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CLIMATE CHANGE AND VARIABILITY: FARMERS' PERCEPTIONS IN SEKOTA *WOREDA*, NORTHEASTERN ETHIOPIA

BY

GETAMESAY BEHAILU DAGNE

MSc *THESIS* SUMMITED TO CENTER FOR FOOD SECURITY STUDIES

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APPROVAL SHEET
ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES

As *thesis* research advisor, we hereby certify that we have read and evaluate this *thesis* prepared under our guidance, by Getamesay Behailu, entitled '*Climate Change and Variability: Smallholder Farmers' Perceptions and Indigenous Adaptation Responses in Sekota Woreda, Amhara Region, Northeast Ethiopia*'. We recommend that it be accepted as fulfilling the *M.Sc. thesis* requirements.

Amare Bantider (PhD) ___________________ _____________
Major Advisor **Signature** **Date**

Desalegn Yayeh (PhD) ___________________ _____________
Co-advisor **Signature** **Date**

As members of *Board of Examiners of the M.Sc. thesis open defense examination*, we certify that we have red and evaluated the *thesis* prepared by Getamesay Behailu, and examined the candidate. We recommended that the thesis be accepted as fulfilling the *thesis* requirement for the Degree of Master of Science in Food Security and Development Studies.

Signed by the examining committee:

External Examiner: _______________________Signature __________ Date _______________

Internal Examiner: _______________________Signature ___________ Date _______________

Chairperson: _______________________Signature ___________ Date ______________

DECLARATION

I, the undersigned, declare that this study is original and has not been submitted for any other degree award to any other university before and that all the sources and materials used for the *thesis* has been duly acknowledged. The examiners' comments have been dully incorporated.

Declared by:

Name: Getamesay Behailu **Signature: ______________**

Date of Submission: _______________

Departement: Center for Food Security Studies

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

Place: Addis Ababa University, College of Development Studies, Center for Food Security Studies**,** Addis Ababa

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ABBREVIATIONS AND ACRONYMS

AfDB	African Development Bank
ANRS	Amhara National Regional State
APA	American Psychological Association
BoA	Bureau of Agriculture
BoFED	Bureau of Finance and Economic Development
CC	Climate Change
CDKN	UK-based Climate and Development Knowledge Network
CEEPA	Centre for Environmental Economics and Policy in Africa
CRGE	Climate Resilient Green Economy
CSA	Central Statistical Agency of Ethiopia
DfID	Department for International Development
DPFSPCO	Disaster Prevention and Food Security Program Coordination Office
DPPC	Disaster Prevention and Preparedness Commission
FDRE	Federal Decmocratic Republic of Ethiopia
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HOA	Horn of Africa
IES	Institute for Environmental Security
IPCC	Intergovernmental Panel on Climate Change
KII	Key Informant Interview
masl	metres above sea level

NGO Non Governmental Organization

NMSA National Meteorological Services Agency of Ethiopia

PSNP Productive Safety Net Program

SCF-UK Save the Children Fund (United Kingdom)

SRS Simple Random Sampling

SSA Sub-Saharan Africa

USAID United States Agency for International Development

UNECA United Nations Economic Commission for Africa

UNEP United Nations Environment Program

UNFCCC United Nations Framework Convention on Climate Change

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ABSTRACT

Climate change is a global concern as it severely affects the livelihoods of the world community in general and agricultural production and food security of the farming community in particular. This study aimed to understand smallholder farmers' perceptions of climate change and variability using a survey of 168 households, key informants interviews (n = 6) and a focus group discussion in Sekota woreda of Amhara region. Survey-based data associated with external biophysical-socioeconomic data both from primary and secondary sources. Simple linear regression, nonparametric Mann–Kendall test and Sen's methods to determine trends and coefficient of variation to determine variability, were used in rainfall and temperature data. Surveyed results showed that a significant number of farmers perceived that climate is changing, and were particularly concerned about the changes in rainfall and temperature over the past three decades. Specifically, the study suggested that increased annual average minimum temperature and average maximum temperature (0.8°C and 1.4°C per decade respectively) and decreased annual precipitation (40.79 mm per decade, both from gridded station meteorological datasets) were correctly perceived by 82 % and 87 % of the respondents respectively. Climatic trends also show fluctuations in both main rainy season and short rainy season rainfall (43.68 mm and 59.94 mm per decade respectively) and suggest a statistically significant changes over the last 30 years. The study concluded that farmers' perceptions of climate change and variability reflect meteorological analyses which demonstrate increasing temperature and decreasing rainfall significantly.

Keywords: *Climate Change, Farmers' Perceptions, Mann–Kendall test, Sen's method, Sekota, Ethiopia*

CHAPTER ONE: INTRODUCTION

1.1 Background

As has been indicated by Tripathi and Mishra (2017), climate change is a reality. It has happened, it is happening, and it will continue to happen. In its wake it is affecting livelihood systems. Climate change is a global concern as it severely affects the livelihoods of the world community in general and agricultural production and food security of the farming community in particular. It could have an adverse effect on various biophysical and economic activities like agriculture, water resources, forestry, human health, biodiversity, and wildlife. Its consequences are severe in developing countries in which agriculture is the primary source of livelihood (World Bank, 2008).

It is worrisome that Africa is especially vulnerable to climate change and variability because large proportions of the population are poor and depend on agricultural activities, which is highly sensitive to rainfall variability and change in temperature (The World Bank Group, 2010).

Even though climate change is not a new phenomenon, it continues to strongly impact agriculture in Sub-Saharan Africa, where smallholder farmers dominate the agriculture sector and are most vulnerable to adverse effects of climate change. The fact that climate change will adversely affect agriculture in the region has become a challenge for sustainable development on the continent (Juana, Kahaka and Okurut, 2013). Countries in Sub-Saharan Africa (SSA) are particularly vulnerable to the adverse effects of climate change because of their dependence on agricultural production and their limited capacities to effectively adapt. Most farmers are already facing considerable threats, and climate variability and change only worsen these threats through losses in farm profits. Challenges such as persistent poverty and socioeconomic inequality, low levels of development, limited economic capacity, and countless governance and institutional failures (CDKN, 2014) have led to low adaptive capacities and a significant adaptation deficit in SSA (Niang *et al*., 2014).

Climate change is serious in the Horn of Africa (HOA); several researchers found that the annual mean temperature and precipitation were, respectively, raised and declined in the Sub-Saharan African countries in general (Amjath-Babu *et al*., 2016) and in the HOA in particular (Goytom and Hansen, 2016). Acourding to Van de Giessen, in 2011 the Institute for Environmental Security (IES) had reported that conflict and migration are extremely serious in the HOA, especially during drought periods. In this region, above 80% of the population engage in rain-fed agriculture and herding at a very low production (Gebreyesus, Kirubel and Abadi, 2016; Goytom and Hansen, 2016; Mihretab *et al*., 2016; Awange, Khandu, Forootan, and Heck, 2016); thus, poverty is extremely high although they are enjoying a little economic growth in the last 10 years. In the future, drought and flooding will be expected to continue in the HOA because temperature is expected to rise in the next century (IPCC, 2014; Van de Giessen, 2011).

The adverse impact of climate variability in Ethiopia is significant since the political economy of country depends on rain feed agriculture (Mintewab, Di Falco and Alemu, 2014; UNECA, 2011). It is recognized that Ethiopia is particularly vulnerable to the adverse impacts of climate change. This vulnerability has spurred much policy debate in recent years and Ethiopia is one of the few countries to have formally merged its aims of developing a green economy with building greater resilience to climate change under a single policy framework: the 2011 Climate Resilient Green Economy (CRGE) Strategy. Even before these different strategic plans for a climate-resilient green economy were launched, Ethiopia was implementing important climate compatible initiatives, particularly in terms of natural resource management and renewable energy. For instance, a report by the Overseas Development Institute shows that even before the development of the Climate Resilient Green Economy Vision in 2011, around 14.5% of the national budget was used for interventions relevant to climate adaptation and mitigation (Zewdu *et al*., 2014).

According to the Climate Change Vulnerability Index, Ethiopia is ranked seventh among countries at risk from the impacts of climate change (Maplecroft, 2015). This vulnerability largely emanates from its low level of development and dependence on agriculture – the mainstay of Ethiopia’s economy, which contributes 40.2% of GDP, employs 80% of its population and accounts for 70% of export earnings (African Development Bank (AfDB), 2015). As indicated by FDRE (2007), most climate models predict temperatures in Ethiopia will rise over the coming years, increasing by 2.1°C in 2050 and 3.4°C by 2080 and over the past five decades, rainfall has shown a high degree of variability. This is expected to continue, and the frequency and severity of droughts and flood is expected to increase (Temesgen, Hassan and Ringler, 2011).

It is recognized that Ethiopia is particularly vulnerable to the adverse impacts of climate change. This vulnerability has spurred much policy debate in recent years and Ethiopia is one of the few countries to have formally merged its aims of developing a green economy with building greater resilience to climate change under a single policy framework: the 2011 CRGE strategy. In 2014 as it has been disclosed by Zewdu and colleagues, even before these different strategic plans for a climate-resilient green economy were launched, Ethiopia was implementing important climate compatible initiatives, particularly in terms of natural resource management and renewable energy.

Thus, the main purpose of this study was to assess smallholder farmers' perceptions and comparing their perceptions with the real world meteorological data with a need to establish and document facts for the study area.

1.2 Statement of the problem

The adverse impact of climate variability in Ethiopia is significant since the political economy of country depends on rain feed agriculture (Mintewab, Di Falco and Alemu, 2014; UNECA, 2011). Considering the history of recurrent drought and rainfall variability in Ethiopia, conducting long term trend and variability studies with robust methods to obtain important information on what has been changing in the past few decades has a vital contribution (Daniel, Woldeamlak and Lal, 2014). As a result, accurate estimation of the spatio-temporal distribution of rainfall and observing its trends are crucial input parameters for securing sustainable agricultural production (Dereje *et al*., 2012).

Among the Ethiopian regions, Amhara is one of the most vulnerable areas to climate variability and change. The increase in temperature along with a decrease in precipitation, have becoming a serious problem in the region that frequently affected the agricultural sector. Crop-pest, livestock epidemic, hailstorm, drought, flood become the most dominant and frequently occurring climate related shocks in the region (Misganaw, Enyew and Temesgen, 2014) and the same is true in Sekota *woreda*.

Wag Hemera zone in general and Sekota *woreda* in particular, are/were frequently hit by natural and manmade hazards that greatly affect crop and animal production and productivity. Most people in Sekota are small-scale farmers, mainly growing staple crops such as tef (a highly valued Ethiopian staple), barley, wheat and beans. Communities in Sekota are structurally food-insecure. Sekota is a marginal area that produces just enough for survival in a good year. Most households have fragmented land holdings; land is divided into smaller and smaller parcels, often too small to support a family and therefore also known as 'starvation plots'. Poverty in Sekota has been increasing over recent decades, because of a complex array of factors such as land degradation, soil erosion, deforestation and more unpredictable rains (Sharp, Devereux and Yared, 2003). Though trend analysis of meteorological variables is not new in Ethiopia, no one conducted a research on farmers' perceptions on climate change and variability in Sekota *woreda*. Since it is among drought-prone areas of the country, due attention should be given in thoroughly detecting trends of climatic variables with the background that the problem of one community is not very similar with others.

Hence, considering this knowledge gap, the researcher studied on the local level of smallholder farmers' perceptions of climate change and variability and compared their perceptions with the real world meteorological data in Sekota *woreda*.

1.3 Objectives of the study

1.3.1 General objective

The general objective of this study was to investigate smallholder farmers' perceptions on climate change and variability and compare the observed perceptions with the recorded real meteorological data in Sekota *woreda.*

1.3.2 Specific objectives

Specifically, the study was designed to:

- analyze farmers' perceptions towards climate change and variability over the last 30 years.
- assess the accuracy of such perceptions by comparing the observed perceptions with the recorded real world meteorological data.
- estimate trends and variability of temperature and rainfall of 30 years (1987-2016).
- recommend reasonable policy interventions that match farmers' perceptions and experiences in the study area.

1.4 Research question

This study has addressed the following research questions:

- Do smallholder farmers perceive CC?
- Do farmers' perceptions compute with records provided by weather monitoring stations?

1.5 Significances of the study

This study enabled us to assess farmers' perceptions and analyze trends and variabilities of rainfall and temperature in the study area. Although this is a small scale study, the findings from this study will complement and act as a reference point for other similar studies to be conducted in other parts of the country or the world.

This study also provides empirical data to support the perceived assertion of climate change and farmers' responses so it serves as a contribution of new knowledge about the world, at least from the perspective of the participants in this study.

1.6 Limitation and Delimitation of the study

First, this research was concentrated on the smallholder farmers in Sekota *woreda* only to be as a domain of the study. Second, relying on a cross-sectional survey design means that a measure of farmers' perceptions at one point in time, limiting the ability to make causal inferences. Third, the smaller size of the sample may affect the adequate power to detect significant difference between predictors so findings from this *woreda* may not be considered conclusive nor exhaustive, but only indicative of what may be found in similar situations and the general situation in some of Ethiopia's rural areas. The main challenge with this knowledge is that it is location specific and hence potentially inapplicable beyond the context of the study area. Last but not list is that this study relies on farmers' recall of climate and weather changes. This imposes a limitation in this study as it could have been difficult for most farmers to remember past events.

1.7 Ethical considerations

The respondents for this research were not subjected to any risk that could harm them physically or mentally. Clearance to undertake the research in the study area was taken from the relevant authorities, Addis Ababa University. The rights of respondents as participants were emphasised and observed throughout the study. The decision to participate in the study was voluntary. The respondents had the right to decide not to participate, or to stop taking part at any time without providing a reason for doing so, without any undue effects. In this study, none of the respondents refused to participate.

Individual informed consent to participate in the study was sought before each interview. This process involved the enumerators outlining the objectives and purpose of the research. The respondents were also assured that the data would be properly handled to ensure their safety and the confidentiality of respondents. They were assured that the data would only be accessed by the researcher and would be solely used for research purposes.

1.8 **Organization of the thesis**

The remaining parts of this thesis are organized as follows. Chapter Two is the literature review section that provides the conceptual and theoretical basis of this study by explaining the concepts of indigenous knowledge and adaptation to climate change as they are employed in the climate change field. Chapter Three, the description of the study area and research methodology section**,** where descriptions of the study area and an overview of the methods used in the study is provided. This section outlines the step by step progression of the research from the data collection exercise to the analysis of the data. It goes on to explain the different methods developed to address the research objectives, and explains the selection of the study site and the regional setting of the study area. Chapter Four presents the results and discussions of the study. In this chapter, key findings of the study are briefly discussed. Chapter Five presents conclusion and recommendations based on the findings of the study.

CHAPTER TWO: REVIEW OF RELATED LITERATURES

2.1 Theoretical literature review

2.1.1 Overview of climate change

The Intergovernmental Panel on Climate Change (IPCC) (2007) defined climate change as statistically significant variations in climate that persisted for an extended period, typically decades or longer. It includes shifts in the frequency and magnitude of sporadic weather events as well as the slow continuous rise in global mean surface temperature. The effects of climate variability such as rising temperature and changes in precipitation are undeniably clear with impacts already affecting ecosystems, biodiversity and people. These conditions determine the carrying capacity of the biosphere (IPCC, 2001). One of the most widespread anthropogenic challenges affecting agricultural production is climate change and climate variability (Torquebiau, 2016). Changes in mean temperature and precipitation are the main direct effect of climate change. Precipitation is particularly import, because changes in precipitation pattern may lead to floods or drought (Boko *et al*., 2007). Climate change with expected long-term changes in rainfall patterns and shifting temperature zones are expected to have significant negative effects on agriculture, food and water security and economic growth in Africa; and increased frequency and intensity of droughts and floods is expected to negatively affect agricultural production and food security (DfID, 2004).

