CLIMATE CHANGE, ADAPTATION STRATEGIES AND THEIR DETERMINANATS: THE CASE OF WONDO GENET WOREDA, SIDAMA NATIONAL REGIONAL STATE, ETHIOPIA

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ADVISORS APPROVAL SHEET

This is to certified that the thesis entitled **“Climate Change, Adaptation Strategies and their Determinants; the case of Wondo Genet Woreda Sidama National Regional State Ethiopia,** “submitted to partial fulfillment of the requirement for the degree of **Master’s** with specialization in **climate change and sustainable agriculture,** the graduate program of the **School of Environment, Gender and Development Studies,** and has been carried out by **Adugna Fiche ID.No GPCCSAR/0001/15,** under my supervision. Therefore, I recommend the student for defence.

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Name of major advisor	Signature	Date

.

DECLARATION

I declare that this thesis entitled "Climate Change, Adaptation Strategies and their Determinants in Wondo genet Woreda Sidama National Regional State of Ethiopia" is my original work carried out independently with the close advice and guidance of my advisor. This thesis has not been submitted to any degree/diploma in this or any other institution, and that all sources used in the thesis have been duly acknowledged.

Adugna Fiche

Signature ——————————

Date ————————————

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ACRONOMY

SPSS	Stastical Package for Social Science
HHs	House Holds
FAO	Food and Agricultural Organization
WGWAO	Wondo Genet Woreda Agriculture Office
CSA	Climate Smart Agriculture
GDP	Gross Domestic Product
IPCC	Inter Governmental Panel on Climate Change
UNFCCC	United Nation Frame Work Convention on Climate Change
UNDP	United Nation Development Program
M a sl	Meters above sea level
R K A S	Rural Kebele Administrations
T L U	Tropical Livestock unit
WMO	World meteorological organization
ETB	Ethiopian birr
NA	Normal average
NMSA	National meteorology service agency
SSA	Sub-Saharan Africa

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ABSTRACT

Agriculture is a sector that dominates Ethiopia's economy which suffers from increasing frequency and intensity of climate-related disasters. In the past few years, reducing vulnerability and adapting to climate change through implementing sound adaptation strategies has become an urgent issue for the world's developing countries like Ethiopia. This study also assessed climate change, adaptation strategies and their determinants in wondo genet woreda. A total of 123 households were randomly and purposive selected from two rural kebeles of wondo genet woredas, Sidama national regional state, Ethiopia. Data were collected through households' survey, focus group discussions, field observations and key informant interview, and thereby analyzed through a descriptive statistics and multi nominal logit model. The results also showed that 84.55% of the respondents perceive a decrease in rainfall amount, while 87.8% perceived an increase in temperature over the past 30 years which was supported by rainfall and temperature trend analysis of Hawassa metrological Agency data (1992- 2022). The result also showed that the most widely preferred adaptation methods by farmers were planting drought resistance crop (88.99%), building water harvesting scheme (85.5%), crop diversification (56.9%), changing planting date (43.9%), soil and water conservation (56.9%), use of irrigation (86.2%), and farming to non-farming activity (66.6%). The logistic regression model result showed that gender and age of the household, accesses to extension service, accesses to credit, and accesses to climate information, farm size, family size, farm income, and nonfarm income are the most significant factors that influence farmers' adaptation to climate change. The regional government and non-governmental organizations must therefore help to improve farmers' adaptation capacity by providing credit accesses, enhancing farmers with awareness of climate change adaptation strategies and technologies, providing extension services as well as formal and informal education, and investing on the long run climate mitigation projects.

Key words: adaptation, climate change, MNL, temperature, rainfall, wondo genet woreda.

CHAPTER ONE: INTRODUCTION

1.1 Back ground of the study

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

Climate change affects agriculture and agriculture also affects climate change. Many African countries have economies largely based on weather-sensitive agricultural production and are particularly vulnerable to climate change (FAO, 2016). Borona *et al*., (2019) agreed that as rain-fed agriculture is a sector that is highly vulnerable to climate variability and change. Africa is highly dependent on seasonal rainfall agricultural production; including access to food, in many

African countries and regions is projected to be severely compromised by climate variability and change. The area suitable for agriculture, the length of growing seasons and yield potential, particularly along the margins of semi-arid and arid areas, are expected to decrease. This would further adversely affect food security and exacerbate malnutrition in the continent. In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020 (Burton et al., 2005 and IPCC 2007). The high intra-seasonal rainfall variability and the lack of adaptive capacities are the major limiting factors for rain-fed agricultural production in smallholder farming systems across Sub-Saharan Africa (Boko *et al*., 2007).

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

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

1.2 Statement of the Problem

Agriculture is the major driver of economic growth especially in developing countries. Ethiopia is one of the least developing countries in which majority of its population depend on agriculture sector. Rising the agricultural production at the national level leads to improve overall economic growth and development. However, currently climate change has become a serious threat to sustainable economic growth (Gebreegziabher *et al.,* 2012).

The impacts of climate change have been adversely affecting the economic growth. These impacts affect all economic sensitive sectors especially agriculture sector. Ethiopia is a poor country and its economy is highly depending on agriculture which had failed to meet the growing food demand. This is due to the fact that the negative effect of climate changes on agricultural production (World Bank, 2007). Moreover, According to Deressa (2007) Ethiopian agriculture sector is negatively affected by climate related disasters with drought and flood being the major one.

Adaptation is an essential strategy to enable farmers to cope with the adverse effect of climate change and variability which in turn increase 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).

Climate change is unexpected impact because it is a natural phenomenon that varies with location, socio economic and environmental conditions. The capacity to adapt to climate change is unequal across and within societies. This fact implies that the adaptation measures at small holder farm household level are important to get truth and appropriate policies. According to Maddison (2007) there is a difference in the propensity of farmers living in different locations to adapt. Farmers in different area or agricultural zone have unequal propensity and capacity to climate change impact and adaptation.

Farmers of Sidama region, like farmers in any other part of Ethiopia, are suffering from climate upheavals which have become common natural disasters in the country. Sidamas farmers are heavily vulnerable to shocks, yet limited researches on climate change adaptation and their determinants. One of the few studies on climate change, vulnerability and adaptation strategies was by Hamiso (2015), Mathiwos (2019) and Lamiso (2020). Still factors influencing adaptation strategies were not addressed. Of course there is still big variation even between woredas of zone in terms of vulnerability to climate change. Wondo Genet as one of the woreda in sidama zone is affected by flooding, drought, land slide, and harvest failures. Drought and flood have negative effect on crop production for both food and cash crops, in the worst cases causing crop failure. To fill this information gap, the researcher was interested to assess climate change, adaptation strategies and their determinant in wondo genet woreda.

1.3 Objective of the study

1.3.1General objective

The general objective of the research is to assess Climate change, Adaptation Strategies and their Determinants in Wondo Genet woreda.

1.3.2 Specific objectives

1. To assess climate change.

2. To examine climate change adaptation strategies. And

3. To assess the determinants of adaptations strategies to climate change in the study area.

1.4 Research Questions

1. What is the current status of climate change?

2. What are the major climate change adaptation strategies implemented by farmers in the study area? And

3. What factors are affecting climate change adaptation strategies in the study area?

1.5 Significance of the Study

Taken as a whole, this study assesses the potential impact of climate change on farmers' socio-economic and the options for adaptations, to provide a meaningful insight and contribute to efforts aimed at ensuring sustainable development of farmers. Therefore, the study was conducted since samples in Wondo Genet Woreda, can be superimposed to all districts in the adjacent woredas of the Rift Valley of Ethiopia in general and Sidama Region in particular, and extend these to other woredas of similar agro-ecological environment that are under the impact of climate change and play decisive roles on farmers livelihood and adaptation strategies.

1.6 Scope of the study

Selection of research topics, and study site are important aspects for conducting research. The challenging nature of this task of selection is clear when the study area is characterized by diversity in major feature of interest for the research. However, for practical reason such as administrative and resource consideration, the research report was relied on understanding adaption strategies and farmers' perception for their choice of 123 households selected using purposive and systematic random sampling procedure in the study area. However, this does not limit the relevance and rational of the finding of this study to other neighboring districts under similar setting. In this regard, attempts were made to make a much more comprehensive review of the relevant literature and available federal and regional policy document that can be applicable to other areas having similar agro ecological condition.

1.7 Limitations of the Study

The major limitation of this study was the inclusion of only eight climate change adaptation strategies in the model and the sample size was not large because of financial and time constraint.

1.8 Organization of the thesis

The thesis organized as follows, chapter one introduction deals with background, statement of the problem, research questions, objective of the study, significance of the study, scope and limitation of the study. The second chapter briefly reviews of related literature. The third chapter deals with research methodology and chapter four deals on result and discussion. Finally, conclusion and recommendation are presented in the fifth chapter based on the main finding of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Climate change issues

According to the Intergovernmental Panel on Climate change (IPCC, 2007), climate change refers to a change in the average long-term conditions of the climate owing to natural alteration or human activity. Climate change research and debate have intensified over the last few decades. Climate change research includes geological data including marine and lake deposits, ice boreholes, cave deposits, and tree rings (Maslin 2004). Climate change supporters accept that increases in atmospheric concentrations of human-induced greenhouse gases are the main causes of climate change. Therefore, they suppose that reductions in greenhouse gas emissions and increasing carbon absorption are necessary to reduce further climate change in the future. However, other scientists strongly disagree with this interpretation and argue that natural factors are the key drivers of climate change rather than carbon dioxide emissions from human activity.

Here, I review the evidence that supports anthropogenic climate change. The evidence includes links between population growth, industrialization and the increase in carbon dioxide concentrations, the relationship between carbon dioxide levels and climate change, and finally, the increase in extreme climate disasters caused by climate change.

2.2. Concept of adaptation strategy

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

2.3. Climate Change in the Context of Ethiopia

Climate change is the worldwide environmental threats that seriously have an emotional impact on agricultural productivity and which affects humankind in several ways, including its direct influence on food production (Enete and Onyekuru ,2016.) Africa is one of the parts of the world that is the most vulnerable to the impacts of climate change (IPCC, 2014). The impacts of climate change across Africa will vary: At mid- to high latitudes, crop productivity may increase slightly for local mean temperature increases of up to 1 to 3 °C, while at lower latitudes crop productivity is projected to decrease for even relatively small local temperature increases (1–2 °C) (IPCC,2007). The historical climate record for Africa shows warming temperature of approximately 0.7°Cover most of the continent during the twentieth century; a decrease in rainfall over large portions of the Sahel (the semi-arid region South of the Sahara); and an increase in rainfall in east and central Africa (Juana *et al*., 2013).Ethiopia is highly affected by climate change due to three main reasons; (i) about 80% of the population is largely dependent on rain-fed agriculture (ii) low-income country (iii) varied geographical locations with different magnitude of climate impacts. Climate change-induced El-Nino increases the average temperature and affects rainfall patterns in time and space leading to a recurrent drought which results in food insecurity particularly in dry and semi-dry areas of the country. The country has experienced 16 major national droughts since the 1980s, along with dozens of local droughts (Alemu and Mengistu, 2019). Recently in 2015/16 10 million peoples, in 2017 5 million peoples are food insecure, as a result of drought caused by climate change-induced El Nino (Alemu and Mengistu, 2019). In Ethiopia climate change is already taking place now, thus past and present changes help to indicate possible future changes. Over the last decades, the temperature in Ethiopia increased at about 0.2–0.37 °C per decade (Aragie, 2013). The increase in minimum temperatures is more pronounced at roughly 0.4 °C per decade (IPCC, 2014). The temperature will very likely continue to increase for the next few decades with the rate of change as observed (Aragie, 2013 and IPCC 2014a). The average annual volume of rainfall over the past 50 years (from 1951–2000) remained more or less constant for the whole country (NMA 2001). Many authors agreed that mean annual rainfall showed a slightly decreasing trend and higher year to year variation was observed in 1950–2010. However, rainfall distribution across the country shows a marked difference.

