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ADDIS ABABA UNIVERSITY

SCHOOL OF GRAGUATE STUDIES

FOR ENVIRONMENT AND DEVELOPMENT STUDIES

ASSESSMENT OF LOCAL CLIMATE CHANGE ADAPTATION OPTIONS IN AGRICULTURE: A CASE OF KUTABER WOREDA, SOUTH WOLLO ZONE

BY

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JULY, 2020

ADDIS ABABA,

ETHIOPIA

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APPROVAL SHEET OF THESIS

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This is to certify that the Thesis prepared by Nuru Sherif Seid entitled Assessment of Local Climate Change Adaptation Options in Agriculture: A Case of Kutaber Woreda, South Wollo Zone, and submitted in partial fulfillment of the requirement for the Degree of Master of Arts in Development Studies (Environment and Sustainable Development) complies with the regulations of the university and meets the accepted standards with respect to originality and quality.

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DECLARATION

I declare that this MA thesis is my original work, has never been presented for a degree in this or any other university and that all sources of materials used for the thesis have been fully acknowledged.

Declarer's Name: Nuru Sherif Signature __________ Date __________

Advisor's Name: Belay Simane (Prof) Signature __________ Date __________

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ABBREVIATIONS/ACRONYMS

Agri.	Agriculture
CBO	Community Based Organization
CSA	Central Statistics Agency
EACC	Economic Adaptation to Climate Change
EEFRI	Ethiopian Environment and Forest Research Institute
EIA	Environmental Impact Assessment
EMA	Ethiopian Meteorological Agency
EWDPP	Early Warning Disaster Prevention and Preparedness
FAO	Food and Agricultural Organization of the United Nation
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
Ha	Hectare
HHH	Household Head
IPCC	Intergovernmental Panel for Climate Change
masl	Meter Above Sea Level
MK	Mann-Kendall
PAC	Percentage Accuracy in Classification
PhD	Doctor of Philosophy
PSNP	Productive Safety Net Program
SSA	Sub-Saharan Africa
UNDP	United Nation Development Program

ABSTRACT

Adaptation is considered an appropriate response to climate change, especially for farmers. This study was conducted in South Wollo Zone, Kutaber Woreda on assessment of local climate change adaptation options in agriculture. The 22 Kebeles of Kutaber were stratified into the three agro-climatic zones and one Kebele was selected randomly from each agro-climatic zone. Sample households were selected with proportionate random sample technique from each Kebele. Household survey, key informant interviews and focus group discussion were employed to collect quantitative and qualitative data. Grid climate data of the three kebele was obtained from the National Meteorological Agency. The perception of households and adaptation strategies were analyzed using descriptive statistics, percentages and farmers perception was triangulated from recorded meteorological data using Mann Kendall's trend test while the determinants of farmer's choice of adaptation was analyzed using binary logistic regression. The analysis of farmers' perceptions of climate change indicates that most of the farmers (83% and 89%) are aware that temperature is increasing and the level of precipitation is declining respectively. Mann Kendall's test result revealed that annual minimum temperatures have been significantly increasing for Alansha only on December while the annual maximum temperature have been significantly increasing for Alansha on February, March, April and September, for Drie on February, March, April, May, September, October, November and December and for Kundi on February, March and April. The total annual rainfall distribution has been significantly decreasing on January, June, August and December for Alansha, on July and August for Drie and on July and November for Kundi. The household's use adaptation strategies include soil and water conservation practice, changing crop sowing date, use of improved crop variety, practicing irrigation and forestry practices. The major factors determining farmer's decision to adapt or not include farm holding size and sex of farmers house hold head with significant value of 0.018 and 0.008 respectively. The research recommended the need to enhance women's empowerment, promote water harvesting technologies and irrigation, use advanced technologies and agricultural inputs like organic fertilizers and improved crop varieties on smallholders' farm land intensive management are crucial

Key words: Adaptation, Binary Logistic Regression Model, Climate Change, Perception.

1. INTRODUCTION

1.1 Background and Justification

Global climate change is commonly regarded as one of today's most important problems facing society (Arbuckle, Morton and Hobbs, 2015). Since the mid-nineteenth century, the average temperature of Earth has increased by about 0.6 °C (Wolfson and Schneider 2002). The temperature rise corresponds to a rise in global carbon dioxide emissions from fossil fuels (Roco, Engler and Jara-Rojas, 2015), driven primAprily by population size, economic activity, lifestyle, energy use, pattern of land use, technology and climate policy (IPCC, 2014).

Climate change poses an environmental danger to all economic industries, especially the agricultural sector (Abid *et* al., 2015), a sector that plays significant part in worldwide gross national product (GDP) and offers jobs for an approximately 1.3 billion people (22 percent of the world's population) (Allahyari, Ghavami and Masuleh, 2016). It is one of Africa's most critical problems in general, especially nations such as Ethiopia. Ethiopia is the second most populous nation in Africa next to Nigeria with a population of nearly 100 million (Seid, Taffesse and Ali, 2015). Farming is the cornerstone of rural families, despite the reality that climate variability and change has become a significant task for rural families to guarantee sustainable production and food security. Climate-related risks mostly impact poor individuals by impacting their livelihoods directly, for example by reducing crop yields or destroying their homes and indirectly by raising food prices and food insecurity (IPCC, 2014).

Wollo is one of the country's drought-prone regions affected by climate-related impacts (Eshetu and Tessema, 2017) and historically known to be food insecure and extremely endangered by resource degradation (Agidew and Singh, 2018). Especially, in South Wollo Zone the main economy of household is dependent on rain-fed agriculture including crop production and supported by livestock rearing. Agriculture in this area is frequently affected by drought due to severe environmental degradation, soil erosion, nutrient depletion, rugged topography, moisture stress and erratic rainfall. Most of the

Woredas in South Wollo are drought prone and the population is chronically food insecure. Due to the fact that majority of South Wollo rely on agriculture, climate change is generally increasingly being acknowledged as a significant factor contributing to poverty in this area, however, there is no site specific research information.

Therefore, Understanding the local level adaptation options to climate change impacts are crucial element to formulate site specific adaptation strategies against the vulnerability of climate change and variability. The objective of this paper is therefore, to assess local level adaptation options to climate change impacts in Kutaber Woreda of the South Wollo Zone.

1.2 Statement of the Problem

The impact of climate change is increasingly being recognized around the world (Kalisch, AA, 2014). Its impact on agriculture, especially precipitation and temperature variability, has an issue of increasing importance (Allahyari, M.S; Sighavami, Z.D, 2016).

Increasing temperatures and changes in rainfall over time, associated with frequent droughts, are becoming solid proof of changing climate in Ethiopia. Reports show that, Ethiopian agriculture is the most significant economic sectors due to climate change there by affects the food security, income of households, industry raw materials, and so on. The problem, however, is that the farming methods are extremely dependent on seasonal rain.

Farmers in Kutaber Woreda are highly dependence on rain-fed subsistence agriculture. This area is characterized by undulating topography, high deforestation, land degradation, and erosion which lead crop failure and yield reduction. According to Woreda office of agriculture, most of the households in the Woreda depend on government support through Productive Safety Net Program (PSNP) due to continuous crop failure. This increases the household’s vulnerability to climate change impact which requires responses of adaptation strategy. But the adaptation options are not clearly understood as a strategy. Moreover, previous researches with respect to climate adaptation is lacking in the area.

As climate change may have a distinct effect in the different agro-ecological zone and farmers in the respective agro-ecologies may have different methods of adaptation (Belay *et a*l., 2017), it is essential to diagnose the adaptation options in agriculture and its determinant factor in the area since understanding local climate change adaptation options is crucial to formulate strategies to alleviate the problem in Kutaber Woreda.

Therefore, this study is attempting to address this gap by trying to assess local climate change adaptation options in agriculture in kutaber woreda of south wollo zone and the research tries to address the following questions:

- How do farmers′ in Kutaber woreda perceive towards the trends of temperature and annual rainfall?
- What are the adaptation strategies used by farmers in the study area to adapt climate change?
- What are the determinant factors that influence adaptation strategies pursued by farmers?

1.3. Objectives of the Study

1.3.1. General Objectives

The overall goal of the study is to assess farmer's adaptation options to respond the climate change impacts in agriculture in Kutaber Woreda of South Wollo Zone,

1.3.2. Specific Objectives

The specific objectives of the study include;

- To investigate farmers' perception on the trends of temperature and rainfall;

- To identify adaptation options practiced by farmers in response to climate change in kutaber woreda.
- Determine factors influencing farmer's decision to adaptation option to climate change.

1.4. Significance of the Study

The aims to understand local farmers adaptation option, perception to climate change and determinants of adaptation decision. The findings in perceptions, adaptation strategy to climate change and determinants to adaptation option based on the investigated socio-economic and environmental factors will facilitate promotion and implementation of best adaptation strategies in study area and beyond.

1.6 Scope of the Study

The research seeks to analyze the factors that influence farmer's decisions to adapt to climate change, to assess farmer's perception on climate change and identify different climate change adaptation options practiced by farmers at Kutaber Woreda's of three selected Kebeles of different agro ecologies. A wide-range variety of data were gathered including family demography, endowment of resources, farming practice, perception of farmers, adaptation practice and meteorological data. The analysis of data was focused on local level adaptation measures.

1.7 Limitations of the Study

Since the study was limited to Kutaber district in three sample Kebeles, this may limit the representativeness of the study while intending to use it at zonal and other higher administrative level. Besides, the study also based on a one-time approach and did not collect data over seasons in order to establish future location-specific adaptation strategy.

2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1. Definition of Terms

Climate Change refers to a change in the state of the climate that can be identified (e.g. by using a statistical test) by changes in the mean, and/or the variability of its properties, and that persists for an extended period (IPCC, 2007).

Adaptation is the adjustment in human or natural systems in response to actual or expected climatic incentives or their effects, which moderates harm or exploits beneficial opportunities (Seppälä, Buck and Katila, 2009).

Coping Mechanisms are strategies that have developed over time in dealing with the known and understood natural variety they expect over the season, coupled with their particular reaction to a season as if it unfolds (UNDP, 2009).

Weather is the temperature, moisture, rainfall, cloudiness and wind we encounter at a particular place in the atmosphere at a specified moment (Institute, public health, 2016). **Perception** refers beliefs or opinions often held by many people based on how things seem to them (Kisauzi *et al.*, 2012).

According to IPCC (2007), climate change is expressed as variations from a global climate defined by long-term measurement research, typically over a period of at least 30 years, or the normally observed climate conditions and a distinct but recurring collection of climate conditions across a given region of the world. The Intergovernmental Panel on Climate Change (IPCC) predicts that billions of people, especially in developing countries, will face changes in rainfall patterns that will lead to severe water scarcity or floods, and rising temperatures that will trigger crop-growing seasons to move. This will increase food shortages and the distribution of disease vectors, resulting in increased health and life risks for populations. The projected temperature increase from 1 to $2.5^{0}C$ by 2030 would have significant effects, including lower crop yields in tropical areas.
Climate change adaptation options can be divided into autonomous or private, planned or adaptation plans for the public sector. Private adaptation plans include actions taken in

response to climate change by non-state agencies such as farmers, communities or associations and or companies. According to Bruin (2011), adaptation techniques include crop changing, crop calendar shifting, employing new management methods for a different climate regime, modifying irrigation systems, and selecting various crop technology.

2.2. Causes of Climate Change

Increasing greenhouse gas emissions worldwide has contributed to accelerated climate change. Climate change is naturally induced, but in recent years the major cause has been anthropogenic impact. Agricultural activities have been shown to make a significant contribution to climate change as it ranks third after energy use and output of chlorofluorocarbon in-greenhouse emissions. (Irohibe, J., 2014). In Ethiopia Agriculture and associated deforestation contribute about 87% of the national greenhouse gas emission (CRGE, 2011). Natural causes such as variations in the intensity of the sun or slow shifts in the orbit of the Earth around the sun; natural processes within the climate system (e.g. variations in ocean circulation); human actions that alter the composition of the atmosphere (e.g. by burning fossil fuels) and the surface of the soil (e.g. deforestation, urbanization) (Sene *et al*., 2006).

2.3. Indicators of Climate Change

The climate system is a complex interactive system made up of atmosphere, land surface, snow and ice, oceans and other water bodies, and living things (Prentice *et* al., 2012). Climate change is the change in the world's normal weather patterns over an extended period of time, typically decades or longer (Stone and Chacón León, 2010). Greenhouse gases (GHGs) are important for their ability to trap heat from the sun and create an atmosphere that supports life on Earth (Dahal *et* al., 2009) but rising temperatures are among the top problems affecting to climate change (Kussel, 2017).

An improved greenhouse gas effect caused by anthropogenic activities is the main concern of both science and public communities (Zakieldeen, 2009). About 97% of climate scientists agree that climate change is taking place now (Institute, public health, 2016) and that anthropogenic climate change is a truth (CCC; 2009). Human activity has led and continues to cause major changes in atmospheric composition (Zakieldeen, 2009). Climate change is causing five critical environmental challenges which include warming temperature of the earth's surface and the oceans, changes in the global water cycle, declining glaciers and snowpack, sea level rise, ocean acidification (Institute, 2016).

2.4. Climate Change and Agriculture

Climate is one of the main determinants of agricultural production (Asha, Gopinath and Bhat, 2012). Agriculture depends much on the environment in the process of providing the lives and livelihoods of millions who depend on it for food and subsistence (Prantilla and Laureto, 2013). Climate change affects agriculture and agriculture also affects climate change (Deressa, Hassan and R. M.C., 2011). Agriculture is not only a fundamental human activity at risk from climate change, it is a major driver of environmental and climate change (Tubiello, 2012).

There is important concern around the globe about the impacts of climate change on agricultural production and its variability (Asha *et* al, 2012). The observed changes in the two parameters of climate namely temperature and precipitation have affected the agriculture and livelihoods of the people (Zeray and Demie, 2015).

Africa's climate change problem has the potential to undermine efforts for sustainable development if distinct measures are not taken to address its negative effects (Juana, Kahaka and Okurut, 2013). Rain-fed agriculture is the mainstay of economic development in East Africa (Nganga, 2006). The agricultural sector remains the main source of livelihoods for rural communities in Ethiopia but faces the challenge of changing climate (Belay *et* al, 2017). Highly climate-sensitive, mostly rain-fed agricultural leads to food insecurity (Gupta, 2011) owing to climate is the main determinant of agricultural productivity (Prantillza and Laureto, 2013).

Climate change is fast pushing the poorest and most marginalized communities beyond their capacity to respond (Pettengell, 2010). Ethiopia is susceptible to climate change effects due to interlinked causes such as poverty, recurrent drought, high population growth, inequitable land distribution, over-exploitation of natural resources, rain-fed subsistence agriculture, etc. (Zeray and Demie, 2015).

2.5. Farmers Perception on Climate Change

Perception is the process of recognizing (being aware of), organizing (gathering and storing), and interpreting (binding to knowledge) sensory information (Matthew O. Ward, Georges and Daniel, 2010). It is an important aspect and first step in the adaptation process (Madulu, 2014). It deals with the human sense that generates signals from the environment through sight, hearing, touch, smell and taste (Matthew O. Ward, Georges and Daniel, 2010). Farmers ' perception of climate is mainly based on their sense of weather patterns reliable or variable in their own area (Roco *et* al, 2015). Perception on changes in the local climate can assist farmers to make decision at the right time to either change their practices to accommodate themselves to the changes or do adapt otherwise (Madulu, 2014). Farmers with precise perceptions make choices on what crops to grow, when and with what inputs (Abid, 2016). Moving from option choice to implementation is mainly affected by the social context and partly by its effect on the perception and ability of actors to do so (Moser and Ekstrom, 2010)

Perception is a set of processes by which an individual become aware of and interprets information about climate change to give particular response and feedback for the impacts (Bord, J., O'Connor, 2000). Human perceptions to climate have become an important to understand climate society interaction and to develop coping mechanisms for the hazards of it. It is also assumed as an effort to reduce human induced causes of climate change (Havsken, 2004). Actors and institutions associated with different scales may have different perceptions of the need for adaptation as well as the factors that constrain or enable adaptation (Klein, *et al.*, 2015). Individuals always look at new problems, tasks and solutions through the lens of their pre-existing values , beliefs, norms, and experiences (Antwi-Agyei, Dougill and Stringer, 2015).

Smallholder farmers′ perceptions to climate change is the most important to develop local and national based adaptation strategies and minimizing adverse impacts of the variability (Palutikof *et al*., 2004). In buffering the adverse impacts of climate variability and change, decision-making at household and community level is significant (Zizinga *et al*., 2017).

Actors and institutions associated with various scales may have distinct perceptions of the need for adaptation as well as variables limiting or enabling adaptation (Klein *et* al., 2014). Individuals are always looking at new questions, task solutions through their pre-existing values, beliefs, norms and experiences (Ekstrom, Moser and Torn, 2011). Despite the global importance attached to adaptation to climate change, families in Africa still lack knowledge of implementing adaptation strategies (Antwi-agyei, Dougill and Lindsay, 2013).

