low production and productivity, the major factors responsible for low productivity include reliance on traditional farming techniques, soil degradation caused by overgrazing and deforestation, poor complimentary services such as extension, credit, marketing, infrastructure and climatic factors such as drought and flood this made the agriculture is unable to feed the population. These problems are further intensified by climate change (Jirata et al., 2016). The sector is dominated by small-scale mixed crop-livestock production with very low productivity (Jirata et al., 2016). Ethiopia suffers from increasing frequency and intensity of climate-related disasters: recurrent droughts, floods and erratic rainfall(FAO, 2016).which need to be adapted by appropriate adaptation strategies.

Societies in Ethiopia in general and in the study area, in particular, have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, irrigation, water management, disaster risk management, and insurance (Boko et al., 2007). In the past few years, reducing vulnerability to climate change has become an urgent issue for the world's developing countries (Burton et al., 2005a). Effective adaptation of agriculture to climate change is crucial to achieve food security in Sub-Saharan Africa (IFPRI, 2011a). In response to the recurrent droughts and related environmental disasters, farmers in Ethiopia have developed different coping strategies. "Adaptation is a process by which individuals, communities and countries seek to cope with the consequences of climate change, including variability" (Burton et al., 2005, Adger et al., 2007 and Tazeze and Haji, 2012). Adapting to current climate variability is the best initial step in preparing for future climate change. The communities in the study area have been dealing with practices of land and water management, and food losses to constitute a fundamental parts of adaptation practices (FAO, 2016).

1.2.Statement of the problem

The shreds of evidence for climate change are certain and its impacts are already being felt globally. The poorest countries are suffering more and as a result, learning how to live with these impacts is becoming a priority for human development (Asfaw et al., 2018). Particularly in Sub-Saharan Africa, climate change is set to hit the agricultural sector the most severely and cause suffering, particularly for smallholder farmers (Berck et al., 2018a).

Different studies regarding farmers' choices of adaptation options and their determinants were carried out in different countries including Ethiopia. However, most of the studies were undertaken at a macro level, which might make the results vague to generalize about specific households (Juana et al., 2013). In other hand, according to (Deressa et al., 2009a) many studies on agriculture analysed the monetary or yield impact of climate change and suggested adaptation measures but failed to indicate the factors affecting the choice of the suggested adaptation methods to have a knowledge of adaptation strategies at farm or/and household level is critical.

According to an estimation on the Climate-Resilient Green Economy (CRGE, 2011) document indicates that Ethiopia has less than 0.3% of global GHG emissions. This figure is a good guide or indictor as the country should focus on adaptation than mitigation.

Lume woreda in East Shewa of the Oromia national regional state also among districts faced climate change variability challenges in the Great Rift Valley of Ethiopia. Particularly this district experienced both flood and drought because the district is situated close to Awash River and Qoqa reserve for the hydrological dam. The *Kebeles* of the district covered by this study have a wide range of adaptation strategies which can be an input for designing appropriate adaptation strategies at the district level and national level policy. Farmers in the area used to practice mixed crop and livestock system which gives a chance to sow and study strategies in the area from different aspects and dimensions. Very limited studies were conducted in the area related to adaptation strategy and factors that govern the farmers' decision during choosing strategies for adaptation to climate change and variability. Therefore, this study was focused on the farmer's choice of adaptation strategies for variability and climate change in the area.

1.3.Objectives

1.3.1. General objective

The general objective of this study was to investigate farmer’s perception and the factors affecting choice of adaptation strategies against climate change; in the case of farmers in the Lume district of central Ethiopia to bridge this gap of knowledge in the area and guide policymakers on ways to promote adaptation.

1.3.2. Specific objectives

- ✓ Assess farmer’s perception climate change and variability in the area.
- ✓ Explore the adaptation strategies farmers have already adopted to adapt the consequences of climate change.

- ✓ Analyse the determinants of farmers' choice of adaptations strategies to climate change in the study area.

1.3.3. Research Questions

- ➢ How did farmers perceive long-term climate change and variability?
- ➢ What are the existing adaptation strategies for climate change and variability effect in the area?
- ➢ What factors are affecting farmers' choice of climate change adaptation strategies?

1.4.Significance of the Study

Knowledge of the adaptation methods and factors affecting farmers' choices enhances efforts directed towards tackling the challenges that climate change is imposing on farmers and critical in designing appropriate adaptation strategies (Deressa et al., 2009 and Adger et al., 2007). As indicated by Shinbrot et al. (2019) recently understanding kind of what adaptation strategies are used to moderate, reduce, or offset the impacts of climate change for these farmer households can help to inform future management and policy strategies.

To survive today's life and to think about tomorrow, we must have understood how we can cope with the already happened change using relevant adaptation strategies. To design and introduce different adaptation strategies, knowing existing strategies and factors driving farmer's choice toward strategies is critical, this is what this study tries to do. This information is important to promote effective adaptation strategies for climate change and variability challenges. Particularly, the findings of the research will play a great role in modelling a scientific adaptation strategy based on mere facts on the ground for long-term adaptation and mitigation. Also, it will be useful for policymakers, students and researchers.

2. Literature Review

2.1.Definition of terminologies

2.1.1. Climate change

The most broadly used definition of climate change is, as defined by the IPCC (2007), refers to "statistically significant variation in either the mean state the climate or its variability, persisting for an extended period typically decades or longer" Besides, the World Meteorological Organization (WMO) gives a wider definition of climate variability as "variations in the mean state and other statistics of climate on temporal and spatial scales beyond individual weather events"(WMO, 2015).

2.1.2. Concept of adaptation strategy

The Intergovernmental Panel on Climate Change (IPCC 2018) defines adaptation as "…adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities". Adaptation is therefore not limited to mitigating harmful effects but also includes taking up potential opportunities from changing climate patterns. The use of the term 'adaptation' has been criticized for a tone which "burdens and blames the victim" and focuses on climate hazards rather than wider underlying causes of poverty and environmental degradation (Cinner et al., 2018). Similarly, Khan and Roberts (2013) argued that international climate policy has focused on adaptations which are added to the ongoing adjustments to changing environmental or societal pressures, meaning a focus on technical solutions, and a lack of attention to local knowledge and wider social or environmental causes of climate change(McKendry, 2016). As motioned by (Kabubo-Mariara and Mulwa, 2019) Adaptation framework built around four major principles which are short-term climate variability and extreme events, adaptation levels in society, policy ad measures and stakeholder.

2.1.3. Perception

Difficult to get globally agreed definition of the term. Also on review paper done on farmer's perception by Soubry et al., (2019) mentioned that as getting consistence definition of the term is difficult. However review by described some of definitions used frequently by so far published paper such as "farmers' perceptions as observations of weather and climate events which have been made over a period of time and which can then be applied to adaptation strategies" and "the process of receiving information from the surrounding It environment and transforming it into physiological awareness". Other researchers suggest perceptions to be "practical knowledge rising from concrete situations" (Chérif et al., 2016). Still others consider them inseparable from local knowledge (Juana et al., 2013). In the paper set, farmers' perceptions could affected by social and cultural factors (Ogalleh et al., 2012) or they could be entirely objective (perceiving that rainfall had increased or decreased, as in (Ayeri et al., 2012).

2.1.4. Adaptive capacity

Different authors give varies definition of the term which have some intersection between each other. It represents the pre-conditions that reflect the learning, and the flexibility to experiment and adopt innovations in response to a broad range of challenges is suggested definition by (Kangogo et al., 2020). (Khan and Roberts, 2013) defined adaptive capacity as an attribute of management that creates opportunities for learning and provides the ability to experiment, adapt, and foster novel solutions in complex social–ecological environments. More precisely, Walker et al. (2004) present adaptive capacity as the ability of actors in a system to influence resilience. This follows that the higher the adaptive capacity within a system, the higher the probability that the system will be resilient to climate change. Accordingly, Cinner et al. (2018) identified five domains that are necessary in building adaptive capacity for resilience. These are the assets that people can draw upon in times of need, the flexibility to change strategies, the ability to organize and act collectively, learning to recognize and respond to change, and the agency to determine when and how to change. Additionally, past research showed that an actor's adaptive capacity is shaped by interacting processes that occur at multiple scales, including membership in FOs and farmer–buyer relationships (Kangogo et al., 2020).

2.2.Climate Change in the Context of Ethiopia

Climate change is the worldwide environmental threats that seriously have an emotional impact on agricultural productivity and which affects humankind in several ways, including its direct influence on food production (Enete and Onyekuru ,2016.) Africa is one of the parts of the world that is the most vulnerable to the impacts of climate change (IPCC, 2014). The impacts of climate change across Africa will vary: At mid- to high latitudes, crop productivity may increase slightly for local mean temperature increases of up to 1 to 3 °C, while at lower latitudes crop productivity is projected to decrease for even relatively small local temperature increases (1–2 °C) (IPCC,2007).

The historical climate record for Africa shows warming temperature of approximately 0.7°C over most of the continent during the twentieth century; a decrease in rainfall over large portions of the Sahel (the semi-arid region South of the Sahara); and an increase in rainfall in east and central Africa (Juana et al., 2013).Ethiopia is highly affected by climate change due to three main reasons; (i) about 80% of the population is largely dependent on rain-fed agriculture (ii) low-income country (iii) varied geographical locations with different magnitude of climate impacts. Climate change-induced El-Nino increases the average temperature and affects rainfall patterns in time and space leading to a recurrent drought which results in food insecurity particularly in dry and semi-dry areas of the country.

The country has experienced 16 major national droughts since the 1980s, along with dozens of local droughts (Alemu and Mengistu, 2019). Recently in 2015/16 10 million peoples, in 2017 5 million peoples are food insecure, as a result of drought caused by climate change-induced El Nino (Alemu and Mengistu, 2019). In Ethiopia climate change is already taking place now, thus past and present changes help to indicate possible future changes. Over the last decades, the temperature in Ethiopia increased at about 0.2–0.37 °C per decade (Aragie, 2013). The increase in minimum temperatures is more pronounced at roughly 0.4 °C per decade (IPCC, 2014). The temperature will very likely continue to increase for the next few decades with the rate of change as observed (Aragie, 2013 and IPCC 2014a). The average annual volume of rainfall over the past 50 years (from 1951–2000) remained more or less constant for the whole country (NMA 2001). Many authors agreed that mean annual rainfall showed a slightly decreasing trend and higher year to year variation was observed in 1950–2010. However, rainfall distribution across the country shows a marked difference.

There is a tendency for less rain to fall in the northern part of the country where there is already massive environmental degradation. The same trend can be observed in the southeast and northeast of the country which is both often affected by drought. However, in central Ethiopia where most of the population and the country's livestock are located, and where the soil is severely depleted and degraded, more rain is falling. The western and North-west parts of the country have also received more rain (Aragie, 2013).

Farmers and pastoralists are experiencing that the rain is becoming more unpredictable or is failing to appear at all. In some places, the rain falls more heavily and the degraded soil is unable to absorb this ran which falls over a shorter period. According to (Soubry et al., 2019), the farmers in the central part of the country have lost up to 150 tons of soil per hectare. The rise in temperature and fluctuations in rainfall create many problems for the pastoralists who live in the already drought-stricken areas which are receiving less and less rain. They have already switched from cattle to goats and camels, as they are more able to endure long periods of drought. In the central part of the country, more rain will mean further erosion of the soil and lower crop yields for smallholder farmers and lead to flooding in the more low lying areas. Climate change is affecting how long the farmers have to grow their crops. Besides, warmer weather provides better growing conditions for pests and other diseases that attack crops and destroy the farmers' harvests (Deressa et al., 2009).

Therefore, it is possible to conclude that not only the rainfall distribution that has changed but it has also become warmer in the last 60 years. Hence, there is already a great demand for improved seed which is more drought and pest resistant, and for seeds that mature faster as the rains have become more unpredictable and shorter in some places. Today the forest covers are very low (less than 10%), so the soil has become more vulnerable to erosion. People cut down the forest to create more farmland and to harvest firewood for cooking. Population growth will put pressure on the already degraded soil, and marginal plots will be brought into use which worsens the situation (Deressa et al. 2008).