While many populations suffer from outcomes, climate change poses the most significant threat to vulnerable populations. Individuals living in low- or middle-income countries are more likely to be affected, due to historical low levels of food supply, poor access to improved sanitation and potable water, inadequate countrywide efforts to mitigate and adapt, and large populations living on coastal regions. People living in low- and middle-income countries are also more affected by climate change outcomes because of fragile health infrastructure and the poor ability of government policymakers to respond and adapt to changes in resulting health and disease patterns (Skolnik, 2016).

Tabari and Talaee (2011) have noted that trend analysis of climatic variables has received a great deal of consideration from scholars recently. Characterization of the intra-and inter-annual spatio-temporal trend of meteorological variables in the context of a changing climate is vital to assess climate-induced changes and suggest feasible adaptation strategies and agricultural practices.

Considering the history of recurrent drought and rainfall variability in Ethiopia, for instance, conducting long term trend and variability studies with robust methods to obtain important information on what has been changing in the past few decades has a vital contribution (Daniel, Woldeamlak and Lal, 2014). As a result, accurate estimation of the spatio-temporal distribution of rainfall; and observing its trends are crucial input parameters for securing sustainable agricultural production (Dereje *et al*., 2012).

Climate change mitigation and adaptation issues have become subject of intense global discussions in the past few decades. Mitigation entails all anthropogenic interventions or policies aimed towards reducing greenhouse gas (GHG) emissions or enhancing the sinks for GHGs (Chambwera and Stage, 2010; IPCC, 2001). Mitigation is regarded as a crucial long-term solution to addressing ongoing climate change and minimising its negative impacts in the future. Adaptation, on the other hand, refers to all adjustments or moderation in natural or human systems in response to actual or expected climate change as well as taking advantage of new/arising opportunities (Adger *et al*., 2003; IPCC, 2001).

2.1.2 Farmers' perceptions about climate change

Perception has been defined as the process by which organisms interpret and organize sensation to produce a meaningful experience of the world (Lindsay and Norman, 1972); and that a person's perceptions are based on experiences with natural and other environmental factors that vary in the extent to which such perceptions are enabled (Hartig, Kaiser and Bowler, 2001). It is clear that people experience changes in local weather patterns. These may not necessarily reflect long-term local and global trends in the climate. Nevertheless, drawing from behavioural research, many have argued that the perception of changes in the weather can play an important role in adaptation and in supporting climate policy (Howe *et al*., 2013; Clayton *et al*., 2015).

Farmers' perceptions about climate are based primarily on their sense of the reliability or variability of weather patterns— especially rainfall, temperature, and drought—in their own regions and this perception is an important determinant for adaptation decision (Piya, Maharjan and Joshi, 2013; Osbahr *et al*., 2011; Patt and Schro¨ter, 2008). However; as diclosed by Amogne *et al*. (2018), focusing on annual or seasonal trend alone might mislead and should be supported by variability analysis and perception of the farmers. Moreover, incorporating the experiences of farmers in trend analysis discourse which could offer important insights on the nature of meteorological processes that could not capture by the analysis of recorded data alone is very important. So farmers' perceptions of climate change governance and adaptation is pivotal for future plans aiming to deal with challenges arising as a result of CC. Farmers who perceive potential consequences from climate change are more likely to support policies and programs that aim to address it (Niles, Lubell and Haden, 2013; Arbuckle *et al*., 2013). However, in many parts of the world CC awareness, mitigation and adaptation mechanisms are marginally known. The spatial behavior and behavioral responses of individuals and communities are often shaped around their perceptions of problems (Getis, Getis and Fellman, 2000; Nzeadibe and Ajaero, 2010) and this urges scholars to investigate the problem of CC in the context of particular socioeconomic settings.

As evidenced from Speranza, Kiteme and Opondo (2009), awareness and perceptions of a problem shape motivation to act or not to act on the problem related to CC. This is important because a person's response to change can be strongly influenced by their knowledge and perception (Ferguson and Bargh, 2004). It is noted that perceptions of risks by rural communities are also important in configuring the climate risk as it can shape the variety of adaptive actions taken.

As researchers also disclosed that farmers' perceptions on climate change plays a key role for appropriate adaptation and mitigation strategies related to land use and agricultural practices decision making (Adger *et al*., 2003; Kemausuor *et al*., 2011). For rural households, perceptions of local climate change help them to make decisions to change their daily practices in order to adapt to climate change risks (Ndaki, 2014).

Acourding to Wolf and Moser (2011), understanding and conceptualization of climate change risks by people is greatly influenced by how they perceive other issues and relate those to climate change. Mertz, Mbow, Reenberg and Diouf (2009) in their research analysed farmers' perceptions of climate change and adaptations in the savanna zone of Senegal and showed us that knowing communities' perceptions has become a prerequisite and elemental task in climate change and disaster management. Climate change perception researchers concluded that perception decides over resource allocation. Without perceiving the risk adequately, all other determinants seem to be meaningless (Falaki, Akangbe and Ayind, 2013). Therefore, assessing households' perception of climate change could be a pre-condition for adaptation. Hence, it is important to understand the level of people's perception, its correctness, and how perception of CC motivates farmers to decide on adaptation ingeneral and in this study area in particular with a different model.

2.1.3 Climate change and Agriculture

Climate change and agriculture are interrelated. The interrelationship between the two is on the one hand, agriculture and changes in land cover, food system, emit greenhouse gases that contributes to climate change and on other hand, climate change affects agriculture. Given the over-dependence on rain-fed agriculture by the majority of people living in rural areas, climate change and variability has been one of the major limiting factors in agricultural production, resulting in food insecurity and low-income generation (Tanner and Mitchell, 2008). The studies conducted by Rosenzweig (2002) revealed that changes in rainfall patterns and amounts have led to loss of crops and reduced livestock production. As has been also indicated by Chakraborty, Tiedemann and Teng (2000), climate change affects agriculture in two ways—direct and indirect. Changes in climatic factors (for example, temperature, and rainfall) affect agricultural productivity through physiological changes in crops. In addition, climate change also affects other factors of production in agriculture, such as water availability, soil fertility, and pests (Porter *et al*., 2014). The overall effect of climate change on agriculture could be positive or negative; the magnitude of impact can also vary from very low to very high, depending on regional or geographical location and status of socioeconomic development (Mendelsohn, Dinar and Williams, 2006; Tol, 1995; Tol *et al*., 2004; Tripathi, 2016).

Increasing impacts of climate change and variability on agriculture have been associated with various adaptations and coping mechanisms (Gwambene, 2007). Agricultural adaptation is a vital policy response that will shape the future severity of climate change impacts on food security. In 1999, Adams and colleagues indicated that adaptation can lessen the yield losses that might result from climate change, or improve yields where climate change is beneficial.

2.1.4 Definitions of key concepts used in this thesis

The following sub-section briefly explains key concepts used in this thesis. More detailed explanations can be found in IPCC (2001).

Climate variability: variation in the mean state and other statistics (such as standard deviations, occurrence of extremes, etc.) of climate on temporal and spatial scales beyond that of individual weather events. Variability may be due to natural processes within the climate system (internal variability), or due to anthropogenic forcing (external variability).

Climate change: A change in the state of the climate that can be identified by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcing or to persistent anthropogenic changes in the composition of the atmosphere or in land use systems.

Adaptation: all adjustments or moderation in natural or human systems in response to actual or expected climate change as well as taking advantage of new/arising opportunities.

Mitigation: a crucial long-term solution to addressing ongoing climate change and minimizing its negative impacts in the future.

Vulnerability: The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes.

2.2 Empirical literature review

2.2.1 Farmers' perception of climate change

Farmers in developing countries have been and are living in harmony with climate change. Therefore, they are the right people to tell about climate change and its impact on their livelihood. It has been said that awareness or knowledge about climate change is a pre-condition for mitigating or adapting to its adverse effects (Maddison, 2006; Juana, Kahaka and Okurut, 2013). Different empirical studies in different areas indicated farmers' perceptions about climate change.

As evidenced from Gandure, Walker and Botha in 2012 that farmers in South Africa have perceived increase in temperature, and indicated that summer temperatures were warmer while winter temperatures were colder. The same study also pointed out that warmer temperatures in the area are associated with high evaporation and increased crop water requirements. The farmers also reported that there has been a perceived decrease in rainfall or precipitation. Maddison (2006) reported that perceptions about climate change showed that a significant number of farmers believe that temperature has already increased and that precipitation has declined for eleven African countries. Another study conducted by Acquah de Graft (2011) in

Ghana, indicated that 60% of the farmers reported that there has been a noticeable increase in temperature and 49% reported a decrease in rainfall. Acquah-de Graft and Onumah (2011) also analyzed perceptions of climate change in western Ghana, the majority of the farmers in the study area perceived an increase in temperature and decrease in precipitation.

Sofoluwe, Tijani and Baruwa (2011) realized that the majority (more than 75%) of farmers in Osun State of Nigeria perceived increase in temperature and decrease in precipitation pattern. Mandleni and Anim (2011) also pointed out that about 86% livestock farmers in the eastern cape of South Africa were aware of the increase in temperature pattern and that weather conditions in the province was dominated by drought. Moreover, a study conducted by taking samples from Benin, Burkina Faso, Ghana, Niger and Togo indicated that most of the respondents reported a decrease in rainfall, change in rainfall pattern with delayed rains and early cessation and a significant increase in temperature characterized by an increase in the number of hot days (Akponikpe, Johnston and Agbossou, 2010).

A study conducted by Mertz and colleagues (2009) showed that farmers in savanna zone of Senegal were aware of climate change and variability, and identified intensive wind and occasional excess rainfall as the most destructive climatic factors. The study also figured out that households in the area noticed a decreasing trend in overall rainfall and increased temperatures throughout the year and that cold periods have become shorter and hot periods longer. Apata, Samuel and Adeola (2009) also analyzed arable food crop farmers' perceptions about climate change and adaptation strategies in southwestern Nigeria and the results of the study indicated that about 89% of the farmers perceived a significant increase in temperature, 72% perceived higher evapo-transpiration rates, 68% indicated that there has been violent rain and hailstorms and 65% experienced delayed rainfall and early cessation.

Other empirical studies also found that the temperature and humidity in Ethiopia have significantly increased over the years (Temesgen, Hassan and Ringler, 2008; Mahmud *et al*., 2008). Nhemachena and Hassan (2007) also examined farmers' adaptation strategies in South Africa, Zambia and Zimbabwe and reported that most farmers perceived long-term increase in temperature and that the region was getting drier, with changes in the timing of the rains and frequency of droughts.

2.2.2 Climate change trend analysis and variability

Different trend analysis studies have been conducted in many countries of the world and in Ethiopia at different spatio-temporal scales and came up with mixed results.

A study by Gebremedhin, Shetty and Nandagiri (2016) in Northern Ethiopia disclosed a mix of non-significant positive and negative trends. As evidenced by Daniel, Woldeamlak and Lal (2014) that a statistically significant increasing trend of temperature while the case for precipitation was mixed over the upper Blue Nile river basin of Ethiopia. Seifu and Abdulkarim (2006) had tried to cover relatively wider spatial coverage and disclosed no significant trend of *belg* rainfall totals while *kiremt* rainfall exhibited a significant decreasing trend. Osman and Sauerborn (2002), on the other hand, had reported a clearly decreasing trend of annual and summer rainfall which was started around the end of the 1910s and continued with a progressive downward trend. NMSA (2001) had reported an increasing trend in annual rainfall in central Ethiopia while a declining trend has been observed over the Northern half and Southwestern part of the country. Negash, Goel and Jain (2013) had investigated the spatiotemporal variability of annual and seasonal rainfall over Ethiopia and reported decreasing trends of *kiremt* and annual rainfall in northern, northwestern and western parts of the country; while an increasing trend in annual rainfall was observed in a few grid points in eastern parts of the country.

A study by Woldeamlak (2007) pointed out that, though there were intra-annual and intra regional differences in amount and variability of rainfall in Amhara region (where the extent of variability is higher in the eastern part of the region, geographical area where our study area is found), no systematic pattern of change across the region regarding trends in annual and seasonal rainfall was obtained. Conway (2000), after analyzing data for longer period of time in Wollo and Tigray, had concluded absence of evidence for a long-term trend or change in the annual rainfall except a slight increase in *belg* rainfall (from 1980s up to 1996) and very slight decrease in *kiremt* rainfall up to the mid of 1980s at Kombolcha. Another study in the upper Blue Nile River basin by Tabari, Meron and Willems (2015) revealed insignificant decreasing trends in annual precipitation at most of the stations. A study by Meze-Hausken (2004) in Northern Ethiopia, which was accompanied by the perception of local communities, have asserted that small rainy season (*belg*) has been lost and the main summer rains have shortened in duration. Gutu, Bezabih and Mengistu (2012) had reported a gradual decline in yearly average rainfall and pronounced reduction both in belg and meher rains. Additionally, irregularities in onset and cessation have been observed which affects the cropping calendar of the farmers. Marked onset and cessation variability in both space and time was also reported by Zewdu and Lamb (2005).

A relatively recent study conducted in central highlands of Ethiopia (which is very similar to our study area) by Arragaw and Woldeamlak (2017) disclosed that annual and June–September (*kiremt*) rainfall exhibited statistically insignificant increasing trends while March–May (*belg*) rainfall depicted significant decreasing trends. Rosell and Holmer (2007) in the eastern part of South Wollo (Ethiopia) had found a slight decrease in rainfall during the short belg season while the long rainy season (*kiremt*) had shown an increasing trend through time. Both the short and the long rainy seasons have become shorter and rainfall variability had increased. Jury and Funk (2012) using long term grided data had reported upward trends in air temperature and downward trends in rainfall over Ethiopia's southwestern region in the period 1948–2006. Similarly, Yilma and Zanke (2004) disclosed a significant decline in the annual and *kiremt* rainfalls for the eastern, southern and southwestern stations since about 1982.

CHAPTER THREE: RESEARCH METHODS

3.1 Description of the study area

Geographic location

This research was conducted at Sekota *woreda* (district) in Wag Hemera Zone, Amhara Region, Ethiopia. Sekota *woreda*, which is located between 12^0 23′and 13^0 16′N latitudes and 38^0 44′and 39^0 21′E longitudes (Figure 3.1), is one of the six *woredas* of Wag Hemera special administrative zone. The *woreda* is surrounded by Tigray region in the East, Gazgiblla *woreda* in the South, Abergelle *woreda* in the North, Ziquala *woreda* in North West and Dehana *woreda* in the West. Sekota town (the capital of the *woreda)*, which is also the capital of the zone, is 720 km North of Addis Ababa and 540 km north east of the regional state capital, Bahir Dar (BoFED, 2013).

Population

Based on the Population projection values of 2017 conducted by the Central Statistical Agency of Ethiopia (CSA), this *woreda* (excluding the town population) has a total population of 129,836 of whom 64,552 are men and 65,284 women. A total of 26,903 households were counted in this *woreda*, resulting in an average of 4.18 persons to a household, and 25,941 housing units. Sekota *woreda* has a population density of 75.38 per square kilometer, which is greater than the zone average of 47.15 persons per square kilometer.The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 99.82 % reporting that as their religion (CSA, 2013).

Topography

Wag Hemera zone in general and Sekota *woreda* in particular, is characterized by rugged topography and full of mountains. About 34.07 % of the zone has slopes from 16 to 32. The regional average in this rage is 20.59 %. And also 8.84 % of the zone has a slope greater than 32. Only 3.7 % of the zone has 0 to 2 slopes whereas the regional average in this range is 19.46 % (Amhara Region Bureau of Finance and Economy Development, 2014).

The nature of topography of Sekota *woreda* is challenging for arable farming. The *woreda* has very undulating landscape: more than 35% of the area has rugged topography, 36 % hilly, and 2 % valley. It is only 27 % of the total area with more or less plain topography (Wag Hemera Zone Agriculture Development Office, 2015).

