CLIMATE VARIABILITY ADAPTATION STRATEGIES IN COFFEE PRODUCTION, AND IT'S IMPLICATION TO HOUSEHOLD FOOD SECURITY: THE CASE OF NANSABO WOREDA, WEST ARSI ZONE, OROMIA REGIONAL STATE, ETHIOPIA A THESIS SUBMITTED

BY:

ANSHA NURE

A THESIS SUBMITTED TO CENTER FOR FOOD SECURITY STUDIES COLLEGE OF DEVELOPMENT STUDIES ADDIS ABABA UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND DEVELOPMENT STUDIES

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Addis Ababa

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APPROVAL SHEET OF RESEARCH PAPER

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This is to certify that the thesis presented by Ansha Nure the title of climate change adaptation strategies in coffee production, and it's implication to household food security: the case of Nansabo Wereda and submitted in partial fulfillment of the requirement for the degree of Master of Science complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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DECLARATION

I, Ansha Nure Tussa, do hereby declare to the Senate of Addis Ababa University that this thesis is my own original work and that it has neither been submitted nor concurrently being submitted for a degree award in any other University and all the sources of materials used for the thesis has been duly acknowledged.

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Place: Addis Ababa University Date of Submission:________________

This thesis has been submitted for examination with my approval as a supervisor.

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BBREVIATIONS

ADPCC	Adaptation to Climate Chang
CSA	Central Statistical Authority
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Products
GHG	Green House Gases
HFIAS	Household Food Insecurity Access Scale
HH	Household
ICPAC	Climate Prediction and Applications Centre
ICC	International coffee community
IEH	Institute de Studios del Hambre)
IFAD	International Fund Agency for Development
IPCC	Inter governmental Panel on Climate Change
NAPA	National Adaptation Plan of Action
NGOs	Non-Governmental Organizations
NMA	National Meteorological Agency
ONRS	Oromia National Regional State
PCI	Problem Confrontation Index
SPSS	Statistical Package for Social Science
SSA	Sub Saharan Africa
UN	United Nation
UNDP	United Nation Development program
UNFCCC	The Framework Convention on Climate Change
UNFCC	Unite Nation Framework Convention on Climate Change
WB	World Bank
WMO	World Metrological Organization
WAI	Weight Average Index

ABSTRACT

Climate change is the biggest challenges of the 21st century. It is one of the greatest environmental, social and economic threats facing our world today. Disasters generated by the phenomenon of climatic modification have deep influence on agriculture. Ethiopia is vulnerable to the impacts of climate change mainly due to poor adaptive capacity of communities and high diversity of agro ecologies, cultures, production systems and livelihood strategies. The effect of climate change and variability is adversely affecting coffee production in study area. However, no study has been conducted concerning the issue of climate change adaptation strategies on coffee production and its implication to rural household food security. The study is motivated by the belief that the effect of climate change on coffee production is high while less understood in the study area. The study was conducted in two kebeles' of Nansabo Wereda, of Oromia Region. These Kebeles' were selected purposely based on their potential to coffee production and susceptibility to climate change and variability related food insecurity. The study was based on a total number of 181 coffee producers and which was randomly selected for survey. Descriptive statistics such as mean, standard deviation and percentage were used to describe sampled respondents in terms of some desirable variables. A binary logit model was also used to analyze the factors affecting climate change adaptation strategies. Fifteen variables were included in the model of which ten were found significant at (P<0.10) probability level. The finding of this study indicates that age, education level, farm experience, family size, farmland size, market distance, total Coffee income, access to climate change information, frequency of extension contact and access to agricultural information services, were found to be highly important variables influencing factors for Climate change adaptation strategies.The ranking of adaptation strategies which based on coffee producers households'perceived one of the best strategies mentioned in in this study. From eight adaptation options three of them particularly shade management, improved coffee varieties and intercropping strategies were the first three with WAI;2.3,2.21 and 2.2, respectively. The finding of metherological data indicates that in study area, changes in climate particularly rainfall and temperature patterns were reported by more than half of the surveyed households. The survey results indicates that households perceived erratic rain fall increase and/or decrease in annual rainfall has resulted in prolonged dry spells and droughts.

Key Words: Climate Variability; Adaptation Strategies; Coffee Production; Food Security,

CHAPTER ONE

1. Introduction

1.1 Background of the Study

Climate change is unequivocal as there is now ample evidence that the earth's climate system is warming at an unprecedented rate leading to ice melting and sea-level rise (IPCC, 2014). In terms of this, the inevitability of changing climate is increasingly accepted around the world by scientists and the public. According to Porter et al (2014), an average increase of 0.85°C in the global combined land and ocean surface temperatures was calculated for the period of 1880 to 2012). The report further states that the average world temperature is expected to raise another 2.0 to 7.0°C continuously. AS Ray et al. (2015) increasing climatic variability may further complicate agricultural production and food security, and almost one-third of yield variability is related to climatic variability.

The perspective study of IFAD (2010) shows that, developing countries are the most adversely affected by the negative effects of climate induced events because of their low level of adaptation. Also, Ang et al. (2014), most areas of the African continent lack sufficient climate station data to draw conclusions about trends in annual rainfall, and poor climate change adaptation strategies. Accordingly, climate in the region has been experiencing unpredictable rainfall patterns, consequently resulting to declining and uneven yield trends with significant effects on household (HH) food security.

According to FAO (2006), Agriculture contributes more than 30 percent to the Gross Domestic Product (GDP) in the different countries of sub-Saharan Africa (SSA) and occupies more than 70 percent of the active population. Accordingly over 90 percent of the population in this region depends on rain-fed agriculture for food production. This makes agriculture in these countries highly dependent on climate change.

According to IEH (2012), It is undeniable that 75% agriculture has received a great deal of attention in recent times when action for tackling climate change has been placed at very top of the world's political agenda; because of, more human beings derive their livelihood from agriculture than from any other economic activity and the majority are self-employed subsistence farmers living in the tropics. According to Vergara et al. (2014) report, the adverse effect of climate change on agriculture will occur predominantly in the tropics and subtropics mainly at sub-Saharan Africa and, to a lesser extent, South Asia. Jassogne et al. (2012), the most alarming effect on coffee producing regions have been identified as being at a high risk and need to make extra efforts to prepare for the future. In the case of the coffee crop, the expected impacts are negative due to the increase in temperatures that will provoke changes in the crop cycle, with consequences ranging from higher vulnerability to some diseases to more complicated harvesting and post-harvest tasks. The reduction in coffee yield and quality has had direct impacts on the livelihoods of thousands of smallholders and harvesters.

As Urquhart et al. (2014) in Ethiopia, coffee is seen as green gold for the nation; it has been and remains the leading cash crop and export commodity, accounting for about 4 per cent on average of the country's gross domestic product (GDP), 10 per cent of agricultural production, and about 37 per cent of total export earnings over the past decade. According to (MOA, 2014), coffee is the largest agricultural contributor to gross domestic product (GDP) in Ethiopia.

As the report states coffee production is mostly in the hands of smallholders and about 4.2 million smallholder farming households contribute between 93 and 95 per cent of national coffee production. As the report further elaborated, coffee is one of high-value crop impacting by climate change, potentially leading to major impacts on national economies. According to Dula (2018), Climate change already had (and will continue to have) a severe and negative effect on coffee production. Accordingly this in Ethiopia, rapidly increasing temperatures kill the plants at an alarming rate, pests and disease that target coffee plants have raised in prevalence.

And also, according to Mekonnen and Daba (2018), rising temperatures and erratic rainfall are threatening sustainable coffee production by enabling outbreak of diseases and infestations of insect pests that decrease the quality and yield of coffee berries by citing, Kifle and Demelash (2015). A study on vulnerability and poverty in Africa under taken by Thornton et al. (2006), shows that Ethiopia is one of the country's most vulnerable to climate variability and change, in view of the fact that, the degree to which an agricultural system is affected by climate change depends on its adaptive capacity. In terms of this adaptation is widely recognized as a vital component of any policy response to climate change. As Easter ling et al. (1993), without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, vulnerability can largely be reduced. According to Admassie and Adenew (2008), ongoing efforts developed in Ethiopia under National Adaptation Plan Action, contributed multidisciplinary technical working groups have been formed to assess the country's vulnerability to the adverse consequences of climate change, determine current adaptation efforts, and identify ways in which public agencies could assist in minimizing the adverse impacts of climate change. The study conducted by Dercon (2004, 2005) shows that the implementation of adaptation strategies can, thus, be very important to enhance the resilience of agricultural sectors, especially cash crops. This is particularly true for coffee producers in Nansabo Wereda whose economic welfare and food security depends on Agriculture. Nansabo Wereda has been growing coffee widely as the cash crop for more than 20 years, and land coverage of coffee crop is about, 36000 hectares prevailing in16 kebeles of 19 existing in the Wereda (2018). However, in the recent years, the coffee production has faced severe difficulties resulting into low yielding and affecting of number of coffee trees, which contribute by climate change and variability.

Thus, it is essential to adapt coffee crop to current and future climate changes, since most people of livelihoods and living values are affected by the effect of climate change. Therefore, the proposed study was intend to explore climate change adaptation strategies, with undertaking valuable research that would provide important understandings; with regard to the climate change adaptation strategies in coffee production and farmers' perceptions, substantially, to adapt the adverse effects of climate change and variability in Oromia National Regional State of Nansabo wereda.

1.2 Statement of the Problem

One of the biggest challenges of the 21st century is climate change. As Chomitz et al. (2006), Climate change is one of the greatest environmental, social and economic threats facing our world today. Disasters generated by the phenomenon of climatic modification have deep influence on agriculture Agossou *et al*. (2012). According to the IPCC (2014), it has been predicted that climate change will potentially affect all aspects of food security, including production of food, food accessibility, and food usage and price stability if local temperature increases by 2°C or more above late 20th century levels.

According to Belay et al. (2017), Ethiopia is vulnerable to the impacts of climate change mainly due to poor adaptive capacity of communities & high diversity of agro ecologies, cultures, production systems and livelihood strategies. As (Mokria et al. (2017), Ethiopia's climate is naturally both highly diverse and extremely variable, and as a consequence of this nature climate of the country dramatically changing in recent years. Accordingly the phenomenon leads to experiencing the impacts of both climate variability and change as droughts and famines, flooding, expansion of desertification, loss of wetlands, loss of biodiversity, decline in agricultural production and productivity, scarcity of water, and increased incidence of pests and diseases. Among agricultural production, Coffee is the world's most importan*t* tropical export cash crop as recognized by (Craparo et al. 2015).

The study conducted by Baker and Hagar (2007), erratic temperature and rainfall can affect coffee plants directly, by bringing about sub optimal growing conditions, and indirectly, by providing favorable conditions for pests and diseases such as coffee rust and the berry borer and coffee berry disease which ultimate result in reduced coffee quantity and quality. As Camargo (2010), climate variation such as soil water balance during different growth stages of the coffee crop, can affect the available soil water and decrease of the final yield. In similar studies of Jassogne et al. (2013), the negative impacts of climate variability and change are manifested unpredictable rains which will make coffee to flower at various times throughout the year, making the farmers to harvest small quantities continuously.

(FAO, 2008),coffee producers was face food shortage because of climate change events that can damage of livelihood assets as well as loss of income and employment opportunities are further constraints and lead to loss will be influenced by food price fluctuations and a higher dependency on food aid. There are several studies conducted so far on the issues of climate change impacts and adaptation strategies. However**,** most of the studies conducted were focused on certain issues of the identify household and farm characteristics and institutional factors as the determinants of adoption. For instance; Ochieng et al. (2012) and determinants of climate change adaptation strategies (Esham et.al 2013). And others had seen the effects of climate change on agricultural productivity and food security as (Bryant et.al, 2002). On the other hand others seen on farm level adaptation to climate change across different disciplines in various countries which explored farmers' adaptive behavior and its determinants (Deressa et al., 2009). And also similar studies undertaken by Dula (2018), regards to variations of climate variability and its determinants of farmers' decision to undertake adaptation measures to climate variability.

Despite internationally extensive research on adaptation in the agriculture sector to climate change, it is quite rare to find recent works that attempt to address the issues of climate change adaptation strategies in coffee production and its implication to rural household food security. Coffee producers farmers' demonstrate strategies are diverse, and they are embedded in a "complex web of institutional, ideological and economic relations" (Eakin et al. 2009, Eakin et al. 2012). In order to build more knowledge on the diversity of farmers' responses and drivers behind these, it is important to conduct more case studies within coffee-producing communities (e.g. Eakin 2005; Ponette-González 2007; Tucker et al. 2010).

The same is true for Nansabo Wereda coffee producers' households, that agricultural sector of coffee particularly vulnerable to current and future climate risks because of low adaptive capacity of coffee producers households' such as lack of awareness and technical skills, poverty, and lack of assets and capital to recover or to shift to alternative livelihoods. As to the consciousness of the researcher, no earlier studies have been conducted on the climate variability initiate to adaptation strategies in coffee production in the study area and abroad.

In Nansabo wereda, Oromia Region are; primarily, the effect of climate change and variability is adversely affecting coffee production and no study has been conducted concerning the issue of climate change adaptation strategies on coffee production and its implication to rural household food security. Thus, this study designed to make a contribution towards bridging the gap.

1.3 Objectives

1.3.1 General Objectives:

The overall objective of the study is to examine determinants of households' adaptation response in climate variability of coffee production and implications to household food security in Nansabo Wereda, Oromia Region.

1.3.2 Specific Objectives

The specific objectives of the study will be to.

i. Assess household's perception on extreme weather; temperature and rainfall situation.

ii. ii. Identify household's adaptation strategies in response to climate change and variability.

iii. Identify determinants of household's climate variability adaptation options in the coffee production.

iv. Identify the effects of climate variability on coffee production and its implication to households' food security.

1.3.3. Research Questions

This study was intend to answer the following questions.

i. How are coffee producers households in the study area perceive about extreme weather situation?
ii. What are the households' climate change adaptation strategies in the coffee production in the study area?
iii. What are the determinants of household's climate change adaptation options in the study area
iv. What are the possible determinations about the effects of climate variability on coffee production and its implication to households' food security in the study area?

1.4 Significant of the Study

The purpose of this study is to provide insights to the climate change adaptation strategies in coffee production. The output of the research could help farmers to adjust themselves to the current and projected impact of climate variability and build their adaptive capacity. Besides, it could also update the existing literature in the area i.e. the impact of climate variability and farmers adaptive strategy. It is also the issue that important for coffee producers to prepare for adaptation in ways that apply appropriate strategies temporally and spatially presenting specifically to its own circumstances regards to rural households and stakeholders will be identified together.

And also, the study is to examine the adaptation strategy to adverse effects of climate change and variability problem in Nansabo Wereda in an effort to explore the underlying constructs and determinants implication for adaptation strategies. Hence, the enquiry will try to investigate the adverse effects of climate change on coffee production problem in Nansabo Wereda and will come up with a way forward to alter the situation there by the core notion of the study.

The study was prominent for development policies because it intends to create awareness of how climate change problem significantly affects coffee production. Also it guides policy makers and stakeholders on how climate change adaptation strategies, in coffee production and implicate on to food security problem in the country can be solved. In assessing the adverse effects of climate change and variability problem on coffee production and exploring adaptation strategy.

The study was different from other studies conducted so far. Thus, the study have striven to give a new perspective to the climate change adaptation strategies in coffee production and implication to food security in Nansabo wereda.

At the end of the study, more comprehensive information on the major trends associated with climate change adaptation strategies in coffee production in the Wereda will have provided, which have critical for future research on the topic.

1.5. Scope of the Study

The study was undertaken in Nansabo Wereda, which is found in west Arsi Zone, Oromia National state. The Wereda consists of nineteen rural kebeles, out of nineteen Kebeles in the Wereda; the study was specifically conducted in two Keble's of the Wereda, which are Nansabo Chebbi and Mandoyu. The reasons to focus in these Kebeles are the actually and potentially coffee producers and now a day's some of the small households faced with climate change and variability threats and exposed to food insecurity. I was conducted survey on coffee producers' households' adaptation strategies to climate change and variability by taking quantitative and qualitative approach in order to make a detail analysis. So to control such vulnerability and consequence of climate change impacts interfering with climate variability adaptation strategy issue is much broader and needs perception mission to see all kebeles' of Wereda and to make it manageable the study to undertake climate change adaptation strategies in coffee production be critical in assuming of inevitability of its vulnerability and consequences become threat to income earned and food security for rural households and their livelihoods coupled with rain fed agriculture and natural resource based.

1.6. Limitation of the Study

Subsequently all study kebeles' was influenced by many adaptation factors. A factors which was found to enhance a particular strategy in one and at the same time might be found to hinder or irrelevant for perception like in terms of socioeconomic impacts of climate change differ from those of other, from the perspective of infrastructure, terrain, topography, land use, and climate being in the other kebeles' of Wereda.

It was difficult to conducting survey regarding to food security status during coffee harvesting time because at that time there was resilience period for rural households of coffee producers due to periodically income generating time. Also readiness to preciseness of the subjects, there was no ample or lack of secondary data and failure of respondents to return questionnaires due to remoteness of the area, infrastructure and sufficient budget run for this objective and time constrain.

CHAPTER TWO

2. Related Literature Review

Concepts and definition of terms

Climate; The World Meteorological Organization WMO (2016) defines climate as the "average weather," which is defined as the measurement of the mean and variability of relevant quantities of certain variables (such as temperature, precipitation or wind) over a period of time, ranging from months to thousands or millions of years".

Climate change refers to progressive changes in the global system that result from anthropogenic heating of the planet due to continuous increases of the emissions of greenhouse gases, and the loss of the vegetation cover and other carbon reservoirs (FAO, 2008; Mugula, 2013). It can also be defined by (Krishna, 2011; Mugula, 2013), as gradual changes in climate norms, particularly the temperature and changes in the frequency, scope and severity of climate and time extremes, explained as a persisting change on the average and variability of climate variables such as temperature, rainfall, humidity, and soil moisture. Climate change is defined by the Intergovernmental Panel on Climate Change IPCC (2007) as the "statistically significant variation of the mean state of climate that can be detected through modifications of the mean and/or the variability of its properties and which persists over a long period, generally for decades or more" as stated and described by (Arouna *et al*., 2012). The measure in which the geophysical, biological and socioeconomic systems are sensitive to the negative impact of climate change, including climatic variability and climate extremes, is defined as the state of climatic variability (IPCC, 2007; Mugula 2013). For Arouna *et* a*l*. (2012), stated that it is the inherent characteristics to the climate that manifest themselves through changes and deviations in time.

Climate variability: Refers to variations in the current state of the climate, and is a natural modification of the climate and therefore independent of human activity e.g. the amount of rainfall received from year to year; also includes extended droughts, floods, and conditions that result from periodic El Niño and La Niña events in affirmed of (ENSO) cited in (Dimon 2008).

Climate risk in agro climatology, risk is characterized by the frequency of the occurrence of a climatic or biological event that can be harmful to development (Houndénou, 1999). Risk can be climatic drought, cyclones, wind blasts, excesses or deficits of temperature, and crop attacks by insect pests. Climate risk can be defined as the probability of having insufficient rains that cause partial loss of the harvest (Eldin, 1989). Thus, risk implies a notion of heavy consequences. In agriculture, Broussard (1979) defines risk as the variance of producers' revenues due to the vagaries of weather. As part of this study, we consider as climate risk, the frequency of drought occurrence, wind blasts, and excess water (floods), because these are the major factors that could affect in the current conditions the development of plants.