2.3.Climate change impact on agriculture

Sub-Sahara Africa is among the most vulnerable continents or regions to climate change impacts, because the majority of the sub-Sahara African population lives in abject poverty, and are heavily dependent on rain fed agriculture for their economic and livelihood sustenance (Juana et al., 2013). Agriculture remains vital to the economy of most African countries, employing more than 60% of the population and contributing to about 25% of the GDP; its development has significant implications for food security and poverty reduction in Africa (World Bank, 2008; ACET, 2017 and Tesfaye et al., 2019).

Agriculture is the main sector of the Ethiopian economy. It contributes about 52% of the GDP, generates more than 85% of the foreign exchange earnings, and employs about 80% of the population (Deressa et al., 2009). However, climate-related risks and variability will continue to have far-reaching consequences for the agricultural sector in Africa, affecting resource-poor and marginalized smallholder farming communities who depend on agriculture for livelihood (Tesfaye et al., 2019). The recently issued Assessment Report 5 of the Intergovernmental Panel on Climate Change (IPCC,2018) states that negative impacts of climate trends have been more common than positive ones worldwide this also indicated by (Stocker et al., 2019.). Climate change has been affecting the agrarian communities in different ways particularly confusion on planting dates due to unpredictable nature of the rainfall, forced to stop irrigation activities due to a shortage of water, reduction in crop yield, forced to travel along distance in search of water and reduction in the productivity of domestic Animals (Asfaw et al., 2018).

Although climate change may affect the agricultural sectors of different countries in different ways, what is clear is that these changes will bring about substantial welfare losses, especially for smallholders whose main source of livelihood derives from agriculture (Berck et al., 2018b). Climate change is therefore recognized as the leading challenge to the performance of the agricultural sector threatening global food security and we need to generate suitable climate-smart agricultural technology along with appropriate adaptation strategies by the farmers to mitigate the adverse impact of climate change (Raghuvanshi and Ansari, 2019).

2.4.Adaptation strategies toward climate change and variability

Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities(IPCC, 2018 and Deressa *et al*., 2009a). This term described by Temesgen *et al*., (2017) as adaptation is the term used to describe all activities aimed at preparing for or dealing with the impact of climate change, bet it at the level of individual households, community, and firms, or of entire economic sectors, watershed and countries.

According to IPCC 2007 report adaptation strategies are not a new concept, Societies have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, irrigation, water management, disaster risk management, and insurance. However, it not practiced in the same fashion across the globe. At a global level, several individuals and a combination of strategies are implemented. As a result different type of strategies is used in local and farmers attribute context. Socio-economic characteristics of smallholder farmers refer to their human qualities that could enhance their agricultural production and climate change adaptation. These attributes also assist in getting a rich understanding of the behaviour of these farmers which may give a clue towards explaining their disposition that could bring about an increase in production and adaptation to prevailing climatic conditions (Alih *et al.*, 2019).In response to perceived long-term changes, farm households implemented several adaptation measures, including changing crop varieties, adopting soil and water conservation measures, harvesting water, planting trees, and changing planting and harvesting periods (IFPRI, 2011b). A wide range of adaptation options are available to reduce the risks to natural and managed ecosystems (e.g., ecosystem-based adaptation, ecosystem restoration and avoided degradation and deforestation, biodiversity management, sustainable aquaculture, and local knowledge and indigenous knowledge), the risks of sea-level rise (e.g., coastal defense and hardening), and the risks to health, livelihoods, food, water, and economic growth, especially in rural landscapes (e.g., efficient irrigation, social safety nets, disaster risk management, risk spreading and sharing, and community-based adaptation) and urban areas (e.g., green infrastructure, sustainable land use and planning, and sustainable water management)(IPCC, 2018).

However, current and future climate change trends no allow society to survive with what strategies used for adaptation so far. Even if global society tries to cop the change though exciting strategies, they are not well used in the communities which safer the climate change and variability. A study conducted in the Nile basin of Ethiopia by (IFPRI, 2011b) indicates that 58 percent of farmers took no action to adapt to long-term shifts in temperatures, and 42 percent took no action to respond to long-term shifts in precipitation. More than 90 percent of those respondents who took no action to adapt cited lack of information and shortages of labour, land, and money as the major reasons. Adaptation measures that also consider climate change is being implemented, on a limited basis, in both developed and developing countries. These measures are undertaken by a range of public and private actors through policies, investments in infrastructure and technologies, and behavioral change (Adger et al., 2007).

2.5. Factors determining framers choice of adapting strategies

A different study finds that farmers choice for adaptation strategies against climate change and variability is strongly affected by different factors (Taye & Global, 2010, Bryan, Deressa 2009, , Tazeze and Haji, 2012, Fosu-Mensah et al., 2012 and Bryan et al., 2013). There are individuals and groups within all societies that have insufficient capacity to adapt to climate change (Adger et al., 2007). The result from the multinomial logit analysis shows that sex, age, and education of the household head, family size, livestock ownership, farm income, off/non-farm income, access to credit, distance to the market center, farmer-to-farmer extension, agro ecological setting, access to climate information, and extension contact have a significant impact on choice of climate change adaptation method (Tazeze and Haji, 2012).

Another study conducted by Bryan et al., (2009) in Ethiopia and South Africa find that shortage of land and lack of credit/money respectively are the most factor affecting the adaptation strategies choice of farmers. In Ethiopia shortage of land was reported by 27 percent of respondents as a major constraint to adaptation, while lacking information (23 percent), lack of credit/money (21 percent), shortage of labor (8 percent), and lack of access to water for irrigation (3 percent). Also from review finds that no inform factors that determined Farmer's choice across the globe even it is different at the farm level (Bryan et al., 2009). This study Also tries to generalize the components determine farmers a choice in four categories (1) the characteristics of the stress, (2) the characteristics of the system, including the cultural, economic, political, institutional and biophysical environment, (3) multiple scales, and (4) adaptive responses.

2.6.Farmer's perception of climate change and variability

Scientific evidence, research shows that the general population cannot readily distinguish Changes in seasonal weather patterns from climate change(Makate et al., 2017). For making agriculture sustainable and resilient to unpredictable weather threats, assessment of household perception is a prerequisite to understand local needs and concerns and to streamline them within the rural developmental framework(Singh et al., 2019). Over the past 20 years, considerable efforts have been invested in exploring how the public understands climatic change in Europe and North America, but little is known about perceptions of climate change in developing countries(Singh et al., 2019)

However, according to the African Technology Policy Studies Network (ATPS) study around the Blue Nile, There is a growing understanding that climate variability and change pose serious challenges to development in Ethiopia (2013). Previous analyses (Kahsay et al., 2019; Makate et al., 2017; Singh et al., 2019; Soubry et al., 2019) have found that variables associated with socioeconomic status, production systems, and social capital can affect farmers' awareness of the climate change phenomenon. Individual farmers' characteristics (age, level of education and training, and experience in farming) can play an important role in the development of the perception of climate change. (Amanuel et al., 2019 and Ngoe et al., 2019.) Found a negative relationship between age and climate change awareness, while Hansen et al. (2004) reported a negative impact of age on the perception of the usefulness of weather forecast information for decision-making.

2.7.Household Vulnerability to Climate Change

Vulnerability is the degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity(Borona et al., 2019). Vulnerability varies widely across communities, sectors, and regions. This diversity of the "real world" is the starting place for a vulnerability assessment. The current vulnerability can be expressed as the conjunction of the climatic hazards, socio-economic conditions, and the adaptation baseline (Burton et al., 2005a). There are recent studies conducted to understand farmer's vulnerability to climate change for instance study made in two districts (districts) in East Shewa of Oromia Ethiopia by Taye and Global, (2010)on farmer's vulnerability.

Social vulnerability to climate variability is a key aspect in determination of vulnerability to climate change. According to survey conducted by Taye and Global, (2010) in Lume and Adama districts Estimates show that about 62 percent of the households are observed to be poor during the survey. Computed using 0.5 as a threshold above which a household is called vulnerable, about 68 percent of the households are also vulnerable to poverty during the coming year. An attempt to show the sources of vulnerability indicates that about 52 percent of the households are vulnerable to poverty due to low consumption mean and about 16 percent of them are vulnerable due to high consumption volatility. Moreover, the study has attempted to track the correlates of household vulnerability to poverty by assuming household vulnerability is linearly related to household and environmental characteristics.

It was observed by many studies as household head's age and education level, land size, livestock size, proximity to roads and market reduce household vulnerability to climate change, whereas family size and experiencing shocks tend to increase household vulnerability to climate change. Use of inputs such as fertilizer and extension services, access to irrigation and non-farm income also reduces household vulnerability to poverty(Borona *et al.*, 2019 and Tesfaye *et al*., 2019).

The particular importance to this study was that all climate and environment-related factors are found to affect household vulnerability to poverty. For instance, an increase in mean seasonal rainfall above the long-run average reduces household vulnerability to poverty, whereas an increase in mean minimum temperature above long-run average increases household exposure to poverty. Moreover, the nature of the soil is also related to vulnerability to poverty. Sandy loam soil was found to reduce household vulnerability to poverty but Vertisols tend to aggravate household vulnerability to poverty. On the other hand, the use of one or more adaptation method was found to reduce the incidence of the vulnerability of households (Kahsay et al., 2019).

2.8.Estimating factor governs farmers' choice of adaptation strategies.

There are different methodologies used for survey and estimation of farmer's choice adaptation strategies based on different drivers. There are models used to estimate factors affect farmer choices such as multinomial logit (MNL), multinomial probit (MNP) process-based crop models (PBCMs) binary response model and others. However, most of the studies) utilized multinomial logit (MNL) model its simplicity and relevancy (Tazeze & Haji, 2012, Fosu-Mensah et al., 2012, Bryan et al., 2009 and IFPRI, 2011a).

The analytical approaches that are commonly used in adoption studies involving multiple choices are the multinomial logit (MNL) and multinomial probit (MNP) models. Both the MNL and MNP are important for analyzing farmers' adaptation decisions like these are usually made interchangeable (Tazeze and Haji, 2012). The main difference between the probit and logit models lies in the assumption of the distribution of the error term. The error term is assumed to have the standard logistic distribution in the case of the logit, and the standard normal distribution in the case of the probity model (Bryan *et al*., 2009).

The multinomial logit model has been the most commonly used model for the analysis of discrete choice data. MNL computes a different continuous latent variable for each choice, and these variables are like evaluation scores of each individual for each choice the higher the score, the more likely that the individual chooses that alternative (Kropko, 2008).

3. Materials and Methods

3.1. Description of the Study Area

3.1.1. Geographical Location

The study was conducted in Lume district, East Shewa of Oromia national regional state central Ethiopia. Lume woreda (district) is located 77 kilometer southeast of capital Addis Ababa. Geographically Lume district is situated at 8° 35' 0''N and 39° 10' 0''E. The total area of Lume district is 709.85 km^2. Lume is bordered on the south by the Koka Reservoir, on the west by Ada'a Chukala, on the northwest by Gimbichu, on the north by the Amhara Region, and on the east of Adama. Particularly *kebeles* where this research conducted situated where Mojo River joined Awash River at the koka reservoir.

3.1.2. Topography and Climate

Most of this district range in altitude from 1500 to 2300 meters above sea level, except for a small portion in the northern part, which is over 2300 in altitude. The study area is mostly kola (70%) and the rest (30%) is Woina Dega *(*Dry Mid-highlands*)*. The rainfall pattern of the study area shows high variability. The variance of long-run average annual rainfall is 365mm, indicating high variability from year to year. The long-run average rainfall computed for the last 30 years was around 1000mm. In the study area, the long-run average maximum and minimum temperatures are 28.86 and 13.59 degrees Celsius, respectively. The variability of maximum and minimum temperatures is 0.935 and 0.726 degrees Celsius, respectively. The deviation of maximum and minimum temperature from the long-run average is not as high as that of rainfall, but there are fluctuations around long-run averages that affect crop production. The major soil type in the study area is sandy loam, which covers 50 percent of the woreda. Vertisols and Andosols also cover a significant portion of the land, 7 and 23 percent, respectively, of the study area (Taye and Global, 2010).