Climate change adaptation requires farmers to first notice that climate changes has changed, and then identify and implement useful adaptations. In general, studies of farmers ' perceptions of climate change adaptation have generated considerable interest in Africa's research. In one of these studies, Maddison (2006) states that the understanding of climate change seems to rely on the experience of farmers and the availability of free extension advice directly related to climate change. Gbetibouo (2009) argues in another study that farmers with access to extension services are likely to see climate change as extension services include climate and weather information.

Therefore, understanding and perception of a problem forms action or inaction on the climate change issue.

Climate change adaptation includes all behavioral or economic structure adjustments that reduce society's vulnerability to climate change and adaptability refers to the degree to which adjustments can be made to projected or actual climate change in systems practices, processes or structures. Adaptation can be spontaneous or prepared and can be done in reaction or in anticipation of conditions change (Smih et al., 2009).

2.6. Climate Change Responses

Adaptation relates to the positive features of the characteristics of individuals that can decrease the risk presented by a certain hazard (Cardona, 2012). Climate change management usually falls within two main areas: mitigation and adaptation (CCC; 2009). Mitigation is aiming at reducing greenhouse gas emissions and increasing sinks (IPCC, 2007), while adaptation is the capacity to contribute significantly to reducing the adverse effect of climate change (Tesfaye and Seifu, 2016).

Many attempts to adapt to climate change are aiming at addressing the impact of potential changes in the frequency, intensity and duration of weather and climate events that influence the threat of extreme effects on human culture (Cardona, 2012). In reaction to real and anticipated effects of climate change in the context of interacting non-climatic changes, it includes changes in social-ecological systems (Ekstrom, Moser and Torn, 2011). Although societies have always adapted to socio-ecological changes, it is anticipated that climate change will require further efforts to adapt (Biesbroek Robbert G., 2014).

Adaptation strategies and actions can vary from short-term coping to longer-term, deeper transformations, aim to achieve more than climate change objectives, and may or may not be able to moderate damage or exploit useful opportunities (Moser and Ekstrom, 2010). Effective adaptation strategies and practices also rely on a detailed knowledge of exposure and vulnerability dimensions as well as a correct evaluation of modifications in these dimensions (Cardona, 2012). The types of adaptation strategies taken by households in response to multiple risks including climate variability may vary by country or by region within countries depending on local climate conditions, natural resource endowments and the patterns of agricultural and livestock activities (Bandyopadhyay, Wang and Wijnen, 2011).

Adaptation has the ability to significantly reduce the predicted adverse effect (Kussel, 2017). Successful adaptation requires not only the identification of adaptation options and the assessment of their costs and benefits, but also the use of available mechanisms to expand human and natural systems ' adaptive capacity (Klein *et* al., 2014).

For a quarter of century climate change is debated. After two decades of climate change mitigation policies that failed to curb global greenhouse gas emissions and frequent disastrous signs of already changed climate patterns in many regions of the world (IPCC, 2007a), adapting to these and future changes became an increasingly important policy issue around the world. Although “adjustment in natural or human systems in response to actual or expected climatic changes or their effects, which moderates harm or exploits beneficial opportunities” (IPCC, 2007a)(IPCC, 2001) has been the rule rather than the exclusion throughout the history of humankind, the adaptation to the impacts of anthropogenic climate change poses new challenges to individuals, organizations and societies (Bauer *et al*., 2012). Adaptation to the adverse consequences of climate change could be viewed from two distinct perspectives; i) the awareness of the risks of climate change and their capacity to adapt to climate change and ii) how adaptation can be carefully planned and implemented to avoid the possibility of mal-adaptation (FAO, 2007).

2.6.1. **Coping Mechanisms**

Societies are self-motivated and they use all possible strategies to reduce the vulnerability to climatic impacts. There are two kinds of responses to crisis that overlaps across the temporal scale, coping mechanisms and adaptive capacity (Shuaibu *et al*., 2014). Coping mechanisms may develop into adaptive strategies through time.

Traditional and current climate variability and extreme coping mechanisms in Ethiopia include changes in crop and planting practices, reduction in consumption levels, collection of wildlife, use of inter-household transfers and loans, increased production of small commodities, temporary and permanent migration in search of employment, grain storage, sale of assets such as livestock and agricultural tools, mortgaging of land, credit from merchants and money lenders, use of early warning system, food appeal/aid (Deressa, 2008)

2.6.2. Adaptation Strategies

Ethiopia is historically prone to extreme weather events. Rainfall in Ethiopia is highly erratic, and most rain falls intensively, often as convective storms, with very high rainfall intensity and extreme spatial and temporal variability. Since the early 1980s, the country has suffered seven major droughts, five of which led to famines in addition to dozens of local droughts (Diao, 2007). Survey data show that between 1999 and 2004 more than half of all households in the country experienced at least one major drought shock (UNDP, 2007).

Another study made of Africa as a whole that analyzed the historical and current climatic conditions based on observed changes, reports that based on historical records a warming of approximately 0.7°C over most of the continent during the 20th century is reported in the IPCC (2007c). On the other hand, East Africa has displayed a stable rainfall regime. Drought and famine, flood, malaria, land degradation, livestock disease, insect pests, and earthquakes have been the main sources of risk and vulnerability in most parts of Ethiopia. Recurrent droughts, famines, and recently floods are the main problems that affect millions of people in the country. Policy failure and Climate hazards, mainly droughts, have caused instability in national economic performance and have hampered poverty reduction efforts (EACC, 2010). While the causes of most disasters are climate-related, the deterioration of the natural environment due to unchecked human activities and poverty has further exacerbated the situation. For example, the impacts of past droughts such as those in 1972/73, 1984, and 2002/03 are still new in the memories of many Ethiopians. Other extreme events, like the floods in 2006, caused significant loss of human life and property in many parts of the country. Changes in rainfall will affect the transmission potential and the presence (or absence) of vector- and water-borne pathogens (IPCC, 2001).

In most regions, vulnerability to climate change in Ethiopia is highly linked to poverty (loss of copying or adaptive capacity) (Deressa, 2008). Adaptive capacity and vulnerability are important concepts for understanding adaptation; vulnerability can be viewed as the circumstance under which adaptation occurs (IPCC 2001). Those societies that can respond to change quickly and successfully have a high adaptive capacity (Press, 2006).

2.7. Climate Change Impacts in Wollo, Northern Ethiopia

The study conducted in south Wollo by taking daily rainfall obtained from six meteorological stations such as Mekaneselam, Guguftu, Kabe, Wereillu, Kelala, and Wogdi in the period (1984–2014) and revealed that rainfall pattern of the studied stations was changed into mono modal (summer) and the inter-annual and seasonal rainfall variability was high (Tesfaye, 2018). The annual rainfall variability was lower compared with the seasonal variations. But the variability in seasonal rainfall was highest from Dec-Feb where dry condition (Bega) prevails in northern Ethiopia and lowest in summer (June-August). It is classified as less than 20, moderate (20 < CV<30), and high (CV>30) according to the degree of variability of the rainfall events (Tesfaye, 2018).

Food security is a measure of the availability of food and individuals' accessibility to it, where accessibility includes affordability. South Wollo, in northern Ethiopia, is one of the zones hit by food insecurity. The concept of persistent poverty in South Wollo has an important historical dimension. The population depends on agriculture and livestock for its livelihood. But recurrent drought has forced them to sell many assets and plunged them into destitution. High levels of food insecurity continue in the *belg*- dependent areas of this zone, which exposed already affected very poor and poor households to acute food crisis. Monitoring reports indicate that cases of acute malnutrition are widespread in some woredas including Dessie Zuria and Legambo of South Wollo. As mountainous soils are eroded, the increasing pressure on available land makes matters worse. In October 2000, the Ethiopian Red Cross Society (ERCS) initiated a programme to reduce vulnerability to drought. They distributed cash totaling US$ 760,000 to 62,000 people in Ambassel and Kutaber districts of South Wollo (Anonymous, 2003). In the past 20 years there were major food security disasters in 1983–84, 1991–92, 1999–2000, and, again, in 2002, and minor ones in almost one out of three years. In the 1999–2000 drought, about 75 percent of the population in the study area received food aid (Kristiansen, 2011).

2.8. Determinants of Adaptation to Climate Change

Several factors have been suggested to explain the presence or absence of climate change adaptation. In order to explain adaptation in Africa, Downing *et* al.(1997) explore fairly standard variables. Nhemachena and Hassan (2007) described key determinants of adaptation to climate change in South Africa, Zambia and Zimbabwe as access to credit and extension, as well as knowledge among farmers about climate change. As such, this study suggested increasing access to credit and environment and agronomy information in order to improve the adaptation of farmers to climate change. Ishaya and Abaje (2008) found that lack of awareness and expertise on climate change and adaptation approaches, lack of capital and improved seeds, and lack of irrigation water played a significant role in preventing climate change adaptation in Jema'a Nigeria.

Gbetibouo (2009) indicated that the main driver affecting farmers ' adaptation to climate change in the Limpopo Basin, South Africa, is how they formulate their future climate plans in coping with changing weather patterns. According to this report, insufficient access to credit is the major factor limiting the adaptation of farmers to climate change. He also argued that the main factors fostering adaptive potential are the income of farmers, the size of the family, the experience of farmers and non-farm operation.

According to Yesuf *et* al. (2008), the adaptation of climate change adaptation strategies by farmers is affected by regular and more reliable climate information from meteorological centers, formal and informal institutions, access to information on credit and extension, amount of seasonal rainfall, geographic location, household size, age and head literacy. Deressa *et* al. (2008) urged that livestock ownership, local temperatures and precipitation should also determine households ' choice to adapt to climate change.

2.9. Conceptual Framework

According to Yesuf *et al*. (2008) farmers' adaptation of climate change adaptation strategies is influenced by frequent and more accurate climate information from meteorological centres, formal and informal institutions, access to credit and extension information, amount of seasonal rainfall, geographical location, household size, age and literacy of household head. Deressa *et al.* (2008) urged that livestock ownership, local temperatures and amount of precipitation also determines the choice of households when adapting to climate change

Literature review on climate change adaptation indicated that, adaptation to climate change is vital for rural people, which they can use to improve their productivity, income and to manage the resources, on which they depend, in sustainable way. Adaptation to climate change is the subject of considerable importance to rural population, especially to smallholder farmers who commonly suffer from isolation and have difficulties in communicating their priorities to decision makers adaptation to climate change depends to large extent on the extent of understanding of climate change, how to adapt with it and climatic information exchange between and among smallholder farmers on the one hand, and a broad range of other actors on the other hand to plan effective adaptation activities.

The conceptual framework used in this study defines the relations between factors that affect smallholder farmers ' climate change adaptation options. Figure-1 Represents the conceptual framework that will build on the premise that the decision to adapt to climate change is based on different driving forces behind farmers ' decisions. Economic factors such as farm size and annul income are some of the driving factors that lead to adaptation choices. Institutional considerations such as credit access, exposure to climate change information, demographic factors including HHH's sex, farmers ' education, and farmers ' experience on farming. A psychological factor is the farmers ' view of climate change. The factors that determine adaptation strategy like sex of household and landholding size are part of the framework as follows.

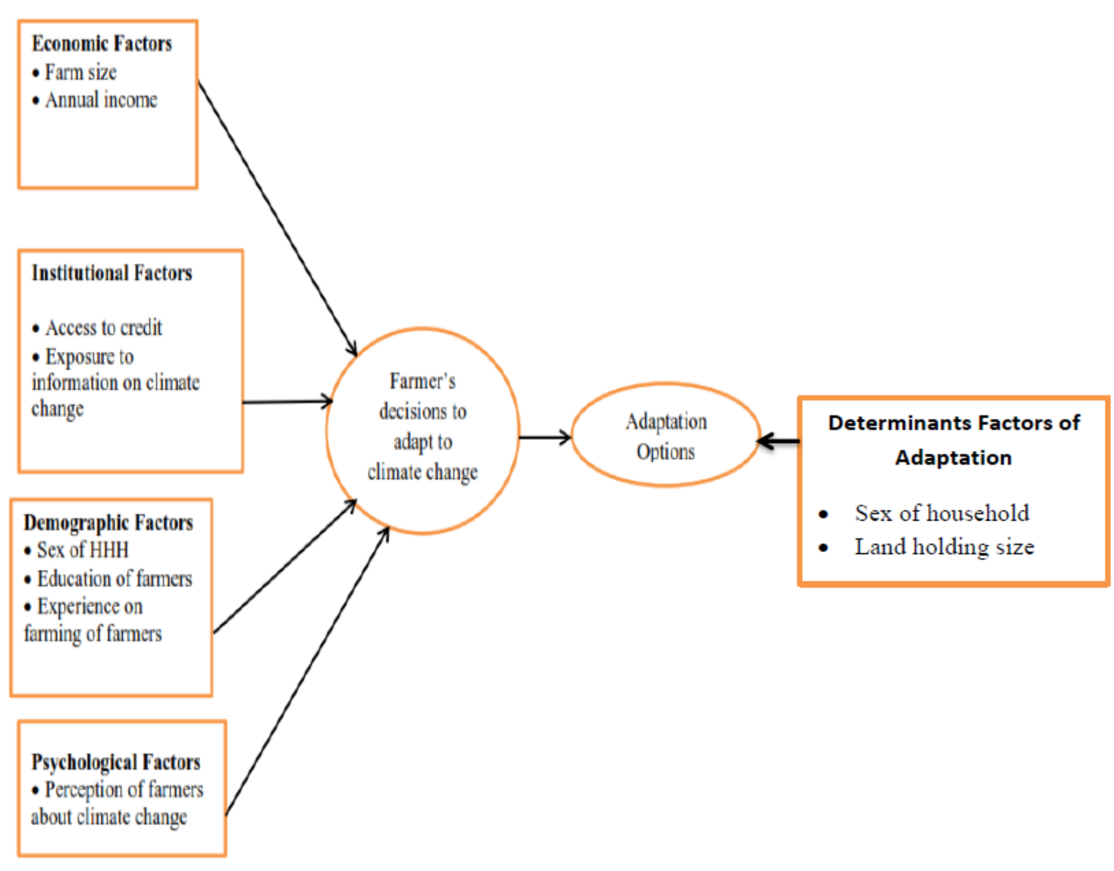

Figure 1 : Conceptual framework

3. DESCRIPTION OF STUDY AREA, RESEARCH DESIGN AND METHODOLOGY

3.1. Site Description

This study was conducted in Kutaber Woreda of south Wollo zone. Kutaber woreda is located in Amhara Regional State in north-central Ethiopia's South Wollo Zone. It is 495 km east from the regional capital city of Bahir Dar, 419 km north from Addis Ababa, and 18 km north from Dessie. It is surrounded by Dessie zuria in the South, Tenta, in the West, Ambassel in the North and Tehulederie woredas in the East. The geographic location extends from 39°18′ E –39°38′ E Latitude and 11°8′ N –11°29′ N, Longitude and an elevation of between 1400- 2850m above sea level. Its total area 86.486 km^2 (Kassaw, 2010).

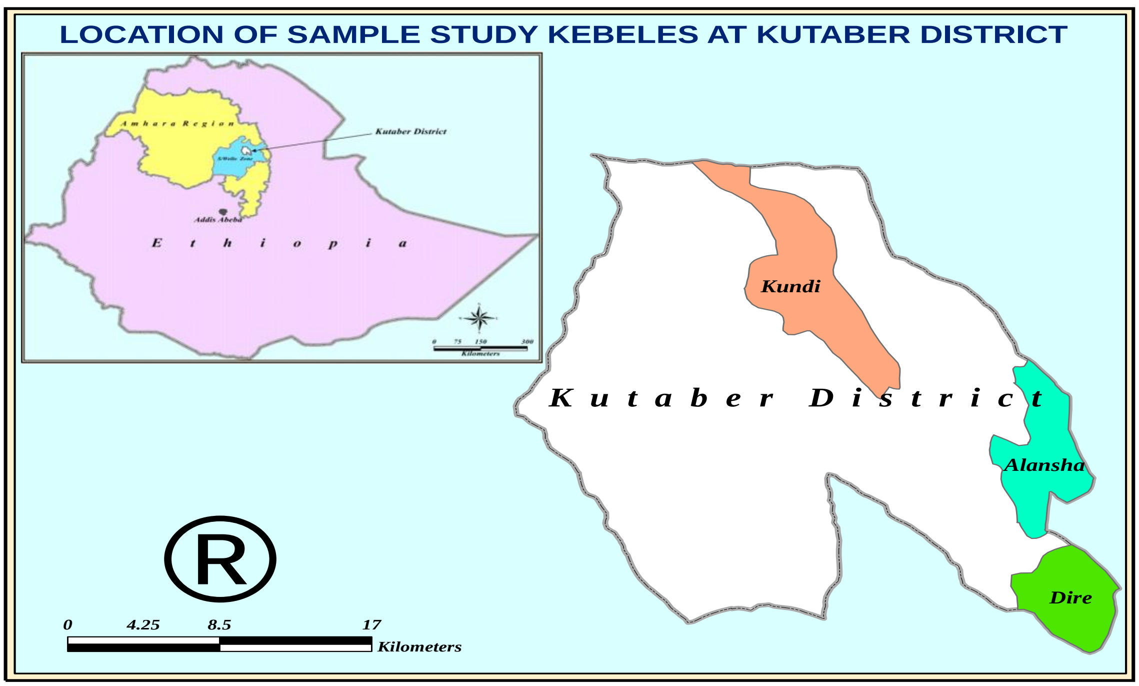

Figure 2 : Location map of the study area

Source: CSA, (2007)

The total population of Kutaber woreda is to reach 113,112 of which 8,618 are town, and 104,514 are rural dwellers (CSA, 2013). The average size of the family is 5-6. The woreda is fully inhabited by the people of Amhara, and the majority of the inhabitants are Muslim, with 87.83%, while 12.01% of the populations are Ethiopian Orthodox Christian (CSA, 2007).