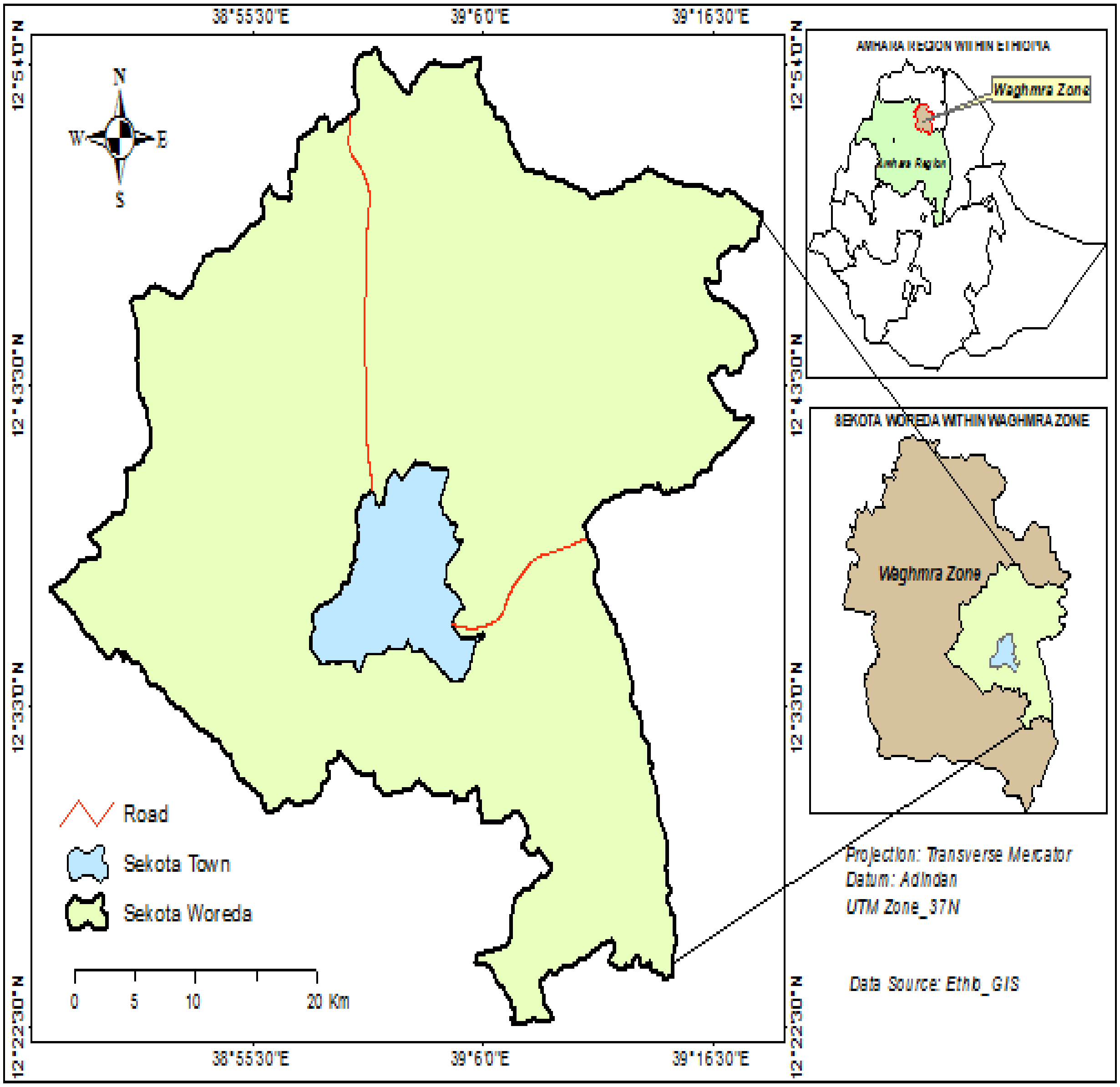

Figure 3.1 Location map of the study area.
Source: Ashenafi (2018).

Land use and land cover

The *woreda* has 33 *kebeles* (the lowest administrative units) with an area of 167,157.29 hectares, which is about 19 % of the Wag Hemera zone (BoFED, 2013). Out of the total area, only 29,962.5 hectare (18 % of total area) has been used for annual and perennial crop production, with the average land holding size per household of 0.75 ha. The remaining areas of the *woreda* are roughly classified into grazing (3%), bush land (38%), road and settlement (7 %), and marginalized land (34 %) (Wag Hemera Zone Agricultural Development Office, 2015).

Climate

The major environmental characters of the *woreda* are given in Table 3.1. The mean annual rainfall ranges between 398 mm and 974 mm. The area receives rainfall which usually onsets in June and stops early September. Its distribution is also erratic that mostly breaks in late July. Sekota *woreda* is/was frequently hit by natural hazards that greatly affect crop and animal production of the people. The main hazards for Sekota *woreda* are drought (reportedly occurring every three years, late onset or early cessation of rains), crop pests and diseases affecting crop production and livestock pests (anthrax, blackleg, sheep fever, foot and mouth disease and New Castle are the top five.) Though not a major hazard, other natural hazards like harsh rain and ice fall and flood can have a severe effect on households in the local area of impact (ACF, 2013).

Table 3.1 Background data on climate of Sekota *woreda*.

Climatic variable	**Lowest**	**Highest**
Rainfall (mm)	398	974
Evaporation (mm)	1044	1798
Mean max. Temp. (^{o}C)	25.34	32.03
Mean min. Temp. (^{o}C)	11.07	17.64
Absolute max. Temp. (^{o}C)	15	36
Absolute min. Temp. (^{o}C)	-3.0	13.8
Elevation (m.a.s.l)	1086	3810

Source: National Meteorological Services Agency of Ethiopia (NMSA, 2018).

Livelihood zone

Wag Hemera zone covers two different livelihood zones: mixed cereal livelihood zone (MCLZ), and Tekeze lowland sorghum and goat livelihood zone (TSGLZ). The entire area of Gazgiblla *woreda*, most part of Sekota and Dehana *woredas* lay in mixed cereal livelihood zone. Abergelie, Sehala, Ziquala, some part of Sekota and Dehana *woredas* are in low land sorghum and goat livelihood zones. Particularly, 26-*kebeles* of Sekota *woreda* are in MCLZ. And the remaining 6-kebeles are in TSGLZ. In both zones, communities rely on mixed farming (livestock and agricultural production) as a source of food and income. The main food crops in TSGLZ are sorghum, haricot beans and teff. In MCLZ wheat, barley and teff are the main ones. The livelihood zones are both categorized by poor agricultural performance and food insecurity (DPFSPCO, 2007). The sample study area selection takes the livelihood zone classification into account.

Economic activity

Agriculture is the main source of economic activity in Sekota *woreda*. About 93 % of the population is engaged in mixed farming and the rest 7 % of the population engaged in trading, government officials, daily laborer, weaving and etc. The farming system can generally be characterized as mixed, and includes crop production and livestock rearing. The level of production for both sectors remains far below its potential, mainly because of adverse climatic conditions due to erratic rainfalls and long standing drought periods. Other reasons include, the relatively small land holdings; which range from 0.25 to 0.75 hectares, and insufficient application of basic agricultural inputs such as fertilizers and pest control techniques (DPPC, 2000).

Infrastructural facilities

Water sources: The main sources of water for drinking and other purposes are rainfall, rivers and springs. There are about 25 rivers of which majority are perennial. However, ironically, only about 13,902 (8.3 %) out of the total of 167,504 people of the *woreda* have access to potable water. The remaining population gets its water requirement from spring, wells, collected run-off and rivers in the proportion of 75 %, 9.5 %, 5.0 %, and 2.2 % respectively (Wag Hemera Zone Agricultural Development Office, 2015).

Transport and communication: Due to the emphasis given by the present government, within the last decade, about 515 km all-weather roads were constructed which connect Sekota town with Tigray, North Wollo and the two *woredas* of the zone (Ziquala and Dehana) and acquired access to a semi-automatic telephone service. However, the telephone services are not extended to the other small towns of the *woreda*.

Education and health service: According to the 1994 census (CSA, 2004), the illiteracy rate of the total population was as high as 94.8 % and in the rural areas it was even more (96.0 %). However, government and NGOs have built 24 elementary and junior secondary schools since 1992. Before that there were only seven elementary and one high school in the study area.

The health facilities are not much different from what is seen in education. For the entire Wag Hemera zone, there is only one hospital with 20 beds, one health center, eight clinics and four health posts. However, more than the infrastructure skilled manpower and lack of equipment limit the utilization of the existing facility to its full capacity (Wag Hemera Zone Agricultural Development Office, 2015).

3.2 Methods

The research was designed to use a household-based cross-sectional survey which in turn was based on multi-stage sampling procedure and used grided station meteorological data for comparison. Using this design, samples of the population were selected, and from these individuals, using a semi-structured questionnaire (see “Appendix A”), data on a number of socioeconomic, farm and household characteristics, data related to the farmers’ perception of climate changes, various adaptation practices adopted and institutional attributes were collected to help answer the research questions. This design was selected for the advantage that the information about independent and dependent variables that were gathered represent what goes on at only one point in time (Olsen and George, 2004). To assess whether the instruments were suited and appropriate to the study, the pretest of questionnaires to 10% of the sampled households were made. Pretested *Kebeles* and participants were not involved in the actual survey. After pretesting, ambiguous words and, inappropriate questions were deleted and replaced. To obtain reliable responses on climatic information, the questionnaire administration was conducted using appropriate local terms in the common local language (Amharic) spoken by the people in the study area.

3.2.1 Sampling techniques

The study followed a multi-stage sampling technique where both probability and non-probability sampling techniques (purposive and simple random sampling) were combined to select the *woreda*, *kebeles* (all rural *kebeles)*, villages and households. For primary data collection, in the first stage, Sekota *woreda* was purposively selected. This was based on the availability of climate data, its location to the Tekeze River Basin with highly undulated topography and frequent susceptibility to climate-related problems such as erratic rains, frequent drought, crop pests, and livestock diseases, amongst others. In the second stage, seven *kebeles* were randomly selected from the total of 33 *kebeles* based on their coverages by productive safety net program (PSNP). Since the area is vast and is difficult to undertake a survey in all villages of the *kebeles*, about seven villages were randomly selected from the seven *kebeles* (i.e one village from each *kebele*). In the third stage, 24 respondents (the sample size was equally distributed across villages) were selected from a household list developed for each of the villages by the survey team using simple random sampling (SRS) technique, which resulted in a total of 168 households. In each village, trained data collection team dedicated a day to complete the household listing. Once the household listing was completed, all listed households were given a unique identification number. Then households were randomly selected using a systematic random sampling technique. If the selected village had fewer than the required households, all households in the village were interviewed. The remaining number of households needed was added from an adjacent village following the same procedure. Simplified formula provided by Yamane (1967, p.886) was used to determine the required sample size at 95% confidence level, 5% degree of variability and 8% level of precision. This value is acceptable since it is less than 10%.

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

Where **n** is the sample size, **N** the population (total household) size and **e** is the level of precision.

n = 26,903/1+ 26,903*0.0064

n = 26,903/173

n = 156

Although the formula indicated a sample size of 156, considering that the calculated number is an estimated and indicative figure, so extrapolating to 168 sample farm households was assumed adequate by taking equal number of (24) respondents per the respective villages in each study *kebele*.

3.2.2 Types of data and data collection methods

As per the objectives of the study both qualitative and quantitative data types (a mixed method approach) were collected from both primary and secondary data sources in March 2018 so that the overall strengths of each of the approaches would be complemented (Creswell, 2009; Onwuegbuzie, 2003) and it covered seven villages in the *woreda*. Primary data were collected from key informants, focus group discussants, and household survey. Secondary data were also collected from various government offices in the district, CSA, meteorological stations and published and unpublished written sources. With the help of secondary data on climatic variables, trends were estimated for various seasons as well as the trends for annual averages from 1987-2016. To explore the farmers' perceptions of climate change and variability, these grided station meteorological data were compared with the perceived responses of the farmers about the climatic variables.

Qualitative data were collected through focus group discussions having a composition of 8 discussants (all focus group discussions were conducted in one village called Juran out of seven studied villages during the month of March 2018. The reason for selecting farmers only from this village for FGDs is that soil and water conservation works are more done than from other six villages), and key-informant interviews with 8 respondents. Data from the FGDs and KIIs were used to complement the information obtained through a household survey in order to have a better understanding of farmers' perceptions of climate changes and variability and adoption of adaptation strategies by the respondents. Quantitative data were collected through the use of household questionnaire. The dataset consisted of perceptions of changes in various climatic variables and extreme events (changes in temperature and rainfall); adaptation options or response strategies (agro-based adaptation practices and nonagro-based adaptation practices); farm attributes (landholding, livestock ownership, agricultural practices, land tenure, land use, income sources); institutional attributes (access to weather forecast and climate information, access to credit services, access to extension services). The survey also covered data on several factors including households' demographic and socioeconomic characteristics (age, education, gender, marital status and family size) as well as biophysical variables such as access to the early warning system, about the occurrence of drought, and their experience's in crop failure due to climate change and variability (Table 3.2).

Table 3.2 Main survey themes of the study.

S/N	Theme description
1.	Demographic and socioeconomic characteristics.
2.	Perceptions of changes in various climatic variables and extreme events.
3.	Adaptation options or response strategies.
4.	Institutional attributes.
5.	Biophysical attributes.

Source: Field survey (2018).

Perceptions of change in various climatic variables for the last 30 years were collected using a 5-point Likert scaled attitude items: strongly agree, agree, unsure, disagree and strongly disagree. In the case of adaptation strategies, the respondents were asked about their range of practices. The rainfall and temperature grided data for the observation station nearest to the study area on monthly precipitation, monthly mean maximum temperatures (calculated from the maximum temperatures observed each day), and monthly mean minimum temperatures (calculated from the minimum temperatures observed each day) were collected from meteorological archives of the National Meteorological Services Agency of Ethiopia [NMSA], Addis Ababa.

From the raw monthly data at the station, total annual rainfall, seasonal average rainfall and mean maximum temperatures and mean minimum temperatures were calculated. For consistency with the survey questions, rainfall trends during the main rainy season (June, July, and August) and short rainy season (March, April and May) were focused.

3.2.3 Techniques of data analysis

Statistical analyses such as descriptive statistics, variability and trend analysis for the temperature and rainfall data were conducted to compare these with household perceptions about climate change parameters (precipitation and temperature are two of the most important variables). Rainfall and temperature variability analysis involved the use of Coefficient of Variation (CV) and Standardized Precipitation Anomaly (percentage departure from the mean). Trend detection and analysis were performed through parametric and non-parametric tests.

Mann-Kendall test with Sen's slope estimator was applied for nonparametric test and simple linear regression for parametric test. The parametric test considers the simple linear regression of the random variable Y on time X. The regression coefficient of the interpolated regression line slope coefficient was computed from the climate data based on Mongi, Majule and Lyimo (2010). This type of trend line used the following linear equations to calculate the least square fit for a line using MS Excel:

$$Y = \beta x + c$$

Where Y is physical factor (separately computed for change in temperature and rainfall) B is slope of the regression equation, X is number of years from 1987- 2016 (30 years), C is regression constant.

MS EXCEL (where the nonparametric Mann–Kendall and Sen’s methods were used to determine whether there was a positive or negative trend in rainfall and temperature data with their statistical significance) was used to analyze the survey data.

In accordance to Newing (2011) data from focus groups and key informants was summarized according to key themes and illustrated by direct quotes, recounting particularly relevant experiences and views of smallholder farmers, essential for authenticity of findings.

CHAPTER FOUR: RESULTS AND DISCUSSION

This section presents and discusses the results studied, the respondents' insights about climate variability and climate change in the study area. From individual local perspectives of the phenomenon, climate variability and change will be referring to climate changes specific to the area.