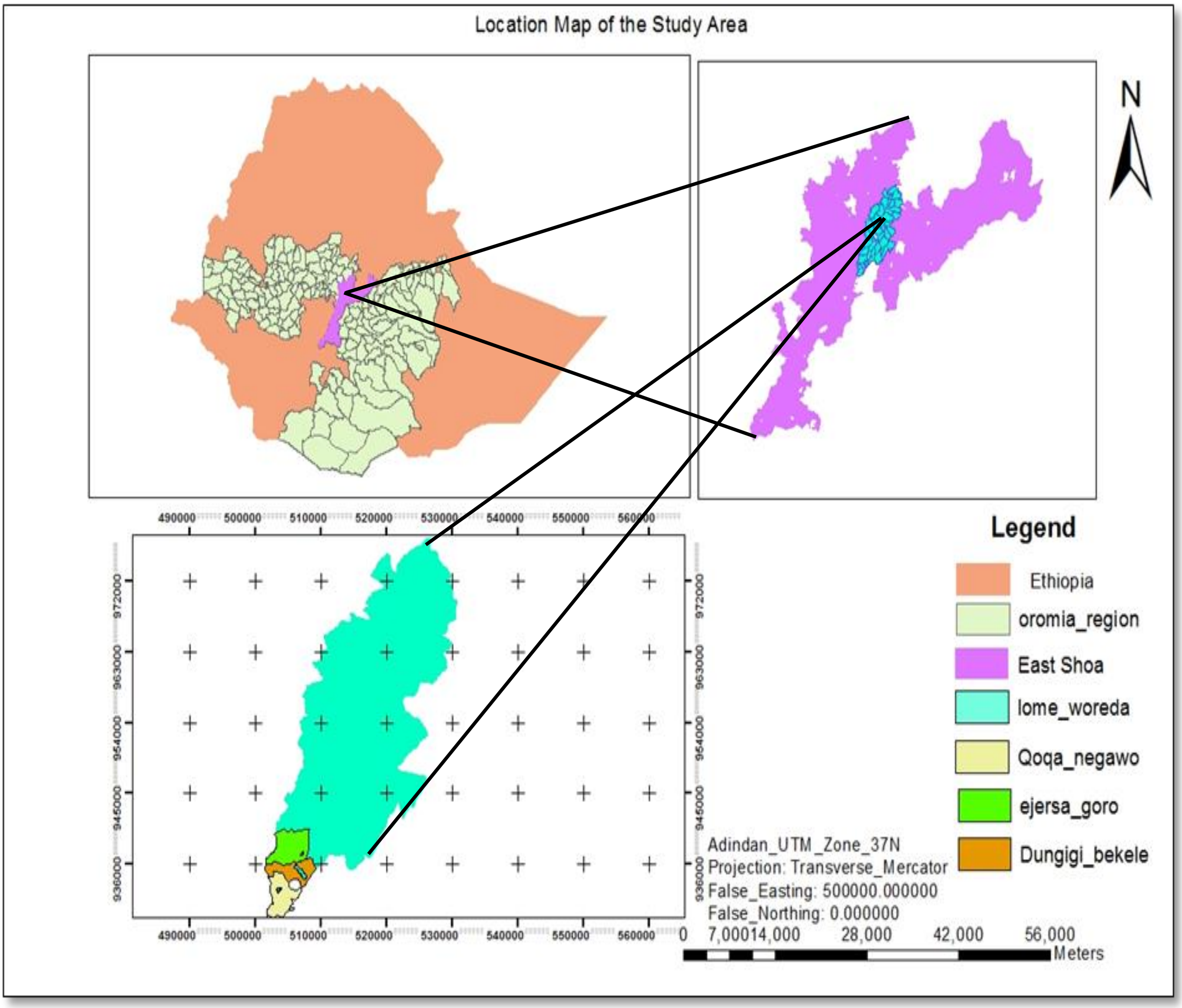


Figure 1 Map of the study area

3.1.3. Socio-economic and land use

The 2007 national census reported a total population for this district of 117,080, of whom 60,125 were men and 56,955 was women; 38,771 or 33.06% of its population were urban dwellers. However, for this study number households particularly in *kebeles* where the study was conducted obtained from respective *kebeles* administration offices. Accordingly 727, 878 and 842 was number of households in Ejrsa-joro, Dungigi-bekele and Qoqa-nago *kebeles* respectively. The average family size in the district is 5.91 persons per household, which is comparable with the regional level number of 5 persons per household and particularly closer to East Shewa zone number of 5.13 persons per household. A survey of the land in this district shows that 54.3% is arable or cultivable, 3% pasture, 2% forest, and the remaining 20% are considered degraded or otherwise unusable(lume wored agricultural office 2019). Households in the study area are engaged in crop production and rearing of livestock as their primary activity. The sample households mostly keep animals like oxen, cows, sheep, goat, donkey, poultry, etc. In the surveyed area, Crop production is conducted only during the main rainy season that runs from May to September/November. Apart from those who have access to irrigation, all the farmers' households produce once in a year. Vegetables such as tomato, onion, cabbage, and watermelon are an important cash crop. Also, the district is known for its teff production (Taye and Global, 2010).

3.1.4. Vegetation

The natural vegetation in the area is highly degraded and sparsely located only around the periphery of rivers, valleys and steep slope areas which is not suitable for crop cultivation. On most of the plain areas on which crop cultivation is dominant, *Acacia albida, A. tortilis, A. seyal, A. nilotica, Croton macrostachyus, and Ziziphus mauritian*a are scattered along the farm plots which are the main components of agro forestry type of agricultural system with crops. They provide shade for crops and livestock, fuel wood, improve soil fertility and used for the fence.

3.2. Sampling techniques and sample size

3.2.1. Primary Data

3.2.1.1.Household survey

The study has been undertaken in the Lume District (woreda) of the East Shewa zone of Oromia regional state of Ethiopia. A multi-stage sampling procedure was used to select the study district, *kebeles* and sample households. In the first stage, the district was selected for this study based on affect by climate change like recurrent drought and erratic nature of rainfall. According to Taye & Global (2010), farmers in the district have practiced climate change vulnerable mixed crop and livestock livelihood in different extremes of climate change (both drought and flood because of Awash and Mojo River).

In the second stage, three peasant associations or *kebeles* were selected purposely out of the 35 total *kebeles* in the district based on their situation such as degree of vulnerability, distance from Awash and Mojo River as well livelihood type. Namely Dungigi Bekele, Qoqa Nago, and Ejersa joro *kebeles* or peasant associations were selected. Finally, 128 HHs were selected from 3 *kebeles* proportionally based on their wealth category using a stratified random sampling technique. The sample size for the survey was computed based on Kothari (2004) using the formula indicated in equation (equation 1).

The household survey was conducted from Feb 16 till March 24, 2019, in selected *kebeles.* After the list of HHs was collected from respective *kebeles.* offices which shows wealth status and the village of the HHS. The total sample size distributed proportionally to villages based on the contribution of the village household's number to total household number in the *kebeles.* After sample size was determined at the village level proportionally the samples were distributed further based on wealth status to the village.

Stratification of HHs was done based on their wealth status using the information obtained from the respective *kebeles* administration office with the help of the DA and village coordinators. To triangulate and cross-check the accuracy of the data obtained from each kebele was used to stratify the HH wealth status through the information obtained during FGD was used to categorize the wealth status of the HH. Both data from the *kebeles* and information from FGD mainly use landholding size and livestock numbers for the wealth category. The study by Makate *et al*, (2016) also stated and used the major assets of a given community as criteria for determining wealth class vary. Agricultural land is an important source of livelihood and indictor of wealth in rural areas.(Alemayehu and Bewket, 2017) As indicated in the table

(table1) HH for survey distributed for the sample frame using a stratified random sampling technique.

Table 1. Characteristic used to determine wealth category of the household

Wealth category	Respective criterion
Rich:	Own > 2ha (8 kert in local unit) and/or 6 or more livestock. They could have a milk cow, one or more calves and one or more pairs of oxen for ploughing. They may have donkey, sheep and/or goats. They are able to purchase agricultural inputs (fertilizer, artificial chemicals and improved seeds).
Medium:	Own $1<X \leq 2$ ha of farmland and having one pair of oxen and donkey. They are also able to afford the costs of fertilizer and improved seed.
Poor:	Owing 0.25 to 1 ha of land. They may/may not have one pair of oxen. But they are unable to purchase agricultural inputs (fertilizer and improved seed). So they commonly borrow loans from the government to have fertilizer and improved seed. They also spend their time on other off/non-farm activities to secure their income like fishing.

However, there was an exception for some farmers especially farmers under the rich and medium category. Some farmer have destocked their livestock especially oxen because they use a rental tractor for ploughing. Also, those farmers rent large size of land to produce vegetables (onion and tomato). So the main criteria used by kebele expertise and participant of FGD by considering the exception.

$$n = \frac{Z^2 * N*p*q \ \ldots}{e^2(N-1)+Z^2p*q} \quad \text{……………………………. **equation 1**}$$

where 'n' is the desired sample size, 'N' is the total targeted population, 'Z' is the standardized normal deviation set at 1.96–95% confidence level, 'p' is the estimated proportion attribute that is not present in the population (1 − p) (.5), at .05 alpha level. Of a (.5), 'q' is the estimated proportion of an attribute that is present in the population and 'e' is degree of accuracy required normally set.

Table 2. Sample frame and sample size

Kebeles name	Total household	Percent to total household	Sampled household	Percent to total sample HHS
Ejras-jorro	727	29.7	38	29.7
Dungigi-Bekele	878	35.9	46	35.9
Koko-nago	842	34.4	44	34.4
Total	2447	100	128	100

3.2.1.2.Key Informant Interview

A key informant interview was conducted to gather information on adaptation strategies and perceptions of climate change from knowledgeable persons in the community. Representatives who have enough and long experience of agriculture was selected as a key informant. Key informants selection was taken by DAs and head of kebele administer based on a checklist (annexe3) prepared to select KIs. 24 key informants were interviewed for this study which includes 2 DAs and one model and one experienced framer for each village in all selected *kebeles*. 2 DAs work at *kebeles* levels so they are common for all 3 villages in the same *kebeles* which made 8 number of the key informants at kebele level. The interview was made with key informants using a checklist attached as annex at the end of this document. Farmers selected for key informant interviews were interviewed using a checklist about the way they perceive the long term climate change and variability.

National events such as regime change, election and others were used as time benchmark to help the respondent farmer recall. Also, the respondent was asked about the problem faced because of the change and the way they try to adapt the change using any adaptation strategies including local innovation.

3.2.1.3.Focus group discussion

For all selected *kebeles* there were FGDs which consists a group of 9, 9 and 11 in Ejrsa-jorro, Koka-Nago and dungig-bekele respectively. Participant of FGD including farmers from 3 villages in *kebeles* diversified interims of both sex and age as well as development agents and agricultural experts. The discussion focused on long term climate shift and short term variability and impact on their farm. The discussion also includes the strategies they used to adapt the change and variability. FGD output used to structure the survey questioner in a local context by understanding the way they are use terms about climate change and adaptation strategies. FGD result was used to triangulate crosscheck data from primary and secondary sources.

Figure 2 photo during FGD discussion with selected farmers at kebele level

3.2.2. Secondary Data

Both primary and secondary data sources were used to collect qualitative and quantitative data for this study. Primary data were collected as indicated above from sample households survey, key informant and focus group discussions in the district by preparing and distributing semi-structured questionnaires through the interviewing method. Time series rainfall and temperature data were collected from the National Meteorological Agency (NMA) and the HHs list indicates their wealth status including village from where HH has been taken from respective *kebeles* administration offices are the secondary data sources for this study. Also data from district agricultural office were used about general information of the district. Secondary data sources have been an important source of information for this study to compare farmer's perceptions about climate change and variability with the real climatic data.Time series rainfall and temperature data was collected from the National Meteorological Agency (NMA).

3.3. Data analysis techniques and model specification

After data were edited, coded and entered into Stata 13, then analysed using descriptive statistics, percentage, and weighted average mean index, Chi-square, and t-test. Chi-square test and t-test were applied to see associations and differences between adopters and non-adopters over different attributes. Determinants of adaptations were estimated using a multinomial logistic regression (MNL) model.