Kutaber is one of the Woredas in South Wollo zone, highly affected by climate extremes and characterized by rugged topography and environmental degradation, have three agro-ecologic zones. The woreda's average annual rainfall is 1110.57 mm per year. The woreda rainy season begins in June and finishes in September and the brief rainy season ends in January in Belg and finishes in February. The woreda's average minimum temperature during October and November is 6.56 ° C and average maximum temperature of 23.13 ° C during May (kutaber woreda Agri.Office, 2007).

The soils for the study area are predominantly Lithic Leptosols and Eutric Vertisols. The general slope ranges on from 0 to 79.85 % in which these soils occur. The area is usually found in landscapes of mountain and major scraps, uplands and bottomlands, and minor valleys (FAO, 1997).

The rain-fed farming methods and livestock rearing are the community's economic bases in the woreda. Mixed farming continues the primary activity of livelihood. Teff, Barley, Wheat, Bean, Field peas, Maize, Chickpeas, and Sorghum are the main plants grown. Overall, there seems to be very restricted activities other than agriculture. Agriculture is an important household resource that plays significant role to household food security, income generation. Cattle, sheep, goat, cow and ox are the most common domestic animals raised in the rural area and in the urban area; main activities are trade, cattle raring, daily labor, employees in the government and non-government organization (KWARDO, 2007).

3.2 Research Design and Sampling Methods

The research follows a descriptive research design. A multi-staged sampling technique was employed to select specific study Kebeles, which is the lowest level administrative unit under the Federal Democratic Government of Ethiopia. In the first step, Kutaber Woreda was selected from south Wollo zone purposely.

In the second phase, three kebeles were selected, and one Kebele was randomly chosen from each agro-ecology. The assumption of selecting one Kebele from each climate zone is due to the fact that farmers in a separate agro-ecological area may have distinct levels of vulnerability to climate change, varying perception and methods of adaptation.

The households was chosen randomly and allocated to each Kebele in proportion. The sample sizes were determined by using the formula developed by (Yamane, 1967) as follows:

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

- n= required sample size.
- N=population size.
- e=desired level of precision (10%).

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

$n=4,343/1+4,343\ (0.1)^{2}=99$

Table 1: Sample size distribution across the study area

Woreda	Kebele	Agro-ecology	Total household	Sample Size
Kutaber	Kundi	Lowland	1,500	34
	Alansha	Highland	1,803	41
	Drie	Mid-altitude	1,040	24
	Total		4,343	99

Source: Kebele Administration 2020

3.3. Data Collection Methods

Qualitative and quantitative data were collected. Grid climate data was collected from National Meteorological Agency (NMA) for each kebele (1981–2016 years) to understand the trends of temperature and precipitation and to triangulate the perception of farmers on climate change. Household survey, key informant interview, and focus group discussion were employed to collect data on various parameters. Secondary data was obtained through a desk review of related literature and reports and records on landslides, flooding and prolonged drought events at a Woreda level were gathered from the Woreda office of agriculture. The farmers' perception of temperature and rainfall changes was triangulated with trend analysis of recorded data (African, T. 2013).

The quantitative data collection method was household survey of 99 households and this was carried out between November and December 2019. Semi-structured Structured questionnaires were used to assess household perception and adaptation strategies (Tesfaye and Seifu, 2016). Using non-sampled households, the questionnaire was pre-tested and appropriate modifications were produced. Three development agents from the respective kebele were chosen and trained as enumerators for data collection.

Three focus group discussions were conducted from youth, elders and women in each Kebele (Belay *et* al., 2017). The number of participants in each group was between six and ten (Jenkins, 1998). A total of 9 focus group discussions constituting 67 members were conducted. The researcher moderate the discussions using a checklist of entertaining climate change parameters targeted at understanding community perception of changes, major effects of climate change, and the type of adaptation strategies implemented by communities, challenges and opportunities to adapt to climate change variability effects.

Key informants were identified and interviewed from the different team of the office of agriculture, livestock promotion, cooperative promotion, food security and water resource development purposely. Checklist was prepared in relation to climate variability, its impact in the Woreda and adaptation strategies practiced by the community. A total of 9 key informants were selected and interviewed.

3.4. Data Analysis

3.4.1. Farmers Perception and Adaptation Strategy to Climate Change

Descriptive statistics based on summary counts of the questionnaire framework was used to evaluate farmers ' perception of climate change, adaptation options and local climate effects. The trend line test of the historical meteorological record data of gridded aerial data of the study area was collected from National Meteorological Agency (NMA) for each kebele (1981–2016 years) was used to compare household perception on temperature and precipitation with that of the data from the stations. The nonparametric Mann-Kendall test (MK), is widely used to evaluate trends in agro-meteorological and hydrological time series (Blain, 2013). The advantages of using this test include, it is a non-parametric test and does not require the data to be normally distributed and has low sensitivity to abrupt breaks due to inhomogeneous time series (Karmeshu, 2012).

According to this test, the null hypothesis H_0 assumes that there is no trend (the data is independent and randomly ordered) and this is tested against the alternative hypothesis H_1, which assumes that there is a trend (Karmeshu, 2012). The computational procedure for the Mann Kendall test considers the time series of n data points and Ti and Tj as two subsets of data where i = 1,2,3,…, n-1 and j = i+1, i+2, i+3, …, n. The data values are evaluated as an ordered time series. Each data value is compared with all subsequent data values. If a data value from a later time period is higher than a data value from an earlier time period, the statistic S is incremented by 1. On the other hand, if the data value from a later time period is lower than a data value sampled earlier, S is decremented by 1. The net result of all such increments and decrements yields the final value of S.

The Mann-Kendall S Statistic is computed as follows (Karmeshu, 2012):

$$s = \sum_{i-1}^{n-1} \sum_{j=i+1}^{n} sign\,(Tj - Ti)$$

$$\text{sign}(Tj - Ti) = \begin{cases} 1 & if\ Tj - Ti > \quad 0 \\ 0 & if\ Tj - Ti\ = \quad 0 \\ -1 & 0if\ Tj - Ti < \quad 0 \end{cases}$$

Where, Tj and Ti are the annual values in years j and i, j > i, respectively (Karmeshu, 2012)

If n < 10, the value of |S| is compared directly to the theoretical distribution of S derived by Mann and Kendall. The two tailed test is used. At certain probability level H_0 is rejected in favor of H_1 if the absolute value of S equals or exceeds a specified value Sα/2,where Sα/2 is the smallest S which has the probability less than α/2 to appear in case of no trend. A positive (negative) value of S indicates an upward (downward) trend. For n ≥ 10, the statistic S is approximately normally distributed with the mean and variance.

Software used for performing the statistical Mann-Kendall test is Addinsoft's XLSTAT 2014. The null hypothesis is tested at 95% confidence level for both, temperature and precipitation data for the 12 months of three stations. In addition, to compare the results obtained from the Mann-Kendall test, linear trend lines are plotted for each month using Microsoft Excel 2007.

3.4.2. Determinants of Local Farmers Adaptation Option

The study used a binary dependent variable taking the value 1 if the farmer adapted to climate change and 0 otherwise (Mudzonga, 2012). Binary choice models was used when the farmer faces two choices such as whether they adapt or not. This is done to distinguish between farmers who adapted and those who did not in the study area. The assumption here is that farmers adopt a new technology only when they perceived utility or profit from using this new technology and if its contribution is significantly greater than their traditional method (Mudzonga, 2012). Logit model was used in adoption decision studies and computationally easier and more convenient (African, T. 2013).

The model specification is;

Let Y=1, be the probability of dependent variable happening, Y=0, the probability of not happening. This relationship (Y=1) can also be presented as Pi= E(Y=1/Xi) or p(Y=1/xi); where E is expectation. Y=0 can be expressed as p(Y=0)/xi or as (1-Pi);

The odds ratio (likelihood) in favor of Y=1 is given as;

(Pi/ 1-Pi).. (1)

If (1) >1- increased odds; (1)<1- reduced odds; (1)=1- equally likely odds Thus taking natural log of equation (1) above, the logit Y as ln p(Y=1/xi)/p(Y=0)/xi = ln (Pi/1-Pi), so that

$ln[pi/(1-pi)]$ = β0 +β1X1+…+βnXn ……………………………………………………(2)

Where Yi is the dependent variable,

X1-n are explanatory variables

β_0 is the intercept, the probability of the dependent variable when all explanatory variables are zero;

β_1-n is coefficients to be estimated in the analysis.

The empirical model can be reduced to:

Yi=β0+β1X1+β2X2+β3X3+β4X4+β5X5+β6X6+β7X7 …………………... (3)

Where Yi is a dichotomous dependent variable (farmer using at least one climate change adaptation technology or not, specified as yes=1, 0=otherwise).

β_0 is the Y- intercept

β_1- β_7 is a set of coefficients to be estimated.

X_1-X_7 are explanatory variables hypothesized, based on theory and related empirical work, to influence adaptation to climate change.

The Dependent Variable: A farmer is considered to have adapted to climate change if he/she has employed at least one of the adaptation strategies such as use Soil and water conservation, afforestation, Improved Crop Variety, Irrigation, and Changing Planting Date and so on.

Independent Variable: The choice of independent variables to be used in the study is influenced by literature reviewed on factors that influence farmers' decisions to adapt to climate change and the availability of data in the study and the knowledge about adaptation to climate change in Kutaber Woreda. This research considers the following as potential factors affecting farmers' decisions to adapt to climate change: sex of household head, education level of household head, total area of farm land, availability of climate related information, farming experience of the farmers, access to credit and total annual income of the farmers and so on. This is to test whether these variables affect farmers' adaptation to climate change in Kutaber Woreda. The functional relationship of adaptation strategy and the independent variable was hypothesized in the following way.

Table 2: Adaptation strategy hypotheses and functional relationship

Variables	Explanatory variable	Description	Expected sign	Reason
X1	Sex	Dummy, 1 = male, 0 = female	±	Female heads have less access to resources for adaptation
X2	Education	Dummy, 0= Illiterate, 1=literate	+	More education favors adaptation due to faster knowledge acquisition
X3	Farm size	Continuous (hectare)	+	The larger the land size increases adoption of technologies
X4	Total annual income	Continuous (ETB)	+	More total annual income enable to utilize adaptation technology
X5	Access to climate information	Dummy, 1 = Yes, 0 = No	+	More information on climate change increases adoption of adaptation technology
X6	Access to credit	Dummy, 1= if farmers have access to credit, 0= no access	+	Availability of credit enhances probability of a farmer to adapt strategies that reduce the negative impact of climate change to her/his household
X7	Farming Experience	Continuous (years)	+	The more experienced the farmers are likely to employ adaptation measures that reduce the effect of climate change on her agricultural activities.

Source: adopted from (Mudzonga, 2012)

4. RESULTS AND DISCUSSIONS

4.1. Results

4.1.1. Socioeconomic and Demographic Characteristics of Respondents

The demographic and socio-economic data for the surveyed household showed that 89% of the farmers are within the active working age group while 11% were greater than 65 years old. 6% of the households were landless, 19% have less than 0.5 ha, and 45% have 0.5 to 1 ha while 30% has greater than 1 ha of farming land. 83% 0f the respondents has greater than 20 years farming experience and 15% has greater than 10 years farming experience while 2% has less than 10 years farming experience. The family size of the households was highest in Kundi (5.76) followed by Drie (5.54) but Alansha has (3.3). The educational status of respondents was 35% educated and 65% non-educated. From the total respondents, 77% of the households are male household headed and 23 % of the households are female headed (Table 3).

The respondents have accessed information on climate change and variability from different source including from extension agent, local leader, radio, woreda experts, their neighbor and contact farmer as indicated below (Table 4).

Table 3: Socio-demographic profiles of the household in percent (n=99)

Characteristics	Category	Drie	Alansha	Kundi	%
Sex of HH head	Male	20	28	28	77
	Female	4	13	6	23
Educational level	Educated	8	13	14	35
	Non-Educated	16	28	20	65

Source survey 2019

Table 4: Sources of Information about Climate Change in %

Sources of Information	Total HH	Sample Kebeles 02(Drie)	03(Alansha)	013(Kundi)	Total %
Extension Agent	99	83	0	94	53
Local Leader's	99	12	2	12	8
Radio	99	75	39	65	57
Woreda Expert	99	0	0	29	10
Neighbor	99	29	17	0	14
Contact Farmer	99	21	7	0	8

Source: survey data 2019

4.1.2. Perceptions on Climate Change

4.1.2.1. Farmers' Perception of Climate Change and Its Impacts

According to the survey data indicated in (table 5) 83% of the respondents confirm increased in temperature for the last two decades. In the same way rainfall is decreasing year to year for the last two decades as 89% of household respondent confirmed. Results obtained from FGDs and key informant interviews confirmed that the temperature has been increasing from time to time. Another 83% of households indicated that environment suffer from excessive devastation due to climate change (Table 5). Similar results were obtained from the focus group discussion and key informant interview. Generally, farmers believe that the decreasing precipitation trend was associated with the changes in temperature.

Table 5: Farmers Perception on Climate Change in %

Description of Statements	Disagree	Neutral	Agree	Total	%
Temperature rising in the last two decades	10	7	82	99	83
Rainfall decreasing every year in the past two decades	3	8	88	99	89
The Environment suffers from excessive devastation due to climate change	0	17	82	99	83
Climate Change has led to the decline of Forest Resources	5	15	79	99	80
Climate Change has led to the Change of Farming System	7	30	62	99	63
Occurrence of Livestock Diseases has Increased due to Climate Change	9	27	63	99	64
Food Insecurity has Increased due to Climate Change	16	14	69	99	70
The Community here are Aware of the Effects of Climate Change	20	19	60	99	61

4.1.2.2. Temperature and Rainfall Trends

The respondent's perceptions were triangulated using gridded aerial data of the study area. The temperature and rainfall data of each kebele were analyzed using Mann-Kendall trend test. The available historical record data from 1981 to 2016 precipitation and temperature data from each kebele were obtained from the National Meteorological Agency.

A. Trends of Temperature

Analysis of minimum and maximum annual temperature data was undertaken to detect the variability and trend of temperature change based on each kebele gridded aerial data for a period 1981-2016. As demonstrated in below, Mann Kendall's test result revealed that annual minimum temperatures have been significantly increasing only for Alansha on December. But the annual maximum temperature have been significantly increasing for Alansha on February, March, April and September, for Drie on February, March, April, May, September, October, November and December and for Kundi on February, March and April as indicated in the following Figures.