Vulnerability: In the context of climate change, vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity as defined by, (IPCC 2007). Vulnerability is almost exclusively related to climate change (Arouna *et al.*, 2012). It is the degree according to which a system is susceptible, or becomes incapable of tolerating the adverse effects of climate change, notably climate variability and extreme climatic conditions. But Kasperson *et al*. (2001) define vulnerability as the degree to which a unit of risk undergoes damage after having been exposed to a perturbation or a constraint and the capacity of that unit to withstand it in order to recover or disappear. It can be schematized by the following functional relation: Vulnerability = Risk (danger x exposure) +/- Adaptation (Responses/ Options) (Dimon, 2008).

Similarly considered by (Zongo, 2014) innovations are as considered adaptation strategies developed and implemented for international institutions, regional organizations, national governments, and local stakeholders (producers; NGOs) to reduce vulnerability to climate change in order to increase agricultural production

Vulnerability to climate change Vulnerability of the agricultural sector to climate change is translated by a decrease in yields with the following consequences: food insecurity or famine, poverty intensification, increase in the price of agricultural products, and low contribution to the rest of the economy (IPCC, 2014). In such a context, it is commonly accepted that innovation is crucial in addressing the challenge of climate change adaptation in order to insure food security and increase farmers' revenues (Rivera *et al.,* 2005; OCDE-CRDI, 2010; Zongo, 2014). The adverse effects of vulnerability to climate change on agricultural production stimulate not only organizational and technological innovations, but also institutional developments in agriculture (Chhetri *et al.,* 2012; and Zongo 2014). The term "food security" has attracted attention worldwide after the world food conference in 1974.

Adaptation to climate change

According to Isa (1995), adaptation is defined as the whole adjustment made or self-made within natural and human systems as a curative or preventive response to current or future climate stimuli or to their effects in order to reduce harm or take advantage of it at the right time. As Ramsey *et al*. (2008) adaptation is an adjustment in ecological social and economic systems in response to real or expected climate stimuli and to their effects or impacts. Accordingly, these are changes in processes, practices, and structures to reduce potential damage or to take advantage of opportunities associated with climate change defined it as a change of procedures, practices and structures that aims at limiting or eliminating the potential damages or to take advantage of the opportunities created by variability and climate change.

2.1. Theoretical Review of the Study

Impacts of climate change and variability on Agriculture

According to IPCC (2014), Climate change undermines crop production; resulting to large risks on food insecurity globally. Africa is one of the most vulnerable regions to climate change in the world. Previous assessments by Mary and Majule (2009) concluded that Africa is particularly, temperature and rainfall changes and extreme events adversely impacts crop production and impose a major constraint on farming vulnerable to the impacts of climate change due to the factors such as widespread poverty, repeated droughts, and inequitable land distribution and over dependence on rain fed agriculture. As (Howden and White (2009), climate change and climate variability compel limitations to crop growth and it also affects the choice of crop species and cultivars including farm management decisions.

Climate Variability and Crop Production

In its report of IPCC (2007), worldwide climatic changes have been raising concerns about potential changes to crop yields and crop production system. This statement is well supported by studies conducted to assess the impact of climate change on agriculture and the increasing atmospheric concentrations of greenhouse gases could lead to regional and global changes in temperature and precipitation. In additional assessments of IPCC (2007), these changes are projected to have impacts on crop production system. According to Schreck and Semazzi (2003), global warming has increased the intensity of heat and reduced the reliability of rainfall in East of Africa thus, causing droughts and floods which have been reported to cause failure and damage to crop production. Similarly, a study conducted by Rosenzweig (2002) revealed that, changes in rainfall patterns and amounts have led to loss of crops in many parts of Africa. Generally, rainfall and temperature changes are likely to reduce yields of desirable crops. Changes in rainfall patterns may increase the likelihood of crop failures in the short run and decline in production in the long run. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on crop production are expected to be negative (Rosenzweig *et al.,* 2002). Increase in average temperature can lengthen growing season in regions with relatively cool spring and fall; adversely affecting crops in regions where summer heat already limits production (Burke, 2009). In addition, temperature increases lead to higher respiration rates, shorter periods of seed formation and, consequently, lower biomass production (Battisti and Naylor, 2009). Furthermore, higher temperatures result in a shorter grain filling period, smaller and lighter grains and, therefore, lower crop yields and perhaps lower grain quality (Waggoner, 1983). An increase in temperature of below 1ºC may affect transpiration rate up 30% for some plants (Kimball, 1983). Also temperature increases may cause changes in runoff and groundwater recharge rates, which affect water supplies and changes in capital or technological requirements such as surface water storage and irrigation methods (Oki *et al.*, 2006).

According to(Olsen and Bindi, 2002), climate changes will more likely lead to a major spatial shift and extension of croplands as it will create a favorable or restricted environment for crop growth across different regions and as climate is a primary determinant of agricultural productivity, any significant changes in climate presently and in the future will influence crop productivity.

Climate Change and Variability & Coffee Production

In studies of Haggar & Schepp (2012), Coffee productivity and quality is highly dependent on temperature and rainfall conditions and is relatively sensitive to drought, excessive moisture, and wind damage. Similar studies under taken by Tucker et al. (2010) shows, the blossoming and fructification of Arabica coffee, in particular, requires a specific series of dry and rainy seasonal alternation. Haggar & Schepp, (2012) and ICC, (2015), steps in coffee production and potential impacts are from the sever effects of climate change and variability. As ICC,(2015), accordingly, although future variations in climate across regions remains uncertain, rising temperatures and unpredictable rainfall patterns are expected to have negative consequences on coffee production in terms of quality, yield, and pests and diseases. Study undertaken by Camargo (2009), Climate change and variability is threatening coffee production in every major coffee producing region of the world. Higher temperatures, long droughts punctuated by intense rainfall, more resilient pests and plant diseases all of which associated with climate change and in most cases have reduced coffee production. Temperature and rainfall conditions are considered to be important factors in determining growing of coffee. Studies conducted by Marengo and Antonio (2009) states that mean temperatures above 23°C hinder the development of coffee and a continuous exposure to daily temperatures as high as 30°C could result in reduced production. Nevertheless, scientific research and participatory assessments illustrated, many of the current coffee growing regions are already suffering from climate changing and variability conditions and are very likely to be affected in the near and long term future. According to (TACRI, 2009), quality problem could arise, from the faster plant growth that will lead to lower coffee fruit quality. Besides, high maximum temperatures during summer months may cause an excessive fruit ripening, against fruit quality. Coffee trees are well resistant to high temperature and drought, but the increase of extreme conditions can escort to physiological stresses, such as the reduction of photosynthetic efficiency. As Muya (2008), the known critical stage that may be affected are flowering and maturing in relation with the expectation of bud potential break. Moreover, high temperature and dry conditions during the reproductive phase can be critical for the optimum coffee production and quality. The setting of adequate air temperature limits for coffee is decisive for the distribution and economic exploitation of the crop. As temperatures rise over the highland areas, coffee yields will be adversely affected. As Baker and Hager (2007),temperature increases will favor certain pests and diseases, e.g. the coffee berry borer, which currently has little impact over 1500 to 1600m above sea level in many countries Some diseases and pests that are currently of little importance may achieve greater prominence, especially perhaps in countries that will become wetter. (Morales, 2010) study shows, the greater soil erosion is likely to occur due to increased severity of rainstorms, whereas soils will dry out faster as temperatures increase.

Climate Change Adaptation Strategies

According to ICC, (2015 & US EPA), climate change effects are both complex and highly uncertain. So, adaptation strategies are to be efforts by society or ecosystems to prepare for adjusting future climate change either by proactive to minimize negative impacts of climate change or opportunistic to inspire and initiate new development practices. Although (Salik , Byg, 2007 & US EPA,) studies shows that people have faced and adapted to climatic changes, since its species evolved the climate change predicted for the century is far greater and faster than anything previously known in human history and prehistory. Deressa & Hassan (2009), due to the increasingly interdependent world, negative effects of climate change can have repercussions in every social sector and ecosystem. In order to implement the appropriate intervention to adapt to the impacts of climate change, governments and agencies need to understand the main factors of smallholders' choices of strategy and major barriers of selected adaptation strategy Ringler, Alemu, & Yusuf (2009). Smallholder producers could either change their agricultural practice by altering planting dates or other methods to increase their crops' resiliency, or explore other income streams to increase their livelihood resiliency to climate change Komba & Muchapondwa (2015) & Lin (2011). For this project, in order for smallholder producers to adapt to uncertain future climate change impacts, it is important to ensure that all aspects of their livelihood strategies are resilient to changing and unpredictable conditions via adaptation strategies. As Solomon et al.(2007)Illustrated it is important to note that adaptation alone may have limitations in the face of climate change, and further mitigation strategies may be necessary to fight with climate change effects. Ongoing efforts are required from governments and communities to sufficiently not only adapt to all the projected impacts of climate change, but also to mitigate its causal factors (e.g., greenhouse gas emissions)

Agricultural adaptation to climate change and variability

This is surprising given the sheer number of papers exploring the impact of climate change on agriculture. This is draws heavily on Kolstad et al. (1999), who concern themselves with the transitory cost of adapting to climate change. According to their paper, a farmer may perceive several hot summers but rationally attribute them to random variation in a stationary climate. The authors distinguish between the cost of adaptation once all desired adjustments have been made and expectations no longer lag behind reality, and the transitional cost arising from misperceptions. The difference between the cost of adaptation and the transitional cost is best explained as follows. The cost of adaptation is the difference between the maximum value of net revenues per acre evaluated in the current and in the perfectly perceived future climate. The transitional cost is the difference between the maximum value of net revenues per acre following perfect adaptation and the net revenues actually experienced by farmers given that their expectations of (and therefore response to) how the climate will change lag behind what it actually does. If farmers could at each instant correctly predict the climate then there would be no transitional cost.

The main issue addressed by Kolstad et al., (1997) therefore, is the manner in which agriculturalists update their expectations of the climate in response to unusual weather patterns. One possibility is that farmers engage in simple Bayesian updating of their prior beliefs according to the standard formula. Kolstad et al. argue that this process of updating is likely to be slow and that one should not expect decades of information to be thrown out overnight. However, Kolstad et al. cite some evidence suggests that farmers do not update their priors in this way. In particular, it appears that some farmers place more weight on recent information than is efficient in description paper of Smith, et al. (1997).

2.2. Empirical Literature Review of the Study

Climate change impacts on Agriculture; Coffee production and Food security

One of the most widespread anthropogenic challenges affecting agricultural production is climate change and climate variability as stated by Torquebiau (2016). While climate change affects agricultural production, the latter in turn contributes to the global climate change phenomenon by emitting greenhouse gases (GHG) through e.g. deforestation, decomposition of organic residues and fertilizer use. Consequently agriculture, forestry and land use changes account for around 25% of global emissions in report of IPCC (2014).There is, therefore, an increasing need for approaches in agriculture that not only help farmers adapt to a changing climate but also minimize the contribution of farming to global warming.

Furthermore UTZ (2015) describes, making efficient use of resources using less energy from non-renewable sources and reducing waste and pollution reduces farmers' contribution to climate change. Thus, the agriculture sector is highly sensitive to climate change. In Africa for instance, studies have shown that climate change embodies a significant threat to current production systems, infrastructures, and markets, and therefore farmers' livelihoods in accordance of Smith et al, (2007).Furthermore, in semi-arid Africa where many people subsist on rain-fed agriculture with limited access to safety nets, climate change can exacerbate food shortage and low income conditions of the already visibly poor in society. The study conducted in Ghana, shows that climate change effects (e.g. rainfall variability) have led to decrease in volume of annual production staple crops, (Haile et al, (2005).

According to Haggar & Schepp (2012), Coffee productivity and quality is highly dependent on temperature and rainfall conditions is relatively sensitive to drought, excessive moisture, and wind damage blossoming and fructification of Arabica coffee, in particular, requires a specific series of dry and rainy seasonal alternation. The Initiative for Coffee & Climate (2015) argued that the steps in coffee production and potential impacts from climate change are included in coffee cultivated in more than 80 countries in Central and South America, Africa and Asia, ranks among the world's most valuable agricultural commodities. Coffee cultivation provides livelihoods for 20-25 million farming families.

Studies by Deressa et al. (2006) shows, coffee production engages over 100 million people in its producing, processing and smallholder coffee farmers together with their families and rural workers produce over 70 per cent of this labor intensive crop. Women comprise half the productive workforce and play a crucial role that often goes unnoticed. However, to retain the involvement of rural youth is a challenge as they often aspire to a different future and seek employment outside the coffee sector. Erratic temperature and rainfall can affect coffee plants directly, by bringing about sub-optimal growing conditions, and indirectly, by providing favorable conditions for pests and diseases such as coffee rust and the berry borer Davis, Baena

& Moat et al (2012), stated in their study that; 'these changes affect yields and quality, and increase production costs leading to drastic reductions of producer income'. Due to the interconnected nature of livelihoods climate change impacts, it aggravates existing problems in food security, water supplies and agricultural production. Especially vulnerable are poor households with small coffee landholdings, who generally depend on this crop and have few other sources of income.

As analyzed in their study Funk et al. (2014) for many smallholder coffee farmers, climate change impacts are already outpacing their ability to cope.

In many tropical and subtropical regions climate change threatens to become an environmental disaster for farmers due to decreased water availability, new or different pest and disease attacks and more frequent extreme weather events. Crop yields are at risk, in terms of quality and quantity and hence farmer income. Robusta as well as Arabica coffee are especially vulnerable to such climatic hazards as they depend on a very narrow climatic range. Scientific projections warn that climate change can reduce the area climatically suitable for coffee production by up to 50% especially in lower altitudes if no action is taken. Bunn et al (2014), approved in their study, that Hunger and food insecurity constitute a complex global development dilemma, as it is estimated that 842 million people suffer from chronic hunger worldwide FAO (2013). While it is widely believed that hunger is a result of a globally insufficient food supply, the problem is actually a product of poverty and inequality. As studies have noted, the world produces ample food to feed everyone a sufficient diet Caswell & Kremen et al. (2012).

The existing empirical studies that examine hunger and food security specifically among coffee-growers are heavily concentrated in Latin America, although it is undoubtedly an urgent and perhaps more worrisome issue among growers in Africa and Asia where poverty tends to be more extreme and social safety nets are less available. For example, Sub-Saharan Africa suffers the highest rates of hunger in the world with roughly one quarter of the population being malnourished in statistical report of FAO (2013).

Studies from Central America have revealed that a significant percentage of farmers experience food insecurity at some point during the harvest production cycle each year. For example, a 6-year study that surveyed 177 smallholders in Nicaragua found that 69% of them were unable to meet their nutritional needs throughout the year Bacon (2008). Similarly, a study that surveyed 469 households in Mexico, Nicaragua, El Salvador, and Guatemala found that 63% of coffee households suffered food insecurity during the year Mendez (2010).

As it seems that growing cash crops like coffee is often likely to improve food and nutrition security, owing to higher incomes earned and the complementary that can apply between growing industrial and food crops. The few studies that directly observe outcomes confirm this, while those that report reduced poverty and inequality support it. In its approved that food security is dependent on three core elements: adequate food availability, adequate access to food by all people, and appropriate food utilization FAO (2009). Given the multi-dimensional and complex nature of food security, it is not possible to easily measure these different components at once and the proper measurement of food security in different dimensions has therefore been the subject of a large literature Coates (2013) and Macours (2014). In their study, they focused on the food access element. To do so, through measure food (in) security using the Household Food Insecurity, access Scale (HFIAS) and in previous study as developed by Coates, Swindale, & Bilinsky, (2007). Survey undertaken by Coates et al (2010) also shows, using nine different questions to explore households' perceptions on food security and their individual coping mechanisms, HFIAS was found to provide a reliable measure of food security in different countries and including Ethiopia.

As similar survey conducted by Gebreeyesus et al. (2015) details the farmers experienced a food security issue in the previous 12 months, such as a concern that their household would not have enough food. Ascertained computation of HFIAS, a household received zero points if it reported that the event did not happen during the last 12 months, one if it rarely occurred (1 or 2 times), two if it sometimes (3–10 times) occurred, and three if it occurred often (more than 10 times). The sum of these frequency scores for the nine questions then yields a food insecurity score ranging between 0 and 27 Gebreeyesus et al. (2015). As illustrated above that how the food insecurity score is distributed within the study sample. Nearly 40 per cent of the households reported being fully food secure, since they reported zero incidences of these nine food insecurity measures in the previous 12 months. The remaining 60 per cent of the sample reported some food insecurity of varying degree. To facilitate the interpretation of food security/insecurity, during the survey was collected detailed information about households' income from food and cash crops, including coffee, as well as non-crop income. The non-crop income includes rental income, wage income and income from non-farm enterprises and remittances. The study focus on contrasting coffee income with income from food crops or livestock related activities. Despite dramatic improvements in global crop yields over the past half-century, chronic food insecurity, hunger, and undernourishment persist in many parts of world. Nearly 800 million people do not have enough to eat and, alarmingly, in Africa, despite recent economic growth, this number is on the rise as report of FAO, IFAD, and WFP (2015). This issue will remain one of the key development challenges for national governments and their development partners for some time to come. As study conducted Crawford (1988), one of the central ongoing topics in food policy debates, has been the role of growing cash crops for achieving food security in low income countries. There are a number of channels through which cash crop production could contribute to food security. First, specialization in a commodity which provides a higher return allows farm households to buy food as well as non-food consumption goods, and thereby achieve a higher level of welfare, including food security. Timmer (1988) Second, the benefits arising from cash cropping also accrue to non-cash crop producers through increases in labour opportunities, since their production is often labour intensive Poulton, Al-Hassan, Cadisch, Reddy, & Smith, (2001). In third analytical report of Govereh & Jayne (2003) shows, cash income relaxes liquidity constraints thus facilitating the purchase of improved inputs. This cash income ultimately offers opportunities for farmers to invest and improve the management of their farms, thus stimulating agricultural innovation and increasing yields.

According to Reardon, Delgado, and Matlon (1992), producing cash crops is also more susceptible to risks related to production, markets, and prices than is the case for food crops. Hence, rather than fully specializing in Correspondence Address: Kale Hirvonen, the production of a single commodity, farm households often prefer to diversify their production portfolio and therefore smooth their consumption over time Fafchamps (1992). The empirical evidence on this topic remains inconclusive. For instance, Pierre-Louis, Sanjur, Nesheim, Bowman, and Mohammed (2007) show positive correlations between the production of peanuts in Mali and food security and dietary diversity. Von Braun (1995) and Kennedy and Peters (1992) also document a positive contribution of cardamom production in Papua New Guinea, rice in the Gambia, maize in Zambia, and potatoes in Rwanda.

Negash and Swinnen (2013) found positive correlations of food caloric intake with the participation of the household in the production of castor beans used for bio fuel in Ethiopia. On the other hand, negative correlations were found with cash crop production of cassava in Ecuador (Leonard, Dewalt, Uquillas, & Dewalt, 1994), cacao and sugarcane production in Mexico Dewey (1981), and cold-weather vegetable production in Guatemala Immink & Alarcon (1993). Dewalt (1993) and Kennedy and Bouis (1993) also highlighted mostly mixed evidence in revisiting the question in the context of coffee production in Ethiopia. Coffee is one of the most important cash crops produced and marketed, not only in Ethiopia, but also in more than 50 developing countries. Small-scale farmers are estimated to contribute 70 per cent of the world's coffee supply Eakins, Winkles, & Sendzimir (2009).

Even though the central role of coffee in the Ethiopian economy (it is Ethiopia's biggest export crop and it is grown by over four million smallholders) and high levels of food insecurity in the country, there is a lack of knowledge about how coffee production shapes the food security of smallholder coffee farming households. We contribute to this knowledge gap using data collected by the authors on about 1600 coffee farming households in Ethiopia. Apart from the usual household characteristics, the survey instrument contained detailed questions about household food security and coffee production .Although coffee is mainly harvested at the same time as main food crops, it is sold throughout the year, which consequently provides coffee farming households cash income during the lean season when food stocks in coffee growing areas are generally low.