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

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

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

2.4 Impact of climate change Globally and Africa

The impact of climate change vulnerability varies globally. However, the adverse effect of climate change is particularly devastating in developing regions, especially sub-Saharan Africa

(Kandji et al, 2006). The rapidly declining precipitation levels, increasing temperatures, low adaptive capacity, high dependence on natural resources, inability to detect the occurrence of extreme hydrological and meteorological events due to low technology adoption (Kurukulasuriyaand Mendelson,2006). Limiting infrastructure, illiteracy, lake of skill, is constraints for African countries to cope with climate variability (UNDP, 2006).

Temperatures are expected to rise fastest in Africa and a decline in rainfall volume is also anticipated. According to the IPCC (2007), sub-Saharan Africa is likely to experience increases in both minimum the impact of climate change vulnerability varies globally. However, the adverse effect of climate change is particularly devastating in developing regions, especially sub-Saharan Africa (Kandji *et al.*,2006). Sub-Saharan Africa suffers from natural fragility (two-third of its surface area is desert or dry land) and high exposure to droughts and floods, which are forecast to increase with further climate change. The region economies are highly dependent on natural resource. Biomass provides 80 percent of domestic primary energy supply. Rain-fed agriculture contributes 23% of GDP (excluding South Africa) and employs about 70% of the population. Inadequate infrastructure could hamper adaptation efforts, with limited water storage despite abundant resources. Malaria, already the biggest killer in the region, is spreading to higher, previously safe, altitude. (World Bank 2010).

According to the IPCC (2007), the scope of vulnerability of Africa to climate change is disquieting, with one third of Africa people already living in drought-prone areas. In the 2006, UNDP human development report, overexploitation of land resources including forest, increases in population, desertification, and land degradation identified as additional (1.8ºc) and maximum (4.7ºc) temperatures. Minimum precipitation levels are likely to change by 9% and 13% respectively (Christensen *et al*., 2007).

2.5 Adaptation to climate change

Adaptation is adjustment in natural or human system is response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Various types of adaptation can distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation (IPCC TAR, 2001).

Adaptations are adjustments in ecological-social-economic system in response to actual or expected climatic stimuli, their effects or impacts (IPCC, 2001; Smit& Olga, 2001). Farmers 'perceptions play a big role for successful implementation of adaptation strategies to mitigate climate change impact as agricultural practices concerned. Some of the adaptation measures are crop rotation, mixed farming, early planting, crop diversification and minimum tillage practice.

Thus, adaptation can reduce adverse impact of climate change on human health and well-being, and increase the capacity to take advantage of the opportunities (IPCC, 2007; Smit& Olga, 2001). Regarding human dimension, adaptation to climate change entails adjustments in socio-economic arrangements that reduce the vulnerability of households, communities, groups, sectors, region, or countries to change in the climate system (Smith, 1997; Wandel, 2006; Fussel, 2007). Adaptation is widely recognized as a vital component of any policy response to climate change. It is a way of reducing vulnerability, increase resilience, moderating the risk of climate impact on lives and livelihood, and taking advantage of opportunities posed by actual or expected climate change. Adaptation to environmental change is a norm rather than exception.

Throughout human history, societies have adapted to natural climate and environmental change by altering settlement and agricultural patterns and other facets of their economies and lifestyle (McCarl *et al*.,2001); Easter ling, Hurd & Smit, 2004; burton *et al.*,2006; Adger *et al*., 2007;

Heltberg, Siegel & Jorgenson, 2008). However, communities are more vulnerable and less adaptable to human-induced climate change. Adaptation to climate change has become one of the focal points of current development discourse, particularly agriculture. As a result, has found expression as a response strategy in the (MUNFCCC and the resulting Kyoto protocol in 1997).

The goal of climate change adaptation is to build the resilience of communities towards different kinds of change in their environment. Resilience is the capacity to maintain component functioning in the face major life stressors (Adger, 2000). Thus, it demonstrates the capacity of human system or entities to bend without breaking in the face of disturbance and, once bent, to spring back to its pre-disturbance steady state (Easterling *et al* ., 2004). Unlike natural ecosystems, human systems have the capacity of foreseeing and adapting to possible environmental change (Adger, 2000; Folke *et al*., 2002; Easterling et al., 2004). When a social or ecological entity loses resilience, it become more vulnerable to change that previously could be absorbed to (Folke et al., 2002). Sustainability of humans on earth linked to resilient socio-ecological system, which influenced by human capital and institutional arrangement (O'Brien *et al.*, 2012). Adaptation types have differentiated according to numerous attributes. Commonly used distinctions are purposefulness and timing (Smit& Olga, 2001).

The IPCC (2007) recognizes three types of adaptation: First, autonomous, or spontaneous adaptation are considered to be those that take place- invariably in unconscious and reactive response- after initial impacts are manifest to climate stimuli as a matter of course, without the intervention of public policy. Second, anticipatory, or proactive adaptation takes place before the impacts of climate change are apparent. Third, planned adaptation based on an awareness that condition have changed or return to, maintain, or achieve desired state.

Whereas planned adaptations are intervention strategies, autonomous adaptations occur naturally without interventions by public agencies (Smith *et al,* 1996). Thus defined, autonomous and planned adaptations largely correspond with private and public adaptation, respectively. However, it is the autonomous adaptation that forms a baseline against which the need for planned anticipatory adaptation can be evaluated (Smit& Olga, 2001).

2.6 Climate change adaptation strategies in Ethiopia

Adaptation to altering environmental conditions is a natural part of our everyday live. Frequently, these adaptations are a response to changes which have previously occurred. Climate change is inevitable; even if we implemented the best mitigation measures such as greenhouse gas emission reductions immediately (Zebisch M. *et al.,* 2005 and Endeshaw, 2014). Climate change adaptation strategy is a mechanism of minimizing vulnerability, strengthening resilience capacity, minimizing the severe climate induced hazards on lives and livelihoods, and bringing benefits of opportunities delivered by actual or forecasted climate change (Belay, 2016). Adapting to climate change is the system of adjusting oneself to enhance and survive from the impacts of climate change. It also includes the accommodation of extreme climate change risks and long-term resistance to it. It is a long-term strategy that humans adjust their systems of living in response to the actual rate of climate change (Endeshaw, 2014). Based on a study conducted by (Zeray, N., & Demie, A., 2016, 2015; Getachew, 2020; Edeshaw, 2014; Abirham, 2017) and Sorhaug A.K., 2011) the following adaptation strategies were applied in different parts of Ethiopia. Crop diversification is a mechanism that pursues to avoid threats of overall crop disaster rather than increasing yields of one particular crop. It is the most frequently practiced strategy to reduce the impacts of climate changes in Ethiopia. This strategy is safer due to the fact that if one variety fails, there are some other crop varieties that are successful.

In addition, with revolving of crop varieties on the land, soil fertility will be sustained and the soil might not be exhausted. Combining crop production with pastoralism like mixed species herds, widespread and seasonally available pastures, splitting animals into discrete herds, and mobility in response to seasonal variation in pasture productivity are main mechanisms of adaptation in Ethiopia. Tree planting is used to adapt to climate changes in Ethiopia. Vulnerability to climate changes can be alleviated if off-farm activities are being practiced by the farmers. Sale of labor is also a mechanism of coping strategy by farmers in the Upper Awash Basin of Ethiopia through drought times. Customary and modern coping strategies in Ethiopia are also being practiced like increased petty commodity production. Off-farm practices may be selling of honey, clothes, or home-made products like mattresses, hot food, beverages, whips and ropes. The other adaptation mechanism commonly practiced is soil and water conservation. Most parts of Ethiopia are mountainous and the crop fields are hardly flat. Often, they are found in a hill side or in a valley side. This generates additional demand for soil and water conservation to avert the soil and rainwater from being washed away. Practicing new or suitable seed varieties is a way of climate change adaptation strategy used in Ethiopia. Even though farming systems in the country are still somewhat outdated, farmers in several parts do have the choice of practicing new, higher-yielding crop varieties. In addition, planting drought resistant plants like Enset, irrigation and diverting of water are also the adaptation strategies commonly used in Ethiopia.

2.7 Barriers of climate change adaptation

The main barriers of climate change adaptation can be grouped in to three major type. The first is the opportunity of humans to live in the state of natural uncertainty that is the non-predictable ecological disturbance like earthquake, rapid increase of sea level, rising of temperature and other sudden catastrophic events are the main barriers of climate change adaptation. The second is human action like technological factors and limited knowledge about environmental conservation mechanism can be taken as a barriers. Thirdly socially constructed norms that limit community response to climate change resilience are also taken as barriers of adaptation, and they might be institution like belief system, norms valve and others, which are called normative restriction that prevent individual or groups from seeking the most appropriate forms of adaptation (Edeshaw, 2014).

According to a study conducted by (Demamu, 2018; Israel,2019; Menberu,2014,Meseret,2009; and Sorhaug A.K,2011), wealth: gender of heads of household; education; age; household size; access to information; access to weather for cast; access to credit; agricultural education or training; social capital; distance to market; agro ecological setting; climate change adaptation policies, measure, and strategies; system in place for dissemination of information; weii-functioning social system; access to labor; irrigation potential; equitable distribution of power, access to land, ethnicity; stable and effective institution, access to technology and productive use are the main barriers for climate change adaptation in Ethiopia. A huge proportion of farmers in Ethiopia, although they notice change in temperature and rainfall, did not make any adjustments to their farming practice because lack of access to land, lack of information on adaptation methods, and financial constraints including credit scheme.

2.8 Conceptual framework of the study

The conceptual framework applied in this study to describe links between the farmers' perception of climate change and variability and their adaptation strategy. 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 and change are shaped by Household demographic characteristics, Socio-economic status and farming characteristics. And also those driver factors are interrelated with each other and show their influences on agricultural production.

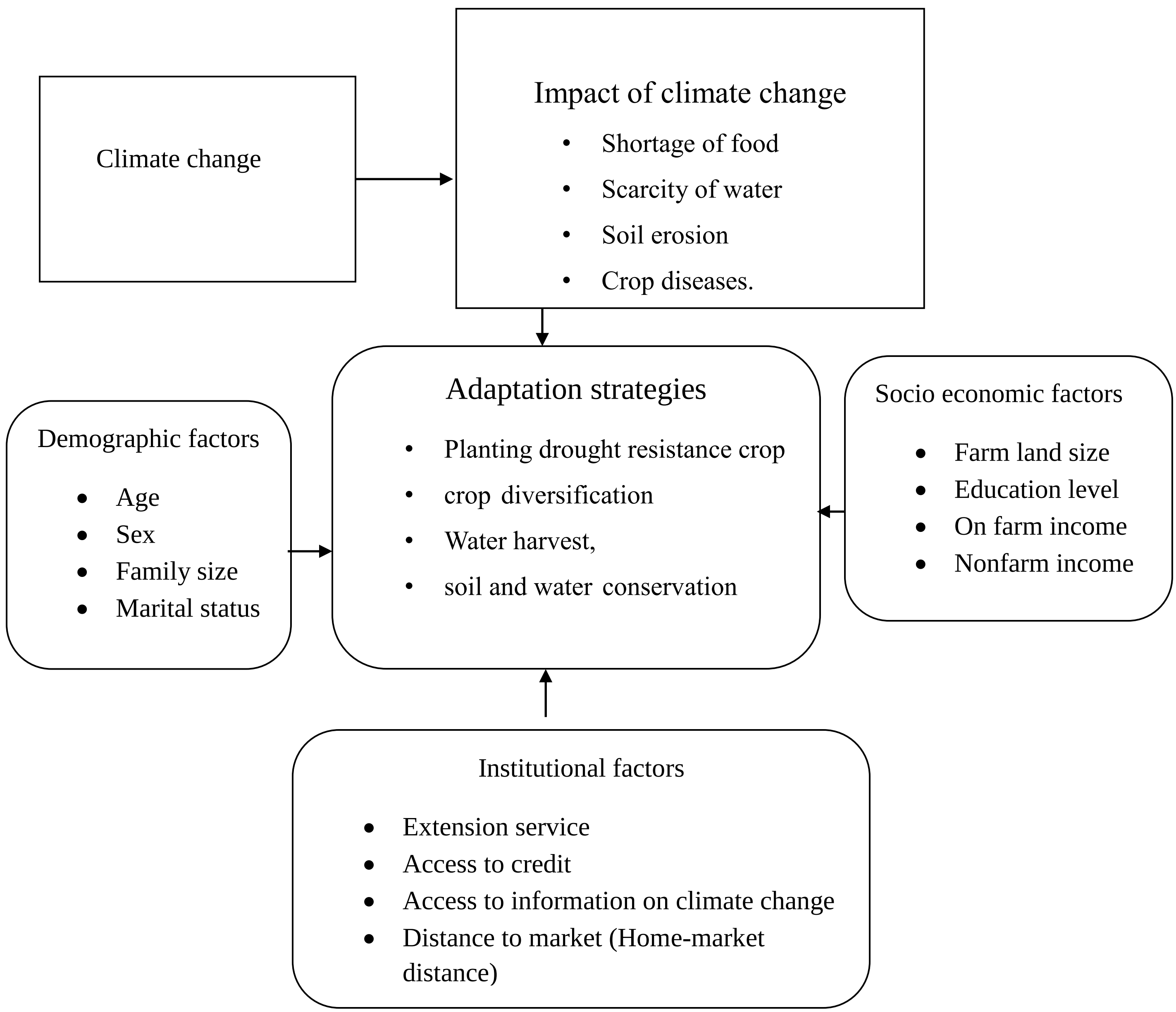


Figure 1.A conceptual frame work of the study**.**

Source: - Modified after (Deresse*et et,al*., Tekeste 2019 and Mysoon 2015)