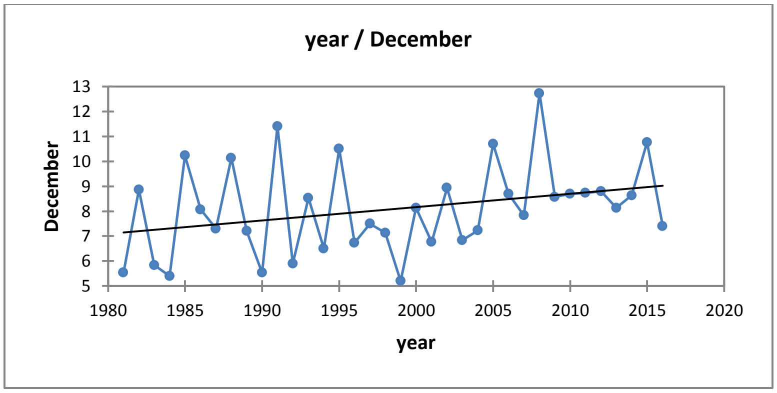

Figure 3: Results of Mann-Kendall test for Alansha minimum temperature

Source survey data 2019

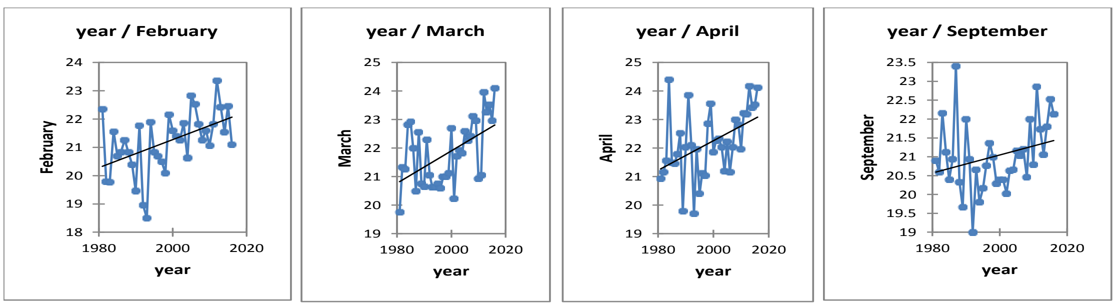

Figure 4: Results of Mann-Kendall test for Alansha maximum temperature

Source survey data 2019

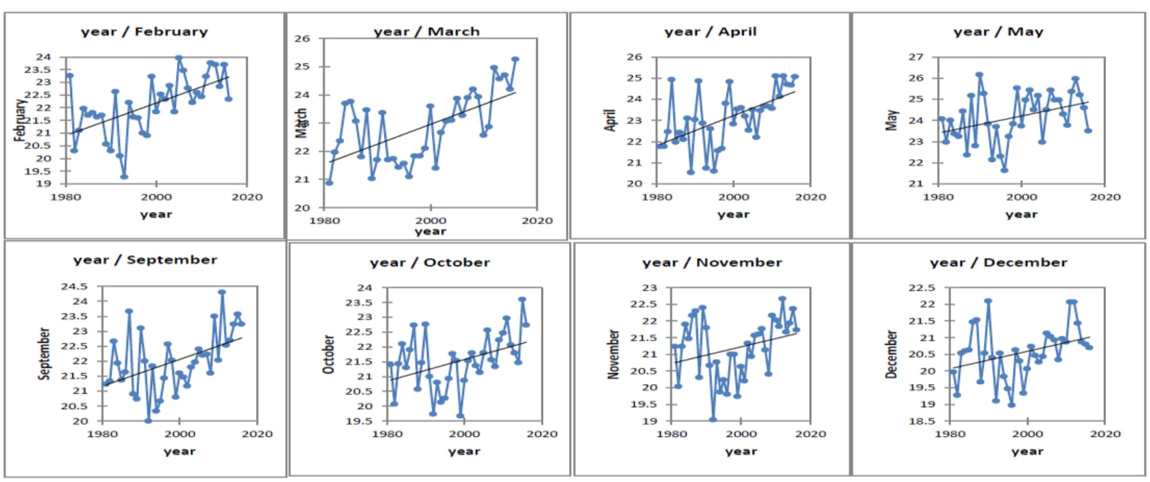

Figure 5: Results of Mann-Kendall test for Drie maximum temperature

Source survey data 2019

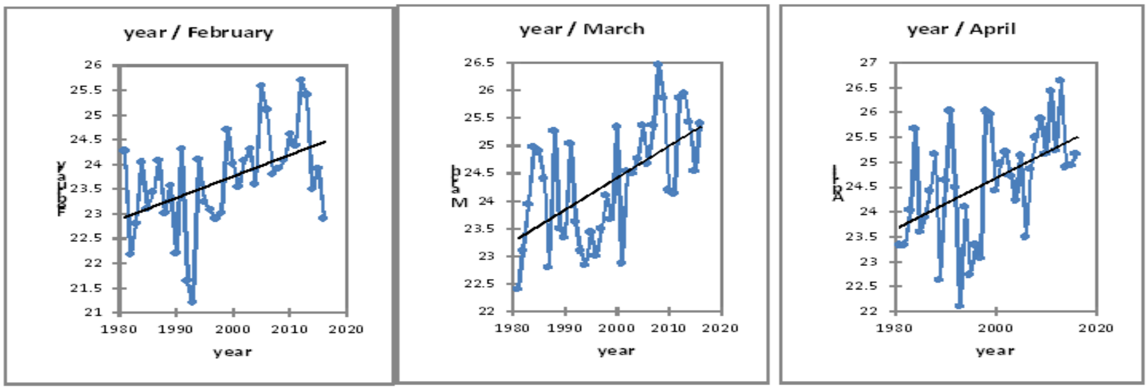

Figure 6: Results of Mann-Kendall test for Kundi maximum temperature

Source survey data 2019

On running the Mann-Kendall test on minimum and maximum temperature data, the following results in (Table 6, 7, 8 and 9) were obtained respectively. If the p value is less than the significance level α (alpha) = 0.05, Ho is rejected. Rejecting Ho indicates that there is a trend in the time series, while accepting Ho indicates no trend was detected.

Table 6: Results of Mann-Kendall test for Alansha minimum temperature

Month	Kendall's tau	S-Mann Kendal statistics	Var(S)	p-value (Two-tailed)	Alpha	Test interpretation
January	-0.067	-42.000	5385.333	0.576	0.05	Accept
February	-0.158	-99.000	5387.000	0.182	0.05	Accept
March	-0.220	-138.000	5381.333	0.062	0.05	Accept
April	-0.156	-98.000	5384.000	0.186	0.05	Accept
May	-0.043	-27.000	5385.000	0.723	0.05	Accept
June	-0.014	-9.000	5382.333	0.913	0.05	Accept
July	0.148	93.000	5382.333	0.210	0.05	Accept
August	0.080	50.000	5376.667	0.504	0.05	Accept
September	0.048	30.000	5376.667	0.692	0.05	Accept
October	-0.124	-78.000	5385.333	0.294	0.05	Accept
November	-0.067	-42.000	5384.000	0.576	0.05	Accept
December	**-0.256**	**-161.000**	**5387.000**	**0.029**	**0.05**	**Reject**

Source survey data 2019

Table 7: Results of Mann-Kendall test for Alansha maximum temperature

Month	Kendall's tau	S-Mann Kendal statistics	Var(S)	p-value (Two-tailed)	Alpha	Test interpretation
January	0.078	49.000	5384.333	0.513	0.05	Accept
February	**0.318**	**199.000**	**5379.667**	**0.007**	**0.05**	**Reject**
March	**0.375**	**235.000**	**5385.000**	**0.001**	**0.05**	**Reject**
April	**0.381**	**239.000**	**5384.333**	**0.001**	**0.05**	**Reject**
May	0.131	82.000	5386.000	0.270	0.05	Accept
June	0.002	1.000	5373.000	1.000	0.05	Accept
July	-0.075	-47.000	5385.000	0.531	0.05	Accept
August	0.041	26.000	5386.000	0.733	0.05	Accept
September	**0.249**	**156.000**	**5383.333**	**0.035**	**0.05**	**Reject**
October	0.094	59.000	5387.000	0.429	0.05	Accept
November	0.142	89.000	5382.333	0.230	0.05	Accept
December	0.113	71.000	5385.000	0.340	0.05	Accept

Source survey data 2019

Table 8: Results of Mann-Kendall test of Drie maximum temperature

Month	Kendall's tau	S-Mann Kendal statistics	Var(S)	p-value (Two-tailed)	Alpha	Test interpretation
January	0.165	103.000	5378.333	0.164	0.05	Accept
February	0.422	264.000	5382.000	**0.000**	0.05	**Reject**
March	0.452	284.000	5386.000	**0.000**	0.05	**Reject**
April	0.444	279.000	5387.000	**0.000**	0.05	**Reject**
May	0.235	147.000	5380.333	**0.047**	0.05	**Reject**
June	0.145	91.000	5387.000	0.220	0.05	Accept
July	0.137	86.000	5384.000	0.247	0.05	Accept
August	0.164	103.000	5387.000	0.165	0.05	Accept
September	0.374	235.000	5387.000	**0.001**	0.05	**Reject**
October	0.309	194.000	5383.333	**0.009**	0.05	**Reject**
November	0.231	145.000	5387.000	**0.050**	0.05	**Reject**
December	0.262	164.000	5383.333	**0.026**	0.05	**Reject**

Source survey data 2019

Table 9: Results of Mann-Kendall test of Kundi maximum temperature

Month	Kendall's tau	S-Mann Kendal statistics	Var(S)	p-value (Two-tailed)	Alpha	Test interpretation
January	0.027	17.000	5387.000	0.827	0.05	Accept
February	**0.295**	**185.000**	**5382.333**	**0.012**	**0.05**	**Reject**
March	**0.422**	**265.000**	**5385.000**	**0.000**	**0.05**	**Reject**
April	**0.351**	**220.000**	**5380.667**	**0.003**	**0.05**	**Reject**
May	0.185	116.000	5384.000	0.117	0.05	Accept
June	0.000	0.000	5384.000	1.000	0.05	Accept
July	-0.059	-37.000	5380.333	0.624	0.05	Accept
August	0.005	3.000	5377.667	0.978	0.05	Accept
September	0.166	104.000	5386.000	0.160	0.05	Accept
October	0.054	34.000	5376.667	0.653	0.05	Accept
November	-0.005	-3.000	5375.667	0.978	0.05	Accept
December	0.032	20.000	5381.333	0.796	0.05	Accept

Source survey data 2019

B. Trends of Rainfall

Even though 89% of respondents confirmed the decrease in rainfall, the gridded aerial data shows trends on rainfall only on January, June and December for Alansha, on July and August for Drie and on July and November for Kundi. Analysis of total annual rainfall data was undertaken to detect the variability and trend of rainfall change based on gridded aerial data for each kebele for a period 1981-2016 as demonstrated in (Figure 7, 8 and 9) respectively,

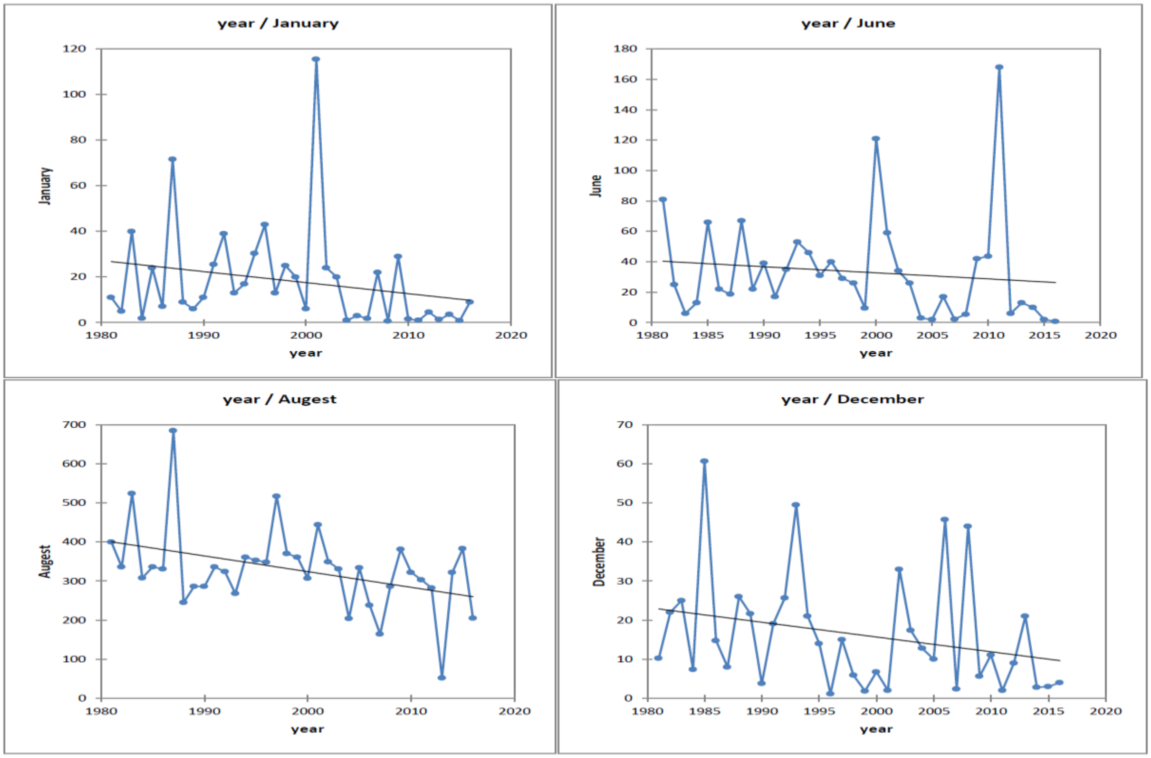

Figure 7: Results of Mann-Kendall test for Alansha annual rainfall

Source survey data 2019

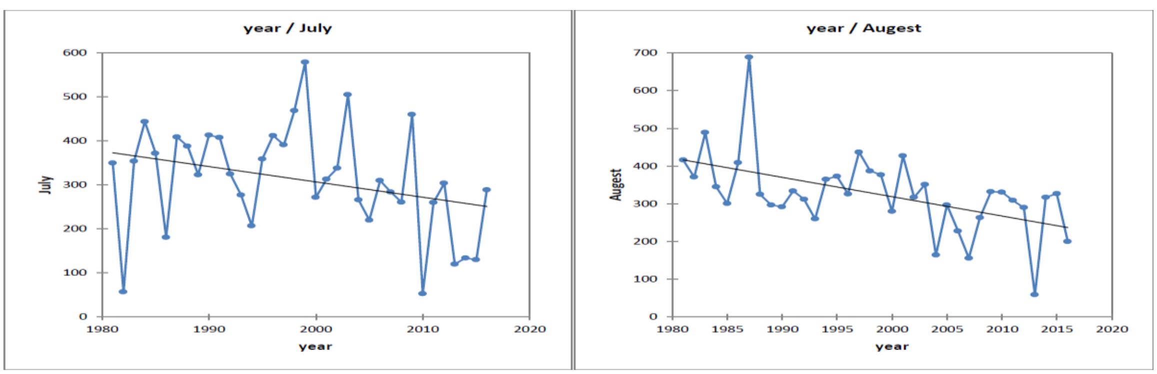

Figure 8: Results of Mann-Kendall test for Drie annual rainfall

Source survey data 2019

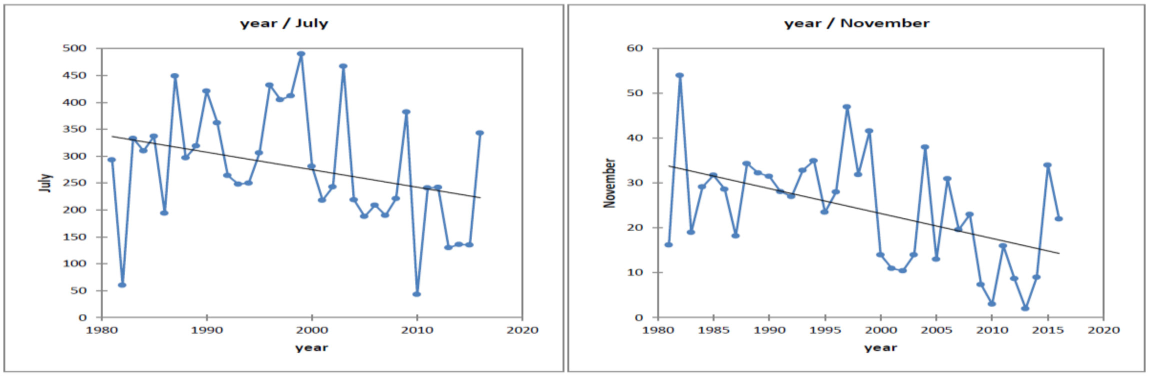

Figure 9: Results of Mann-Kendall test for Kundi annual rainfall

Source survey data 2019

On running the Mann-Kendall test on rainfall data, the following results in (Table 10, 11 and12) were obtained respectively. If the p value is less than the significance level α (alpha) = 0.05, Ho is rejected. Rejecting Ho indicates that there is a trend in the time series, while accepting Ho indicates no trend was detected.

