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Centre for Food Security Studies College of Development Studies

**FARMERS' PERCEPTION AND ADAPTATION STRATEGIES TO
CLIMATE CHANGE: IMPLICATIONS TO HOUSEHOLD FOOD
SECURITY IN LAY GAYINT DISTRICT, AMHARA REGION, ETHIOPIA**

BY

EYASU MELKAMMERI

(GSE/4028/10)

NOVEMBER, 2020

ADDIS ABABA, ETHIOPIA



**COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR FOOD SECURITY STUDIES**

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EYASU MELKAMMERI

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ADVISOR: DESALEGN YAYEH (Ph.D)

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

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CENTER FOR FOOD SECURITY STUDIES

Declaration

I, Eyasu Melkammeri, hereby declare that this thesis is my original research work and findings. It has not been submitted to any other university for any academic degree. Materials and information other than my own are duly acknowledged and a reference list has been attached. In presenting this thesis in partial fulfillment of the requirements for the degree of MSc. in Food security and Development studies, I grant to Addis Ababa University the non-exclusive royalty-free right to archive, reproduce, distribute, and display in any forms including electronic format, via any digital library mechanisms maintained by the University.

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

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Abbreviation

- AEZ : Agro-Ecology Zone
- ANRS: Amhara National Regional State
- ATW: AbayTekeze Watershed Livelihood Zone
- CDKN: Climate and Development Knowledge Network
- CEEPA: Central Environmental Economics Policy in Africa
- COVID-19: Coronavirus Disease
- CSA: Central Statistics Agency
- DPPO: Disaster Prevention and Preparedness Office
- FAO: Food and Agriculture Organization
- FDRE: Federal Democratic Republic of Ethiopia
- FEG: Food Economy Group
- GDP: Gross Domestic Product
- GHG: Green House Gases
- GHL: Guna Highland Barley and Potato Livelihood zone
- HH: Household
- IPCC: International panel for climate change
- KII: Key informant Interview
- LGWARDO: Lay Gayint Woreda Agriculture and Rural Development Office
- LHZ: Livelihood Zone
- LPM : Linear Probability Model

MoFED: Ministry of Finance and Economic Development

NBE: National Bank of Ethiopia

NCCF: National Climate Change Forum

NGO: Non-Governmental Organization

NMC: North East Woinadege Mixed Cereal Livelihood Zone

NMSA: National Metrology Service Agency

PCGCC: Pew Center on Global Climate Change

PSNP: Productive Safety Net Program

RKA: Rural Kebele Administration

SDCC: Social Dimensions of Climate Change

SNNP: South Nations Nationalities and People

SPSS: Statistical Package for Social Science

TSG: Tekeze Lowland Sorghum and Goat Livelihood Zon

UNDP: United Nation Development Program

UNFCCC: United Nations Framework Convention on Climate Change

USD: United states dollar

WoFED: Woreda Finanice and Economic Development

WHO: World Health organization

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Abstract

Climate change is a global phenomenon rapidly emerging as one of the most serious threats that humanity ever faces. Its impact on developing countries with limited adaptive capacity has become a pressing issue as it highly affects the performance of agricultural production and food security. This study was designed to examine the situations of climate variability and its implications to food security. To achieve the stated purpose, the researcher used explanatory research design. It is based on analysis of data collected from 354 randomly selected household farmers and all 6 agriculture experts were included from 6 agriculture experts and decade's document analysis from NMA. Frequency and percentage are in this study. The data collection instrument was questionnaire from 354 farmers; key informant interview used to analyze farmers' perception and adaptation to climate change whereas standard anomaly is applied to analyze Climate trends and Variability. The results indicated that both maximum and minimum temperature has been increasing and rainfall had a fluctuating trend during the last three decades and it impacts on agricultural production and food security. The majority of the participants were perceived there was climate change. However the adaptation mechanisms was low and vary from individual to individuals; because of this almost 88 % of the farmers were not secure their household food security. Eventually, it is recommended that the government, agriculture experts and farmers should Promoting farm-level climate change adaptation mechanism to increase the household food security.

Keywords: *Climate change/ variability; Adoption; Perception; Food security; Farmers*

Chapter One

1. Introduction

1.1. Background of the Study

Agriculture is the most energetic sector in Sub-Saharan Africa, but it is forecast to be negatively impacted by climate change (Deressa, 2006; Moussa & Amadou, 2006; Jain, 2006). Climate change will cause substantial welfare losses especially for smallholders whose main source of livelihood derives from agriculture. The climate forecast for West Africa predicts increasing temperatures and decreasing and irregular rainfall. Time-series analyses show that since 1970, temperatures have increased by between 0.5 and 0.8 °C (Collins, 2011), and since 1950, precipitation has decreased and is projected to drop by 10% over the 21st C (Hulme *et al.*, 2001; Nicholson, 2001).

This situation is intensified by inherent stressors such as poor soil fertility, scarcity of water, and limited or inexistent infrastructural and institutional support. This is hampering the promotion of adaptation and the enforcement of mitigation actions due to technical, managerial, or financial limitations (CDKN, 2015). Therefore, there's a requirement to neutralize the potential adverse effects of global climate change if welfare losses to the present vulnerable segment of the society are to be averted (Hassan & Nhemachena, 2008; Molua & Lambi, 2006). In Ethiopia, climate change features such as drought, flood, and soil degradation are among the major factors responsible for low agricultural productivity (Asrat & Simane, 2017a; Yirga, 2007).

Farmers' interest in climate mainly regards the need to estimate whether to adjust their cropping decisions (Roncoli, 2006) or applying local and traditional knowledge on climatic coping systems and peoples' vulnerability, resilience, and adaptability (Adger *et al.*, 2014). However, the mixing of local and knowledge domain remains limited by the unfinished understanding of local knowledge systems and therefore the lack of approaches and tools to integrate both (Ford *et al.*, 2016). These including heavy reliance on traditional farming techniques and poor complementary services (such as extension, credit, marketing, etc.) reduce the adaptive capacity or increase the vulnerability of smallholder farmers to climate change, which in turn affects the performance of the already weak agriculture (Asrat & Simane, 2017b). Technically, farming adaptation refers to minimizing the carbon and nitrogen concentrations within the air, vegetation, and soils and promoting the efficient use of macro- and micro-nutrients in physiological processes (Hillel & Rosenzweig, 2011).

To cope with water scarcity, the use of supplemental irrigation, improvement of storage capacities, utilization of surface and shallow groundwater, and strengthening of community-based management is recommended (Mdemu *et al.*, 2010). However, despite being based on sound science, the implementation of these measures does not always increase farmers' adaptive capacities (Crane *et al.*, 2011). Other factors may hinder farmers' adaptation to global climate change, like the shortage of sound weather forecasts, poor access to financial means, depleted natural stocks, farmland scarcity, and insecure land tenure and limited access to inputs (Maddison, 2016; Fosu *et al.*, 2012). In general, these factors are related to poverty (Nhemachena & Hassan, 2007) and rarely to knowledge (Maddison, 2016) which supports the assumption that the economic, political, and social conditions are at least as important as the reactive measures (Mertz *et al.*, 2009).

Hence, it is clear that to succeed, adaptation measures have to suit the local biophysical conditions (Rusinamhodzi *et al.*, 2011) provide complementary goods, benefits and services to householders (Leakey, 2012), enlarge the scope to broader scales, mainly in terms of policy and trade (Ifejika, 2010), and finally, due to the high unpredictability of climate change and variability, embrace resilience as a key feature (Ifejika, 2010; Callo & Ewert, 2014) to be feasible, multilateral settings and enhanced partnerships between governments, non-governmental and even private organizations are necessary (Pretty *et al.*, 2011; Wheeler & Von, 2013).

Understanding climate change and implementing adaptation mechanisms by farmers in the livelihood was secure food security. Climate change can affect food security and poverty (IPCC, 2007a). Also, food security can be broadened to include nutritional aspects based on the diversity of diet. However, the adaptation practices used were found to be positively associated with education, male household heads, land size, household size, extension services, access to credit, and wealth. Farmers adopting more adaptation practices had higher food security levels (8–13%) than those who did not, and experienced lower levels of poverty (3–6%). Climate change adaptation practices at the farm level can thereby have significant development outcomes additionally reducing exposure to weather risks and secure their food (Akhter & Olaf, 2016).

Therefore, Farmers' perception and adaptation to climate change are considered to be essential to ensure food security through rising agricultural production, and proper utilization in the right diversity and stability. There were insufficient empirical studies based on climate change perception and adaptation strategies in the study area so far to identify the farmers' perception and adaptation to climate change implication on household food security.

Hence, in order to contribute to fill the research gap this study is planning to assess the perception of farmers towards climate change, identify their adaptation responses and its impact on household food security in Lay Gayint woreda, ANRS, Ethiopia.

1.2. Statement of the Problem

Climate change is a serious threat for agriculture, food security and fight against poverty in Sub Saharan Africa in general and in Ethiopia. In particular crop failure due to erratic climate shocks incidents such as drought (shortage of rainfall) and flooding (excessive rain) increase a risk of longer period of hunger and more severe livelihood hardship of many rural poor who rely on small-scale farming for food and income across the world (UNFCCC, 2014).

Ethiopia is vulnerable to climate variability and change, and it frequently faces climate related hazards, commonly drought and floods. The variability of rain fall and the increasing temperature were a cause for frequent drought and famine, and putting disastrous impact on the livelihood of the peoples (Temesgen *et al.*, 2014). Indeed, Ethiopia has experienced at least five major national droughts since 1980, along with literally dozens of local droughts. The impacts of climate change have been adversely affecting economic growth. These impacts affect all economically sensitive sectors especially the agriculture sector. Ethiopia is a poor country and its economy is highly dependent on agriculture which had failed to meet the growing food demand. This is since the negative effect of climate changes on agricultural production and food security (World Bank, 2017). Moreover, (Deressa, 2006) the Ethiopian agriculture sector is negatively affected by climatic related disasters with drought and flood being the major one.

According to National Meteorological Services of Ethiopia (NMS, 2007) indicate that the average minimum and maximum temperatures have been increasing by about 0.25°C and 0.1°C, respectively over the past decade whereas the rainfall has been characterized by a very high level of variability over the past 50 years. Besides, rainfall and temperature patterns show large regional differences (Zerga & Gebeyehu, 2016).

Ethiopia is vulnerable to climatic variability due to its low adaptive capacity accountable to low level of socioeconomic development, high population growth, inadequate infrastructure, lack of institutional capacity and high dependence on climate sensitive natural resource-based activities (NMA, 2007). Adaptation is an essential strategy to enable farmers to cope with the adverse effect of climate change and variability which in turn increases the agricultural production of the poor farm households (Yesuf *et al.*, 2008). Similarly, knowledge of the adaptation methods on the side of smallholder farmers may make it better to tackle the challenge of climate change (Deressa *et al.*, 2009) and also the practical measure expected from the Ethiopia government.

However, developing adaptation strategies and enhancing the adaptive capacities of the local people and concerned stakeholders (FDRE, 2010) was the policy guideline of Ethiopian disaster risk management agency. In all cases the responsible body for handle such kind of climate change and make sure household food security by local knowledge and by the farmers itself; but the farmers perception and adaptation strategies on climate variability was low.

Coming to the study areas, there is a research gap to farmers' perception and adaptation strategies to climate change, initiated the researcher to raise the issue under consideration. Therefore, this study was identifying the gaps, like the different perception of farmers to climate change, limited adaptation strategies and inadequate relevant information, knowledge and skills. Hence, to enhance farmers' perception and adaptation strategies to climate change by providing awareness creation and opportunities to smallholder farmers ensure household food security. Therefore, to contribute in filling this gap and meet the local research need the study was aims to assess the trends and variability of temperature and rainfall in the study area, perception of farmers towards climate change, identify adaptation responses mechanisms and asses the implication to household food security.

1.3. The objective of the Study

1.3.1. General objective

The general objective of this study was to investigate “farmers’ perception and adaptation strategies to climate change and its implications to household food security in Lay Gayint, ANRS, Ethiopia”.

1.3.2. Specific objectives

The specific objectives of this study were:

- ✓ To determine temperature and rainfall trends and variability at different time scale (1987 - 2016).
- ✓ To assess the perception of farmers towards climate change.
- ✓ To identify the farmers’ adaptation responses to perceived changes in rainfall and temperature.
- ✓ To assess the effect of climate change on household food security status.

1.4. Research Questions

This research intended to answer the following basic questions which are derivative from the abovementioned research objectives:

- 1) To what extent varies temperature and rainfall and its variability at different time scale in the study area from 1987 to 2016?
- 2) How do farmers in the study area perceive climate change?
- 3) What are adaptation mechanisms practiced by farmers to perceived changes in rain fail and temperature?
- 4) How does climate change effects on the status of household food security in the study area?

1.5. Significance of the Study

As an academic endeavor, this research was giving clues or knowledge about the perceptions of farmers and climate change adaptation impact on household food security. The researcher expects the following as the benefits after rigorous investigation.

The study was providing comprehensive knowledge about the perceptions of farmers and climate change adaptation impact on household food security in Lay Gayint. This study was providing valuable information and help to the farmers, agriculture experts, NGOs, and any concerned bodies to address gaps and to understand the perception of the farmers to climate change and its strategies. The research served as a reference for farmers, agriculture experts and researchers, and the community at large who would like to hunt further scholarships from a new perspective and outlook of the district's household food security development.

1.6. Delimitation of the Study

This study is limited to the perceptions of farmers and climate change adaptation implication on household food security in Lay Gayent. Because of the surveillance, the birthplace of the researcher, data management, the sake of data gathering, and familiarization of the study area the researcher lay Gayint from different Woredas in south Gonder zone, Amhara region Ethiopia. In addition to this, the study was taking into considerations only the perception of farmers towards climate change, their adaptation mechanizes, and household food security from the various agro-climatic zones by considering the factors that may expect to affect the lives of the household.

Furthermore, the study was used mixed research approached to reach/ identify the perception of the farmers and climate change adaptation; implications in households live in lay Gayent. And still, data collecting mechanisms only by using questioner, in-depth interview, and decade's document analysis was the menses of data collection. As the nature of data collection, the size of the study area, the number of participants was limited the conclusion was made only in the study area.

1.7. Limitation of the Study

The study was specifically focused on “farmers’ perception and adaptation strategies to climate change: implications to household food security Lay Gayint, ANRS, Ethiopia”. The researcher tried to do all the best to maximize its fruitfulness of the study is subjected to some limitations. Like the awareness of the respondents to fill the questioner freely without frustrate, needs some benefits to fill the questioners, willingness to record their sounds, and the transmit ion of coronavirus (COVID-19). But thanks to my friends and Lay Gayint agriculture expert by, creating awareness on the benefits of the study. The relevant data were collected from the participants by applying the WHO rules and regulations of the COVID-19 pandemic.

It may also have methodological limitations since it used a simple random sampling technique to get sample respondents in each. Besides lack of SPSS skill but thanks to technology and my advisor, this is already solved.

1.8. Operational Definition of Terms

Household: - A household consists of one or more people who live in the same dwelling and share meals. It may also consist of a single-family or another group of people. A dwelling is considered to contain multiple households if meals or living spaces are not shared.

Food security: - Food security is a measure of the availability of food and individuals' ability to access it. Affordability is only one factor.

Perception: - Perception is the organization, identification, and interpretation of sensory information to represent and understand the presented information or environment. All perception involves signals that go through the nervous system, which in turn result from physical or chemical stimulation of the sensory system.

Farmer: - A farmer is a person engaged in agriculture, raising living organisms for food or raw materials. The term usually applies to people who do some combination of raising field crops, orchards, vineyards, poultry, or other livestock.

Climate change adaptation: - 'the process of adjustment to actual or expected climate and its effects.