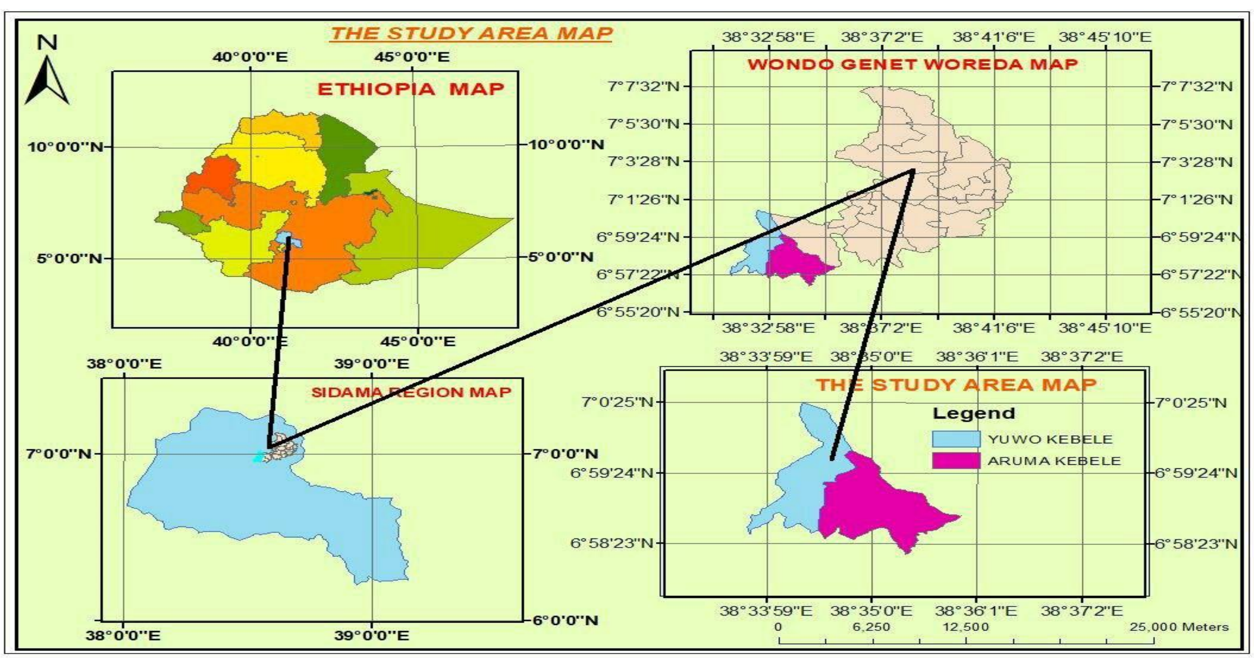
CHAPTER THREE: RESEARCH METHODOLOGY

3.1 Description of the study area

3.1.1 Location

Wondo Genet is found in Sidama National Regional State, Ethiopia. Geographically it is located on the Eastern escarpment of the central rift valley of Ethiopia, which 7^{o}06’ N and 38^{o}37’ E. 1720-2620 m a.s.l. about 272 km south of the capital city, Addis Ababa, and about 24 km east of Hawassa city (WGWA, 2020). The whole area of the Woreda is 15,145 ha or 151.45 km².About 93.58 ha of the Woreda is protected as a swamp. While 10106 ha is used for agriculture, 556.56 ha for grazing, 2484.68 ha for forest, and bush and shrub 1333.8 ha, the residential area is including 571. 38ha. The Wereda is bordered by Oromia Region in the North, Melga Woreda in the East, Habela Tula Kifle Ketema in the South, and Oromia in the West. Currently, the Woreda contains 13 kebeles and two city administration (WGWANRO, 2020).

Figure: 2**,** Map of the study area



Source: Ethiopia GIS data (2024)

3.2 Description of Bio-Physical features

Topography

According to Hailegiorgis (2004), Wondo Genet comprises escarpments, ridges, plateau, undulating to rolling and dissected plains, depressions and swamps. Most of the bottomlands are flat, but some of the areas at border have deep gullies and degraded lands caused by erosion and deforestation.area comprises the hills of Abaro, Bachil Gigissa, Gariramo, Kentere and Cheko, as well as the depression surrounded by these hills. The height of land varies between 2,580 m above sea level at Abaro and 1,600 m above sea level around the marshy area (Belaynesh 2002).

Geology

The geology of wondo genet it consists of volcanic rocks (ignimbrites, basalts, tephra) and volcano lacustrine sediments of plio-pleistocene age. Morpho-dynamic activities have developed rugged and dissested landscap. These have been coupled with frequent heavy precipitation and accelerating human impact to produce frequent landslide problem.

Climate

The rainfall and the temperature scenario of the vicinity have been described based totally on the data accumulated from 2009-2018 through the National Metrological Services Agency (NMSA) from Hawassa station. The result of the analysis of information from NMSA proven that vary of endorse month-to-month minimal and most temperature of the find out about location.The hottest month is February with the most temperature of 30.1 ^{0}C and the coldest month is December with a minimum temperature is 10.2^{0}C. The agroecology of the Woreda has 23% humid and 73% sub humid and receives an average annual rainfall of 1163mmper year and shows a bimodal form of the wet season. Short rain season is between March and May accounting for 28% (Belg or Spring) of whole rainfall, and the main rain season between July and October accounting for more than 50% of the universal rainfall.

Vegetation

The remnant forestland flora at Wondo Genet can be categorized as 'Dry evergreen Afro montane' forests. Dry evergreen Afro montane forests have been described as forests with drought duration of approximately 1/2 the yr in one or two intervals and annual precipitation between 400-1700 mm. They occur in each of the Northwest and Southeast Highlands of Ethiopia, at altitudes from 1500-2700 m, with average annual temperatures of between14-20^{0}C can annual rainfall among seven hundred and 1100 mm (Demel and Teketay, 1999). According to elderly nearby informants, most of the Wondo Genet area is blanketed with such forests till approximately the 1920s. However, high deforestation rates over the years have left the simplest extraordinarily disturbed remnant forests which are now constrained to the mountain slopes. A limited location of plantation forests that belong to Wondo Genet College of Forestry (WGCF) and the former Munessa-Shashemene State Forest Development Project (hooked up in 1969) also exist in similar places as the natural forests. On the other hand, trees have been frequently maintained (and now and then planted) on homesteads, farmlands, and farm boundaries and give rise to, what might be defined as a homestead's and/or 'scattered trees on crop lands' (parkland) types of agroforestry systems. While a variety of fruit trees and shrubs and cash tree crop (e.g. Mangiferaindica, Coffea Arabica). Maize (Enseteventricosum), a staple food in the location and most of southern Ethiopia, is grown inside the homestead together with sugarcane (Saccharumofficinarum), diverse root vegetation, and vegetables. The different main plants encompass inset, khat, sugarcane, maize, and potatoes (WGANRO 2020).

Drainage

The area is also rich in water resources, given the four major streams: Wosha, Worqa, Hallo and Lango. At the bottom of the hills there are also small springs. The water from these springs and streams not only supports people in the area, but also in nearby towns, for example in Shashemene from 1974/1975 and onward (Zerihun 1999).

Soil

Due to the variation in landforms, the soil types also show a variation. Though there is variation in color and texture of soil from area to area, the dominant soil, which covers over large area of the Woreda, is sandy loam. Clay loam with reddish color is also found in some parts of the area. Dark brown with loamy-to-loamy sand texture soil is also visually observed in some part of the area. Generally, the soils are fertile with the exception of soils in sloppy lands whose fertility is reduced due to low organic matter. Soil exhaustion due to long continued plugging, soil erosion losses due to deforestation, over grazing and extensive farming are some of the causes of loss of fertility in the area (Hailegiorgis, 2004).

3.3 Description of socio-economic conditions

Education

In the past time there was only one school that was built by Italians. This school is called wondo genet primary school. Now a day it is dramatically increased to know 26 (twenty six) schools in wondo genet woreda.

Health

Before three or four decades there was only one health center that is called wondo genet health center. Which was established by Italian government and nurses? In this center every things are supported by them. But know a day this number is changed gradually increased to one health center, six health stations and nine clinics in wondo genet woreda.

Economic activity

The economic activity of the town was mostly based on agriculture. The farmers produce different products like maize, wheat, potato, barely, chat, kerkeha, tid onion, and animal rearing. Few percent of the people engaged in a trade activity in the town. They buy and sale chat, wheat, tid, onion travelling to shashemene town and Hawassa city.

Livestock

Although the productivity is low, the livestock population is relatively excessive in Wondo Genet Woreda. The cattle resources of the Woreda have now not but utilize. The range of livestock in the Woreda includes: cows 43073 out of this 36315 are indigenous. Oxen 5551 out of this 6758 hybrid and 5375 are indigenous, 176hybrid. Sheep 21696; goat 13523 horse1258, donkey 1911and mules 88. In the Woreda stay as a great contribution to the agricultural economic system As rural farming, transport, and source of income. The most not unusual animal diseases inside the Woreda include bacterial infection (anthrax, mastitis, blackleg, and avian salmonellosis), viral infections (rabies, African horse sickness foot, and Mouth sickness and lamp pores and skin diseases) ectoparasites (insect flies, lice, and ticks and mites) (Wondo Genet Woreda Animal head office, 2019).

Population

The total population of the Woreda is 181377 out of which 93205are male and 88172 are female. Different ethnic groups live in Wondo Genet. The majorities are Sidama, Oromo, Kembata, Wolayta, Amhara, and Hadiya. The Sidama language is spoken by most of the people. The population size in addition to the density of Chuko Kebele is the highest a few of the Kebeles inside the study area. It is about 27484 people. Abaye kebele it's approximately 17105 people beings the second populated kebele inside the study area. Baja Fabrika and Aruma kebeles are the third and fourth kebele concerning population size which account for 17064 people beings and 16446 people respectively, the majority of inhabitants follow Protestant, orthodox and Muslim religions (Wondo Genet Woreda Administration 2019).

Land use and agriculture

In the wereda agriculture covers about 85% and the rest are trade and others. Mixed farming is a common practice prevailing in the wereda as a result the livelihood of the rural population is depending on coffee, chat and crop production and livestock rearing. The current land use is predominantly smallholder agriculture with an average landholding size of less than one hectare per household (ARWGWAO, 2022). The major perennial, annual and root crops include enset, chat, sugarcane, maize, teff and potatoes. Wondo Genet is agriculturally fertile but now un expectable reduction of product because population pressure. A dramatic agricultural change is taking place. In this intensively cultivated area a new cash crop, chat, has rapidly become a major source of income. This has profound effects on the livelihoods of the local people as well as on the local environment and its social effect is a matter of concern.