Adaptation to climate change and farmers perception

The recognition that climate change related threats to agriculture also represent threats to quality of life on a global scale has led to an increasing amount of attention to adaptation and mitigation strategies for agriculture. As approved in their studies Howden (2007) & McCarl (2010), adaptations are adjustments or interventions, which take place in order to manage the losses or take advantage of the opportunities presented by changing climate. Adaptation practices are pre-nature and are meant to lessen adverse effects and take advantage of potential benefits of an envisaged change in climatic variables. Several studies have conducted by Ndamani et al. & Okonya et al. (2013) shows that various adaptation practices in agriculture notwithstanding the significant efforts that have been made in the development and dissemination of climate change adaptation options, these measures have not been utilized adequately and not integrated effectively into the agricultural development.

The results obtained from the study of Pilo et al. (2013) illustrated, “Impact of adaptation strategies on farm households’ farm income: a bio economic analysis” following the modeling of the increase in the intensity of all the strategies used in the study zone, except the decrease in fertilizer use, has a positive effect on farm revenue. Moreover, the studies on the impact of climate change adaptation strategies are new. It is a new field of the study. Analysis of the work shows that the different stakeholders try to conceptualize the phenomenon differently. Two categories of models are used: the econometric models and the bio-economic models. The bio-economic model is a complex model that needs several types of different data under several formats. However, the econometric model is more flexible to use and requires less data. Moreover, irrigation can more than just compensate for the negative impacts of climate change. It has a positive effect on farm households. Irrigation helps to face the adverse effects of climate change while increasing agricultural yield. On the contrary, the decrease in fertilizer use seems to increase the vulnerability of farm households.

Deportee et al. (2015) they showed in their studies, the impact of climate change on adaptation strategies in Bangladesh through using a regression function, some adaptation strategies to climate change cannot be used by the poorest; change of type of crop and change of culture. The revenue decreases because climate adaptation strategies are expensive. The well-to-do households invest much in irrigation. The results also show that educated producers invest more in changing varieties as an adaptation measure. Adaptation is easier for large households that, access to the number of years of experience in agriculture favor adaptation to climate change through crop varieties. The results also show that a decrease of 1 percent in agricultural revenue due to climate change pushes 3 percent of the households to adopt a strategy. However, certain strategies are too expensive and cannot be used in bad moments. Adoption of agricultural technologies in agriculture is also considered to be synonymous with the adaptation strategies that farmers undertake in fight against the adverse effects of climate change in study by Nhemachena and Hassan (2007) and as a result, the adoption literature can be applied in studies regarding climate change adaptation.

Empirical literature is also wide on farmer characteristics that affect the adoption of agricultural technologies. For instance, studies on agricultural technology adoption by Gbetibouo (2009) and Adesina and For son (1995) observe that there is no consensus in the literature as to the exact effect of age in the adoption of farming technologies because the age effect is generally location or technology specific and hence , an empirical question. On one hand, age may have a negative effect on the decision to adopt new farming technologies simply because older farmers may be more risk-averse and therefore, less likely to be flexible than younger farmers. On the other hand, age may have a positive effect on the decision of the farmer to adopt because older farmers may have more experience in farming and therefore, better able to assess the features of a new farming technology than the younger farmers. In relation to gender, Asfaw and Admassie study (2004) note that households headed by males have a higher probability of getting information about new farming technologies and also undertake more risky ventures than female headed households. A similar observation is made by Tenge and Hella (2004) who point out that female headed households are less likely to adopt soil and water conservation measures since women may have restricted access to information, land, and other resources due to traditional social barriers. Nonetheless, Nhemachena and Hassan (2007) have contrary results to the effect that female headed households are more likely to adopt different methods of climate change adaptation than male headed households. With regard to education, Norris and Batie (1987) argue that farmers with more education are more likely to have enhanced access to technological information than poorly educated farmers.

Furthermore, Igoden et al. (1990) and Lin (1991) observed a positive relationship between the education level of the household head and the adoption level of improved technologies and climate change adaptation. As such, farmers with higher levels of education are more likely to perceive climate change and adapt better. Related studies by Madison (2006) and Nhemachena and Hassan (2007) indicate that farming experience, just like farmers education level, increases the probability of uptake of adaptation measures to climate change. As for the household size, Croppenstedt *et al.* (2003) argue that larger households have a larger pool of labor and as a result, they are more likely to adopt agricultural technologies than smaller households. Moreover, Yirga (2007) notes that the size of the household influences individuals' adaptation to climate change in two perspectives. In the first perspective, households with large families may be forced to divert part of the labor force from farm to off-farm activities in an attempt to earn some income that can ease the consumption pressure imposed by a large family in the face of climate change. In the second perspective, households with a large family size are considered to have a larger pool of cheap labor resource, which can readily be employed on the farm for crop and/or livestock production, unlike families with smaller household size. Therefore, households with large families are more likely to adapt to climate change than households with small families. Access to climate change information and other extension services by farmers is another essential factor, which may influence the adoption of farming technologies. In their respective studies, Madison (2006) and Nhemachena and Hassan (2007) observed that the awareness by farmers of climate change attributes - whether precipitation or temperature or both, is of essence in as far as their adaptation decision-making process is concerned. In this study, it was therefore expected farmers with access to climate change information were more likely to observe changes in climate and were therefore more likely to adapt than those without access to climate change information. Income of the farmers, whether farm or nonfarm, represents the wealth of individual households. Empirical evidence by Franzel (1999) and Knowler and Bradshaw (2007) indicate that farmers' income has a positive relationship with the uptake of farming technologies since any adoption/adaptation process requires that the farmer has sufficient financial wellbeing.

As for the role of credit in the uptake of farming technologies Yirga (2007), Pattanayak et al. (2003) and Caviglia-Harris (2002) pragmatic that a positive relationship exists between the level of adoption and the availability of credit since credit eases the cash constraints and allows farmers to buy inputs such as fertilizer, improved crop varieties and irrigation facilities. As well, this study also hypothesized that there would be a positive relationship between availability of credit and adaptation to climate change.

Another factor that influences the adoption of agricultural technologies is farmers' accessibility to the market places. A study by Madison (2006) notes that long distances to market centre's decrease the likelihood of farm adaptation and that market places provide important avenues for farmers to congregate and share information. In addition, Nyangena (2007) shows that in Kenya, distance to market places has a negative and significant effect on the adoption and use of soil and water conservation technologies. With respect to agro-ecological zones in which households dwell or practice their farming, Nhemachena and Hassan (2007) and Madison (2006) agree that different agro-ecological zones impact differently on different households such that different households differ in the uptake of adaptation methods. The primary reason for the differences is that environmental factors, climatic conditions, and soil composition vary across different agro-ecologies, which may affect the way different farmers perceive climate change and their respective decisions to adapt. It was therefore hypothesized in the study that farmers would perceive and/or adapt to climate change depending on the agro-ecological zones in which they dwell or carry out their farming. Adaptive capacity of individuals, households and communities is shaped by their access to and control over natural, human, social, physical and financial resources Care (2010).

Although, study by Salik, Byg 2007 and US, EPA (2014) undertaken, people have faced and adapted to climatic changes since the species evolved, the climate change predicted for this century is far greater and faster than anything previously known in human history and prehistory. Due to the increasingly interdependent world, negative effects of climate change can have repercussions in every social sector and ecosystem.

According to Deressa, Hassan, Ringler, Alemu, & Yusuf (2009) studies, in order to implement the appropriate intervention to adapt to the impacts of climate change, governments and agencies need to understand the main factors of smallholders' choices of strategy and major barriers of selected adaptation strategy. Similar studies conducted by Komba & Muchapondwa (2015) and Lin (2011) shows that smallholder producers could either change their agricultural practice by altering planting dates or other methods to increase their crops' resiliency, or explore other income streams to increase their livelihood resiliency to climate change. For this project, in order for smallholder producers to adapt to uncertain future climate change impacts, it is important to ensure that all aspects of their livelihood strategies are resilient to changing and unpredictable conditions via adaptation strategies. Nevertheless, it is important to note that adaptation alone may have limitations in the face of climate change, and further mitigation strategies may be necessary to fight with climate change effects.

Finley-Lezcano, King and Wang (2016), Masters Project illustrated, adapt to all the projected impacts of climate change, but also to mitigate its causal factors (example greenhouse gas emissions) in prospective studies of Solomon et al. (2007) shows. Income diversification is the adoption of alternative income-generating activities, generally with the goal of reducing risks to shocks in markets Delgado & Siamwalla (1997). When a farmer's income is diversified, they are more resilient to various shocks in or changes to markets, and can better adapt accordingly. Smallholders and rural populations worldwide diversify their income by seeking paid work in their community or migrating, by incorporating value-added products into their portfolios, by growing a variety of crops, among other options; however, research on diversification is still lacking in determining conditions under which it is most successful and the impact it has on livelihoods (Läderach, 2012). In accordance with Thomas (2008), it is important to account for scale in any diversification project, particularly ongoing efforts are required from governments and communities to sufficiently considering the varying impacts climate change can have at different levels.

According to Stree (1999), and Temesgen et al. (2011), many times strategies are local and customized; however, these tend to be reactive, while institutional approaches can be anticipatory, which may be necessary for something as serious as climate change.

Studies by Osbahr et al. (2008), have argued that poverty reduction and income diversification strategies should be geared towards smallholders in particular, and attempt to foster improved access to markets and financial tools, as the size of one's landholding is the main constraint in crop diversification Research has shown that rural populations including farmers depending on a single source of income earn a lower, more inconsistent income than those with a higher degree of diversification as based on various studies of Bigsten & Tengstam (2011); Delgado & Siamwalla (1997); Israr, Khan, Jan, & Ahmad (2014). The degree to which farmers diversify is directly related to their assets and resources, including land and human capital, and access to markets and financial resources.

Moreover, studies have shown that farmers experienced improved food security and increased income when following conservation agriculture practices, which mandate a variety of crops grown in succession or groups in described study of Friedrich & Kienzle, n.d.; Jat, Reosa,(2010 & Kassam, (2013;). However, in study of Speranza (2013) described, so many still diversify their income through outside business or salaried work, which is particularly effective in terms of livelihood resiliency Cooperatives have also been shown to provide significant assistance in helping members maximize income streams by supporting diversification amongst smallholder farmers. During Brazil's financial crisis in the 1980s, coffee cooperatives pushed product diversification strategies as Martins & Lucato (2014) studies approval, and in similar context of Osbahr et al. (2008) explanation, smallholders can also have difficulty producing enough volume to enter market and be competitive higher up in the value chain, as has been shown in Mozambique, which is where cooperatives can sometimes play a role to help pool volume of a secondary crop for market Globally, many studies have been used to understand farmers' perceptions about climate change and its associated effects on agriculture.

Although perceptions are not necessarily consistent with reality, they must be considered to address socioeconomic challenges McCarthy et al. (2012); Prokopy et al. (2008), and previous studies had shown that the way in which people experience climate shocks varies across different social groups, geographic locations, and seasons of the year, with men, women, and children all experiencing different levels of hardship and opportunity in the face of climate change.

According to McCown et al. (2005) discussions on agriculture, climate change and adaptation processes need to be informed by empirical data from farmers and adaptation practices in agriculture are generally location-specific in the studies. In similar study of Jon Hobbs et al. (2013) hence, it is crucial to understand farmers' perceptions about the risks they face. In basing report of Pinning J.et al. (2000) & FAO, 2010), to ensure farmers' readiness for 17 extreme weather events and collaboratively learn about the evolution of weather patterns, efforts to focus on farmers and their current activities, knowledge, and perceptions are essential Farmers' willingness to accept and use prescribed measures could be enhanced if their perceptions and understanding are considered in designing such measures. By contrast, as studies by BiYe.et al. (2012; & 2015) approved, current models used in predictions of climate change and adaptation practices are at a global scale and need to be downscaled to accommodate realities at the community level Crawford-Brown (1999).

According to Baumgartner-Getz, A.et al. (2008),studies in Ghana have shown that though majority of farmers are aware of climate change, a significant number of them still do not use adaptation practices. This is largely due to the fact that the proposed adaptation processes have failed to adequately 37 addressed farmers' awareness, perceptions and concerns of climate-risks. Previous studies on agricultural conservation practice adoption have reported positive correlation between awareness of environmental problems, attitudes toward potential solutions, and willingness to adopt those solutions. Furthermore, it is when situations come to be perceived as problems that attitudes regarding potential ameliorative actions are more predictive of behavior change Ankeny, (2005).Farmer concerns about the impacts of climate change are keys to successful adaptation and mitigation Tubiello et al. (2007).

According to Morton et al. (2013), farmers' willingness to implement adaptation and mitigation policies supported by public authorities and governments also depend upon their beliefs regarding climate change and their perceptions of climate change related risks. Study by, Leuthold et al. (2000) has also shown that appropriate risk perception can be seen as a prerequisite for choosing an effective risk-coping strategy, because a farmer that is not aware of the risks faced is clearly unable to manage them effectively. Knowledge on the factors that influence farmers' perceptions of climate change related risks is critical in developing and promoting appropriate adaptation practices in agriculture thereby boosting the tempo of adaptation among farmers. As Borges et al (2012) of previous research studies focusing on, factors determining differences in the level of risk perception have shown that farmers' perceptions are largely determined by socio-economic features of the farmers and the characteristics of their farms.

Their studies, Sulewski et al.(2014), concise the previous findings have also suggested that since farmers from various countries live within different climatic and institutional conditions, differences in risk perception can be a result of either different probabilities of certain risk factors, or different farmers' mentality and awareness, or a mixture of both. As Greiner et al.(2008) describes other climate risk perception predictors identified in previous studies include drought Yield risk and price risk for agricultural products MPM et al.2008), and weather and natural disasters Palinkas et al. (2008).

Farmers' behavioral change towards adaptation and willingness to take action are as important as are policy decisions based on the study of (Gebreyesus). The study approved by Lobell et al., (2008) and Yegbemey et al. (2014) shows, need for adaptation to ensure food security, particularly in Africa, is highly justified and supported at the political and policy levels Similar study by Souza et al.(2015), these policy level adaptation needs are insufficiently supported by local level farmers' choices. The difficulty in understanding farmers' choices of adaptation holds back the development of concrete measures. That is why the success of various policy proposals has been limited, reflecting a difficulty in linking policy studies to real local farmers' contexts, needs and capacities (García de Jalón et al., 2013). According to; Merot et al., 2014), studies concerning farmers' adaptation choices and determinants of choices are insufficient, unlike analysis of public perception.

As approved in similar studies of García de Jalón et al., (2013), Two points are noted in this regard: there are many micro studies on attitudes of African farmers faced with climate change as sited Fosu-Mensah et al. and Silvestre et al. (2012), large surveys have also addressed farmers' perceptions towards climate Nhemachena and Hassan (2008), and ethnography has outlined how limiting factors relate to adaptation choices at a conceptual level as analyzed by Souza et al. (2015), where representation of local context is one of the limitations. The study conducted by, Francis Ndamani, (2016) bridges the massive surveys and the ethnographic approaches, examining the relations between perception and adaptation, in order to explore the reasons behind the farmers' choices. Even in a local context, perception and adaptation to climate change vary across production systems due to differences in opportunities and determinants. In rain fed crops production, adaptation for instance comprises practices such as adopting drought resistant varieties Teucher et al. (2016), as study by US EPA (2015) shows the efforts by society or ecosystems to prepare for or adjust to future climate change" These can be either proactive to minimize negative impacts of climate change or opportunistic to inspire and initiate new development practices and The Initiative for Coffee & Climate (2015).

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Fosu-Mensah et al. (2012) & Silvestre et al. (2012), large surveys have also addressed farmers' perceptions towards climate change.

According to the study of Madison (2007), Nhemachena and Hassan (2008), ethnography has outlined how limiting factors relate to adaptation choices at a conceptual level based on Souza et al. (2015), where representation of local context is one of the limitations. Even in a local context, perception and adaptation to climate change vary across production systems due to differences in opportunities and determinants. In rain fed crops production, adaptation for instance comprises practices such as adopting drought resistant varieties as study under taken by Tauscher et al. (2016), or intercropping of different crops Lobell et al. (2008), while changing breeds, and alternative feeding strategies Seo(2010) are common in the livestock sector, economic and climate pressures are already major issues and all climate scenarios project further temperature increase Silvestre et al., (2012);and policy actors are starting to look for micro studies on farmers' action in);environmental dynamics and climate change were the factors for the steady decline of production Davis et al., (2012). In report of World Bank (2016), the area of climate change adaptation farmers may be unable to adopt their most preferred strategies due to different determinants affecting their adaptive capacity, including inadequate climate information Deressa et al. (2009), partial understanding of climate impacts and low level of awareness about benefits of adaptation Iglesias et al.(2011),which perception and concern towards future change Madison (2007), disconnection between climate science and policy, insufficient institutional infrastructure, such as access to credit and extension services as approved by similar studies conducted by Bryan et al. (2009) and Yegbemey et al. (2014).

2.3. Conceptual Frame Work

The conceptual frame work is clearly showing a set of relationship among independent and dependent variables. From this perspective, the determines and significance level of these explanatory variables differ across adaptation strategies, that determines of perception and adaptation strategies of independent variables(demographic features) tend to cause effect on adaptation strategies transversely to stress to coffee crop production (dependent variable) depends on adaptation strategies. Such stresses trigger adaptation strategies which may help a coffee community to adjust to the impacts. Supportive study by Gbetibouo et.al (2009) shows, age may have a negative effect on the decision to adopt new farming technologies simply because older farmers may be more risk-averse and therefore, less likely to be flexible than younger farmers. On the other hand, age may have a positive effect on the decision of the farmer to adopt adaptation strategies, because older farmers may have more experience in farming and therefore, better able to assess the features of a new farming technology than the younger farmers. In relation to gender, Asfaw and Admassie study (2004) note that households headed by males have a higher probability of getting information about new farming technologies and also undertake more risky ventures than female headed households. The area of climate change adaptation farmers may be unable to adopt their most preferred strategies due to different determinants affecting their adaptive capacity, including inadequate climate information disconnection between climate science and policy, insufficient institutional infrastructure, such as access to credit and extension services as approved studies conducted by Deressa (2009) and Yegbemey et al. (2014). With regard to education, Norris and Batie (1987) argue that farmers with more education level are more likely to have enhanced access to technological information than poorly educated farmers.

Commonly the framework shows the forward and backward linkages of variables between determines of perception and adaptation strategies in perspective of demography, institutions and perception strategies that determines adaptation strategies.