Woreda: -are the third-level administrative divisions of Ethiopia.

1.9. Organization of the Thesis

This study was organized into five sections accordingly. the first chapter introduces; background of the study, statement of the problem, objectives of the study, basic research questions, significance of the study, delimitation of the study, limitation of the study, and operational definition of terms. In the second chapter related to the review of related literature, chapter three; research method and materials; is collected research design, description of the study area, the population of the study, sampling techniques and sampling determination, source of data, data collection procedures, methods of data analysis and ethical considerations. Interpretation and discussion of the results were chapter four and the last chapter was organized; summary, conclusion, and recommendation based on the findings were made. Lastly, the reference and appendix sections are attached.

Chapter Two

2. Review of Related Literature

2.1. Climate change

According to IPCC (2010) Climate change is rapidly emerging as one of the most serious threats that humanity may ever face. It has recently become a pressing issue in various development, environment and political forums at the national, regional and international levels. Many regional summits worldwide have dedicated discussion sessions on climate change based on the recognition that the global climate is changing and this has become more evident in recent years with the warmest year ever in record being 2010. Hence, climate change is happening and thus become the most important topical development policy and global governance issue in the 21st century (African Development Bank, 2010). Although no country is immune from the potential impacts of climate change, the impacts are highly significant in developing countries which have contributed least to greenhouse gas emissions (IPCC, 2010). These countries have limited adaptive capacity as compared to the developed countries because of their limited financial resources, skills and technologies, high levels of poverty, and their excessive reliance on climate sensitive economic sectors such as agriculture. Agricultural production in Africa is also adversely affected by Climate change.

It is widely recognized that climate variability and the occurrence of extreme weather conditions are among the major risk factors affecting agricultural production and food security in Africa and especially in Sub-Saharan Africa. In the region, the rainfall pattern is influenced by large-scale inter-seasonal and inter-annual variability resulting in frequent extreme weather events such as droughts (Mengisteab, 2005). According to projection by International Panel of Climate change (2010); in the coming decade's climate change, rainfall variability, and extreme climatic events are expected to adversely affect agricultural production and food security. Thus, by 2020; yields from Africa's rain-fed farm production could decrease by 50% as a result of changes in climatic conditions (Boko *et al.*, 2007; Christensen *et al.*, 2007). Climate variability has attracted much attention in recent decades, not only because of the globally unparalleled persistence of anomalously low rainfall, but also because of the low capacity of society and economical systems to cope with climate change related risks. As a result of this low capacity, extreme climate variability, such as drought; is frequently accompanied by ecological decline, decimation of livestock herds, widespread food scarcity, mass migration and great loss of human life (Temesgen *et al.*, 2014).

2.1.1. Climate Change in Ethiopia

The climate of Ethiopia is mainly controlled by the seasonal migration of the Inter-tropical Convergence Zone (ITCZ), which follows the position of the sun relative to the earth and the associated atmospheric circulation, in conjunction with the complex topography of the country (NMSA, 2001). There are different ways of classifying the climatic systems of Ethiopia, including the traditional, the Köppen's, the Throthwaite's, the rainfall regimes, and the agro-climatic zone classification systems (Yohannes, 2003). The most commonly used classification systems are the traditional and agroclimatic zones. According to the traditional classification system, which mainly relies on altitude and temperature for classification, Ethiopia has five climatic zones.

Table 2.1: Traditional climatic zones and their physical characteristics

Zone	Altitude (m)	Rainfall (mm/year)	Average annual temperature (°c)
Witch(upper highlands)	3200 plus	900-2200	>11.5
Dega(highlands)	2,300-3,200	900-1,200	17.5/16.0—11.5
Weynadega(midlands)	1,500-2,300	800—1,200	20.0—17.5/16.0
Kola(lowlands)	500-1,500	200-800	27.5—20.0
Bereha(desert)	Under 500	Under 200	>27.5

Source: MoA (2000)

Over these diverse agro-ecological settings, mean annual rainfall and temperature vary widely. Mean annual rainfall ranges from about 2,000 millimeters over some pocket areas in the southwest to less than 250 millimeters over the Afar lowlands in the northeast and Ogden in the southeast. The mean annual temperature varies from about 100 °C over the high table-lands of the northwest, central, and southeast to about 350 C on the northeastern edges.

In addition to variations in different parts of the country, the Ethiopian climate is also characterized by a history of climate extremes, such as drought and flood, and increasing and decreasing trends in temperature and precipitation, respectively. The history of climate extremes, especially drought, is not a new phenomenon in Ethiopia. The recorded history of drought in Ethiopia dates back to 250 BC, and since then droughts have occurred in different parts of the country at different times (Webb *et al.*, 1992).

Even though there has been a long history of drought, studies show that the frequency of drought has increased over the past few decades, especially in the lowlands (Lautze *et al.*, 2003). Studies also indicate that mean temperature and precipitation have been changing over time. According to (NMSA, 2018), the average annual minimum temperature over the country has been increasing by about 0.25 °C every 10 years, while the average annual maximum temperature has been increasing by about 0.1 °C every decade. Even though the change in precipitation is not as pronounced as the change in temperature, there is a decreasing trend (NMSA, 2018). Knowledge of the climatic conditions of the country and the adaptation options available to farmers will assist policy aimed at decreasing the vulnerability of farmers to future climate changes.

Ethiopia is vulnerable to climatic variability due to its low adaptive capacity accountable to the low level of socioeconomic development, high population growth, inadequate infrastructure, lack of institutional capacity, and high dependence on climate-sensitive natural resource-based activities (NMA, 2018) similarly (Negussie & Ashebir, 2016), South Nations Nationalities and People (SNNP), and Benishangul-Gumuz region were relatively not vulnerable, whereas Afar, Amhara, Oromia, and Somali regions were vulnerable. The lesser vulnerability of SNNP was associated with its relatively higher access to technology and the food market, its highest irrigation potential, and its literacy rate. Afar, Somali, Oromia, and Tigray regions were among the highly vulnerable regions. The vulnerability of Afar and Somali was mainly associated with lower levels of regional development. Even though these regions were less populated than the other regions, the people with access to institutions and infrastructure remain very low due to the lowest level of regional development.

2.2. Impact of Climate Change on Agriculture and Food security

Climate change is likely to influence agricultural production and food security worldwide. The climate variables of temperature, rainfall, radiation, etc. are necessary to consider crop productivity in various ways. The temperature increasing greater than 3°C is likely to affect negatively all of around the world. (IPCC, 2007; Lobell & Field, 2007) explained warming temperature, followed by carbon dioxide concentration regarding increased temperature, affects the yields of crops from a small result to a significant one in year-to-year difference within 20 years (Lobell & Field, 2007). Warmer winters have important effects, e.g., winter freezes are critical in many regions for minimizing future pest and disease outbreaks (Hansen *et al.*, 2012). Risks such as floods and drought are likely to be exacerbated due to changes in temperature and rainfall.

The impact of climate change on agriculture is the most important sector in sub-Saharan Africa, but it is predicted to be negatively impacted by climate change. Climate change will bring about substantial welfare losses especially for smallholders whose main source of livelihood derives from agriculture (Paulos & Belay, 2018). Changes in climate extremes are already having impacts on social, economic, and natural systems, and future changes associated with continued warming will present additional challenges (Karl *et al.*, 2008). The change in climate poses significant challenges for the event of agricultural-based countries (Adger *et al.*, 2003). The higher variability of climate, including temperature, precipitation, and other hazards is likely to increase the impacts on agricultural production due to the response of crops (Lin, 2011) explain that the consequences include also shifting in nutrient cycling and soil moisture, also as changes in pest and diseases infestation: all of which will greatly influence food production and food security (Fuhrer, 2003; Jones & Thornton, 2003).

Moreover, these changes are expected to increase abiotic and biotic stress, forcing the agricultural system to function under greater levels of discomposure in the future (Lin, 2011). The study of (Matsui *et.al*, 2001) found out that the high temperature decreases the number of germinated pollen grains per stigma, mainly through poor pollination in japonica rice (Matsui *et al.*, 2001); changes in soil moisture, land, and water condition, change in frequency of fire and pest infect, and the distribution of diseases (Edwards *et al.*, 2009). Even though, the impact is categorized as direct and indirect. Thus, the impact of climate change is detrimental to countries that depend on agriculture as the main livelihood. Using the single-index approach, the study results indicate that the combined riskiness of crop portfolios at a household level responds negatively to annual rainfall variability, while seasonal rainfall variability has a less consistent impact on livelihood. Therefore, the deferent researchers/studies were recommender the farmers are more likely to select less risky crops with less return, even when intercrop interactions are taken into account (Bezabih *et al.*, 2011).

Even though Climate change causes wide-ranging effects on the environment, and on socio-economic and related sectors, including water resources, agriculture and food security, human health, terrestrial ecosystems, and biodiversity. Changes in rainfall patterns are also likely to lead to severe water shortages and/or flooding. Rising temperatures also will cause shifts in crop growing seasons which affects food security and changes within the distribution of disease vectors putting more people in danger from diseases such as malaria.

Temperature increases will potentially severely increase rates of extinction for several habitats and species (UNFCCC, 2007). The intensity of tropical cyclones (Knutson *et al.* 2010) and frequency of heavy precipitation events are very likely to increase over many areas during the twenty-first century, with consequences for the risk of floods. At the same time, the proportions of arid lands are projected to increase, in addition to a tendency for drying during summer, especially in the subtropics, low and mid-latitudes (Bates *et al.* 2008). The vulnerability of these sensitive regions to impacts of hydro-meteorological disasters, in terms of loss of assets and economic value, has increased dramatically over the past few decades despite ongoing efforts in several sectors including agriculture (Mills, 2005).

According to the study of (Deressa, 2006) for Ethiopia, by using the Heckman sample selection model both increasing temperature and decreasing precipitation are damaging Ethiopian agriculture. Additionally, Climate change has a strong impact on the agricultural sectors and forestry by modifying or degrading productive capacities and by directly and indirectly increasing the risks associated with production (FAO, 2011).

2.3. Climate Change Perception

Perception is a process of receiving information and stimuli from our surroundings and converting them into psychological responsiveness (Van & Hawkins, 2000). Perception of climate change, as a tremendously difficult idea for the farmers, has limited boundaries as the individual's perception differs with the past and present situation (Saarinen, 1976) and the study of (Khan *et al.*, 2012) conducted a study in the coastal region of Bangladesh about farmers perception of climate variability and found that farmers who were previously engaged in fisheries are now moving to agriculture crop production. The farmers are reacting to understanding the events of climate change, especially temperature and rainfall.

It is explained by (Mekonon, 2013) that Global climate change has been described as “the mother’ of all problems”. This rhetoric suggests that catastrophic events will unfold as humanity marches blindly forward demanding more and more autos, jet travel, and air-conditioned homes. Once having crossed over the precipice, there will be no returning to that earlier world. The Earth’s atmosphere will have been irreversibly violated and humans must forever reap the consequences of their profligate lifestyle. This is what the global science, politics and environmental economics have been talking (James, 2003). But the issue is how the most vulnerable group in the least developed countries like Ethiopia perceives this mother of all problems. Despite the widespread scientific

debate and international forums concerning the impacts of climate change and variability, not much is known about rural farming households' perceptions of these impacts on their agricultural practices and role of their perception on choice of adaptation.

Farmers update their expectations of the climate in response to unusual weather pattern is promoted and very significant and should be supported with scientific research. No evidence was found that Ethiopian farmers plan on the basis of climatic norms but rather a higher weight is given to more recent years due to the pressure posed by the climate change impact (CEEPA, 2006). Understanding and analyzing the role of perception of farmers is important to identify and act appropriate agricultural practices and climate change adaptation strategy as part of an effort to promote variety of techniques such as farmer level adaptation, learning by doing, and copying from instruction.

On this regarded (Prager & Posthumus, 2010) the adopter perceptions paradigm posits that the adoption process starts with the adopters' perception of the problem and technology proposed. This paradigm argues that perceptions of adopters are important in influencing adoption decisions. Perceptions are context and location specific due to heterogeneity in factors that influence them such as culture, education, gender, age, resources endowments including land, and institutional factors (Prager *et al.*, 2010).

The study of (Paulos & Belay, 2018; Deressa *et al.*, 2011) revealed that farmers living in the dry lowland area perceived more change in climate than farmers in the wet lowland. This could either be related to the repeated drought events occurring within the area in recent years or might be linked to varied environmental changes that cause reduced water availability and agricultural yield within the dry lowland areas.

Concerning adaptation, better awareness and use of adaptation measures are revealed in the wet lowland condition as compared to the dry lowland. This difference between the two locations may call for further heightening of intervention to facilitate the scene for enhanced climate change perception and adaptation. Similarly, the study of (Deressa *et al.*, 2011), the age of the head of the household represents experience in farming, and studies have indicated that experienced farmers are more likely to perceive climate change.

The degree of education of the head of the household is also hypothesized to be positively related to awareness of climate change. Access to information on climate change through extension agents or other sources creates awareness and favorable conditions for the adoption of farming practices that are suitable under climate change. Higher-income positively affects the public perception of climate change. Similarly, it is hypothesized that higher farm and non-farm incomes positively influence farmers' perception of climate change.

A perception study conducted by (Marye, 2011) in South Gondar, a change of climate was well perceived by communities as most of them have been observing changes in temperature, precipitation and timing of rainfall and related frequent drought. Almost all participants understood that the change of climatic conditions over the past 20 years was obvious so that their reactive measures of climate impacts are highly attributed to their perception. Hence, this study compliments the climate change information in the area by integrating perception of the local community with adaptation responses.

2.4. Climate Change Adaptation in Agriculture

Adaptation is essentially an adjustment in human and/or natural systems to deal with the impacts of actual or expected changes in climate (IPCC, 2014; Adger *et al.*, 2003; FAO, 2011). Even though there was a climate change the residences were adaptation is widely recognized as a vital component of any policy response to climate change. Studies show that without adaptation, climate change is generally detrimental to the agriculture sector; but with adaptation, the vulnerability can largely be reduced (Smit & Skinner, 2002).

The degree to which an agricultural system is suffering from global climate change depends on its adaptive capacity. Indeed, adaptive capacity is that the ability of a system to regulate global climate change (including climate variability and extremes) to moderate potential damage, to require advantage of opportunities, or to cope with the consequences (IPCC, 2014). Thus, the adaptive capacity of a system or society describes its ability to modify its characteristics or behavior to cope better with changes in external conditions.

Adaptation to global climate change requires that farmers first notice that the climate has changed, then identify useful adaptations and implement them (Maddison, 2006). Many agricultural adaptation options are suggested in the literature. They encompass a good range of scales (local, regional, global), actors (farmers, firms, government), and types: (a) micro-level options, like crop

diversification and altering the timing of operations; (b) market responses, such as income diversification and credit schemes; (c) institutional changes, mainly government responses, such as removal-preserve subsidies and improvement in agricultural markets; and (d) technological developments the development and promotion of new crop varieties and advances in water management techniques (Smith & Lenhart, 1996; Mendelsohn, 2001; Smit & Skinner, 2002; Kurukulasuriya & Rosenthal, 2003).

Most of these represent possible or potential adaptation measures rather than ones adopted. Indeed, there is no evidence that these adaptation options are feasible, realistic, or even likely to occur. Furthermore, they might only be possible with complete and accurate knowledge of future climate, which is why these were aptly named "clairvoyant farmer" scenarios (Risbey *et al.*, 1999, cited by Belliveau *et al.*, 2006). Thus, climate change impact studies often assume certain adaptations and little explicit examination of how, when, why, and under what conditions adaptation occurs in economic and social systems.