Multinomial logit (MNL) and multinomial probit (MNP) are common analytical approaches used in many studies on farmer's adaptation decisions. These approaches are also appropriate for evaluating alternative combinations of adaptation strategies, including individual strategies (Waongo et al., 2015, Tazeze & Haji, 2012, Bryan et al., 2009, Kropko, 2008 and Di Falco & Veronesi, 2013). For this study, MNL was utilized to analyze drivers of farmer's adaptation strategies choice. The multinomial logit model has been commonly used model for the analysis of discrete choice data (Alemayehu and Bewket, 2017; Alih et al., 2019; Asfaw et al., 2019, 2018 ,Rashid & Charles, 2008, Waongo et al., 2015, Tazeze & Haji, 2012, Fosu-Mensah et al., 2012, Bryan et al., 2009, and IFPRI, 2011). Multinomial Logistic Regression is the regression analysis to conduct when the dependent variable is nominal with more than two levels. Similar to multiple linear regression, multinomial regression is a predictive analysis. Multinomial regression is used to explain the relationship between one nominal dependent variable and one or more independent variables (Kropko, 2008).

As described by Tazeze & Haji, (2012) using an MNL model has an advantage because of its computational simplicity in calculating the choice probability that is an expression in analytical form. Choice probabilities in an MNL model are relatively simple, and computers can maximize the resulting likelihood function almost instantaneously, even for a large number of choices. In the context of maximum likelihood estimation, a choice probability is a formula to predict the probability that an individual chooses a certain alternative and the likelihood function for such models is the product of the choice probabilities for each individual (Kropko, 2008). The main limitation of the model is the IIA property, which states that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Tazeze & Haji, 2012).

The household decision of whether or not to undertake adaptation strategies for climate change was considered under the general framework of utility or profit maximization (Asfaw et al., 2019; Ojo and Baiyegunhi, 2019,Deressa et al., 2008; Norris and Batie, 1987). It will assume that economic agents such as households used adaptation options only when the perceived utility or net benefit from using a particular option will significantly greater than in the base category. In this context, the utility of the economic agents is not observable, but the actions of the economic agents could be observed through the choices they made. Supposing that Ui and Uj represent the household's utility for two choices, i and j respectively, the linear random utility model could then be specified as follows: The multinomial logit model has been the most commonly used model for the analysis of discrete choice data. MNL computes a different continuous latent variable for each Choice, and these variables are like evaluation scores of each individual for each choice: the higher the score, the more likely that the individual chooses that alternative. So for each choice j and individual i

$U_{ij} = \beta_j x_i + £_{ij}$………………………………………………………… 2

4. Results and Discussions

4.1. Socio-economic characteristic of HHs

According to information obtained from respective *kebeles* administration offices in the study area there are 2447 households. Out of 2447 HHs, 128 HHs were considered for the HHs survey in the study area. The household survey, respondents were 18(14.1%) and 110(85.9%) female and male, respectively. The average respondent age was 49.24 years with a minimum of 35 years and a maximum of 72 years with 9.134 estimated standard deviation. Estimated Mean Family size from the survey was 6 with a minimum of 2 and a maximum of 11 persons. The average HH size in the study area was almost the same with east Shewa zone mean HH size which was 5.5. From sampled HH 81.3% (104) are married, 7% (9) are divorced and 11.7% (15) are widowed. The percentage of illiterate was 38.5% as estimated from the survey as well as respondents attend formal school was 29.7%, 21.9% and 10.2% 1-4 grade, 5-8 grade 9-12 grade, respectively.

The other basic parameters used by *kebeles* experts and the local community (as discussed during FGD) which was adopted for this study which determine or express economic status or wealth category of HHs in the study area is landholding size and number of livestock's (cattle's). Especially the size of land that can be irrigable is basic sub-parameter from the total landholding size of the HHs for expressing HHs economic status. The landholding size in the study area was not significantly different across the villages when compared using the average HH landholding size. However, there is a significant difference in irrigation land size across *kebeles* and from one HH to the other. Finding from the survey indicate (Table 3) that the average landholding size in the area is 4.5ha with maximum value 10.25ha and minimum value 0.75ha and the average tropical cattle equivalent (TLU) is 9.2. Accordingly using the data about landholding size and number of cattle from totally surveyed HHs (128) the proportion of wealth status is 44(34.4%) rich, 45(35.2%) medium and 39(30.5%) poor.

Table 3 farmland size in the study area

Source: Own survey

	N	Minimum	Maximum	Mean	Std. Deviation
homestead	128	.25	1.00	.6195	.25233
cultivation	128	.50	6.00	3.0625	2.02324
private grazing	128	.00	.50	.1094	.17954
woodlot	128	.0000	.2500	.015859	.0578421
irrigated land	128	.00	3.00	.7003	.84277

The dominant livelihood type in the study area is crop production (figure 4) as it is ranked first during the survey by 124 respondents with mixed livestock production as it ranked secondly by 90 respondents. Vegetable production especially using irrigation is significantly ranked third by 62 respondents. Also, other livelihood types are practiced in the study area such as off-farm and non-farm haves share in the area.

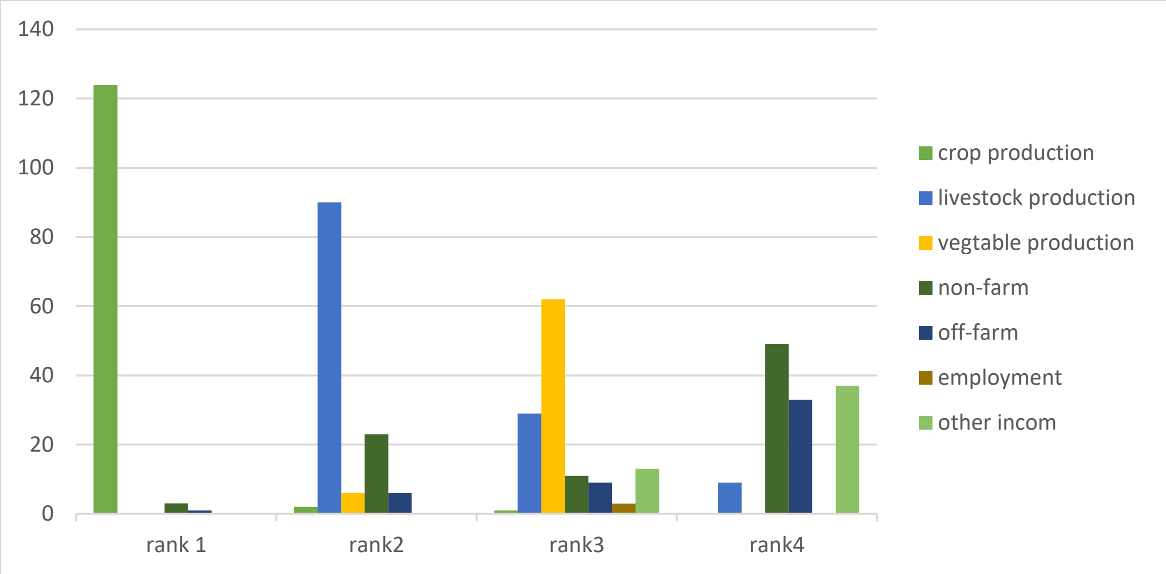


Figure 3 chart indicate summarized livelihood type proportion in the study area

Source: Own finding

4.2.Farmer's perception on climate change and variability

To understand the perception towards climate change and variability at a household level in the study area, respondents were asked if he/she observes and/or sensed any long and/or short term change on the climate system. The question was asked in multistage first as general about the climate system and next, particularly on precipitation and temperature. The result is summarised in the next table 4. In general, almost all respondents felt the change and agree that as climate has become unpredictable. During the HHs survey, around 90% of the respondent perceived long-term change and 10% of the respondents answered the open question as they didn't felt any change or as the term is new to them. The results agree with research done in Tigray Ethiopia by (Kahsay et al., 2019) and also with other research findings like (Asfaw et al., 2018 and Alih et al., 2019). The results on perception towards climate change and variability were deferent during respondents give answers for open-ended and close-ended questions as indicated in table 4.

Table 4. Summary of farmer's perception toward climate change and variability

		Frequency	Percentage
Have you sensed any climate change?	No	13	10.2
	Yes	115	89.8
Temperature change	No change	9	7
	increasing number of hot days annually	115	89.8
	Unpredictable	4	3.2
Precipitation change	No change	17	13.3
	Changed	111	86.7
	Unpredictable	95	74.2

Source: Own survey

Farmers believed as there is long term or/and short term change when answering questions regarding a change on specific climate parameter (precipitation and temperature) than a general question. Mainly agree on the change in terms of pattern in the other words farmer mainly believe that climate and weather conditions are unpredictable in the study area.

Farmer's perception of change and variability of precipitation was summarized under three categories (no change, changed & unpredictable). The categories of response were not mutually exclusive because farmers understood the change in rainfall in different ways. Some farmers believe as there is no change in the amount of rainfall but they all agree as the pattern becomes unpredictable and others felt as the rainfall amount changed (decreased) significantly also as it becomes unpredictable. Based on this, around 86.7% of respondents felt a change in precipitation and believe it is unpredictable. Other respondents that are about 13.3% didn't perceive a change in climate conditions. Hence, some of them agreed that climate conditions as the pattern have become unpredictable.

Long term change and/or variability on temperature was perceived by 90% of respondents in the study area. As discussed during FGD and key informant interview farmers in the study area understood temperature change as increment of number of hot days annually and daily temperature. As indicated in table 4 findings from the survey illustrate that temperature is less unpredictable than rainfall. Based on the FGD and key informants' temperature is more predictable than rainfall because it has only increment trend and the study area has a long dry season.

Farmers' self-reported climate perception is not sufficient to generalize about the actual trends of climate change and variability in the area. Their perception of climate change is highly personal, site-specific, and influenced by several factors. Therefore, it helps compare farmers' climate change perception and the actual meteorological data in the study area to recommend the right adaptation strategies(Kahsay et al., 2019). The results from the survey regarding farmer perception towards climate change and variability in the study area were compared with the actually observed rainfall and temperature data of the study area was obtained from Ethiopian National Meteorology Agency (ENMA 2019). This comparison was used to understand the actual climate trend and to evaluate the ability of farmers to perceive the real change in the study area. Accordingly to get and indicate the climate trend in enough time frame or time serious climate data recorded for the study area from 1987 to 2018 was used. To illustrate the climate trend annual mean value was used. Annual mean values for both temperature and precipitation were calculated using the data from Ethiopian National Meteorology Agency (ENMA) which recorded on daily basis data after monthly mean calculated summarized.