3.4 Research Design

A cross-sectional survey design was used to collect data from the respondents of households in Wondo genet Woreda, in Yuwo and Aruma kebeles. This design included the conceptual structure within which the study was conducted (Dawson, 2002). Accordingly, both qualitative and quantitative study strategies were employed in this study. A Cross-sectional survey was used through a questionnaire to collect data about a particular topic and it was used to identify the relationship between variables and to acquire the objectives of the study.

3.5 Sampling method

The strategy to identify the study area and sampling method are as follows the combination of simple random sampling and purposive sampling techniques employed in the selection of study site and sample house hold two kebele was selected based on agro ecology conditions.

3.6 Sampling size determination

For a household survey a number of approaches was used to determine the sample size including, using a census for small populations, using published tables, imitation a sample size of similar studies, and applying formulas to calculate a sample size, from several approaches to determine a sample size. They are two (2) rural kebeles administrations. About 22,666 household heads are residing in the study area. Out of 22,666 household heads, 8528, 14138 household heads are residing in two kebeles (Table 3.1).The study employed a formula provided by yemane, (1967) provides a simplified formula to calculate sample size.

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

Where n= is the sample size, N= is the population size, e= is the level of precision. Accordingly the formula, N=22,666 and e=5% is used and n=123 HH.

The study was also use a proportional to size approach, meaning the number of respondent selected from each rural kebele Administration was proportional to the size of that number in the population. This method ensures that each respondent was accurately represented in the sample, enhancing the reliability and validity of the research findings. Therefore, the following tables shows that number of respondents will be incorporated from each kebele.

Table: 3.1, The sampling distribution of the household head in the two rural kebele administrations

Name of kebele	Total household	Percentage	Proportional sample HHs
Yuwo	8528	37.6%	46.3
Aruma	14136	62.4%	76.7
Total	22,666	100%	123

Source: The rural Keble administration (RKAs) office, 2024.

3.7 Data types and sources

Both primary and secondary source of data. Primary data was gathered using questioner, household survey, focus group discussion, key informant interview and direct observation the impact of climate change on agricultural production, productivity and improved climate change adaptation strategies, effectiveness of adaptation strategies in improving agriculture production, obstacles and opportunities in the choice and implementing the adaptation strategies, indigenous people preferences among the adaptation strategies.

Secondary data sources applied include published and un published documents, records of 30 year's climatic data of the study area revised from Ethiopia National Meteorological Services Agency, others include reports and research results, published materials of research center, MA/Msc Thesis, PhD Thesis Journals, proceedings and others.

3.8 Data collection methods

House hold survey

Questioners are the instruments it was employed to collect information from the sample households of Yuwo and Aruma kebeles. The survey question was prepared to collect both qualitative and quantitative data. Based on the research questions, structured questionnaires, with both open and closed-ended questions was designed. The questionnaire covers a wide range of questions such as the background of socioeconomic characteristics of the respondents and the demographic characteristics of the respondents, climate variability, and change (temperature and rainfall), related impacts and adaptation strategies. The questionnaire was accepted by my study advisor and then distributed to selected households with the help of data collectors. To convey the questions effectively to the local interviewees, since the households in the study area speak Amharic and Sidamu affo, the questionnaires initially are prepared in English and then translated to Sidamu affo finally, the questionnaires were distributed to respondents of households of the sample study area.

Key informant interview

The investigated used semi-structured interview for collecting primary data because of its flexibility and makes clear any time when there is ambiguity. A key informant interview was particularly important in getting information about socio economic characteristics in the district.

The key informant interviews were conducted from representatives of different stakeholder including, two elders, one agricultural extension officer, one development agent from each kebele, and one expert from WGWA office. The issue contain in the check list questions were adaptation to climate change and variability about farmers perception undertaken by farming community. All interview process was supervised by the researcher with the aim of making further investigation on the basis of the information received from the respondents.

Focus group discussion

The focus group discussion was an important source that complemented primary data acquired through household survey and interview. For this study, 8 individual per group of different social segments were considered. The investigator selected eight individuals in one kebeles. Data specific to objective of the study was collected. The individual participants of the FGDs were purposively selected based on the information obtained from DAs in the study areas; their interest of participant in group discussion and their knowledge and backgrounds about the study areas. The people in this discussion include three elders' farmers, two DAs and three kebeles managers. Therefore, totally eight target respondents were selected from each kebeles administration.

3.9 Method of data Analysis

Collected data were using the SPSS Version 26 software. A descriptive statistical method such as frequency and percentage was used to analyze and summarize the data.

Qualitative data collected from questioners, key informants interview, household survey, focus group discussions and field observation. The legit model was be applied to examine the characteristics that best explain the variation in farmers' attitudes and adaptation levels to climate change and factors influencing.

The multinomial logit model was used to determine if crop choice by farmers is climate sensitive, and to analyze how livestock species choice is climate sensitive.

3.9.1 Econometric model

In order to achieve the objective, the study employed Multinomial logit model. The model was used to determine factors that influence farmers' choice of adaptation method to climate change and identifying the farmers' adaptation strategies in response to climate change. The mathematical specifications of the model are given below.

Multinomial logit model

The multinomial logit model is easy, simple in calculating the choice of probability of climate change adaptation strategies and expressed in analytical form. The main limitation of the model is the independent of irrelevant (IIA) property, which state that the ratio of the probability of choosing any two alternative is independence of the attributes of any other alternative in the choice set (Tse 1987); Hausman and McFadden, 1984). The multinomial probit (MNP) model specification for discrete choice model does not require the assumption of the IIA. Due to the fact that this MNP model an inconvenient specification test as compared to the MNL model (Hausman and McFadden, 1984).

To describe the multinomial logit model, let Y denoted vectors of adaptation option for climate change chosen by farmer household. Assuming the adaptation option farmer's choice are depends on climatic factors, institutional factors and socioeconomic characteristics of the farmers. The multinomial logit model for the adaptation choice can be specified as in the following relationship between the probability of choosing option and a set of explanatory variables X Greene (2003).

$$\text{Prob}\,(Y_i = j) = e^{\beta_j x_i} / \sum_{k=0}^{5} e^{\beta_k x_i}, \qquad j=0, 1, 2 \ldots\ldots\ldots 5 \quad (1)$$

Equation (1) is normalized to remove indeterminacy in the model by assuming β_o=0 and the probabilities can be estimated as:-

$$\text{Prob}\,(Y_i = j\,(\chi_i)) = e^{\beta_j x_i} / 1+\sum_{K=0}^{J} e^{\beta_K x_i}, \qquad j= 0, 1, 2, \ldots\ldots J,\ \beta_o=0 \ldots\ldots \quad (2)$$

Maximum likelihood estimation of equation (2) yield the log-odds ration

$$\ln\,(p_{ij} / P_{iK})\ x_i\ (\beta_j - \beta_K) = \chi_i\ \beta_j, \qquad \text{if } k=0 \ldots\ldots\ldots \quad (3)$$

The dependent variable of any adaptation option is therefore the log of odd in relation to the base alternative.

According to Greene (2003), the MNL, coefficients are difficult to interpret and associating the β_j with the jth outcome is tempting and misleading. Marginal effect is useful to interpret the effect of independent variable on the dependent variable in terms of probabilities.

$$\partial p_j / \partial \chi_i = P_j\,(\beta_j - \sum_{K=0}^{J} P_K \beta_j) = P_j\,(\beta_j - \beta) \ldots\ldots\ldots \quad (4)$$

The marginal effects, measure the expected change in probability of a particular choice being made with respect to unit change in explanatory variable Green (2003). The MNL model was used by many researcher to model climate change adaptation practice of smallholder farmers

(Deressa et al,, 2009, Nhemachena and Hassan, 2008, Atinkut and Mebrat 2016, Maysoon 2015). Hence , use of MNL model is appropriate to the model of climate change adaptation practice of smallholder farmers in the study area.

3.10 Definition of Variables

3.11 Dependent Variable

The dependent variables of this study were climate change adaptation practice that the farmers employed in response to climate change. It is nominal variable. The dependent variable for multinomial log it model has five choices which take five value 0,1,2,3,4 and 5.Employed as follows planting drought resistance crop = 1, irrigation schemes = 2, diversify crops = 3, using soil and water conservation = 4, and diversify farming to non-farming activity 5

3.12. Independent Variables

The choice of independent variables used in the study were determined by reviewing literatures on factors that affect farmers' choices of adaption strategies to climate change. Household characteristics, farm characteristics, and institutional factors were used to explain the dependent variable. Hence, sex of households, age of the household head, education of the household head, family size, distance to market, off-farm/non-farm income, access to credit, agricultural extension service, access to climate information and farm size.

Age of the household head (AGE): this is a continuous variable defined as the number of years of the respondents starting from the year of birth.

Sex of the house hold head (SEX): It is the femaleness or maleness of household head. Sex is a dummy variable which indicate1 if male household head and 0 otherwise.

Level of education of the HH head (EDU): this is ranked as to assess the literacy level of head of the household for acquiring education and the expected sign was positive. According to Madison (2006) there is a positive relationship between education and adaptation to climate change.

Family size (FMSIZE): household size is the total family member can adopt the effect of climate change easily. Therefore, it is expected that household size (those with working age) has a positive sign for the farmers who are used adaptation method to climate change. This variable is also a continuous variable.

On farm income (ONFARMI): on farm income is an income return to the household from farming activities. This is measured in the form of Ethiopian Birr. This is a continuous variable. Farm income of the household has appositive and significant impact on conserving soil and using improved crop varieties adaption options (Deressa et al.,2009).

Nonfarm income (NONFARMI): this is an income of household obtain from outside of farming activities. For example trade, remittance and government employee are among others. Such income makes the farmers not to follow up or motive properly to agriculture. It is a continuous variable. This variable is measured in Ethiopian Birr. Aymone (2009) suggested that expanding smallholder farmer's access to off/non-farm sources of income increase the probability that they will invest in farming activities. Thus, for this study, non/off farm income was hypothesized to affect using irrigation, improved crop varieties, crop diversification and soil conservation practice as climate change adaptation strategies negatively or positively.

Access to credit service (ACREDIT): the availability of credit is important for the farmers in order to make adaptation strategies. Credit helps farmers to by improved crop varieties, fertilizers and oxen. Finding by Deressa et al, (2009) showed that access to credit significantly influences the farmer to adapt climate change.

Distance to market (DISMARK): this is a continuous variable to be measured in kilometers from home of the household. The closer the farmer is to the market the more likely the farmers receive valuable information and purchase agricultural inputs. Proximity to market is an important determinant of adaptation, presumably because the market serves as a means of exchanging information with other farmers (Maddison,2006).

Agricultural extension service (AGRIEXS): This is a formal service and play a great role that affect for farmers to adopt strategies in response to climate change. This variable is also dummy which represent 1 if farmers get agricultural extension service 0 otherwise.

Farm land size (FMLSIZE): is the total landholding of the farm household that uses for the farming activities. The household with large farm land has more to use adopted and the farm size measure in terms of hectare. It is a continuous variable. Large size allow farmers to diversify their crop and livestock option and help spread the risk of loss associated with change in climate Nhemachena (2008). This study therefore hypothesized that land holding has positive relation with using irrigation, improved crop varieties, crop diversification and soil conservation practice to adapt to climate change.

Access to climate information (ACLIM): this is dummy variable indicating 1 if the household head access to climate change 0 other wise. This variable is also expected a positive sign for the farmers who used adaptation method to climate change. Hassan and Nhemachena (2007) find access to information about climate change forecasting adaptation option and other agricultural activities remain important factors determining use of various climate change adaptation option. These factors are summarized on (Table 3.2).

Table.3.2Model considers the relationship between dependent variable and independent variable.

Variable	Description	Measurement	Expected relationship
Independent variable			
Age of the HH head	Continuous variable	Year	+
Sex of the HH head	Dummy variables	0 for females and 1 for male	+
Education of the HH head	Categorical variable		+
Family size	Continuous variable	Number	+
Farm income	Continuous variable	ETB	+
Nonfarm income	Continuous variable	ETB	+
Access to credit	Dummy variables	1 if yes 0 for no	+
Agricultural extension service	Dummy variables	1 if yes 0 for no	+
Farm size	Continuous variable	Hectare	+
Access to climate information	Dummy variables	1 if yes 0 for no	+
Distance to market center	Continuous variable	Km	-
Dependent variable			
Adaptation strategies to climate change	Nominal		

CHAPTER FOUR: RESULTS AND DISCUSSION

This chapter presents the results of the study on climate change adaptation strategies and determinants using data obtained from 123 sample households, focus group discussions and interviews with key informants. It has two parts. The first segment describes the characteristics of sampled households, climate change understanding and adaptation methods used in the study area by farm households. The second section presents econometric outcomes of the determinants of the climate change adaptation strategies in the study areas.