4.1 Socio-demographic characteristics of the respondents

This section is mainly concerned with the description and interpretation of the findings of the descriptive analysis. The results of demographic information of the households presented in Figures 4.1 and 4.2 show that majority of the respondents were within the age range of $\geq$ 20–50 and the average age of the participants was 46 years aged between 22-81 years. Out of the respondents, 85.71 % (n=144) were male-headed households and 14.29 % (n=24) were female headed households. 82.1% (n=138) of the respondents have no educational background, 10.7 % (n=18) attended some primary education, 4.8 % (n=8) attended secondary education and 2.4 % (n=4) have attained a college education. The average family size was 4.6 (with a range of 1-10 family members) which was greater than that of the national average 4.3 and the regional average 4.5 (CSA, 2010).

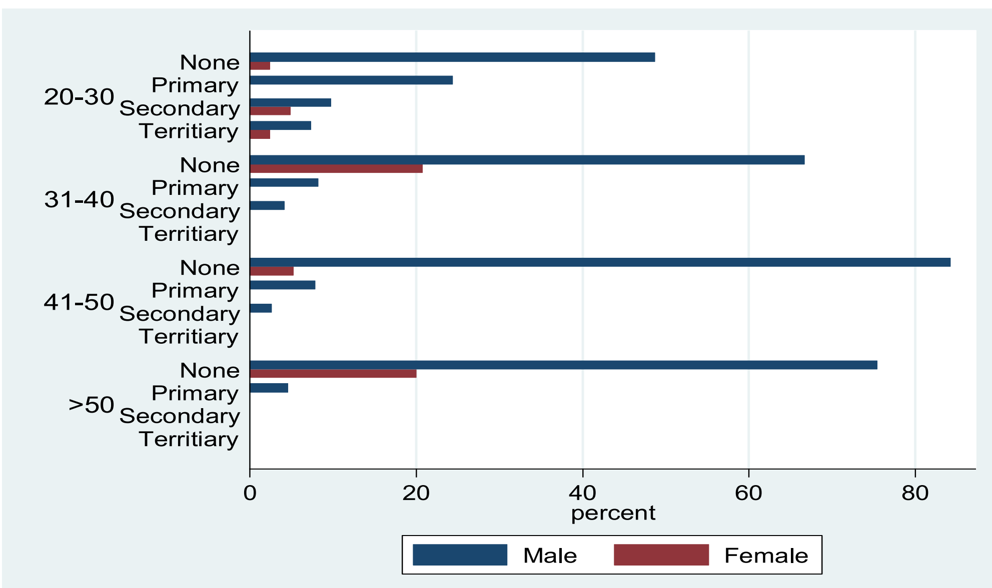

Figure 4.1 Household educational level and age groups by gender in the study area.
Source: Field survey (2018).

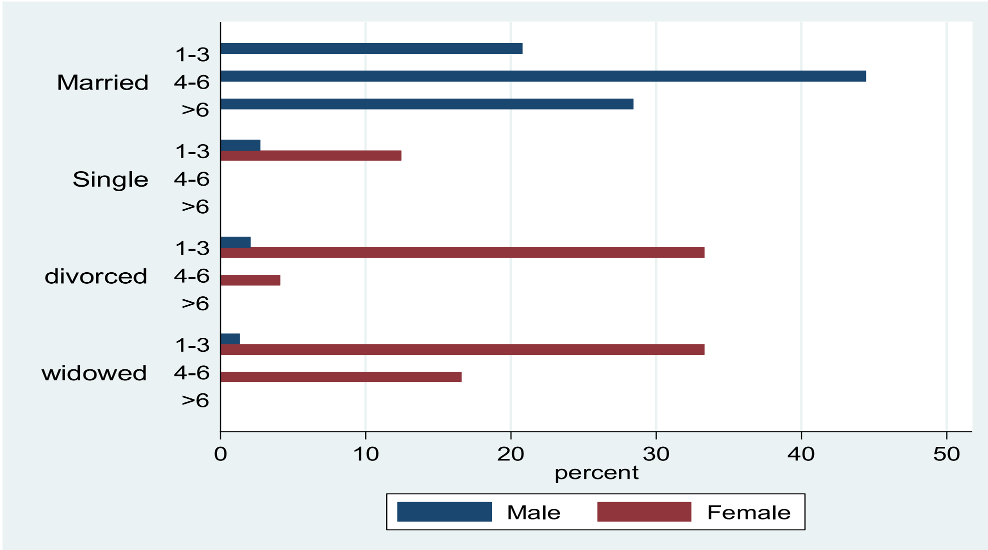

Figure 4.2 Household marital status and fanily size by gender in the study area.
Source: Field survey (2018).

As presented in Table 4.1 below, the average farm land holding was 0.6 hectare, with the majority of the households 101 (60.1 %) having less than 0.5 hectare of land. The dominant income source in the study area is crop production (who grow crops on their own or rent lands for their primary income) followed by food- or cash-for-work, where 42.3 % and 35.9 % of households reported to have participated, respectively. Casual labor (who involve in agriculture worker, carpenter, wage laborer and home based worker) (15.4 %) and petty trade (6.4 %) were also important sources of income for the respondents. This indicates that the majority of the farmers depend on rain fed crop production which made them sensitive to climate change and variability and during production disappointment they depend on food aid.

Table 4.1 Resource ownership among the surveyed households in the study area.

S/No.	Variables	Description	Frequency	Percent
1.	**Total farm size** (hectare)	Farm land holding of household head (categorical)		
		Average farm size (ha) = 0.6		
	<0.5		101	60.1
	0.5-1		17	10.1
	1-2		49	29.2
	>2		1	0.6
	Total		168	100.0
2.	**Agricultural practice**	Agricultural practices (categorical)		
	Rain-fed agriculture		154	91.7
	Irrigated agriculture		0	0
	Both rain-fed and irrigation		14	8.3
	Total		168	100.0
3.	**Land tenure**	Land tenure (categorical)		
	Owned land		124	73.8
	Rented land		17	10.1
	Owned + rented land		27	16.1
	Total		168	100.0
4.	**Land use**	Land use (categorical)		
	Annual crops		165	98.2
	Perennial crops		3	1.8
	Total		168	100.0
5.	**Income source***	Income source for the HHs (categorical)		
	Crop produced		165	42.3
	Food- or cash-for-work		140	35.9
	Casual labour		60	15.4
	Petty trade		25	6.4
	Total		390	100.0

Source: Field survey (2018). *= Multiple answers were possible.

While nearly all of the participants perceived climate change to some extent only 33.9 % (n=57) had access to credit, 33.9 % (n=57) were informed by up-to-date climate information and 84.5 % (n=142) got access to extension services (Table 4.2). so this implies that the government has to do more on providing credit access and up-to-date climate information to the farmers in the study area.

Table 4.2 Descriptive statistics of institutional factors of the study.

S/No.	Variables	Description	Frequency	Percent
1.	**Extension services**	Extension services for HHs (Dummy variable)		
	Yes		142	84.5
	No		26	15.5
	Total		168	100.0
2.	**Information accesses**	Information accesses for HHs (Dummy variable)		
	Yes		57	33.9
	No		111	66.1
	Total		168	100.0
3.	**Credit accesses**	Credit accesses for HHs (Dummy variable)		
	Yes		57	33.9
	No		111	66.1
	Total		168	100.0

Source: Field survey (2018). HH = Household

4.2 Perception of climate change in the study area

This section attempts to identify how local households in the study area perceive and explain their local climate conditions (Figure 4.1). About 16.1 % (27) of surveyed respondents from all the study villages reported knowing very little regarding climate variability and change, whereas 14.3 % (24) of the respondents know about climate variability and change. Figure 4.1 further depicts that 69.6 % (117) reported knowing a lot regarding climate variability and change. This group of respondents who are within or above the average age (> 40) had knowledge regarding climate variability and change. Those who knew a lot and knew little reported to have heard information about climate variability and change from different sources.

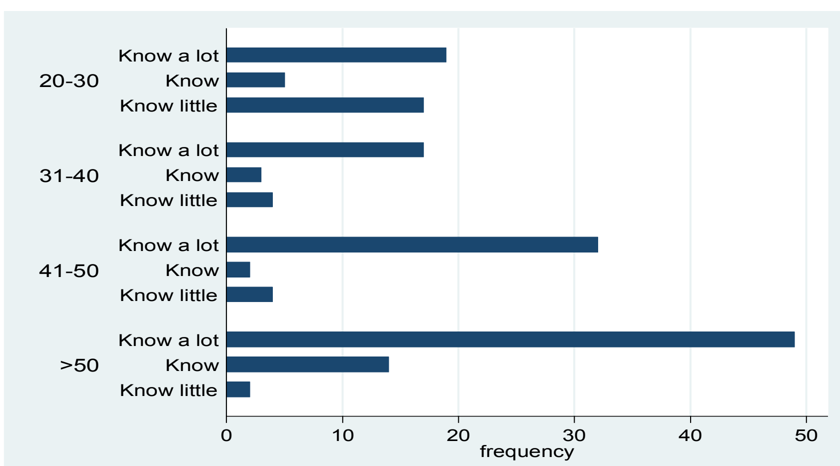

Figure 4.3 Household perception of climate change by age groups.
Source: Field survey (2018).

As showed below, the majority of respondents perceived changes in annual mean temperature and rainfall within the thirty-year period between 1987 and 2016. In this regard 82.1 % of the respondents (138) reported strongly agree that temperature had increased while 15.5 % (26) and 2.4 % (4) agree about an increase in temperature and unsure about the issue respectively as compared to the previous decades (Table 4.4 and Figure 4.2).

Table 4.3 Farmers' perceptions of climate change and variability in the study area.

Climatic variables	**Farmer's response N (%)**				
	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree
Temperature increase	138(82.1)	26(15.5)	4(2.4)	-	-
Temperature decrease	-	-	4(2.4)	131(78.0)	33(19.6)
Rainfall increase	-	-	3(1.8)	131(78.0)	34(20.2)
Rainfall decrease	129(76.8)	38(22.6)	1(0.6)	-	-
Rains longer	-	-	4(2.4)	33(19.6)	131(78.0)
Rains shorter	129(76.8)	31(18.4)	8(4.8)	-	-
Early onset of rains			3(1.8)	35(20.8)	130(77.4)
Late onset of rains	136(81.0)	29(17.2)	3(1.8)	-	-
Increase of strong winds	15(9.0)	141(84.0)	12(7.0)	-	-

Values are presented as number of respondents followed by percentage of the respondents in brackets.
Source: Field Survey (2018).

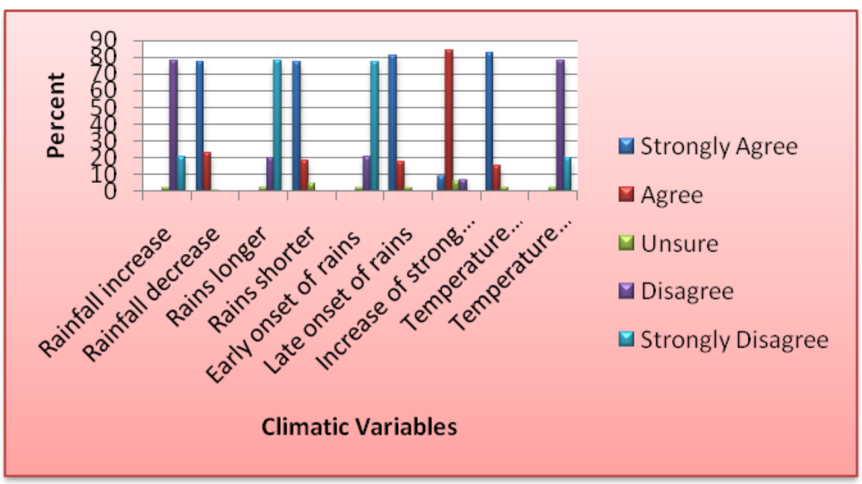

Figure 4.4 Households' perceptions of climate change in Sekota *woreda*.
Source: Field Survey (2018).

4.3 Comparing farmers' perceptions with the meteorological data

Farmers' perceptions were compared with the results of historical trends from grided station meteorological data. The analysis of rainfall and temperature involved characterizing long-term mean values, calculations of indices of variability and trend at annual and seasonal time steps. Standard anomaly was calculated for rainfall and temperature by:

$$SRA = \frac{P_t - P_m}{\sigma}$$

Where P_t is annual (rainfall or temperature) in year t, P_m is long-term mean annual (rainfall or temperature) over the period of observation and σ is standard deviation of rainfall. And CV was calculated to evaluate the variability of the rainfall and temperature by the formula:

$$CV = \frac{\sigma}{\mu} x100$$

Where CV is the coefficient of variation, σ is standard deviation and μ long-term mean annual (rainfall or temperature) over the period of observation.

As it was suggested by Sneyers (1990), Mann-Kendall test was used to detect trends and the significance level of the slope was estimated using Sen's method. Accourding to Salmi and colleagues (2002), the nonparametric Mann-Kendall test and Sen's method are less affected by outliers.

4.3.1 Temperature trends and variability

As depicted in graphs below, trends and anomalies of mean annual temperatures (i.e. mean of maximum and minimum temperature) of Sekota *woreda* (1987- 2016) are presented in Figure 4.3 and Figure 4.4 respectively.

According to NMSA (1996), CV is used to classify the degree of variability of rainfall/temperature events. So a temperature amount with CV of less than 0.20 is less variable, CV between 0.20 and 0.30 is moderately variable and CV greater than 0.30 is highly variable. As of the graph in Figure 4.3 below, less variability in the mean annual maximum (CV =5.5 %) and minimum temperature (CV= 9.8 %) were observed in the study area (see Table 4.5 also).

Table 4.4 Trends of Annual Temperatures (^{0}C) (1987–2016).

	Minimum			**Maximum**			**Mean**		
Station	LTM	**SD**	**CV**	LTM	**SD**	**CV**	LTM	**SD**	**CV**
Sekota	12.9	1.3	0.098	27.6	1.5	0.055	20.3	1.3	0.063

SD= standard deviation; CV= coefficient of variation; LTM= Long-time Mean
Source: National Meteorological Services Agency of Ethiopia (NMSA, 2018).

In the study area, the rate of change of minimum and maximum temperature was defined by the slope of the regression line which was about 0.079 ^{0}C per year and 0.143 ^{0}C per year with 0.1 %

and 5% of level of significances respectively. So there was a warming trend identified by the black line going up.

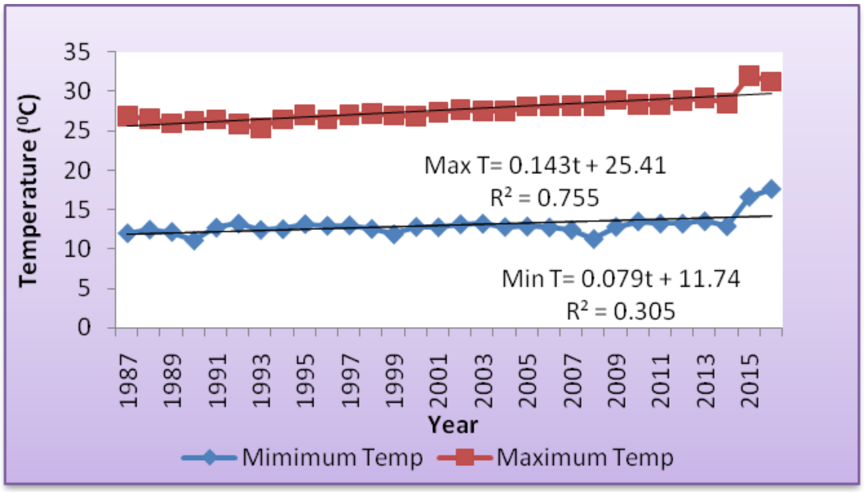

Figure 4.5 Maximum and minimum temperatures trends in Sekota (1987–2016).
Data source: National Meteorological Services Agency of Ethiopia (NMSA, 2018).