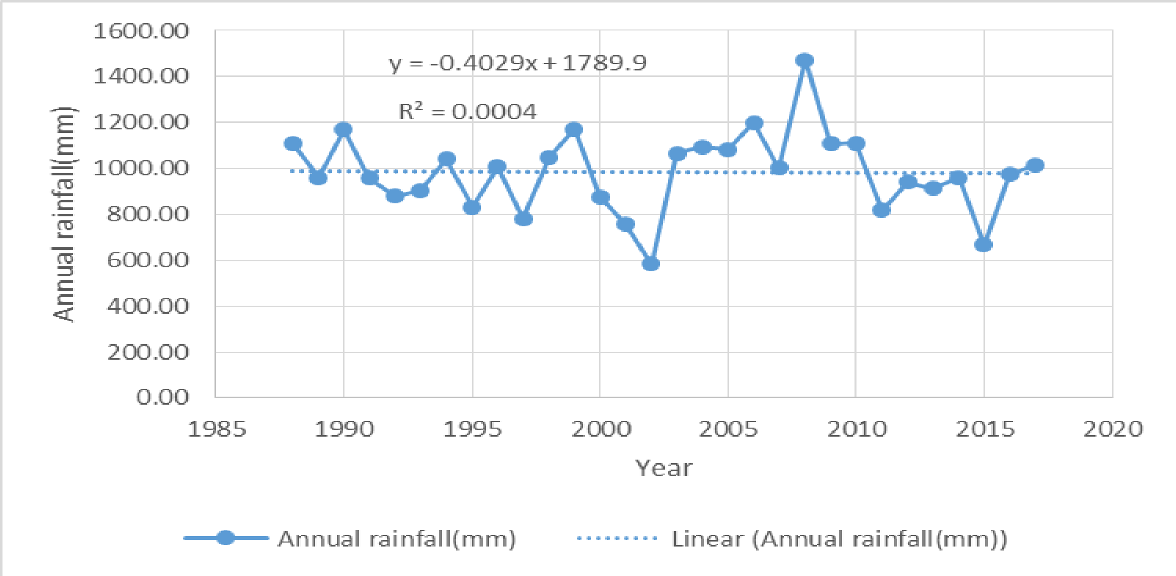


Figure 4 chart indicate summarized annual rainfall for 30 years of the study area

Source: Own summary

The results indicate that there was a slightly decreasing trend on annual precipitation since 1987 with strong variability (R^2 =0.0004). This result confirms as the perception of farmers towards long term change on precipitation mainly most respondents (74.5%) agree that the rainfall in the area became unpredictable in the other word it was variable indicated in figure 5

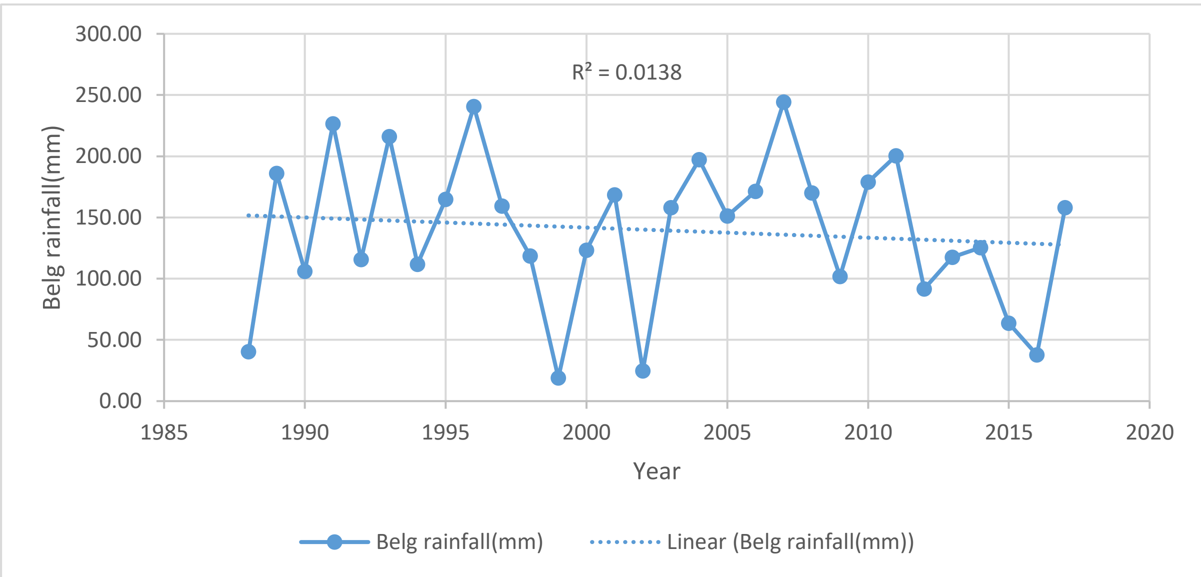


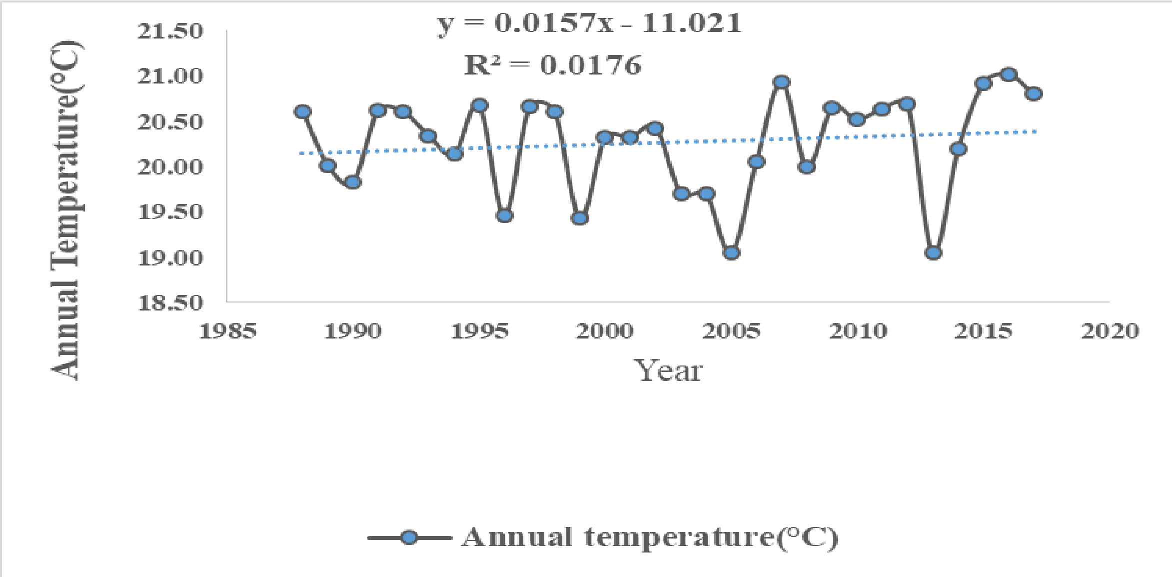
Figure 5 chart indicate summarized Belg season rainfall for 30 years of the study area

Source: Own summary

Climate trend more and strongly changed in belg season interims of amount and variability. This also perceived by farmers as they mention during FGD, Key informant interview and HH survey. FGD participants discussed that they almost stop cultivating or producing crops during belg season due to a significant reduction amount and unpredictability of rainfall. Meteorological rainfall data analysis was also in line with farmers' perception of rainfall decline. Generally, data from Ethiopian National Meteorology Agency (ENMA) also confirmed that what perceived by local farmers as there was a significant reduction of rainfall in the belg season. The rainfall reduction was unpredictable and significantly fluctuated as indicated in chart 6 with the value of R^2 =0.00138.

The temperature was the other climate parameter were discussed during FGD and key informant interview as well as computed from the survey. Accordingly, most of the respondent in the area have perceived an increasing trend on temperature (Table 4). As regarding the precipitation, it is necessary to know whether farmers' perceptions are consistent with real temperature. If their perceptions deviate from fact, then there is a risk that they might not respond at right times when they should be responding with appropriate adaptation strategies. Data from Ethiopian National Meteorology Agency (ENMA 2019) also indicate an increasing trend on the temperature in the study with significant variability (R^2=0.0176) chart below. This finding also agrees with the findings of (Kahsay et al., 2019, Berck et al., 2018b and Karienye et al., 2019) as most farmers perceived a long term climate change that observed on actual climate data recorded for almost the last three decades.

Farmers' perceptions about climate change and its adverse impact on agriculture is critical for implementing mitigations and adaptation strategies. Risk perception is social phenomena that express the relationship between risk objects (farmers) and the object at risk (agricultural productivity).



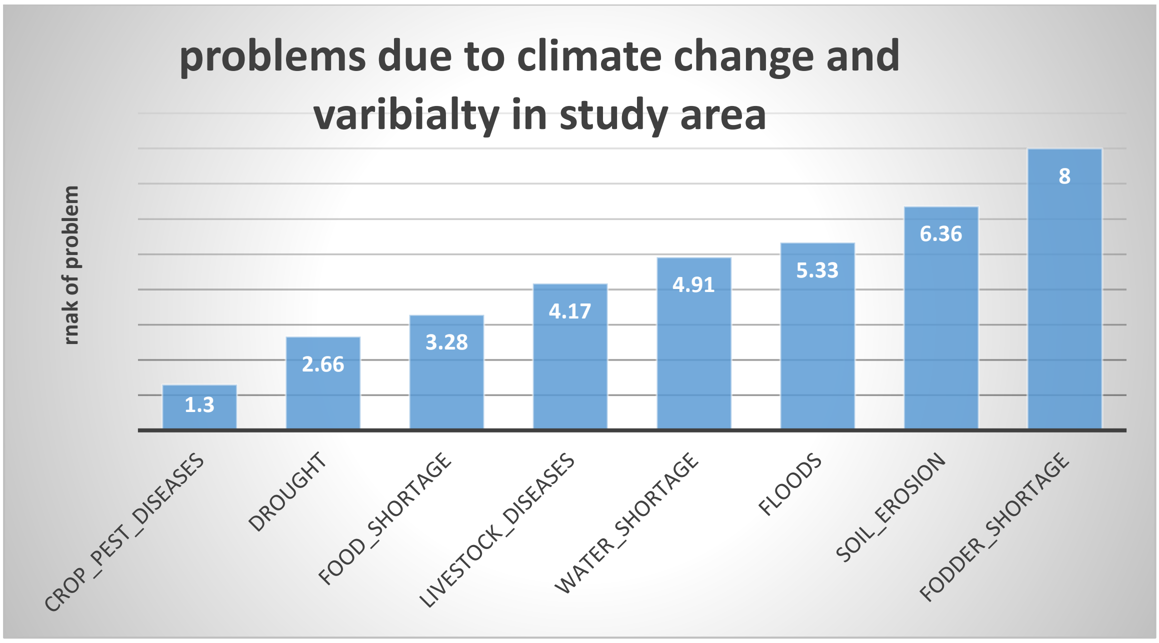
Source: Own summary

Figure 6 chart indicate summarized annual temperature for 30 years of the study area.

Sound and accurate measurements of farmers' perception about the risks and uncertainties associated with climate change and its adverse impact on agriculture will, therefore, help in undertaking appropriate mitigation measures and adaptation strategies (Raghuvanshi and Ansari, 2019).

4.3.Problem attributed to climate change and variability and Adaptation strategies in the study area.

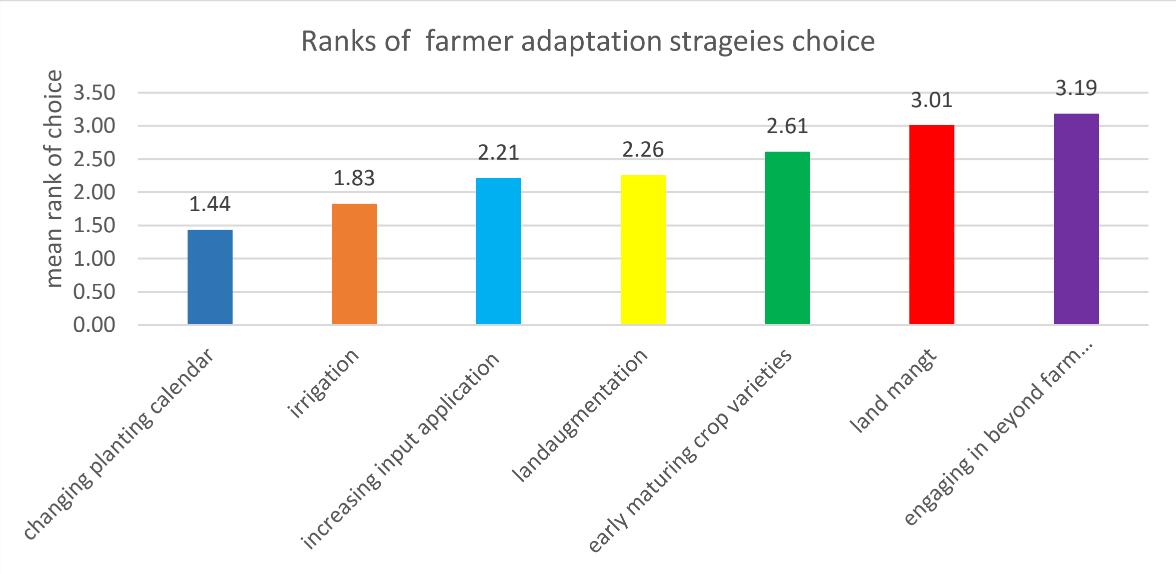
Several studies have identified a lot of problems due to climate change and variability enforces farmers to adopt adaptation and mitigation measures. To understand well adaptation strategies in the area looking at common challenges experienced by farmers is critical. During FGD, discussants identified problems in the area those attributed to climate change and variability are crop pest & diseases, drought, livestock diseases, water shortage, flood, soil erosion, fodder shortage, food shortage, and others. Accordingly, respondents asked to rank from frequently faced to list faced problems from the total (8) identified problems during FGD which has a strong linkage with climate change and variability based on their experience.