2.41. Approaches to Climate Change Adaptation

Research on climate change–agriculture interactions has evolved from a "top-down" approach to a "bottom-up" approach. The top-down model starts with climate change scenarios, and estimates impacts through scenario analysis, based on which possible adaptation practices are identified. The bottom-up approach, on the other hand, takes on a vulnerability perspective where adaptation strategies are considered more as a process involving the socioeconomic and policy environments, producers' perceptions, and elements of decision-making (Bryant *et al.*, 2000; Wall & Smit, 2005; Belliveau *et al.*, 2006).

In the top-down, scenario-based approach, adaptations are assumed and are invariably treated as primarily technical adjustments (for example, changing to different crops, adopting efficient irrigation systems, or altering production systems) to the impacts identified. Most of these adaptations represent possible or potential adaptation measures, rather than measures that have been adopted. Indeed, there's no evidence that these adaptation options are feasible, realistic, or maybe likely to occur. Furthermore, they might only be possible with complete and accurate knowledge of future climate, which is why they need been aptly named "clairvoyant farmer" scenarios (Risbey *et al.*, 1999, cited by Belliveau *et al.*, 2006). These approaches are often found in spatial analysis, climate impact modeling, and Ricardian studies.

Most studies on climate impacts using the top-down approach carried out in South Africa (Kiker, 2002; Kiker *et al.*, 2002; Poonyth *et al.*, 2002; Deressa, 2003; Gbetibouo & Hassan, 2005) predicted adverse impacts on the agricultural sector with significant adverse effects on crop yields and marginal crop areas in the western part of the country, which might become unsuitable for the assembly of maize, the most staple crop. Vulnerability studies have shifted the focus of research from the estimation of impacts to the understanding of farm-level adaptation and decision making. Explores actual adaptation behavior Up-to down approaches that insist by the institution, government, and policymakers, whereas the down to top approach.

(Deressa *et al.*, 2009) analyses the determinants of farmers' choice of adaptation methods in the Nile Basin of Ethiopia using cross-sectional data from a survey of farmers. They are used a multinomial logit model to analyze the determinant of farmers' choice of adaptation strategies. This study found that the adaptation methods are changing planting dates, using different crop varieties, planting tree crops, irrigation, soil conservation, and not adapting.

According to the finding, the most common adaptation method was the use of different crop varieties while irrigation was the least common method. The result indicated that the reasons for not adapting are lack of information on climate change impacts and adaptation technology, lack of financial resources, labor constraints, and land shortages. The levels of education, age, sex, household size of farmers' were to be significant determinants of adaptation to climate change in the study area.

Besides, (Deressa et al. 2010) was used the Heckman model to the same data where a Multinomial model referred to above was used to assess farmers' adaptation to climate change. This model initially assesses farmers' perceptions that climate is changing followed by an examination of the response to this perception in the form of adaption. Thus, the Heckman model has two equations; the selection equation and the outcome equation. The study reveals that education of the household head, household size, whether the household was male, livestock ownership, use of extension services on crop and livestock production, availability of credit, and temperature all positively and significantly affected adaptation to climate change. However, large farm size and high annual average precipitation were negatively related to adaptation.

The study by (Tessema *et al.*, 2013) examined smallholder farmers' about climate change, types of adaptation strategies, factors influencing adaptation choices, and barriers to adaptation in Eastern Hararghe Zone, Ethiopia. The data collected from smallholder farmers' in the study area and employed a multinomial logit model. The result revealed that planting trees, early planting, terracing, irrigation, and water harvesting. Planting a tree is a major adaptation method and the results of the multinomial logit model showed that non-farm income, farm to farm extension, access to credit, distance to selling markets, distance to purchasing markets, income affect the choice of adaptation strategies. Finally, the study identified that lack of information as the most important barrier to climate change adaptation.

The other barrier includes; lack of farm input, shortage of land, lack of cash, lack of water, and lack of labor. However this study still focuses only on some variables of climate change adaptation. Therefore, this studies was included other variables and correlate with food security via the study area difference. The study of (Aemro *et al.*, 2012) identifying the determinants of farmer's choice of adaptation strategies to climate change in the Bailie district of Eastern Ethiopia. They collect and use the data both primary and secondary for this study.

Primary data were collected from a randomly selected 160 sample households interviewed through a semi-structured questionnaire, key informants interview, and focus group discussion. And also they give as a policy recommendation on awareness creation on climate change through different sources such as mass media and extension, encouraging informal social networks, facilitating the availability of credit, enhancing research on the use of new crop varieties that are more suited to drier conditions and different agro-ecological zones.

2.5. Barriers to Climate change Adaptation

The analysis of barriers to adaptation of climate change in the Nile basin indicates five major constraints to adaptation. These are lack of information, lack of money, shortage of labor, shortage of land, and poor potential for irrigation. Most of these constraints are associated with poverty. For instance, a lack of information on appropriate adaptation options could be attributed to the dearth of research on climate change and adaptation options in the country. Lack of money hinders farmers from getting the necessary resources and technologies that facilitate adapting to climate change.

Adaptation to climate change is costly (Mendelson, 2004), and the need for intensive labor use may contribute to this cost. Thus, if farmers do not have sufficient family labor or the financial means to hire labor, they cannot adapt. A shortage of land has been associated with high population pressure, which forces farmers to intensively farm a small plot of land and makes them unable to prevent further damage by using practices, such as planting trees that compete for agricultural land. Given the fact that the Nile Basin in Ethiopia is very rich in water resources (FAO, 1997), poor irrigation potential is most likely associated with the inability of farmers to use the water that is already there, due to technological incapability. Farmers in Ethiopia in general are very poor and cannot afford to invest in irrigation technology to adapt to climate change or sustain their livelihoods during harsh climatic extremes, such as drought.

2.6. Conceptual Framework

The conceptual framework was applied in this study to describe links between the farmers' perception of climate change variability and their adaptation strategy and its impact on household food security. Figure-1 describes the conceptual framework that has been constructed based on the assumption that there are various driving forces behind farmers' perception and adaptation strategies to climate variability and change. Some of the influencing factors that lead to farmers' perception and adaptation strategies to climate variability/change are shaped by Household demographic characteristics, Socio-economic status and farming characteristics. And also those driver factors are interrelated with each other and it influences household food security.

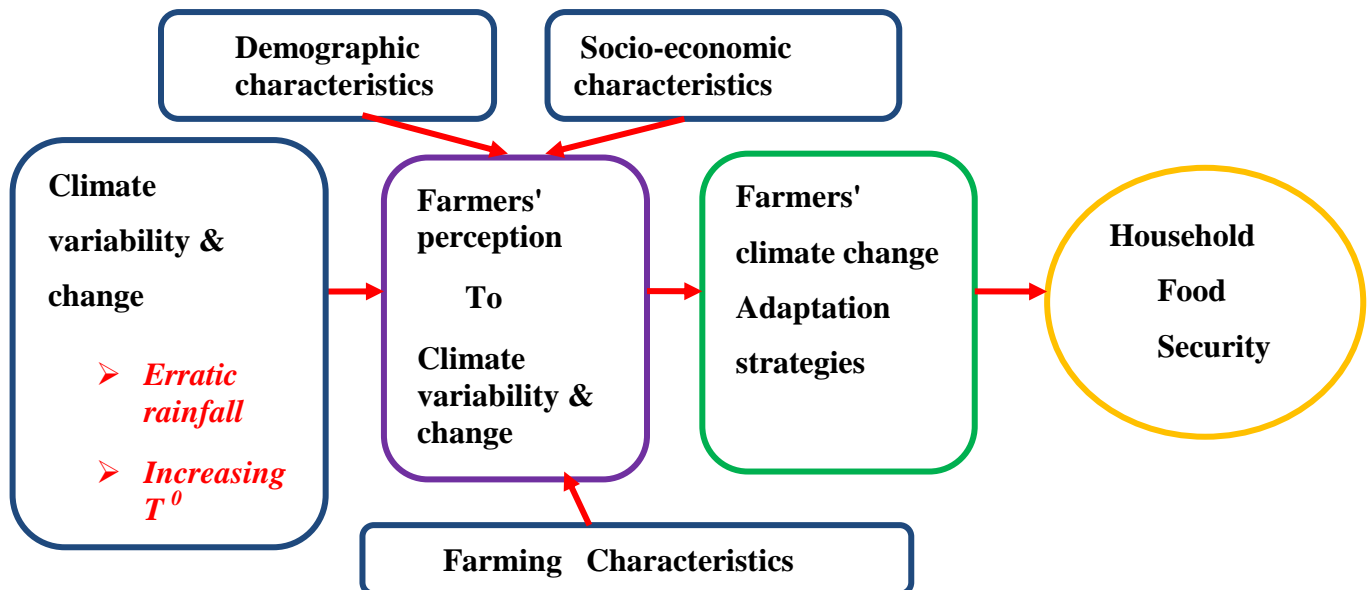


Figure 1: Conceptual framework, Source: Adapted from (Tekeste, 2019)

Chapter Three

3. Research Methodology

3.1. Description of the Study Area

Location

Lay Gayint is one of the ten woredas of South Gondar zone, Amhara National Regional State (ANRS) of Ethiopia. Lay Gayint is bordered by Mekiet woreda in the east, Ebinat and Bugina in the north, Estie, and Farta in the west, and Semada and Tach Gayint in the south. It is far about –737 km away from Addis Ababa. The study area is located in between of 11°32' - 12°16' N latitude and 38°12'-38°19' E longitude (CSA, 2008). The district covers a total area of 1519 km² with a total population of 200,293 of which 98% are living in the rural area and engaged on agriculture. It is one of the densely populated woredas in the Region with a population density of 185 persons per km² (CSA, 2007). The woreda is sub-divided into 28 rural kebeles and 3 urban with the center (Nefas Mewcha town) (LGWARDO,2019).

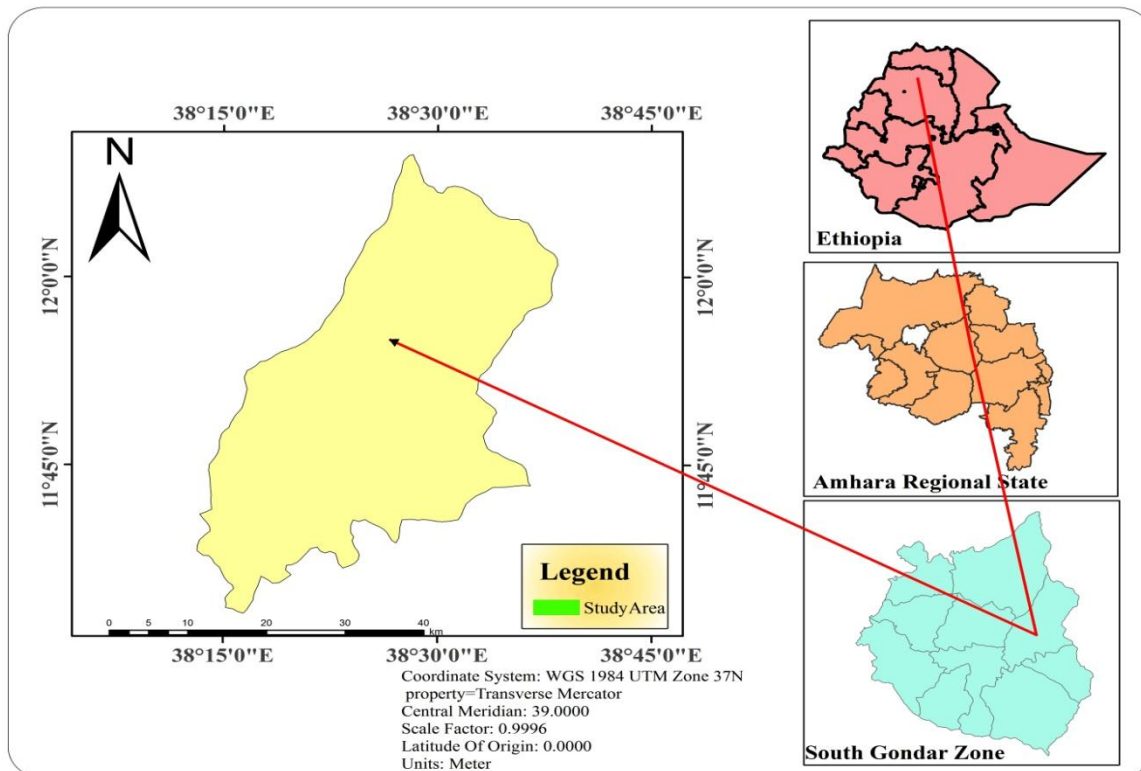


Figure 2: Map of Lay Gayint district, woreda (Source: CSA, 2007 based on national census data)

Population

The study area has a total population of 200,293 of which 98% are living in the rural area and engaged in agriculture (CSA, 2007). The total number of household being 3,045 with 2,708 male and 337 female. The study area was categorized into four livelihood zones: Abay-Tekze watershed Livelihood zone (ATW), Guna Highland Barley, and Potato Livelihood Zone (GHL), North East WoyinaDega Mixed Cereal Livelihood Zone (NMC), and Tekeze Lowland Sorghum and Goat Livelihood Zone (TSG). From the four livelihood zones, GHL has the largest household number (1061) whereas ATW with the smallest (569). (LGWAO, 2019).

Table 3.1: The total household number distribution in Livelihood zone

Livelihood zone	Household number		
	Male	Female	Total
ATW	489	80	569
GHL	918	143	1061
NMC	614	50	664
TSG	687	64	751
Total	2708	337	3045

Source: Lay Gayint Woreda Agriculture Office (2019)

Physical set up

It is one of the densely populated Woredas in the Region with a population density of 185 persons per km². The area has a very steep valley and incised stream channels with slopes ranging from 30.5% to 50%. The major land-use patterns of the study area comprise cultivated land (44.32%), grazing land (14.31%), forest/bush land (5.26%), water body (2.38%) infrastructure and settlement (5.92%), and unproductive land (28.44%) (LGWARDO, 2018).

The topography of the woreda is dominated by a chain of mountains (50 %), hills, and valleys (5 %) extending from Tekeze Gorge (1500 meter) to Guna Mountain Summit having the highest elevation of 4230 meters above sea level (masl). The flat terrain constitutes only 10 % of the total area. The woreda is divided into four elevation and temperature-based agro-ecological zones, namely: lowland/kolla (12.5%), midland/woynadega (39.42%), highland/dega (45.39%), and alpine/wurch (2.71%). Most of the rural population settled in the highlands and plateau areas. The main soil types are brown (55 %), red (15 %), black (15 %), grey (10 %) and other soil type (5 %) (LGWARDO, 2018).

Climate

The annual mean minimum and maximum temperatures range from 8° C to 29° C; the long-term average rainfall is 635 mm and is characterized by high variability and uncertainty. Problems of deforestation, overgrazing, poor quality soil, and lack of water conservation measures have contributed to the prevalence of drought in the woreda. The main rainy season occurs between June and September which represents the long rainy season (Meher) and the small rainy season (belg) occurs between March and May. For crop production, the highland areas (Dega) depend in most cases on Belg rain whereas the Woina-Dega and Kolla areas depend on Meher rain (LGWARDO, 2018).

Most of the people in the Woreda are engaged in mixed agriculture (crop cultivation and livestock rearing). Crop production is entirely rain-fed, except in very specific and small areas where vegetables are cultivated using traditional and small-scale irrigation. The most commonly produced crops in the study area are annual crops such as wheat, teff, maize, sorghum, barley, chickpea, beans, and oil crops. The main soil types found in the Woreda are brown (55%), red (15%), black (15%) grey (10%), and other soil types (5%) (LGWARDO, 2018).

3.2. Research Design

The major purpose of this study was to examine the farmers' perception and adaptation strategies to climate change: implications to household food security LGWANRS, Ethiopia. To accomplish the objectives of this study, explanatory research design was employed. In this study, mixed approach (qualitative and quantitative methods) was followed to triangulate the interpretation of data and results to enhance the reliability and validity of findings. In qualitative approach in-depth key informant interview (KII) guide, and field observations were tools for data collection.