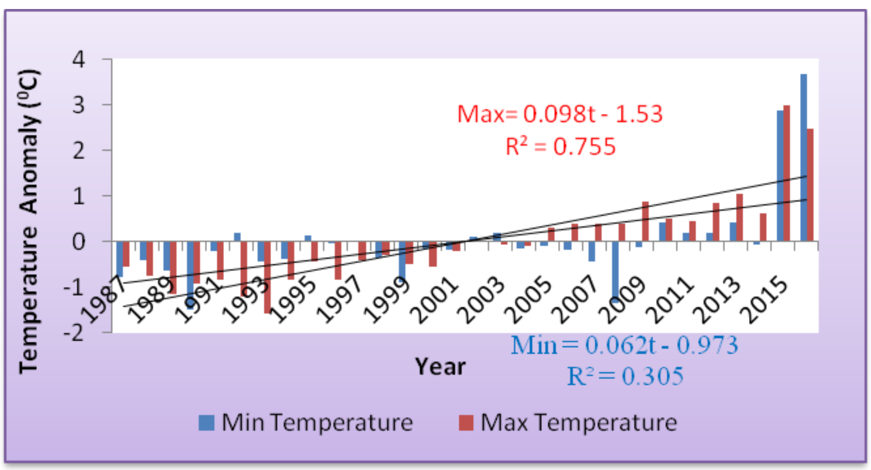

Figure 4.6 Maximum and minimum temperature anomalies (1987–2016).
Data source: National Meteorological Services Agency of Ethiopia (NMSA, 2018).

The average annual maximum and minimum temperature anomalies were not consistent throughout the 30 years because it showed deviations from the annual mean in both cases. Due to increasing surface air temperature mean, minimun mean temperature in 2015/2016 was warmer than a maximum temperature during the 1990s. For example, the results illustrate that most of the study area's warmest years have occurred over the last decade (especially in the years 2015 and 2016). 1990 and 2008 were cold years. The highest mean annual minimum temperature was recorded in 2016 and 1993 was recorded with the lowest maximum temperature in the study area

(Figure 4.4). Different empirical studies showed related results that temperature has increased over the years (Acquah-de Graftand Onumah, 2011; Temesgen, Hassan and Ringler, 2008; Maddison, 2006; Mandleni and Anim, 2011, Acquah-de Graft, 2011; Akponikpe, Johnston and Agbossou, 2010; Gandure, Walker and Botha, 2012; Mahmud *et al*., 2008; Daniel, Woldeamlak and Lal, 2014 etc). These perceptions about temperature increase in Africa confirm IPPC (2007) predictions about an overall increase in temperature between 0.7 and 3.5°C in Africa by 2050.

4.3.2 Rainfall trends and variability

The study applied Agnew and Chappel's (1999) drought severity assessment method. This method provides a more elaborate classification of drought magnitudes. The model differentiated drought severity into four scales: extreme drought, severe drought, moderate drought and no drought ($S<-1.65$), ($-1.28 > S > -1.65$), ($-0.84 > S > -1.28$) and ($S > -0.84$) respectively.

Inaddition, according to NMSA (1996), a rainfall amount with CV of less than 0.20 is less variable, CV between 0.20 and 0.30 is moderately variable and CV greater than 0.30 is highly variable.

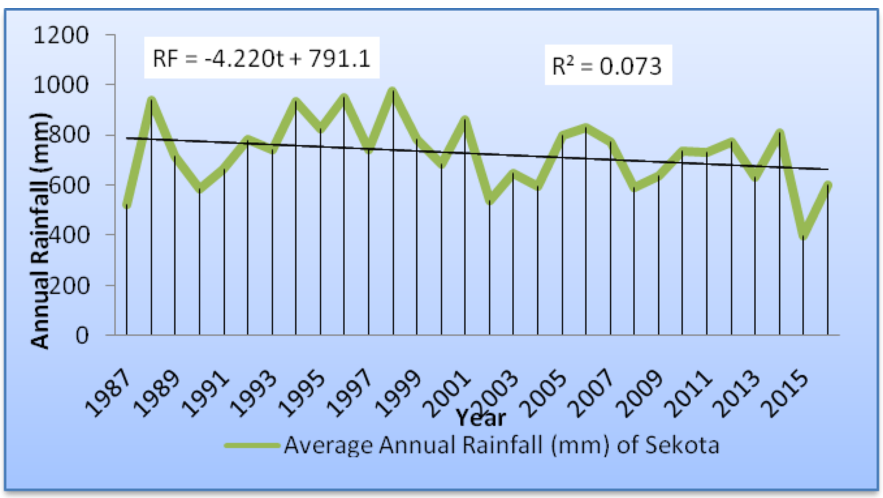

Figure 4.7 Annual mean rainfall trends in the study area (1987–2016).
Data source: National Meteorological Services Agency of Ethiopia (NMSA, 2018).

The results from Figure 4.5 above reveal that, there was an inter-annual fluctuation trend in average annual rainfall ($p < 0.001$). Some exceptional drought years experienced very low annual rainfall as low as around 400mm when dry and as high as above 1000 mm when wet. The rate of change defined by the slope of regression line was about -4.220 mm per year for annual rainfall. Rainfall in Sekota district shows a moderate decreasing trend with significant average annual rainfall trends of greater than -40.79 mm per decade and had as low as -122.38 mm per year. These results imply that those years actually experienced lower-than-normal rainfall.

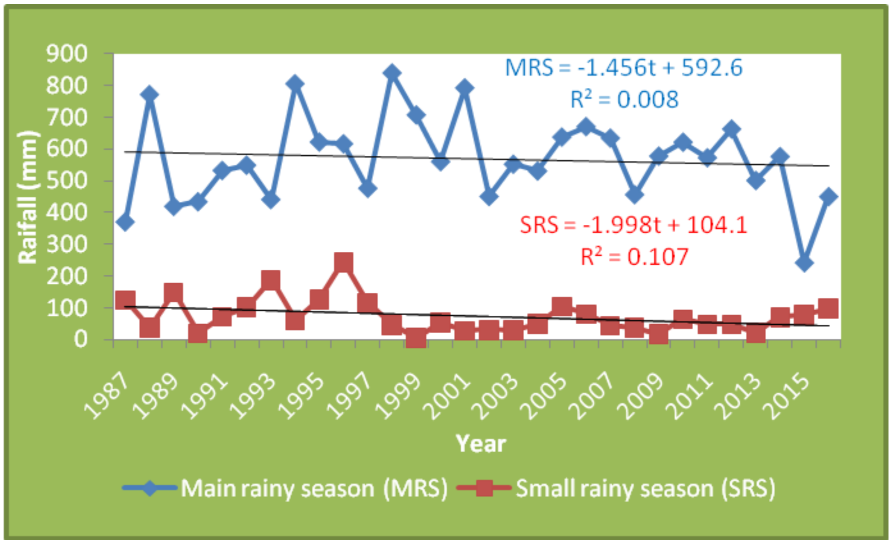

Figure 4.8 Mean rainfall trends of the main and short rainy seasons (1987–2016). Data source: National Meteorological Services Agency of Ethiopia (NMSA).

It has further been verified that farmers observed fluctuations in intra-seasonal rainfall distribution (in the main (long) and short rainy seasons), which they considered to result in reduction in the *kiremt*'s rainfall in recent years. There are three seasons in Ethiopia. From September to February is the long dry season also locally known as the *bega*, which is followed by a short rainy season, called the *belg*, in March, April and May. The long rainy season (*kremt*) is in June, July, and August. The results in Figure 4.6 show significant fluctuations in rainfall during the rainy seasons. The trend in main rainy season (*kiremt*) runs from June through August and short rainy season (*belg*) runs from March through May shows a decreasing trend of 14 mm ($p < 0.001$) and 19 mm ($p < 0.05$) per season respectively. The rate of change which is defined by the slope of regression line was about -1.456 mm/year for *kiremt* and -1.998 mm/year *belg* rainfall respectively. Generally speaking, as depicted in Table 4.6, there was interannual variability in seasonal rainfall, i.e, high rainfall variability was observed in SRS (CV=73.5%) and moderate variability in MRS (CV= 23.8%). Though the declining trends of *belg* and *kiremt* rainfall are both statistically significant, the CV (73.5%) of SRS rainfall is higher than that CV (23.8%) of MRS rainfall, which implies more interannual variability of *belg* rainfall than *kiremt* one. The result agrees with the findings of (Yilma and Zanke, 2004; Rosell and Holmer, 2007;

Arragaw and Woldeamlak, 2017) where more variability in *belg* rainfall than the *kiremt* rainfall in most parts of Ethiopia was disclosed.

Table 4.5 Trends of annual and seasonal rainfall (mm) (1987–2016).

Station	Annual (total)			Main Rainy Season			Short Rainy Season		
	LTM	SD	CV	LTM	SD	CV	LTM	SD	CV
Sekota	734.8	146.0	0.199	570.1	135.7	0.238	73.2	53.7	0.735

SD= standard deviation; CV= coefficient of variation; LTM= Long-time Mean
Source: National Meteorological Services Agency of Ethiopia (NMSA, 2018).

So rainfall in Sekota district shows an interannual variability and a decreasing trend. Mean annual, *belg* and *kiremt* rainfall has decreased, on average, by 40.79 mm, and 59.94 mm and 43.68 mm respectively in the past three decades. Thus, these results imply that those years actually experienced lower-than-normal rainfall. These results show a general and consistent negative value for *Kiremt* rainfall, which implies that the rainfall during the long rainy season has reduced. This might confirm the farmers' perception that main and short rainy seasons rainfall were oscillating and reduced in the MRS and SRS rainfall in recent years. Previous studies in other areas also reported similar results that the importance of short rainy season has been declining due to climate change (Riché *et al*., 2009; Oxfam International, 2010; Meze-Hausken, 2004; Gutu, Bezabih and Mengistu, 2012 etc).

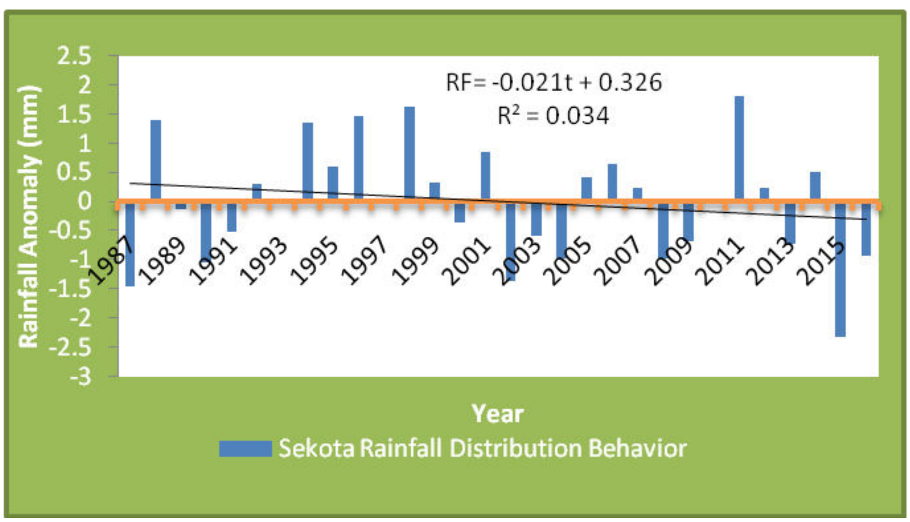

Figure 4.9 Annual mean rainfall anomalies of the study area (1987–2016).
Data source: National Meteorological Services Agency of Ethiopia (NMSA, 2018).

The average annual rainfall anomalies (defined as deviations from the 30-year mean rainfall) were not consistent throughout the 30 years because it showed inter-annual rainfall fluctuation. Approximately half of the years within the study periods experienced annual rainfall that was below normal (mean) in the study area (Figure 4.7). For example, the results illustrate that 11 out of 30 years experienced annual rainfall below normal. 2015 alone was the extreme drought year with S= -2.31 (i.e, S less than the cutting point -1.65) followed by 2002 and 1987 severe drought years. The highest average annual rainfall was recorded in 2011. The rest were with in the moderate and no drought year categories. As indicated by Amogne and colleagues (2018) in their study, surprisingly these results were coincided with recent documented droughts of 1987, 1991–1992, 1993–94, 2002, 2009, 2012, 2015/16. Rainfall in the study area is often erratic and unreliable.

Incidentally, above perceptions of farmers on climate change are in line with the observed trends in climatic variables. Analysis of climatic data from secondary sources shows an increasing trend in temperature and decreasing the annual amount of rainfall in Sekota district. The values support the farmers' perceptions that there is recently variability in the quantity of rainfall and the rainy days.

Again this is consolidated by similar results in other researches by different scholars as the amount of rainfall has been decreasing in many areas of the country, but increasing in some areas. For example, climate change and its impacts have been perceived by local people, who express (from their indigenous knowledge and experiences) climate variability and change in that generally the rainfall is decreasing (Apata, Samuel and Adeola, 2009; Akponikpe, Johnston and Agbossou, 2010; Acquah de Graft and Onumah, 2011; Mertz *et al*., 2009; Maddison, 2006; Mahmud *et al*., 2008; Sofoluwe, Tijani and Baruwa., 2011; Seifu and Abdulkarim, 2006; Negash, Goel and Jain, 2013; Yilma and Zanke 2004 etc).

Climate change projections for Ethiopia, for instance, showed that, compared to the 1961-1990 normal, mean annual temperature will increase in the range of 0.9–1.1°C by 2030, 1.7–2.1°C by 2050 and 2.7–3.4°C by 2080, and a small increase in annual precipitation will occur over the country, with an increase of 1.3–6.1% by 2030, 2.4–11.6% by 2050 and 3.9–18.9% by 2080 (IPCC, 2007), which very much reflects near the results in this study.

In conclusion, meteorological data suggested a clear climbing trend in the analyses that annual minimum average temperature (0.8°C increase per decade, R^2 =0.305) and annual maximum average temperature (1.4 increase per decade, R^2 = 0.755) and with a moderate declining trend and significant variability in annual rainfall (40.79 mm decrease per decade, R^2 =0.073) in the study area from 1987 to 2016. These results might confirm the farmers' perceptions that the temperature was becoming hot and hot in recent days which affects their agriculture a lot and is very likely an indication that the climate is changing. This implies that agricultural activities are highly vulnerable to such changes. This should be aggravated because of the full dependency of the farmers on rain-fed agriculture for their livelihoods. Therefore, it is clear from the analysis that climate change is intensely happening in the study area and appropriate adaptation strategies should be properly designed and implemented.

4.4 Various perspectives of the respondents on the changes observed

The qualitative information largely coincides with the information collected through questionnaire surveys. Most of the respondents had the view that temperatures in the study area were increasing and the rainfall decreaseing at an unusual rate compared to the past 30 years. The following remarks had been given by one of the respondents:

> 'In recent years, temperatures have increased compared to the past 30 years…. I don't know what has happened to this time, because productivity is decreasing from time to time, the weather is too hot, land size is minimized due to high population, and the soil is not fertile as it was before… so unless God brings good times for us it is hard now to servive.'

This was discussed during the focus group discussions in order to understand the how they perceive CC. One respondent had the following remarks:

> 'We are thinking that may GOD punished us by things that happened…… before we were sowing varieties of crops like barley, wheat, teff, maize amongst others but nowadays some crops are not productive due to hotness so may God help us my son.'

Most of the participants during the focus group discussion felt that the weather had grown more unpredictable. One old participant had the following sentiments:

> 'Nowadays it is common to face unexpected and unreliable rains and manifestations of unknown pests…... Thus seasonal changes have lowered the production of food crops and cash crops. This situation attests to how the recent weather conditions are unpredictable.'

Other women participant, during the focus group discussion, added her opinion by saying that:

> 'Little rain during *kiremit* has seriously affected *meher* crops. The production of barley and some other crops has significantly reduced. There are more insects and pests attacks on crops.'