4.1 Descriptions of sample households' demographic and socio economic characteristics

In wondo genet woreda sidama region of Ethiopia during the study conducted in 2023

Table: 4.1. Description of sample households' characteristics

Categories		
Sex of HH head	Frequency	Percent
Male	104	84.6
Female	19	15.4
Level of education		
Unable to read and write	5	4
Grade 1-4	20	16
Grade 5-8	48	38.4
Grade 9-12	30	24
Certificate	10	8
Diploma	5	4
First degree and above	5	4
Marital status		
Married	105	85.4
Unmarried	4	3.3
Widowed	4	3.3
Divorce	10	8.1

Sources**:** Own survey, 2024

Regarding the sex distribution of sampled respondents, 84.6% of the respondents were male and the rest15.4% account for females. Therefore, the majority of respondents included in the study were male. According to focus group discussion men's were more information about climate change in the study area were carried out by male members of the family, and females were limited mostly to performing domestic activities.

The educational status of the respondents was from illiterate to diploma and above, i.e. about 4 % of the respondents were unable to read and write, 16% of the respondents completed grade 1-4, 38.4% 0f the respondents completed grade 5-8, 24% of the respondents were 9-12, 8% at certificate level, 4% diploma level and 4% of the respondents were first degree and above According to the focus group discussion result, farmers' education helped them tackle climate change problems . Likewise, the key informants' results indicated that as the educational level increases, the tendency to seek different climate change adaptation option increases.

The finding indicates that the marital status of the majority of the respondents (85.4%) was married. This study also found out there were 3.3% unmarried, 8.1% of divorced households and 3.3% were widowed. The result indicated that the majority of households that participated in the study were married.

Table: 4.2, Description of sample households' age and family size characteristics in wondo genet woreda sidama region of Ethiopia during the study conducted in 2023.

Age of HH head	Frequency	Percent (%)
20-30	15	12.2
31-40	64	52
41-50	33	26.8
Family size		
1-5	54	43.9
5-10	40	32.5
≥10	29	23.6

Sources: Own survey, 2024

The respondent age category of 31-40 (52%) second age categories 41-50 (26.83%), 20-30 (12.2%).This indicate the majority of the respondent age categories were 31-40. The results of the focus group discussants indicated that the economically active class dominated the study area. It can allow the household to engage in more adaptation strategy to climate change and variability practices to improve their agricultural productivity. On the other hand, the key informants explained that old-aged household heads encountered a challenge to implement climate change adaptation strategies. Additionally respondent family size was 1-5 (43.9%), 5-10 (32.5%) and ≥10 (23.67%). Generally the majority of respondent family size in the study area was 1-5 (43.9%).

Table: 4.3, Institutional characteristics of sample households in wondo genet woreda sidama region of Ethiopia during the study conducted in 2023.

	Frequency		Percent (%)	
	Yes	No	Yes	No
Access to credit	43	80	34	66
Access to climate information	102	21	82.9	17.1
Extension visit	84	39	68.3	31.7
Distance to market	105	18	86	14
Total	123		100	

Sources: Own survey, 2024

Concerning institutional characteristics of sample respondents, household heads who have Access to credit, extension service, climate information and distance to market account 34% of respondent for Yes and 66% No, 68.3% of respondent for Yes and 31.7% No, 82.9% of respondent for Yes and 17.1% No and 86% of the respondent for Yes 14% No respectively. Some of the sample household heads have access to Climate related information from radio, television, and mobile in addition to obtaining the Information from the extension (government) agent. (Table 4.2).

Farm income of the surveyed households ranges between 10000 to 100000 birr with an average of 60000 birr per annual. Surveyed household income from nonfarm activity ranged between 5000 -10000 and 5000 birr with an average of 8000 birr per annual. The land holding of sample households range between 0.125 to 5 hectares with an average size of 0.25 hectares.

4.2 Trend of local Climate

The year 2010 registered the highest amount of rain fall (1423 mm) while the year 2015 recorded the least volume of rainfall (344mm). The years 2010, 2019, and 2018 had generally high rainfall records, 1423mm, 1405mm and1340mm respectively. The 2015, 2014 and 2009 recorded the least rainfall with volumes of 344mm, 615mm and 687mm respectively. The trend analysis between annual rainfalls an d time using data obtained from metrology agency (appendix 1) indicated that annual rainfall in the study area decreases by 0.5mm each year over a period of 30 years under review (Figure 3).

Annual average RF

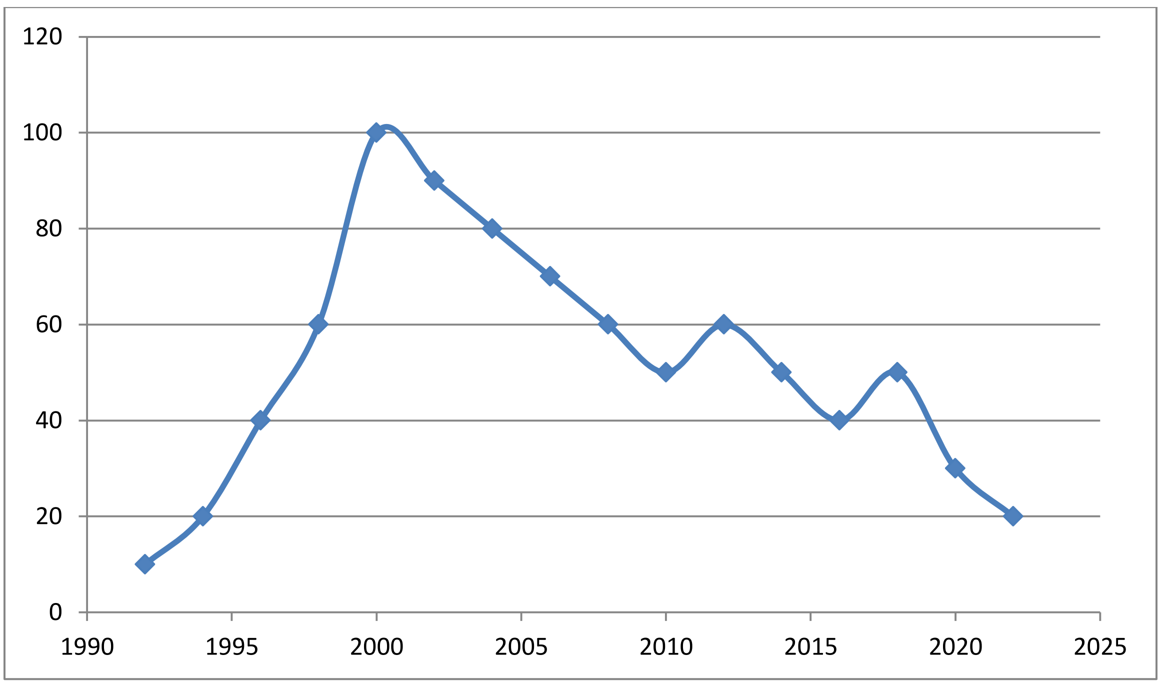


Figure 3.Trend of annual rainfall (1992 -2022).

Source: NMSA, 2022

The trend analysis between mean maximum and minimum annual temperature and temporary condition also indicated an increasing trend by about 0.026 and decreasing by 0.01ºc each year respectively (Figure, 4). The statistical record of temperature data (appendix, 1) from the area between 1992 and 2022 also showed an increasing trend.

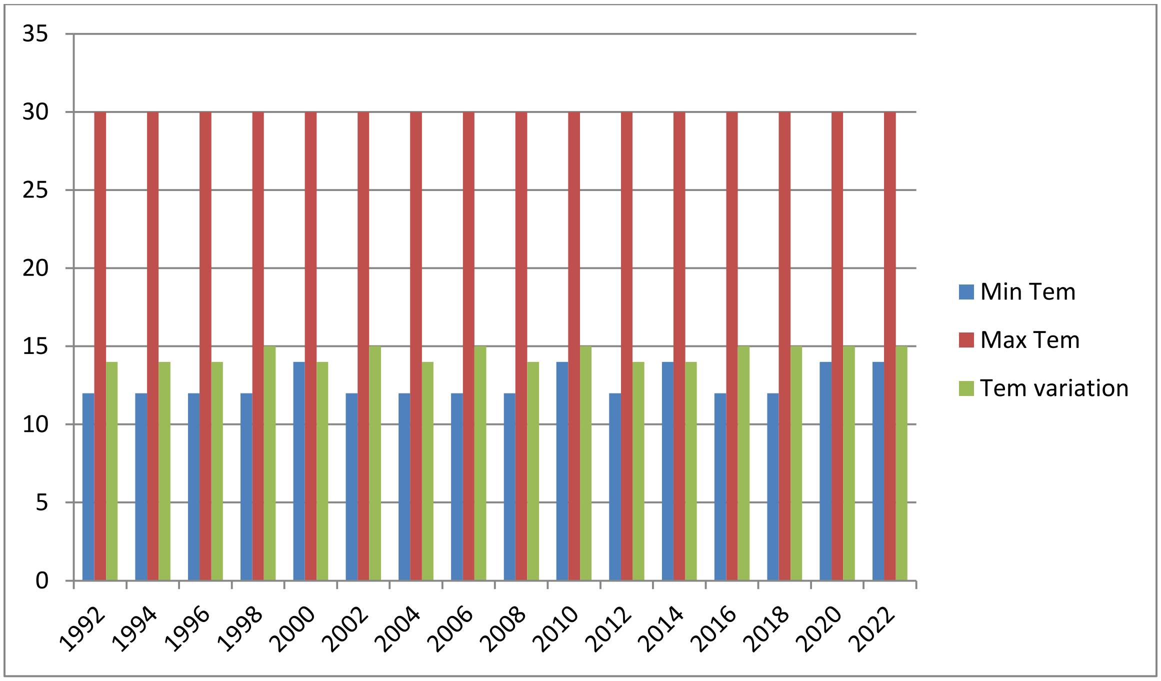


Figure 4.Trend of average annual maximum and minimum temperature in the study area (1992-2022)

Source: NMSA, 2022

Over the period 1992-2022, the area experienced annual average temperature range of between 22.4-26.4 ºc. The year 2002 registered the highest temperature of 26.4ºc and the year1999 registered the least temperature of 22.4ºc. The trend analysis between average annual temperature and time indicated the average temperature in the study area increased by about 0.0014ºc each year (Figure, 5). Therefore, farmers' perception on temperature change matched the quantitative data of climatic data of the area.

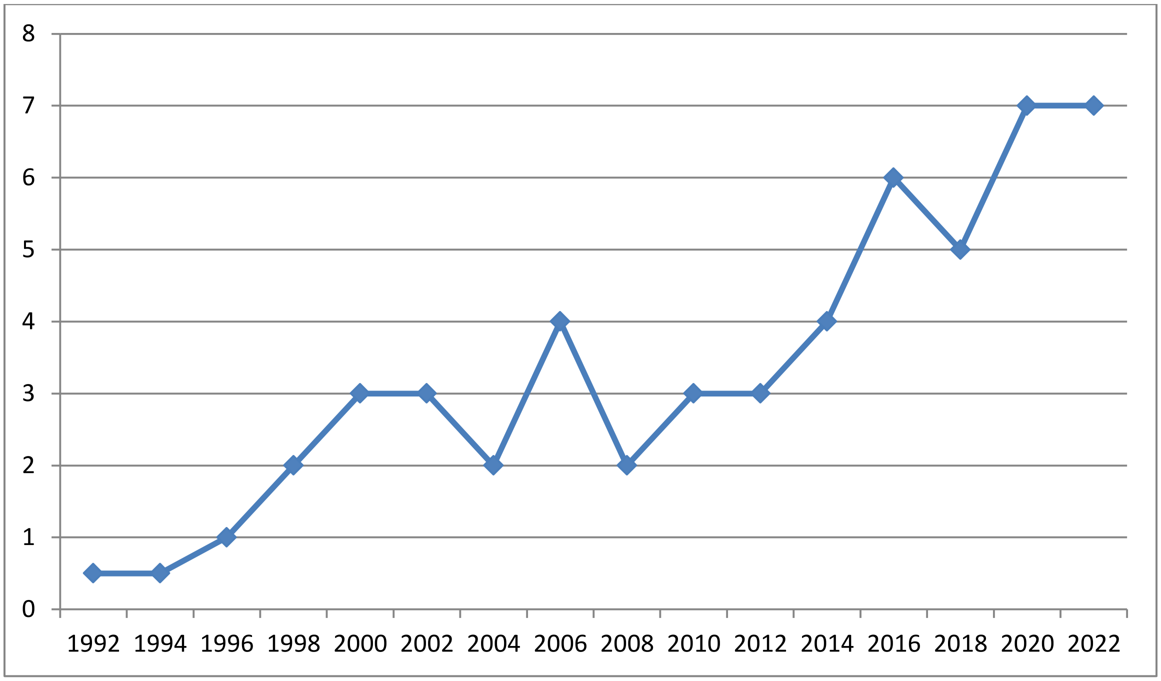


Figure 5, Trend of average annual temperature in the study area (1992-2022)

Source: NMSA, 2022.