In the quantitative approach household survey on the basis of structured questionnaire interview was conducted by researcher. Therefore, collecting quantitative data was help to get baseline information about the district farmer's perception and adaptation strategies to climate change; and qualitative information was help to have detailed information about knowledge and practices as well as the factors that affect the household food security either negatively or positively.

3.3. Research Method

3.3.1. Sampling techniques and Sample Size Determination

Multistage sampling techniques were used to get valuable information from the respondents. According to (Schutt, 2008) purposive sampling is one of the methods used in non-probability sampling, which is a sampling method in which the selection of population elements is unknown. Likewise (Torrance, 2012), Purposive sampling can be very useful for situations where one needs to reach a targeted sample quickly and where sampling for proportionality is not the primary concern.

Stratified sampling was used to create different strata in the livelihood zones (i.e. ATW, GHL, NMC &TSG). From each zone, vulnerable Kebeles (i.e. Shimada (06), Mekuabia (02), Mongolia (18), and Abiarbi (24)) were selected. The sample kebeles are more vulnerable to climate change variability and affected by this change also more representative according to obtained from the woreda agricultural office. Based on the information obtained from Lay Gayint woreda administration office, the sampling frame is 3,045 in the four kebeles. Then the number of sample households determined to be about 354 (11.62 % of the total households) by using a simplified formula proportion and the sampling method was used simple random sampling. According to (Yamane, 1967) provides a simplified formula to calculate sample sizes. Assume a 95% confidence level and 5% the desired level of precision.

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

$$n = \frac{3045}{1 + 3045 * (0.05)^2}$$

$$n:- \text{ sample size} = 3045/8.612$$

$$N: - \text{ total population of} = \underline{354}$$

$$e:- \text{ sampling error}$$

The sample size was determined (Yamane, 1967) formula to know the sample respondents from four livelihood zones owners. Therefore, from every livelihood zones the distribution of sample households in the sample kebeles proportion on their cluster as follows in the below table:

Table 3.2: Distribution of sample households in the sample kebeles based on livelihood zones

Livelihood zone	Selected kebeles	Total HH number	% out of a total population	Allocated sample size
ATW	Shemeda(06)	569	18.7	66
GHL	Mekuabia(02)	1061	34.8	123
NMC	Mongolia(18)	664	21.8	78
TSG	Abi-Arbi(24)	751	24.7	87
Total		3045	100%	354

Source: Lay Gayint Woreda Finance and Economy Development Office (2019)

Among from four livelihood zones, the total number of the household was 3045, among them in each zone the number of the household varied from one livelihood to livelihood because of this the number of participants varies as there proportion; i.e. ATW zone 569 total number of households (18.6%) which means 66 households were a participant of this study; GHL 1061 household numbers 34.8% which means 123 households; in NMC livelihood zone there was 751 household in this 21.7% of the households which means 87 subjects were participants of this study and from TSG livelihood zone 751 household owners among them 24.7 % which means 87 household owners were parts of this study. Totally 354 participants were part of this study selected by using simple random sampling and, 2 agriculture heads and 4 agriculture experts in the study area were included. Totally 360 participants were included.

3.3.2. Data collection tools and Sources

To obtain reliable data on the farmers' perception and adaptation strategies to climate change: implications to household food security LGW-ANRS, Ethiopia both primary and secondary data were used. The primary data was collected through close-ended standardized liker scale type questionnaires on the perception of climate change, adaptation strategies, and household food security status of farmers because such data collection instrument was developed together with large data and avoid pressure on the respondents (Creswell, 2003). And semi-structure key informant interview was administered to the experts and office administrators. Because the human language is

very useful in opening what lies behind people's actions and a small number of respondents (Zikgmund, 1994).

Secondary data was collected from National Meteorology Agency about the trend in temperature and precipitation in the study area. The use of triangulation or multiple data collection methods is a way of enhancing the credibility of data collected (Best & Kahn, 1999) to have a complete picture.

In this study, the data was collected through the following data collection tools:

Survey Method

A preliminary survey was apprehended in the research site to collect baseline information. The organized questionnaire was equipped to gather quantitative information from the farmers. The questionnaire was prepared first in English and then was translated into Amharic language (indigenous language) to make the questionnaire easily comprehensible for the respondents (annex:1). Before tangible data collection, the questionnaire was verified for its pertinence on small numbers of respondents out of the study area via a pilot study with a smaller number of participants. The data for the study samples were collected.

Key Informant Interview (KII)

Four agricultural experts and two office administrators, totally six key informants were nominated based on not only their familiarity with the local people's language and culture but also having knowledge, skills, and abilities of the guiding to validate and provide supplementary insights to in-depth personal interviews. The woreda agricultural office heads and Agricultural development agents were interviewed.

Document Analysis

Document analysis was another form of instruments to get relevant information, from the Ministry of Agriculture, Central Statistical Agency (CSA), and National Metrological Agency (NMA) and Environmental Protection Agency and specifically a 30 years *Woreda* metrology data were obtained from NMA.

3.3.3. Methods of Data Analysis

Descriptive data analysis

For the quantitative information, descriptive statistics such as percentages, frequency tables, means, and standard deviations were used to summarize and present demographic, socio-economic, and institutional factors depending on the nature of the data. Accordingly, the statistical analysis was carried out by using MBI SPSS version 25, for each variable the statistical test was conducted at 0.05 α level. The measure of central tendencies (mean) and measures of dispersion (standard deviation) were the major descriptive techniques that were used to summarize and compare the data.

The data collected qualitatively was transcribed and analyzed using thematic analysis methodology. Thematic analysis is a good research approach to find out some things about people's views, opinions, knowledge, experiences, or values from a set of qualitative data. Qualitative data obtained through key informant interviews, and field observation. The data organized, summarized, analyzed, and interpreted concerning the survey results. Both quantitative and qualitative data were used to assess the perception of farmers towards climate change and farmers' adaptation responses because of its implication to household food security in the area.

Analysis of rainfall and temperature variability

Rainfall and temperature variability over 30 years was analyzed by calculating the coefficients of variability (CV) of the rainfall and temperature values at different time scale. The CV of annual and monthly rainfall and temperature calculated by using the following formula as (Agrawal, 2010):

$$CV = \frac{\sqrt{\sum f(x_i - \bar{x})^2}}{n \cdot \bar{x}}$$

Where, \bar{x} mean annual rainfall in mm, n-number of years for which the rainfall data are available, x_i - annual rainfall (mm) of the year (i) of a given station, and δ - standard deviation.

According to NMSA (1996) the annual rainfall variability of an area with a coefficient of variation, where, $CV < 20\%$ is less variable, CV is between 20% and 30% moderately variable, and $CV > 30\%$ is highly variable.

The analysis of rainfall and temperature involved characterizing long-term mean values, calculations of indices of variability and trend at annual and seasonal time steps.

The standard anomaly was calculated to assess rainfall and temperature variability.

$$\text{SRA} = \text{Pt} - \text{Pm} / \delta$$

Where **Pt** is annual (rainfall or temperature) in year **t**, **Pm** is a long-term mean annual (rainfall or temperature) throughout the observation, and δ is the standard deviation of rainfall. Mann-Kendall test as described by Sneers (1990) was used to detect trends. The significance level of the slope was estimated using Sen's method. Mann-Kendall test and Sen's method are less affected by outliers (Salmi et al., 2002). The study applied Agnew & Chappel's (1999) drought severity assessment method. This method provides a more elaborate classification of drought magnitudes.

The model differentiated drought severity into four scales: extreme drought ($S < -1.65$), severe drought ($-1.28 > S > -1.65$), moderately drought ($-0.84 > S > -1.28$) and no drought ($S > -0.84$).

3.4. Ethical Considerations

The central ethical issue surrounding data collection through interviews is that participants should not be harmed or damaged in any way by the research. If a respondent becomes upset during an interview, the session should be immediately abandoned. Confidentiality should be offered to respondents when completing questionnaires and participating in interviews. Furthermore, respondents have the right not to answer individual questions or to terminate the interview before its completion (Gray, 2006).

Thus, the researcher has protected the rights and well-being of participants in the research; and they were told that all information they are supposed to provide was kept secret and used only for research purposes. Moreover, the researcher communicated with the participants about what procedures are involved and their purpose; the relationship between the researcher and the participants; any discomfort or risk; answering questions with their consent; and the participants' right to withdraw consent at any time without prejudice.

3.5. Pilot Test and Reliability of the Instruments

To check its content and face validity, the questioners were adapted from previous studies. The English version of the questionnaires was translated to Amharic by the researcher and translation experts, back translation was made and it was also commented by linguistic professionals just for correcting language use and to check face validity. Before collecting the whole data from the participants and applying statistical tools pilot taste was done in objective groups from 50 subjects, which were not included in the sample units. Testing of the reliability of the scale is very much important as it shows the extent to which a scale produces consistent results if measurements were made repeatedly by different respondents in the same questions. Cronbach's alpha is the most

widely used method to check the reliability of the questioners. It has mentioned that its value varies from 0 to 1 but the satisfactory value is required to be more than 0.6 for the scale to be reliable (Cronbach, 1951). In the present study, the researcher used Cronbach's alpha scale as a measure of reliability and the value showed that perception (.813). This means that it's reliable and the researcher was confidential to collect the data by using the instruments.

Chapter Four

4. Result and Discussion

4.1. Socioeconomic and Demographic Characteristics of the respondents

As shown in Table 4.1, the Participant' demographic characteristics the total households sampled in the survey is 295 (81.94%) were males and 65 (18.05%) females. According to Tekeste (2019), male-headed households were in a better position to pull more labor force than the female-headed ones and they also made decisions on farming activities.

Table 4.1: Demographic Characteristics of Respondents

Variable		Frequency	Percent
Sex	Male	295	81.94
	Female	65	18.05
Age category	20-29	22	6.11
	30-39	90	25.00
	40-49	180	50.00
	50 and above	68	18.88
Marital status	Single	5	1.23
	Married	343	95.27
	Divorced	3	0.83
	Windowed	9	2.5
Family size	Number of families ≤ 5	215	60.73
	Number of families > 5	139	39.27
	Average family size	4.8	
Educational level	Illiterate	149	41.38
	Read and write	98	27.22
	8 th grade Completed	74	20.55
	10 th grade completed	34	9.44
	Graduate	5	1.38

Source filed survey data (2020)

The survey result in the Table 4.1, indicates that out of the total household age is indicated by their first birthday, 22 (6.11%) were 20 to 29 years, 90 (25 %), 30 to 39 years, 180 (50 %) 40 to 49 years and the remaining 68 (18.88%) were > 50 years. The studies of (Santrock, 2011) the age has positive significant effect on the perception of farmers in the study area toward rainfall change, drought, and frequency of drought and crop failure due to shortage of rainfall. They also feel there is an increment of temperature in the past 30 years. With regard to marital status of the household head showed that 5 (1.23%) single, 343 (95.27%) married, 3 (0.88%) divorced and 9 (2.5%) was widowed.

The family size of the sampled household ranges between 1 to 10 and the average family size of the sample household is 4.8 which is slightly below the national average family size of five. The survey result in the Table 4.1 indicates that out of the total household size in the study area 215 (60.73) of the respondents has > 5 family members and 139 (39.27%) has < 5 family members. This number of family size has their own positive effect on climate change and adaptation (Dereessa, 2007) the large family size is normally associated with a higher labor endowment, which would enable a household to accomplish various agricultural tasks.

On the other hand, (Tekeste, 2019) argue that as household size increases, obviously the number of mouths to feed from the available food increases. Hence, it is hypothesized that household size and food insecurity are positively related. This study support that the second argument which indicates the negative relationship between family size and climate change household food security.

And their education level 149 (41.38%) were illiterate who are unable to read and write, 98(27.22%) can read and write, 74 (20.55%) can complete 8th grade, 34(9.44%) can complete 10th grade and the remaining 5(1.38%) was graduate in higher education. The educational level of farmers has a direct link with the perception to climate variability. Farmers with relatively higher education levels have opportunities to get information from schools, environmental clubs and other sources of information. Thus farmers with higher educational level have better perception than farmers with lower levels of education. This result was in lined with (Deressa *et al.*, 2010)The levels of education, age, sex, household size of farmers' were to be significant determinants of adaptation to climate change in the study area.

Table 4.2: Household Head Socio-Economic Status of Farmers

Variable		Frequency	Percent
Annual Household income	Below 10,000:00 ETB	11	3.10
	10,000:00—20,000:00 ETB	192	54.23
	20,000:00—30,000:00 ETB	113	31.92
	30,000:00—50,000:00 ETB	28	7.90
	Above 50, 000:00ETB	10	2.82

Source: Lay Gayint Woreda Finance and Economy Development Office (2018)

Table 4.2 shows the household economic status of the farmer's was measured by using annual household income, 11 (3.10 %) < 10,000:00 ETB, 192 (54.23%) 10,000:00 to 20,000:00ETB, 113 (31.92%) 20,000:00 to 30,000:00 ETB, 28 (7.90%) 30,000:00 to 50,000:00 ETB and 10 (2.82%) <50,000:00 ETB annually by different income-generating activities. As the researcher to find out the source of income activities from their respondents through field survey, 5 (1.41 %) was cattle rearing, 83 (23.44 %) crop production, 78 (22.03 %) mixed farming, 7 (1.97%) both farming and trade and 181 (51.12 %) were farming and daily laborer. Therefore, this indicates that all most all of farmers in the study area gaining annual income from farming practice, and direct linkage with climate change and variability.

Table 4.3: Farming characteristics the respondents

Variable		Frequency	Percent
Types of farming	Rain-fed	222	62.71
	Irrigated	78	22.03
	Mixed	54	15.25
Purpose farming	Subsistence	201	56.77
	Profit-making	7	1.97
	Both substance & profit	146	41.24
Farming year/experience	11-20 years	24	6.77
	21-30 years	85	24.01
	31—40 years	107	30.22
	41—50 years	100	28.28
	Above 51 years	38	10.73
Farming method	Labor	13	3.67
	Animal traction	341	96.32
	Tractor	-	-

Source filed survey data (2020)

Table.4.3 shows that 222 (62.71 %) was farming by rain-fed, 78 (22.03%) irrigated, and 54 (15.25 %) mixed farming. Therefore, most of farmers in the study area depended on rain-fed agriculture and highly venerable to climate change. The purpose for farming was 201 (56.77%) for subsistence daily and annual feeds, 7 (1.97%) for profit, and 146 (41.24%) for both substance and profit. Therefore, most of farmers was practiced farming activities for the purpose of subsistence to feed the household members than profit gaining, this indicates that the climate variability affect on the farmers livelihood.

According to (Amadou *et al.*, 2015) farmers with high experience are more perceive climate change. This can be as a result of their ability to understand the farming systems better and respond accordingly. In line with his argument the respondents in the study area about 24 (6.77 %) was 11 to 20 years, 85 (24.01 %) 21-30 years, 107 (30.22 %) 31 to 40 years, 100 (28.28 %) 41 to 50 years and 38 (10.73%) were above 51 years farming experience. Therefore, this finding reveal that most of farmers experienced with the farming above 20 years and better to perceived climate variability and their phenomena in the past decades. The farming method of the farmers was 13 (3.67 %) by labor and 341 (96.32%) were farming by using animal tracking. This indicates that still the most farmers in the study area used traditional farming method than modern and mechanized.

4.2. Temperature and Rainfall trend and variability

Meteorological stations in Ethiopia are few in number and data for most of the stations is very scant and incomplete even for the available stations. There is no established meteorological station in Lay Gayint wereda. Hence, there is no reliable detailed information on aspects of the climate of the area. Monthly temperature and rainfall trends and variability data of 30 years 1987 to 2016 for the study area were obtained from the National Meteorological Service Agency of Ethiopia (NMSA).