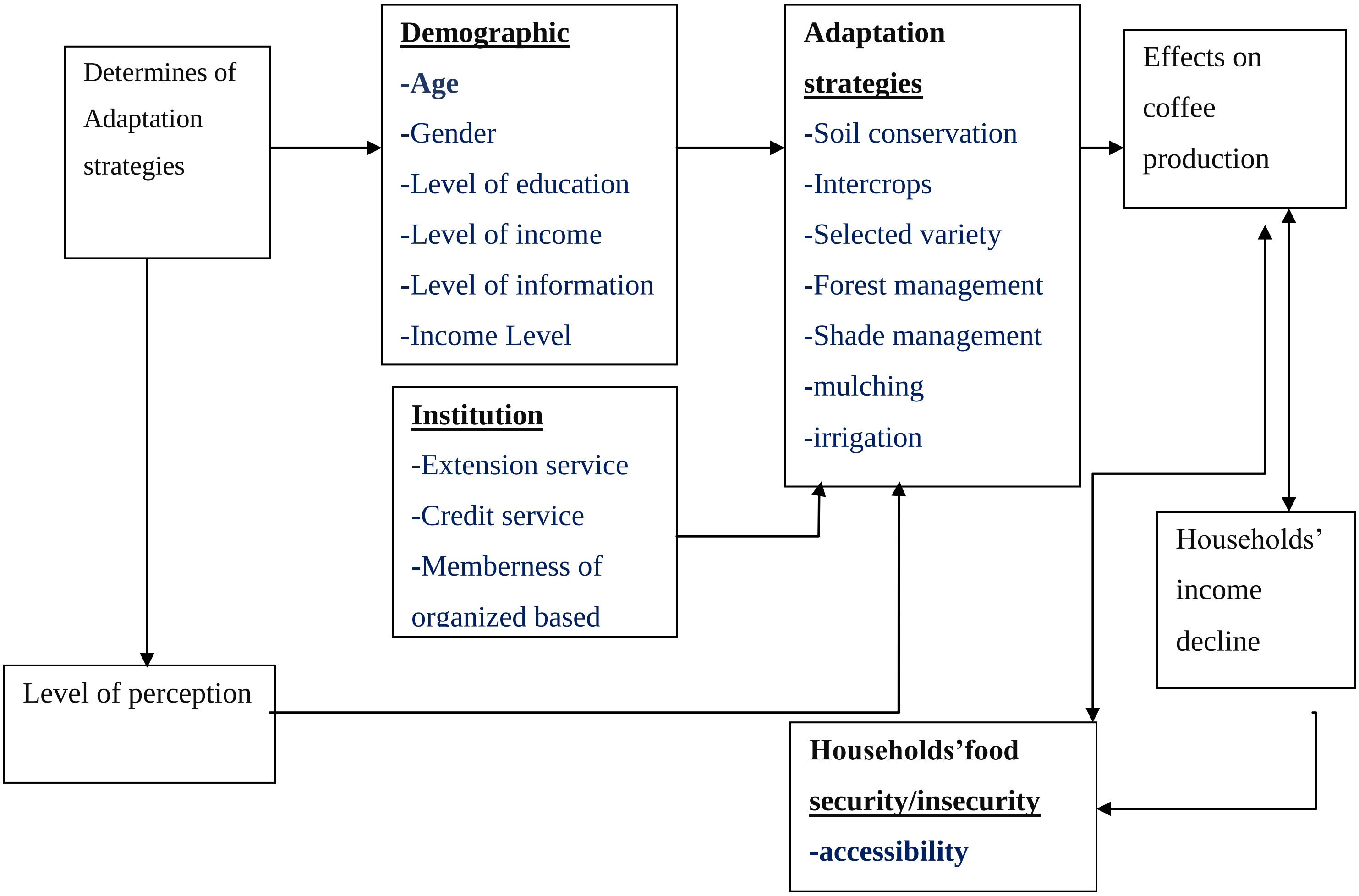


Fig.1 Conceptual Framework of level of perception and determines of adaptation strategies in coffee production

Source: (own construction)

CHAPTER THREE

3. Description of the Study Area, Research Design and Methodology

3.1 Description of the Study Area

Nansabo is one of the woredas in the west Arsi Zone, Oromia Regional state of Ethiopia. And bordered on the south by the Guji Zone, on the west by the Southern Nations, Nationalities and Peoples Region, on the northwest by Kokossa, on the north by Dodola, on the northeast by Adaba and on the east by Bale Zone. Capital town of Nansabo is Werka. The district has more than three important agro-ecological zones, which consist of wet Kolla, Wienadega and Dega zones, which lies within location of 6°35′N 39°10′E and altitude between 1450 and 3500 meters above the sea level with annual rainfall of 750-2000 mm. Soil characters of the area is, deep fertile clay loam/nit sol soil which suitable to coffee production and other horticultural crops. Coffee is the major cash crop of this wereda. Most of the people living in the wet kola and wienadega agro climatic zone are depends on coffee production with agro forestry system and intercrops enset with other vegetables and fruits crop production for their livelihoods. Thus, coffee producing zone covers a greater part of 16 kebeles' from 19 rural kebeles' of the Woreda. Overview Hills and mountain ranges characterize 70% of this woreda; the remains consists of arid lands and plateaus. Perennial rivers include the Hodem, Kuke, Bedessa, Aebamo and Bohera. A survey of the land in this woreda shows that 22% is arable or cultivable (11% was in annual crops), 18.5% pasture, 58% forest and shrub land, and the remaining 1.5% is considered swampy, degraded or otherwise unusable. Teff, wheat and enset are important local crops BOFED (2009).

Coffee is an important cash crop; over 35,000 hectares are planted with it. 'coffee production" Oromia Coffee Union (2010). Industry in the wereda includes a few small scale industry as well as some retailers and service providers. Deposits of gold, graphite, nickel, beryllium and marble are present in this wereda, but have not been commercially developed. There were 12 Farmers Associations with 6,243 members and 10 Farmers Service Cooperatives with 1,367 members. Nansabo has 40 kilometers of rural road, for an average road density of 23.7 kilometers per 1000 square kilometers. About 4.6% of the total population has access to drinking water.

Based on figures published by the Central Statistical (2007) reported a total population for this wereda of 114,559, of whom 56,976 were men and 57,583 were women; 6,068 or 5.3% of its population were urban dwellers. The majority of the inhabitants were Muslim, with 62.91% of the population reporting they observed this belief, while 24.14% of the population said they were Protestant, 8.77% of the population practiced Ethiopian Orthodox Christianity, 2.22% were Catholic, and 1.77% practiced traditional beliefs(PHC,2009).

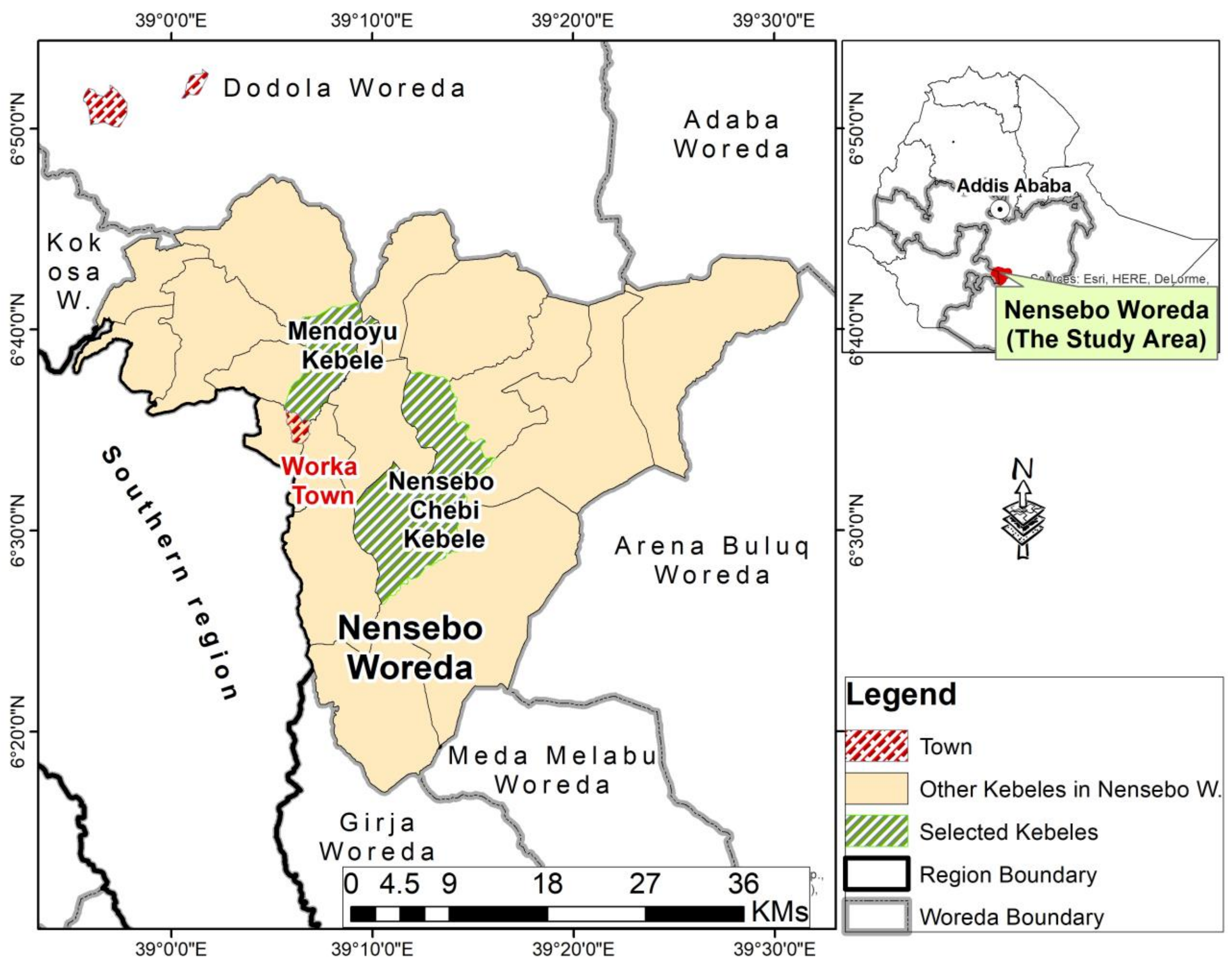


Figure 2: location of study area of Nansabo Wereda on the map of Ethiopia and Oromia. (Source: ESRI, ARC-GIS-10.5, 1999-2017)

3.2. Research Design

In terms of primary data, the study was used a cross sectional design. Cross sectional design that allows in depth data collection from different groups of respondents because it assign at one point at time Bailey (1998) Chris & Diane (2004). Accordingly, the enquiry was also pay a cross-sectional study, meaning, the study was conducted at single point in time. Meanwhile, the offered time for finalizing the fully fledged research document was limited; this ultimately forced the data to be gathering in single time interval. For the secondary data, Longitudinal data of thirty-three years weather condition trends from Ethiopian meteorology agency were taken to triangulate the house holds response with the actual average climate change in the study area. The study targeted farmers who grow coffee and concerned stakeholders in the Nansabo wereda. Concerning the variables of the study; the dependent variables of the study were level of climate change adaptation. Whereas the independent variables of the study are; demographic, institution and, perception of the coffee producer households. The study employed mixed method research that combines both qualitative and quantitative forms. The reasons why the study was tried to employ a mixed methods design is to broaden understanding of the climate change adaptation strategies associated with coffee production & its implication to food security, by incorporating both qualitative and quantitative research, or to use one approach to better understand, explain, or build on the results from the other approach. Quantitative data was used to collect household socioeconomic, demographic characteristics, perceptions, adaptation practices and determinants of adaptation practices using questionnaire survey. Qualitative data also used to grasp coffee producer household's & key stakeholders' perceptions towards the impact of CC on coffee production & adaptation practices using interview and focus group discussions (FGD). As (Cress well and Plano Clark, 2007) mixed method providing with an expanded understanding of research problems, and the overall strength of a study was greater than either qualitative or quantitative research. Amongst the mixed method approach, the concurrent embedded strategy was employed in the enquiry. Concurrent embedded mixed strategy was identified by its use of one data collection phase, during which both quantitative and qualitative data were collected simultaneously levelssee Tashakkori and Teddlie (1998). The purpose of the concurrent embedded strategy is to use quantitative data and results assists in the interpretation of qualitative findings Creswell (2009).Since the impartial of the study was explored and described climate change adaptation strategies associated with coffee production and its implication to food security in the study area. Therefore, this impartial was well addressed with the concurrent embedded strategy**.**

3.3. Data Sources and Tools

The study employed both primary & secondary data. In collecting the primary data for this study; questionnaire, FGD and interview were used; the selection of FGD was based on the accessibility and knowledge of agriculture and climate variability issues. For the secondary data; Published and unpublished documents were used. Published documents like journal articles, books and different related literature reviews were & Ethiopian metrology agency were referred, whereas unpublished data like, coffee production figures collected from the study wereda agricultural office, and government reports.

Semi-structured questionnaires, open-ended and close ended questions were used to get adequate information from the survey. Face to face Interviews was conducted with key stakeholders and focus group discussions used. Whereas, semi-structured questionnaires was carried out to the farmer's survey. Thus, questionnaire employed to gather quantitative data from rural household coffee producer farmers. This was aimed at getting insights about the existing climate change adaptation practices in the study area. During the field study, recommended key stakeholders was also interviewed. The published and unpublished documents were referred from Nansabo Wereda Agricultural Office through secondary data collection method. Meteorological data of thirty-three years of rainfall and temperature was also collected from National meteorological Agency. The method was intended to gather data concerning the effects of climate change on coffee production and farmer's adaptation practices as well as its implication to coffee production and food security in the study area.

3.4. Sampling Technique and Sample Size

The study was conducted in Nansabo Chebbi and Mandoyu kebeles' of Nansabo Wereda, of Oromia Region. These Kebeles' were selected purposely based on their potential coffee production and susceptibility to climate change and variability related food in security. As Nansabo wereda Agriculture office unpublished report, 2016 the already stated, these kebeles were exceedingly vulnerable to climate change impacts, and as a result, supported by food aid program. This study was based on across two kebeles' with a total number of 181 coffee producers and was randomly selected for survey. These was normally from the total numbers of the households found in these kebeles' of 1640. Data was collected using simple random sampling technique proportionately for quantitative survey and semi-structured questionnaires to investigate farmers perceived climate change. For qualitative data, the sampling technique was employed purposely selected.

Respondents were selected based on their validity for a certain issue, and they were selected based on the key informants of the study area and the enquirer. For two FGDs 8-10 coffee producers participants with proportionately participation of both sexes are selected from each kebeles selected to conduct the study, because to allow a small group of respondents was conducted by a skilled intermediary to increasing levels of focus and strength on the key issues of the research topic. For in-depth interview 10 individuals, 5 from concerning government staffs; Agricultural office, Climate change and environmental protection authority and land use administration and 5 from non-government stakeholders; coffee industry owners and Coffee traders were purposely selected.

Table 1: Determining households' sample size

Selected Kebeles	Households	Sample size
Nansabo Chebbi	880	97
Mandoyu	760	84
Total	1640	181

Table 1: research sample size

The sample size was determined basing on Yamane Taro (1967).

n=N/1+N (e) *2=1640/1+1640(0.07)2=3060/16=181*

Where; n=sample size, N =Number of, p= households, e=precision/error level

3.5. Method of Data Analysis

Data from the respondents was verified, compiled, coded, summarized and analyzed using the Statistical package of STATA version 14. The findings were also presented using frequencies, tables and graphs. Both descriptive and econometric analysis were employed to analyze data collected from various sources. Appropriate procedures of thematic content analysis such as identification of themes, paragraphing and synthesizing were applied. The proceeding steps; data triangulated, analyzed from observation, in-depth interview, and focus group discussions, questionnaires and secondary resources were conducted. Descriptive statistics were used to analyze the quantitative data and were presented in percentages in figures and tables.

For quantitative findings; logistic regression and logit models were computed to analyze the determinants of climate change adaptation strategies in the study area. As Kassie et al. (2012), the determinants of perception and adaptation examine using logit models. A binary logistic regression model was used to estimate the effect of hypothesized explanatory variables on the probability of being adapter to climate change adaptation strategies or not.

For qualitative analysis of information from household survey, focus group discussions and key informant interviews was used throughout the study. Determination of variations in temperature seasonal and annual trends of maximum and minimum temperatures and Rainfall trend patterns were computed. Annual Mean linear Trend models were used on mean temperature of seasons of different years to determine trend of mean temperature in the past consecutive 33 years. And Mean Squared Deviation was used to compare goodness fit of different trends in annual rain fall.

The analysis of qualitative data through narrating and description was conducted to explore the climate change adaptation and perception of coffee producer's rural households and selected stakeholders in the study area. In addition, cross tabulation was used to make comparison, through comparing the climate change adaptability practices of selected respondents.

Percentages, freqenceies and means were used to present households perceived in rainfall and temperature. Mean and standard deviation were also used to show households'socio economic,demographic,adaptation options,reasons for adaptation and actual adaptations being implemented These were the basic descriptive variables of statistical analysis tools for adaptation proportions, reasons for adaptation and actual adaptations options were analyzed. The Weight Average Index was used to rank the effects of climate change and variability on coffee performance and households' socio economy.

The Weight Average Index was applied to rank farmers-perceived rate of occurrence of weather extremes to measure the implication of adaptation practices on coffee production and food security in the study area.In deciding Households'perceived and adapted importance of adaptation practices, respondents were requested to rank selected practices based on a 0 to 3 scale situations. As Devkota et al.(2014) and Watanabe et al. (2015) studies shows the Weight average index was used to rank the effects of climate change on crop performance, environment, households socio economy and psychological threats.In the same way, Weight Average Index was applied to rank farmers perceived rate of occurance of weather extremes (temperature and rainfall).Respondents were asked to score as they asked weather extremes based on;

WAI = F1 (1) + F2 (0.8) + F3 (0.6) + F4 (0.4) + F5 (0.2)/ N

Where F =frequency;W =weight of each scale; Where, WAI = Weighted Average Index, F1 = Frequency responding for the 1st rank, F2 = Frequency responding for the 2nd rank, F3 = Frequency responding for the 3rd rank, F4 = Frequency responding for the 4th rank and the weight(i) is given as 3=high; 2 =moderate;1 =low effect and 0 =not atall

The adaptation practices also where ranking by using the weighted average index

WAI=∑FiWi/∑Fi

Where F=frequency of response; W=weight of each score; and i=score (3=highly important; 2=moderately important; 1=less important; 0=not important).

The weight average index (WAI) was then estimating using the formula below;

WAI=F2+F1W1+F0W0/F2+F1+F0 Where: F=frequency, W=weight of each scale, I=weight, 2=high occurrence, 1=moderate occurrence, 0=low occurrence and in the case of climate effects, the weight is given as 3=high effects, 2=moderate effects and 0=no effects.According to their analytical study,to identify the critical constraints that determine/hinder households from using adaptation practices,a ranking was conducted by using the problem confrontation index.Where respondents were asked to grade their perceived barriers/determinants based on a 0-3 scaling method.The problem confrontation index (PCI) value was estimated using the formula:

*PCI=Pn * 0 +pi * 1 + pm * 2 + ph * 3*

Where:PCI=problem confrontation index,Pn=Number of respondents who graded the constraints as no problem;,Pi=Number of respondents who graded the constraint as low;Pm= Number of respondents who graded the constraint as moderate;Ph=Number of respondents who graded the constraint as high

The other method is house hold food in access scale (HFIAS), this was based on the idea that the experience of food insecurity (access) causes predictable reactions and responses was captured and quantified through a survey and summarized in a scale. This model has developed for qualitative research with low-income households in the U.S., provided into the households experience food insecurity access Hamilton et al. (1997). The HFIAS module yields information on food insecurity (access) at the household level.

HFIA Prevalence:

$$\frac{\text{Number of households with HFIA category}}{\text{Total number of households with a HFIA category}} \times 100$$

3.6. Hypotheses and Definition of Variables to be tested in the Study

This study focuses assessing determinants to climate change adaptation strategies. The factors affecting climate change adaptation strategies were analyzed using binary logit model. Logistic regression model was used to identify the determinants of Climate change adaptation strategies. Feder, *et al.* (1985) pointed out that the most commonly used qualitative response models are the logit model, which corresponds to a logistic distribution function, and the probit model. However, logit model is simpler in estimation than probit model and operationally selected for regression analysis

These models specify a functional relation between the probability of adapting CC strategies and various explanatory variables. Hence, factors (independent variables) that affect farmers in adopting CC strategies can be expressed both quantitatively and qualitatively.