Some of the participants revealed that some of crop species being cultivated within the community were brought by themselves from nearby discricts through market exchanges. These crops included drought resistant sorghum (*kirkim*), as well as early maturing teff (*bunign* and *jigla*) and wheat (*sekota*) seeds that were helpful in adapting to their localities. The following quote from an agricultural expert reflects this sentiment:

> 'They sow these kinds of crops with the expectation that it will help them during the drought seasons to improve their food security. It was expected to rain between mid Junes to mid September but it comes late and stops early so affects their agricultural activities. The soil fertility is poor so it is tried through extension services to do soil and water conservation works and it is somehow effective in some watershed areas but still needs extra hard works to change the attitudes of the people and create awareness on how to conserve natural resources.'

Similar practices have also been reported by a researcher from Sekota Dry Land Agricultural Research Center:

> 'We are practicing dry land agricultural researches…. Already identified what types of crops they are using locally like sorghum, millet, teff and wheat and our tested early maturing varieties.'

One of the respondents from Wag Hemera Development Associtíon I interviewed had the following remarks on:

> 'The land is degraded and there is shortage of rain so we as an association help farmers to do soil and water conservation works through food-for-work and supply seeds to selected farmers both local varieties and newly tested short day variety seeds like millet from agricultural researches….. Farmers' tasks are more difficult due to unpredictable climates characterized by extreme weather events and changing growing seasons.'

A number of predictions have also been accustomed (although the question of accuracy often arises in discussions of indigenous knowledge), mentioned during the key informant interviews and focus group discussions, to indicat that the rains are about to start. Weather forecasting based on observation of ongoing conditions is common knowledge. These include shifts in the direction of prevailing winds; the flowering patterns of trees, especially when shrubs and trees locally called *dedeho* (*Euclea shimperi)*, *Bisana (Croton macrostachyus)*, *Shisha* (*Boscia angustifolia)* flowers a normal rainy season is forecasted for the short and main rainy seasons.

As demonstrated by Desalegn *et al*. (2015), although the precision and reliability of the forecasting system needs research in depth, it makes the respondents to perceive and be proactive in the decisions they make based on the forecasted information.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study draws upon both qualitative and quantitative approaches to analyze the smallholder farmers' perception of climate change and variability in northeastern Ethiopia and compare their perceptions to grided station meteorological data. The study sites are dominated by small farm households. The majority of farming systems are rain-fed. Thus climate change has adverse impacts on agriculture because there is a link between climate and the agricultural sector in Ethiopia. Primarily, the study established the evidence of climate change and variability and generated district-level data plots in the study area through analysis of grided station meteorological data over the past 30 years and also makes available the underlying data for use in further research.

The findings of this paper suggest that farmers are aware of changes in climatic variables, especially increasing temperature and decreasing in annual rainfall and changing the seasonal patterns. The study further elicited farmers' perceptions of recent climate change and variability from meteorological data analysis. Both temperature and rainfall trends and variability were analyzed and correlated with the farmers' perception of climate change. It is obvious from this study that the farmers' perceptions of climate change and variability were based on local climate parameters identified by farmers.

The results indicated that farmers have noticed changes and variability in climate. They perceived changing times for the start and finish of the rains during the growing seasons and noticed that some crop yields are lower in recent years compared to past 30 years. Both farmers' perceptions and meteorological data show that rainfall is much more unreliable in recent years. In conclusion, nearly all the farmers perceived changes in the mean annual and seasonal rainfalls and changes in mean maximum and minimum temperatures in the study area and climate change is already affecting agricultural production in the study area and thereby household food security.

5.2 Recommendations

Despite different initiatives have been undertaken by the government and NGOs and people have perceived, interacted with, and made use of their environment with its scarce natural resources and changing climatic conditions, the agricultural sector does not look promising, particularly for the rural poor population. In the context of the Sekota district in the Tekeze River basin, the situation is becoming worse due to different agricultural changes, which have been observed by local communities in recent years. Moreover, it is crucial to enhance their understanding of risks associated with climate change so that they will have realistic expectations and are better prepared not only for the potential negative impacts but also for taking advantages of any opportunities climate change offers proatively. The results of this study also help to expand upon prior knowledge about Ethiopia and insight into the local context to help shape environmental perceptions and concern at the regional or national levels. Based on the findings of this study, there is also a need to forward a recommendation that adequate and regular information on current issues related to the effect of climate change on agriculture be provided to the respondents through mass media campaign especially radio.

REFERENCES

Acquah-de Graft, H. (2011). Farmers' Perceptions and Adaptation to Climate Change: a willingness to pay analysis. *Journal of Sustainable Development in Africa* 13(5), pp. 150-161.

Acquah-de Graft, H. and Onumah, E. (2011). Farmers' Perceptions and Adaptations to Climate Change: An estimation of willingness to pay. *Agris*. 3(4), pp. 31-39.

Adams, R.M., Hurd, B.H., Lenhart, S. and Leary, N. (1998). Effects of Global Climate Change on Agriculture: an interpretative review. *Climate Research* 11, pp. 19-30.

Adger, W.N., Huq, S., Brown, K., Conway, D. and Hulme, M. (2003). Adaptation to Climate Change in the Developing World. *Prog. Dev. Stud*. 3(3), pp. 179–195.

AfDB (African Development Bank) (2015). Ethiopia Economic Outlook. Retrieved from: (www.afdb.org/en/countries/east-africa/ethiopia/ethiopia-economic-outlook).

Agnew, C.T. and Chappel, A. (1999). Drought in the Sahel. *Geojournal* 48(4), pp. 299–311.

Akponikpe, P., Johnston, P. and Agbossou, E.K. (2010). Farmers' Perceptions of Climate Change and Adaptation Strategies in Sub-Sahara West Africa. 2nd International Conference on Climate, Sustainability and Development in Arid Regions, Fartaleza-Ceara, Brazil.

Amhara Region BoFED (2014). *Population Size of the Amhara Region by age group.* Bahirdar.

Amhara Region BoFED (2013). *Statstical abstrat 2.* Bahirdar.

Amhara Region DPFSPCO (2007). Amahara Region Livelihood Zone Report. Retrieved from Sekota livelihood zone: http:www.livelihood zone/Sekota.

Amjath-Babu, T., Krupnik, T.J., Aravindakshan, S., Arshad, M. and Kaechele, H. (2016). Climate Change and Indicators of Probable Shifts in the Consumption Portfolios of Dry Land Farmers in Sub-Saharan Africa: implications for policy. *Ecological Indicators* 67, pp. 830-838.

Amogne Asfaw, Belay Simane, Ali Hassen and Amare Bantider (2018). Variability and Time Series Trend Analysis of Rainfall and Temperature in Northcentral Ethiopia: A case study in Woleka sub-basin. *Weather and Climate Extremes* 19, pp. 29–41.

Apata, T.G., Samuel, K.D. and Adeola, A.O. (2009). Analysis of Climate Change Perceptions and Adaptation among Arable Food Crop Farmers in South Western Nigeria. Contributed paper presented at 23rd Conference of International Association of Agricultural Economists, Beijing, China, August 16-22, 2009.

Arbuckle, J.G., Prokopy, L.S., Haigh, T., Hobbs, J., Knoot, T.; Knutson, C., Loy, A., Mase, A.S., McGuire, J., Morton, L.W., Tyndall, J. and Widhalm, M. (2013). Climate Change Beliefs, Concerns, and Attitudes toward Adaptation and Mitigation among Farmers in the Midwestern United States. *Clim. Change* 117, pp. 943–950.

Arragaw Alemayehu and Woldeamlak Bewket. (2017). Local Spatiotemporal Variability and Trends in Rainfall and Temperature in the Central Highlands of Ethiopia. *Geografiska Annaler: Series A, Physical Geography* 99(2), pp. 85-101
Retrieved from: https://doi.org/10.1080/04353676.2017.1289460.

Awange, J., Khandu, M.S., Forootan, E. and Heck, B. (2016). Exploring Hydro-meteorological Drought Patterns over the Greater Horn of Africa (1979–2014) Using Remote Sensing and Reanalysis Products. *Advances in Water Resources* 94, pp. 45–59.

Boko M.I., Niang A, Nyong C, Vogel A, Githeko M, *et al*. (2007). Africa. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the

Fourth Assessment Report of the Intergovernmental Panel on Climate Change. In: Parry M.L, Canziani, O.F, Palutikof, J.P., van der Linden, PJ., Hanson,C.E. (eds.) Cambridge University Press, Cambridge UK, pp. 433-467.

CDKN (2014). The IPCC's Fifth Assessment Report: What's in it for Africa? Executive Summary. ODI, London. UK-based Climate and Development Knowledge Network (CDKN).

Chakraborty, S., Tiedemann, A.V. and Teng, P.S. (2000). Climate Change: potential impact on plant diseases. *Environmental Pollution* 108(3), pp. 317–326.

Chambwera, M. and Stage, J. (2010). Climate Change Adaptation in Developing Countries: Issues and Perspectives for Economic Analysis. International Institute for Environment and Development, 3 Endsleigh Street, London WC1H 0DD, United Kingdom. Retrieved from: <www.iied.org/pubs/display.php?o=15517lIED>.

Clayton, S., Devine-Wright, P., Stern, P.C, Whitmarsh, L., Carrico, A., Steg L, Swim, J. and Bonnes, M. (2015). Psychological Research and Global Climate Change. *Nature Climate Change* 5, pp. 640–46.

Conway, D. (2000). Some Aspects of Climate Variability in the north east Ethiopian Highlands-Wollo and Tigray. *SINET Ethiop. J. Sci.* 23, pp. 139–161.

Creswell, J.W. (2009). Mixed Method Research: Introduction and application. In Cizek, G.J. (Ed.), *Handbook of educational policy*. San Diego: Academic Press. pp. 455–472.

Central Statistical Agency (CSA) (2013). Population Projection of Ethiopia for all Regions at Wereda Level from 2014 – 2017, August 2013. Addis Ababa.

CSA (2010). The 2007 Population and Housing Census of Ethiopia. National Statistical Summary Report, Population Census Commission, Addis Ababa.

Daniel Megistu, Woldeamlak Bewket and Lal, R. (2014). Recent Spatiotemporal Temperature and Rainfall Variability and Trends over the Upper Blue Nile river Basin, Ethiopia. *Int. J. Climatol.* 34, pp. 2278–2292. Retrieved from: https://doi.org/10.1002/joc.3837.

Dereje Ayalew, Kindie Tesfaye, Girma Mamo, Birru Yitaferu and Wondimu Bayu (2012). Variability of Rainfall and its current Trend in Amhara Region, Ethiopia. *Afr. J. Agric. Res.* 7(10), pp. 1475–1486. Retrieved from: https://doi.org/10.5897/AJAR11.698.

Desalegn Yayeh, Solomon Desta, Getachew Gebru, Kinyangi, J., Recha, J. and Radeny, M. (2015). Opportunities and Challenges of Indigenous Biotic Weather Forecasting among the Borena Herders of Southern Ethiopia. *SpringerPlus* 4, pp. 1-11.

DfID (2004). The Impact of Climate Change on the Vulnerability of the Poor. Global and Local Environment Team, Policy Division, Department for International Development, London, UK.

Falaki, A., Akangbe, J. and Ayinde, O. (2013). Analysis of Climate Change and Rural Farmers' Perception in North Central Nigeria. *Journal of Human Ecology* 43, pp. 133-140.

Federal Democratic Republic of Ethiopia (FDRE) (2007). Climate Change Adaptation Programme of Action (NAPA) of Ethiopia Ministry of Water Resources and National Meteorological Agency, Addis Ababa.

Ferguson, M.J. and Bargh, J.A. (2004). How Social Perception can automatically Influence Behavior. *TRENDS in Cognitive Sciences* 8(1), pp. 33–39.

Gandure, S., Walker, S. and Botha, J.J. (2013). Farmers' Perceptions of Adaptation to Climate Change and Water Stress in a South Africa Rural Community. *Environ. Dev.* 5, pp. 39–53.

Gebremedhin Kiros, Shetty, A. and Nandagiri, L. (2016). Analysis of Variability and Trends in Rainfall over Northern Ethiopia. *Arab. J. Geosci.* 9(6), p. 451. Retrieved from: https://doi.org/10.1007/s12517-016-2471-1.

Gebreyesus Brhane Tesfahunegn, Kirubel Mekonen and Abadi Tekle (2016). Farmers' Perceptions on Causes, Indicators and Determinants of Climate Change in northern Ethiopia: implication for developing adaptation strategies. *Applied Geography* 73, pp.1–12.

Getis, A., Getis, J. and Fellman, J.D. (2000). Introduction to Geography, 7th edition, McGraw-Hill, New York.

Goytom Abraha Kahsay and Hansen, L.G. (2016). The Effect of Climate Change and Adaptation Policy on Agricultural Production in Eastern Africa. *Ecological Economics* 121, pp. 54–64.

Gutu Tesso, Bezabih Emana and Mengistu Ketema (2012). Econometric Analysis of Local Level Perception, Adaptation and Coping Strategies to Climate Change Induced Shocks in North Shewa, Ethiopia. *Int. Res. J. Agric. Sci. Soil Sci.* 2(8), pp. 347–363.

Gwambene, B. (2007): Climate Change and Variability Adaptation Strategies and its Implications for Land Resources in Rungwe District, Tanzania, M.Sc. Dissertation, IRA, University of Dares Salaam, Dares Salaam, Tanzania.

Hartig, T., Kaiser, F.G. and Bowler, P.A. (2001). Psychological Restoration in Nature as a Positive Motivation for Ecological Behavior. *Environment and Behavior* 33(4), pp. 590–607.

Howe, P.D., Markowitz, E.M., Lee, T.M., Ko, C.Y. and Leiserowitz, A. (2013). Global Perceptions of Local Temperature Change. *Nature Climate Change* 3, pp. 352–356.

IPCC (2014): Summary for Policymakers. In: *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, S., von Stechow, C., Zwickel, T. and Minx, J.C. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPCC (2007). Synthesis Report. *Contribution of Working Group I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on climate change Core writing team*. In: Pachauri R.K. and Reisinger, A. (eds). Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, p. 996.

IPCC (2001). Climate Change Impacts, Adaptation and Vulnerability. *Contribution of Working Group II to the Third Assessment*. Cambridge University Press, Cambridge.

Juana, J.S., Kahaka, Z. and Okurut, F.N. (2013). Farmers' Perceptions and Adaptations to Climate Change in Sub-Sahara Africa: A Synthesis of Empirical Studies and Implications for Public Policy in African Agriculture. *Journal of Agricultural Science* 5(4), pp. 121-135.

Jury, M.R. and Funk, C. (2012). Climatic Trends over Ethiopia: regional signals and drivers. *Int. J. Climatol.* 33(8), pp. 1924-1935. Retrieved from: https://doi.org/10.1002/joc.3560.

Kemausuor, F., Dwamena, E., Bart-Plange, A. and Kyei-Baffour, N. (2011). Farmers' Perception of Climate Change in the Ejura-Sekyedumase District of Ghana. *ARPN Journal of Agricultural and Biological Science* 6(19), pp. 26-37.