Table 10: Results of Mann-Kendall test for Alansha annual rainfall

Months	Kendall's tau	S-Mann Kendall's statistics	Var(S)	p-value (Two-tailed)	Alpha	Test interpretation
January	**-0.257**	**-161.000**	**5383.000**	**0.029**	**0.05**	**Reject**
February	0.214	134.000	5384.000	0.070	0.05	Accept
March	0.089	56.000	5386.000	0.454	0.05	Accept
April	-0.152	-95.000	5380.333	0.200	0.05	Accept
May	0.045	28.000	5386.000	0.713	0.05	Accept
June	**-0.241**	**-151.000**	**5385.000**	**0.041**	**0.05**	**Reject**
July	-0.218	-137.000	5389.000	0.064	0.05	Accept
August	**-0.232**	**-145.000**	**5379.667**	**0.050**	**0.05**	**Reject**
September	0.199	125.000	5387.000	0.091	0.05	Accept
October	-0.096	-60.000	5386.000	0.421	0.05	Accept
November	0.024	15.000	5389.000	0.849	0.05	Accept
December	**-0.238**	**-150.000**	**5388.000**	**0.042**	**0.05**	**Reject**

Source survey data 2019

Table 11: Results of Mann-Kendall test for Kundi annual rainfall

Months	Kendall's tau	S-Mann Kendall's statistics	Var(S)	p-value (Two-tailed)	Alpha	Test interpretation
January	0.119	75.000	5387.000	0.313	0.05	Accept
February	0.006	4.000	5386.000	0.967	0.05	Accept
March	0.040	25.000	5387.000	0.744	0.05	Accept
April	-0.035	-22.000	5386.000	0.775	0.05	Accept
May	0.037	23.000	5384.333	0.764	0.05	Accept
June	-0.123	-77.000	5384.333	0.300	0.05	Accept
July	**-0.260**	**-164.000**	**5384.333**	**0.026**	**0.05**	**Reject**
August	-0.210	-132.000	5388.000	0.074	0.05	Accept
September	0.169	106.000	5388.000	0.153	0.05	Accept
October	-0.118	-74.000	5383.333	0.320	0.05	Accept
November	**-0.313**	**-197.000**	**5389.000**	**0.008**	**0.05**	**Reject**
December	-0.089	-56.000	5385.333	0.454	0.05	Accept

Source survey data 2019

Table 12: Results of Mann-Kendall test for Drie annual rainfall

Months	Kendall's tau	S-Mann Kendall's statistics	Var(S)	p-value (Two-tailed)	Alpha	Test interpretation
January	0.077	48.000	5383.333	0.522	0.05	Accept
February	-0.183	-115.000	5386.333	0.120	0.05	Accept
March	-0.131	-82.000	5380.667	0.269	0.05	Accept
April	0.079	50.000	5388.000	0.504	0.05	Accept
May	0.075	47.000	5384.333	0.531	0.05	Accept
June	-0.049	-31.000	5382.333	0.683	0.05	Accept
July	**-0.257**	**-162.000**	**5382.333**	**0.028**	**0.05**	**Reject**
August	**-0.350**	**-220.000**	**5388.000**	**0.003**	**0.05**	**Reject**
September	-0.124	-78.000	5388.000	0.294	0.05	Accept
October	0.086	54.000	5388.000	0.470	0.05	Accept
November	0.056	35.000	5389.000	0.643	0.05	Accept
December	-0.083	-52.000	5385.333	0.487	0.05	Accept

Source survey data 2019

4.1.3. Farmers' Perception on Major Causes of Climate Change

In the study farmers were also asked about the major causes of climate change. Both the survey households (74% respondents) and the key informant and focus group discussion participants mentioned increasing level of deforestation as major cause of climate change. The other 12% said due to Poor land management practices, 9% said due to urbanization and the rest 5% said due to God/ancestral spirit.

4.1.4. Major Impacts of Climate Change in the Study Area

The households' assessment of the major impacts of climate change over the past 20 years in the area shows that, the increase in temperature and reduction of precipitation cause moisture stress and leads to reduced crop production (65% of respondents). The increase in temperature is causing livestock and human disease.

Frequent flooding in the Woreda was also reported by the Woreda early warning, disaster risk prevention and preparedness team. The continuous assessment of the team showed flooding which is aggravating soil erosion and reducing the quality and quantity of crop yield. This climate change impacts lead the local farmers unable to cover annual food consumption for their family. According to the respondents, only 52% confirmed that they can cover year-round food consumption to their family from their products. The rest 48% indicated that they have experienced food gap for their family with a range of 9 to 3 months.

FGDs and KII respondents also confirmed that some native tree species like *Cordia africana* and *Olea africana* are highly decreased in number and some wild animals are totally departed from the study area due to climate change and by human activities due to the consequences of climate change

4.1.5. Source of Climate Information

The respondents were also asked about the source of information they obtained on climate related issues. From the respondents 57% of them confirmed that their source of information was radio, 53% of them confirmed extension agent, 14% of them confirmed from neighbor (other farmers) and 8% them confirmed from local leaders (Figure. 7). That means, most respondents selected more than one sources of climate information yes as the total is more than 100%. This implied that mass Medias and extension service play a major role with respectively to offering climate change and site specific adaptation measure to farm households at the study areas.

4.1.6. Farmers Climate Change Response Practice

4.1.6.1. Coping Mechanisms

During the study farmers were mentioned there coping strategy to the challenges of climate change impact. 35% of the respondents were depending on government support while 26% were migrating to other areas for wage labor. The other 20% replied that they have got support from relative either in the form of food or money and 18% selling animals. Other strategies such as reducing meal and mortgaging land were also part of coping mechanisms for some of the households in the area.

4.1.6.2. Adaptation Strategies

The farmers were subsequently asked if they have responded through adaptation to counteract the impact of climate change. The key informant and the focus group discussions show that the farmers in Kutaber woreda have been using different strategies to respond to climate variability. The results shows that majority of the respondents (75%) employed at least one adaptation measure.

Table 13: Adaptation strategies and decision in % (n=99)

	Farmers adaptation decision and strategies	Sample Kebeles			
		Drie	Alansha	Kundi	Total
Adaptation	Not adapted	25	32	18	25
Decision	Adapted	75	68	82	75
	Soil & Water conservation	58	54	82	65
Type of	Improved Crop Variety	38	27	50	37
Adaptation	Afforestation	63	83	12	63
Option	Irrigation	42	17	65	39
	Changing Planting Date	63	68	68	67
	Mulching	4	5	71	27

Source: Survey data 2019

According to the survey data (82%) of low altitude kebele household use soil and water conservation options as adaptation strategy. Similarly the low altitude area household use mulching (71%) than the mid and high altitude area. On the contrary, the high altitude and mid altitude kebele households use afforestation as adaptation strategy (83%) and (63%) respectively than low altitude households. The most common adaptation measures among the surveyed households were changing planting dates (67%), soil and water conservation (65%), afforestation (63%) use of and irrigation (39%) as well as use of improved crop varieties (37%).

4.1.7. Determinants of Climate Change Adaptation Responses

According to results from the binary logistic regression model, sex of household head had negatively and significantly and total land holding size had positively and significantly affected the probability of farmer's adaptation to climate variability and change as expected. But other variables influence was not significant (Table 15).

A Binary Logistic Model was employed to estimate the determinants of farmers' choices of adaptation practices to reduce the impact of climate change. The model examined the relationships between the choice of adaptation and the determinants that significantly affect the local farmers to adapt to climate change and variability.

According to (Pallant, 2011) the model is good fit if the Sig. value for Omnibus test and Hosmer and Lemeshow sig. value $p < 0.05$ and $P > 0.05$ respectively and this model has Omnibus test value .000 which is less than 0 .05 and Hosmer and Lemeshow value 0.148 is greater than 0.05 and the model is good fit (Table).

Table 14: Omnibus of Model Coefficients and Hosmer and Lemeshow Test

		Chi-square	df	Sig.
Step 1	Step	21.8169	7	0.002732
	Block	21.8169	7	0.002732
	Model	21.8169	7	0.002732

Step	Chi-square	Df	Sig.
1	12.08168	8	0.148

The usefulness information of the model is obtained from the Cox & Snell R Square and the Nagelkerke R Square values provide an indication of the amount of variation in the dependent variable explained by the model (from 0 to 1) (Pallant, 2011). This model is useful and has a value of Cox & Snell R Square of 0.198 and the Nagelkerke R Square of 0.292 respectively.

Table 15 : binary logit model results

Determinant Variables	B	S.E.	Wald	df	Sig.	Exp(B)
Sex of HH(1)	-1.700	0.636	7.138	1	0.008*	0.183
Education level(1)	-0.924	0.579	2.551	1	0.110	0.397
Land holding size	1.324	0.561	5.564	1	0.018*	3.757
Total annual income	0.000	0.000	0.501	1	0.479	1.000
Access to credit(1)	-0.574	0.611	0.884	1	0.347	0.563
Climate information(1)	-0.582	0.547	1.131	1	0.287	0.559
Experience in agriculture	-0.011	0.023	0.253	1	0.615	0.989
Constant	2.012	0.921	4.772	1	0.029	7.477

*Significant, Reference category: not adapted

Source: survey data 2019

4.2. Discussion

PERCEPTION ON CLIMATE CHANGE

Farmers in Kutaber Woreda were aware that there is a significant change in climate variability. They are able to perceive increase in temperature and decrease in precipitation over the past few decades due to their long time experience. The farmer's perception was also supported by the historical records of meteorological data as supported by previous researches by (Tesfaye and Seifu, 2016; Simane, Zaitchik and Foltz, 2014; Alemayehu and Bewket, 2017).

Mann Kendall's test result revealed that annual minimum temperatures have been significantly increasing only for Alansha on December. But annual maximum temperature have been significantly increasing for Alansha on February, March, April and September, for Drie on February, March, April, May, September, October, November and December and for Kundi on February, March and April. The finding also in line with studies by Karmeshu, (2012). The MK trend test shows there is trend for these months. But for the other months the null hypothesis H_0 is accepted and thereby implying that no trend can be seen in the data. The increase in temperature shows, it could become essential to understand how this may affect ecosystems and human life if such a trend continues. Change in temperature variability could lead to a shift in species habitat for forests and insects, result in intense heat waves that could be challenging for aging and other vulnerable populations. .

On the other hand, trend analysis of total annual rainfall based on Mann Kendall's test was found to be a decreasing trend on January, June, August and December for Alansha, on July and August for Drie and on July and November for Kundi kebele. The MK test result shows decreasing trends for these months only. But for the other months of the year, the null hypothesis H_0 is accepted and thereby implying that no trend can be seen in the precipitation data. This indicated that, it has great variability in the amount of rainfall. That is high amount of rainfall in a short period of time was experience in the area that leads to aggravate erosion and crop failure. The increase in temperature and prolonged drought, erratic distribution and high amount of rainfall in a short period of time leads the area to severe soil erosion; degradation and moisture stress can cause the failure and reduction of production in the area. The study revealed that the perceived climatic changes had led to change agricultural productivity mostly the reduction of crop yield. About 65% of the respondents confirmed that climate change affects their crop failure and reduction in productivity. Similar impact of climate change was also reported in a previous study by (Belay *et al.*, 2017; Moyo *et al*., 2012) in Ethiopia.

The respondents agreed the increasing level of deforestation considered as primary causes of climate change in the areas. The majority of the respondents (74%) confirmed that climate change is mainly caused by deforestation followed by poor land management (12%) and urbanization (9%). But the rest 5% confirmed due to the anger of GOD.

Adaptation Strategies

The key informant and the focus group discussions show that the farmers in the Kutaber woreda have been using different strategies to respond to climate variability. Farmers do not rush to adopt new things. They may know the problem, but they take time to adopt new methods. The study show that low altitude kebele households use mulching and soil and water conservation strategies more than the other kebele. This is because of the moisture stress and high evapotranspiration in the low land area inhibit crop growth and productivity.

According to (Deressa *et* al. , 2010), climate change adaptation is a two-phase process that needs farmers to interpret climate change in the first phase and respond by adaptation to the changes in the second. The most adaptation strategies selected in the study area were changing planting date, soil and water conservation, use of improved crop varieties, irrigation, and afforestation which is supported by previous study (Tesfaye and Seifu, 2016; Deressa, Ringler and Hassan, 2010).

Soil and Water Conservation: Soil and water conservation techniques have been linked to climate change adaptation measure due to the fact that it reduces soil erosion, improve soil fertility and improve the availability of water for crops. Soil and water conservation techniques reduces soil loss from farmers plot, preserving critical nutrients and increasing crop yields (Tesfaye and Seifu, 2016). Land degradation and reduction of soil fertility are major problem in the area that aggravates poverty and food insecurity. Climate change causes soil erosion and land degradation. Therefore, soil and water conservation is one of the technologies considered as adaptation strategies. The reasons for the majority of farmers to practice these strategies is due to the fact that soil and water conservation measures are largely practiced by the government through community mobilization and farmers are not required to add costs without labor contribution as supported by previous researches (Alemayehu and Bewket, 2017).

Changing Planting Date: Farmers in the rain fed agriculture waits the onset of rainy season to plant their crop due to it is cheap practice. Farmers change the planting date in response to rainfall variability (Tesfaye and Seifu, 2016). Changing planting dates is cheap practice that can be easily implemented by the farmers (Alemayehu and Bewket, 2017).

Improved Crop Variety: The use of improved crop variety was used as an adaptation strategy due to improved crop variety increases the yield. Agriculture productivity can only come from growth in yields from adoption of improved crop varieties (Zivanomoyo, 2009). The use of improved crop varieties as an adaptation strategy was least. The reason for this was the fact that the use of improved crop variety requires financial capacity which the farmers cannot afford (Alemayehu and Bewket, 2017).

Afforestation : Forestry/agroforestry was considered as an adaptation strategy due to it can reduce the impact of rainfall and reduce erosion, reduce the recurrent land slide and used as fodder (Panthi *et al.*, 2015). It also increase soil fertility and used as source of energy and income generating activity. Respondents in the highland Kebele (Alansha) in particular were planting *Eucalyptus globules* which are becoming source of income, energy and construction material.

Irrigation: Irrigation was considered as an adaptation strategy in Kundi and Drie Kebeles. The use of irrigation technology as adaptation strategy was reported by previous studies (Evelyn.J, Charles.K and Patricia, 2017). The reason for least used of irrigation as an adaptation strategy was the fact that the use of irrigation technology requires financial capacity which the farmers cannot afford.

DETERMINANTS OF ADAPTATION OPTION

The most common determinant factors that influence farmers whether to adapt or not was indicated in the empirical studies include sex of house hold head and land holding size that significantly affect their choice of adaptation.

Sex of household head (SEX): Female status of household head is negatively correlated as expected with climate change adaptation decision. As compared to male the decision about climate changes adaptation option of the female decreased by a factor of nearly 0.18 times than male. This is because in the study area women engaged in many activities than male such as child care and home management. Traditionally not participate in planning and decision making processes. Many evidences show that female household have less access to improved technologies, credit and extension service (Ellis and Mudhara, 1995). Therefore, the local government can play a significant role by promoting policies aimed to enhance adaptation at household level through empowering women and the support of extension services, meteorological information about weather changes in an understandable way and credit access so that they can be able to plan for their future farming and the likelihood of adapting to climate change will increased.

Land Holding Size (LHS): A farmer's ownership with large farm land is positively significant to make climate change adaptation decision. Research result revealed that the availability of farm lands to farmers in Kutaber woreda increases the adaptation options of the farmers by a factor of nearly 3.7 times than the households having lower size of farm land. This is in line with other research states that the bigger the size of the farm the greater the proportion of land allocated for improved crop varieties (Gershon *et al.*, 1985). This is because the bigger the farm size, the more likely the farmer is to adapt suitable climate change adaptation options.

5. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

This study was conducted in Kutaber woreda with the aim of investigating smallholder farmers' perception to climate change, their adaptation strategies and determinants that affect adaptation decisions. The analysis of farmers' perceptions of climate change indicates that, climatic variability was mainly characterized by increase in temperature and decrease in precipitation. Their perception was also supported by the historical records of Grid meteorological data using Mann Kendall's trend test of temperature and precipitation during the past 36 years of each kebele data. Major climate related impacts mentioned at all agro-ecology include reduction of productivity and failure of crop production over time and food insecurity.

Farmers are trying to adapt to respond impacts of the changing climate by practicing soil and water conservation, changing sowing date, use of improved crop varieties, forestry and irrigation. The results of binary logistic regression model shows that sex of household head and total land holding size were the most important determinants factors to the farmer's decision to adapt or not to climate change and variability at the study Woreda.

6.2. Recommendations

The study offers outstanding insights and new viewpoint for local government and planners in helping them take practical measures in the context of climate change in Kutaber woreda. The study recommended that the adaptation of the local communities should be enhanced through intensive land management including: tree based livelihood development, water harvesting technologies and irrigation, provision of improved crop variety, bio-physical soil and water conservation practices. Furthermore, the ongoing community mobilization for physical soil and water conservation activities should get attention for sustainability by all actors. Income generating activities such as integrating watershed management with beekeeping, fattening, tree planting, fruit and horticulture production, petty trade for landless youths and farmers with small land holding size could be considered by the local government and the community.

Besides, the study recommended that, the local government could play a significant role by promoting women’s empowerment aimed to enhance adaptation at household level and the support of extension services so as to enable them to plan for their future farming and the likelihood of adapting to climate change impacts.