3.7. Model Specification

The three most commonly used models are the linear probability model (LPM), the logit model and the probit model. The simplest of these models is the one, which the dependent variable Y is binary (it assumes only two values denoted by 0 and 1). The econometric model applied for analyzing factors affecting CC adaption strategies is the Logistic model. This model was chosen because, it has an advantage over other model (LPM, Tobit and Probit) in that it reveals both the probability of using and not.

The definitions of the variables for the logit model can be defined as following:

The logistic regression model is econometrically specified as follows where p_i donates the probability of the adopting CC strategies by farmers that is $Y_i = 1$ and exp (Z_i) stands for the irrational number *e* to the power of Z_i.

The model can be written as:

$P_i = E(Y=\frac{1}{xi}) = \frac{1}{1+e^{-(\beta 0+\beta 1x1)}}$ -- (1)

For the case of explanation we write (1) as;

$P_i = \frac{1}{1+e^{-zi}}$ -- (2)

The probability that given household is adopting CC strategies is expressed as by (2) while, the probability of not adopting CC strategies is;

$1\text{-}P_i = \frac{1}{1+e^{zi}}$ --- (3)

Therefore, we can write;

$\frac{Pi}{1-Pi} = \frac{1+e^{zi}}{1+e^{-zi}}$ --- (4)

Now (Pi/1-Pi) is simply the odds ratio in favor of adopting CC strategies. The ratio of the probability that a household will adopt CC strategies to the probability of that will not adopt CC strategies. Finally, taking the natural log of equation (4) we obtain:-

$L_i = \ln(\frac{Pi}{1-Pi}) = Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 +$ ------------------------------------- $+ \beta_n X_n$ ------------------- (5)

Where P1 = is a probability of being adopting CC strategies ranges from 0 to 1

Zi = is a function of n explanatory variables (x) which is also expressed as:-

$Z_i = \beta o + \beta 1X1 + \beta 2X2 + --------+ \beta nXn$ --- (6)

βo, is an intercept

$\beta_1, \beta_2,$ ----------------------β_n are slopes of the equation in the model

Li = is log of the odds ratio, which is not only linear in Xi but also linear in the parameters.

Xi = is vector of relevant household characteristics

If the disturbance term (Ui) is introduced, the logit model becomes

$Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 +$ --- $+ \beta_n X_n + U_i$

In this study, the above econometric model was used to analyze the data. The model was estimated using the interactive maximum likelihood estimation procedures. This estimation procedure yields unbiased, efficient and constant parameter estimation.

3.7.1. Parameter Estimation

In order to fit the logistic regression model the estimation of the values of the unknown parameters $\boldsymbol{\beta_0}$ and $\boldsymbol{\beta_1}$'s is required. Unlike the linear regression, which uses the least square estimation (OLS) method, this model estimates the parameters using the maximum likelihood (ML) method (Gujarati, 1988). Due to the nonlinearity of the logistics regression model, an interactive algorism is necessary for parameter estimation, (ML) is a very general method of estimation that is applicable to a large variety of problems. The ML methods of estimation suggest choosing as estimates the values of the parameters that maximize the likelihood of the function (Maddala, 1983). In many cases, it is convenient to maximize the logarithm of the likelihood function rather than the likelihood function itself and the same results are obtained.

Before entering the selected variables into the logit model, it is necessary to check for the existence of multi co-linearity among the continuous variables and verify the degree of association among discrete variables. The reason for this is that the existence of multi co-linearity will affect the parameter estimates seriously. The variance inflation factor (VIF), which used to test for the existence of multi co-linearity between continuous explanatory variables.

VIF shows how the variance of an estimator is inflated by the presence of multi co-linearity (Gujarati, 1995). If R^2 of the multiple correlation coefficient that results when the explanatory variable, $\boldsymbol{x_i}$, is regressed against all the other explanatory variables, VIF is computed as follows.

Tolerance = $1 - R^2$ where R^2 is the coefficient of determination for the regression of that variable on all remaining independent variables.

$$VIF = 1/1 - R^2$$

As R^2 approaches 1, the VIF approaches infinity. That is as the existence of co-linearity increases, the variance of the estimator increases, and in the limit it can become infinity. If there is no co-linearity between repressor, the value VIF will be 1. As a rule of thumb, values of VIF greater than 10, is often taken as a signal for the existence of multi-co linearity problem in the model (Gujarati, 1995).

According to the, working hypotheses used in logistic regression. Dependent variable of the model is represented in the model by 1 for these who are adapter of CC strategies and by 0 for no adapter. Independent variables, based on literature review and experience, the following factors are expected to affects CC adaptation strategies.

3.7.2. Working Hypothesis and Definition of Variables

Working hypothesis

This study focuses factors affecting CC adaption strategies in Nansabo Wereda. Variable, to be used in the analysis of the research model and the associated working hypothesis to analyze for adapting CC strategies is influenced by a set of combined effect of a number of social, economic, institutional factors. Hence, in the following section, the variables to be used on the analytical model and the associated working hypotheses will be presented.

The following variables are hypothesized to influence the utilization of the rainwater harvesting technologies in the study area.

Definitions of variables

Dependent Variable of the model: The dependent variable for logit analysis was CC adaptation strategies, which has a dichotomous in nature. It is represented in the model by (1) for those farmers who are adapting CC strategies and (0) otherwise for those farmers who are not adapting CC strategies.

Independent variables: Based on literature review and researchers personal experience, the following factors, which are expected to affect CC adaptation strategies, are presented with their operationalization.

Age: A continuous variable measured years. It is assumed that age have a negative relationship with dependent variable.

Education: Education helps to increase farmer's ability to obtain, process, information relevant to the CC adaption strategies. Education is thus expected to increase the probability of Adapting CC strategies.

Family size: It is the total number of person living in the household working for and dependent on household for their living. Nemachena and Hassan, (2008) mentioned that household size has mixed impacts on farmers' use of agricultural technologies. Larger family size is expected to enable farmers to take up labor intensive adoption measures. Alternatively, a large family might be forced to diver part of its labor force in to non-farm and off farm activities to generate more income and reduce consumption demand. Nevertheless, larger family size entails more economic dependency and more pressure on the household hence assumed to have negative effect on CC adaption strategies.

Farm size: It is expected to be positively associated with the CC adaption strategies. This means that those farmers who have relatively large farm size are more likely to different adaptation strategies and then adopt CC strategies. And the reverse is true for small farm size owners (Wagayehu, 2003).

Total Coffee Income: Total on Coffee income is operationally defined as the value of the products of the household from coffee output after home consumption and expressed in birr per year. The income level is anticipated to have a positive relationship with the dependent variables since normally it becomes a facilitating factor.

Nonfarm and off farm income: The households engaged in nonfarm and off farm activities are better endowed with additional income to employee labor used for different agricultural activities. Therefore, it is expected that the availability of nonfarm and off farm income is positively related to CC adaption strategies.

Credit: It is expected that access to credit will increase the probability of adopting CC strategies. Farmers who have access to credit may overcome their financial constraints and therefore buy input and other related tools (Nigigi, 2003).

Extension contact: Extension service provided to farmers is the major source of new information in the study area. It is hypothesized as frequency of contact by the extension functionaries of government with the respondents and it was measured as frequency of contact per month. This variable was expected to have positive relationship with CC adaptation strategies.

Frequency of town visiting: It is the degree of orientation of the respondents towards outside the social system specially town to which he/she belongs. It is measured in terms of frequency of visits to outside her village and the purpose of such visits. Frequency of town visiting was expected to have positive relationship with the dependent variables since it provides more chance of exposure to external information

3.8. Ethical Considerations

Any attempt to an empirical study should be done in consideration with ethical norms as they contribute to the trustworthiness of the study. Ethics in the context of research involve a set of norms and principles that researchers in their respective disciplines comply with and apply Bobbie (1990) & Bernard (2006). Initially a formal letter was sought from Addis Ababa University Department of Food security and development studies for Nansabo Wereda Administer and Nansabo wereda Coffee, Tea and Spices Development and Coffee quality & Marketing Authority. Additionally, the permission was sought to kebeles before conducting the study. Furthermore, a letter of informed consent was written and plainly read and explained to the households' questionnaires and conduct key informant interviews was consensual. If the respondents demonstrate or articulate discontent, the interviews was re scheduled or cancelled. Respondents were present with the consent form requesting for their authorization. Besides, they were informed beforehand that should parts of their interview be used in a publication, their name was not being recorded and any details related to their privacy kept confidential. The benefits from this study which involve building climate adaptation and reducing vulnerability in Nansabo Wereda coffee producers' communities was well explained to the respondents. These justifications enhance respondents' interests in this research. After compilation of the final report, copies were made available to those informants who request them.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

This chapter deals with the analysis of the survey data and interpretation of the results of study. Specifically, the social and demographic, economic, situational and institutional factors affecting climate change adaptation among the sampled households discussed using descriptive statistics. Moreover climate change adaptation strategies and household food security status were presented. Finally an econometric result of logistic and multiple logistic regressions is discussed here under. The descriptive statistics was run to observe the distribution of the independent variables. The social and economic characteristics of the sampled households such as family size, age, religion, level of education, land holding, frequency of visiting town, credit availability, extension contact, climate change adaptation strategies, *etc*. are analyzed. Results about the significance difference between the means of the climate change adapter and non-adapter are provided.

4.1. Demographic Characteristics of Respondents

The age structure of the sample households showed that the about 59.67 percent of household were found in age group of 35 to 54 years of age while the remaining 26.52 and 13.18 percent of household head were found in age group of 15 to 34 and above 55 years of age respectively. As the T-test shows, there was significance difference in average age of the two groups (p<) (Table 1). With respect to family size, the average of family size of the sampled households was about 7.40; the largest family size being 16 and the smallest being two. As the T-test value 6.36 indicates that there was significant difference in family size of climate change adapter and non-adapter and also statistically significant ($p<0.05$) (Table 3).Sample households were composed of both male and female household heads. It was found that among the total sampled household heads 83.98 percent were male and the remaining 16.02 percent were female.

The proportion of male-headed households was percent for climate change adapter and percent for non-adapter. The result revealed that the percent of male-headed households of climate change adapters were higher than that of female-headed households. The result of gender issue of female headed households, including. The chi-square test of sex distribution between the two groups was run and the difference was found to be significant with chi-square value of 5.73 ($p<0.05$) (table 2).

The survey result shows that 86.74 percent of the sampled farmers were married, while 7.18 and 6.08 percent were divorced and single respectively. The T-test for significance of marital status was checked and it was statistically insignificant.

Table 2: Sex, Marital status and Age of sampled households (N=181)

Variables		CC Adapter		Non Adapter		Total	
		N	percent	N	percent	N	percent
Sex	Male	86	47.3	66	36.5	152	83.98
	Female	12	7	17	9.25	29	16.02
Marital status	Single	4	1.2	8	4.14	11	6.08
	Married	87	36.55	70	55.24	157	86.74
	Divorced	7	4	6	3.25	13	7.18
Age of HH head							
15 to 34		22	12.36	26	14.2	48	26 .56
35 to 54		64	35.4	44	24.24	108	59 .64
Above 55		11	6.3	14	8	25	14.3

**significant at 1%, ** 5% and *10% probability level

Source :(Author)

4.1.1. Education Status of Sampled Households

The educational status of the sampled households indicates that 19.89 percent of the farmers were illiterate, while the remaining 80.11 percent were literate with different educational background. On the other hand, percent and percent of the CC adapter farmers were illiterate and literate, respectively. The mean score of educational level was 1.09 for total sampled household with standard deviation of 0.06.   The mean educational level of CC adapter and non-adapter was and with standard deviation of and respectively. The t-test value showed that significant variation was found between CC adapter and non-adapter farmers with respect to the calculation (p<) (Table 3).

On the other hand very few (7.44) percent of total sampled respondents have CC training in study area. Further 6.38 and 1.07 percent of CC adapter and non-adapter have climate change adaptation training respectively. The chi-square result indicates there were significant difference between CC adapter and non-adapter in relation to climate change adaptation training ($p<0.01$) (table 3).

Table 3: Education and other training of sampled households (n=181)

Variables	CC Adopter		Non Adopter		Total		
	N	percent	N	percent	N	percent	P-value
Education status							
Illiterate	17	9.4	19	10.5	36	19.89	
1 to 8	55	30.4	48	26.5	103	56.91	
9 to 12	19	10.5	13	7.2	32	17.68	
Certificate and above	6	3.3	4	2.2	10	5.52	
Mean score	2.797		1.04		1.880		.000***
CC train Yes	12	6.38	2	1.07	14	7.44	
No	62	32.98	112	59.57	174	92.55	
Mean score	.174		.0267		.092		.003***

***significant at 1%, ** 5% and *10% probability level

4.1.2. Extension contact, frequency of households' farm visiting and market distance

Agricultural extension and rural training services provided by the agricultural development offices are believed to be an important source of information for improved agricultural technologies. The area of climate change adaptation farmers may be unable to adopt their most preferred strategies due to different determinants affecting their adaptive capacity, including inadequate climate information disconnection between climate science and policy, insufficient institutional infrastructure, such as access to credit, market and extension services as approved studies conducted by Deressa (2009) and Yegbemey et al. (2014). The frequency of extension contact for climate change adapter and non-adapter was 55.45 percent and 45.1 percent respectively with mean of 2.1 and 2.32 respectively and standard deviation of zero and respectively, these shows statistically significant difference (p<) (Table). Sampled respondents used to contact with extension agents once in month, once a week, two or three times in a month. Depending up the situation. With regard to frequency of visiting town sampled respondents used to visit the nearby town most often 48.6 percent, once a week 24.3 percent, daily 15.3 percent and sometimes 11.8 percent respectively. Furthermore, statistical significances were checked for frequency of town visit and it was insignificant. Market distance on the other hand identified as one important factor in this study. Nonetheless, it indicates that market distance was statistically insignificant.

Table 4: Access to Extension and Credit services

Variables		CC adapter		Non adapter		Total		
		N	percent	N	percent	N	percent	P-value
Extension contact								
Yes		98	62.13		81.3	127	67.55	
No		9	4.3	52	18.7	61	32.45	
Mean score		1		0.987		0.990		.0165**
Access to credit	Yes	28	15.46	48	26.52	76	41.99	
	No	57	31.01	48	27	105	58.01	0.125NS
Frequency town visiting								
Often		35	46.7	35	50.7	70	48.6	
Once a week		19	25.3	16	23.2	35	24.3	
Daily		8	10.7	14	20.3	22	15.3	
Mean score		2.580		2.293		2.431		.227NS

4.1.3. Access to Credit Service

Access to credit enables farmers use their finance to buy agricultural technologies. In the study area the Oromia Saving and Micro Finance (OSMF) and Local Cooperative are the main source of credit for farm households. In this study access to credit was expected to increase the probability of adapting climate change, nonetheless, the credit access is statistically insignificant.

Credit is an important institutional service to finance poor farmers for input purchase and ultimately for utilization of new technology. However, some farmers have access to credit while others may not have due to problems related to repayment and down payment in order to get input from formal sources.

Hence, some farmers eschew farm credit. The survey result indicated that 41.99 percent of the CC Adopter out of total sampled households had access to credit, while about 58.01 percent of the non-adopter households had no-access to credit in 2011 E. C. The chi-square result shows access to credit was statistically no significant (Table).

4.1.4. Land Holding, Land Size and Income Category of Sampled Households

There is no farming without land. Land is the single most important factor that determine rural livelihood in Ethiopia. Specific to the study area, land holding is assumed as one of the factor while land has significant contribution on families' income. This study has thus looked into the trend in land holding of sampled households.

The average land size of sample households was 2.16 of which CC adapter and non-adapter own on average 2.2 and 1.90 ha respectively. With regard to land use patterns, from the total land holdings sampled households the maximum land plot used for cropping (cultivated land) purpose. Moreover, 91 percent of land size used for cultivation while 5.2 and 3.8 percent were fallow and grazing land respectively. The T-test result (1.95) for farm size showed that there was significant variation between CC adopter and non-adopter farmers with respect to the calculation (P<0.1) (Table 4.1.5).

Table 5: Land holding, land size and income category

Variables	CC adapter(N=84)		non-adapter(N=97)		Total		
	N	percent	N	percent	N	percent	P-value
Land holding							
Yes	63	75.00	68	70.10	131	72.38	
No	21	25.00	29	29.90	50	27.62	
Mean score					0.910		.0485**
Off farm income							
Yes	21	30.43	10	13.3	31	21.53	
No	48	69.57	65	86.7	113	78.47	
Mean score					0.299		.826NS
Non-farm income							
Yes	27	39.1	8	10.7	35	24.31	
No	42	60.9	67	89.3	109	75.69	
Mean score					0.410		0.001***

The incomes from nonfarm activities is normally used for various purposes, like purchase of inputs, farm implements, and livestock and hire labor, to buy agricultural technologies and rent land. The same holds true in the study area.

Table 6: Land size and income level of sampled households (n=181)

Variables	CC Adapter(n=121)		Non-adapter(n=60)		Total		
	Mean	SD	Mean	SD	Mean	SD	p-value
Land size	3.11	2.94	2.31	1.91	2.16	2.48	0.053*
Cultivated land	2.51	2.34	2.04	1.67	2.26	2.02	0.163NS
Grazing land	0.38	0.47	0.10	0.28	0.15	0.39	
Fallow land	0.22	0.39	0.18	0.19	0.28	0.31	
On farm income	4159.42	2339.70	2613.33	1795.16	3354.167	2112.132	0.000***
Off plus non-farm income	1933.33	2440.39	1072	1558.70	1484.722	2164.731	0.017**

4.2. Households access to weather information

The result in Table 4.1.2. Where *Households* asked Information about climate change. Majority of the respondents (above 88%)responses they are access to weather information from different sources of channels.According to this, The main sources of information for climate were Radio/Television which accounts more than 57.06%. The other sources that have been used as source of information were Extension Workers (39.88%), and least sources from farmers' partners (3.07%) with total frequency of 160. And the remains 21(11.6%) didn't access any weather information and they concluded their response by 'No' as field survey shows.So, in demonstration of these results,the househods of these kebele's had awarenes to climate change and variability with a chance to response with extreme weather characters.Similar findings were reported in Ghana(Francis Ndamani,2016). Feedback from the group discussions showed he majority of respondents households used crop diversification activities for actually implementing adaptation practices in these categories.

Table 7: Households access to weather information

Characteristics/Variables	Responses	Frequency	Percentage
Information About rainfall and other Weather actions	Yes	160	88.40
	No	21	11.60
Extension Workers	Yes	65	39.88
	No	8	4.42
Radio/TV	Yes	92	57.06
	No	12	6.63
Other Farmers/Partners	Yes	5	3.07
	No	1	0.6

Source: Field Data

The results of households ‘perceptions towards occurrence of weather extremes, as presented in the above Table 4.2.1.Generally Rural households perceive weather extremes in terms of The number of rainy days that has decreased over the last 20 years, patterns of rainfall that affecting cropping calendar and followed by the amount of rainfall decreasing from time to time in highest level than other variables. Their rate of occurrence in terms of respondents rank (WAI=1.39, WAI=0.99 and WAI=0.91); 1st, 2nd and 3rd respectively. And also some information were obtained from Focus group and Key informant discussions, farmers claimed high temperature and erratic rainfall occurred and troubling coffee planting, flowering and harvesting patterns.When supportive evidences of several studies in Africa revealed by Mustapha et.al (2012) and around the world have already yielded similar close results. According to their discussions and changes observed are, rainfall disturbances, increasing temperature and other extreme events were rising from time to time. The mean temperature of winter and summer has increased by 0.03^{o}c/year in Nansabo. Effects of temperature and rainfall variability on coffee production as results of the Seasonal Linear Trend Model for temperature is negative which suggests that a one 0.03^{o}c increase in the temperature. The maximum increase in mean temperature is 0.04^{o}c/year.