Kendall, M.G. (1975). Rank Correlation Methods, second ed. (New York: Hafner).
Lindsay, P.H., and Norman, D.A. (1972). Human Information Processing: An Introduction to Psychology. San Diego, CA, US: Academic Press, Inc.
Maddison, D. (2006). The Perception of and Adaptation to Climate Change in Africa. *Discussion Paper No. 10.* Centre for Environmental Economics and Policy in Africa (CEEPA), University of Pretoria, South Africa.
Mahmud Yesuf, Di Falco, S., Temesgen Taddese, Ringler, C. and Kohlin, G. (2008). The Impact of Climate Change and Adaptation on Food Production in Low-Income Countries: evidence from the Nile Basin, Ethiopia. IFPRI Discussion Paper 00828, pp. 1-24.
Mandleni, B. and Anim, F. (2011). Perceptions of Cattle and Sheep Framers on Climate Change and Adaptations in the Eastern Cape Province of South Africa. *Journal of Human Ecology* 34(2), pp. 107-112.
Mann, H.B. (1945). Nonparametric Tests against Trend. *Econometrica* 13, pp. 245–259.
Maplecroft, (2015). Climate change vulnerability index 2015. Maplecroft's Climate Change and Environmental Risk Atlas (CCERA) Maplecroft, UK.
Mendelsohn, R., Dinar, A. and Williams, L. (2006). The Distributional Impact of Climate Change on Rich and Poor Countries. *Environment and Development Economics* 11(2), pp. 159–178.
Mertz, O., Mbow, C., Reenberg, A. and Diouf, A. (2009). Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in Rural Sahel. *Environmental Management 43*, pp. 804–816.
Meze-Hausken, E. (2004). Contrasting Climate Variability and Meteorological Drought with Perceived Drought and Climate Change in Northern Ethiopia. *Climate Research* 27, pp. 19–31.
Mihretab Ghebrezgabher, Yang, T., Yang, X., Wang, X. and Khan, M. (2016). "Extracting and Analyzing Forest and Woodland Cover Change in Eritrea Based on Landsat Data Using Supervised Classification," *The Egyptian Journal of Remote Sensing and Space Sciences* 19(1), pp. 37 47.
Mintewab Bezabih, Di Falco, S. and Alemu Mekonnen (2014). On the Impact of Weather Variability and Climate Change on Agriculture: Evidence from Ethiopia. *Environment for Development*, *Discussion Paper Series*, EfD DP 14-15, pp. 1-38.
Misganaw Teshager, Enyew Adigo and Temesgen Tilahun (2014). Investigating the Determinants of Adaptation Measures to Climate Change: a Case of Batii District, Amhara Region, Ethiopia. *Int. J. Agric. Res*. 9(4), pp. 169–186.
Mongi, H., Majule, A.E. and Lyimo, J.G. (2010). Vulnerability and Adaptation of Rainfed Agriculture to Climate Change and Variability in Semi-arid Tanzania. *African Journal of Environmental Science and Technology* 4(6), pp. 371-381.
Ndaki, M.P. (2014). Climate Change Adaptation for Smallholder Farmers in Rural Communities: The Case of Mkomazi Sub-Catchment, Tanzania. PhD Thesis. University of Oldenburg, Carl Von Ossietzky.
Negash Wagesho, Goel, N.K. and Jain, M.K. (2013). Temporal and Spatial Variability of Annual and Seasonal Rainfall over Ethiopia. *Hydrol. Sci. J.* 58(2), pp. 354–373.
Newing, H. (2011). Conducting Research in Conservation. A Social Science Perspective. London: Routledge.

Nhemachena, C. and Hassan, R. (2007). Micro-level Analysis of Farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper 00714, IFPRI, Washington.

Niang, I., Ruppel, O.C., Abdrabo, M.A., Essel, A., Lennard, C., Padgham, J., Urquhart, P. (2014). Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1199–1265.

Niles, M.T., Lubell, M. and Haden, V.R. (2013). Perceptions and Responses to Climate Policy Risks among California Farmers. *Global Environ. Change* 23, pp. 1752–1760.

NMSA (2001). Initial National Communication of Ethiopia to the United Nations Framework Convention on Climate Change (UNFCCC). National Meteorological Services Agency (NMSA), Addis Ababa, Ethiopia.

NMSA (1996). Assessment of Drought in Ethiopia. Addis Ababa.

Nzeadibe, T.C and Ajaero, C.K. (2010). Assessment of Socio-economic Characteristics and Quality of Life Expectation in Rural Communities of Enugu State, Nigeria. *Applied Research in quality of Life* 5(4), pp. 353-371.

Olsen, C. and George, M. (2004). Cross-Sectional Study Design and Data Analysis. College Entrance Examination Board, New York, pp.1-53.

Onwuegbuzie, A.J. (2003). Effect Sizes in Qualitative Research: A prolegomenon. Quality and Quantity. *International Journal of Methodology* 37, pp. 393–409.

Osbahr, H., Dorward, P., Stern, R. and Cooper, S. (2011). Supporting Agricultural Innovation in Uganda to Respond to Climate Risk: linking climate change and variability with farmers' perceptions. *Expl. Agric.* 47(2), pp. 293–316.

Osman, M. and Sauerborn, P. (2002). A preliminary assessment of characteristics and longterm variability of rainfall in Ethiopia - basis for sustainable land use and resource management. In: Conference on International Agricultural Research for Development; Witzenhausen, October 9-11, 2002.

Oxfam International, (2010). The Rain Doesn't Come On Time Anymore: poverty, vulnerability, and climate variability in Ethiopia. Addis Ababa: Oxfam International- Ethiopia.

Patt, A.G. and Schro¨ter, D. (2008). Perceptions of Climate Risk in Mozambique: implications for the success of adaptation strategies. *Global Environmental Change* 18(3), pp. 458–467.

Piya, L., Maharjan, K. and Joshi, N. (2013). Determinants of Adaptation Practices to Climate Change by Chepang Households in the Rural Mid-Hills of Nepal. *Regional Environmental Change* 13(2), pp. 437–447.

Porter, J.R., Xie, L., Challinor, A.J., Cochrane, K., Howden, S.M., Iqbal, M.M., Lobell, D.B. and Travasso, M.I. (2014). Food Security and Food Production Systems. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., Barros, V.R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girmaw Bogale, Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 485–533.

Riché, B., Hachileka, E., Awuor, C. and Hammill, A. (2009). Climate-Related Vulnerability and Adaptive Capacity in Ethiopia's Borana and Somali Communities. Final Assessment Report. Addis Ababa: Save the Children UK and Care International, Ethiopia. pp. 21-29.

Rosell, S. and Holmer, B. (2007). Rainfall Change and its Implications for *Belg* Harvest in South Wollo, Ethiopia. *Geogr. Ann.* 89(4), pp. 287–299.

Rosenzweig, C., Tubiello, F.N, Goldberg, R., Mills, E. and Bloomfield, J. (2002). Increased Crop Damage in the U.S. from Excess Precipitation under Climate Change. *Global Environ. Change*: *Human Dimensions and Policy* 12(3), pp. 197-202.

Salmi, T., Määttä, A., Anttila, P., Ruoho-Airola, T. and Amnell, T. (2002). Detecting Trends of Annual Values of Atmospheric Pollutants by the Mann-Kendall test and Sen's slope estimates - the Excel template application MAKESENS. *Finnish Meteorological Institute, Air Quality Research* No. 31, Helsinki, Finland.

Seifu Admassu and Abdulkarim Seid (2006). Analysis of Rainfall Trend in Ethiopia. *Eth. J. Sci. and Technol.* 3(2), pp. 15–30.

Sen, P.K. (1968). Estimates of the Regression Coefficient Based on Kendall's tau. *J. Am. Stat. Assoc.* 63, pp. 1379–1389.

Sharp, K., Devereux, S. and Yared Amare (2003). Destitution in Ethiopia's North-Eastern Highlands (Amhara National Regional State) Final Report. Institute of Development Studies at the University of Sussex, Brighton, UK, SC–UK Ethiopia.

Skolnik, R. (2016). Global Health 101 (3rd ed., pp. 186–187). Burlington, MA: Jones and Bartlett Learning.

Sneyers, R. (1990). On the Statistical Analysis of Series of Observation. WMO: Geneva, Switzerland; Technical Note No.143.

Sofoluwe, N., Tijani, A. and Baruwa, O. (2011). Farmers' Perception and Adaptations to Climate Change in Osun Satte, Nigeria. *African Journal of Agricultural Research* 6(20), pp. 4789-4794.

Speranza, C.I., Kiteme, B. and Opondo, M. (2009). Adapting Public Agricultural Extension Services to Climate Change: Insights from Kenya. Paper Presented in the Amsterdam Conference on the Human Dimensions of Global Environmental Change, 2-4 December 2009. Friday December 4, 2009. Panel 9: Vulnerability and Adaptation in Agricultural and Food Systems.

Tabari, H., Meron Teferi Taye and Willems, P. (2015). Statistical Assessment of Precipitation Trends in the Upper Blue Nile River Basin. *Stoch. Environ. Res. And Risk Assess*. 29(7), pp. 1751-1761.

Tabari, H. and Talaee, H. (2011). Analysis of Trends in Temperature Data in Arid and Semi-arid Regions of Iran. *Global and Planetary Change* 79(1), pp. 1-10.

Tanner, T. and Mitchell, T. (2008). Entrenchment of Enhancement: Could Climate Change Adaptation Help to Reduce Chronic Poverty? *Institute of Development Studies Bulletin* 39(4), pp. 6-15.

Temesgen Taddese, Hassan, R.M. and Ringler, C. (2011). Perception of and Adaptation to Climate Change by Farmers in the Nile Basin of Ethiopia. *J. Agric. Sci.*149(1), pp. 23–31.

Temesgen Taddese, Hassan, R.M. and Ringler, C. (2008). Measuring Ethiopian Farmers' Vulnerability to Climate Change across Regional States, IFPRI Discussion Paper 00806, International Food Policy Research Institute (IFPRI). Washington, DC, USA.

Tol, R.S.J., Downing, T.E., Kuik, O.J. and Smith, J.B. (2004). Distributional Aspects of Climate Change Impacts. *Global Environmental Change* 14(3), pp. 259–272.

Tol, R.S.J. (1995). The Damage Costs of Climate Change toward more Comprehensive Calculations. *Environmental and Resource Economics* 5, pp. 353-374.

Torquebiau E. (2016). Climate Change and Agriculture Worldwide. Heidelberg: Springer, p. 373. Retrieved from: http://doi.org/10.1007/978-94-017-7462-8.

Tripathi, A. and Mishra, A.K. (2017). Knowledge and Passive Adaptation to Climate Change: An Example from Indian Farmers. *Climate Risk Management* 16, pp. 195–207.

Tripathi, A. (2016). Socioeconomic Backwardness and Vulnerability to Climate Change: Evidence from Uttar Pradesh State in India. *Journal of Environmental Planning and Management* 60(2), pp. 328-350.

UNECA (2011) Climate Science, Information, and Services in Africa: Status, Gaps and Policy Implications. United Nations Economic Commission for Africa, African Climate Policy Centre (ACPC), Working Paper 1.

UNFCCC (2007). Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Retrieved from: <www.unfccc.int>.

Van de Giessen, E. (2011). Horn of Africa Environmental Security Assessment. Institute for Environmental Security, 2518 BC The Hague, The Netherlands. Retrieved from: http://www.envirosecurity.org/.

Wag Hemera Zone Agriculture Development office (2015). Wag Hemera zone 2007 E.C arable land report. Sekota.

Woldeamlak Bewket (2007). Rainfall Variability and Agricultural Vulnerability in the Amhara Region, Ethiopia. *Ethiop. J. Dev. Res.* 29(1), pp. 1–34.

Wolf, J. and Moser, S.C. (2011). Individual Understandings, Perceptions, and Engagement with Climate Change: Insights from In-depth Studies across the World. *WIREs Climate Change* 2(4), pp. 547-569.

World Bank (2008). World Development Report 2008: Agriculture for development. Washington DC: World Bank.

World Bank Group (2010). Economics of Adaptation to Climate Change, Ethiopia country study. Washington DC. Retrieved from: http://climatechange.worldbank.org/content/ethiopia economics adaptation climate change study.

Yamane, T. (1967). Statstics. An Introductory Analysis 2nd Edition. Harper and Row, New York.

Yilma Seleshi and Zanke, U. (2004). Recent changes in rainfall and rainy days in Ethiopia. *Int. J. Climatol.* 24, pp. 973–983. Retrieved from: https://doi.org/10.1002/joc.1052.

Zewdu Eshetu, Belay Simane, Gebeyehu Tebeje, Workneh Negatu, Aklilu Amsalu, Abeje Berhanu, Bird, N., Welham, B. and Canales Trujillo, N. (2014). Climate Finance in Ethiopia. London: Overseas Development Institute; Addis Ababa: Climate Science Centre. Retrieved from: (www.odi.org/publications/8203-climatefinance-ethiopia).

Zewdu Tessema Segele and Lamb, P.J. (2005). Characterization and Variability of *Kiremt* Rainy Season over Ethiopia. *Meteorol. Atmos. Phys.* 89(1), pp. 153–180. Retrieved from:https://doi.org/10.1007/s00703-005-0127-x.

APPENDICES

Appendix A: Questionnaire (English Version)

Consent Information Sheet

Dear Study Participants:

I would like to give you information regarding the study as follows: My study attempts to investigate **'*Climate Change and Variability: Smallholder Farmers' Perception and Indigenous Adaptation Responses in Sekota woreda, Amhara Region, Northeast Ethiopia*'**.

You are randomly selected to participate in this study. The study and its procedures have been approved by the appropriate authorities (**Addis Ababa University Ethical Committee**). There is a questionnaire which has **four parts** and to be filled by you. This questionnaire is focusing on the overall situations about your perception and adaptation strategies to climate change and variability in your area.

In order to obtain reliable and scientific information, it is crucial to answer as honestly as possible. No need of name, identification number, or other identifying details; hence your answers are anonymous. The information from you will be treated as confidential. This research imposes no risk and therefore no compensation will be provided for participation in this study. There are no direct benefits as a research participant. You can refuse to participate or withdraw at any time without harming you. You can ask any question concerning this research and have those questions answered before agreeing to participate in or during the study. Or you may contact the investigator at the phone number below. You are voluntarily making a decision whether or not to participate in this study.

Your signature certifies that you have decided to participate, having read and understood the information presented.

Consent Form

I have been explained all information and procedures that are part of this study. I understand that the research imposes no risk on me and my families.

I hereby agree to participate in this research and give my voluntary consent. I hereby also give rights to the researcher for collecting the data that are required for the study.

	Agree	Disagree
Name of the Participant:	________________	________________________
Signature of the Participant:	________________	________________________
Date:	________________	________________________
Name of Investigator:	Getamesay Behailu	Phone number: 0911-90-91-96

Quantitative – Household Survey Questions

This research aims to investigate perception and adaptation of smallholder farmers to climate change and variability by exploring how people perceive climate change, how vulnerable they are, and what they do to adapt to climate change. Your responses will be treated as confidential and will be used for research purposes. The results of the questionnaire will not be used in any way other than for the purpose of conducting this research.

Thank you in advance for your willingness to discuss with me. Below are my questions to you:

Basic Information

Region: Amhara Regional State
Zone: Waghemera
District: Sekota
Name of Village (Kebele): _______________
Name of Household Head: ________________
Name of the Respondent: ________________
Household Code (ID): ____________________
Date of interview: ______________________
Starting time: ___________________________
Ending time: ___________________________
Name of enumerator: _____________________

Household's GPS Coordinates

East (Longitude): ____
North (Latitude): ____
Elevation (Altitude): ____

Instruction: Dear enumerator, please circle the number representing respondent's answer from given alternatives and/or write their answer for the rest questions requiring quantitative and other responses.

Part I: General Household Informaion

101. Gender
[1] Male
[2] Female

102. Marital status
[1] Married
[2] Single
[3] Divorced
[4] Widow

103. Religion
[1] Orthodox Christian
[2] Muslim
[3] Catholic Christian
[4] Protestant Christian
[5] Traditional belief system
[88] Other, specify: _______________

104. Education
[1] None
[2] Primary (grade 1-8)
[3] Secondary (grade 9-12)
[4] Tertiary (college, university)
[88] Other, specify: __________________

Part II: Demographic and Socioeconomic Background

105. Age of the household head: ____

106. Size of the household: How many people are living in your household?

Female: ___________

Male: ___________

Total: ___________

107. What kind of farming do you practice?

[1] Crop farming [2] Mixed farming

[3] Agro forestry

108. What kind of agriculture are you practicing?

[1] Rain fed agriculture [2] Both rain fed and irrigated agriculture

[3] Irrigated agriculture [88] Other, specify: ______________________

109. What is the size of the farm land you have (owned)? Measured in:

Local units ('Timad'): ______________

In hectare: _________________________

110. What are the major crops grown by your household last year?

Cereal crop	**Acreage (timad)**	**Yield (quintal)**	**Cash crops**	**Acreage (timad)**	**Yield (quintal)**
Maize			Sugar cane		
Teff			Onion		
Sorghum			Garlic		
pea			Potato		
bean			Vegetables		
barley			Chat		
wheat			Banana		
others					

111. How many kilograms of chemical fertilizer you use on your total farm land?

(Both DAP and Urea) ____

112. Do you own (have) livestock (like cattle, sheep, goat, etc.)?

[1] Yes [2] No

If yes which ones?