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Appendix 1: Household Questionnaire

Serial No of the Interview Schedule _________

General Information

Peasant Association/Kebele____________________

Village______________________________

Respondent's Name: ____Respondent's Code_______

Number of year's respondent living in the village_______________________

Date of Interview: _________________________

Enumerator's Name: ____

A. Interview for farmers household

I. General Questions on Demographic and Socioeconomic Characteristics

Sex of household head (0=male; 1 =female	Category of farmers Code A	Marital status Code B	Age (years)	Education Code C	Experience in agriculture (years)	Main occupation Code D	Land tenure Code E	Religion Code F	Family size		
									Male	Female	Total

Codes A
1 farmer from female Headed HH
2 Women from male HH

Code B
1 Married living with spouse
2 Married but spouse away
3 Divorced/separated
4 Widow
5 Never married
6 Other, specify…

Code C
1 Educated
2 Non-educated

Codes D
0 No occupation
1 Farming (crop + livestock)
2 Salaried employment
3 Self-employed off-farm
4 Casual laborer on farm
5 Casual laborer off-farm
6 Herds girl
7 Housekeeping
8 Non-farm agribusiness
9 Other business (shops, trade, tailor, etc)
10.Other, specify………

Code E
1 Owned
2 Rent in
3 Share in
4 Share out

Codes F
0 Muslim
1 Christian
2 other, specify.

2. What type of agricultural production do you produce?

Agricultural production	Mark
Crops production only	
Livestock production only	
Mixed agricultural	
Others, ________________________	

3. How much your farm size is if you have any?

S/No	Crops grown	Area coverage (ha)	Purpose
1			
2			
3			
4			
5			

2. Do you own livestock Yes ☐/ No ☐

3. If the answer to Q.2 is yes how many livestock do you own?

S/No	Livestock type	Quantity
1	Cows	
2	Oxen	
3	Heifer	
4	Calf	
5	Equine	
6	Shots	
7	Poultry	
8	Bee colony	
9	Others (specify)	

4. Household's annual farm income from sale of crops last year in quintals?

Types of crops Grown		Annual harvest	Consumed	Sold		Total price Birr
				Amount	Unit price Birr	
1						
2						
3						
4						
5						
6						

5. Income from sale of livestock last year?

No	Animal type	Number	Number sold	Unit price	Total price
1	Cows				
2	Oxen				
3	Heifer				
4	Calf				
5	Equine				
6	Shots				
7	Poultry				
8	Others(specify)				
9	Total				

6. Income from sale of livestock products last year?

No	Product	Amount collected per year	Amount consumed	Amount sold	Unit price	Total price
1	Milk					
2	Hide and skin					
3	Egg					
4	Honey					
5	Butter					
6	Others					

7. Do you or any member of your family have off-farm activities? Yes ☐ / No ☐

8. If the answer to Q.7 is yes, indicate the type of activities

No.	Family member	Type of activities	Annual income (Birr)
1			
2			
3			
4			
Total			

9. Do you have access to nonfarm employment? Yes ☐ / No ☐

10. If yes type of work? Hand Craft / ☐ Trading / ☐ Casual labour ☐

Others specify______________________

11. How many members of your family engage in nonfarm activities? ______________________

12. Total annual income earned from nonfarm activities during this year? __________ _Birr

13. Total house hold income of the household from all sources _____________________Birr

II. **Questions related to first objective of the Study**.

- To assess farmer's perception on climate change

Use the options below to answer the following questions according to your level of agreement or disagreement:

5-Strongly Agree, 4- Agree, 3- Somewhat Agree

2- Disagree 1–Strongly Disagree

S/No	Description of statements	Options				
		5	4	3	2	1
1.	Temperature is rising in the last two decades					
2.	Rainfall is decreasing every year in the last two decades					
3.	The Environment suffers from excessive devastation due to climate change.					
4.	There is change in both temperature and rainfall in the last two decades					
5.	Climate change has led to the decline of forest resources.					
6.	Climate change has led to the change of farming system.					
7.	Frequencies of floods during raining season have increased.					
8.	Occurrence of livestock diseases has increased due to climate change.					
9.	Food insecurity has increased due to climate change.					
10.	The community here are aware of the effects of climate change					

11. What are the local indicators that show the variability/change in temperature through time in your surroundings? 1= Frequency of occurrence of drought and floods 2= Human and animals diseases that has not been seen before 3= the emergence of new species of animals and plant in your local area 4=Changes of clothing style of the communities 5= Degradation/deterioration of rivers through time 6= Change of animal and plants/crop type 7= Other, please specify____

12. What are the causes of climate change 0=Deforestation 1=poor land management practice 2=urbanization 3=God/ancestral spirit 4= Don't know

13. What major changes in weather variability do you have observed in your area over the last 20 years? 0= Floods 1= prolonged droughts 2= very hot seasons 3= very wet seasons 4=haven't observed any changes

14. What was the main impact of these changes on the local community? 0= Crop failure 1=reduction in productivity 2= Livestock deaths 3= Human disease outbreak 4= Food insecurity 5= Infrastructure failure

14. What do you think are the causes of the yield decline? 0=Natural causes (droughts, floods) 1= Pest damage 2=Disease outbreak 3= Lack of farm inputs 4= Lack of water

15. Do you think climate change has already happened? Yes ☐ / No ☐

16. If the answer to Q.11 is yes how did you feel that on your farming activities?

____

17. Did you face any crop shortage during the last five crop season due to any effect of climate change?
Yes ☐ / No ☐

18. If the answer to Q13. is yes for which of the following options did you face?
Fluctuation of onset date ☐/ High temperatures ☐ / Increase the rainfall ☐ Short rainy season☐
/ Lack of irrigation water☐ /Other specify

19. How did you solve the above problem? __________________________________

20. How do you evaluate the trend of crop production for the last ten years?
Increasing ☐ / Decreasing ☐ / The same ☐/ I do not now ☐

21. Have you faced any disaster or failures in crop production in recent years?
Yes ☐ / No ☐

22. If the answer to Q.17 is yes quantify the failure in crop production__________________

23. Have you ever faced any climate related effect in last 10 years? Yes ☐/No, ☐ if yes, what type of climatic shock? ______________________________________

24. If the answer to Q19 is yes, did it affect your cattle or/and crop and other types of your livelihood? Yes ☐ / No☐ , if yes how much? ___________________________________

25. How do you see the trend in distance you travel to locate the grazing land for livestock through time?
Increased☐ / Decreased ☐/ The same ☐/ I do not know☐

26. If say 'increased', why? ____

27. What are the measure challenges you face in livestock production?

____

28. Did you lose any of your livestock in the last drought year? Yes ☐ / No ☐

29. Which season (s) is/are rainy season? ______________________________________

30. Have you noticed any change in the length of dry seasons and the temperature to it in recent years? Yes ☐ / No ☐

31. If "yes", specify the changes____

32. In what way the changes "above" affect farming and livestock production?

33. Is there any governmental body that warns you of any unexpected weather and related disasters? Yes ☐ / No ☐

34. If "No", how do you know such unexpected weather before occurring?

____

35. Did you observe changes in cropped areas? ☐ If yes, Decrease ☐ / Increase ☐

36. Did you observe changes in types of crop grown? ☐ If yes, Decrease ☐ / Increase ☐

III. **Questions related to second objective of the Study.**

- To identify the factors influencing farmer's decisions in adaptation to climate change

1 . Access to credit

1.1. Did you receive any type of credit? Yes ☐ / No ☐

1.2. If the answer to Q2.1. is yes, would you please give us the following details?

Source of credit	Mark	Purpose of credit	Mark
Micro-finance		To purchase Farm animals	
Cooperatives		To purchase grain for food	
Bank		To purchase modern agricultural .	
Individual lenders		To purchase farm implements	
Others, specify		Others , specify	

2.3. If the answer to 2.1. is no Why? (Multiple answers are possible)

Fear of inability to pay ☐ / Lack of asset for collateral ☐ No one to give credit ☐ High interest rate ☐ / No need for credit ☐

I can use other sources ☐ / others (specify) ☐ ________________________

3. Extension services

3.1. Have you got advice in agricultural activities from extension service?

Yes ☐ / No ☐

3.2. If the answer to Q3.1. is yes who provided you the advice? (Multiple choices is possible)

Government ☐ extension officers ☐ /Farmer group ☐ / NGOs (specify) ☐/ Marketing agents ☐ / others (specify) ____________

3.3. On which area the advice was given? Crop husbandry☐Crop diversification ☐ Animal Husbandry ☐ / Marketing ☐/ Irrigation ☐ / Post harvest ☐/ Climatic information / ☐ others ______________________

3.4. If the answer to Q3.1. is no why you are not getting the service from agents on different agricultural products? ____

4. Training

4.1. Have you participate in any of the climate change adaptation trainings organized by NGO, government, etc? Yes ☐/ No ☐

4.2. Do you think the training was helpful for your practical problem? Yes ☐ / No ☐

4.3. If the answer to Q.4.2 is yes what was your reason to adapt to climate change? __________

4.4. If the answer to Q.4.2. is no, why? ____

4.5. What was your reason to adapt to climate change? _____________________________

5. Access to the market

5.1. Do you sell agricultural product? Yes ☐ / No ☐

5.2. Did you face any marketing problem to your farm products? Yes ☐/ No ☐

5.3. If the answer to Q5.2. is yes, prioritize problems? Low output price ☐ / High input price ☐/ Price fluctuation for outputs☐/ Price fluctuation for inputs☐ /Transportation cost ☐ / Lack of storage facilities ☐ / others, specify ☐_______

5.4. The distance of market place from your home: Near ☐ / Far ☐

6. **Participation in social organization**

6.1. Are you involved in any activities of formal and informal institutions /organization in your area? (social participation) Yes ☐ / No ☐

6.2. If the answer to Q6.1. is yes ,type of institution /organization and type of membership and frequency of participation in activities

Organization/ Institutions	Member	Committee member	Leader	Frequency of participation in Activities		
				Never	Sometimes	Always
No participation						
Cooperatives						
Farmers association						
Women association						
Youth association						
Others						

IV. Questions to Third Objective of the Study

 To identify climate change adaptation options by farmers in Kutaber woreda

1. Do your farming activities depend on rain? Yes ☐ / No ☐

2. What measures do you take when enough rain is not available for your farm?

____

3. What kind of measures do you take when the grazing land in your area cannot provide enough to feed your livestock?______________________________

4. According to your view, are those measures effective enough to save crops or livestock?

Yes ☐ / No ☐ If "No", what are what happens______________

5. Have you heard about the information any one of climate change adaptation options? Yes ☐, No ☐

6. If the answer to Q.5 is yes how did you know about climate change adaptation? Through: Extension agent ☐, local leader ☐, Radio ☐ , Woreda Expert ☐ , Neighbors ☐ , Contact farmer ,☐ others specify ______

7. Do you practice any climate change adaptation? Yes ☐ , No ☐

8. If the answer to Q.7 is yes, which type?

Soil and water conservation ☐ , Mulching ☐ , Afforestation ☐ Changing planting date ☐ Improved crop variety ☐ Irrigation ☐ ,No strategy ☐ , other specify __________

9. From where did you get information about different adaptation options to climate change? From neighbor's ☐, From extension agent's ☐ From market place ☐, From research center ☐

10. Can you mention the major challenges in confronting the climate change effects?

____

11. Does the local government provide any support in facing challenges related to climate change? Yes ☐ No ☐

12. Have you ever observed when other farmers were using climate change adaptation practices? Yes ☐ No ☐

13. If yes to Q.12 who are the source of information?

Farmers ☐ , NGO ☐ , Extension agent ☐, others specify,__________

14. Are you interested in using adaptation practices? Yes ☐ , No ☐

15. If the answer to Q.14 is yes why? ________________________

16. Do you have planned to use adaptation practice in the future? Yes ☐, No ☐

17. If the answer to Q.16 is no, why? ____________________________

Appendix 2: Checklists for Key Informant Interview (for experts)

Name…………………………...…Position/profession...............……………...............

Organization...

1. What do you understand by the term climate change, and climate variability?
2. What are the indictors of the occurrence of climate change?
3. How do you evaluate the climate situation (precipitation, and temperature) in the district over the last 20 years?
4. What are the major damages caused by climate change to the society?
5. What do you think about the vulnerability of the society by climate change impacts?
6. Is climate change an important agenda for Agricultural Development Offices? If yes what are the development interventions introduced in the district or study kebeles?
7. Are the development interventions appreciated, and owned by the community? Are they sustainable?
8. Do you think that farmers are aware of climate change, and variability in their localities? If yes how did they acquired the awareness?
9. What coping and adaptation strategy do farmers use in times of drought in the district to withstand the impacts of climate change?
10. What challenges do framers face to effectively implement coping, and adaptation mechanisms?
11. What social capital has rural households to avert the dangers that arise as a result of climate change, and variability?
12. How do you evaluate the impacts of climate change on rural household's livelihoods, water resources (rivers, streams and ponds), grazing lands, woodlands, farmlands, livestock's?
13. Which segment of the local community is more affected by climate variability/climate change?
14. Is there any local level organizational arrangement made that helps farmers to overcome the damages caused by climate change/climate variability?
15. How do you evaluate the role, and strength of local level organization to sustain development interventions?
16. What assistance are they provided to make them empowered?
17. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? If yes how?

18. Of the development interventions, which one is more important to reduce damages that could be caused by climate change/climate variability?
19. How does agricultural research in the region attempt to address the need for crop varieties tolerant to moisture stress, and other supporting technologies to tackle climate change?
20. What are the challenges faced by the agricultural research and extension services to address climate change issues?
21. How do you evaluate the role of the Disaster prevention, and preparedness team contribution to coping with climate change?
22. How does the Meteorology Agency contribute to efforts to withstand climate change, and variability? Does the agency have strong institutional set up to provide adequate weather information?
23. What is the success stories you observed in relation to coping, and adaptation strategies adopted by farmers to withstand climatic shocks?

Appendix 3: Checklists for FGD

1. Location of FGD-------------------------------------size of group--------------------------------
2. Team composition Female----------male-----------youth-----------kebele leader------------
3. Major agricultural crop in the study area
4. Season calendar of agricultural crop
5. Important livelihood stratifies
6. Change in major climatic hazards of the area
7. Flowering and fruiting of plants
8. Do you observe visible changes of climate variability in your locality--------------
9. What changes you perceive
    a. Precipitation---------------
    b. Temperature--------------------
    c. Deforestation---------------------
    d. Crop productivity-------------------
    e. Water availability-----------------
    f. The frequency of drought---------------------
10. What do you think the cause of drought---------------------
11. Have you heard about climate change before? When did you hear?
12. What are the local indicators you used that climate is changing---
13. What are the major impacts you face due to climate variability?
14. What coping , and adaptation strategy the local community used to alleviate the challenges of climate change
15. Do farmers in your locality have knowledge about climate change adaptation option?
16. What kind of meteorological information do you get from the government (DAs)?
17. Does development agents able to motivate the local community?
18. Do you achieve a success in adaptation to climate change impacts?
19. Do farmers in your locality have institutional arrangement, and cooperation in time of damages caused by climate change?
20. What do you think to alleviate the impacts of climate change impacts in the future?