Table 8: Farmers ‘perception on climate change and the rate of weather extremes (N=181)

Summarized on rate of weather extremes	Ranking of weather Extremes					
	High	Moderate	Low	Not at all	WAI	Rank
Awareness of increasing temperature	150	96	6	0.4	1.39	1st
The number of rainy days that has decreased over the last 20 years	133	31.2	3.6	1.2	0.99	2nd
patterns of rainfall that affecting cropping calendar	108	56	1.2	0.4	0.91	3rd
amount of rainfall affects agricultural production	101	56.8	3.6	0.8	0.89	4th
amount of rainfall affects agricultural production	93	62.4	5.4	0.4	0.89	5th
Shifting of occasion and onset of rainfall	93	60	7.2	0.4	0.88	6th
rain variability increase and with increasing incidence of crop disease	78	72.8	6	0.8	0.87	7th
using land pattern due to increasing temperature	72	71.2	12	0	0.86	8th
Effect of rising temperature affect coffee production	47	98.4	6	1.2	0.84	9th
Changes in warming condition of Temperature	42	105.6	3.6	0.4	0.84	10th
Consequence of coffee pest and disease	34	104	9	0.8	0.82	11th
Frequency occurrence of drought	38	8	22.2	2	0.39	12th

(Source: Author)

4.3. Households' Adaptation Strategies

The ranking of adaptation strategies which based on coffee producers households'perceived one of the best strategies mentioned in the table below. Among from which adaptation options of eight variables shade management, improved coffee varieties and intercropping strategies were ranked first,second and third with WAI;2.3,2.21 and 2.2, respectively.The increament of temperature, rainfall fluctuation and deplation of sol fertility leads and enforced coffee producers households to use exiosting adaptationstrategies to withstand hardship conditions and conserving soil fertility indirectly supporting with adequate information and choice these strategies than given options.On the other hand,irrigation and farm diversification practice are ranked the last and least with WAI 1.2 and 1.21, respectively. In their responses, strategically choices irrigation needs extra investment and techniques with improved experience to handle the benefits on time and farm diversification also, needs extra land size and awareness with previous experience to participate sustainably.Adiitionally,results from FGDs and Key informants evidence shows us households considered income generating activities and intercropping as guaranted adaptation strategies during season lap period of difficulty respçonse to copping from climate variability in coffee production.

Agro-forestry practice, income generating activities soil conservation are rankrd as moderately adaptation choices that important for climate change adaptation responses.As Similar findings were conveyed by several authors, Gebreeyesus et.al (2017),the main adaptation strategies of farmers identified include intercropping, use of improved varieties, Agroforestry and Diversification of income-generating activities.Regards to this,from total 181 households' respondents 83(45.9%) are not adopt of different adaptation options and strategies.

Table 9:Households'ranking of choice of adaptation strategies

Adaptation strategies	Frequency by each level of rank					
	High	Medium	Low	Notatall	WAI	Rank
Improved coffee varieties	54	109	17	1	2.21	2
Irrigation	20	55	45	61	1.2	8
Intercropping	49	117	12	3	2.2	3
Farm diversification	39	102	30	10	1.2	7
Soil conservation	38	76	57	10	1.8	6
Income generating activities	47	91	24	19	2	4
Agro-forestry practice	29	100	48	3	1.9	5
Shade management	79	83	16	3	2.3	1

The results of actual adaptation strategies ,measures the strategies being implemented by households are presented above Table 10 Majorityof the respondents (77.9%) use improved coffee crop varieties in response to climate change effects and Mulching is chosen by the households (71.82%) while intercropping (66.85%).The households also use Farm diversification and Income generating activities in the same level of choice (51.93%) each, Soil conservation and Agro-forestry practice used simultaneously (43.65%) and both produce the same rate in evaluation by the respondents.The last and the least number of respondents are chosen is irrigation practice for actual adaptation to climate change and variability (25.41)

Table 10: Actual adaptation strategies being used by households respondents (n=98)

Adaptation practices	**% of respondents**	**Actual adaptation measures and specific practices**
Improved coffee varieties	**9.73**	More productive,frost and pest resistance variety
Irrigation	3.17	Rainfed agriculture dependency option & dry season gardening and enables them to produce towice & more annually with diversion of rivers and spring water.
Intercropping	8.35	To diverse income and resisting difficulty of bad weather;planting Maize/,onion & d/t spices Corn in coffee farm
Farm diversification	6.49	For more income purpose;Apiculture,livestock etc.
Soil conservation	5.45	Using different conservation strategies;biological & physical construction to maintain fertility and keeping productivity of soil
Income generating activities	6.49	For risk of food secirity and more investing/trade,labor work etc.
Agro-forestry practice	5.45	Different purpose of tree planting;timbering etc.
Mulching	8.97	Nitrogenous species of tree planting

4.4. Perceived Determinants of Adaptation to Climate Change

As illustrated in Table 11,the result of the problem confrontation index value of increased rainfall variability and fluctuation is ranked 1st (500) and the most hinderance to use of adaptation optionsfollowed by decrease certain plant species,increased temperature,decreased in forest area and decreased soil fertility become,2nd,3rd,4th and 5th in rank respectively.Also FGD and Key informants information shows the main problem of the area additional to mentioned in the same level,access to credit especially interest free credit service influence and determine them to perceive extreme weather situation.

Table 11: problem confrontation index (n=181)

Constraint/Determinants to Adaptation	Degree of Constraint/Determinant					
	High	Moderate	Low	Not at all	PCI	Rank
Decrease soil fertility	101	80	0	0	463	5
High cost of inputs	116	61	3	1	428	7
Increase pest and disease attack	35	120	24	2	369	8
Decrease crop yield	86	81	14	0	434	6
Decrease area under crop cultivation	49	62	65	4	336	11
Decrease in forest area	125	46	8	2	475	4
Decrease certain plant species	132	39	8	2	492	2
Increase in poverty	51	86	37	7	362	12
Increase in-out migration	12	43	97	28	249	13
Decrease in household food security and incomes	58	101	18	4	336	10
Increased temperature	131	45	4	1	487	3
Increased drought	47	91	38	4	361	9
Increased rainfall variability	140	38	3	0	500	1

4.5. Econometric Results for Objective Two

4.5.1 Analyzing Determinants of Household's Climate Change Adaptation Strategies

In the preceding section of this thesis the descriptive analysis of important explanatory variables that were expected to affects climate change adaptation, farmers' perception to climate change, and climate change adaptation strategies were presented. In this section, the selected explanatory variables were used to estimate the binary logistic regression model to analyze the determinants climate change adaptation strategies in coffee production. A binary logistic regression model was fitted to estimate the effect of hypothesized explanatory variables on the probability of being adopter to climate change adaptation strategies or not.

The logit model was used to analyze the determinants of farmers' determinants climate change adaptation strategies in coffee production of household either adopter to climate change adaptation strategies or not. Consequently, the variable to show climate change adaptation was used as a binary dependent variable, taking a value 1 indicating the farmer is adapting climate change strategies and, 0 otherwise.

Seventeen explanatory variables were included in the model. The summary of the variables hypothesized to determine climate change adaptation strategies are presented here below (Table).

Table 12: Summary of explanatory variables included in the logistic regression model (n=181)

Variable	Mean	SD	T-value	χ^2
Age	44.708	12.331	7.087***	
Sex of house hold head	1.146	0.354		5.725**
Education	3.528	3.790	10.923***	
Farm Experience	0.097	0.297	8.878***	
Farm size	7.396	3.178	6.363***	
Family size	2.692	2.480	1.951*	
Total Coffee income	3354.167	2112.132	4.701***	
Climate Change Information	1.778	2.251	-6.505***	
Distance to Market	1.948	1.173	1.599NS	
Non-farm and off farm income	1484.722	2164.731	2.426**	
Frequency of extension contact	2.410	1.099	2.427**	
Frequency of town visiting	2.521	2.075	1.2127NS	
Access to agricultural information	0.833	0.374		14.475***
Access to credit	0.611	0.489		1.174NS

Prior to running the logistic regression analysis, both the continuous and discrete explanatory variables were checked for the existence of multi collinearity using Variance Inflation Factor (VIF) and contingency coefficients, respectively. As can be seen from the results presented in (Table 13), there is no strong association among the variables. For this reason, all of the explanatory variables were included in the final analysis.

Table 13: Variance Inflation Factor (VIF) for Explanatory Variables (n=181)

Variables	R-squared	Tolerance	VIF
Age	0.509	0.491	2.04
Sex of house hold head	0.455	0.545	1.84
Education	0.335	0.665	1.50
Farm Experience	0.330	0.670	1.49
Farm size	0.325	0.675	1.48
Family size	0.283	0.717	1.40
Total Coffee income	0.247	0.753	1.33
Climate Change Information	0.224	0.776	1.29
Distance to Market	0.218	0.782	1.28
Non-farm and off farm income	0.162	0.838	1.19
Frequency of extension contact	0.141	0.859	1.16
Frequency of town visiting	0.133	0.867	1.15
Access to agricultural information	0.120	0.880	1.14
Access to credit	0.090	0.910	1.10

Once the decision was made regarding the variables to be included in the model, the Maximum Likelihood method of Estimation (MLE) was used to elicit the parameter estimates of the binominal logistic regression model. Out of the sixteen explanatory variables hypothesized to determine climate change adaptation strategies in the study area, seven were found to be significant at less than or equal to ten percent probability level, shows the signs, magnitude and statistical significance of the estimated parameters and how much the observed values were correctly predicted by the logistic regression model (Table 14).

The likelihood ratio test statistic exceeds the Chi-square critical value with 16 degree of freedom. The result is significant at ($P<0.01$) probability level indicating that the hypothesis that all the coefficients except the intercept are equal to zero is rejected. The measure of goodness of fit used in logistic regression analysis is the count R^2 that indicates the number of sample observations correctly predicted by the model. The count R^2 is based on the principle that if the estimated probability of the event is less than 0.5, the event will not occur and if it is greater than 0.5 the event will occur. In other words, the i^{th} observation is grouped as climate change adaptation strategies adapter if the computed probability is greater than or equal to 0.5, and as a non-adapter otherwise. The model results show that the logistic regression model correctly predicted 178 of 181, or 98.34 percent of the sample households. The sensitivity (correctly predicted CC adaptation strategies) and the specificity (Non-adapter) of the logit model are 94.7 and 94.2 percent, respectively. Thus, the model predicts both groups accurately (Table 14).

Table 14: Parameter estimates of the logistic regression model (n=181)

Variables	Odd ratio	St. Error	z	p>|z|
Age	0.886*	0.062	-1.72	0.086
Sex of house hold head	5.705(NS)	12.821	0.77	0.438 NS
Education	1.807***	0.407	2.63	0.009
Farm Experience	0.427***	0.133	-2.72	0.006
Farm size	1.503**	0.293	2.09	0.036
Family size	0.258**	0.1666	-2.10	0.036
Total Coffee income	1.001**	0.000	2.12	0.034
Climate Change Information	0.033*	0.062	1.83	0.068
Distance to Market	1.070(NS)	0.395	0.18	0.855(NS
Non-farm and off farm income	2.801**	1.072	2.69	0.007
Frequency of extension contact	121.985*	325.798	1.80	0.072
Frequency of town visiting	0.058*	0.093	1.79	0.073
Access to agricultural information	322.477**	760.606	2.45	0.014
Access to credit	40.842(NS)	107.125	1.41	0.157
LR chi2(16)	164.80			
Probability > chi2	0.0000			
Pseudo R^2	0.8266			
Log likelihood	-17.288271			
Number of observation	181			

*** Significant 1%, ** 5% and * 10% probability level, NS= not significant

4.5.2. Significant Explanatory Variables in Logit Model

In this study, sixteen explanatory variables were used. Based on the model results, farm size, family size, distance to nearest market and participation in other business activities were found to have a negative sign, while the remaining variables; age, sex, education, farm experience, total coffee income, climate change information, total on farm income, non-farm and off farm income, frequency of extension contact, frequency of town visiting, access to agricultural information and access to credit had a positive sign of association with climate change adaptation strategies. Out of the fifteen variables, ten of them were statistically significant in the model while the rest were not significant at ($p<0.10$) probability level.

Despite their differences in relative weighting of factors, most researchers Gbetibouo et.al (2009) shows, age may have a negative effect on the decision to adopt new farming technologies simply because older farmers may be more risk-averse and therefore, less likely to be flexible than younger farmers. On the other hand, age may have a positive effect on the decision of the farmer to adopt adaptation strategies, because older farmers may have more experience in farming and therefore, better able to assess the features of a new farming technology than the younger farmers. In relation to gender, Asfaw and Admassie study (2004) note that households headed by males have a higher probability of getting information about new farming technologies and also undertake more risky ventures than female headed households. Came up with different results as to what factors can influence climate change adaptation strategies considered the socio-economic, cultural and technological characteristics as the decisive factors that determine climate change adaptation strategies. To mention some, household characteristics (age, sex, family size, education level, and so on), farm characteristics (farm size, off, non and on farm income), and institutional arrangements (access to agricultural information, distance from market, frequency of town visiting, frequency of development agent contact, availability and adequacy of credit facility are to be considered. As previous findings depicted widely, access to climate change information and other extension services by farmers is another essential factor, which may influence the adoption of farming technologies. In their respective studies, Madison (2006) and Nhemachena and Hassan (2007) observed that the awareness by farmers of climate change attributes whether precipitation or temperature or both, is of essence in as far as their adaptation decision-making process is concerned. In this study, it was therefore expected farmers with access to climate change information were more likely to observe changes in climate and were therefore more likely to adapt than those without access to climate change information.As for the role of credit in the uptake of farming technologies Yirga (2007), Pattanayak et al. (2003) and Caviglia-Harris (2002) pragmatic that a positive relationship exists between the level of adoption and the availability of credit since credit eases the cash constraints and allows farmers to buy inputs such as fertilizer, improved crop varieties and irrigation facilities. As well, this study also hypothesized that there would be a positive relationship between availability of credit and adaptation to climate change.

Another factor that influences the adoption of agricultural technologies is farmers' accessibility to the market places. A study by Madison (2006) notes that long distances to market centers decrease the likelihood of farm adaptation and that market places provide important avenues for farmers to congregate and share information. In addition, Nyangena (2007) shows that in Kenya, distance to market places has a negative and significant effect on the adoption and use of soil and water conservation technologies.

The significant variables included Age, education, farm experience, access to cc information, frequency of extension contact, total coffee income, access to agricultural information, frequency of town visiting, frequency of extension contact and total non/off-farm income. Nevertheless, the rest were insignificant variables. The interpretations of the significant explanatory variables are given below.

Age: the variable is significant at ($p<0.05$) and related negatively with the farmers adaptation to CC. This trend has significant implication for CC adaptation strategies as elderly people might be less interested in the adapting new production systems. The odd ratio (0.886) shows that under constant assumption CC adaptation strategies decreases by a factor of (0.886) as the age of household head increase by one year.

Education: The model result reveal that education affect CC adaptation strategies positively and significant at ($p<0.01$). The result is in line with the hypotheses that those farmers who are literate have the probability to adopt climate change adaptation strategies. The odd ratio (1.807) indicates under constant condition the adoption of climate change strategies increases by a factor of (1.807) as the education status of house hold head increase by one year of schooling. In approval of similar studies with in a country and abroad also shows, Haji et .al. (2012),the educational level has significantly influenced the choice of all adaptation strategies, educated and experienced farmers are expected to have more knowledge and information about climate change and the agronomic practices that they can use in response accordingly. Furthermore, Igoden et al. (1990) and Lin (1991) observed a positive relationship between the education level of the household head and the adoption level of improved technologies and climate change adaptation.

Farm Experience: the variable is significant at ($p<0.01$) and related positively with the farmers adoption to CC adaptation. This trend has significant implication for climate change adaptation as experienced people might be very interested in the adaptation to different agricultural practices. The odd ratio (0.427) shows that under constant assumption adoption to climate change strategies increases by a factor of (0.427) as the experience of house hold head increase by one year. This result is supported by the finding of Chalchisa et al.(2016), indicating farming experience facilitates the identification and implementation of any adaptation strategy and experienced farmers are expected to have more knowledge and information about climate change and the agronomic practices that they can use in response accordingly.

Farm size: Availability of appropriate farm size is highly important when farmers are ready to adopt new technology. Farm size was positively related to the adoption to climate change adaptation strategies and significant at ($P< 0.05$). This Constitute with what was expected earlier in the logical framework that a farmer require relatively large size constitute to use different climate change adaptation strategies as farm size affect income of house hold. The positive relationship shows that the odds ratio in favor on the probability of adopting climate change adaption strategies increases. The odds ratio of 1.503 for availability of farm size implies that, other things being constant, adoption of climate change adaptation strategies increases by a factor of 1.503 as farm size increases by one unit. When comparing results of the same studies carried out with in a country,Farm size determines the decision to combine multiple strategies to cope with climate change. As confirmed by Sani & Chalchisa (2016),who reported that large-scale farmers are more likely to adapt to climate change because they have more capital and resources.

Total Coffee Income: Reasonable household crop income implies that the sampled farmers with the higher amount of coffee income can easily participate than the sampled house hold with the lower amount of coffee income and the variable is significant at ($p<0.01$). The positive value indicates that the odd ratio in favor on the probability of adopting CC strategies increases as the value household coffee income increases. The odd ratio of 1.001 indicates, other thing being constant, adoption of CC adaptation strategies increases by factor of 1.001 as income of sampled house hold increases by one birr Empirical evidence by Franzel (1999) and Knowler and Bradshaw (2007) indicate that income of the farmers, whether farm or nonfarm, represents the wealth of individual households. Entirely, farmers' income has a positive relationship with the uptake of farming technologies since any adoption/adaptation process requires that the farmer has sufficient financial wellbeing.

Non/off-farm income: the variable is significant at ($p<0.1$) and related positively with the farmers adaptation to CC. This has significant implication for CC adaptation strategies as having diversified income sources may improve capacity to adapt CC adaptation strategies. The odd ratio (2.801) shows that under constant assumption CC adaptation strategies increases by a factor of (2.801) as the non/off-farm increase by one birr.

Frequency of town visiting: the variable is significant at ($p<0.1$) and related positively with the farmers adaptation to CC. This trend has significant implication for CC adaptation strategies as having more frequency of town visiting may improve their understanding to cc adaptation strategies. The odd ratio (0.058) shows that under constant assumption CC adaptation strategies increases by a factor of (0.058) as the frequency of town visiting increase by one day.

4.6. Analysis and Discussion of Climate Data Trends

This part of the study focused on analysis of secondary data such as mean maximum and minimum annual temperature, mean seasonal maximum temperature, total annual rainfall and seasonal rainfall trends analysis and interpretation. Thus, for comparison with the awareness of farmers who believe that temperature has increased and precipitation has been fluctuated, the following sections show the actual change in temperature and precipitation as recorded by National Meteorological Agency.

In Nansabo, changes in climate particularly rainfall and temperature patterns were reported by more than half of the surveyed households. The survey results indicates that households perceived erratic rain fall increase and/or decrease in annual rainfall has resulted in prolonged dry spells and droughts. Moreover, they also experienced an increase in temperature and increase incidence of pests to coffee production. As sympathetic study of Baker and Hager (2007), temperatures rise over the highland areas, coffee yields will be adversely affected. As temperature increases will favor certain pests and diseases.

In the study area, temperature and erratic rainfall have increased, and the majority of households also observed a rise in temperature. More than 55 % respondents of households and focus group discussions, reported that resulting rising of temperature, incidence of coffee diseases had also increased in their areas. This is consistent with other studies Bandhyopadhyay (2004) where changes in temperature, rain-fall patterns and humidity were directly related to increased incidences of agricultural production. This is understandable because changes in temperature, timings of seasons and rainfall patterns may lead to increased populations of weeds in grasslands, and incidences of pests and diseases of grasses and crops (Sirohi and Michaelowa 2007).