[1] Cows and Oxen [2] Donkeys

[3] Goats & Sheep [4] chickens

[5] Camels [88] Other, Specify:______________________

Part III: Household risk and climate change over the past 30 years

A. **Knowledge and Perceptions of Changes of Climate Variables**

201. Are you aware of climate change?

[1] Know a lot [2] Know

[3] Know little [99] Don't know

202. How do you perceive the status of climate variables in your village?

S/N	**Answer Code:** 1= Strongly agree, 2= Agree, 3= Neither Agree nor Disagree/Unsure, 4= Disagree, 5= Strongly disagree	**Answer Codes: (Circle)**				
1.	Increasing rainfall amount during rainy season	**1**	**2**	**3**	**4**	**5**
2.	Decreasing rainfall amount during rainy season	**1**	**2**	**3**	**4**	**5**
3.	Increasing length of rain season	**1**	**2**	**3**	**4**	**5**
4.	Decreasing length of rain season	**1**	**2**	**3**	**4**	**5**
5.	Early onset of rain days	**1**	**2**	**3**	**4**	**5**
6.	Late onset of rain days	**1**	**2**	**3**	**4**	**5**
7.	Increase of strong winds events	**1**	**2**	**3**	**4**	**5**
8.	Increasing temperature of the area	**1**	**2**	**3**	**4**	**5**
9.	Decreasing temperature of the area	**1**	**2**	**3**	**4**	**5**
88	Other, specify: ____					

203. Have you encountered extreme/unusual weather events due to climatic variability?

[1] Yes [2] No

[99] I don't know/cannot remember

204. If yes, what?

[1] Flooding due to heavy rainfall [2] Shortage of rain

[3] Drought [4] Famine

[5] Crop failure [6] Increases flood disaster

[7] Poor livestock productivity [8] Loss of income

[9] Loss of pasture land [10] Increase deforestation

[11] Loss of agricultural land [12] High intensity wind

[13] Severe soil erosion [14] Drying of vegetation

[15] Shortage of water [99] I do not remember/know

[88] Other, specify: ___________________

205. What effects did it has on you?

[1] Damage to property [2] Loss in livestock

[3] Loss in agricultural production [4] Loss in income

[5] Health hazards [6] Lack of potable water

[7] None [99] I don't know

[88] Other, specify: ____

B. Indigenous knowledge practices and climate change adaptation strategies adopted at household level (What has been done to adapt with climate change?)

206. Please mention different sources of knowledge concerning climate change adaptation?

[1] Personal experience	[2] Parents/Family
[3] Friends/Neighbors	[4] Social groups
[5] Church/mosques	[6] Community gathering
[7] Village leaders	[8] Media
[9] Extension staffs	[10] NGOs

[88] Others, specify: ____

207. Do you have any traditional weather prediction methods?

[1] Yes [2] No

208**.** For how long have you been using this knowledge in your everyday farming and livestock keeping activities? ____

209. Which local indicators do you use to evaluate the temperature trend in the area? (Please support your choice with example).

[1] Prevalence of human and animal diseases that are not familiar to the area (malaria etc).

[2] Introduction of plant and animal species that were not popular in the area (goat in highland not common).

[3] Observation of physical structures and societal clothing styles (frost damage become uncommon, drying up of rivers, streams, swampy areas ,lakes, dressing light cloths etc.

[88] Other, specify: ____

210. Has climate change and variability created any good opportunities for you?

[1] Yes [2] No

211. If Yes, Please support your answer with explanation: ____________________________

212. Are there any adaptation strategies you made for the change in climate (precipitation and temperature)?

[1] Yes [2] No

[99] I don't know

213. If yes, for Q 25, what drives you to take measure against the change? _________________

214. If the answer for Q 25 is No, What are the perceived hindrances to adaptation to climatic events and or change?

S/N	**Answer Code: Scale of Hindrance:** 1= Not at all, 2= Little-bit, 3= Often, 4= Very often, 5= Mostly	**Answer Codes: (Circle)**				
1.	Lack of improved seeds /New varieties adaptable to new climate	**1**	**2**	**3**	**4**	**5**
2.	Poorly developed new varieties (new variety not suitable for the place)	**1**	**2**	**3**	**4**	**5**
3.	Lack of access to source for irrigation / No irrigation facilities	**1**	**2**	**3**	**4**	**5**
4.	Conflict in resource stewardship / entitlement (source of water/forest/grazing) /Insecure property rights	**1**	**2**	**3**	**4**	**5**
5.	Lack of information on weather incidence/ reliable forecast/ short and/or long-term	**1**	**2**	**3**	**4**	**5**
6.	Lack of sufficient and current knowledge on adaptation methods	**1**	**2**	**3**	**4**	**5**
7.	Lack of money to acquired modern techniques/ Lack of credit services/ Lack of market accessibility	**1**	**2**	**3**	**4**	**5**
8.	Low perception on long term climate change	**1**	**2**	**3**	**4**	**5**
9.	Lack of external support (I/NGO, Development Agencies)	**1**	**2**	**3**	**4**	**5**
88	Other, specify: ________________________________					

215. Which, and at what level, of the following strategies have you/ your family adopted to reduce the loss / or adapt to climatic events or change over last 30 years?

S/N	**Answer Code:** 1= Not at all, 2= Little-bit, 3= Often, 4= Very often, 5= Mostly	**Answer Codes: (Circle)**				
	Strategies Adopted for continuation of agro-based livelihood systems					
1.	Changed crop varieties / practicing / selection of crops with short growing season/Introduction / use of new crops varieties	**1**	**2**	**3**	**4**	**5**
2.	Changed the irrigated to dry farming (selected drought resistant crop types)	**1**	**2**	**3**	**4**	**5**
3.	Different planting dates (crop-calendar changed)	**1**	**2**	**3**	**4**	**5**
4.	Changed cropping system (crop diversification, rotation, inter-cropping, crop spacing, crop location)	**1**	**2**	**3**	**4**	**5**
5.	Regulated distribution and use of water resource / improve irrigation (channeling, lining, drip-irrigation)	**1**	**2**	**3**	**4**	**5**
6.	Increased water sources for irrigation (improved/brought from new sources/accessing from ground water extract / rain water-harvesting)	**1**	**2**	**3**	**4**	**5**
7.	Increased use of chemical fertilizer / insecticide	**1**	**2**	**3**	**4**	**5**
8.	Mulching/ soil conservation / moisture protection, practiced zero tillage	**1**	**2**	**3**	**4**	**5**
9.	Making ridges across farms, degradation and erosion control	**1**	**2**	**3**	**4**	**5**
10.	Specialized livestock as per cold/hot period	**1**	**2**	**3**	**4**	**5**
11.	Used mixed/ integrated agriculture (Crop-Livestock vegetable/fruits)	**1**	**2**	**3**	**4**	**5**
12.	Farming experience / received training/ formally educated family member joined in agriculture	**1**	**2**	**3**	**4**	**5**
13.	Farm size change (increased land to grow more food) (bought new land/ conversion of other use to farm land)	**1**	**2**	**3**	**4**	**5**
14.	Farm land change (conversion of farm land type: slopping terrace to					

	level terrace)	**1**	**2**	**3**	**4**	**5**
15.	Farm size change (conversion of farm land to other use: grass land/forest/barren due to poor productivity)	**1**	**2**	**3**	**4**	**5**
16.	Changed livestock types / size/ feeding practice (from grazing to stall-feed)	**1**	**2**	**3**	**4**	**5**
17.	Afforestation / grass seedling and fodder trees planting	**1**	**2**	**3**	**4**	**5**
18.	Increased use of agricultural residue as fodder/firewood	**1**	**2**	**3**	**4**	**5**
19.	Changed house structure (foundation up-lifted, roofing material/roof structure changed)	**1**	**2**	**3**	**4**	**5**
20.	Installed / added heating/cooling systems, and mosquito nets	**1**	**2**	**3**	**4**	**5**
21.	Started rain water harvesting	**1**	**2**	**3**	**4**	**5**
	Other Strategies adopted for change / change in livelihood options					
22.	Crop/livestock insurance	**1**	**2**	**3**	**4**	**5**
23.	Transhumance for longer period/even higher altitude	**1**	**2**	**3**	**4**	**5**
24.	Receiving food aid/ subsidies and other external supports	**1**	**2**	**3**	**4**	**5**
25.	Advocacy and campaign and / or quest of external support	**1**	**2**	**3**	**4**	**5**
26.	Shifted from agriculture to non agriculture occupation	**1**	**2**	**3**	**4**	**5**
27.	Migration of family members to nearby town/market center for different occupation	**1**	**2**	**3**	**4**	**5**
28.	Migration of family members to city for different occupation	**1**	**2**	**3**	**4**	**5**
29.	Migration of family members to other rural area (for agro-based occupation)	**1**	**2**	**3**	**4**	**5**
30.	Migration of family members to other country (labor migration)	**1**	**2**	**3**	**4**	**5**
31.	Prayer / accept God's blessing	**1**	**2**	**3**	**4**	**5**
88.	Other, specify: ______________________________					
32.	At what scale you think that you have adopted above strategies because of perceived climate change?	**1**	**2**	**3**	**4**	**5**

Part IV: Institutional Factors

301. Do you get agricultural extension services in your area?
    [1] Yes   [2] No

302. Do you have access to information media?
    [1] Yes   [2] No

303. If your answer is yes, which medium do you posses?
    [1] Radio   [2] TV
    [3] Newspaper   [4] Extension agents
    [88] Other, specify: ______________________________

304. Do you have access to credit?
    [1] Yes   [2] No

Thank you for your help and cooperation.

Qualitative – Semi-structured Interview Questions for KI
Guiding Questions for Smallholder Farmers

1. What visible changes have you observed as related to rain fall, temperature, soil fertility, forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought etc during your life time in the village?
2. How often is the occurrence of drought in the locality? And what are the probable causes?/How is the trend of the rainfall during the past 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?
3. What coping and adaptation strategies have community members practiced to alleviate problems arising as a result of climatic variability/drought?.
4. Can you tell us the sowing time of common grown crops some 30 years back and what time of the year do you practice seed sowing in recent years?
5. What development interventions are carried out in the village to avert the impact of climate change? (afforetation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.)
6. What agricultural technology and meteorology information system do you access regularly and during climatic extremes?
7. Do you receive early warning information on short term variations and/or long term climate change from any sources ?
8. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?
9. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?
10. What should the government and the community do together to avert the impact of climate change in the *kebele*?

Guiding Questions for Government Institution Staffs (Agricultural Development Offices, Land Administration Offices, Meteorological Agency, Agricultural Research Center and NGOs representatives)

1. What are the indictors of the occurrence of climate change?
2. How do you evaluate the climate situation in the district over the past 30 years?
3. What are the damages caused by climate change to the society?
4. Is climate change an important agenda for Agricultural Development Offices? If yes what are the development interventions introduced in the *woreda* (*kebeles*)?
5. Are the development interventions appreciated and owned by the community? Are they sustainable?
6. Do you think that farmers are aware of climate change and variability in their localities? If yes how did they acquired the awareness?
7. What coping mechanisms do farmers use in times of drought in the *woreda*? Also what adaptation strategies do rural households use to withstand the ill effects climate change?
8. What challenges do framers face to effectively implement coping and adaptation mechanisms?
9. How do you evaluate the impacts of climate change on rural household's livelihoods, water resources (rivers, streams, ponds), grazing lands, woodlands, farm lands?
10. Which segment of the local community more affected by climate variability/climate change?
11. Is there any local level organizational arrangement made that helps farmers to overcome the damages caused by climate change/climate variability?
12. How do you evaluate the role and strength of local level organization to sustain development interventions?
13. What assistances are they provided to make them empowered?
14. How integrated are government institutions working on activities that are deemed helpful to avert climate shocks?
15. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?
16. Of the development interventions which ones are more important to reduce damages that could be caused by climate change/climate variability?
17. 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.

18. What are the challenges faced by the agricultural research and extension services to address climate change issues?
19. How do you evaluate the role of the NGOs contributions to coping against climate change?
20. 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?
21. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?

Suggestion and expectations for effective adaptation

1. How can vulnerability be reduced and how can adaptation are promoted? What can be done at community level and what sort of external support is needed (list current adaptation gaps in particular sector/ particular incident)

2. What do you want to recommend to local communities, Development Agencies and NGOs and State to enhance adaptation to climate change?

3. Is there anything you want to share? If so please share your issues

Thank you for your help and cooperation.

Guiding Questions for Focus Group Discussion (FGD) (with selected farmers representing cross section of the community, women group, youth group, Kebele leaders)

Address (location) of the village: ______________________________________

Focus group size: ____

Focus group composition: Male headed households/women headed households/youth group, *kebele* leaders

1. What visible changes have you observed related to rain fall, temperature, soil fertility forest vegetation, wildlife, crop productivity, livestock productivity, flow of streams, occurrence of big floods, incidence of drought, forest vegetation cover, river/stream flow etc during your life time in the village?
2. How often is the occurrence of drought in the locality? And what are the probable causes?
3. Have you heard of "climate change"? If yes from which sources?
4. What are your traditional or local indicators to realize that there is climate change?
5. How is the trend of the rainfall and the temperature during the past 30 years? Is it increasing, decreasing, coming on time and stopping at the right time?
6. What coping and adaptation strategies have community members crafted to alleviate problems arising as a result of climatic variability/drought?
7. Do farmers have sufficient knowledge about adaptation options to climate change?
8. Are the crops you cultivate now the same as the crops your father or forefathers were growing? If no, reasons for changing the crops?
9. Are the animals you are raring now the same as the animals your father or forefathers used to rare? If no, reasons for changing the animals?
10. What customary self-help arrangements are there to support each other in your villages during the times of climatic extremes?
11. What effect has climate change caused on the livelihood of the local people?
12. Do you believe that it is possible to reduce or totally stop the negative impacts of climate change? if yes how?
13. Can you tell us the sowing time of common grown crops some 30 years back and what time of the year do you practice seed sowing in recent years?
14. What development interventions are carried out in the village to avert the impact of climate

change? (afforetation, water harvesting, irrigation, soil and water conservation, off farm employment, etc.)

15. Do you agree that development interventions in the village are well planned, well discussed and undertaken after consensus or lack these attributes?
16. Do you feel that farmers are happy to participate in development activities such as soil and water conservation, forestry development without payment?
17. How do you evaluate the sustainability of development interventions promoted by government and nongovernment organizations?
18. How do you evaluate the agricultural extension agents' role in motivating and mobilizing the community to strengthen their adaptive strategies to climatic changes?
19. How do you evaluate the value of tree planting to individual households' livelihood improvement and improving climate change?
20. What trainings are given to the community to reverse climatic shocks?
21. What agricultural technology and meteorological information/early warning are provided to farmers to avert climate shocks? If any by whom?
22. Do farmers have strong organizational arrangement that could enhance local development and social cohesion? Please give your opinion.
23. What are the success stories you observed in relation to coping and adaptation strategies adopted by farmers to withstand climatic shocks?
24. What should the government and the community do to avert the impact of climate change in the kebele?

Suggestion and expectations for effective adaptation

1. How can vulnerability be reduced and how can adaptation are promoted? What can be done at community level and what sort of external support is needed (list current adaptation gaps in particular sector/ particular incident)

2. What do you want to recommend to local communities, Development Agencies and NGOs and State to enhance adaptation to climate change?

3. Is there anything you want to share? If so please share your issues?

Thank you for your help and cooperation.