Ethiopian agriculture is highly exposed to climate variability, and in particular to drought and related heat stress. There are close correlations between changes in rainfall, agricultural productivity, growth of the domestic product, and broader human well-being. Global circulation models predict an increase in temperature of 1.7 to 2.1 degrees Celsius by 2050. The combination of higher temperatures and more unpredictable rains has negative implications for the length and reliability of the growing season (World Bank, 2017).

4.2.1. Temperature and Rainfall trend

In Ethiopia, climate variability and change in the country are mainly manifested through the variability and a decreasing trend in rainfall and increasing trend in temperature. Besides, rainfall and temperature patterns show large regional differences. The Ethiopian climate is also characterized by a history of climate extremes, such as drought and flood, and increasing and decreasing trends in temperature and precipitation. The average annual minimum temperature over the country has increased by about 0.37°C , since, the average annual largest temperature has increased by about 0.1°C every decade (NMA, 2007).

Temperature trend

The trend of maximum and minimum temperature in the study area was shows that a slight increment from year to year between 1987-2016. As indicated in (Fig 4.1), the maximum and minimum annual temperature of the study area has increased by 0.58°C and 0.39°C in the past three decades. On the other hand, the result showed that the trend of average annual temperature has increased by about 0.49°C in the past three decades. Therefore, the effect of increased temperature will depend on the crop's optimal temperature for growth and reproduction. In some areas, warming may help the types of crops that are typically planted there, or allow farmers to shift to crops that are now grown in warmer areas. But, in the study area factors that affect agricultural production, such as changes in farming practices and yields was decline.

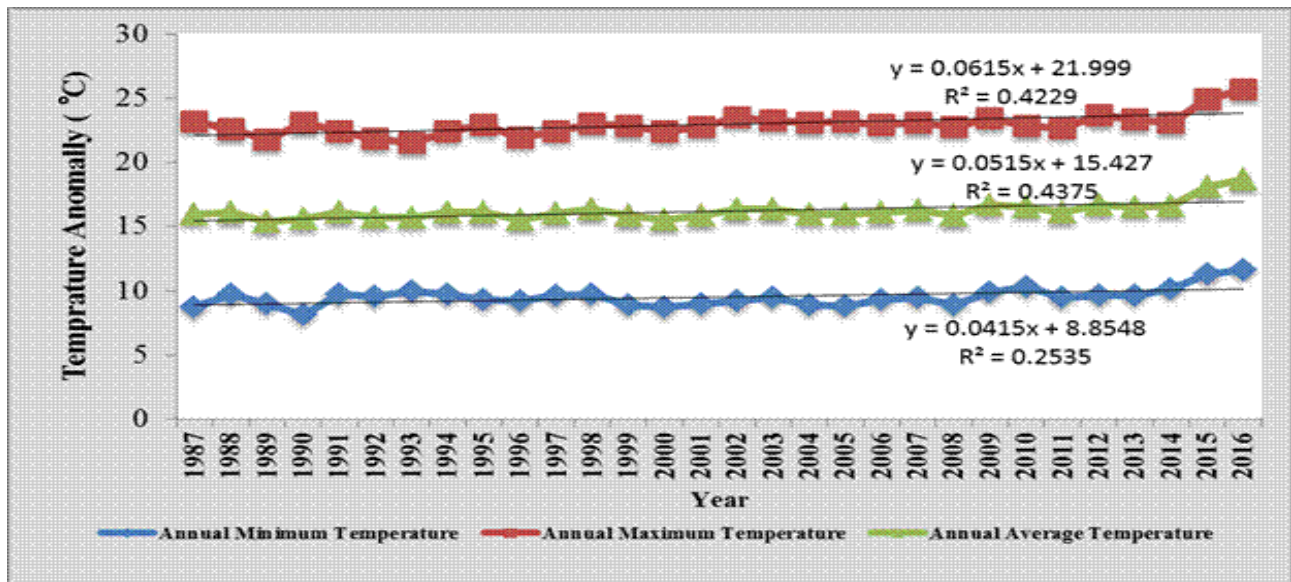


Figure 4.1: Trends of annual average maximum and minimum temperature in the study area (Source: NMSA, 2020).

Rainfall trends

Three seasons in Ethiopia; *Belg* (spring), *Kiremt* (summer), and *Bega* (winter). *Belg* (February-May) is the small rainy season in Ethiopia. Much of the northeastern, central-southern, eastern and southeastern parts of the country receive a considerable amount of rainfall during this season. *Kiremt* (June-September) is the main rainfall season for most parts of the country except for the lowlands of southern and south-eastern Ethiopia. *Bega* (October-January) is mostly a dry season for most parts of the country except for southwestern as well as the lowlands of south and southeast Ethiopia (NMA, 2015).

The data obtained from NMA, the annual rainfall of Lay Gayint *woreda* ranges between 689.6 mm as a least, and 1284.1mm as the most, for the past 30 years (Annex:7). Analysis of the linear trend of annual rainfall indicates an increasing trend in the station. As it is shown in Figure 4.2 annual rainfall has experienced inter-annual variability over the past 30 years (1987-2016). The inter-annual patterns of rainfall distribution showed that annual amounts were below the average (1091.24 mm) for 12 years out of the considered 30 years. This indicates that the trend of rainfall does not show any consistent increase or decrease through periods but it shows that there is great variability in different years.

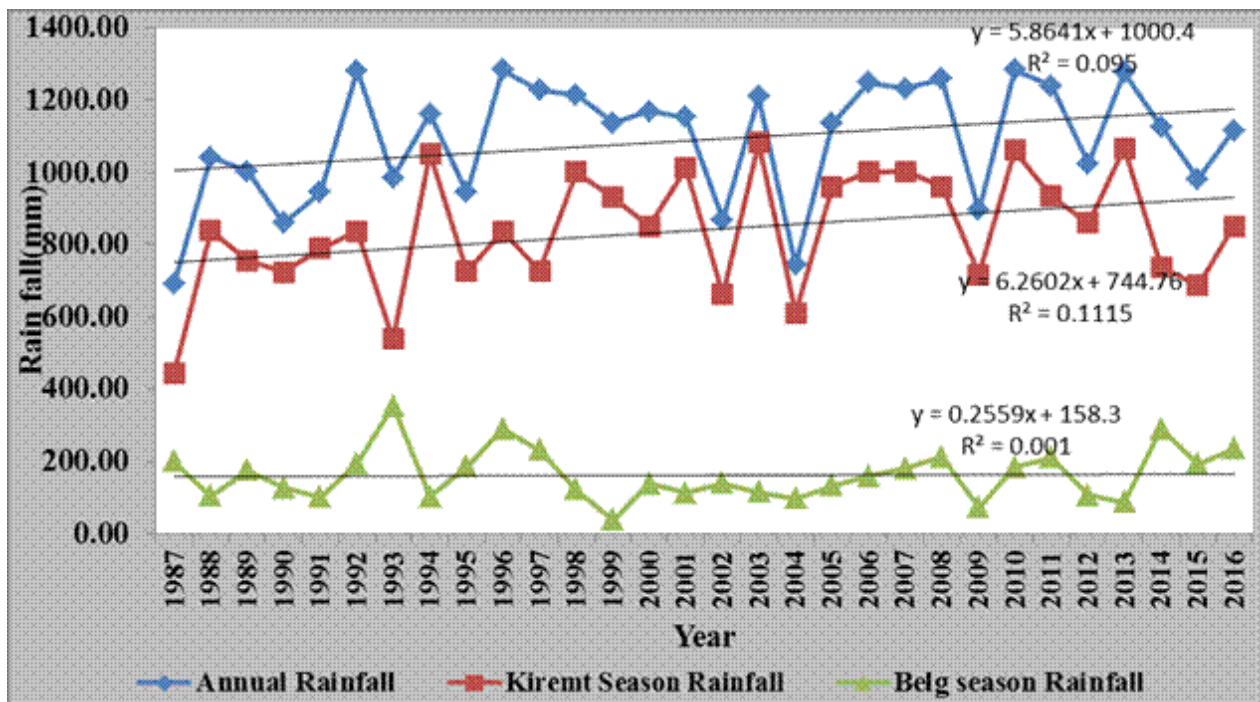


Figure 4.2: Trend of Annual and Seasonal Rainfall

Source: NMA (2020)

The trend of Annual, *Belg*, and *Kiremt* rainfall of the study area is indicated in Figure 4.2. Annual rainfall has been increased much by 170.1 mm for the last thirty years and increased by 56.68 mm in per decade, in small rainy season (*Belg*) rainfall has decreased by 7.39 mm for the last thirty years and decreased by 2.46 mm in per decade, this shows that insignificant trends, and in main rainy season (*Kiremt*) rainfall have increased significantly by 181.54 mm in the past three decades and 60.51 mm in per decade. In the past three decades, the study area annual rainfall and main rainy season rainfall show a significant increasing trend. Whereas, small rainy season rainfall very high decreased trend. This indicates that insufficient precipitation in the *Belg* season and it affects the farming practice in the study area.

4.2.2. Temperature and Rainfall Variability

In the study area, the average monthly rainfall and temperature distribution were analyzed. According to NMA (2020) data shows that July is the wettest month of *Kiremt* season with the highest average rainfall of 342.5 mm and average temperature 15.7 °C; while January is the driest *Bega* season with an average rainfall of 6.6 mm and an average temperature of 15.5 °C. On the other hand, during *Belg* season observed the highest average rainfall in May 61.88 mm and the highest average temperature observed in May 17.7 °C in the study area.

Temperature variability

The temperature distribution was characterized by minimum, maximum and average annual temperature variability. According to the data obtained from NMA the annual average temperature distribution in the study area was 16.2 °C with the minimum average 9.5 °C and maximum average 22.9 °C characterized by a general trend of increase and inter-annual variability as show (Annex:5). The annual average maximum temperature was 22.3 °C in the first decade (1987-1996) and 23.5 °C in the last decade (2007-2016) of the years considered by the study since the annual average minimum temperature was 9.3 °C in the first decade and 10 °C in the last decade of the study. This shows that there is an average temperature increase of 0.7 °C and 1.2 °C respectively in the minimum and the maximum average temperature of the study area. This lead to the climate extremes, such as drought. It's the main manifestation of climate change in the study area, can shrink household farm production and could lead to the death of livestock and household food insecurity.

Rainfall Variability

According to NMA (2020) data shows that the rainfall distribution in the study area was analysed. on the base of this data, average mean for annual rainfall, small rainy season (*Belg*) rainfall, main rainy season (*Kiremt*), and dry season (*Bega*) rainfall was computed as 1091.25 mm, 162.26 mm, 841.80, and 87.19 mm with a standard deviation of 167.48, 71.0, 165.06 and 65.09 respectively. Similarly, the coefficient of variation in Annual, Belg, kismet, and Bega season rainfall is 15.35%, 48.76%, 19.61 and 74.66% respectively, which means this much amount of rainfall has deviated from the mean (Annex: 7).

Table 4.4: Annual and seasonal rainfall (mm)

Rainfall	Mean	SD	CV	CV %
Annual	1091.25	167.48	0.15348	15.35
Belg	162.26	71.0	0.437595	48.76
Kiremt	841.80	165.06	0.196084	19.61
Bega	87.19	65.09	0.746574	74.66

Source: (NMA, 2020)

Rainfall variability has historically been a major cause of food insecurity and famines in the country (Bewket, 2009). Therefore, changes in rainfall conditions have a direct and immediate impact on the performance of the agricultural sector as well as in the country's total GDP (FAO. 2006). According to NMSA (1996) classified the rainfall variability of an area shown the coefficient of variation in annual rainfall variability is less than 20% is less variable, CV between 20% and 30% is moderately variable and CV greater than % 30 is highly variable.

On the base of rainfall variability classification, the analysis of rainfall variability CV in annual rainfall variability is less than 20% (15.35%) which shows less variation. The coefficient of variability in *Belg* season rainfall is greater than 30% (48.76%) which indicated highly variable, in *kiremt* season rainfall is less than 20% (19.61%) indicated less variable and in the *Bega*, season rainfall is greater than 30% (74.66%) is highly variable in the past three decades.

4.2.3. Drought Characteristics

Drought is a natural local or regional phenomenon, its basic cause being the lack of precipitation over a while. Drought may be studied from the environmental or the water resources point of view. Environmental droughts can be classified into meteorological, hydrological, and agricultural drought (Wilhite and Glantz, 1985). This study was focused on meteorological drought, which can be expressed by the so-called drought indices.

According to Agnew & Chappel (1999) drought severity assessment method classifies the drought severity into four scales: extreme drought, severe drought, moderate drought and no drought ($S < -1.65$), $(-1.28 > S > -1.65)$, $(-0.84 > S > -1.28)$ and $(S > -0.84)$ respectively. Based on this drought severity assessment method Figure 4.7 shows that the drought severity scales in the study area between the years 1987-2016. Extreme droughts observed in the study area in the year 1987 and 2004 (-2.40 and -2.08 respectively), severe drought appeared in 1990 and 2002 (-1.38 and 1.33 respectively), moderate drought shows in the years 1991, 1995, and 2009 (-0.88, -0.87, and -1.18 respectively). The rest year was not observed drought in the study area.

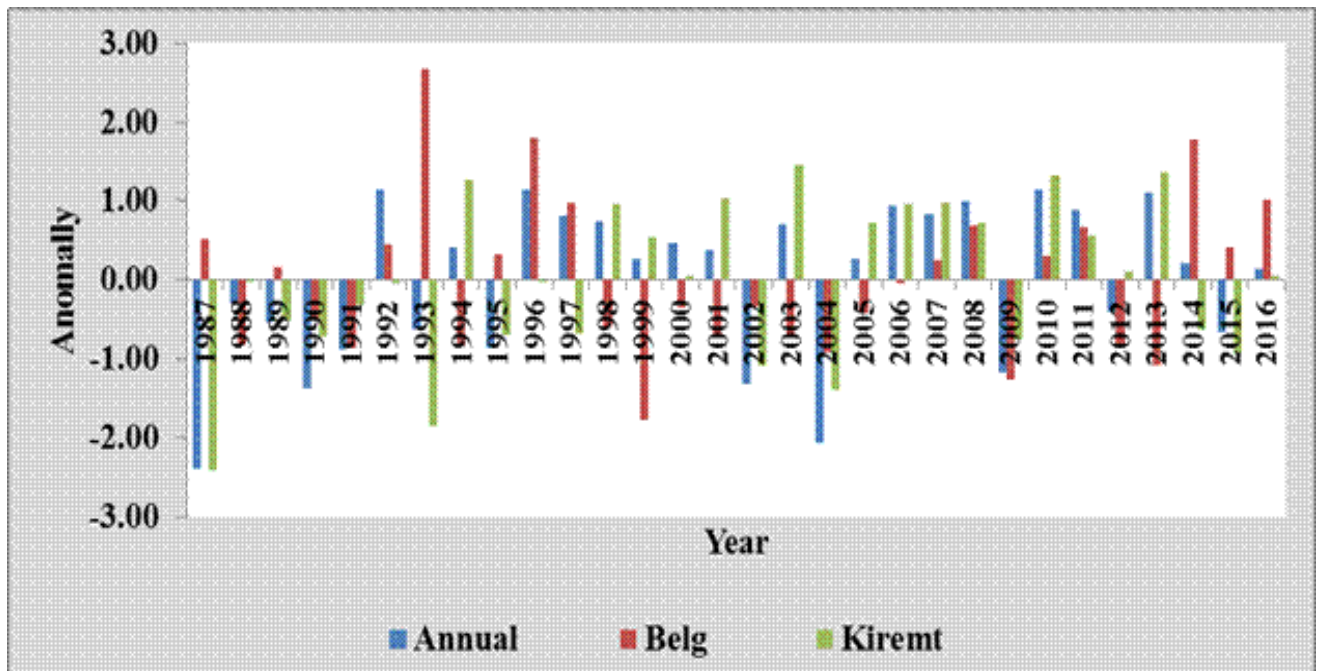


Figure 4.3: Drought severity. Source: NMA (2020)

The above figure indicates wet and dry years, 1993 was an extremely wet year due to the occurrence of high rainfall or other phenomena.