Table 15: Effect of temperature and rainfall variability on coffee production.

Yields	Coef.	Std. Err.	T P>t
Temp	3.435772 ***	1.0322	0.001
RF	3.673073 ***	1.500063	0.014
_cons	-8.551651***	2.875614	0.003

The relationship between climate variability and coffee production in Nansabo Wereda

The amount of rainfall received and temperature in the study area significantly affect coffee production at (P>0.001%) probability level,(Table 15) .The Effects of temperature and rainfall variability on coffee production as result of the multinomial logit analysis; the coefficient for temperature and rainfall which suggests that an increase level associated with increasing in coffee production; while a level of Temperature and Rainfall probability of positive increasing which suggests that a one ˚C and a one mm associated with probability of increase level of coffee yields keeping with other things held constant. Regards to Temperature and Rainfall increase from table 8 above, the results shows that if rainfall and Temperature increases by a unit (1 mm, and ˚C) the coffee production will rise by 3.673 quintal per hectare. With constantly decreasing by 8.55 quintal from the total hectare. The results also indicate that, all the regression coefficients of Constant, Rainfall and Temperature effect on amount of coffee yield (-8.6, 3.7 and 3.4) have significant effect on amount of coffee (p-values are 0.003, 0.014 and 0.001

respectively). This implied that, as much as rainfall and temperature required to give a satisfactory production on the other side production may increase at on significant rate.

4.6.1 The Annual Mean Trend of Rainfall

Trend Comparison

The goodness of fit of different trends can be compared by using Mean Squared Deviation (MSD), Mean Absolute Percentage Error (MAPE), and Mean Absolute Deviation (MAD) where a trend with minimum of these measures is 'best' in describing the actual time series data.

Table 16: Annual Mean Trend of Rainfall Comparison

Wereda	Trend type	MAPE	MAD	MSD
	Linear	*13.83*	*13.15*	*236.42*
Nansabo	Quadratic	14.32	13.71	254.55
	Exponential	14.31	13.92	265.26

Accordingly, it can be seen that the linear trend model describe the mean annual precipitation data well compared to quadratic and exponential models for both study area of wereda. Rainfall data was disaggregated into two growing seasons belg (March to May) and meher (June to September). The main growing season is meher while the second growing season is belg. Both exhibit variation in seasonal rainfall in amount and monthly spread. Analysis of belg and meher rain has shown increasing with moderate variation trend from 1983 to 2016. Annual Rainfall also increased by about 50.69 mm every year during the past three decades (Figure 4). In addition, year to year with moderate variability of rainfall of meher/summer and belg season which indicates there was higher year to year of rainfall in belg than meher/summer season.

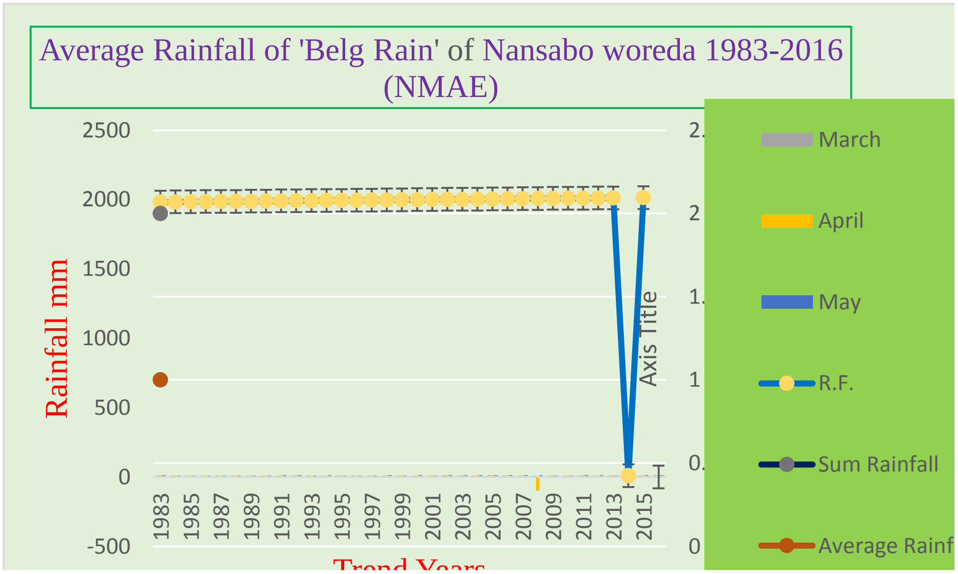


Fig. 3: Average Rainfall of spring/belg/ season.

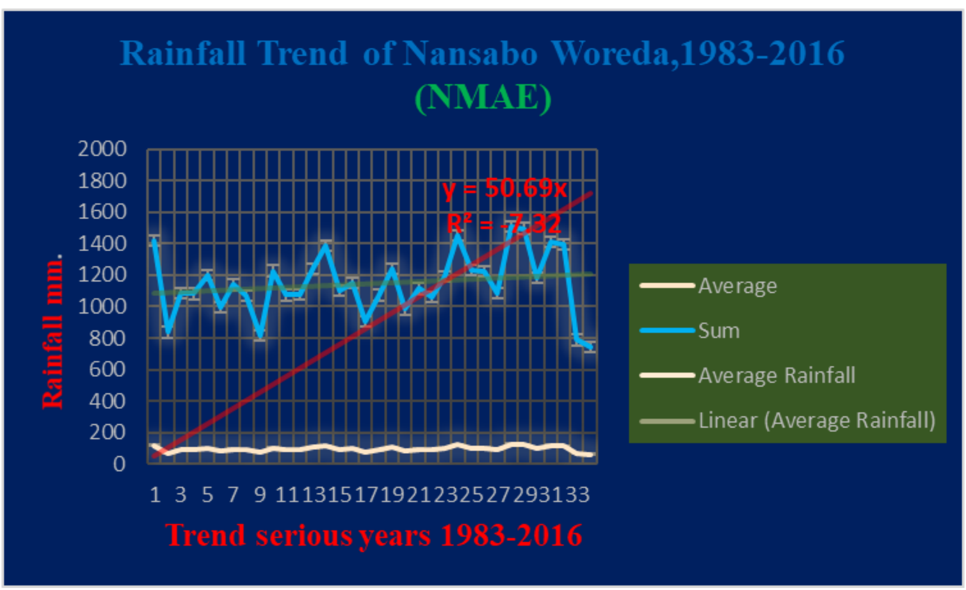


Fig.4: Annual Rain fall trend and variability of Nansabo Wereda, 1983-2016 (NMAE)

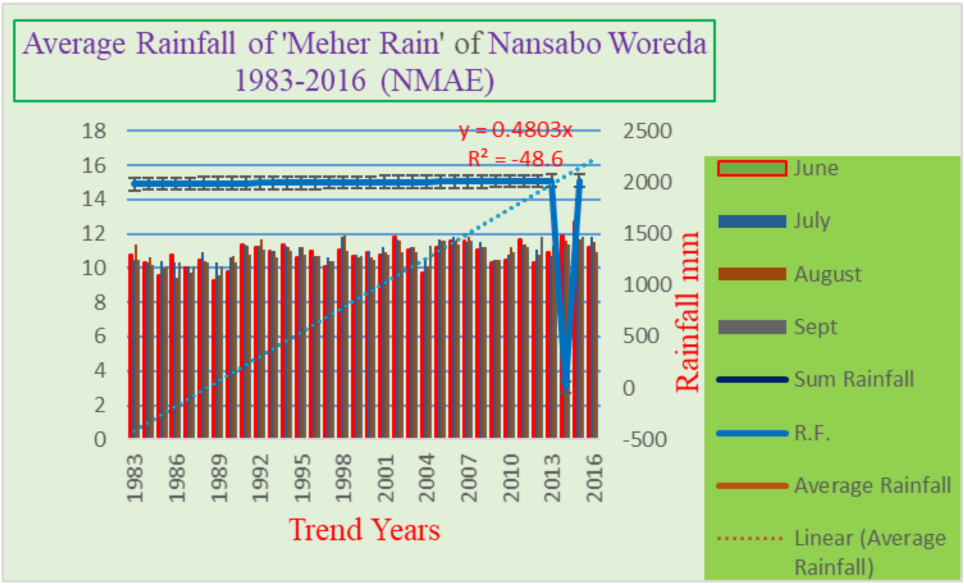


Figure 5: Meher/Summer/ mean Rain Fall for Nansabo wereda

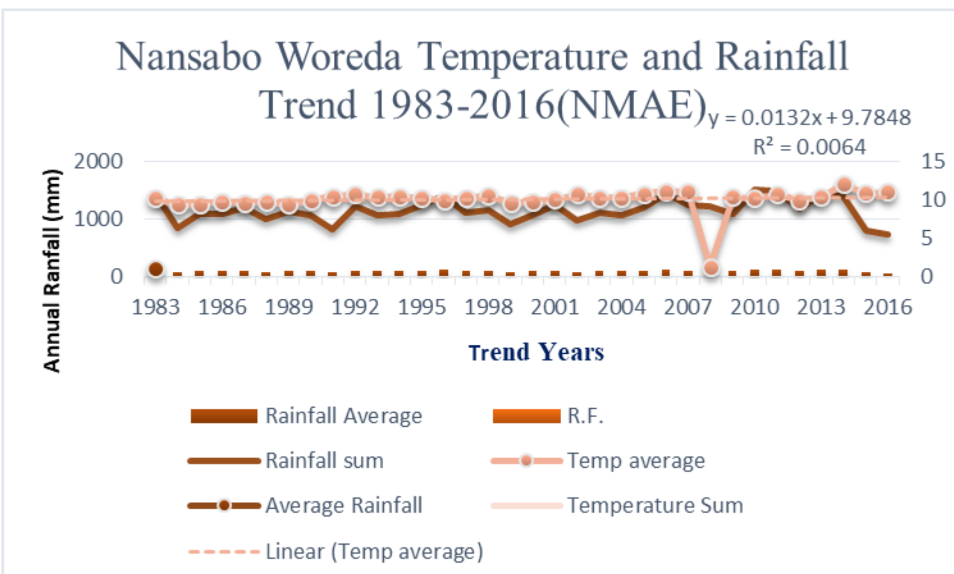


Figure 6: Annual mean Temperature and Rain Fall for Nansabo wereda

The results of meteorological data for rainfall during the rainy season from October to May showed an increasing and fluctuating trend for the last 33 years from 1983 to 2016. Trend analysis of rainfall data (Fig.7) indicates great variation in inter-annual rainfall. Regardless of this variations in inter-annual rainfall, overall rainfall amount was found to increase over the years. Geographically, the area has an altitude of between 1450 and 3500 mm above sea level with characteristics of total annual rainfall ranging from 741-1510 mm. Over the thirty-three years period (1983-2016) the lowest rainfall recorded in the area occurred in 2016 with an amount of 741 mm while the highest rainfall recorded within the period was 1510 mm in 2010. However, Data showed that, within the time (1983-2016) only seven years experienced annual rainfall of less than 1000 mm, while twenty-six years experienced rainfall more than 1000 mm. and totally increasing character with 50.69 mm. per year. This illustrates the fact that rainfall is fluctuating and increasing in the area.

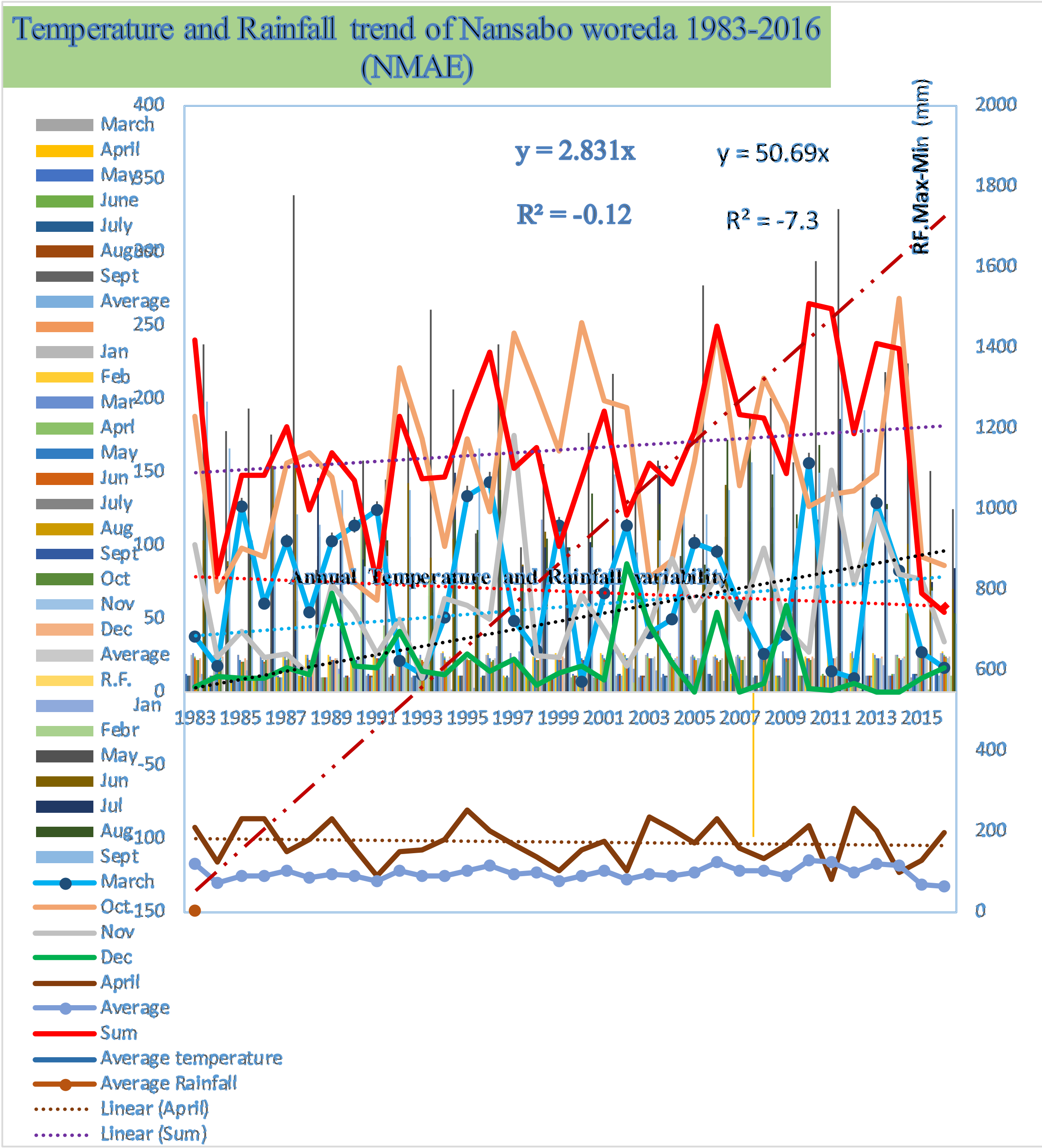


Fig.7: Annual Temperature and Rainfall variability trend in Nansabo Wereda.

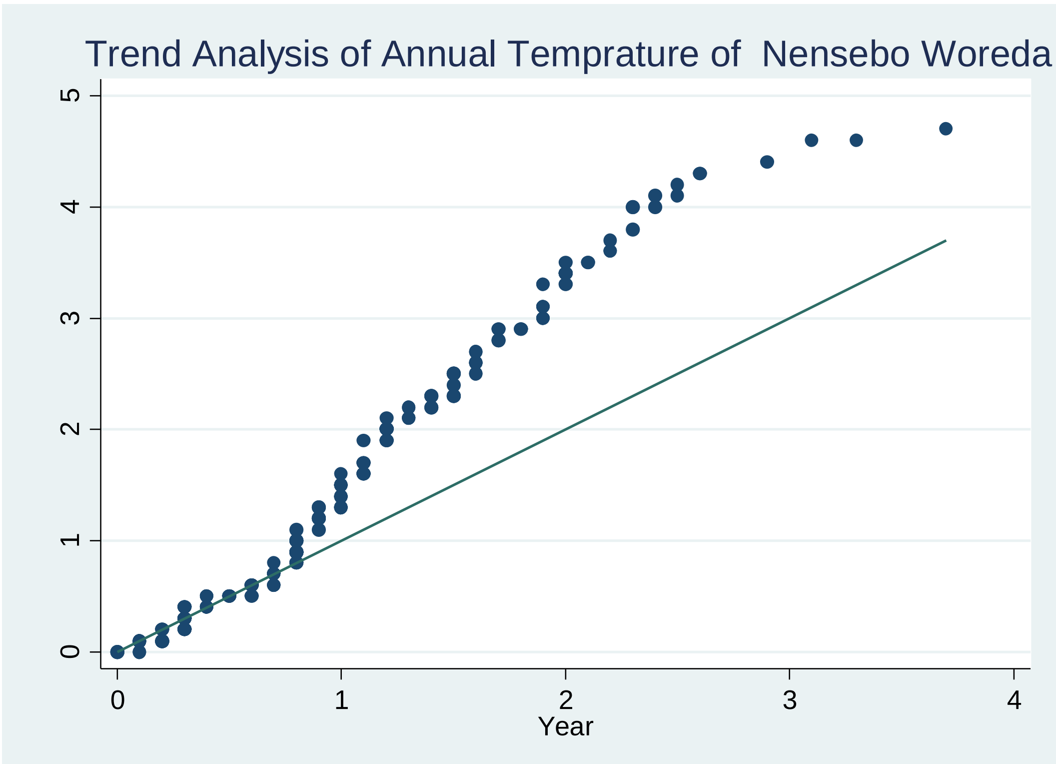
4.6.2. Annual Mean Trend of Temperature

Table 17: Testing Significance of the parameters of Annual Linear Trend Model

Wereda	Intercept			Slope		
	Estimate(β_0)	SE	Pr(>|t|)	Estimate(β_1)	SE	**Pr(>|t|)**
Nansabo	18.19	0.11	<0.01	0.03	0.01	0.46

The above trend analysis on annual mean temperature helps to decide on the presence of change in mean temperature during the past 33 years in Nansabo wereda. Further as presented in fig the mean annual temperatures of Nansabo wereda increased during the past 3 decades at different rates.

Figure 8: Figure: Annual mean temperature for Nansabo wereda



Source: computed from NMA, 1983-2016

Seasonal Linear Trend Model

The following periodic linear trend models were fitted on mean temperature of seasons of different years to determine if there is trend of mean temperature in the past consecutive 33 years of winter, spring, summer and autumn.

Table 18: Seasonal Linear Trend Model for temperature

		Intercept			Slope		
	Season	Estimate(β_0)	SE	Pr(>|t|)	Estimate(β_1)	SE	**Pr(>|t|)**
Nansabo	Winter	14.03	0.12	<0.01	0.03	0.01	**<0.01**
	Spring	15.19	0.15	<0.01	0.04	0.01	**<0.01**
	Summer	15.02	0.11	<0.01	0.03	0.01	**<0.01**
	Autumn	13.67	0.11	<0.01	0.04	0.01	**<0.01**

The magnitude of the trend in seasonal rainfall as determined by least square estimator is given table. At 5% significance level, seasonal average temperature the magnitude of the trend varies from season to season. The mean temperature of winter and summer has increased by 0.03^{o}c/year in Nansabo. Effects of temperature and rainfall variability on coffee production result of the Seasonal Linear Trend Model for temperature is negative which suggests that a one 0.03^{o}c increase in the temperature is associated with significant effect in coffee production. The maximum increase in mean temperature is 0.04^{o}c/year. According to Woodside (2016), around the coffee producing area, rising minimum growing temperatures, changes in rainfall patterns, and rising pest and disease incidence, are already making life harder for coffee farmers. When comparing with national projected minima, Ethiopia's average annual temperature, for example, has risen by 1.3°C between 1960 and 2006. UNDP (2010).Supportive studies describes comparing with Ethiopia's climate projected to warm by as much as 3.1°C by 2060 and around 5°C by 2090 under the most likely emissions scenarios *revealed* under the Intergovernmental Panel on Climate Change (McSweeney et al., 2010).