Appendix Table 1: Annual Rainfall for Alansha

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	11	25	67	103	102	81	298	400	122	34	21	10
1982	5	4	34	424	123	25	58	336	100	17	36	22
1983	40	21	65	116	125	6	333	524	142	83	51	25
1984	2	6	28	31	9	13	340	308	22	56	2	7
1985	24	27	93	100	46	66	351	336	63	37	23	61
1986	7	13	57	40	160	22	183	331	111	21	4	15
1987	72	9	31	165	13	19	427	685	28	0	3	8
1988	9	8	36	48	192	67	334	245	40	37	7	26
1989	6	4	36	14	58	22	288	286	194	42	14	22
1990	11	32	29	75	10	39	388	286	99	17	3	4
1991	26	10	94	37	47	17	336	336	129	37	12	19
1992	39	4	58	61	72	35	281	324	57	10	22	26
1993	13	6	53	79	5	53	257	268	98	53	32	49
1994	17	27	59	57	13	46	235	361	121	21	18	21
1995	30	6	54	68	16	31	348	353	122	15	9	14
1996	43	80	97	7	79	40	451	348	137	4	3	1
1997	13	4	12	41	52	29	424	517	167	77	21	15
1998	25	14	17	14	12	26	445	370	192	162	18	6
1999	20	17	50	48	17	9	529	361	150	51	14	2
2000	6	35	42	35	24	121	323	307	74	101	66	7
2001	115	23	65	65	179	59	288	444	88	30	15	2
2002	24	28	34	134	72	34	255	349	104	32	21	33
2003	20	10	30	45	74	26	530	331	159	54	47	17
2004	1	12	53	108	69	3	236	204	194	78	51	13
2005	3	24	69	61	29	2	186	334	170	61	27	10
2006	2	51	91	7	106	17	278	238	133	20	13	46
2007	22	65	43	22	33	2	230	164	149	13	6	2
2008	1	12	100	40	34	5	238	286	128	19	13	44
2009	29	55	5	68	15	42	402	381	172	31	14	6
2010	2	24	114	40	272	44	59	322	90	61	40	11
2011	1	55	38	86	79	168	239	303	137	11	5	2
2012	5	8	31	137	68	6	269	282	131	2	1	9
2013	1	14	26	13	160	13	146	52	79	6	3	21
2014	4	21	81	46	157	10	132	322	114	14	17	3
2015	1	39	71	37	25	2	127	383	214	60	50	3
2016	9	6	164	64	11	1	337	205	69	20	24	4

Appendix Table 2: Annual Rainfall for Drie

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	2	9	216	69	15	15	350	416	105	28	23	13
1982	20	43	94	47	36	49	57	371	174	58	31	21
1983	10	38	100	123	138	7	354	489	106	21	17	37
1984	12	48	52	0	119	45	444	345	100	7	6	21
1985	18	12	43	156	58	10	372	301	130	8	5	10
1986	15	58	63	98	73	187	181	409	152	11	9	32
1987	9	34	123	72	243	11	409	689	85	61	35	76
1988	13	52	5	103	18	41	388	325	235	45	35	6
1989	8	32	119	71	20	9	323	297	166	41	24	58
1990	16	81	73	51	15	66	413	292	219	19	15	55
1991	2	41	85	39	72	11	408	334	168	32	19	34
1992	46	32	97	88	29	52	325	312	191	54	42	24
1993	34	32	58	179	100	36	277	260	266	60	35	64
1994	13	6	43	77	87	33	207	365	144	3	41	3
1995	31	39	32	207	103	47	359	373	107	39	23	40
1996	33	16	107	101	225	57	412	326	87	36	60	4
1997	25	31	73	79	51	100	391	437	81	128	74	14
1998	20	25	49	52	42	78	469	387	172	71	33	2
1999	21	4	10	4	15	37	579	377	211	146	84	6
2000	1	1	3	78	56	45	272	280	215	96	45	35
2001	37	47	110	25	105	40	313	427	160	24	14	44
2002	26	24	67	120	21	15	338	317	167	15	10	24
2003	22	28	66	162	19	42	505	351	172	0	14	44
2004	5	16	45	94	6	38	266	164	107	76	52	23
2005	18	11	116	88	113	37	220	297	84	30	17	8
2006	6	51	143	50	81	23	310	228	184	52	37	17
2007	33	86	57	106	27	40	284	156	125	29	3	1
2008	1	2	7	21	67	29	261	263	210	31	97	44
2009	23	14	43	71	4	39	460	332	37	53	5	2
2010	11	18	51	157	90	9	53	331	49	18	20	9
2011	22	31	73	64	164	25	260	309	83	26	21	9
2012	23	37	105	149	57	69	304	290	66	39	12	17
2013	12	37	74	53	34	11	120	59	76	88	8	4
2014	14	23	65	107	113	3	134	317	178	106	32	45
2015	15	19	45	70	141	37	130	327	119	15	54	24
2016	18	29	57	169	105	75	289	200	170	29	33	46

Appendix Table 3: Annual Rainfall for Alansha

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	25	17	47	133	95	64	293	356	99	15	16	16
1982	12	12	44	1	103	39	60	284	87	12	54	13
1983	33	23	63	128	141	6	333	512	150	78	19	26
1984	2	6	22	36	3	15	310	298	22	29	29	12
1985	6	61	92	93	41	62	337	336	64	22	32	9
1986	1	40	73	51	163	35	194	227	118	15	29	0
1987	3	32	48	232	28	44	449	497	45	80	18	2
1988	7	8	41	54	35	53	297	193	62	31	34	79
1989	6	57	85	36	83	31	319	254	193	70	32	5
1990	35	48	6	80	12	40	421	261	83	21	31	1
1991	95	56	89	50	49	9	362	360	131	45	28	3
1992	3	3	42	76	55	28	264	349	55	56	27	73
1993	9	5	72	92	5	44	248	262	85	42	33	55
1994	24	43	59	66	48	48	250	341	122	21	35	28
1995	25	3	43	73	10	21	306	302	103	19	24	19
1996	12	6	88	9	71	39	432	316	108	4	28	1
1997	7	53	11	43	49	34	405	459	138	50	47	18
1998	19	4	7	24	14	28	412	315	192	151	32	11
1999	22	26	67	64	17	12	490	333	147	47	42	3
2000	17	0	37	48	21	100	281	261	63	108	14	8
2001	49	0	77	65	161	66	218	422	86	41	11	3
2002	22	44	39	137	60	30	243	327	90	32	10	32
2003	4	7	24	40	49	22	467	290	134	99	14	29
2004	11	7	36	132	70	7	219	193	180	66	38	19
2005	46	37	64	58	42	1	188	308	148	52	13	15
2006	45	99	154	14	110	13	209	184	108	21	31	6
2007	18	77	42	24	59	14	190	157	121	12	20	43
2008	9	20	112	61	38	4	221	273	124	21	23	74
2009	9	54	7	67	12	28	382	412	132	15	7	3
2010	19	22	126	54	208	45	43	328	70	42	3	8
2011	23	64	46	105	44	130	241	257	110	11	16	2
2012	22	26	16	170	69	252	242	268	122	4	9	12
2013	2	2	23	12	140	5	130	60	112	6	2	16
2014	41	22	89	58	159	14	136	266	73	27	9	2
2015	11	39	63	55	25	6	135	312	177	44	34	3
2016	12	6	169	82	14	299	343	272	88	23	22	4

Appendix Table 4: Annual Minimum Temperature for Alansha

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	5.97	6.97	10.13	9.27	7.97	8.50	8.97	9.27	8.33	8.60	7.10	5.53
1982	8.63	9.50	9.07	9.33	9.63	9.53	9.50	9.40	9.03	10.13	11.43	8.87
1983	6.03	8.00	9.40	10.23	10.10	9.97	10.33	10.63	9.07	11.83	10.40	5.83
1984	5.83	4.90	8.10	8.87	9.63	9.57	9.23	9.03	7.93	7.43	8.60	5.40
1985	3.63	6.23	8.47	9.83	9.87	9.80	9.90	9.73	8.63	8.23	7.47	10.23
1986	4.10	8.30	9.03	9.77	9.90	10.17	9.77	8.70	7.87	10.70	8.40	8.07
1987	5.87	6.63	9.07	9.23	9.60	8.37	8.73	8.57	8.03	11.17	8.10	7.30
1988	6.30	7.37	8.20	9.30	9.07	8.97	8.53	8.63	8.10	10.50	7.70	10.13
1989	6.63	7.27	8.07	8.13	8.93	9.27	8.63	8.57	8.97	11.60	9.47	7.20
1990	8.83	11.13	9.60	9.20	9.60	9.67	10.63	9.77	9.77	10.63	10.20	5.53
1991	6.80	9.40	10.13	9.30	9.20	8.63	10.40	9.70	8.50	10.37	7.97	11.40
1992	8.67	9.47	9.20	10.07	9.97	10.00	10.23	9.67	8.77	10.63	9.33	5.90
1993	7.10	7.80	7.33	9.33	9.83	9.93	9.83	9.40	8.93	10.67	8.33	8.53
1994	6.10	7.53	8.67	8.43	8.80	9.47	9.03	9.30	8.23	8.43	8.60	6.50
1995	5.33	6.70	8.10	8.70	8.83	9.53	9.27	9.33	8.67	8.80	7.73	10.50
1996	7.57	6.50	8.60	8.53	8.93	8.83	9.10	8.90	8.70	9.23	8.33	6.73
1997	5.90	5.30	8.50	8.40	8.07	9.30	9.33	8.90	8.33	12.33	11.13	7.50
1998	6.93	7.53	9.27	9.20	8.50	8.97	10.27	9.67	8.77	11.50	6.47	7.13
1999	4.90	2.80	6.87	6.40	6.37	8.13	8.50	8.20	8.47	11.43	7.47	5.20
2000	4.57	3.93	6.83	8.37	8.67	8.80	8.90	8.70	8.43	10.73	8.07	8.13
2001	4.23	5.23	8.63	8.03	9.43	8.53	9.30	9.37	8.10	10.63	6.77	6.77
2002	7.07	5.40	8.57	8.37	8.90	8.93	9.60	9.20	8.70	9.27	7.17	8.93
2003	6.40	7.10	8.50	9.00	8.63	8.70	9.43	9.93	8.77	8.50	7.37	6.83
2004	7.23	5.43	7.40	9.40	7.60	8.37	8.97	8.90	8.23	8.70	7.37	7.23
2005	6.43	5.67	9.07	9.27	9.93	9.00	9.43	9.27	8.87	9.50	7.20	10.70
2006	6.37	8.87	9.30	9.73	9.27	9.93	10.47	9.53	9.27	12.47	10.10	8.70
2007	6.87	9.17	8.03	9.10	9.13	8.87	9.60	8.70	8.47	8.87	7.73	7.83
2008	5.27	4.63	5.13	7.97	9.03	8.77	9.70	9.10	8.30	9.57	8.40	12.73
2009	5.10	7.03	8.70	8.33	7.87	9.77	9.23	9.03	8.27	10.60	8.63	8.57
2010	5.43	8.17	8.20	9.47	9.80	9.23	9.13	9.43	8.57	10.00	7.77	8.70
2011	5.87	4.43	7.07	8.40	9.47	8.17	9.67	9.73	8.27	9.67	10.57	8.73
2012	3.93	6.07	7.47	10.30	10.07	10.57	10.27	9.23	8.13	9.27	11.73	8.80
2013	5.87	5.37	9.10	9.13	9.43	9.93	9.63	9.50	8.50	10.43	8.70	8.13
2014	6.03	7.37	8.03	8.90	9.47	8.53	9.23	8.73	8.47	10.40	8.50	8.63
2015	5.60	6.50	7.83	8.10	10.70	10.77	10.53	10.90	10.17	8.13	8.00	10.77
2016	8.93	8.23	9.70	11.57	9.40	10.80	11.33	11.00	10.07	7.83	6.13	7.40

Appendix Table 5: Annual Maximum Temperature for Alansha

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	21.13	22.37	19.77	20.93	23.67	25.53	21.77	21.33	20.90	21.33	21.03	19.40
1982	19.10	19.80	21.33	21.17	22.53	25.53	23.43	20.63	20.60	19.27	19.37	18.40
1983	19.00	19.77	21.27	21.57	23.13	24.77	24.77	21.20	22.17	21.20	20.93	19.87
1984	20.37	21.57	22.83	24.40	22.73	23.47	22.83	23.73	21.13	21.13	20.97	19.57
1985	20.90	20.70	22.93	21.50	22.57	24.77	22.23	21.90	20.40	20.30	20.47	19.63
1986	20.43	20.83	22.00	21.47	23.90	23.73	22.33	21.03	20.93	21.87	21.47	20.40
1987	20.57	21.27	20.50	21.80	21.87	24.53	24.13	21.60	23.40	21.53	21.40	20.43
1988	21.60	20.83	22.57	22.53	24.17	23.50	20.07	19.67	20.33	20.10	19.50	19.93
1989	19.00	20.40	20.77	19.80	22.80	24.77	22.10	20.63	19.67	20.80	21.47	19.70
1990	20.20	19.47	20.67	22.03	25.13	26.27	22.90	23.07	22.00	21.90	20.63	21.10
1991	21.57	21.77	22.30	23.87	24.37	26.10	21.47	20.23	20.93	19.87	19.47	19.00
1992	18.10	18.97	21.07	22.10	23.00	24.40	22.03	19.37	19.00	18.60	17.90	18.10
1993	17.63	18.50	20.63	19.70	21.33	23.50	21.77	21.07	20.67	19.70	19.60	19.53
1994	20.63	21.90	20.63	21.97	23.10	24.10	20.13	19.27	19.80	19.10	18.77	19.13
1995	19.93	20.83	20.77	20.40	21.67	23.50	20.40	19.80	20.17	19.37	19.40	18.63
1996	18.23	20.70	20.60	21.13	20.80	22.17	21.23	20.13	20.77	20.53	19.53	17.83
1997	18.73	20.50	21.00	21.03	22.70	22.80	21.03	20.60	21.37	20.53	20.10	20.10
1998	19.33	20.10	21.00	22.87	22.83	25.80	21.73	19.90	21.00	20.50	19.97	19.23
1999	19.33	22.17	21.13	23.57	24.43	24.57	20.13	20.10	20.30	19.30	18.97	18.67
2000	20.00	21.60	22.70	21.87	22.97	25.07	21.37	19.97	20.40	20.10	19.53	18.73
2001	18.97	21.40	20.23	22.27	23.77	23.23	20.73	20.03	20.40	20.47	19.53	19.87
2002	18.83	21.27	21.73	22.33	24.37	24.87	22.70	20.73	20.03	20.70	20.27	19.47
2003	19.43	21.87	21.93	22.03	23.13	24.13	21.17	20.53	20.63	20.23	19.83	19.17
2004	21.07	20.63	21.83	21.20	23.80	23.67	21.67	21.03	20.67	19.73	20.23	19.30
2005	20.03	22.83	22.60	22.23	21.73	23.90	21.13	20.87	21.17	20.20	20.07	20.07
2006	21.27	22.53	22.27	21.17	23.37	25.20	21.00	20.03	21.03	21.57	20.77	20.13
2007	19.33	21.83	22.43	22.03	24.03	23.00	20.73	20.70	21.20	20.57	20.07	19.90
2008	20.40	21.27	23.13	23.00	23.90	24.43	22.30	20.80	20.47	20.33	19.40	19.23
2009	19.90	21.60	22.97	22.83	24.10	26.30	22.20	21.53	22.00	21.00	21.13	19.50
2010	19.60	21.07	20.93	21.97	22.83	24.47	21.93	21.37	20.80	20.93	20.60	19.13
2011	19.53	21.83	21.07	23.23	22.17	24.77	22.80	20.73	22.87	21.57	20.50	21.00
2012	21.40	23.37	23.97	23.20	24.33	25.53	21.67	21.17	21.73	21.10	21.70	21.13
2013	21.03	22.43	23.27	24.17	24.07	24.17	20.83	19.50	21.07	20.03	20.13	19.90
2014	20.63	21.53	23.53	23.43	23.97	24.93	23.33	20.83	21.80	19.97	21.07	19.43
2015	19.83	22.47	22.97	23.53	23.47	24.37	24.53	23.17	22.53	22.57	21.53	20.00
2016	20.67	21.10	24.10	24.13	22.23	24.53	22.80	21.97	22.13	21.60	20.63	19.63

Appendix Table 6: Annual Minimum Temperature for Kundi

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	7.03	7.40	11.03	10.90	10.77	11.20	11.17	11.07	9.87	6.37	8.40	5.53
1982	8.80	10.23	10.07	11.03	11.47	11.90	11.83	11.77	10.87	7.93	13.43	8.37
1983	7.33	10.50	12.27	11.97	12.07	12.20	12.63	12.70	10.93	8.97	11.70	6.43
1984	6.93	6.33	9.47	10.07	11.27	11.77	11.43	10.97	9.83	5.50	10.37	6.00
1985	5.13	7.43	9.40	10.93	11.30	11.47	11.67	11.50	10.33	5.47	9.07	5.97
1986	5.77	10.07	9.97	10.97	11.57	11.90	11.43	10.53	10.20	7.87	10.20	6.50
1987	7.13	8.03	10.47	10.47	10.87	11.10	11.37	10.60	9.50	8.30	11.43	8.43
1988	8.60	9.10	10.07	11.33	11.67	11.43	11.10	11.50	10.73	8.77	10.00	6.87
1989	7.53	8.83	10.07	11.20	11.60	12.10	11.17	10.93	11.57	8.90	11.50	10.47
1990	10.33	12.77	11.93	11.80	12.30	12.40	13.07	12.13	11.90	8.47	11.90	6.20
1991	8.37	11.30	12.43	11.87	11.60	11.33	12.83	11.87	10.57	7.73	9.67	6.80
1992	9.87	11.00	12.17	12.67	12.73	12.57	12.73	12.10	11.37	9.87	10.63	8.80
1993	8.47	9.60	10.00	11.93	12.17	11.97	11.97	11.40	10.93	8.93	10.37	6.10
1994	7.90	9.40	10.97	11.40	11.70	12.40	11.80	11.60	10.10	6.70	10.43	5.43
1995	7.00	9.10	10.37	11.47	11.20	12.07	12.00	12.20	11.03	7.57	9.80	7.67
1996	8.73	8.03	10.53	10.80	11.13	11.43	11.57	11.27	10.90	7.07	10.17	5.27
1997	7.17	6.87	10.57	10.73	11.27	12.50	12.40	11.23	10.43	9.93	12.37	5.70
1998	8.77	9.63	11.67	12.30	11.77	12.13	12.37	12.63	11.37	9.57	8.33	4.63
1999	6.30	4.57	8.87	8.77	9.57	11.23	11.37	11.00	11.00	10.13	9.87	6.10
2000	6.57	6.27	8.67	10.63	11.30	11.83	11.97	11.07	10.87	8.80	10.93	5.70
2001	6.00	6.83	9.33	10.70	11.70	12.07	11.97	11.33	9.97	8.77	9.43	5.57
2002	8.97	8.60	10.47	10.50	11.43	11.50	12.00	10.87	10.27	7.63	10.20	8.63
2003	8.40	9.67	10.70	11.47	11.33	11.33	12.07	12.00	11.30	7.33	10.03	5.80
2004	9.03	7.97	9.53	11.67	10.60	11.40	10.83	10.83	10.00	6.90	9.93	7.03
2005	7.17	8.00	10.33	11.40	12.00	11.53	12.27	12.10	11.10	7.67	8.37	4.23
2006	7.87	10.47	11.23	12.03	11.77	12.57	12.37	12.53	11.47	9.67	11.53	8.40
2007	8.77	10.47	9.80	11.37	11.80	12.47	12.40	11.93	10.73	7.47	10.23	3.97
2008	7.43	6.80	7.40	10.60	12.20	11.90	12.37	11.87	10.80	8.00	10.07	5.20
2009	7.57	8.47	9.83	10.97	10.90	12.63	12.00	11.57	10.80	8.50	11.00	8.47
2010	7.97	10.73	10.37	12.17	12.60	12.47	12.40	12.60	11.80	8.77	9.97	6.53
2011	8.20	6.43	9.37	10.40	11.87	10.77	11.90	10.73	9.70	7.83	12.30	6.23
2012	5.03	7.77	9.07	12.03	11.83	13.13	12.50	11.50	10.27	6.23	13.50	7.87
2013	7.27	7.33	10.73	11.07	11.80	12.37	12.23	11.97	11.00	9.30	11.20	4.87
2014	8.00	9.63	10.23	11.17	11.50	11.43	11.57	10.57	9.97	8.60	11.47	4.87
2015	6.40	7.23	8.53	8.63	11.13	10.80	10.63	10.97	10.43	7.40	11.87	9.03
2016	11.53	8.00	10.57	11.93	10.83	10.47	11.47	11.00	10.03	7.23	9.00	4.77