Extreme drought severity observed in the years 1987 and 2004; severe drought appeared in the years 1990 and 2002, moderate drought was observed in the years 1991, 1995, and 2009 these shows the periods received below normal rainfall. This event affects the food systems in the study area. Drought may pressure pasture and food supplies, reduces the amount of quality forage available to grazing livestock, changes in crop production, and reduce yields. During wet years, high crop production was experienced, with larger numbers of livestock while, dry years experienced low production of crops, reduced the number of livestock and it may result in the occurrence of household food insecurity. Factors, which contributed to the reduction in the number of livestock during the dry seasons in the study area included lack of pasture and water, selling of livestock at cheap prices to earn money for food, and moving livestock to other places in search of good pastures.

4.3. Farmers Perception to climate variability

Understanding farmers’ perception of climate variation is as equally important as designing local adaptation and coping strategies. Farmers who perceive climate change is hypothesized to make adjustments in their farms to reduce climate change-induced impacts unless they do face some barriers. Although, identification of agricultural adaptation options to climate change is not an easy task as there is no adaptation marked for climate change alone. Most adaptation options have a broad spectrum of values which can be considered an adjustment to climate change, market policy, demographic pressure, economic conditions, resource availability, and technology (Bewuket, 2010).

Table 4.5: Farmers’ perception of annual and seasonal temperature trends

Farmers’ perception	Perceived		
	Increased	Decreased	The same
Annual temperature in the last two decades	301	10	2
%	85.02	2.82	0.56

Source: field survey (2020)

The results on perception of climate change revealed that, 313 (88.41%) were perceived on the annual temperature in the last decades. Among them 301 (85%) perceived there was an increment, 10 (2.82%) decrease, and 2 (.56 %) of the participants perceived no change. In line with this KII participants replayed that there was an increase in annual temperature from time to time. Therefore, it concluded that most farmers were perceived that there were annual and seasonal temperature trends. This result was consistent with the last three decades the largest and minimum annual temperature of the study area has increased by 0.58 °C and 0.39 °C. Therefore, it can conclude that the farmers were perceived trends of temperature.

Table 4.6: Farmer's perception of Rainfall pattern

Farmers' perception	Perceived		
	Increased	Decreased	The same
Change in Amount of Rainfall	44	232	21
%	12.42	65.53	5.93
Change in time of rainfall	38	254	9
%	10.73	71.75	2.54

Source: field survey (2020)

The results revealed that, regardless of the change in the amount of rainfall, 297 (83.89%) farmers were perceived on change in rainfall. Among them 44 (12.4%) perceived there was an increment, 232 (65.53%) decrease, and 21 (5.93 %) of the participants perceived no change. On the other hand, the change in time of rainfall, 301 (85.02%) farmers were perceived on change in time of rainfall. Among them, 38 (10.73 %) was perceived there was an increment, 254 (71.75 %) decreased, 9 (2.54 %) replays the same. Therefore, the most respondents was perceived in the amount of rainfall is decreased from time to time and it affects on the agricultural productivity.

Table 4.7: The perception of farmers on the onset of rainfall

Farmers' perception	Perceived		
	Increased	Decreased	The same
Early on the set of rainfall	289	35	18
%	81.63	9.88	5.04
Late rainfall of rain set	34	287	18
%	9.60	81.07	5.08

Source: field survey (2020)

The results revealed on the early onset of rainfall, the farmers were perceived 289 (81.63 %) were increased, 35 (9.88 %) decreased, 18 (5.04 %) responded there was no change. Therefore, most of the farmers were perceived early on the set of rainfall. This result was also in lined with the KII. This was helped the farmers to prepare for managing the disaster.

On the other hand, the perception of farmers on late rainfall of rain set the result revel that 34(9.60 %) was perceived there was an increment, 287 (81.07 %) decreased, 18 (5.08 %) replays the same. Therefore the farmers were perceived on the early on the set of rainfall. This result was also in lined with the KII.

Table 4.8: Early cessation and poor distribution of rainfall

Farmers' perception	Perceived		
	Increased	Decreased	The same
Early cessation of rainfall	267	0	57
%	75.42	-	16.10
Poor distribution of rainfall	272	0	51
%	76.83	-	14.40

Source: field survey (2020)

The results revealed on the early cessation of rainfall, the farmers were perceived 267 (75.42 %) were perceived to increase and 57 (16.10 %) responded there was no change in the early cessation of rainfall. This implies that the rainfall variability was happened in the study area at the past three decades. On the other hand, the farmer's perception of poor distribution of rainfall, the result reveal that 272 (76.83 %) was perceived there was an increment of poor rainfall distribution and 51 (14.4 %) perceives there was the same rainfall poor distribution. Poor distribution of rain fall affects the agricultural productivity and causes for drought.

Table 4.9: The volume of the flood and strong wind

Farmers' perception	Perceived		
	Increased	Decreased	The same
Frequent high volume flood	271	9	47
%	73.72	2.54	13.27
Strong wind	253	7	83
%	71.46	1.97	23.44

Source: filed survey (2020)

The results revealed the frequency of high volume flood, the farmers were perceived 271 (73.72 %) were perceive there was increase high volume flood, 9 (2.54 %) decreased, 47 (13.27 %) of the responded there was no change in frequency of high volume flood. On the other hand, the perception of farmers on the strong wind, the result reveal that 253 (71.46 %) was perceived there was an increment, 7 (1.97 %) decreased, and 83 (28.44 %) replays there was the same/ no change in strong wind.

From all the climate change variables the farmers were perceived whether or not climate change in the study area. Annual and seasonal temperature, rainfall pattern, the onset of rainfall, early cessation of rainfall, poor distribution of rainfall, and volume of the flood and strong wing were checked. In this regard, most of the farmers were perched the climate change variables in the study area in the last decades.

4.4. Climate Change Coping Practice

Table 4.10: Assessment of coping option to climate change

Copping option to climate change	Yes	(%)	No	%
Migrate to an urban area	237	66.94	117	33.05
Reduce food intake	300	84.74	54	15.25
Look for daily work	314	88.70	40	11.29
Collect fuel wood for sale	255	72.03	99	27.96
Sell assets (livestock, etc.)	237	66.94	117	33.05
Borrow grain from others	293	82.76	61	17.23
Borrow money	282	79.66	72	20.33
Purchase of food by credit	253	71.46	101	28.53
Use safety Net	222	62.71	132	37.28

Source: field survey (2020)

The result was revealed on the perception of farmers on climate change coping options (Table 4.6). The assessment of coping option to climate change and barriers faced in the time of crop failure or climate change varies from the experience of farmers to farmers among them 237 (66.94 %) were used migrate to urban areas, 300 (84.74 %) reduce food intake, 314 (88.70 %) were look for daily work, 99 (27.96 %) collect fuel wood for sale, 117 (33.05 %) sell assets, 61 (17.23 %) borrow grain from others, 282 (79.66 %) borrow money, 253 (71.46 %) was the purchase of food on credit and 323 (91.24 %) of the farmers were replayed that use Safety Net program.

The studies of (Mendelson, 2004) reported that a lack of information on appropriate adaptation options could be attributed to the dearth of research on climate change and adaptation options in the country. Lack of money hinders farmers from getting the necessary resources and technologies that facilitate adapting to climate change. And similarly the adaptation to climate change is costly (FAO, 1997), poor irrigation potential is most likely associated with the inability of farmers to use the water that is already there, due to technological incapability.

Therefore, it can conclude that the farmers perceived the climate change variability. However there adaptation strategies and mechanisms varied from farmers to farmers. This harms the food security of the household owners. drought severity scales in the study area was in lined with the years 1987-2016 shows that there was extreme droughts observed in the study area in the year 1987 and 2004 (-2.40 and -2.08 respectively), severe drought appeared in 1990 and 2002 (-1.38 and 1.33 respectively), moderate drought shows in the years 1991, 1995, and 2009 (-0.88, -0.87, and -1.18 respectively). The rest year was not observed drought in the study area. (NAM, 2020).

The knowledge or perceived the occurrence of any risk was gaining 50% of the solution or any intervention that promotes the use of adaptation measures to climate change may account for location-specific factors that determine farmers' perception of climate change and adaptive responses.

Table 4.11: Adaptation strategies on climate change

Adaptation type	Yes	%	No	%
Enhancing traditional irrigation schemes (including water harvesting)	59	16.66	295	83.33
Using moisture stress-tolerant crop varieties	54	15.25	300	84.75
Using improved crop varieties	154	43.50	200	56.50
Shifting from crop-producing to planting trees	100	28.24	254	71.76
Adjusting planting time	123	34.74	231	65.26
Enhancing livestock rearing practice	92	25.99	262	74.01

Source: field survey (2020)

The result revealed on the use of farmers adaptation strategies on climate change, 59 (16.66%) were use traditional irrigation schemes, 54 (15.25) moisture stress tolerance crop, 154 (43.50 %) applying improved crop varieties, 100 (28.24 %) shifting from the crop- production to planting trees, 123 (34. 74 %) adjusting planting time, and 92 (25.99 %) was enhancing livestock rearing practice. Therefore, most of farmers in the study area was limited adaptation strategies to climate variability and farmers who have the existence of food shortage or deficits at household level. This implies that negative implication to household food security. This result was in lined with (Asrat and Simane,

2012) previous knowledge of climate adaptation, technologies of adaptation, and lack of information are the causes of an effective adaptation mechanism. And also the study of (Mendelson, 2004) studies on barriers to climate change adaptation, the result shows that lack of information, lack of money, shortage of labor, and poor potential for irrigation and forecast was the barriers to adaptation. This harm household food security.

4.5. Climate change adaptation implications to food security

There is a consensus that climate change and agriculture have cause and effect relationships. Agriculture is the most important sector in sub-Saharan Africa, but it is predicted to be negatively impacted by climate change. It is clear that climate change will bring about substantial welfare losses especially for smallholders whose main source of livelihood derives from agriculture (Paulos & Belay, 2018).

According to Deressa et al., (2011) The major adaptation response such as soil and water conservation measures, change and diversify crop varieties, improving the quality of land and change the farm sites, shifting planting dates, adjusting to crop and livestock management, application of irrigation, diversification of off-farm and non-farm activities, change use of capital, labor, and application of chemicals and fertilizers. Those adaptation response apply properly on the base of climatic variability is important for increase agricultural production and ensure food security.

The months of adequate household food provision was applied for both those who perceived climate variability and the non perceived ones just to see if their perception of farmers has impact on climate change adaptation strategies and their household food security status. Accordingly, all those who perceived climate variability have positive impacts on choose proper adaptation response to climate change. On the base of the result farmers in the study area was perceived both temperature increment and erratic rain fall but their adaptation response was limited. This implies that all respondents' exception of the 40 households is unable to access adequate food for 12 months preceding the period of this survey.

Table 4.12: Months of Adequate Food Provision by household on the base of adaptation practice

Description	The Respondents practiced			
	different adaptation strategies	%	Limited adaptation strategies	
Monthly adequate food provision	40	12%	314	88%

Source: field survey (2020)

As above table depicts, it is 12% of the respondents who are reported to have been experiencing adequate food provision at household level throughout the year. On the other hand, this is the percentage of respondents with 12 months of adequate food provisioning. Still, there are respondents, which accounted for 88%, who reported to have faced food deficit even if the months of food shortage vary from household to household in the study area. The respondents said that their perception of climate variability enabled them to produce an adequate and diversified crop for both household consumption and market supply. Most of them reported to have produced diversified crops by intercropping or crop association.

Those farmers who perceived climate variability applied crop rotation in order to obtain diversified crops over the past years. According to KII participants, revealed that those who have positive perception of climate variability, none of them reported the existence of food shortage or deficit at household level. It is stated that every member of the household is having an adequate, nutritious and diversified food items. It is also noted that each member of the household has the access to better quantity and quality of food regardless of their sex and age. Among the household members, no one left behind while serving food, the partakers said. But rather, everybody in the household come together and eats what is served.

Availability of food for household consumption throughout the year has profoundly improved the ability of everyone in the household to access better quantity and quality food. It is mentioned that farmers have been selling crops to purchase other food items from the local markets. They were doing this (selling of crops) for their children to have nutritious food.

Different vegetables are reported to have been grown in their backyards. The purpose of growing vegetable, as to respondents, was to avoid unnecessary costs they incur to purchase them from the market. It is noted that the vegetables they were and are (still) growing helped them to meet the household needs in addition to generating income from it.

The respondents who perceived climate variability, everyone in the household eats as much food as he/she can regardless of their gender. It depends on the consumption of an individual member of the household rather than on the sex or other factors. Therefore, the implementations of climate change adaptation response in the context of specific socioeconomic characteristics of farmers have paramount importance to increase agricultural production and ensure food security. This has significant implication on household's food security status.

Chapter Five

5. Conclusion and Recommendation

5.1. Conclusion

The temperature and rainfall trends and variability of the study area was shows that changed from year to year between 1987-2016. The results indicate that annual maximum, minimum and average temperature trends and variability of the study area has slightly increased trends and inter-annual variability in the past three decades. On the other hand, annual rainfall and main rainy season rainfall show a significant increasing trend. Whereas, small rainy season rainfall show that very high decreased trend. However, *Belg* season, and *Bega*, season rainfall were indicates highly variable. While, *kiremt* season rainfall were indicates less variable in the past three decades.

Farmers in Lay Gayint Woreda perceive the long-term change in temperature and rainfall patterns. They can recognize that frequency of drought has increased over the years and the pattern of rainfall in volume and timing has become unpredictable. The local people's perception of climate change and variability is in line with the climatic records of the meteorological agency. Farmers with different socio-economic characteristics perceive climate change differently; farmers with long farming experience and better educational status perceived more than those farmers otherwise.

Farmers have perceived climate change; however, most of the farmers did not apply different kinds of climate adaptation strategies taken as response measures. Different adaptation options employed by the farmers are reactive and developed through time for which they are highly dependent on-farm experience and locally specific which is born out of necessity by the individual farmers themselves. Their actual adaptation measures are not in line with the perceived adaptation options due to various influencing factors and barriers.

The study area of most farmers was suffered from drought and annual food insecurity in the last decades. Even while the farmers were perceived the climate change variability, there low adaptation strategies and mechanisms impacts on agricultural productivity and the households unable to access adequate food for 12 months proceeding also exposed to annual food insecurity.

5.2. Recommendations

- The National Metrology Agency should be provided adequate extension information services to ensure that farmers receive up-to-date information about rainfall and temperature patterns in the forthcoming season so that they can make well-informed decisions about their planting dates.
- The woreda agricultural office should be enhancing farmers' awareness on climate change and adaptation response by establishing meteorological services to be strengthened to increase local-level adaptive capacity.
- Farmers should be gathering information about climate variability, their impact and adaptation response from woreda and kebele agricultural expertise. Also practicing different adaptation strategies on farming activities.
- Improving access to education, inputs, and extension: Improving education would do the most to enhance using appropriate adaptation options including the application of agricultural technologies and inputs, practicing appropriate off/non-farm income-generating activities through extension services to use the key adaptation options.
- Promoting farm-level adaptation: adaptation strategies need to emphasize the roles of identification and provision of crucial information on better intensification and diversification techniques of production by enhancing farmers' awareness on climate change and creating affordable adaptation strategies.
- Identifying livelihood-specific adaptation measures; relative importance and advantage of each adaptation option for agriculture.
- Protect assets and diversify income source to withstand climate-related shocks: The government should also invest and strengthen non-agricultural sectors, that can create new livelihood and employment opportunities, drain and absorb landless farmers from subsistence farming which create more pressure on the already weak agriculture sector.
- Research institutions and government bodies could contribute to mitigating climate change impacts on agriculture by investing in the perception of local farmers' knowledge and response capability on climate change.