4.7. Effect of Climate change on Household Food Security

Traditionally, agriculture is assumed to contribute to the food security and livelihoods of households through providing diverse foods and contributing to household income. However, due to increasing climatic vulnerabilities and market uncertainties, the contribution of agriculture to household income has significantly decreased over time. In study area, the majority of households reported that coffee production and livestock were sources of their income. However, they are main sources of income for only a small proportion of households due mainly to declining productivity resulting from climatic hazards. Although farm production contributes to household food consumption, yet the local people have to buy several other food items from the market due to declining in crop productivity. Study area, farm production is the main source of food for almost half of the households.

While agriculture remains an important contributor to household food security in mountainous areas, non-agriculture sources such as daily wage, salaried employment, small businesses and remittances, are becoming increasingly important to sustaining livelihoods, especially for households with small landholdings Rasul et al. (2014); Bhandari and Grant (2007). When environmental shocks occur such as floods, prolonged dry spells, drought or erratic rainfall, most farming households in the study area face transitory food insecurity due to damage to their farming systems and other livelihood sources.

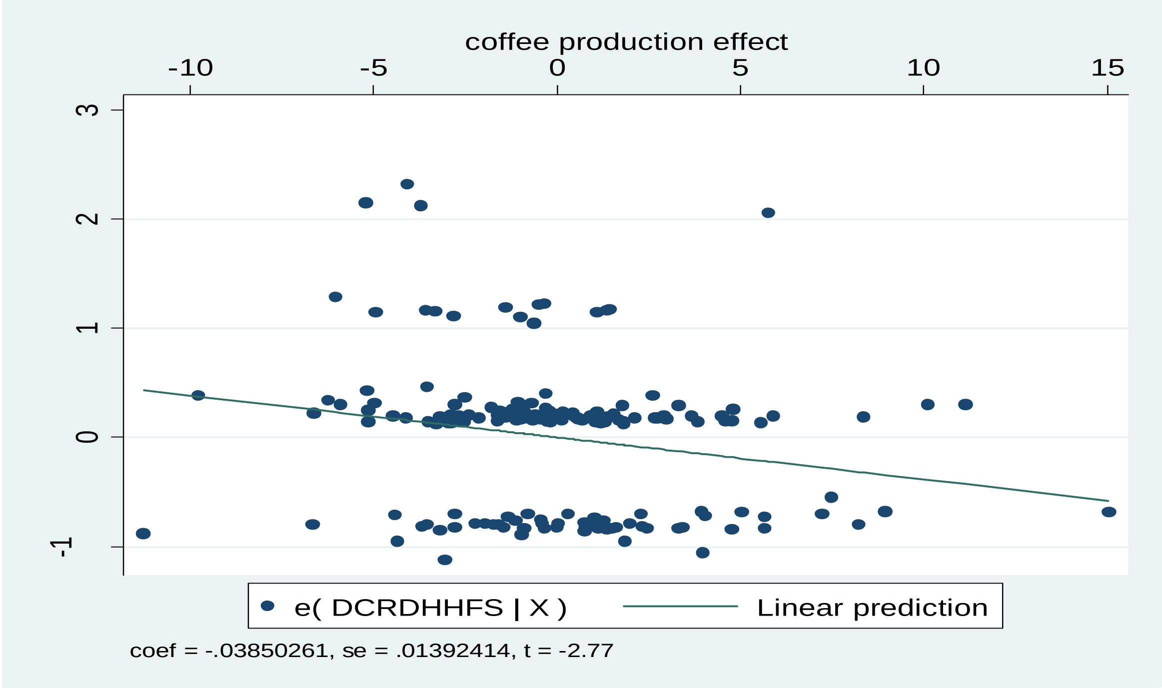


Fig.9: Coffee production and food security relation

Table 19: The results of Household Food Insecurity Access Scale (HFIAS) in the study area.

Questions	Rarely	Sometimes	Often
1a In the past four weeks, did you worry that your household would not have enough food? **How often did this happen?**	118+41	22	0
2a In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? **How often did this happen?**	21	97	8
3a In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources? **How often did this happen?**	12	128	8
4a4a In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? **How often did this happen?**	44	73	8
5a In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? **How often did this happen?**	45	62	6
6aYou or any other household member have to eat fewer meals in a day because there was not enough food? **How often did this happen?**	27	34	9
7a In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? **How often did this happen?**	18	14	3
8a In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? **How often did this happen?**	18	7	1
9a In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? **How often did this happen?**	21	2	1

	Food secure
	Mildly food insecure
	Moderately food insecure
	Severely food insecure

Data source: (Field survey)

Secured 159/848*100=18.75%

Mildly food insecure *22 + 97+ 21+ 12+44/848*100=23%*

Moderately food insecure *8+8+128+73+62+34+45+27/848*100=45.4%*

Food insecure *6+9+3+1+1+14+7+2+18+18+21/848*100=11.79%*

4.8. Effect of Climate change on Household Food Security

Traditionally, agriculture is assumed to contribute to the food security and livelihoods of households through providing diverse foods and contributing to household income. However, due to increasing climatic vulnerabilities and market uncertainties, the contribution of agriculture to household income has significantly decreased over time. In study area, the majority of households reported that coffee production and livestock were sources of their income. However, they are main sources of income for only a small proportion of households due mainly to declining productivity resulting from climatic hazards. Although farm production contributes to household food consumption, yet the local people have to buy several other food items from the market due to declining in crop productivity. Study area, farm production is the main source of food for almost half of the households.

While agriculture remains an important contributor to household food security in mountainous areas, non-agriculture sources such as daily wage, salaried employment, small businesses and remittances, are becoming increasingly important to sustaining livelihoods, especially for households with small landholdings Rasul et al. (2014); Bhandari and Grant (2007). When environmental shocks occur such as floods, prolonged dry spells, drought or erratic rainfall, most farming households in the study area face transitory food insecurity due to damage to their farming systems and other livelihood sources.

Table 20: The relationship of coffee production and food security in Nansabo Wereda

HH FS	Coef.	Std. Err.	P>|t|
COFFPHEK.	-.038502***	.0139241	0.006
TCFHARV.	.0296516**	.0142909	0.039
_cons	2.169786***	.1400957	0.000

In the result of logistic regression above (Table 20), The amount of coffee per hectare produced significantly affect food accessibility in the study area at 1%(p<0.006) percent with decreasing of food accessibility by 39% probability level, on contrary the coefficient of total harvested coffee amount shows a positive suggest that by increasing 30% food access yearly at 5%(p< 0.039) of probability level. This may associated with increments of coffee plantation yearly keeping other things held constant.

CHAPTER FIVE

5. Conclusions and Recommendation

5.1. Conclusions

The findings of this research show that in Nansabo wereda, more than 50% of the households' farmers were aware about the change and variability in the level of temperature and rainfall perception during the last 20 years. The adaptation strategies such as improved coffee varieties, mulching, shade management, intercropping, farm diversification and income generating activities are the most commonly practiced adaptation strategies to climate change and variability by the coffee producer's households. The results of the binominal logistic regression model show that perception about climate variability affected by farm size, family size, distance to nearest market and participation in other business activities. While the remaining variables including age, sex, education, farm experience, total coffee income, climate change information, total on farm income, non-farm and off farm income, frequency of extension contact, frequency of town visiting, access to agricultural information and access to credit have a positive impact on the climate change adaptation strategies.

The analysis of temperature data obtained from National metrological agency (NMA) tends to support the perception of the majority of respondents regarding temperature trends. The mean temperature of winter and summer has increased by 0.03^{o}c/year in Nansabo wereda. Effects of temperature and rainfall variability on coffee production result of the Seasonal Linear Trend Model show that temperature is negative which suggests a minimum average 0.03^{o}c and maximum increase in mean temperature is 0.04^{o}c/year. Increasing in temperature is associated with a reduction in coffee production on average. The study has revealed that rainfall fluctuating in study area have over the thirty three years (1983-2016) and attributes to exposing coffee production to the climate risk. Nansabo wereda households' use adaptation as a means to increase production, for frost risk and for dual purposes. Farmers classify climate change adaptation options in terms of improved coffee varieties, intercropping, shade management, income generating activities and agroforestry practices. Nevertheless, barriers to adaptation strategies are to be minimized to promote climate adaptive practices in coffee production.

The effect of climate change towards household income and results revealed that it contributes a good share to household income. In the year 2017/ 18, their average income decreased by 25% of the total household income. In average effect of climate change to household income in the two Keble's amounts to 23.3%. Results of FGD indicates that having institutional support and large plot of land, participation in different climate change adaptation strategies supported them to overcome food insecurity problems.

5.2. Recommendations

The result of this study revealed that farm size, total coffee income and sum of off farm and non-farm activities are found to affect climate change adaptation strategies positively and significantly. This is due to the fact that most farmers were depend up on their income to adapt to new agricultural technologies. Hence, this study recommends development of alternative income sources to diversify income level. In addition to this, attention should be given to farm management issue to facilitate the agricultural transformation from the extensive farming to intensive farming through efficient utilization of agricultural information.

As presented in the empirical study results that climate change information and level of perception was critical to the adaptation strategies depending on its role and selection models guide effective adaptation strategies to perceive and response to extreme weather through weighting of adaptation level of coffee producers households.

The local government should boost the extent of agricultural based skills through agricultural extension to disseminate technologies that alleviate the barriers of adapting to adaptation options. Finally, the results of the study indicate that family size affect climate change adaptation strategies negatively and significantly. This implies that farmers with more number of family members choose to use his/her income on home consumption and other family expenses than on climate change adaptation activities. Therefore, local government and policy should give due attention to family planning program.

5.3. Further Studies

The current study applies a yardstick model to investigate the factors influencing adaptation to climatic change in agriculture. Further, this study tried to assess households' perceptions to climate variability, determinants and adaptation strategies to CC at household level and contribution of CC to food security. However, analyzing causal linkage between CC and Food security is mandatory. AS such, the model, for example, does not explain what the cause of climate change and variability as well as different wealth categories' of households and coffee industries in the area take decisions on adaptation. Therefore, to make it clearer on more likely to adapt to climatic change in coffee production a dynamic model should be applied in future investigations.

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FIELD SURVEY QUESTIONNAIRES

1: Household questionnaire

Region--

Zone--

Woreda---

Kebele ---

My name is Ansha Nure,

Dear household head, as one of coffee producer, your house hold has been selected that could be used to assess the effect of climate change & variability in coffee production. I assure you that, all the information will be provided are special for academic purpose and not otherwise. Therefore, you are friendly requested to respond truthfully to the following questions. Please read each item separately and indicate your estimation by putting a tick (√) mark under one of these alternatives.

I thank you in advance

A. Questionnaire used to elicit data coffee producers about climate change adaptation strategies and perceptions.

Name of respondent----------------------------Questionnaire Number-----------------------

Part I: Basic information

1. Age: (1) 15 – 34 ☐ (2) 35 – 54 ☐ (3) 55 and above ☐

2. Sex: (1) Male ☐ (0) Female ☐

3. Marital status: (0) Married ☐ (1) Single ☐

4. Educational status: A. unable to read & write ☐ B. 1-8 ☐ C.9-12 ☐ D. certificate & diplom ☐ E. Degree & above ☐

1. 5. Years of experience in farming: (1) less than10 years ☐ (2) 10-25 year ☐ (3) More than 25 years ☐

6. Secondary occupation (Main): (1) Livestock ☐ (2) petty trade ☐ (3) apiculture ☐ (4) others ☐

Part II: Household information

1. Size of farm (hectares) _________

2. Number of members in household______

3. Number of household members who work on the farm_________

4. Average number of man- days on the farm________

5. Main source of household income: (1) Agriculture ☐ (0) others ☐

6. What is the total amount of annual income from coffee farm? (Eth. Birr) ______

7. Secondary sources of household income :(1) Livestock ☐ (2) business/trade (3) Remittances ☐ (4) Others ☐

8. What is the total amount of annual out of coffee income? (Eth. Birr) ______

Part III: Access to weather information, markets and extension services

1. Do you get information on rainfall and other weather actions? (1) Yes ☐ (0) No ☐

If yes, from where? (1) Meteorological staff ☐ (2) Agric. Extension ☐ (3) Radio/ television ☐

2. Do you have access to market for your farm produce? (1) Yes ☐ (0) No ☐

3. Do you have ready access to credit facilities? (1) Yes ☐ (0) No ☐

4. Do you have access to Agricultural Extension Agents & officers? (1) Yes ☐ (0) No ☐

If yes, how many visits per month? (0) 4 ☐ (1) Less than 4 ☐ (2) More than 4 ☐

5. Do you contribute to farming and weather information with other farmers? (1) Yes ☐ (0) No ☐

6. Do you belong to any farmer-based organization? (1)Yes ☐ (0) No. ☐ If NO, why? ______________________________________

7. Following from question 6, if YES, how many meetings do you clutch in a month? _________

Part IV: perception to climate change

Table 1: Fill the right-column with the appropriate number (4) High ☐ (3) Moderate ☐ (2) Less ☐ (1) Not at all ☐

1 Farmers perception on temperature

No.	Statements	1 High	Moderate 2	3 Less	4 Not at all
1.	What is the level of your temperature risk perceptions regarding the changing of warming condition?				
2.	What is your perception level of awareness that increasing temperature in the area?				
3.	What is your level of perception about rise of temperature that can				

	affect coffee production negatively?				
4.	What is the level of your risk perception towards high temperature and its consequence to coffee pests and diseases increase?				
5.	What is your perception level of the frequency occurrences of drought with an increase of temperature?				
6.	What is your perception level in land pattern using due to increasing temperature?				

1.1 Farmers' Perception on Rainfall

No.	Statements	1 Hi	der ate 2	Les s	No t at all
1.	What is the level of your perception on patterns of rainfall that affecting cropping calendar?				
2.	Have you perceive the amount of rainfall decreasing from time to time? If so level it.				
3.	What is the level of your perception towards amount of rainfall affects agricultural production?				
4.	What is your level of perception regarding to rain variability increase and with increasing incidence of crop disease?				
5.	What is your level perception the shifting of occasion and onset of rainfall?				
6.	What have you perceive about the number of rainy days that has decreased over the last 20 years?				

Part V: Determinants of climate risk perception.

4. How do the factors in Table below influence your risk perception about climate change?

Fill the right-column with the appropriate number ---- (3) High ☐ (2) Moderate ☐ (1) Low ☐ (0) Not at all ☐

8. Do you normally experience pest prevalence in the production season? (1) Yes ☐ (0) No ☐

No.	Factors	Response			
		High	Moderate	Low	Not at all
1	Decrease soil fertility				
2	High cost of production				
3	Increase pest and disease attack				
4	Decrease crop yield				
6	Decrease in area under crop cultivation				

7	Decrease in forest area				
8	Decrease in number of certain plant and tree species				
9	Increase in poverty				
10	Increase in out-migration				
11	Decrease in household food security and incomes				
12	Increased temperatures				
13	Increased drought, dry season and flood				
14	Increased rainfall variability				

Part VI: Adaptation to climate change

1. Do you adopt any strategies or measures to reduce the effects climate change on your farming activities? (1) Yes ☐ No (0) ☐

If yes, where do get the modern strategies or measures from? (0) Colleague farmers ☐

(1) Agriculture officer ☐ (2) NGO ☐ (3) Others________________________

1. Do you adopt any strategies or measures to reduce the effects climate change on your farming activities? (1) Yes ☐ (0) No ☐

If yes, where do get the modern strategies or measures from? (1) Farmers training centre/FTC ☐

(2) NGO ☐ (3) Others ________________________________

2. Choices of adaptation strategies;

Adaptation strategies	**Response**			
	Highly	moderately	Less	not at all
Improved crop varieties				
Irrigation				
Crop diversification				
Farm diversification				
Soil conservation				
Income generating activities				
Agro forestry practice				
Improved crop varieties				

Table 3:

4. Actual adaptation practices being used. If your answer is yes write the specific practices.

Adaptation strategies	**Response**		**Specific practices**
	Yes	**No**	
Improved crop varieties			
Irrigation			
Crop diversification			
Shade management			
Farm diversification			
Income generating activities			
Agro forestry practice			
Mulching			

Table 4:

3. Which of the following is your main reason for using adaptation strategies to climate change? (1) Reduce effects of drought__________ (2) Reduce effects of frosts__________ (3) Increase production_________ (4) others________

5. List the coffee/ hectare and total amount of coffee production from 2017 to 2018 season.

Type of crop	Year	Coffee/hectare	Harvest bags/ku.	Average
Coffee	2017			
	2018			
Average				

VII and Table 5: Household Food Insecurity Access Scale (HFIAS) Measurement Tool

No	In the past 30 days,	Yes	No
1	In the past four weeks, did you worry that your household would not have enough food, due to decline of income from coffee production?		
1a	How often did this happen?		
2	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because a decline of		

	income from coffee production?		
2a	If 'yes' how many days within the month? How often did this happen?		
3	In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because a lack of income from coffee production?		
3a	If 'yes' how many days within the month?		
4	Did you or any household member have to eat some foods that you did not want to eat because of shortage of money to obtain other types of food?		
4a	If 'yes' how many days within the month?		
5	Did you or any household member have to eat a smaller meal because there was decline of coffee production and marketing?		
5a	If 'yes' how many days within the month?		
6	Did you or any household member have to eat fewer meals/day because due to shortage of money?		
6a	If 'yes' how many days within the month?		
7	Was there ever no food to eat in your household because of lack of income from coffee production to get food?		
7a	If 'yes' how many days within the month?		
8	Did you or any household member go to sleep at night hungry because there was not enough income to access food?		
8a	If 'yes' how many days within the month?		
9	Did you or any household member go without eating anything a whole day and night because income from coffee production decreasing from time to time?		
9a	If 'yes' how many days within the month?		

Date of interview ____/____/ ________

Woreda ___________________________

Sector ____________________________

1. Checklist for focus group discussions (FGD):

1. What is the pattern of rainfall over the past 10 years: (0) decreasing ☐ (1) increasing ☐ (2) stable ☐

2. In a particular season, how long do the rains last: (1) 3-4 months ☐ (2) less than 3months? ☐ (3) More than 4-months ☐

3. Do you normally experience drought during the coffee production season? (1) Yes ☐ (0) No ☐
If YES, which month? _______________

4. Do you normally experience frost during the production season? (1) Yes ☐ (0) No ☐
If YES, which month? _______________

5. What is the pattern of temperature over the past 10 years? (0) decreasing ☐ (1) increasing ☐ (2) Stable ☐

2. Checklist for key informants

1. Do the prevailing rainfall and temperature patterns affect crop production? (1)Yes ☐ (0) ☐ No If yes, how? ____

2. Do the prevailing rainfall and temperature patterns affect the environment? (1)Yes ☐ (0) No ☐
If yes, how? ____

3. Do the prevailing rainfall and temperature patterns affect the socio-economy? (1)Yes ☐ (0) ☐ No. If yes how? ____

4. Has the temperature been decreasing over the past 10-20 years ago? (1)Yes ☐ No ☐ If yes how? ____

5. Are there any factors contributing to low quality and marketing of coffee in the area? ☐ (1)Yes ☐ (0) No If yes, how? ____

Thank you for your kind co-operation