Analysis of temperature (1992-2022) showed an annual increase by 0014ºc.rainfall recorded showed generally decreasing level of rainfall over the period 1992-2022.The results are in agreement with Stephen (2016) in South Africa and IPCC (2001) indication that with climate change ,temperature will increase while total rainfall will generally decrease. Farmers in the area were aware of what climate is and they are able to share their experience on a changing climate. From both the focus group discussion and the households' survey, rainfall seemed to be the main climate element concern. Temperature of woreda show recognized that climate change over the area not critical concern among the respondents justifying that if there is abundant rainfall, it will stabilize atmospheric temperature. The overall result showed that farming communities of wondo genet woreda recognized that climate has changed over the past 20 years. The perceived climate change does correspond to the meteorological data of the study area. This finding is in agreement with similar studies by Deressa (2009) in the Nile basin of Ethiopia. According to the focus group discussion on future expectation on climate change, they do expect that there will be a varying and short rainy season, increased temperature trend, and sometimes drought. Of course they prefer to heavy future climate change issue to Almighty God than being pessimist about it.

4.3 Farmers adaptation strategies to climate change in wondo genet woreda

Climate change adaptation measures are important for the agricultural production (Daba, 2018). In the study district, different adaptation strategies were employed to reduce the negative effect of climate change and to manage future patterns in climate change. Farming activities is the primary profession for almost all of the sample households. Although most of the times they combine some level of non-farming sources of income like trading were used. Based on the household survey data collected from 123 households. Accordingly, farmers were using different adaptation strategies to reduce the negative impact of climate change.

The majority of male and female headed households despite their differences in sex, age, social roles and agro-ecology perceived occurrence of climate change in the study area. These are manifested in terms of erratic rainfall, draught and an increase in temperature for the last two decades. In response to this, the descriptive statistics found that 89% of households employed at least one adaptation strategy among others to reduce the negative impact of climate change. Based on the importance of each strategy to their livelihood and agricultural activities, planting drought resistance crops, mixed farming, diversifying crop, shift planting date, soil and water conservation and use of irrigation were identified as the major adaptation strategies in the study area (Table 4.4).

Tables: 4.4, Farmers adaptation strategies in wondo genet woreda sidama region.(n=123).

No	Farmers adaptation strategies	Frequency		Percentage (%)	
		Yes	No	Yes	No
1	Planting drought resistance crops	107	16	86.99	13.1
2	Mixed farming	56	67	45.5	54.5
3	Diversifying crop	70	53	56.9	43.2
4	Shift planting date	54	69	43.9	56.2
5	Building a water harvesting schemes	105	18	85.45	14.6
6	Implementing soil conservation	70	53	56.9	43.2
7	Diversify from farming to non-farming	82	41	66.7	33.3
8	Increasing use of irrigation/ground water/watering	106	17	86.3	13.8

Source: own survey, 2024,

In the study area, 86.99% of farmers preferred using draught resistance crop as one of the top adaptation practice.

Out of the total sampled households, 56.9 % used (preferred) soil and water conservation as adaptation strategy to reduce the adverse effect of climate change on farm productivity. The adaptation of practicing technologies that enhance vegetative soil coverage and control soil erosion are crucial to ensuring greater resilience of production system to increased rainfall event, extended intervals between rainfall events, and to potential soil loss from extreme climate event (Gebrehiwote and Veen,2013). According to the FGD with farmers, they sometimes reserved not to practice fully this conservation practice because of some shortage of farm land; the activity delay annual production and needs of sufficiently skilled person and follow ups. There was one study conducted on land degradation and adoption of soil and water conservation technologies.

The result indicated that 86.99%, 86.28%, 85.45%, 66.6%, 56.9%, and 43.9% of the total sample households used improved drought resistance crops, increased use of irrigation, building water harvesting scheme, diversify from farming to non-farming ,implementing soil conservation, shift planting date and mixed farming were the most adaptation strategies used for sample households in the study area.

4.4 Determinants of farmers' adaptation strategies to climate change

Multinomial logit model was used to identify the determinants of farmers choice of adaptation strategies related to climate change. The MNL model was run taking "no adaptation" as a base category against other groups to be compared with. In order to see the probability of a particular choice of adaptation for a unit change in the independent variables, the regression coefficients, average marginal effect and their significance level were used. The likelihood ratio statics from the MNL model indicated that x^2 statistics was highly significant at $p < 0.001$, suggesting that the model has strong explanatory power. The mean values of the independent variables along with the respective standard deviation are presented on table 4.6.

Tables: 4.6. The summary statistics for independent variables

Independent variables	Description	Summary statistics			
		Mean	SD	Min	Max
Age of the HH head	Continuous variable	37.8	7.2	20	50
Education the HH head	Dummy 1 if male,0 otherwise	0.84	0.36	0	1
Sex of the HH head	Categorical variable	3.45	1.31	1	7
Size of HH	Continues variables	6.4	3.6	1	12
Farm income	Continues variables(ETB)	57398	36927	10000	100000
Non-farm income	Continues variables(ETB)	7723	2069	500	10000
Access to credit	Dummy 1 if yes,0 otherwise	0.35	0.48	0	1
Agricultural extension	Dummy 1 if yes,0 otherwise	0.68	0.47	0	1
Farm size	Continues variables	1.8	2.3	0.13	5
Access to climate information	Dummy 1 if yes, 0 otherwise	0.84	0.37	0	1
Distance to market	Continues variables	0.85	0.35	0	1

Source: own survey, 2024.

The result of the outcome model, which analyses factors affecting adaptation, indicates that most of the explanatory variables affected the probabilities of adaptation. The variables that positively and significantly influenced adaptation to climate change include gender of the household head, age, household size, access to credit, nonfarm income, farm income, farm land size and access to extension services, access to climate information and market distance (Table 4.7).

Level of education of a household head and farm income had no statistically significant effect on the selected adaptation measures. On the other hand, irrigation as adaptation measure was not significantly affected either negatively by any of the explanatory variables listed. Of course according to the data gathered from farmers, it was listed preferred strategy and one can imagine that other factors like agro ecology are more influential.

Table 4.7 Determinant of farmers' adaptation to climate change

Explanatory variable	Planting drought resistance crop	Mixed farming	Diversify crop	Building a water harvesting schemes	Implementing soil conservation	Diversify from farming to non-farming	Increase use of irrigation
Gender	2.613***	1.808*	2.900**	2.344***	2.386**	.055	2.744**
	(.006)	(.093)	(.024)	(.002)	(.030)	(.611)	(.022)
Age	-.029	-.127	.016	-.043	-.055	.319*	-.070
	(.618)	(.218)	(.817)	(.398)	(.544)	(.055)	(.312)
Education	.033	.093	.127	-.029	.230*	.856	.158
	(.768)	(.535)	(.336)	(.787)	(.085)	(.319)	(.166)
HH size	-.363	-.360	-.177	-.179	-1.227***	.088	-.300
	(.167)	(.319)	(.504)	(.404)	(.005)	(.856)	(.262)
Farm income	.046	.087	.059	.056	.144*	.737*	.062
	(.263)	(.266)	(.237)	(.124)	(.066)	(.088)	(.232)
Nonfarm income	-.218	-.471	-.015	-.963	.288	.251	-.128
	(.673)	(.672)	(.984)	(.200)	(.653)	(.737)	(.835)
Access to credit	-.299	2.5 65**	4.511***	.646	4.563***	.006	-.090
	(.767)	(.021)	(.000)	(.398)	(.000)	(.251)	(.931)
Agri ext.	-.742	-.272	.116	1.284*	-.576	.398***	1.445*
	(.391)	(.799)	(.896)	(.051)	(.540)	(.006)	(.082)
Farm size	.061	.997	-.230	.135	1.426	.834	.559
Clim info.	(.944)	(.446)	(.814)	(.854)	(.303)	(.398)	(.560)
Number of observation	123						
LR Chi- square	141.61						
Log likelihood	-197.16						
Pseudo R- Square	0.662						

Notes: ***, **, * = significant at 1%, 5%, and 10% probability level, respectively.

4.5 Interpretation of significance of determinant factors of adaptation strategies from the marginal effect result

Sex of the household head

Sex of the household head significantly influenced adaptation using diversifying crop at p<5%. The finding of the marginal effect from the Multinomial logit model showed that male-headed households were 26.4% more likely to use crop diversification relative to the reference category. The finding is in line with the claim of Gebrehiwote and Veen (2013) that male-headed households are often considered more likely to gain information about new technologies and take on risk than female-headed households. This is also supported by Atinkut and Mebrat (2016) as male headed households have greater preferences to use water harvesting schemes as a strategy that require labor, finance and climate information than female headed households.

Age of the household head

The result of MNL model showed that age of the household was found to be positively and significantly correlated with diversify from farming to non-farming at p<0.1. In this case, a one unit increase in the age of household increase the probability of using farming to no farming by 3.2%. older farmers are more likely to involve than younger ones. The probable reason may be that older farmers are less likely to take other adaptation measures like soil conservation and change diversify crop which require more labor.

Family size

Family size has also significant and positive effect on adaptation strategies to climate change. It is positively and significantly correlated with use of irrigation and soil conservation at $p<10\%$ and $p<5\%$ respectively. A one person increase in the family member at productive age can increase the probability of using the two adaptation measures by 2.6 and 7.5%, respectively. Households with larger family have an opportunity to use various adaptation options in the face of climate variability. This is in agreement with other finding by Atinkut and Mebrat (2016) and Deressa et al.,(2009). On the other hand a significant negative correlation was observed between household size and planting drought resistance crop.

Farm land size

It is also a statistically significant explanatory variable. That means farmers adaptation strategy to climate change is also significantly affected by the farm size that the farmer owned. A unit increase (in one hectare) per household would increase the probability of using changing crop varieties adaptation strategies increases by 51% at 5% level of significance. This indicates that the bigger the size of the farm, the greater the proportion of land allocated for diverse crop species as an adaptation strategies that the farmers are likely to adopt. Farm size is also positively associated with planting drought resistance crop, which means that a one hectare increase in farm size increase the probability of using planting drought resistance crop as adaptation strategies by 14.7 times at 10% level of significance.

Farm income

The farm income of the household surveyed has a positive and significant impact on use of diversify crop. This could be justified as use of improved crop varieties requires financial resource to purchase improved seed and hence increased income will contribute a lot on using this type of adaptation option. As one of adaptation constraints mentioned by farmers was financial. This finding is in line with Seid S (2014)

Nonfarm income

The result of the analysis reveals that nonfarm income of household had a positive and significant influence on using water harvesting as adaptation strategy in one way this can be justified as those households involve in different income generating activities prefer water harvesting because other farm adaptation strategies will take more time and attention. Opposing to this findings, Gbetibouo (2009) reported that expanding smallholder farmers access to non-farming source of income increased the likelihood they would invest more in farming activities

Access to credit

Among the institutional factors, access to affordable credit increases financial resources of farmers and their ability to meet transaction costs associated with various adaptation option they might want to take (Hassan and Nhemachena, 2008). The result of the analysis showed that access to credit had a positive impact on the likelihood of using different types of crops in the course of change in climatic conditions. Increasing a farmer's access to credit increased the likelihood of choosing diversify crop measures by 16.7%. Adaptation method to climate change needs money to purchase improved inputs such as fertilizer and seeds. The result of the is similar with the findings of Gebrehiwote and Veen (2013).