Source: Own survey

Figure 7 chart indicate frequently faced problems by farmers in the study area

Choices are ranked by calculated overall average ranking score accordingly the Crop-pest and diseases are the main problems happened in the area so far as it was ranked first by the respondent with mean rank 1.3 and the least ranked problem is fodder shortage with the mean. This implies also as discussed by FGD participants even if the crop failed due to crop pest and disease or other problems crop residue used as fodder for cattle or they move there livestock's to intensively irrigated area around Awash River to use cash crop residues. The secret why fodder shortage ranked last because most of the farmers in the area have culture storing or stockpiling crop residue especially teff residue which can be used for more than one and a half years. The drought was the second most mentioned problem in the area. The rank indicated by figure 8 show the general finding by study. But some problems pronounced at different magnitude between *kebeles* and the difference extended at village level. For instance crop-pest- diseases ranked first in village farmers practice irrigation based farm than farmers practice rain feed crop production. In the other way round livestock diseases mentioned by farmers who don't have access water.



Source: Own survey.

Figure 8 adaptation strategies identified by the survey in the study area.

Available adaptation strategies at the global and local levels were identified from literature including methods recommended and suggested by an international institution at different time and place. The frequently used adaptation strategies in study area were identified during FGD discussion and key informant interview as well as during the HHs survey. Then the proportion of application was analysed from the survey. Adaptation strategies applied in the study area were not mutually exclusive because particular farmer uses different adaptation strategies together on a single plot of land or/ and different strategies on a different plot of land otherwise different strategies on the same plot of land at a different time and others.

Most of the adaptation strategies identified in the study area were mentioned by many publications the way they implemented in different parts of the globe. However, adaptation strategies in the area not implemented exactly as applied for other areas instead farmers adopt those measures in the local context. The set of activities in each climate change and variability adaptation strategies discussed as follows.

Changing planting calendar: - Climate variables are determine the potential agricultural yield of farmers. Climate variables are also important in determining what crops to grow and when they are planted(Ojo and Baiyegunhi, 2019). Changing the planting dates and crop varieties (categorized under the agronomic adaptation strategies) were implemented and ranked as the primary adaptation respondents(Asfaw et al., 2018). In the study area farmer use the strategy in different ways at the different plots of land or/and at different times. Mainly farmers implement this measure when they are not sure about the starting period of rain so they divide and sow/plant the crop at different times of the rainy season to maximize probability. For example, if the farmer has 1.5ha of land then he/she plant/saw 0.5ha on the beginning of the season next to the other 0.5ha after two or three weeks after the first plantation and the remaining 0.5ha will be planted on the middle of the season. This helped the farmer if the rain comes at early and stop early will get good production from land planted/sawed at the beginning of the season and the other way round also true. Farmers also used this measure by adjusting the planting/sawing date based on the first drop of rain, However, waiting for the raindrop have a risk for the farmer who has a large size of land to plough the land in short period of time. As a solution farmers in the area use mechanized farming practices (rent tractors).

Irrigation: - This adaptation strategy in the study area is the second option used by farmers in the study area especially in the villages that have access to a water source (groundwater, Awash River and Mojo River).Because most farmers agreed as rain becomes unpredictable, they use irrigation to income diversification by producing vegetables in the adaption to rain feed crop production. Also, farmers used irrigation for a crop such as maize and beans which are planted/sawed during beleg season (short rainy season) or when the rain stops early or/and farmers used irrigation at the begging of keremt season (the main rain season) and when if the rain does not start early. Farmers in the study area also used irrigation to fill the long gap if the rain was not evenly distributed during the rainy season.

Increasing agriculture input or/and Land augmentation: - The finding of the survey indicated that most respondent's ranked first pest and disease first among problems due to climate change variability in the area. Since pest and disease are the main problems in the study area farmers use more inputs like insecticides and pesticides to increase productivity in the face of problems associated with climate change and variability. Farmers use more fertilizer to increase the ability of the plant and used more pesticides and insecticides than usual to withstand the problem of pests and diseases newly merging pests and diseases. Land augmentation is the method was applied in the study area to farmers increasing and decreasing the size of land based on the anticipation or prediction of weather next cropping season. Farmers in the area also increased to be used under irrigation to increase crop productivity under the stress climate change or/and variability.

Using early maturing crop variety:- Among strategies implemented to adapt climate change and variability was discussed during FGD and key informant interview as well as identified during HH Using early maturing crop variety is the one. This strategy the more implemented strategies as described in many publication which means it practiced in the same fashion like the part the world.

Land management practices

During the HH survey was conducted there were campaigns of soil and water conservation practices at kebele levels. This was a great opportunity to discuss the practices in-depth and the implication on climate change and variability adaptation strategies. Practices like stone/soil bund, check dam and related physical and biological land management practices were considered under this strategy(Asfaw et al., 2018). So farmers mentioned that they used these practices to reduce the loss of water and soil by runoff due to heavy rainfall after a prolonged drought. Framers in the area applied soil bund and terrace to reduce runoff which brought sedimentation to their farm or erode fertile top soil from their farm.

Engaging beyond farm activities

In the study area farmers as one way of adaptation strategy, they engaged many activities as income diversification because crop production did not generate enough income to support families as a consequence of climate change and variability. Common activities practiced as climate change adaptation and variability by farmers in the study area are charcoal production, fishing, employment in industries and flower farms and women are sell manure as fuel.

4.4.Determinants of farmers' choice of adaptation measure.

Common socio-economical characteristics of the farmers that affect farmer's choices of adaptation strategies are age and sex of the HHs head, economic and educational status of the HH, the size and composition family, the livelihood base of the HH, kebele and access to water sources, access to weather information and credit and general perception toward climate change are variables were used for this study.

Before running the actual MNL model all possible HHs socio-economical characteristics were tested if they have generally effect on farmers decision to take measure of adaptation may or may not using chi-square (X^2) test and t-test for nominal and counties variables respectively. To examine the proportion of adopters in terms of the attributes of respondents, disparities were observed and the Chi-square and t test results confirmed statistically significant associations and differences between adopters and non-adopters based on different attributes. For nominal independent variables X^2 were computed to understand how those variable significantly affected the expected value with effect size which indicate the magnitude of the effect impose by independent variables on dependent variables.

Table 5 chi-square and affect size result independent variables on dependent variable.

		frequency(N) take measures		frequency(N) take measures		Chi-square ($x^{2)}$	effect size
Variable	Description	yes	no	yes	no		
kebeles	Ejresa_joro	25	13	19.5	10.2	17.45***	0.369***
	dungigi_bekele	38	8	29.7	6.3		
	koka-nago	44	0	34.4	16.4		
Sex	female	4	14	3.1	10.9	57.5***	0.670***
	male	103	7	80.5	5.5		
Education status	illiterate	29	20	22.7	15.6	34.59***	0.520***
	1-4 grade	37	1	8	8		
	5-8 grade	28	0	0	0		
	9-12 grade	13	0	0	16.4		
wealth status	Rich	44	0	34.4	0	36.9***	0.537***
	Medium	42	3	32.8	2.3		
	Poor	21	21	16	14.1		
Marital Status	Married	94	10	73.4	7.8	40.7***	0.564***
	Divorced	9	0	7	0		
	Widowed	4	11	3.1	8.6		
access to credit	Yes	77	17	60.2	13.3	2.348**	0.135
	No	19	1	14.8	8		
	I don't want	11	3	8.6	2.3		
perception on CC	Yes	107	8	83.6	6.3	73.7***	0.759***
	N0	0	13	0	10.3		
information availability	yes	10	3	7.8	2.3	8.737**	0.261**
	sometimes	33	0	25.8	0		
	no	64	18	50	14.1		

As indicated in the table 5 all HH attributes expect "access to credit" has strong effect on independent variable (P<0.01). Even "access to credit" significantly different from expected value with X^2 result 2.348 (P<0.05) however, the effect size on dependent variable not significant at all 5% significant level. So all nominal independent variable was used in the MNL model expect access to credit.   .

T-test was used to compere the mean of continues independent variables under the category of dependent variable (take measure or not).The purpose of conducting t-test was to identify continues independent variables with strong significant affect (P=0.05) on dependent variable then to select continues independent variables could be used in MNL model.

Table 6 T-test result continues independent variables on dependent variable.

Source: Own survey

take measure		N	Mean	Std. Deviation	t-test value	P-value
HH Head age	no	21	44.52	7.319	2.649**	0.009
	yes	107	50.17	9.199		
TLU	no	21	4.9952	3.20132	5.369**	0.004
	yes	107	10.0617	4.07990		
TLUS	no	21	2.3738	.87072	3.516***	0.000
	yes	107	4.4399	2.65742		
family size	no	21	5.5714	1.12122	1.192	0.236
	yes	107	6.1308	2.08808		

A test for continuous independent variables indicated that all variables expect family size have significant mean differences along with the dependent variable. After both nominal and continuous independent variables were selected for the MNL model using results from both chi-square(X^2) and t-test was executed. The MNL, however, works under the assumption of the Independent Irrelevant Alternatives (IIA). Following this assumption, the odds of any two outcomes are independent of the remaining outcomes available. Hence, omitting or adding outcomes should not affect the odds of the remaining outcomes). The fitted MNL model was first checked to make sure that it does not violate this assumption by running the model with and without some variables.

Table 7. Summary of MNL mode output on estimation coefficient parameter

independent variables	changing planting calendar	irrigation	engaging beyond farm	early maturing variety	land management	use more inputs
Kebele	1.72***	0.96**	3.12***	1.27**	2.59***	1.27**
wealth status	-2.36***	-2.9**	-2.83***	-2.29**	-5.3***	-3.43
HH head age	0.066	0.11	0.294	0.025	0.1583**	0.11**
sex	3.49***	18.33	18.33	2.565**	18.33	18.33
education level	3.57***	3.47**	2.60**	3.30**	3.70**	3.10**
TLU	0.5273***	0.6711**	0.4272**	0.5589***	0.3734**	0.6714***
TLS	0.3071	0.4967**	0.5041**	0.3352	0.9076***	0.6349**
perception	19.84	19.84	19.84	19.84	19.84	19.84
Information availability	0.7652	0.1940	0.88	0.7652	-0.4368	0.566
Marital Status	-1.0009***	-0.62673**	-7.2130	-0.7263**	-7.2130	-0.09055**

Source: Own survey

Table 8 summary of marginal effect of independent variable on dependent variable from MNL mode output

independent variables	changing planting calendar	irrigation	engaging beyond farm	early maturing variety	land management	use more inputs
kebele	0.11	-0.797	0.068**	-0.012	0.0832**	-0.011
wealth status	0.738	-0.07378	-0.0226	0.041	-0.06	-0.096
HH head age	-0.000948	0.0085**	-0.00288	-0.00518	0.0062**	0.0046
sex	0.188**	0.209**	0.0818**	0.0071	0.099***	0.12**
education level	0.09**	0.006	0.0325	0.027	-0.0639	-0.023
TLU	0.0024	0.0272**	-0.0076	0.0054	0.0137	0.0016**
TLS	-0.2484**	-0.0074	0.0248**	0.02138	0.0089	0.0266**
perception	0.3***	0.199**	0.0782***	0.13**	0.0956***	0.012***
information availability	0.927	0.0397	-0.0665	-0.0432	0.0317	0.0152
Marital Status	-0.07314	-0.02259	-.0.0345097	0.01328	-0.02823	-0.01705

Source: Own survey

Age of the household head

The findings from the HH surveys showed that Age of the household head in the study area ranged from, 35 years to 72 years with 9.134 estimated standard deviation. To check if there was a significant average age difference between adopter and non-adopter of adaptation strategies towards climate change and variability, a T-test was conducted. Accordingly, an independent sample t-test showed that as there was a significant difference (at P=0.009) between the mean of the adopter and non-adopter age. These result shows experiences affect a farmer's choice of adaptation to climate change. After a t-test was conducted this independent variable was used in econometric model multinomial logit (MNL).