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Annexes

Annex 1: Questionnaire for household survey



My name is EyasuMelkammeri, a graduate student at Addis Ababa University. I am researching the partial fulfillment of a Master of Science (MSc) degree in Food Security and Development studies. On the title offarmers’ perception and adaptation strategies to climate change: implications to household food security lay Gayint district, Amhara region, Ethiopia. This is to be completed by the Household Head (Farmer) the main objective of this questionnaire is to understand. This type of local-level study is important for planners as well as decision-makers at a different level. Therefore, the information that you provide is believed to help the concerned bodies in understanding farmers’ knowledge toward climate change, and their adaptive capacity toward problems due to climate change; in household food security Accordingly, you are kindly requested to give answers freely and openly. Any information you give is kept confidential. Thus, your cooperation is very essential to achieve the desired goal of the study.

Your genuine participation by responding patiently to the questionnaire is highly appreciated and thank you for giving your time and willingness to participate in filling this questionnaire.

Household head identification number _____

Enumerator name _____

Date _____

I. Socio-economic profile of households

Below are some statements about the socio-economic profile of household farmers. Please choose the statement that describes your experience and put this “✓”symbol correspondingly in the options of your level of agreement on the questions.

Variable	Response	
Gender	Male	
	Female	
Age category of household	20-29	
	30-39	
	40-49	
	50 and above	
Marital status	Single	
	Married	
	Divorced	
	Windowed	
Religion	Orthodoxies	
	Muslim	
	Protestant	
	Catholic	
Educational level	Illiterate	
	Read and write	
	First cycle complete	
	Secondary education completes	
	High school complete	
	Graduate	
If you liquidate all of your private properties, how much capital (in terms of monetary value) will you have	Below 1000 ETB	
	100-10000 ETB	
	10001—30000 ETB	
	30001—50000 ETB	
	Above 50001ETB	
With this total capital, in which socio-economic group	Rich	

does this household head is categorized?	Medium	
	Poor	
How do you make your life?	Cattle rearing	
	Crop production	
	Mixed	
	Petty trading	
	Farmer and trader	
	Daily laborer	
	Other (specify)	

PART II: - Farming characteristics of household

Below are some statements about the socio-economic profile of household farmers. Please choose the statement that describes your experience and put this “√”symbol Correspondingly in the options of your level of agreement on the questions.

Farming characteristics of household	Response	
What type of agriculture do you practice?	Rain-fed	
	Irrigated	
	Mixed	
Why do you do farming?	Subsistence	
	Profit-making	
How long have you been farming?	10 years	
	11-20 years	
	21-30 years	
	31—40 years	
	41—50 years	
	Above 51 years	
What power do you use for farming?	Labor	
	Animal traction	
	Tractor	

PART III: -Farmers' Perception of Climate Change

PLEASE CIRCLE THE ONE NUMBER FOR EACH QUESTION THAT COMES CLOSEST TO REFLECTING YOUR OPINION

ABOUT IT. Description 1= Perceived 2= Not perceived

Variable	Perception	1	2
Farmers' perception of annual and seasonal temperature trends		1	2
Farmer's perception of Rainfall pattern	Change in Amount of Rainfall	1	2
	Change in time of rainfall	1	2
The perception of farmers on the onset of rainfall	Early on the set of rainfall	1	2
	Late rainfall of rain set	1	2
Early cessation and poor distribution of rainfall	Early cessation of rainfall	1	2
	Poor di stribution of rainfall	1	2
The volume of the flood and strong wind	Frequent high volume flood	1	2
	Strong wind	1	2

PART V: -Farmers’ Perception of Climate Change

Below are some statements climate change adaptation mechanisms of the household farmer. Please choose the statement that describes your experience and put this “✓”symbol correspondingly in the options of your level of agreement on the questions.

Adaptation type	Yes	No
Enhancing traditional irrigation schemes (including water harvesting)		
Using moisture stress-tolerant crop varieties		
Using improved crop varieties		
Shifting from crop-producing to planting trees		
Adjusting planting time		
Enhancing livestock rearing practice		
Food security checklist mechanisms	Yes	No
Migrate to an urban area		
Reduce food intake		
Look for daily work		
Collect fuelwood for sale		
Sell assets (livestock, etc.)		
Borrow grain from others		
Borrow money		
Purchase of food on credit		
Use SafetyNet		

PART IV: Asses household food security status

Now I would like to ask you about your household’s food supply during different months of the year. (Think back over the last 12 months, from this month going backwards).

Please note: This includes any kind of food from any source, whether from one’s own farm, purchased or exchanged, borrowed, given for free, or taken on credit.

<p>1. Were there months, in the past 12 months, in which you did not have enough food to eat for the full month?</p> <p>2. If yes, tick the situation of the food adequacy per month below. If No, go to Section F.</p>		<p>Yes <input type="checkbox"/></p> <p>No <input type="checkbox"/></p>
Month	Enough Food	Not enough food
March 2020	<input type="checkbox"/>	<input type="checkbox"/>
February 2020	<input type="checkbox"/>	<input type="checkbox"/>
January 2020	<input type="checkbox"/>	<input type="checkbox"/>
December 2019	<input type="checkbox"/>	<input type="checkbox"/>
November 2019	<input type="checkbox"/>	<input type="checkbox"/>
October 2019	<input type="checkbox"/>	<input type="checkbox"/>
September 2019	<input type="checkbox"/>	<input type="checkbox"/>
August 2019	<input type="checkbox"/>	<input type="checkbox"/>
July 2019	<input type="checkbox"/>	<input type="checkbox"/>
June 2019	<input type="checkbox"/>	<input type="checkbox"/>
May 2019	<input type="checkbox"/>	<input type="checkbox"/>
April 2019	<input type="checkbox"/>	<input type="checkbox"/>

If you had no months in which you did not have inadequate food, how was your household able to have enough food?

Annex 2: Key informant interview guide

KII check list

Respondent Name _____ Position _____

Organization _____

Mobile Number _____ Date _____

1. Do you notice climate change in the last two decades?

2. Which kind of manifestations of climate change do you notice?

3. _____

4. What are the main climate change adaptation mechanisms?

5. _____

6. How can you adapt to climate change?

7. _____

8. What is your opinion about the current climate change status in your local area?

9. _____

10. Who is more concerned about the impacts of climate change?

11. What are the major factors associated with the perception of farmers about the impacts of climate change on socioeconomic characteristics?

12. _____

13. Were you affected by the past drought? If the answer is yes mention the impact of drought on your wealth (crop production, livestock, food security, health, and drinking water)

14. During a drought period, how people copewith the problem occurred?

15. Is there migration due to drought? If yes, where did you migrate?

16. How many family heads are under food insecure and get food aid from international donors?

17. How many kebeles are graduated due to farmers become self-sufficient crop producer?

Annex 3: Monthly Minimum temperature distribution

Table 1. Monthly Minimum Temperature distribution in Lay Gayint woreda

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
1987	9.023933	9.918358	9.764858	8.594175	8.639975	9.655483	9.31895	8.282167	7.628175	7.017808	8.203275	8.708533	8.729641
1988	9.272925	10.13647	11.34575	11.22246	11.45723	11.08747	10.99228	10.28463	9.618483	8.577717	6.9749	5.925342	9.741303
1989	6.056792	7.949475	9.333592	9.709933	10.68914	11.12206	10.45758	10.06862	9.213608	6.8357	7.854642	7.953	8.937012
1990	7.932792	9.103783	8.832033	7.956633	9.382733	9.1503	8.580883	8.074192	7.6697	5.91155	8.347808	6.8985	8.153409
1991	9.403342	10.18755	10.07883	9.356692	10.36196	11.54533	11.2685	10.45545	9.849933	9.120475	8.980875	6.450233	9.754931
1992	6.93575	9.393117	11.70679	10.84531	11.03483	10.94024	10.11377	10.45269	9.959767	8.95125	7.262492	7.156667	9.562723
1993	7.2205	8.865975	10.35449	9.82185	10.43164	10.94247	10.74637	10.12679	9.473692	10.49806	11.20668	9.608983	9.941458
1994	9.462033	10.10868	10.06803	11.35869	11.04418	11.08429	11.0028	10.53723	8.850733	8.080492	8.025833	7.217033	9.736669
1995	5.835058	8.533942	8.571125	11.09008	11.42594	11.39335	11.17638	11.28848	9.8249	7.692283	7.7268	6.881908	9.286688
1996	6.792675	8.689767	9.780008	11.05019	10.41458	10.61981	10.66597	10.23175	10.27478	8.248108	7.605858	6.056092	9.202466
1997	6.625542	7.355875	9.512808	10.44668	10.5443	11.8366	10.81197	10.57236	10.20176	9.680667	9.522233	8.230708	9.611792
1998	7.503492	8.266833	9.8304	11.66074	11.59748	11.96717	11.15506	11.20062	10.3392	10.34473	7.667333	5.2329	9.730495
1999	7.25195	9.782267	8.738883	9.604467	10.06377	9.764208	10.48963	10.20981	9.52285	8.884842	5.92295	6.1009	8.861376
2000	6.519258	7.682067	9.114083	9.846867	10.08963	10.88014	9.573275	9.288567	8.942942	8.33575	7.3432	6.535483	8.679272
2001	6.612258	8.75235	9.322517	9.9997	10.70013	10.0935	10.40728	10.07568	9.292358	8.754517	6.927892	6.990483	8.994056
2002	7.101367	8.826642	9.768083	10.28169	11.5675	11.53368	10.76768	9.784958	9.0622	7.59945	7.163892	7.045017	9.208513
2003	6.868683	9.35625	9.551475	9.987658	10.75826	11.44304	10.89799	10.75166	9.963975	8.046408	8.5435	7.395142	9.46367
2004	8.685667	7.916733	9.03805	10.47973	10.46453	10.39057	9.967	10.25373	8.698858	6.8711	7.237425	6.190242	8.849469
2005	5.701158	9.318192	9.058683	11.07889	10.53183	10.8418	10.33918	10.08819	9.5111	7.537175	7.241417	3.933742	8.765114
2006	7.302	9.481358	9.104058	9.868683	10.24134	10.94348	11.08079	10.50502	9.506925	8.432575	8.03425	7.590192	9.34089
2007	8.419242	9.693992	8.816258	10.97608	11.57277	11.31049	11.39958	10.65122	10.02071	8.113667	7.479608	5.093558	9.462265
2008	8.6605	8.447092	8.236733	10.77136	10.43477	10.52752	10.34042	9.950775	9.432767	8.236108	6.117858	5.2667	8.868549
2009	7.074608	9.606542	11.01107	10.68619	10.83293	11.43574	10.81779	10.93673	10.5367	9.450625	8.564325	8.035508	9.915729
2010	8.535192	11.04084	9.947625	11.19713	12.03459	12.55115	11.31685	10.77083	10.32578	9.147817	8.907592	7.8717	10.30392
2011	7.768442	9.082175	8.900892	10.49168	10.40816	11.29512	10.93656	10.34705	10.16162	9.084533	8.886	6.6707	9.502743
2012	6.142083	11.17793	10.02276	10.68382	10.7898	11.34497	10.8767	10.1032	9.612917	8.205875	9.468542	7.111717	9.628358
2013	7.917075	9.476108	10.16904	10.67727	11.5194	11.26214	10.69826	10.59315	9.715908	8.799708	8.574458	6.337992	9.645042
2014	8.162083	8.6549	10.21214	11.40952	11.76056	11.48468	11.35081	10.53599	9.73155	9.44535	8.689792	9.781525	10.10158
2015	10.22536	12.36861	11.67858	12.01039	11.1904	12.41556	11.84516	11.09106	10.74848	9.981575	10.90142	11.34067	11.31644
2016	11.43772	13.37979	11.68327	12.35332	11.65978	12.02047	11.87453	11.73564	10.95287	10.28911	9.81295	12.70411	11.65863
Total	7.748316	9.418455	9.785097	10.51726	10.78814	11.09609	10.709	10.30827	9.621508	8.539167	8.173193	7.277176	9.498473

Annex 4: Monthly Maximum Temperature distribution

Table 2. Monthly Maximum Temperature distribution in Lay Gayint woreda

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Total
1987	23.82796	24.59308	23.88575	24.62948	22.8262	22.94763	23.0248	20.62688	22.63384	23.13418	23.00031	22.67211	23.15018
1988	24.17503	23.39682	26.69823	25.72413	25.38791	23.9505	19.06443	18.03052	19.95165	20.78082	21.47485	21.96577	22.55005
1989	22.50634	23.15083	22.03642	21.45157	23.15129	23.16393	20.51228	19.66822	20.50249	20.35963	23.17342	21.43847	21.75957
1990	24.15332	24.16623	25.36705	25.34644	25.84718	24.14275	20.46179	19.89227	20.12757	22.11055	23.12311	22.48638	23.10205
1991	24.26708	24.41073	24.24438	24.42646	24.25093	23.43608	20.064	18.53729	20.84149	21.78023	22.12459	21.15452	22.46148
1992	21.23556	22.6742	24.81426	23.78417	23.41569	24.23499	20.97918	18.56764	20.44585	20.73863	19.58387	21.15743	21.80262
1993	21.89184	22.25766	23.30071	21.22188	21.84894	22.2431	19.51296	19.86717	20.38721	21.18775	22.2823	22.34417	21.52881
1994	23.28098	24.19094	24.95363	24.92837	24.44834	22.38835	18.15879	18.59751	20.61124	22.74362	22.60704	22.45983	22.44739
1995	23.41002	23.92534	24.7206	24.25583	23.98324	24.84618	20.14614	19.81103	21.64558	23.33409	22.68749	22.031	22.89971
1996	22.50726	24.23911	24.37943	23.4213	21.74725	20.95433	20.00705	19.36675	21.12096	22.55436	21.3541	21.51933	21.93094
1997	22.42172	23.89863	24.01103	23.05797	23.30915	22.76717	20.29432	20.39721	22.27405	21.78693	21.88128	22.64303	22.39521
1998	22.99972	24.08886	25.19353	26.33708	24.51626	24.68132	19.76019	19.75043	20.83707	21.96415	22.82458	22.85274	22.98383
1999	22.9771	25.1754	25.66029	25.39833	24.77255	23.87658	20.03681	20.21885	21.54133	20.37706	22.27938	22.10519	22.86824
2000	23.01103	24.30466	25.59193	22.59394	24.62743	24.14323	20.35425	19.1103	20.59945	20.95908	21.72239	22.27829	22.44133
2001	23.3491	24.44968	23.81346	25.21188	24.81508	22.40428	19.96301	19.39756	21.60428	22.69913	22.52639	22.76052	22.74953
2002	22.67191	24.69903	24.90892	25.38402	26.42818	24.47592	21.84546	20.82236	21.58727	23.07833	23.54146	22.92496	23.53065
2003	23.77459	24.67148	24.41545	25.24895	26.01525	24.80954	20.26427	19.79092	21.31255	22.59508	23.07332	22.97772	23.24576
2004	23.82093	24.43601	25.3689	24.06877	25.92167	23.02378	20.85871	20.13233	21.18824	22.23468	22.92364	23.08088	23.08821
2005	22.83833	25.82861	24.7036	25.38953	24.62781	24.65534	19.9802	20.43568	20.87548	22.92523	23.04543	23.13529	23.20338
2006	23.9686	25.476	25.29788	24.87392	23.84032	23.83766	20.27812	19.3264	21.01318	22.62649	22.6066	21.97415	22.92661
2007	22.98697	24.41816	26.433	24.92569	25.51443	22.72278	20.09423	20.3439	21.47193	22.72601	22.97811	22.77178	23.11558
2008	24.02097	24.31871	26.53931	24.2897	22.76	22.41565	20.55218	20.17762	21.46892	22.64373	22.06766	22.04536	22.77498
2009	22.99033	24.48847	25.6312	25.65966	25.8418	25.96173	20.74183	20.50175	21.82943	22.21571	22.67968	22.11224	23.38782
2010	22.86658	24.31657	24.34201	24.8802	25.27782	25.42726	20.77183	19.75171	20.63072	22.08068	22.16339	21.40336	22.82601
2011	22.23447	24.81542	22.97586	25.01363	23.73391	23.9897	20.86309	20.11412	21.06205	22.67384	22.18792	22.46315	22.67726
2012	23.78843	26.49378	25.7488	25.10866	25.41903	24.79528	20.7132	20.29712	21.50896	23.44178	23.38319	23.50075	23.68325
2013	23.94938	25.37943	25.22848	25.99297	25.5828	23.55327	20.58732	19.69532	22.17484	22.39129	22.75658	22.64495	23.32805
2014	23.23688	24.58598	24.62398	24.85089	24.82545	23.8492	21.69763	20.21303	21.01532	22.34418	22.52888	23.1404	23.07598
2015	23.12103	24.89231	25.61391	26.51106	24.64239	25.93805	24.97917	23.63133	23.98183	25.50985	25.6329	24.50805	24.91349
2016	25.10901	26.13605	28.36568	26.80318	26.64322	27.36572	24.15316	23.68253	23.11048	24.92149	25.68708	26.42399	25.70013
Total	23.24641	24.46261	24.96226	24.69299	24.53405	23.90004	20.69068	20.02519	21.31184	22.36395	22.66336	22.56586	22.9516