Access to agricultural extension service

Among the institutional factors, access extension contact is one of those significant variables that affect the farmer's choice of adaptation. Result of MNL model showed that extension service has positive and significant correlation with the likelihood of choosing water harvesting and soil conservation as adaptation measure at $p<0.1$. A one unit increase in the extension contact is likely to increase the probability of farmers to adapt water harvest and soil conservation by 9% higher than those households who do not access extension service.

Climate change information

Information on temperature and rainfall had a significant and positive impact on the house hold using soil conservation and mixed farming. Thus, the finding confirmed that having access to information on climate change increased the house hold adoption soil conservation measure and mixed farming by 9.8% and 23.7%, respectively.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Climate change has currently been recognized across disciplines and groups of people as a serious challenge facing societies today. This study was motivated by the fact that agriculture is a key economic sector in the world feeding all people, providing employment to billions world-wide while supporting economic growth. Agricultural system in Ethiopia is still dependent on seasonal rainfall and the smallholder farming as part of the agricultural sector has immense contribution to food security, economic growth and employment provision. This economic activity however is very vulnerable to impacts of the changing climate due to among others, high dependence on rainfall; poor irrigation potential; and limited access to improved agricultural technologies, input and finance. With all these general facts, the research has focused on climate change adaptation practice.

This study analyzed climate change, adaptation strategies and their determinants in wondo genet woredas Sidama region. The study was designed with the objective of examine climate change, adaptation strategies and their determinants, identifying climate change adaptation strategies and finally determining factors that influence climate change adaptation strategies.

Using the data obtained from meteorology agency tests were under taken for linear trend in average annual temperature, and annual rainfall against time of the study area. The trend analysis of average annual temperature indicated that average annual temperature in the study area increased by about 0.0014^{o}c each year. The trend analysis of annual rainfall indicated that annual rainfall in the study area decreased by about 0.05mm each year.

Adaptation strategies used by farmers in the study area include planting drought resistance crop (86.99%), mixed farming (45.4%), diversifying crop (56.9%), changing/adjusting planting date (43, 9%), building water harvesting schemes (84.5%), use of soil conservation techniques (56, 9%), diversify farming to no farming (66.6%) use of irrigation (86.3 %).

Multinomial logit model result also confirmed that nonfarm income, farm size, and age of household head have a significant impact on the use of planting drought resistance crop as climate change adaptation strategy. The result also showed that household size, access to agricultural extension service and access to climate information significantly affected the use of soil and water conservation to adapt to climate change. Furthermore, gender of household head, household size, access to credit and farm land size significantly affect using crop diversification.

5.2 Recommendations

Based on the evidence obtained from the findings and given the trend in local climate, there is a need for action aimed at addressing factors of climate change adaptation in the study area. Accordingly the following points were drawn i.e.

1. Access to water source (surface/ground) in the area should be improved so that farmers will minimize dependency on rain fed agriculture. Hence, small scale irrigation and surface water harvesting technology are recommended.
2. Agricultural offices and DAs should focus on climate change training which increases farmers' decision making on using different adaptation strategies to reduce the negative impact of climate change.

3. Adaptation to climate change requires credit provisions and reasonable credit would increase financial resource of farmers and ability to by crop variety and other inputs. So development institutions enhance the credit accessibility and provision for farmers.
4. It is also important to encouraged farmers to use different media like radio, television, and traditional leaders or elders to get access to climate information and perception to climate change so that they will be able respond to climate change.
5. Designing programs to increase land size could be a crucial policy issue, given the scarcity of farm land in the area, to strengthen farmer economic capacity to implement various changing planting date, income source diversification and drought tolerant crop as adaptation techniques.
6. Further research direction there are many factors that affect agricultural production, so researchers should give attention to variable without climate change special rainfall and temperature. While, variable like soil fertility status, agro ecology, sources of water, and other determinant factors should be studied by other researchers.

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APPENDICES

Appendix 1: Questionnaire for household survey

Identification Particulars

Enumerator's Name______________________________

Signature and Date ______________________________

Name of the Area /Keble ______________________

Part I Demographic and socio-economic characteristics

1. Gender of households A. male ☐ B. Female ☐
2. Age of households A. 20- 30 years B. 31 -40 ☐
   C. 41 – 50 ☐
3. Educational background A. unable to read and write ☐ B. Grade 1 -4 ☐
   C. Grade 5 – 8 ☐ D. Grade 9 -12. ☐ E. Certificate ☐
   F. Diploma ☐ G. First Degree Above ☐
4. Marital status A. married ☐ B. unmarried ☐ C. ☐ Divorced
   D. Widowed ☐
5. If you are married, what is your family size
   A. 1 – 5 ☐ B. 5 – 10 ☐ C. ≥ 10 ☐

6. What is the main livelihood strategy of your household (possible to have more than one alternative?) A. Crop/horticulture ☐ B. Livestock ☐ C. Mixed ☐

D. Government/service ☐ E. Labour /daily wage ☐

7. How much income can you generate from your farming activities during last production years?

	Source	In birr
Farm income	Crop production	
	Selling livestock and livestock production	
	Selling of fruits and vegetables	
	Selling of crop production	
Nonfarm income	Government employment	
	Remittance from family	
	Trade, Rent. Aid etc.	

8. What are the physical characteristics of your farm, in terms of its exposure to erosion?

A. Susceptible ☐ B. Moderately ☐ C. Not susceptible at all ☐

9. In which category do you classify your farmland on the basis of its fertility?

A. Infertile ☐ B. Less fertile ☐ C. Fertile ☐ D. Highly fertile ☐

Part II Resource Endowed

10. Do you have your own land A. yes ☐ B. No ☐

11. If yes, what is the size of your land holding in hectare ________________________?

12. What type land do you have? (land use/cover)

A. Cultivated ☐ B. Grass land ☐ C. wood land ☐ D. Home garden ☐

E. Forest ☐ F. Agro forestry ☐ G. Range land ☐

13. If your answer is "A" for Q # 12, what type of agriculture do you practice?

A. Rain fed ☐ B. Irrigated ☐ C. Mixed ☐

14. Why do you perform farming?

A. For Subsistence ☐ B. Profit making/ business ☐ C. both ☐

15. If your answer is "A" for Q # 14, does your annual production cover the annual food need of your family? A. yes ☐ B. Partial ☐ C. No ☐

16. How long have you been farming?

A. ≤ 10 years ☐ B.10- 20 years ☐ C. 20-30 years ☐ D. ≥30 years ☐

17. Which types of crops do you have grown currently? Fill the table below

No.	Crop type		rain fed	Irrigated	Remark
1	Perennials	Coffee			
		Enset			
		Banana			
		Chat			
		Shuger cane			
2	Annuals	Maize			
		Teff			
		Wheat			
3	Fruits	Avocado			
		Orange			
		Mango			
4	Vegetable	Tomato			
		sweet potato			
		Potato			
5	others				

Part III climate change, variability, induced effects

18. What is the effect of climate change in your area? Please fill the table below. i.e. Multiple answers are possible.

No.	Climate change and variability effect	Mark (√) your choice
1	Food shortage	
2	Crop disease	
3	Scarcity of water	
4	Soil erosion	
5	Livestock disease	
6	Bio diversity loss	
7	Livestock feed scarcity	
8	Heat waves	
9	Damage to infrastructure	
10	Harvest failure	
11	Other	

Part IV. Climate change and variability perception assessment (circle your answer for the following question)

19. Have you heard of world climate change and variability before? A. Yes B. No

20. If your answer is "A" for Q # 19, from which source do you heard about climate change and variability? (Possible to circle more than a single choice).

A. Television B. Newspaper C. Friends/families D. Radio
E. School/collage F. Government Agency G. Mobile I.Others

21. What do you say about the trends of temperature over the last 20 years?

A. Increased   B. Decreased   C. No changed   D. I don't know

22. Perception on future climate change and possible impact, which of the following do you worry on? A. Recurrent flood B. Recurrent drought C. Crop failure D. Crop diseases E. Loss of livestock F. Price increase for input G. Soil fertility decline H. Short rainy season

23. Have you perceive any change in climate? A. Yes B. No

24. What do you say about the trend of precipitation over the last 20 years?

A. Total rainfall increasing   B. Total rainfall decrease   C. No change

25. Which local indicator do you use to evaluate daily rainfall patterns?

A. Decline of agricultural yield
B. Decrease availability of water
C. Rain starting earlier or later than normal
D. Increase drought recurrences
E. Increase flood recurrences

26. Have you noticed any long-term change in water sources over the last 20 years?

A. Numerous   B. Constant   C. Fewer   D. Good   E. Bad

27. Are you vulnerable to climate change related problems?   A. Yes   B. No

28. If your answer is "A" for Q # 27, which of the following perceived impacts of climate variability and change affect your life? Please put your rank from most sever to least sever (by saying 1st ,2nd , 3rd , 4th etc.)

A. Drought and flood   B. Animal disease

C. Insects and pests   D. Winds

E. Agricultural yield decline   F. Shortage of water

29. What do you think about the causes of climate change? (Encircle you answer)

A. Human activity B. Natural process C. Both D. I have no idea

Part V Public access (Institutional factors)

30	Distance to market	In km	In hrs
	To buy agricultural inputs (seed, fertilizer…etc.)		
	To sell agricultural out put		

31. In undertaking your usual farming activities have you ever faced shortage of finance to purchase agricultural in puts like fertilizer, oxen, seed and others?

A. Yes B. No

32. Do you have access to credit? A. Yes B. No

33. If your answer is "yes" for Q#32 what type of credit access?

A. Fertilizer B .Improved Seed C. Money D. Others

34. Do you have contact with development agent (DA)? A. Yes B. No

35. If yes how money times in years ________________? A, two times B, three times C. four times D. five times

36. What type of extension service you received from development agent (DA)?

A. Advice B. Training (protects soil from erosion, conservation rain water, use modern agricultural input, reduce post-harvest loss, etc. C .practical support

37. Do you have sufficient transport access in your area? A. Yes B. No

38. Which types of transport access in your area?

A. Vehicles B. Donkey and Horse C. Head portrage

39. Do you have health center at your village? A. Yes B. No

40. Do you have education center at your village? A. Yes B. No

41. If your answer is "Yes" for Q# 40 mention types of education. A. Formal B. Informal C. Adult education

42. If there an electric service in your village? A. Yes B. No

43. If your answer to the above question is yes, what is the source of power?

A. Water B. Solar C. Bio-gas D. Wind E. Others

44. Do you have access to improved agricultural inputs and technologies?

A. Yes B. No

Part VI: - barriers for climate change adaptation mechanism

45. What are the factors that influence farmer's choice on adaptation strategies? (Possible to select more than one choice)

A. Lack of information B. lack of capital C. poor potential for irrigation

D. Shortage of farming land E. Shortage of labours F. Access to credit

G. Distance to market H. Absence of agricultural training I. Others

46. What are the major challenge/ problems that you face in your crop production. Please indicate.

No.	Challenges	Rank (1st , 2nd , 3rd etc
1	Drought	
2	Erratic/ uneven rainfall	
3	Lack of water	
4	Lack of fertilizer	
5	Soil fertility	
6	Insecticides	
7	Pesticides	
8	Land shortage/ small land size	
9	Lack of improved seed	
10	Other (specify)	

Part VII Questionnaire for the assessment of adaptation option to climate change and barriers faced.

47. What adjustments in your farming / livelihood have you made to long term change of the rainfall? (Say Yes or No for all of the following)

A. Enhanced traditional irrigation schemes. ______________
B. Used drought resistant crop variability. ______________
C. Shifting from crop production to planting vegetation _____________
D. Used improved crop variability.___________________
E. Adopt crop rotation and mixed cropping. _________________
F. Enhancing animal rearing practice. ________________
G. If there is other list them. ________________

48. Do you think the adaptation option listed in the table is helpful to adopt climate change bad effects while engaged in livelihood?