The model output indicated that the age of the household head was determined whether the HH adopt or not adaptation strategies to adapt climate change and variability. The age of the household head showed a significant effect especially on the possibility of the farmer to choice land management and use more inputs than not adopting any strategies. Also, the marginal effect result of the model shows for each year increment on the HH age will increase the probability of the HH adopting irrigation and land management will increase significantly by 0.0085 and 0.0065 respectively(at P=0.05). The result of the study conducted by(Sadiq et al., 2019) agree with the finding of this study. Ngoe et al., (2019) also found that perception of climate variability is directly proportional to the age of the farmers and older respondents are more efficient in perceiving climate variability than the younger respondents so indirectly support the finding of this .study. However, these results of this study do not support the finding of (Ojo and Baiyegunhi, 2019) who suggested that younger farmers are more likely to choose adaptation strategies than older farmers.

Distance from Awash River and koka reservoir

Access to water in the other word kebele where the respondent lives or the distance of his/her farm from Awash River, Mojo River and koka reservoir determined farmer's choice of adaptation strategies.. The selected kebeles have a different level of access to Awash River and its tributary Mojo River as well as koka reservoir. Among those kebeles, the first kebele is koka-nago has access for all indicted water sources including ground water and the second kebele is dungig-bekele has to access for koka reservoir and partly mojo river including ground water the third kebele Ejers-joro has no access any of indicated water source. From the total households selected for survey 29.7%, 35.9% and 34.4% were selected from Ejrsa-joro, Dungigi-bekel, and Koka-nago respectively based on the contribution for the total population in the study area. After this, independent variables that affect the dependent variable were checked by the chi-square test then MNL mode was excited.

The chi-square test result indicates that the observed result significantly (P<0.001) deferent from expected results when checked along with the independent variable also the effect size significant (P<0.001). Parameter estimated by the multinomial logit model indicated that as the possibility of the farmer choosing one adaptation strategy form the set of strategies than being not adapting significantly affected by kebeles where the farmer lives in. Choosing all adaptation strategies that significantly affected than base outcome conduction which was "no adopting" (table 7).

Since kebeles where the farmer lives in strongly determine the ability of the farmer to access water sources as it was strongly linked with adapting strategies related to water mainly using Irrigation. The results from the model showed the effect of kebeles where farmers live in. Having access to the reliable water source was among the factors which influenced the adoption of irrigation positively. This result in similar to the findings by other studies such as Asfaw et al., 2018,Sadiq et al., 2019 ,Temesgen et al., 2017 and Alih *et al*., 2019.

Wealth status

Wealth status selected as the independent variable for this study because it comprises many parameters (income, ability to purchase input, using technologies and others) that determine the ability of the framer to choose climate change adaptation strategies. For this study, HH was selected proportional based on wealth using a list from respective *kebeles* and cross-checked during FGD. The wealth status of the households surveyed has a positive and significant (P=0.05) impact on all adaptation strategies expect land management (table 7). The marginal effect after multinomial logit showed that there is significant probabilities increment by 0.096(P=0.05) for a unit increase in wealth status for adopting using more input. The study that conducted by (Deressa, 2007)found that the farm income of the households surveyed has a positive and significant impact, using different crop varieties, and changing planting dates. However the find by Deressa (2007) argue on the significances effect wealth status choosing conserving soil. Since the adaptation strategies required many agricultural inputs and renting adaption farm land showed significant probabilities increment when compered from poor to rich. When the main source of income is farming and the amount of land for farming is limited, farmers tend to invest in productivity by increasing the land size they cultivate through additional land rent and using more agricultural inputs. Asfaw et al., (2019) mention that engaged in small-scale business would have the capital required to purchase agricultural inputs which agree with this result.

Sex of the HH head

Gender (Male headed) of households are more likely to get information about new technologies and undertake risky businesses than female-headed households(Alih et al., 2019).According Temesgen et al., (2014)The sex of HH head determines the ability and capacity to adapt climate change variability though taking the measure. Also, the report released by IPCC (2007) about the assessment of adaptation practices indicate that as women in subsistence farming communities are disproportionately burdened with the costs of recovery and coping with drought. From the total HHs selected for this survey around 110(85.9%) was male headed and around 18(85.9%) was women headed. chi-square test was conducted to check the significant difference between the observed result and expected results including the effect size on the dependent variable. The chi-square (X^2=17.45***) and effect size (0.369***) results showed as dependent variable significantly different ($P<0.001$) along with this variable. After the chi-square test, MNL analysis was executed.

Then, the estimated parameters for farmer's gender were positively significant across changing planting calendar and using early maturing crops (3.49***) and (2.565**) respectively. This implies that the gender of the farmers had a strong and positive influence on farmer's choice of choosing to plant early maturing crops and changing planting calendar. The marginal effect result after MNL mode indicates that the odds of choosing changing planting calendar, planting of early maturing crops, irrigation, land management, use more inputs and engaging beyond farm as adaptation measures increases by a factor of 0.188**, 0.0017,0.209*** 0.099***, 0.0818**, and 0.12*** for a unit change in gender respectively. These results agree with a study by(Alih et al., 201, Asfaw et al., 2018; Deressa et al., 2009a and Ojo and Baiyegunhi, 2019) that found that the sex of household head significantly influenced adaptation to climate change.

Marital Status

Farmers marred in the other word headed by men have the ability or probability adopting climate change adaptation than widowed. Their result of the model in table 7 showed negative value for estimative parameter coefficient and this didn't imply that negative effect of this variable. The negative sigh implies the data coded 0, 1 and 2 married, divorced and widowed in, respectively. This means the smallest value assigned from married. Marital status exhibits positive and significant ($P<0.001$) effect on changing planting calendar with estimated parameter coefficient -1.00 and using early maturing varieties, irrigation and engaging beyond farm activities affected positively and significantly(P=0.05) by marital status with estimated parameter coefficient 0.626,0.7206 and 7.213 respectively. Marital status affects negative and significant on use more inputs with the estimated parameter coefficient 0.9055. The estimated marginal effect after running the MNL model showed the increment of the probability of farmer choosing all adaptation strategies than non-adopting for each unit increment of marital status statistically at a significant level of 5%.accoring to Alih et al. (2019) this variable has a strong linkage with the sex of HH head and family size. Which means the effects observed by sex and family size on the choice farmer's adaptation strategies are associated with the effect of this variable. The other thing related with this variable is number of relative. Having more relatives in the got is also positively related to the likelihood of adoption of most of the adaptation methods, although the coefficients are not statistically significant (Temesgen et al., 2014.). The implication of this result is that social networks increase awareness and use of climate change adaptation options.

Education level

The educational status was significant across the use of all adaptation result with, 3.47, 2.60 3.30, 3.70 and 3.10 early maturing variety, land management, irrigation engaging beyond farm activities and use more inputs respectively statistically significant at 5%. Only changing planting calendar statistically significant at 1% with an estimated parameter 3.57. This implies that the educational status of the farmers had a strong influence on the farmer's choice of choosing the use of climate change and variability adaptation strategies. Also indicate that as educational level of the farmer the ability of adjusting the farming system with season strong by changing planting calendar. This result supports the finding by (Temesgen et al.,2014., Asfaw et al., 2019 and Alih et al., 2019). An estimated marginal effect after MNL logit parameter estimation implies that changing planting calendar increase by 0.09 for every unity increment in education level at a 5% significance level.

Farm Size

The total farm size the other independent variable which exhibits a significant difference between averages of the dependent variable. Finding from the survey indicate that the average landholding size in the area is 4.5ha with maximum value 10.25ha and minimum0.75ha. The consequence of this variable on the dependent variable checked by the t-test. Accordingly, the t-test shows the significant difference of mean between adopter and non-adopter of climate change and variability significantly different from expected at 1% (P<0.001) with an estimated value of t-test result 3.51 which shows the effect size of this variable on dependent variable. After the relevance checked by the t-test MNL model was performed to estimate parameter and marginal effect. The result from the model shows that as farm size has positive and significantly affect along all adaptation strategies expect to change planting calendar and using an early maturing variety. This implies farmers who have large size of farmland face a difficulty to change planting calendar since changing planting date required too much work force in given time. This result support a finding by (Alemayehu and Bewket, 2017) which shows farm size was not a significant variable for adaptation by change planting calendar and using an early maturing variety. Farm size displays a positive effect with 1% significance on land management and at 5% on the rest adaptation strategies practiced in the study area. During FGD participant mention that farm who have small farmland didn't will to adopt land management particularly which take share from the land area. Estimated marginal effect indicates that there negative and significant change on changing planting calendar with estimated value -0.2484**for each unity increment on farm size. The choice of the changing planting calendar adaptation strategy was influenced by farm size and it shows the relationship being significantly positive.

Number livestock's

According to Deressa et al., (2009a) the ownership of livestock is also positively related to most of the adaptation options, even though the marginal impacts are not significant. The finding from the survey also shows as the mean tropical livestock unity (TUL) in the area is 9.2 with 2 minimum and 17 maximum**.** T-test indicates there is a significant difference mean TLU between the one who takes measure and not to adapt climate change and variability. The number of livestock per HH in tropical livestock unity affect significantly the choice of HH adaptation strategies. Accordingly, the parameter coefficient estimated by MNL model shows a number of livestock has a significant effect on all adaptation strategies included in this model at a 1% significance level (changing planting calendar and using more input) and the rest at a 5% significance level. For each unity of increment has 0.0272** and -0.0166** marginal effect on irrigation and use more inputs respectively at 5% significant level. The study conducted by Asfaw et al., (2019) mentioned that as a unit increase in herd size decreased the tendency of using use more inputs which is contradict with the finding of this result. This finding of this research also agrees with studies Alih et al., (2019) and Temesgen et al., (2014.).

Perception of farmers on climate change

Perception of framer towards long term climate change and short term variability among independent variables used MNL mode to determine whether they affect farmers' choices of adaptation strategies to climate change and variability. After the Chi-square test was conducted the relevance for the model checked the variable incorporated into the model. Accordingly, the mode parameter coefficient showed perception on climate change has a positive effect on farmer choice adaptation strategies equally than no-adapting but the effect does not show any significance. However, the estimated marginal effect of perception on climate change showed positive and significant increment on the probability of all adaptation strategies than being not taking measure for the unity of increment on perception on climate change at 1%($P<0.001$) significant level. The study conducted around blue Nile by Temesgen et al(2014) found that decreasing precipitation which perceived by farmers in study significantly increases the likelihood of using soil conservation, changing crop varieties, changing planting dates, and irrigating which strongly supported by this study. The result of this study also supported by Kahsay et al., (2019).

Access to weather Information

Around 64.1% of the respondent didn't access weather information, 25.8 of them get information sometimes and 10.1% of the respondents have access to information. During chi-square test access of information along the dependent variable result was significant (X^2 =8.737**) with significant effect size (0.261**). Based on the chi-square test results this variable access to information was entered into MNL mode to estimate its effect on the farmers' choice of adaptation strategies and the marginal effect each adaptation strategy. The result showed that access to information effect on farmers' choice of adaptation strategies to climate change and variability was not significant. In general access of information implies positive effect changing planting calendar, using early maturing variety and engaging beyond farm activity this is agree also with the study conducted by (Deressa et al., 2009a). On the other hand access to information implies a negative effect on land management and irrigation. However, both negative and positive effects exhibited by the access to information on all available adaptation strategies were not significant. The finding of this study agree with Alemayehu and Bewket, (2017) on the effect of information access to determine farmers choice of adaptation strategies.

4.5.Barriers to adaptation

Smallholder farmers were aware of climate change but not all of them responded to adapting to the changing climate due to different constraints mainly due to financial constraints, lack of knowledge and limited early warning information and scarcity of water (Asfaw et al., 2019). The influence of many of these factors on adaptation is examined in the above sections using econometric techniques. However, to get a sense of the relative importance of the various factors shaping farmers' decision to adapt and their adaptation response it is necessary to explore farmers' own perceptions of the barriers they face. The survey data on which this study is based contains information on which factors farmers' perception to be the most important barrier to changing their farming practices. Both Farmers that did and did not adjust their farming practices in response to perceived climate change were asked "what were the main constraints/difficulties to adapt climate change and variability?" While farmers referred to several barriers to adaptation, the most important barriers cited by farmers were a shortage of land, input, and money and lack information in the study area (Fig.10). The literature points too many factors that affect farmers' ability to adapt to climate change. These factors include accessibility and usefulness of climate information (Roncoli et al., 2002), the policy and institutional environment (Burton et al., 2005b) and the socio-economic position of the household among others challenge(Berck et al., 2018b).