Appendix Table 7: Annual Maximum Temperature for Kundi

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	23.43	24.27	22.40	23.33	25.03	27.47	23.77	23.37	23.30	23.27	22.87	22.07
1982	21.93	22.17	23.10	23.33	24.27	27.57	25.67	22.97	23.33	21.70	21.90	21.50
1983	21.47	22.80	23.93	24.03	24.87	26.63	26.93	23.30	24.67	23.47	23.27	22.33
1984	22.77	24.03	24.97	25.67	24.33	25.80	25.40	25.87	23.63	23.23	23.27	21.93
1985	23.53	23.10	24.90	23.60	23.93	27.37	24.60	24.10	22.73	22.37	22.67	21.93
1986	22.83	23.43	24.40	23.90	25.47	25.83	24.83	23.20	23.57	23.93	23.67	22.43
1987	22.70	24.07	22.80	24.43	24.13	27.00	26.77	23.97	25.27	23.63	23.93	23.10
1988	23.97	23.00	25.27	25.17	26.20	26.47	22.03	22.27	23.20	23.03	22.47	23.10
1989	21.73	23.57	23.50	22.63	24.77	27.00	24.13	22.70	23.23	22.90	23.93	22.40
1990	23.00	22.20	23.33	24.63	27.33	28.77	25.17	25.50	24.77	24.23	23.13	23.90
1991	24.07	24.30	25.03	26.03	26.13	28.23	23.87	22.67	23.50	22.03	21.87	21.53
1992	20.80	21.63	23.63	24.50	24.93	26.63	24.30	21.50	21.50	21.03	20.53	20.67
1993	20.27	21.20	23.10	22.10	23.37	25.87	23.97	23.27	23.00	21.83	21.87	21.93
1994	23.10	24.10	22.83	24.10	25.00	26.03	22.37	21.60	22.30	21.40	21.13	21.67
1995	22.63	23.23	23.43	22.73	23.67	25.83	22.53	22.03	22.47	21.70	21.67	21.13
1996	20.77	23.07	23.00	23.33	22.47	24.27	23.43	22.27	23.17	22.60	21.83	20.37
1997	21.23	22.90	23.50	23.07	24.47	25.20	24.03	23.50	23.73	22.63	22.87	22.90
1998	22.27	23.00	24.10	26.03	25.63	28.37	23.90	23.03	24.03	23.37	22.27	22.23
1999	21.80	24.70	23.67	25.97	25.90	27.10	23.00	22.87	23.27	21.90	21.87	21.70
2000	22.93	24.00	25.33	24.43	25.23	27.60	24.27	22.97	23.30	22.37	22.43	21.97
2001	21.33	23.53	22.87	24.97	25.50	26.20	23.67	22.67	23.43	22.97	22.17	22.87
2002	21.57	24.07	24.53	25.20	27.03	27.40	25.93	23.57	23.03	23.37	23.20	22.20
2003	21.80	24.30	24.50	24.73	25.77	26.80	24.03	22.97	23.87	22.87	22.67	22.20
2004	23.83	23.60	24.77	24.23	26.50	26.47	24.43	23.80	23.93	22.87	22.67	22.27
2005	22.17	25.57	25.37	25.13	24.13	26.73	24.03	23.80	24.20	22.90	22.17	22.73
2006	23.87	25.10	24.67	23.50	25.23	27.37	24.17	23.33	23.60	23.63	22.77	22.43
2007	22.23	23.80	25.37	24.87	26.80	26.10	23.10	23.40	23.67	22.80	22.33	22.53
2008	23.63	23.90	26.47	25.50	26.60	27.10	25.23	23.47	23.57	22.90	22.30	22.50
2009	23.13	24.07	25.87	25.87	26.60	28.60	24.07	24.03	24.57	23.40	23.60	22.17
2010	22.93	24.60	24.20	25.17	25.57	27.53	24.93	24.70	24.53	23.57	22.90	21.87
2011	21.83	24.37	24.13	26.43	24.83	26.83	24.23	22.20	24.83	23.27	22.43	23.07
2012	23.63	25.70	25.87	25.23	26.13	27.67	23.70	23.43	24.10	23.17	23.63	23.30
2013	23.67	25.40	25.93	26.63	26.50	26.97	24.03	22.67	24.13	22.87	23.07	22.23
2014	23.23	23.50	25.43	24.90	25.03	27.17	26.03	23.30	23.73	22.70	23.13	22.07
2015	21.43	23.90	24.53	24.93	24.57	24.83	25.07	23.37	22.93	22.63	21.40	20.93
2016	21.10	22.90	25.40	25.17	24.30	25.27	23.10	22.03	23.00	23.20	22.33	20.63

Appendix Table 8: **Annual Minimum Temperature for Drie**

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	6.27	7.43	10.50	9.80	8.57	9.17	9.53	9.97	8.87	8.67	6.87	7.80
1982	8.10	9.07	8.70	10.10	10.20	10.47	10.67	10.23	9.97	11.27	12.30	11.50
1983	6.47	7.13	8.80	10.60	10.53	10.70	11.23	11.33	9.77	12.07	10.50	9.00
1984	6.20	5.03	7.87	9.43	9.87	9.70	9.90	9.57	8.50	8.33	9.27	8.73
1985	4.03	5.73	7.83	10.20	10.47	10.50	10.83	10.70	9.50	8.97	8.00	9.60
1986	4.67	8.93	9.57	10.60	10.70	10.80	10.63	9.97	9.00	11.27	9.27	9.47
1987	5.57	7.10	8.90	10.23	10.60	9.17	10.43	10.53	9.17	12.30	8.53	9.03
1988	7.17	8.17	8.20	10.10	9.67	10.27	11.00	10.37	10.27	11.93	7.83	7.60
1989	6.40	8.03	8.60	9.30	9.60	9.97	10.30	9.73	9.97	12.03	10.23	13.37
1990	9.17	11.53	10.13	9.87	10.23	10.40	11.53	10.73	10.60	11.73	11.03	8.57
1991	7.33	9.87	10.60	10.00	9.63	9.10	11.37	10.80	9.43	10.27	8.77	9.40
1992	9.10	9.63	9.37	10.40	10.00	10.40	10.80	10.40	9.63	11.47	10.17	11.17
1993	7.30	7.97	7.07	9.93	10.17	9.93	10.87	10.37	9.77	11.53	8.70	7.13
1994	5.47	7.87	8.70	8.87	9.23	10.20	10.00	10.07	8.63	9.17	9.17	7.07
1995	4.97	6.43	7.77	9.67	9.10	9.97	10.20	10.20	9.47	9.43	7.80	9.00
1996	7.17	5.87	7.73	9.10	9.43	9.67	10.00	9.70	9.37	9.03	8.03	7.50
1997	6.30	4.70	7.40	8.70	8.80	9.90	10.33	9.67	9.17	13.23	12.00	8.80
1998	7.27	8.33	8.77	9.77	8.77	9.43	11.17	10.33	9.30	12.07	6.77	5.27
1999	5.37	3.27	7.30	6.97	7.63	10.03	10.03	9.83	9.97	12.13	8.17	8.33
2000	5.50	4.27	7.23	9.10	9.23	9.40	10.00	9.60	9.23	11.57	9.20	8.57
2001	4.13	4.90	8.37	8.33	9.70	9.50	9.60	10.13	8.90	11.53	8.07	7.47
2002	7.10	5.27	8.53	8.60	8.63	9.57	10.57	10.13	9.63	10.17	8.37	11.83
2003	6.50	7.67	9.30	9.90	9.43	9.53	10.50	10.97	9.73	9.60	8.83	7.90
2004	7.50	5.93	7.87	10.13	8.07	8.93	10.13	9.97	9.13	9.60	8.53	9.53
2005	6.67	5.60	8.77	9.13	10.50	9.60	10.60	10.40	9.93	10.53	8.73	6.57
2006	6.80	9.23	9.70	10.37	9.77	10.57	11.67	10.67	10.10	13.47	11.03	12.33
2007	7.27	9.57	7.97	9.40	9.20	9.60	10.47	9.63	9.30	9.83	8.67	6.43
2008	5.60	5.13	5.57	8.33	9.47	9.33	10.50	9.87	8.87	10.50	9.30	7.93
2009	5.53	7.47	9.10	8.93	8.33	10.43	10.20	10.10	8.83	11.37	9.13	10.43
2010	5.83	8.57	8.57	10.20	10.23	9.43	9.97	9.93	9.27	10.93	8.87	8.00
2011	6.43	4.90	7.67	9.10	9.70	9.43	12.00	11.23	9.77	10.83	11.47	9.17
2012	4.37	6.47	7.77	10.93	10.57	10.80	11.13	9.87	9.20	10.33	12.47	10.93
2013	6.67	6.30	9.90	10.10	9.97	10.50	10.33	10.40	8.83	11.33	10.17	6.80
2014	6.43	7.67	8.53	9.33	10.07	8.93	9.83	9.50	8.97	11.30	10.13	7.73
2015	5.43	6.30	7.80	8.10	10.93	11.00	11.13	11.53	10.80	9.20	9.00	9.80
2016	9.87	8.00	10.43	12.30	10.33	10.83	11.97	11.63	10.50	9.43	7.30	6.03

Appendix Table 9: Annual Maximum Temperature for Drie

year	January	February	March	April	May	June	July	August	September	October	November	December
1981	22.07	23.27	20.87	21.77	24.07	26.27	22.50	21.90	21.23	21.40	21.23	19.97
1982	19.57	20.30	21.97	21.77	22.97	26.13	24.10	21.47	21.33	20.07	20.03	19.27
1983	19.97	21.10	22.37	22.47	24.00	25.27	25.17	21.77	22.67	21.43	21.23	20.53
1984	21.37	21.97	23.70	24.93	23.37	24.40	23.47	24.13	21.93	22.10	21.90	20.60
1985	21.37	21.70	23.77	21.97	23.23	25.27	22.60	22.30	21.37	21.30	21.47	20.63
1986	21.37	21.80	23.07	22.43	24.43	24.53	22.90	21.87	21.63	21.90	22.17	21.47
1987	21.47	21.63	21.80	22.10	22.37	26.63	25.63	23.60	23.67	22.73	22.30	21.53
1988	22.13	21.70	23.47	23.10	25.17	24.87	22.10	20.90	20.90	20.57	20.30	19.67
1989	19.33	20.57	21.03	20.53	22.80	25.23	22.90	21.37	20.73	21.47	22.40	20.53
1990	21.07	20.30	21.70	23.03	26.17	27.43	24.13	24.23	23.10	22.77	21.80	22.10
1991	22.57	22.63	23.37	24.87	25.27	27.13	22.77	21.47	22.00	21.00	20.67	20.40
1992	19.13	20.10	21.70	22.87	23.83	25.60	22.83	20.27	20.00	19.73	19.03	19.10
1993	18.60	19.27	21.73	20.73	22.13	24.73	23.10	22.33	21.83	20.80	20.77	20.53
1994	21.07	22.20	21.43	22.60	23.70	25.07	20.90	20.03	20.33	20.13	19.87	19.83
1995	20.67	21.63	21.57	20.60	22.30	24.33	21.27	20.67	20.67	20.27	20.23	19.47
1996	19.03	21.60	21.10	21.57	21.63	23.07	21.83	20.83	21.43	20.93	19.80	18.97
1997	19.63	21.00	21.83	21.67	23.23	23.70	21.57	21.73	22.57	21.77	21.00	20.63
1998	20.10	20.90	21.83	23.80	23.83	26.97	23.20	20.93	22.03	21.53	21.00	20.30
1999	20.20	23.23	22.10	24.83	25.53	25.67	20.63	20.60	20.80	19.67	19.73	19.33
2000	20.40	21.83	23.60	22.83	23.73	25.97	22.43	20.97	21.60	20.87	20.63	20.07
2001	19.97	22.53	21.40	23.53	24.97	24.43	21.97	20.83	21.47	21.53	20.20	20.73
2002	19.80	22.33	22.67	23.60	25.43	25.93	23.77	22.00	21.17	21.80	21.33	20.47
2003	20.27	22.87	23.07	23.20	24.50	25.50	22.53	21.63	21.80	21.37	20.93	20.27
2004	22.23	21.83	23.10	22.53	25.17	25.53	23.37	22.37	21.97	21.13	21.57	20.43
2005	21.37	23.97	23.87	23.50	22.97	25.40	22.73	22.27	22.40	21.80	21.60	21.13
2006	22.30	23.47	23.27	22.20	24.50	26.47	22.43	21.40	22.20	22.57	21.77	21.03
2007	20.20	22.77	23.90	23.47	25.43	24.23	21.90	21.83	22.23	21.57	21.13	20.93
2008	21.40	22.20	24.20	23.67	24.97	25.70	23.47	21.97	21.60	21.33	20.40	20.33
2009	20.87	22.60	23.93	23.67	24.97	27.43	23.77	23.13	23.50	22.23	22.17	20.97
2010	21.30	22.43	22.57	23.57	24.30	25.60	23.83	23.00	22.03	22.47	22.03	20.87
2011	21.33	23.23	22.87	25.10	23.77	25.77	24.50	22.00	24.30	22.97	21.83	22.07
2012	22.10	23.77	24.97	24.13	25.37	26.60	22.83	22.07	22.53	22.07	22.67	22.07
2013	22.63	23.70	24.57	25.10	25.97	26.10	23.10	20.70	22.70	21.80	21.67	21.43
2014	22.20	22.83	24.70	24.70	25.20	26.20	24.73	22.77	23.23	21.47	21.93	20.87
2015	20.77	23.70	24.20	24.67	24.60	25.63	26.20	24.40	23.57	23.60	22.37	20.80
2016	21.20	22.33	25.27	25.07	23.50	26.00	23.97	23.10	23.23	22.73	21.73	20.70

Appendix Table 10:: Households Adaptation Strategy to climate Change

Kebele	Do you pratice any climate change adaptation: No	Yes	Total
Drie	6	18	24
Alansha	13	28	41
Kundi	6	28	34
Total	25	74	99

Kebele	Soil conservation as climate change adaptation option: No	Yes	Total
Drie	10	14	24
Alansha	19	22	41
Kundi	6	28	34
Total	35	64	99

Kebele	Using Irrigation: No	Yes	Total
Drie	14	10	24
Alansha	34	7	41
Kundi	12	22	34
Total	60	39	99

Kebele	Afforestation as climate change adaptation option: No	Yes	Total
Drie	9	15	24
Alansha	7	34	41
Kundi	30	4	34
Total	46	53	99

Kebele	Improved Crop Variety: No	Yes	Total
Drie	15	9	24
Alansha	30	11	41
Kundi	17	17	34
Total	62	37	99

Kebele	Changing Planting Date as climate change adaptation option: No	Yes	Total
Drie	12	12	24
Alansha	35	6	41
Kundi	18	16	34
Total	65	34	99

Kebele	Mulching: No	Yes	Total
Drie	23	1	24
Alansha	39	2	41
Kundi	10	24	34
Total	72	27	99