Annex 5: Trends of annual distribution of temperatures

Table 3: Trends of annual distribution of temperatures in Lay Gayint woreda

Year	Minimum Temperature (C ⁰)	Maximum Temperature (C ⁰)	Average Temperature (C ⁰)	Range (Max-Min)Temperature (C ⁰)
1987	8.729641	23.15018	15.93991	14.42054
1988	9.741303	22.55005	16.14568	12.80875
1989	8.937012	21.75957	15.34829	12.82256
1990	8.153409	23.10205	15.62773	14.94864
1991	9.754931	22.46148	16.10821	12.70655
1992	9.562723	21.80262	15.68267	12.2399
1993	9.941458	21.52881	15.73513	11.58735
1994	9.736669	22.44739	16.09203	12.71072
1995	9.286688	22.89971	16.0932	13.61303
1996	9.202466	21.93094	15.5667	12.72847
1997	9.611792	22.39521	16.0035	12.78341
1998	9.730495	22.98383	16.35716	13.25333
1999	8.861376	22.86824	15.86481	14.00686
2000	8.679272	22.44133	15.5603	13.76206
2001	8.994056	22.74953	15.87179	13.75547
2002	9.208513	23.53065	16.36958	14.32214
2003	9.46367	23.24576	16.35471	13.78209
2004	8.849469	23.08821	15.96884	14.23874
2005	8.765114	23.20338	15.98424	14.43826
2006	9.34089	22.92661	16.13375	13.58572
2007	9.462265	23.11558	16.28892	13.65332
2008	8.868549	22.77498	15.82177	13.90643
2009	9.915729	23.38782	16.65177	13.47209
2010	10.30392	22.82601	16.56497	12.52208
2011	9.502743	22.67726	16.09	13.17452
2012	9.628358	23.68325	16.6558	14.05489
2013	9.645042	23.32805	16.48655	13.68301
2014	10.10158	23.07598	16.58878	12.97441
2015	11.31644	24.91349	18.11496	13.59705
2016	11.65863	25.70013	18.67938	14.0415
Avr.	9.498473	22.9516	16.22504	13.45313

Annex 6: Seasonal and annual rainfall distribution

Table 4. Seasonal and annual rainfall distribution in Lay Gayint woreda

Year	Belg					Kiremt				Bega			Annual
	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	
1987	3.03	6.45	48.29	24.36	120.82	31.85	91.98	282.75	36.25	25.99	0.14	17.76	689.66
1988	3.314	47.86	0.458	24.25	31.483	48.627	398.5	286.7	105.4	67.958	8.2797	17.988	1040.87
1989	3.712	3.288	92.25	59.65	18.712	167.19	223.9	244.4	119.4	19.525	4.9407	45.771	1002.78
1990	5.678	47.33	40.49	31.22	6.8136	16.525	306.6	263.6	137.4	1.3305	2.3305	0.00	859.35
1991	0.00	0.00	11.8	31.25	57.356	136.61	319.1	222.6	111.1	6.9746	3.9576	43.458	944.14
1992	7.737	6.161	42.92	82.65	62.212	27.907	214.8	495.8	97.47	123.6	81.492	39.746	1282.
1993	0.424	9.432	62.7	161.3	119.4	37.534	248.8	147.6	103.5	45.746	48.831	0.678	985.96
1994	0.881	5.966	16.64	22.86	57.085	100.31	436.1	395.1	121.3	1.7203	3.1186	0.7712	1161.83
1995	0.00	14.74	38.8	67.58	64.644	29.254	380.4	227.4	88.92	0.9831	4.6356	27.907	945.22
1996	11.03	3.661	80.79	80.05	125.35	119.5	339.4	285	92.5	79.237	66.975	0.00	1283.47
1997	0.00	0.00	72.34	80.74	78.534	128.19	282.2	269	48.77	173.69	87.653	6.322	1227.36
1998	21.67	6.339	39.96	9.983	64.441	59.136	452	362.1	128.3	70.763	0.5763	0.00	1215.33
1999	28.55	0.00	0.00	28.09	8.3051	83.119	483.4	283	80.61	130.12	3.0763	9.1525	1137.46
2000	0.00	0.00	2.636	109.2	25.593	49.949	382.6	311.9	106.2	127.06	22.356	30.941	1168.42
2001	0.00	0.297	35.95	25.53	50.331	110.42	474.5	371.3	55.7	17.627	7.9831	4.0169	1153.69
2002	19.07	5.11	77.31	42.31	13.636	64.669	298.3	219.8	79	5.4407	17.153	27.407	869.19
2003	0.898	39.07	40.14	32.58	2.4576	72.983	364.9	469.8	174.8	0.7458	2.0085	9.7712	1210.15
2004	3.771	19.05	24.9	39.07	13.627	65.407	252.2	238.3	55.63	23.559	7.5508	0.5847	74
2005	13.23	0.00	61.63	24.07	46.763	36.441	411.4	373.7	138.6	6.678	23.517	0.00	1135.99
2006	0.00	0.051	22.92	63.66	72.339	70.008	414.2	414.4	102.1	31.551	36.958	19.576	1247.79
2007	22.79	11.72	42.85	59.25	65.483	176.95	381.2	314	130	8.9153	18.559	0.00	1231.69
2008	21.1	0.00	1.076	66.39	143.18	143.31	291.4	398.6	127.7	53.593	9.9831	2.7373	1259.06
2009	0.331	3.331	41.21	21.79	5.5	18.932	355.2	282.1	59.8	80.72	10.551	14.831	894.27
2010	8.924	2.314	41.17	81.79	58.5	35.085	408.2	464.4	154.2	6.661	6.8814	15.958	1284.05
2011	14.07	0.00	64.85	51.11	93.347	71.525	437.1	306.8	119.2	2.5763	78.466	0.00	1238.97
2012	0.00	0.00	38.41	19.44	46.924	78.941	351.7	310.7	118.1	16.949	39.898	3.3644	1024.32
2013	6.034	0.085	26.58	33.08	25.39	120.13	452.4	426.7	66.36	95.534	23.771	1.2119	1277.32
2014	0.00	5.373	70.05	89.15	124.02	25.034	242.8	313.4	156.8	41.22	55.907	2.7966	1126.47
2015	0.00	11.55	40.81	5.034	134.41	73.542	149.7	342.3	120.7	11.339	34.602	56.771	980.78
2016	1.941	1.771	18.64	94.54	119.69	61.415	430.2	296.2	63.36	21.729	6.2203	0.00	1115.67
Avr	6.61	8.36	39.95	52.07	61.88	75.35	342.50	320.64	103.30	43.32	23.95	13.32	1091.25
Max	28.55	47.86	92.25	161.30	143.18	176.95	483.45	495.75	174.83	173.69	87.65	56.77	1284.05
Min	0.00	0.00	0.00	5.03	2.46	16.53	91.98	147.62	36.25	0.75	0.14	0.00	689.66
SD	8.429	13.33	24.92	34.63	43.403	44.679	97.67	82.54	34.57	47.162	26.434	16.31	167.487
CV	1.276	1.593	0.624	0.665	0.7014	0.593	0.285	0.257	0.335	1.0887	1.1039	1.2247	0.15348

Annex 7: Annual and Seasonal average rainfall, standard deviation, and coefficient of variation

Table 5. Annual and Seasonal average rainfall, standard deviation, and coefficient of variation

Year	Rainfall			
	Annual	Belg	Kiremt	Bega
1987	689.66	199.92	442.83	46.92
1988	1040.87	104.05	839.28	97.54
1989	1002.78	173.90	754.93	73.95
1990	859.35	125.86	724.15	9.34
1991	944.14	100.40	789.35	54.39
1992	1282.49	193.95	835.97	252.58
1993	985.96	352.83	537.45	95.68
1994	1161.83	102.55	1052.79	6.49
1995	945.22	185.75	725.94	33.53
1996	1283.47	289.85	836.38	157.25
1997	1227.36	231.61	728.08	267.66
1998	1215.33	120.72	1001.60	93.01
1999	1137.46	36.40	930.16	170.90
2000	1168.42	137.45	850.61	180.36
2001	1153.69	112.10	1011.96	29.63
2002	869.19	138.37	661.75	69.07
2003	1210.15	114.25	1082.48	13.42
2004	743.62	96.64	611.51	35.47
2005	1135.99	132.46	960.11	43.42
2006	1247.79	158.97	1000.73	88.08
2007	1231.69	179.30	1002.14	50.26
2008	1259.06	210.64	961.00	87.42
2009	894.27	71.83	716.01	106.43
2010	1284.05	183.77	1061.86	38.42
2011	1238.97	209.31	934.55	95.11
2012	1024.32	104.77	859.34	60.21
2013	1277.32	85.14	1065.63	126.55
2014	1126.47	288.59	737.96	99.92
2015	980.78	191.81	686.26	102.71
2016	1115.67	234.64	851.14	29.89
Avr(LTM)	1091.25	162.26	841.80	87.19
Max	1284.05	352.83	1082.48	267.66
Min	689.66	36.40	442.83	6.49
SD	167.487	71.00457	165.0633	65.09128
CV	0.15348	0.437595	0.196084	0.746574

Annex 8: Drought severity of annual and seasonal rainfall

Table 6: Drought severity of annual and seasonal rainfall in Lay Gayint woreda

Year	Annual		Drought severity	Belg		Drought severity	Kirmt		Drought severity	Bega		Drought severity
	Xi	Xi-Mean	Xi-mean/SD	Xi	Xi-Mean	Xi-Mean/SD	Xi	Xi-Mean	Xi-Mean/SD	Xi	Xi-Mean	Xi-Mean/SD
1987	689.66	-401.58	-2.40	199.92	37.65	0.53	442.83	-398.97	-2.42	46.92	-40.27	-0.61864
1988	1040.87	-50.38	-0.30	104.05	-58.21	0.82	839.28	-2.52	-0.02	97.54	10.35	0.159033
1989	1002.78	-88.47	-0.53	173.90	11.64	0.16	754.93	-86.87	-0.53	73.95	-13.24	-0.20337
1990	859.35	-231.90	-1.38	125.86	-36.41	-0.51	724.15	-117.65	-0.71	9.34	-77.85	-1.19598
1991	944.14	-147.11	-0.88	100.40	-61.86	-0.87	789.35	-52.45	-0.32	54.39	-32.80	-0.50386
1992	1282.49	191.25	1.14	193.95	31.69	0.45	835.97	-5.83	-0.04	252.58	165.39	2.540887
1993	985.96	-105.29	-0.63	352.83	190.57	2.68	537.45	-304.35	-1.84	95.68	8.49	0.130452
1994	1161.83	70.58	0.42	102.55	-59.71	-0.84	1052.79	210.99	1.28	6.49	-80.70	-1.23972
1995	945.22	-146.03	-0.87	185.75	23.49	0.33	725.94	-115.86	-0.70	33.53	-53.66	-0.8244
1996	1283.47	192.23	1.15	289.85	127.59	1.80	836.38	-5.42	-0.03	157.25	70.06	1.076319
1997	1227.36	136.11	0.81	231.61	69.35	0.98	728.08	-113.71	-0.69	267.66	180.47	2.772635
1998	1215.33	124.08	0.74	120.72	-41.54	-0.59	1001.60	159.80	0.97	93.01	5.82	0.08944
1999	1137.46	46.21	0.28	36.40	125.86	-1.77	930.16	88.36	0.54	170.90	83.71	1.286065
2000	1168.42	77.17	0.46	137.45	-24.81	-0.35	850.61	8.81	0.05	180.36	93.17	1.431363
2001	1153.69	62.44	0.37	112.10	-50.16	-0.71	1011.96	170.16	1.03	29.63	57.56	-0.88429
2002	869.19	-222.05	-1.33	138.37	-23.89	-0.34	661.75	-180.04	-1.09	69.07	18.12	-0.27836
2003	1210.15	118.91	0.71	114.25	-48.02	-0.68	1082.48	240.69	1.46	13.42	73.76	-1.13322
2004	743.62	-347.63	-2.08	96.64	-65.62	-0.92	611.51	-230.29	-1.40	35.47	51.72	-0.79459
2005	1135.99	44.75	0.27	132.46	-29.80	-0.42	960.11	118.31	0.72	43.42	43.76	-0.67233
2006	1247.79	156.54	0.93	158.97	-3.29	-0.05	1000.73	158.93	0.96	88.08	0.90	0.013797
2007	1231.69	140.45	0.84	179.30	17.04	0.24	1002.14	160.34	0.97	50.26	36.92	-0.56726
2008	1259.06	167.81	1.00	210.64	48.38	0.68	961.00	119.20	0.72	87.42	0.23	0.003511
2009	894.27	-196.97	-1.18	71.83	-90.43	-1.27	716.01	-125.79	0.76	106.43	19.25	0.29567
2010	1284.05	192.81	1.15	183.77	21.51	0.30	1061.86	220.06	1.33	38.42	48.76	-0.74915
2011	1238.97	147.72	0.88	209.31	47.04	0.66	934.55	92.75	0.56	95.11	7.9	0.121729
2012	1024.32	-66.92	-0.40	104.77	-57.49	-0.81	859.34	17.54	0.11	60.21	26.97	-0.41442
2013	1277.32	186.08	1.11	85.14	-77.12	-1.09	1065.63	223.83	1.36	126.55	39.3	0.604753
2014	1126.47	35.23	0.21	288.59	126.33	1.78	737.96	103.84	-0.63	99.92	12.4	0.19568
2015	980.78	-110.47	-0.66	191.81	29.54	0.42	686.26	155.54	-0.94	102.71	15.53	0.238514
2016	1115.67	24.42	0.15	234.64	72.38	1.02	851.14	9.34	0.06	29.89	57.30	0.88025
TM	1091.25			162.26			841.80			87.19		
Max	1284.05			352.83			1082.48			267.66		
Min	689.66			36.40			442.83			6.49		
SD	167.4869			71			165.0633			65.09128		
CV	0.153482			0.437595			0.196084			0.746574		