No	Adaptation option	Rank the most usable one
1	Planting drought resistance crop	
2	Mixed farming	
3	Diversifying crops	
4	Shift planting dates	
5	Building a water harvesting schemes	
6	Implementing soil conservation	
7	Diversify from farming to non-farming activity	
8	Increase use of irrigation /ground water/ watering	
9	Others	

49. Do you think that your area wants help other bodies to coup climatic change problems?

A. Yes B. No

50. If your answer is "Yes" on question # 49, who is responsible for adaptation practice? (Multiple choices is possible)

A. Governmental organization B. Non-governmental organization

C. Local communities D. Interested groups

51. If your answer is "A OR B" on question #50, which of the following solution is more accepted and interested by the community?

A. Enhance adaptation through applicable policies
B. Distribution of new seed variability's
C. Enhance intellectual capacity of the community through consecutive training
D. Drought preparedness and warning

52. If your answer is “A OR B” on question # 51which of the following mechanism is more possible? (Multiple choices is possible)

A. Doing additional non-farm activities B. soil and water conservation

D. Planting drought resisted crop varieties E. water harvesting techniques

F. Crop diversification G. Adjusting seasonal calendar

Part VIII Questions for key informant interview (KII)

1. Was there temperature and rainfall variability, change in the last 20 years? ______. Please mention if those problems encountered.

2. What do you think the causes of climate change? Please briefly discuss.

3. What local indicator can identify to evaluate the climate change and variability? Discuss.

4. Do you think climate change affected the lives of community? List them.

5. What are the local coping mechanisms used to reduce the impact of climate change? List them.

6. What are the institutional level coping strategies to reduce the future impact? List them

Part IX Questions for focus group discussion (FGD)

1. Do you feel temperature is increase? _________.
2. Do you think as there is climate change and variability in your area?_______.
3. What would be the cause? Please list them.
4. What are your local indicators to realize that there is climate change? Please list the most indictors.
5. What are the problem that related to climate change in your area? List them
6. What adaptation strategies have used to reduce problems arising from climate change in your community? Please list major adaptation strategies.

Appendix 2: Monthly average Max, tem.(^{0}c)

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	26.7	28.3	28.5	29.5	26.7	26.2	24.7	24.8	25.1	25.2	26.6	28.0
1999	28.6	30.6	29.5	26.8	27,5	27.5	22.1	24.0	24.6	24.6	24.8	25.9
2000	29.0	29.7	29.8	28.3	20.1	24.7	23.9	24.3	23.9	23.7	25,3	27.1
2001	28.4	28.7	27.5	26.3	26.5	24.2	25.1	25.3	24.6	25.7	27.9	28.1
2002	28.7	29.4	29.1	29.4	29.3	27.5	27.8	26.7	25.6	26.0	27.0	27.0
2003	26.0	29.5	30.1	29.4	28.6	26.9	23.0	26.1	26.6	27.0	27.8	27.6
2004	28.0	28.2	28.3	26.6	27.2	27.0	23.8	24.5	24.1	25.7	26.4	27.5
2005	28.5	30.2	28.7	28.4	24.6	24.3	23.3	24.9	25.0	25.6	26.6	27.6
2006	29.4	29.9	28.2	26.3	26.1	24.7	23.3	24.0	24.5	25.5	26.1	26.3
2007	27.7	29.3	29.9	27.2	26.1	24.0	24.0	23.3	24.2	25.9	26.6	27.4
2008	28.5	28.9	30.5	27.3	24.4	24.5	23.0	23.6	24.8	25.2	25.9	27.1
2009	27.7	28,9	30.5	27.0	26.8	25.7	24.4	25.6	25.7	25.5	27.4	26.4
2010	27.3	27.6	27.0	26.8	25.7	24.8	23.3	24.1	24.2	26.0	27.6	27.5
2011	28.7	30.0	29.8	29.2	26.0	24.6	24.4	23.6	24.6	26.1	26.7	26.4
2012	27.6	29.6	30,7	27.3	26.6	25.0	24.2	24.1	25.0	26.0	26.5	28.2
2013	29.2	30.4	30.2	27.4	26.4	24.8	25.0	24.9	25.1	26.0	26.4	27.3
2014	28.9	28.3	28.4	27.6	26.4	26.1	24.3	24.3	25.0	25.0	26.4	27.0
2015	28.2	30.8	30.0	25.8	27.0	25.2	24.4	25.6	26.6	27.7	27.9	27.5
2016	27.7	29.6	30.0	27.2	25.3	24.2	24.0	25.0	24.5	27.0	27.0	27.3
2017	28.0	29.4	29.2	30.4	26.6	26.5	25.1	25.6	24.4	26.0	27.0	27.0

Source NMSA, Hawassa meteorological service center, Hawassa station (1992-2022)

Appendix 3. Monthly average min.tem (⁰c)

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1998	11.5	12.8	12.8	8.0	10.0	10.2	12.8	14.3	12.9	14.2	11.0	10.0
1999	12.1	10.0	12.4	12.6	13.4	11.7	10.6	6.8	6.2	6.9	4.1	4.4
2000	6.8	7.1	9.7	11.4	11.5	11.3	12.5	12.1	10.5	11.2	12.4	10.0
2001	8.8	8.9	11.1	12.2	12.5	12.9	11.7	13.7	12.7	12.6	10.6	9.5
2002	11.7	11.7	13.5	13.6	13.9	13.3	13.0	13.2	12.1	12.1	10.8	11.5
2003	10.7	10.3	12.2	13.7	12.0	12.5	12.2	12.1	12.0	12.4	11.1	10.6
2004	10.2	10.2	8.1	7.9	10.9	11.4	12.9	13.4	12.8	10.6	11.0	10.5
2005	10.4	10.2	13.2	13.0	12.7	13.2	13.6	13.4	12.2	12.4	9.3	6.6
2006	10.2	10.7	12.6	11.9	12.3	13.0	13.7	13.3	13.5	12.6	11.2	11.3
2007	11.5	12.3	11.0	13.1	13.9	13.6	13.7	13.3	13.4	10.7	10.1	7.5
2008	9.0	9.9	10.3	12.1	13.0	13.1	13,7	13.3	12.7	12.3	9.7	8.5
2009	9.4	10.3	10.7	13,1	12.8	11.9	13.1	13.3	12.8	12.3	10.2	12.2
2010	10.7	13.7	13.0	14.1	14.8	12.4	13.1	13.3	12.2	12.8	9.8	8.9
2011	9.0	8.4	10.6	11.7	12.9	12.8	12.6	12.3	12.8	11.2	11.2	8.3
2012	8.0	5.9	5.9	10,7	11.3	9.9	12.8	12.4	12.8	11.7	11.1	7.7
2013	7.2	7.7	9.4	8.1	8.8	12.8	14.0	11.7	11.3	11.3	8.9	7.5
2014	9.1	10.1	10.8	11.4	9.0	10.2	10.2	12.3	11.7	12.0	12.6	11.0
2015	8.0	12.0	12.0	11.8	10.2	10.4	11.1	11.7	10.9	11.9	10.1	10,5
2016	10.5	12.0	12.5	14.7	13.3	12.7	13.1	13.2	11.9	12.0	12.1	11.5
2017	7.5	10.8	11.0	11.9	12.3	13.4	13.8	13.8	12.2	12.0	13.0	12.0

Source: NMSA, Hawassa meteorologic al service center, Hawassa station

Appendix4. Monthly average rainfall (mm) (1992-2022)

Years	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual RF
1992	46.6	93.7	54.5	134.8	114.0	67.4	145.4	164.3	136.2	213.0	89.6	36.9	1296.4
1993	77.8	96.4	35.1	207.3	157.3	99.4	71.2	96.9	134.4	133.0	13.4	1.9	1124.1
1994	0.7	0.8	130.2	126.4	116.3	141.6	407.9	171.5	147.9	16.4	28.5	0.0	1288.2
1995	0.0	21.7	104.0	212.2	97.1	67.6	134.7	187.6	134.1	19.2	1.0	45.3	1024.5
1996	38.9	19.4	102.8	179.2	105.4	155.9	183.1	246.4	153.3	41.3	19.2	8.2	1253.1
1997	39.5	6.5	54.1	252.3	76.2	192.0	Na	Na	Na	153.5	141.4	4.7	920.2
1998	91.3	157.0	175.1	75.5	155.1	107.8	131.9	99.8	120.9	181.1	9.1	0.0	1304.6
1999	7.7	0.0	127.6	53.3	97.4	62.8	112.1	111.9	130.7	183.9	5.7	23.4	916.5
2000	0.0	0.0	6.5	114.6	104.6	29.7	83.0	83.9	204.2	226.8	63.7	26.6	943.1
2001	0.0	58.5	182.9	87.3	235.3	139.5	100.2	169.2	198.7	106.3	1.3	11.3	1290.5
2002	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na	Na	0.0
2003	Na	Na	Na	Na	31.6	102.0	133.9	149.0	140.1	85.2	11.4	57.2	710.4
2004	65.7	16.4	45.4	98.7	127.2	94.5	89.9	139.0	217.4	69.4	41.9	25.3	1030.8
2005	77.1	10.2	132.3	156.5	170.6	33.2	94.4	77.1	147.3	130.7	73.0	21.7	1124.1
2006	0.0	30.5	157.3	247.0	151.6	70.4	121.4	147.4	180.4	97.3	32.3	30.4	1266.0
2007	28.2	23.9	75.1	232.7	115.7	255.8	73.7	167.1	77.1	74.9	0.8	8.9	1133.9
2008	1.8	0.0	16.5	51.4	67.9	144.0	53.7	174.5	147.9	68.1	127.8	0.0	853.6
2009	36.4	22.8	71.0	43.6	61.7	38.0	56.9	80.1	54.3	145.5	0.0	77.2	687.5
2010	112.8	61.3	188.0	181.9	105.6	175.8	169.9	223.0	96.0	26.9	61.1	21.6	1423.9
2011	10.2	18.4	51.1	71.9	248.3	Na	274.5	234.4	157.9	Na	111.4	6.2	1184.3
2012	0.0	Na	3.2	117.9	123.6	69.5	202.4	121.2	96.2	Na	28.3	13.3	775.6
2013	15.2	6.3	94.1	102.4	110.8	68.0	239.5	188.8	186.8	Na	Na	3.4	1015.3
2014	10.4	54.5	115.8	100.1	0.0	54.1	0.0	135.9	144.9	0.0	0.0	0.0	615.7
2015	2.4	5.4	69.7	35.8	63.7	0.0	0.0	105.3	0.0	31.8	30.2	0.0	344.3
2016	57.1	31.1	0.0	212.6	167.5	0.0	96.8	191.5	104.0	93.4	60.8	6.6	1021.4
2017	0.0	73.0	107.3	83.1	226.6	35.0	160.7	165.7	204.1	126.7	17.0	0.0	1190.2
2018	0.0	77.4	143.6	220.1	232.2	60.0	36.0	251.5	166.4	78.2	60.9	14.2	1340.5
2019	Na	Na	59.3	141.2	212.0	183.9	167.7	290.7	176.0	88.3	77.5	9.0	1405.6
2020	40.1	22.1	94.0	145.2	154.0	106.9	169.6	102.6	174.5	151.9	46.1	9.1	1216.1
2021	0.0	9.5	22.2	151.2	75.0	96.6	132.6	111.0	251.3	85.8	36.9	23.6	995.7
2022	50.7	16.3	34.8	91.0	50.4	99.4	152.9	13.1	164.4	118.4	63.6	10.1	871.1

Source: NMSA, Hawassa meteorological service center, Hawassa station.

BIOGRAPHIC SKETCH

Adugna Fiche Faliso was born in wondo genet town, Ethiopia on March 29, 1995. She attended primary and secondary school in wondo genet Tigil fire school and Hawassa Addis Ketema secondary school respectively. She joined Wolaita Sodo University and obtained B.A Degree in geography and environmental studies on June 28, 2016. She has been working in wondo genet woreda. She joined Hawassa university school of graduate studies in 2022.she is single.