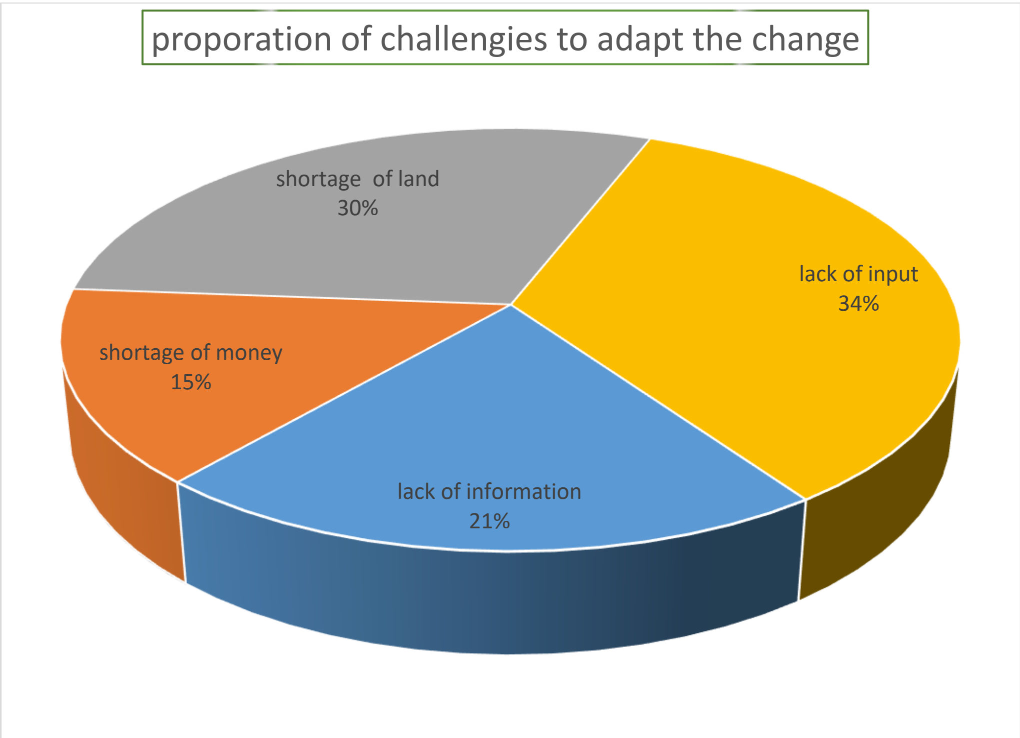


Figure 9 challenges faced by farmers to adopt adaptation strategies

5. Conclusion and Recommendation

5.1. Conclusion

This study was conducted in the three *kebeles* located nearby Awash River and Koka reservoir that is found in the southern part of Lume woreda/district east show zone of Oromia Nation regional State, central Ethiopia. This study was mainly aimed to understand how farmers in the area perceived and adapt long term climate change and variability based on their social-economically and other attributes of them including distance from Awash River. Accordingly, based on the results of this study most of the respondents felt the long term effect of climate change and variability on precipitation and temperature irrespective of their social-economically and other attributes including distance from Awash River. The data obtained from the national meteorology agency confirmed what farmers have observed. However, farmers discussed during both key informant interviews and FGD as they don't have weather information at appropriate time and place even if they get the information from mass media which were rarely used by farmers. The other issue addressed by this study was about adaptation strategies applied in the area by farmers to adapt climate change and variability. In general by FGD and KEY informant interview as well as by individual respondents indicated that changing planting calendar, using early maturing crop variety, irrigation, using more input, land management and engaging in off-farm activities were the most used adaptation strategies in the study area to adapt climate change and variability. Farmers' attributes used in the multinomial logit econometric model were age, sex, education level, marital status, farm size, TLU, access to weather information, Perception of farmers on climate change, distance from Awash River and Koka reservoir and wealth status. Both estimated coefficient parameters and marginal effect (table 7 & 8 respectively) result from the model show that respondents adopted different adaptation strategies based on his/her characteristics.

5.2. Recommendations

Farmers perceived climate change as general but fail to predict individual weather events so providing weather information at a local level is critical with respective supplementary services. The data used for this study were taken from the nation metrology agency recorded, summarized, managed and delivered not in the form that can be used at the farm level by the farmer even by kebele experts it is just raw data so improving the management of observed climate data is a serious problem need policy solution by. Variables not directly related with individual farmers socioeconomic characteristic was among the variables significantly affect farmers choice of adaptation strategies which strongly linked with government infrastructure and good governance such as access to weather information ,access irrigation sachem and agricultural inputs. So based on these findings policymakers have to look away to provide critical inputs that can improve what framers already adopted adaption strategies of climate change and variability than introducing new adaption strategies.

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APPENDIX

Appendix 1: SURVEY QUESTIONNAIRES OF THE HOUSEHOLDS

Code of respondents____________

General information

Date of interview…………………. . Start time ……...End time ……… time elapsed……

District ……………… Keble ……………. Got/village……………..

i. General background information

1. Name of household head ____________________, Age _________

   Sex 1. Male ☐ 2. Female ☐

2. How is the marital status of the household head? 1. Married ____ 2. Single ____ .

   3. Divorced ______4. Widowed ____.

3. How is the educational status of household head: 1. Illiterate _____ 2.1-4 grade ______

   3. 5-8 grade ____ 4. 9-12 grade ____ 5. Above 12 grade____.

4. Household composition & Family Level of education

Household composition				Family Level of education									
Age(years)	Male	Female	Total	Do not read &write		Read and writes		Primary school		Secondary school		College & Above	
				M	F	M	F	M	F	M	F	M	F
<15													
15<X<64													
>64													

*X is age between 15 and 64 years

5. Was the household head born in this Kebele? 1) Yes_______ 2) No _________

6. If your answer is no, from where and for how long you live in this PA? (Zone you was born and year you have live here) ____

7. Can you, please, rank the major livelihood activities the household head is engaged in to sustain his/her livelihood?

No	Livelihood activity	Rank (Currently)	Rank (before 15 years)
1	Crop production		
2	Livestock production		
3	Non-farm (production of NTFPs and fishing)		
4	off-farm (trade, wage labor, business, etc)		
5	employment in GOs or NGOs		
6	Vegetable and fruit production		
7	Bee keeping		

Livestock and crop production dynamics over the last 30 years

8. Livestock production dynamics

No.		Amount owned		
		Now/2019	from the past 15 years to now	Before 15 years ago
1	Cow			
3	Calves			
4	Young bull			
5	Heifer			
6	Draught oxen			
8	Sheep			
9	Goat			

9. Mention agricultural crop varieties and their annual production

Type of crop	Crop species	Annual production (quintal)		Importance rank for subsistence/hh consumption		Importance cash income	
Grains		Present/2019	15 years ago	Present/2019	15 years ago	Present/2019	15 years ago
	Maize						
	Sourgem/millet						
	Teff						
	Bareli						
	White						
	Chickpea						
	Vetch						
vegetable		Appropriate measurement					
	Onion						
	Tomato						
	Chilly						
	Cabbage						
others							

Land holding status

10. Mention how much land is owned by the household presently, how this land holding has changed in the past 30 years? How the use of land is changed?

Type of land	Approximate Size of each parcels of land(timad)	Cause of change

	Now	After 15 years ago	Before 15 years ago	
Homestead				
Cultivation				
Private grazing				
Plantation				
Irrigation				
Total				

11. . Means of land acquisition (tenure) a) 1st distribution b) Redistribution c) Inheritance d) Inheritance and Redistribution e) Gift f) Share cropping g) Renting
12. Do you have an access for credit yes _____ no ________

13. If your answer is yes where did you get the credit pleas rank them

    1. ______________
    2. ______________
    3. _______________
    4. ______________

14.when do you need the credit critically

____

____

____

____

15. Have you ever face a serious drought before in your area

Yes________ no _________

16. If your answer is yes how do you overcome the drought? ____

Perception on climate change and variability

17. You have any idea about climate change and variability

Yes____ or no______

18. If your answer is yes what is that and where did you get the information?
____

19. Are you feel any long or short term change related with climate

Yes____ or no______

20. If your answer is yes what indicator are you feel

a) Temperature change
b) Precipitation change
c) Both
d) Others i) __________________
ii) ___________________
iii) ___________________

21. If you feel change on temperature what attributes you feel

a. Temperature increasing with a day
b. increasing number of hot days annually
c. Shifting of hot season
d. Decreasing of temperature with a day
e. Increasing number of cold days annually
f. Shifting of cold season
g. Other_________________________________

____

22. If you feel any change on precipitation what attributes you recognized

a. Annual amount reduction
b. Change on intensity
c. Distribution change
d. Season month shifting
e. Change on length of season
f. Others _______________________________

27. How do you forecast climate trend in future?

Traditionally____

____

Modern ____

____

Climate change and variability adaptation strategies

23. What are the problems you faced due to climate change or/and variability so far

____

____

____

24. Did you take any measure to adjust your farming with these long-term shift in temperature/rainfall?

Yes ___ No _________

25. What adjustments in your farming have you made to these long-term shifts in temperature/rainfall?

____

____

____

____

____

____

26. Have you applied any of the following adaptation strategies and pleas rank them base on you application choice

28. What are main challenge to adapt climate change and variability by implementing above strategies?

2. ______________________

Strategies		Are apply		Rank base on your choice	Why or when
		yes	no		
using more input					
land management					
irrigation					
water harvesting					
changing planting calendar					
planting early maturing crop varieties					
engaging in beyond farm activities					
Othera1					
Other2					
Others3					

3. ______________________
4. ______________________
5. ______________________

29. What is your expectation about climate trend in the future?____

____

____

____

__

30. What is your expectation on the fate of your farming system related with climate change?

Appendix 2: Checklist for interview key informants

1. What are the main agriculture activities existed in the area, how many of them are rain fed, irrigation and others?

2. What are the main challenges you observe on agricultural activities in the area?

3. How do you understand climate change and variability and other farmers?

4. Did you perceived any long and /or short term change on climate system in your area?

5. What are the main indicators of climate change and variability in the area?

6. How problems on agriculture linked with change on climate system?

7. How did you and farmers in your area try to adapt those problem due to change on climate system?

8. What characteristics of farmers determine farmer's choice of adaptation strategies to adapt climate change and variability?

9. What are other factors determine farmer's choice of adaptation strategies to adapt climate change and variability other than characteristics of farmers?

10. What makes challenge full to adapt climate change and variability by adopting adaptation strategies?

Appendix 3: Checklist for focus group discussion

1. What is/are the most common livelihoods practise in your area?

2. What are the factors determine farmer's choice of livelihood?

3. What are the criteria used in the area to determine household wealth status in three category poor, medium and rich?

4. Let participants to categorize households in *kebeles* using list from respective *kebeles*?

5. What type of agriculture practise in the area?

6. What is the proportion of those agriculture type in the area and depend on rainfall?

7. How did you perceive or understand climate change and variability?

8. What are indicter of climate change and variability observed in the area?

9. What are problems observed on agriculture and other livelihoods system due to climate change and variability?

10. What are adaptation strategies are implemented to adapt climate change and variability?

11. What factors determine farmers' choice of adaptation strategies?

12. What make adapting climate change and variability difficult using adaptation strategies?

Appendix 4: Checklist for key informant selection

- A farmer who have at list 20 and above years' experience on farm activates.
- Farmers live in the area for long enough long to compere long term climatic change and variability.
- Farmers who known for his/her commination skill and ability to describe things well.
- Farmer who taken by other farmers as role model by other farmers.
- Farmer seen by the community as leader and coordinator of different event and association.
- Farmer who adopt technologies first and introduce to other community member.
- Farmers practice diver's livelihood.